Toilets and Urinals

Response to California Energy Commission
2013 Pre-Rulemaking Appliance Efficiency
Invitation to Participate

Docket Number: 12-AAER-2C; Water Appliances

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Summary

The information below provides direct response to the California Energy Commission's (CEC) Invitation to Participate (ITP) for the 2013 Appliance Efficiency Pre-Rulemaking, regarding toilets and urinals, including reference to several primary sources, some of which are attached separately (see References for more details). This document includes all of the questions asked in the ITP, even for those with no response.

California has an excellent opportunity to explore energy efficiency standards for toilets & urinals. 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.

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.

There are many data sources available to the CEC including the extensive research the EPA WaterSense program developed in support of the WaterSense Specification for Tank-type Toilets and the WaterSense Specification for Flushing Urinals. WaterSense also maintains a database of WaterSense Labeled products.

The Department of Energy (DOE) is in the process of updating the test procedures for showerheads, faucets, water closets, urinals, and commercial pre-rinse spray valves. Information from DOE's proceeding is relevant to California's effort to establish revised standards for faucets, toilets, and urinals.

There are also numerous scholarly reports that address, among other topics, performance, usage characteristic, and market share.

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1 Basic Information

1.1 Product Definition and Scope

Current Title 20 standards cover the following types of water closets (i.e., toilets):

- Blowout water closets
- Electromechanical hydraulic water closets
- Flushometer tank water closets
- Gravity tank-type water closets
- Vacuum-type water closets

Current Title 20 standards cover the following types of urinals:

- Urinals (wall or floor mounted)
- Prison-type urinals
- Trough-type urinals
- Vacuum-type urinals

Flush valves for toilets and urinals are not explicitly covered by current T20 standards. As discussed in Section 5.5, DOE has recently issued an interpretation of the federal standards that valves shipped separately from a toilet bowl are not federally covered products, and are therefore not subject to federal standards.

Although the federal efficiency standards for toilets and urinals (1.6 gpf and1.0 gpf, respectively) have been in place since 1992, replacement flush valves designed for higher flush volumes are still readily available. The existing building stock still has many older fixtures and occasionally a valve needs to be replaced. 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.

Also see response to 6.1, 6.2, and 6.3.

1.2 Sources of Test Data

- **WaterSense:** WaterSense maintains a database of WaterSense Labeled products: http://www.epa.gov/watersense/product_search.html
- **Maximum Performance (MaP):** MaP maintains a database of products that meet the MaP requirements: http://www.map-testing.com/about/maximum-performance/map-search.html.
- **CEC Appliance Efficiency Database:** CEC's Appliance Efficiency Database includes toilets and urinals.

- **DOE Compliance Certification Database:** DOE maintains a database of toilets and urinals that are certified to be incompliance with the federal standard http://www.regulations.doe.gov/certification-data/.

1.3 Existing Standards and Standards under Development

1.3.1 Federal Appliance Standards

Prior to 1970, most toilets consumed more 6 gallons per flush or more. Effective January 1, 1978 California law required all toilets to consume no more than 3.5 gallons per flush. 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 nation-wide standards that were enacted with the Energy Policy Act of 1992. The federal standards that took effect in 1994 are 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.

Non-low-flush fixtures may only be installed at historical sites where historically accurate low-flush models are not available, where the installation of the low-flush fixtures would require the modification of the plumbing system behind a finished wall, or where the local government has enacted an enabling ordinance because the unique configuration of building drainage systems or public sewer systems requires more water to function properly.

According to federal law, if ASME revises the standard, the DOE must review ASME's action and consider adjusting the federal standards. If ASME does not revise the standard 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 prerinse 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).

1.3.2 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 that plumbing fixtures installed in residential and commercial buildings constructed before 1994 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

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.

1.3.3 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).

1.3.1 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 has 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

ASHRAE, ICC, and IAPMO have already adopted water efficiency standards for toilets and urinals. 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)
- IAPMO 2012 Green Plumbing and Mechanical Code

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).

1.4 Product Lifetime

A report D&R International developed for the U.S. EPA 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 D&R International report were used in support of WaterSense standards (D&R International 2005).

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 that toilets sold in California after 1978 had to consume 1.6 gpf or less, it is likely that these 3.5 gpf toilets were well over 25 years old (Aquacraft 2011).

A 2002 study performed by East Bay Municipal Utility District (EBMUD) sheds some light on the lifetime of commercial toilets. In 2002, EBMUD surveyed the water efficiency of toilets installed in commercial toilets 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 1, 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).

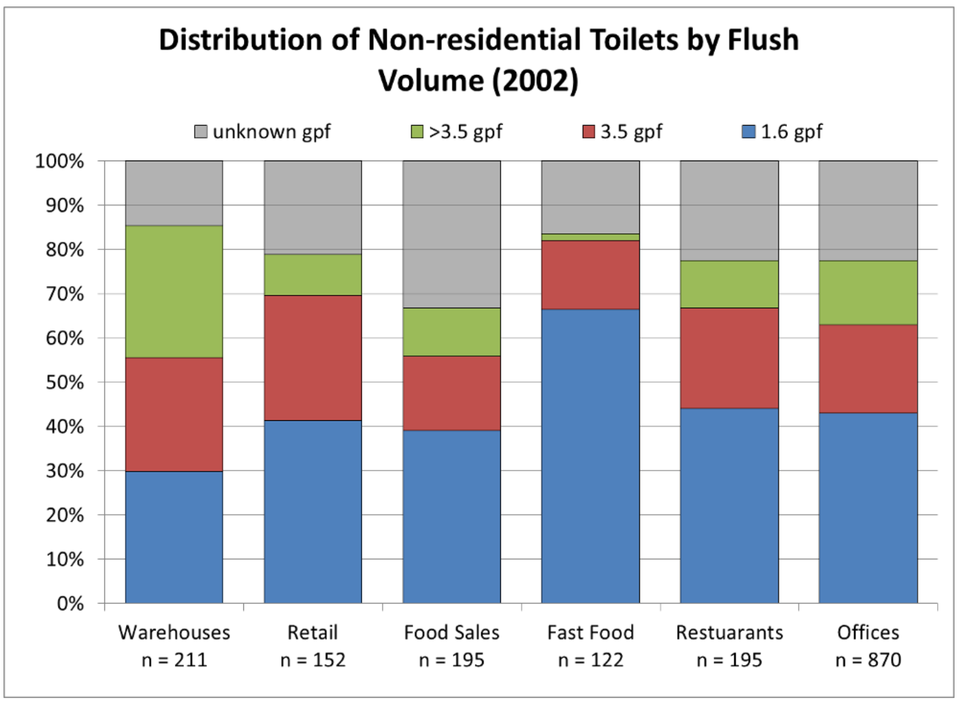


Figure 1: Distribution of Non-residential Toilets by Flow Rate (2002)
Source: EBMUD 2002.

1.5 Product Development Trends

No response

1.6 Design and Sales Cycle

No response

2 Energy Saving Technologies, Components, and Features

2.1 What are the technology options or features that allow toilets and urinals to save water?

See response to 6.1, 6.2, and 6.3.

2.1.1 How much water does each save?

See below in Section 2.1.2 for discussion of water savings and embedded energy savings.

2.1.2 What are the embedded energy savings from the water saved?

Overview of Embedded Energy in California Water

California consumes about 2.9 trillion gallons of water per year for urban uses (Christian-Smith, Heberger and 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. Figures 2 and 3 present the estimated urban water use in 2005 and the associated embedded energy use.

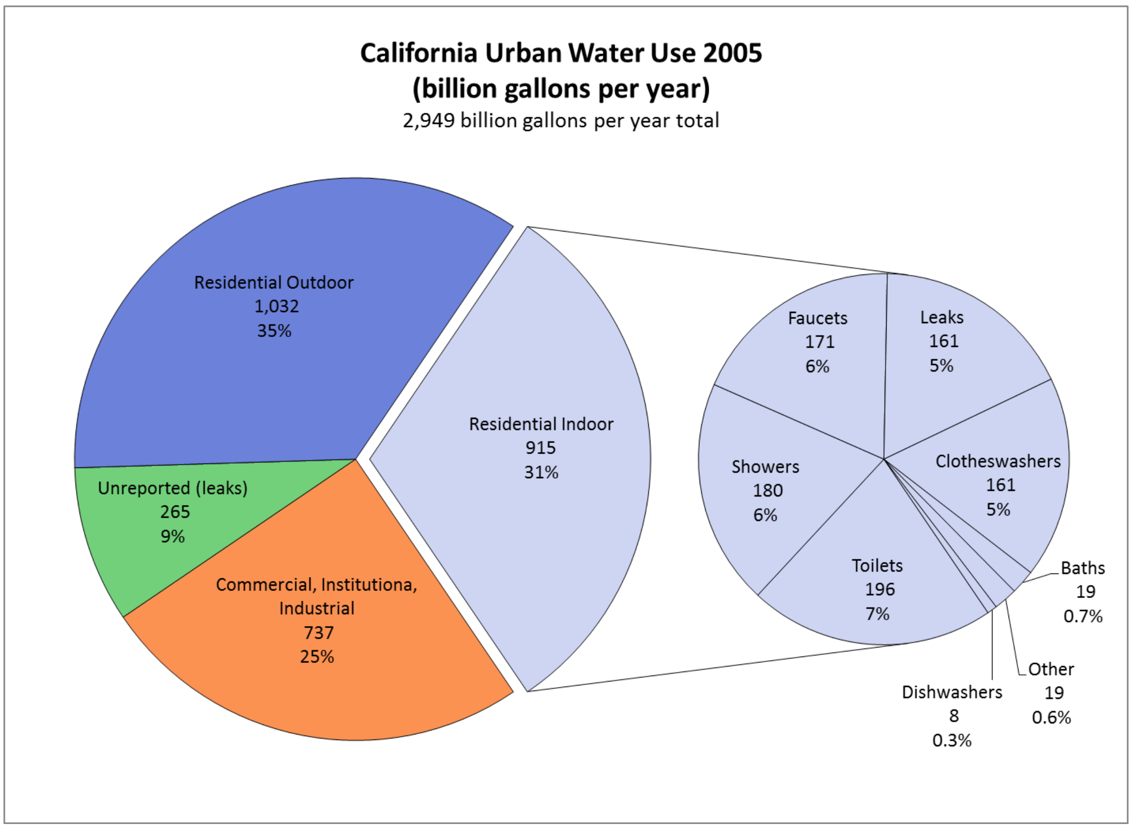


Figure 2: California Urban Water Uses (2005)
Source: Christian-Smith, Heberger, Luch (2012).

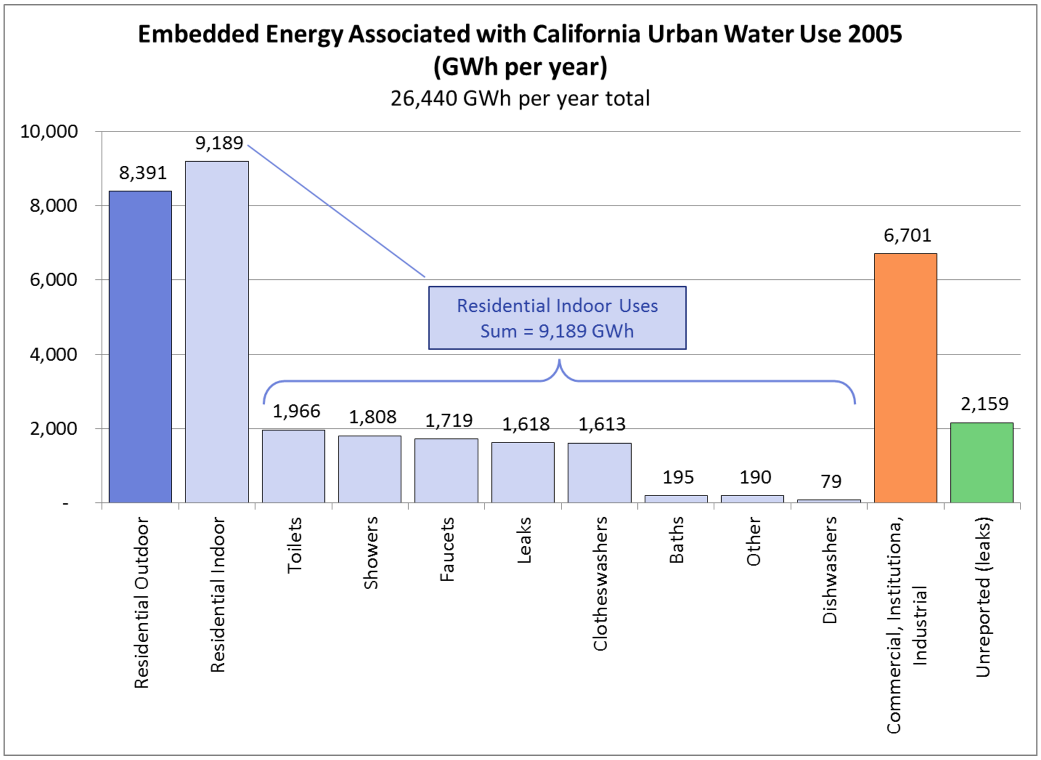


Figure 3: California Urban Water Uses (2005)

Sources: 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.

Embedded Energy in Toilets and Urinals

As shown in Figures 2 and 3 above, 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.

Tables 1-3 present per unit water and embedded energy usage for fixtures of various efficiencies. The tables also present the savings over the baseline efficiency of 1.6 gpf for toilets and 1.0 gpf for urinals.

Table 1: Per Unit Water and Embedded Energy Savings – Residential Toilets

Toilet Efficiency (gpf)	Savings per Flush		Annual Usage		Annual Savings	
	(gallons)	(watt-hrs)	(gallons)	(kilowatt-hrs)	(gallons)	(kilowatt-hrs)
1.6 (baseline)	n/a	n/a	4,322	43.4	n/a	n/a
1.28	0.32	3.2	3,457	34.7	864	8.7
1.0	0.6	6.0	2,701	27.1	1,621	16.3
0	1.6	16.1	0	0	4,322	43.4

Assumptions: 7.4 flushes per toilet per day; 365 flush days per year; 10,045 kWh/MG

Table 2: Per Unit Water and Embedded Energy Savings – Commercial Toilets

Toilet Efficiency (gpf)	Savings per Flush		Annual Usage		Annual Savings	
	(gallons)	(watts)	(gallons)	(kilowatt-hrs)	(gallons)	(kilowatt-hrs)
1.6 (baseline)	n/a	n/a	2,454	24.7	n/a	n/a
1.28	0.32	3.2	4,931	49.5	2,477	24.9
1.0	0.6	6.0	9,245	92.9	6,791	68.2
0	1.6	16.1	24,655	247.7	22,200	223.1

Assumptions: 5.9 flushes per toilet per day; 260 flush days per year; 10,045 kWh/MG

Table 3: Per Unit Water and Embedded Energy Savings – Urinals

Urinal Efficiency (gpf)	Savings per Flush		Annual Usage		Annual Savings	
	(gallons)	(watts)	(gallons)	(kilowatt-hrs)	(gallons)	(kilowatt-hrs)
1.0 (baseline)	n/a	n/a	4,680	47	n/a	n/a
0.5	0.5	5.0	2,340	23.5	2,340	23.5
0.125	0.875	8.8	585	5.9	4,095	41.1
0	1.0	10.0	0	0	4,680	47.0

Assumptions: 18 flushes per urinal per day; 260 flush days per year; 10,045 kWh/MG

Embedded Energy Factor

Over the past decade, the CEC and the California Public Utilities Commission (CPUC) have made notable progress in understanding the relationship between water and energy in California. However, there is no definitive conclusion on how much water is embedded in California's water, what embedded energy factors should be used for programs that span a wide geographic region, or how water efficiency and water conservation programs might reduce energy used for water supply, conveyance, treatment, distribution, wastewater collect and wastewater treatment. The CEC and CPUC research on embedded energy is referenced below, as is our recommendation on which embedded energy factors should be used.

In 2005 and 2006 the CEC published reports that explore how much energy is embedded in water (CEC 2005, CEC 2006). Table 4 shows the embedded energy estimates as presented in the CEC's 2006 report.

Table 4: 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.

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 2007). 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."

In March 2013, CPUC released additional information on the relationship between water and energy in California. CPUC's work on the water/energy nexus is available here: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/Water-Energy+Nexus+Programs.htm

Until there is a definitive answer as to which embedded energy factor is most appropriate, we recommend using a population-weighted average of the embedded energy factors for Northern and Southern California presented CEC's 2006 report. We used this methodology to approximate the embedded energy use reported in Figure 3, we weighted the values in Table 4 based on the population in Northern and Southern California in 2011 (U.S. Census Bureau).[1] The population-weighted indoor embedded energy factors were used for residential indoor use categories (toilets, faucets, showers, clothes washers, etc.). The population-weighted outdoor values were used for residential outdoor use and unidentified (leaks) categories. For the commercial, institutional, industrial use category indoor and outdoor water use was assumed to be equal.

2.1.3 How much does each cost a manufacturer to implement on a per product basis?

See section 4.2.

3 Market Characteristics

3.1 What are the annual historic and projected sales of water products from 2009-2015 (in CA and nationwide)?

A report D&R International developed for the US EPA estimates nation-wide shipments and sales based on market research, population growth estimates, and new construction estimates. Table 5 shows the results from D&R International's analysis. Findings from D&R International report were used in support of WaterSense standards (D&R International 2005).

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

Table 5: Sales Projections

Fixture	Number of Existing Units (million)	Number of Future Units (2003-2030) (million)
Residential Toilets	222	75
Commercial Toilets	44.5	11.1
Urinals	12	3

Source: D&R International 2005

3.2 What is the market share of water efficient products? Provide a brief description of the performance of the units.

AB 715 Reporting Requirements

Provisions in AB 715 require manufacturers that sell toilets or urinals in California to provide the CEC and the BSC with "the percentage of models of high-efficiency water closets plus high-efficiency urinals offered for sale in the state as compared to the total number of models of water closets plus urinals offered for sale". Manufacturers have to provide data for each year between 2010 and 2013. AB 715 requires the following percentage of models offered for sale in the state to be high-efficiency:

- 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.

WaterSense Reporting Requirements

WaterSense requires manufacturers with WaterSense labeled products to report annually on shipment and sales of WaterSense labeled products. http://www.epa.gov/WaterSense/partners/annual_reporting.html.

Aquacraft Report

In 2011, Aquacraft, Inc. Water Engineering and Management published a study of water use trends in California single-family homes. The study helps shed light on how much water toilets installed in California during the evaluation period (2005-2010) consumed. Some of the results from the analysis are presented in Table 6.

Table 6: Water Consumption from Toilets in California Single-Family Homes (2005-2010)

Table 39: Distribution of toilet flush volumes

Bin (gpf)	Flushes	Total volume in bin (gal)	Rel. Freq.	Cum Freq
0.25	19	4	0%	0%
0.50	305	206	0%	0%
0.75	930	835	1%	1%
1.00	2955	3382	2%	3%
1.25	11206	15540	9%	13%
1.50	15877	25749	13%	25%
1.75	14798	27547	12%	37%
2.00	10893	23073	9%	46%
2.25	9249	21858	8%	54%
2.50	7055	18429	6%	59%
2.75	6023	17289	5%	64%
3.00	6506	20273	5%	70%
3.25	5093	17152	4%	74%
3.50	5329	19300	4%	78%
3.75	5488	21251	4%	83%
4.00	4435	18249	4%	86%
4.25	4197	18318	3%	90%
4.50	2886	13315	2%	92%
4.75	2811	13675	2%	94%
5.00	1660	8489	1%	96%
More	5154	33226	4%	100%
Totals	122869	337160	100%	

Source: Aquacraft 2011, 133-143.

3.3 Is there a difference between units sold to residential and commercial sectors?

Most toilets installed in residential buildings are tank-type toilets. Tank-type toilets can also be found in some smaller non-residential buildings (e.g., gas stations, small restaurants, and small offices).

Flushometer toilets are usually found in nonresidential buildings.

Urinals are usually only found in nonresidential buildings.

3.4 Estimated percentile annual growth sale (CA and nation).

Toiles and urinal growth rate is proportional to population, employed population, new building construction rates. The following data sources can be used to estimate growth in these factors:

- United States Census Bureau, Population Division. *Table 1. Annual Estimates of the Resident Population for Counties of California: April 1, 2010 to July 1, 2011 (CO-EST2011-01-06).* Release Date: April 2012.
- United States Bureau of Labor Statistics. *Employment Projections: 2010-2020 Summary.* News Release from February 1, 2012. USDL-12-0160.
- California Employment Development Department, Labor Market Information Division. *California Seasonal Adjusted Industrial Employment & Labor Force – by Month. March 2011 Benchmark.* May 2012.

3.5 How many small businesses are involved in the manufacture, sale, or installation of these products?

No response.

4 Market Competition for Efficient Products

4.1 Are there any test markets for water efficient units?

- There are a number of WaterSense labeled products available on the market today.
- Texas, Georgia, California, and the City of Los Angeles already have standards in place that require high efficiency toilets and urinals.

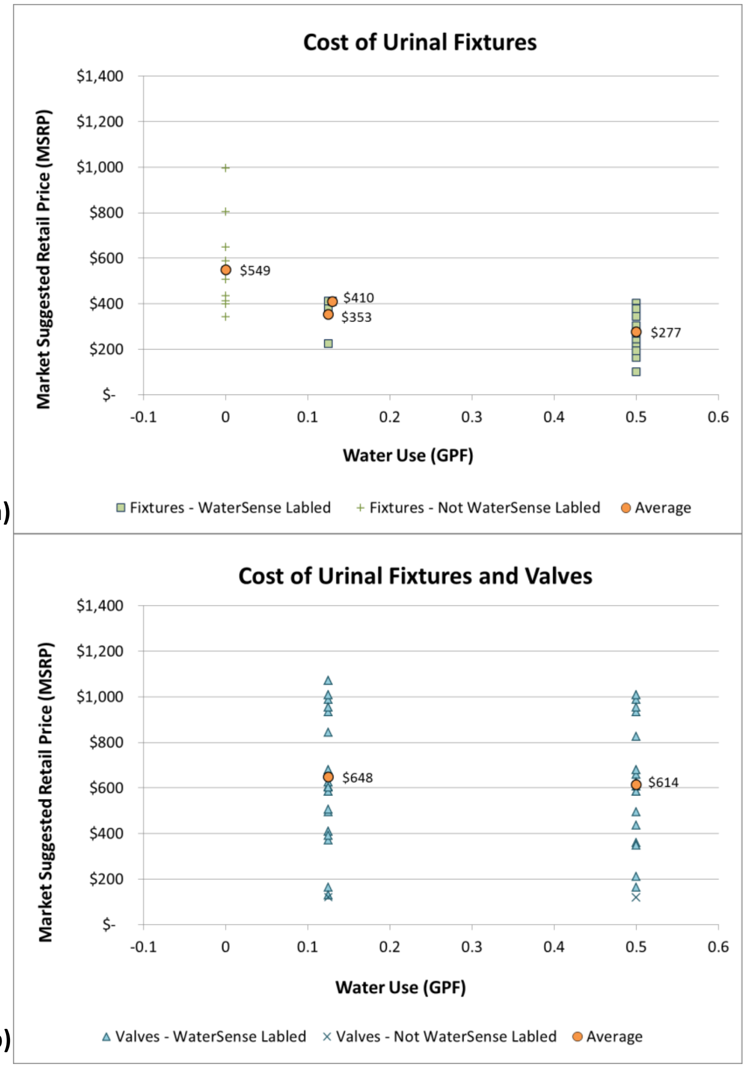
4.2 Breakdown of costs per unit by performance

WaterSense found that there is very little price difference between standard efficiency and high-efficiency water closets and urinals (WaterSense 2007, WaterSense 2009a); 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. 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 IOU 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 illustrated in Figure 4. The average cost of 0.5 gpf fixtures, valves, and fixture-valve systems was $277, $614, and $884 respectively. The average cost of 0.125 gpf fixtures, valves, and fixture-valve systems was $353, $648, and $786 respectively. This analysis suggests that overall there is a price premium of $77 and $33 for 0.125 gpf fixtures and valves over the 0.5 gpf alternatives. This represents a premium of about 12 percent. However, some manufacturers like American Standard offer very comparable 0.125, 0.5, and 1.0 gpf urinal systems for the same price.[2] These systems come with the fixture and the valve for one packaged price.

[2] 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)

Figure 4: Cost of Urinal Fixtures and Valves (0 gpf – 0.5 gpf)
Source: CA IOU Team analysis.

4.3 Product duty cycle

The information provided below pertains to how often toilets and urinals are flushed.

Residential Toilets

- D&R International assumptions: 365 days of use per year; 5.1 flushes per person per day (Based on residential end use study); population estimates from US Census (D&R International 2005)
- Aquacraft: 4.76 flushes per person per day (Aquacraft 2011)
- Pacific Institute: 4.92 flushes per person per day (Gleik et. at. 2003)

Commercial Toilets

- D&R International assumptions: 260 days of use per year; 2 flushes per person per day; nonfarm employees values from US Census

Urinals

- D&R International assumptions: 260 days of use per year; 2 flushes per male person per day; nonfarm employees values from US Census
- WaterSense: 18 flushes per urinal per day (WaterSense 2009b)
- Federal Energy Management Program Energy Cost Calculator: 30 flushes per urinal per day – default setting (http://www1.eere.energy.gov/femp/technologies/eep_toilets_urinals_calc.html)

5 Consumer Acceptance

5.1 What surveys have been done to gauge consumers' acceptance and performance of more efficient units?

- **Consumer Reports 2012 Toilet Ratings:** Consumer Reports ratings provide some insight into consumer satisfaction with high efficiency toilets (Consumer Reports 2012).
- **City of Austin, Texas – Memo Regarding Free Toilet Satisfaction Survey:** In 2009, the City of Austin authorized a program to replace 30,000 toilets with high efficiency toilets. This memo presents results of consumer satisfaction surveys issued to the first 1,066 participants (Meszaros 2010).
- **Jordan Valley Water Conservancy District – Residential ULFT Replacement Program Report:** Jordan Valley Water Conservation District replaced 245 toilets with high efficiency toilets. This report includes results from consumer satisfaction survey as well as water savings realized through the program (Mohadjer 2003).
- **Redwood City** Residential **HET Program – An Overview of Successes Cost and Benefits:** This presentation, delivered at the American Water Work Association 2006 Annual Conference, includes a summary of consumer satisfaction surveys Redwood City administered as part of their residential toilet exchange program (Rosas 2006).

5.1.1 False flushes of toilets and urinals?

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 and Keller 2010).

5.1.2 Multiple flushes needed?

No response.

5.1.3 Sewer system back-up?

A 2012 study from the Plumbing Efficiency Research Coalition titled *The Drainline Transport of Solid Waste in Buildings* investigated the relationship between flush volume and solid waste transport (PERC 2012).

5.1.4 Other: Evaporation of Water in Urinal Traps

A 2012 study from the University of Texas titled *A Study of Water Evaporation in Urinal Traps* investigates the relationship between low flush urinals and trap seal failure due to water evaporation (Bardet 2012).

5.2 Is there any problem due to installation of new units, and whether they perform properly with the current plumbing system and codes?

No response.

5.3 Is there a different design duty cycle for the new and existing units? Residential and commercial? What are they?

Yes, see response to 4.1

5.4 What is the design life of new and existing units?

See response to 1.4.

5.5 What test methods that were used to test the performance of the appliance?

Water Consumption Test Procedure

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.

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. WaterSense™ uses the dual-flush standard and specifies that water consumption of dual-flush water closets is calculated to be the weighted average of two reduced volume flushes and one full flush.

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 upon actual installation.

DOE Rulemaking to Update Test Procedure for Toilets and Urinals

The Department of Energy (DOE) is in the process of updating the test procedures for showerheads, faucets, water closets, urinals, and commercial prerinse spray valves. In a Notice of Proposed Rulemaking (NOPR), issued May 2012, DOE proposed to update the test procedure for water closets to ASME/ANSI A112.19.2-2008/CAS B45.1-08 (77 Fed. Reg. 104, 30 May 2012).

In its NOPR, DOE indicated that they do not plan on using the ASME test procedure for dual-flush toilets (ASME A112.19.14) because there is not sufficient documentation to justify the two-to-one flush ratio. DOE announced they would be conducting an analysis to determine if the two-to-one ratio is accurate for both residential and non-residential applications. However, in a Supplemental NOPR (SNOPR) issued in April 2013, DOE announced they would not be they would not be proposing a weighted average approach to calculate water use from dual-flush toilets (78 Fed. Reg.67, 8 April 2013). The following studies evaluate the flush rations 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*. 2003.
- 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.
- Koeller, John. *Dual-Flush Toilet Fixtures – Field Studies and Water Savings.* 2003.
- Veritec Consulting Inc. *Canada Mortgage and Housing Corporation Dual-flush Toilet Project.* 2002.

Information on the DOE rulemaking is available here: http://www.regulations.gov/#!docketDetail;D=EERE-2011-BT-TP-0061.

Performance Test

In addition to the ASME standards, 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. Two of the most widely used voluntary tests are the Maximum Performance (MaP) Testing: Toilet Fixture Performance Testing Protocol and 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) (Veritec Consulting Inc. & Koeller and Company 2010, LADWP 2005). MaP testing classifies how well a toilet removes waste, and 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. The proposed California standard 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.

Federal law requires performance tests for flushing urinals. Performance standards for ceramic urinals are specified in ASME A112.19.2/CBA B45.4. 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 7below lists the test procedures that are referenced in various federal and state codes and standards for toilets and urinals.

Table 7: 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 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 ASME/ANSI A112.19.14
WaterSense High-efficiency Toilet Specification	ASME A112.19.2/CBA B45.4 ASME/ANSI A112.19.14 UNAR[2]
WaterSense High-efficiency Urinals Specification	ASME A112.19.2/CBA B45.4 ASME/ANSI A112.19.3 IAPMO Z124.9 ASSE #1037
Georgia Standard	ASME/ANSI A112.19.2-2003 ASME/ANSI A112.19.14-2001, as applicable WaterSense™ Listed
Texas Standard	ASME A112.19.2-2008/CBA B45.4-2008 ASME/ANSI A112.19.14-2006, , as applicable WaterSense™ Listed

1. On May 30, 2012 DOE issued a notice of proposed rulemaking (NOPR) to propose changes to test procedures for plumbing fixtures. DOE proposes to incorporate ASME/ANSI A112.19.2-2008, which would replace ASME/ANSI) A112.19.6-1995 (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).

5.5.1 Was there any difficulty, or issue with the mentioned test methods?

The ASME test procedure for dual-flush toilets calls for water consumption of dual flush toilets to be calculated based on weighted ratio of two reduced-volume flushes and one full-volume flush. Anecdotal data suggests that the ratio might be accurate for residential applications, but for non-residential applications the toilets may be flushed at full-volume more often.

A 2012 University of Missouri report evaluated how many times dual-flush toilets installed in a newly constructed nonresidential building were flushed at full-volume and reduced-volume (Arocha 2012).

Several issues have been identified through the DOE rulemaking process including, but not limited to:

- Definition of a "basic model"
- Appropriate trim adjustments for tank-type toilets
- Weighting of results from tests at various test pressures for flushometer toilets
- Need to test automatic sensor in valve mechanisms

These issues are discussed in the DOE NOPR, SNOPR, and public comments, all of which are available in the docket: http://www.regulations.gov/#!docketDetail;D=EERE-2011-BT-TP-0061.

5.5.2 Is there any improvement needed to improve the mentioned test methods?

Refer to DOE test procedure proceedings:
http://www.regulations.gov/#!docketDetail;D=EERE-2011-BT-TP-0061.

6 Information Request for Toilets and Urinals

6.1 Types of water efficient toilets and description of their technologies used to achieve the designed performance. For example, single flush (gravity, pressure assist, electro-hydraulic, valve type, and others) and dual flush (gravity, pressure assist, electro- hydraulic, valve type, and others)

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 5 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.

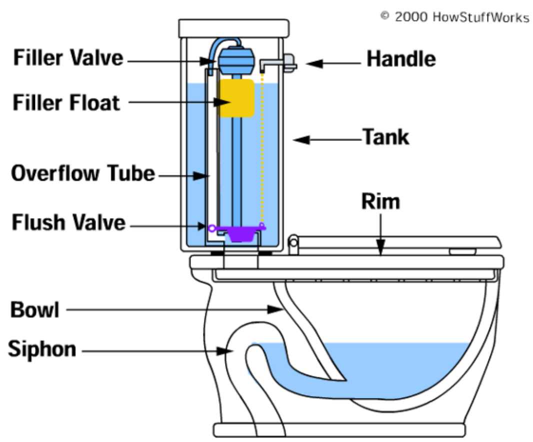


Figure 5: Schematic of Tank-type Siphoning Toilet
Source: Marshall 2013

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 6 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.

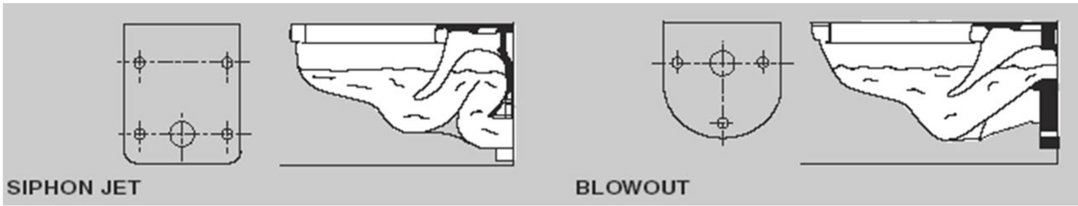


Figure 6: Siphon Jet and Blowout Bowls
Source: Jay R. Smith Mfg. Co

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.

6.1.1 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.

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 7 illustrates gravity-assist and pressure-assist toilets.

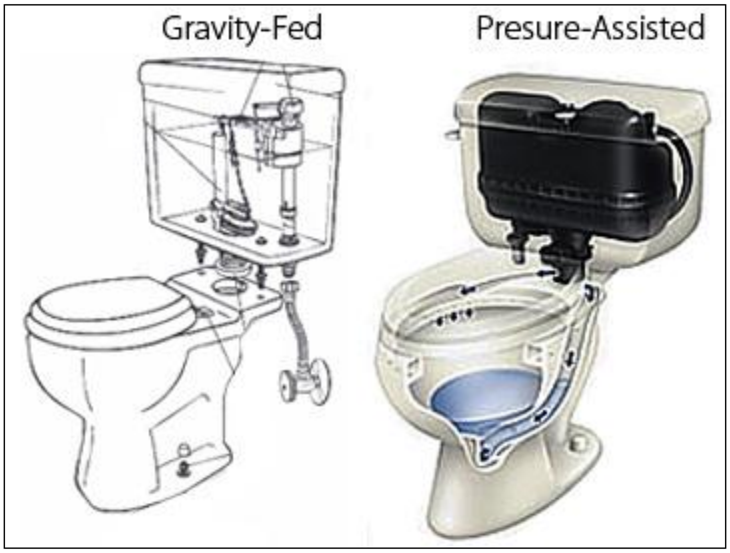


Figure 7: Gravity and Pressure-assist Tank-type Toilets
Source: Upland Plumber 2013

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 use electricity instead of water line pressure. The downsides of power-assist toilets are that they need to be plugged into an electricity outlet and are 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 sometimes require a second flush to clear all waste. They are also more expensive than gravity-assist toilets. Plunging is also more difficult, as one must remove the lid and cover an opening in order to create suction for successful plunging. Figure 8 provides a schematic of a vacuum-assist toilet.

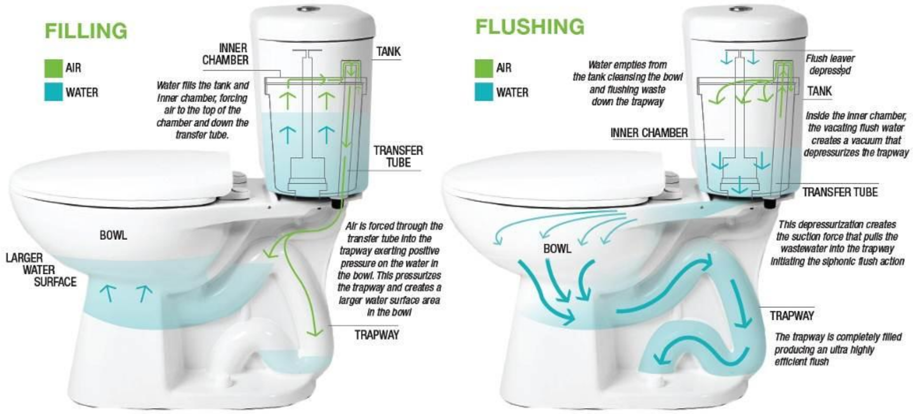


Figure 8: Schematic of Vacuum-assist Toilet
Source: Niagra Conservation

6.1.2 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 9, valve-type toilets can be wall mounted or floor mounted.

Figure 9: Wall-mounted and Floor-mounted Flushometer Valve-type Toilets
Source: American Standard

6.1.3 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. Current standards, including the WaterSense™ [3] specification for tank-type toilets and AB 715 rules, 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; AB 715, 2007). Many dual-flush toilets use 1.6 gpf for a full-volume flush, and the low-volume flush uses between 0.8 and 1.1 gpf depending on the model. However, dual-flush toilets that consume less than 1.28 gpf on the full-volume flush are available. Dual-flush toilets are available for tank-type and valve-type toilets.

6.1.4 Their performance specifications, i.e., gallon per flush.

No response.

6.2 Type of water efficient urinals and description of their technologies used to achieve the designed performance. For example, tank/gravity, pressure assist, electro-hydraulic, valve type, and others

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).

Trough and floor urinals are less common urinal designs that typically use more water than traditional urinals. Trough urinals can be used by several men simultaneously. 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. Floor urinals are larger and more expensive than traditional bowl fixtures, and more expensive to install. Figure 10 shows a trough urinal and a floor-mounted urinal.

[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 10: Trough Urinal and Floor Urinal
Source: Kohler

6.3 Types of Valves

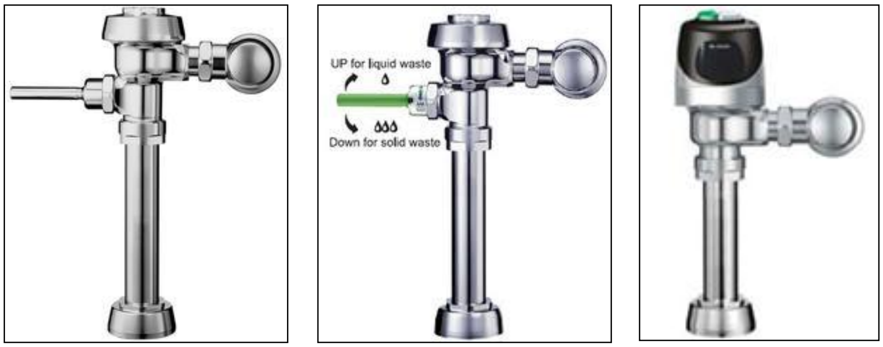
6.3.1 Flushing Devices (Valves)

Toilet and urinal fixtures and valves are oftentimes sold separately. Fixtures come in various shapes and sizes, and valves have a variety of features. Figure 11 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 11: Urinal Fixture with Various Valve Options
Source: Sloan Valve Company

6.3.2 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 12 shows a standard manual single-flush flushometer valve, a manual dual-flush flushometer valve, and a sensor-operated dual-flush flushometer valve.



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

Figure 12: Types of Flushometer Valves
Sources: Sloan Valve Company

As mentioned in section 5.5, DOE is in the process of updating the test procedures for showerheads, faucets, water closets, urinals, and commercial prerinse spray valves. In a 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).

7 References

(References attached separately are highlighted in grey)

[75 Fed. Reg.245, 22 December 2010] Federal Register. *Waiver of Federal Preemption of State Regulations Concerning the Water Use or Water Efficiency of Showerheads, Faucets, Water Closets and Urinals*. 75:245 (22 December 2010). p. 80289.

[77 Fed. Reg.104, 30 May 2012] Federal Register. *Test Procedures for Showerheads, Faucets, Water Closets, Urinals, and Commercial Prerinse Spray Valves; Notice of Proposed Rulemaking and Public Hearing*. 77:104 (30 May 2012). p. 31742.

[78 Fed. Reg.67, 8 April 2013] Federal Register. *Test Procedures for Showerheads, Faucets, Water Closets, Urinals, and Commercial Prerinse Spray Valves; Supplemental Notice of Proposed Rulemaking*. 78:67 (8 April 2013). p. 20832.

Arocha, Jade and Laura McCann. *Behavioral Economics and the Design of a Dual-Flush Toilet*. 2012. http://www.map-testing.com/assets/files/Dual_flush_behavior_economics_paper-Arocha.pdf.

Aquacraft, Inc. Water Engineering and Management. *Residential End Uses of Water Study*. 1999. Prepared for the American Water Works Association.

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.

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. *California Single Family Water Use Efficiency Study*. 2011. http://www.aquacraft.com/node/63. Boulder, Colo.: Aquacraft, Inc. Water Engineering and Management.

Bardet, Jean-Pierre. *A Study of Water Evaporation in Urinal Traps*. 2012. Prepared for Falcon Waterfree Technologies. Available upon request.

[CalEDD 2013] California Employment Development Department, Labor Market Information Division. *California Seasonal Adjusted Industrial Employment & Labor Force – by Month. March 2012 Benchmark*. April 2013. http://www.calmis.ca.gov/htmlfile/county/califhtm.htm.

[CalGreen 2010] California Building Standards Commission. *2010 California Green Building Standards Code California Code of Regulations, Title 24, Part 11*. 2010. Sacramento, CA. ISBN 978-1-58001-979-8. http://www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf.

[CalGreen 2012a] California Building Standards Commission. *Final Express Terms for Proposed Building Standards of the California Building Standards Commission Regarding Adoption of Amendments for the 2013 California Buildings Standards Code, Title 24, California Code of Regulations (CCR), Part 11 California Green Building Standards Code*. 2012. Sacramento, CA.

http://www.documents.dgs.ca.gov/bsc/prpsd_chngs/documents/2012/BSC-07-12-ET-Pt11-Final.pdf.

[CalGreen 2012b] California Building Standards Commission. *Express Terms for proposed Building Standards of the Department of House and Community Development regarding the 2013 California Green Buildings Standards Code (CalGreen) California Code of Regulations, Title 24, Part 11 (HCD)*. 2012. Sacramento, CA. http://www.documents.dgs.ca.gov/bsc/prpsd_chngs/2012/GREEN/HCD-04-12-ET-Pt11-Rev-6-13-12.PDF.

[California AB 715, 2007] California Assembly Bill 715. Assembly Member John Laird. 2007-2008 Legislative Session. (2007). http://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_0701-0750/ab_715_bill_20071011_chaptered.pdf.

[California SB 407, 2009] California Senate Bill 407. Senator Alex Padilla. 2009.

[CEC 2005] California Energy Commission (2005) *California's Water – Energy Relationship Final Staff Report CEC-700-2005-011-SF.* California Urban Water Conservation Council. "Potential Best Management Practices (PBMP) Report: High Efficiency Plumbing Fixtures – Toilets and Urinals." Koeller, J. 2005. Downloaded on May 16, 2012 from: http://www.cuwcc.org/products/pbmp-reports.aspx.

[CEC 2006] California Energy Commission. *Refining Estimates of Water-related Energy Use in California* (CEC-500-2006-118). Prepared by Navigant Consulting, Inc., Public Interest Energy Research Program (December 2006). CEC-500-2006-118. http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

[CEC 2012a] California Energy Commission. 2012. *Adopted California Energy Commission Demand Forecast Report 2012-2022.* 2012. Mid-Case Final Demand Forecast. Updated September 19, 2012.

[CEC 2012b] California Energy Commission. 2012. *Rulemaking on 2013 Building Energy Efficiency Standards.* 2012. Docket number #12-BSTD-01.

[CEC 2013] California Energy Commission (2013). Appliance Efficiency Database. Toilets and Urinals.

[CPUC 2007] California Public Utilities Commission. *Order Approving Pilot Water Conservation Programs Within the Energy Utilities' Energy Efficiency Programs.* December 20, 2007. Decision 07-12-050.

[CPUC 2010a] California Public Utilities Commission Energy Division (2011). *Embedded Energy in Water Studies Study 1: Statewide and Regional Water-Energy Relationship*. 2010. Prepared by GEI Consultants/Navigant Consulting. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm.

[CPUC 2010b] California Public Utilities Commission Energy Division. *Embedded Energy in Water Studies Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles.* 2010. Prepared by GEI Consultants/Navigant Consulting.

http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm.

[CPUC 2011a] California Public Utilities Commission Energy Division *Embedded Energy in Water Studies. Study 3: End-use Water Demand Profiles.* 2011. Prepared by Aquacraft Inc. CALMAC Study ID CPU0052. http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm.

[CPUC 2011b] California Public Utilities Commission. 2011. *Embedded Energy in Water Pilot Programs Impact Evaluation: Final Report.* Prepared by ECONorthwest. http://www.cpuc.ca.gov/NR/rdonlyres/51BF9A0B-42C9-4104-9E71-A993E84FEBC8/0/EmbeddedEnergyinWaterPilotEMVReport_Final.pdf.

Christian-Smith, Juliet; Heberger, Matthew; and Luch Allen. *Urban Water Demand in California to 2100: Incorporating Climate Change.* 2012. Pacific Institute. http://www.pacinst.org/reports/urban_water_demand_2100/full_report.pdf.

City of Los Angeles, California. *Water Efficiency Requirements for New Development and Renovations of Existing Buildings.* 2009. Ordinance Number 180822.

City of New York, New York. *Local Law No. 54. To amend the administrative code of the city of New York, in relation to enhanced water efficiency standards.* 2010.

Consumer Reports. *Toilet Ratings.* 2012.

D&R International. *Plumbing Fixtures Market Overview: Water Savings Potential for Residential and Commercial Toilet and Urinals*. 2005.

[DOE] U.S. Department of Energy Compliance Certification Database: Toilets and Urinals. Accessed April 30, 2013.

Georgia Senate Bill 370. State Senator Ross Tolleson. 2009 – 2010 Regular Session. http://www.legis.ga.gov/Legislation/20092010/103008.pdf.

Gauley, G. and Koeller, J. *Sensor-Operated Plumbing Fixtures: Do They Save Water?* 2010.

Gleik, P. H., Haasz, D., Henges-Jeck, C., Srinivasan V., Wolff, G., Cushing, K.K., & A. Mann. 2003. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*." The Pacific Institute. http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf.

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

Jay R. Smith Mfg. Co. *Water Closet Supports Tech Data.* Accessed February 2013. http://www.jrsmith.com/assets/documents/literature/water_closet_supports_technical_data.pdf.

Kohler. Trough and Floor-mounted Urinals.

Koeller, John. *Dual-Flush Toilet Fixtures – Field Studies and Water Savings.* 2003.

[LADWP] Los Angeles Department of Water & Power. 2005. *Los Angeles Department of Water & Power Requirements for Ultra-Low-Flush Toilets Supplementary Purchase Specification to ASME A112.19.2-2003*.

Marshall, Brian. *How Toilets Work.* Accessed February 2013. How Stuff Works. http://home.howstuffworks.com/toilet.htm.

Maximum Performance (MaP) Database. Accessed April 2013.

Meszaros, Gary. *Memo to City of Austin, Texas Mayor and Council Members Regarding Free Toile Satisfaction Survey*. (2010).

Mohadjer Paula. *Jordan Valley Water Conservancy District Residential Ultra-Low-Flow Toilet Replacement Program*. 2003.

Niagra Conservation. *How the Stealth Toilet Works.* Accessed February 2013. http://www.niagaraconservation.com/water_conservation/products/toilets/stealth-old.

Oregon Senate Bill 692. Committee on Environment and Natural Resources. 2013. http://gov.oregonlive.com/bill/2013/SB692/.

Oregon Senate Bill 840. Committee on Environment and Natural Resources. 2013. http://gov.oregonlive.com/bill/2013/SB840/.

[PERC] Plumbing Efficiency Research Coalition. *The Drainline Transport of Solid Waste in Buildings.* 2012. http://www.plumbingefficiencyresearchcoalition.org/projects/drainline-transport-of-solid-waste-in-buildings/.

Raftelis Financial Consulting. Water and Wastewater Rate Survey. American Water Works Association. 2004.

Rosas, Manny. *Redwood City Residential HET Program – An Overview of Successes Cost and Benefits.* (2006). Presentation for American Water Works Association 2006 Annual Conference. http://www.allianceforwaterefficiency.org/uploadedFiles/Resource_Center/Library/residential/toilets/Redwood-City-HET-Program-2006.pdf.

Sloan Valve Company. Flushometer Valves.

Sullivan, G.P., E.D. Elliott, T.C. Hillman and A.R. Hadley. *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.

Texas House Bill 2667. House Member Hinojosa. 2009 Regular Legislative Session. http://texashistory.unt.edu/ark:/67531/metapth148587/m2/1/high_res_d/HB2667.pdf.

United States Census Bureau, Population Division. *Table 1. Annual Estimates of the Resident Population for Counties of California: April 1, 2010 to July 1, 2011 (CO-EST2011-01-06).* Release Date: April 2012.

[USBLS] United States Bureau of Labor Statistics. *Employment Projections: 2010-2020 Summary.* News Release from February 1, 2012. USDL-12-0160.

Upland Plumber. *Toilets.* Accessed February 2013. http://plumberupland.info/services/toilets.

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

Veritec Consulting Inc. & Koeller and Company. 2010. *Maximum Performance (MaP) Testing Toilet Fixture Performance Testing Protocol Version 4*. http://www.map-testing.com/assets/files/MaP_test_protocol_version4.pdf.

Washington House Bill 1017. 2013. http://dlr.leg.wa.gov/billsummary/default.aspx?year=2013&bill=1017.

Water Resources Engineering, Inc. 2002. *Water Conservation Market Penetration Study*. Prepared for East Bay Municipal Utility District, Water Division. http://www.ebmud.com/sites/default/files/pdfs/market_penetration_study_0.pdf.

[WaterSense 2006a] U.S. EPA WaterSense. *Comments on April 2006 Draft Specification for High-Efficiency Toilets*. 2006.

[WaterSense 2006b] U.S. EPA WaterSense. *Responses to Issues Raised During Public Comments on April 2006 Draft Specification for WaterSense® Labeling of Tank-Type High-Efficiency Toilets*. 2006.

[WaterSense 2007] U.S. EPA WaterSense. *WaterSense® Tank-Type High-Efficiency Toilet Specification Supporting Statement*. 2007.

[WaterSense 2009a] U.S. EPA WaterSense. *WaterSense® Specification for Flushing Urinals: Version 1.0*. 2009.

[WaterSense 2009b] U.S. EPA WaterSense. *WaterSense® Specification for Flushing Urinals Supporting Statement: Version 1.0*. 2009.

[WaterSense 2009c] U.S. EPA WaterSense. *Comments on the January 2009 Draft Specification for High-Efficiency Flushing Urinals*. 2009.

[WaterSense 2009d] U.S. EPA WaterSense. *Response to Comments Received on the January 2009 Draft WaterSense® High-Efficiency Flushing Urinals Specification*. 2009.

[WaterSense 2011a] U.S. EPA WaterSense. *WaterSense® Specification for Tank-Type Toilets: Version 1.1*. 2011.

[WaterSense 2011b] U.S. EPA WaterSense. *Summary of Revisions to WaterSense Specification for Tank-Type Toilets*. 2011.

[WaterSense 2013a] U.S. EPA WaterSense. Database of WaterSense Labeled Toilets. Accessed 4.30.2013.

[WaterSense 2013b] U.S. EPA WaterSense. Database of WaterSense Labeled Urinals. Accessed 4.30.2013.