Water Use in the California Residential Home

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Prepared by

CONSOL

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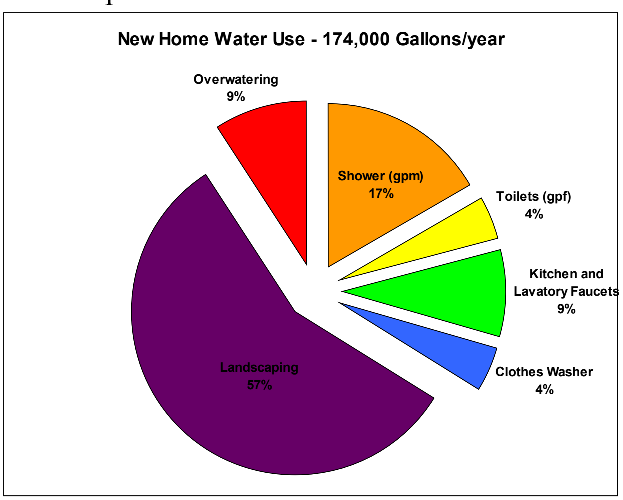
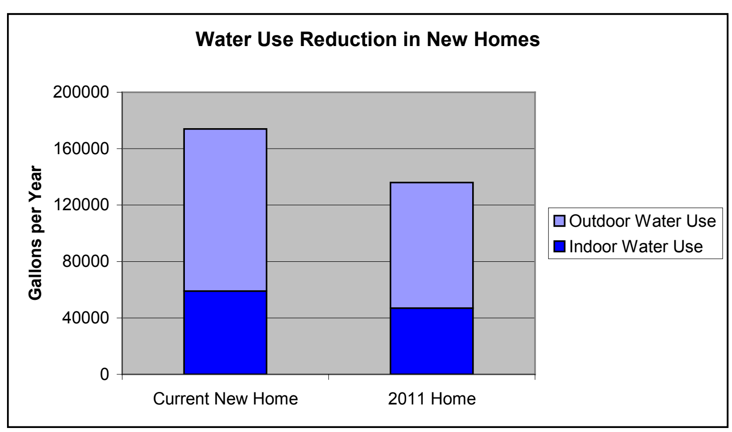
Executive Summary:
A new three bedroom single family home with four occupants is modeled to use 174,000 gallons of water per year. The majority of this water use is due to landscaping. The largest indoor water use is by showers. These estimates are based on assumptions provided in the California Green Building Standards Code (CGBSC) and the California Department of Water Resources' Model Water Efficient Landscape Ordinance.

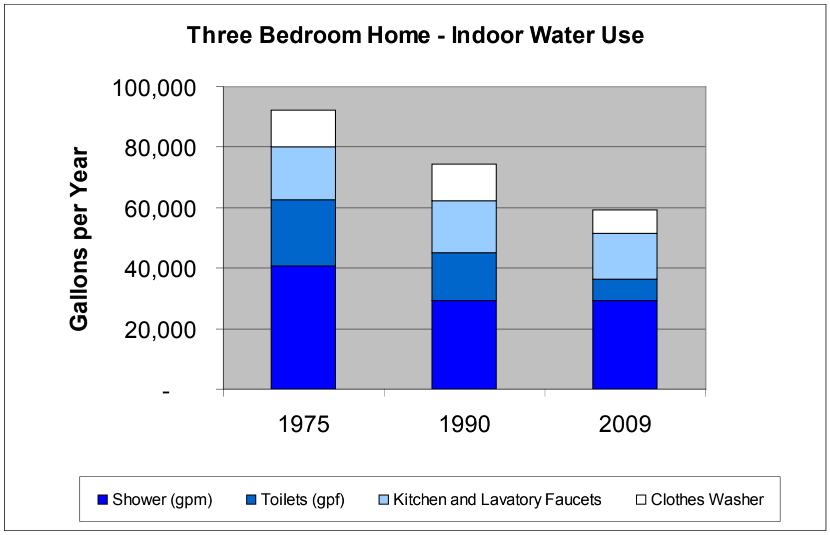


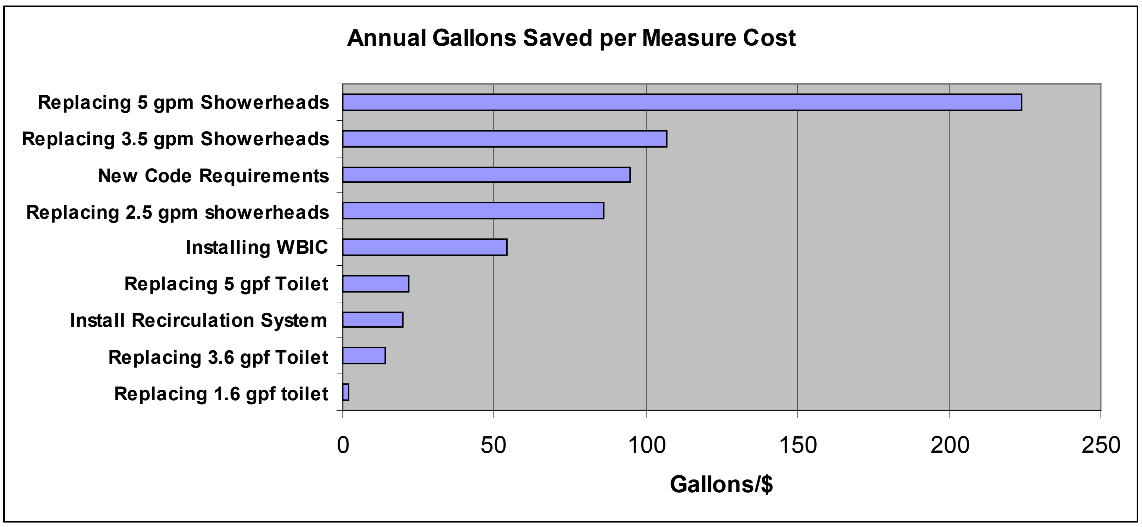
The CGBSC will come into effect in 2011, combined with the Model Ordinance; homes built to these standards will save approximately 38,000 gallons of water per year. One of the largest sources of these savings is the use of Weather Based Irrigation Controllers, which have been shown to reduce the amount of landscape over-watering by 85%, and total household water use by 7%

While there is still significant savings potential in new California homes, older California homes represent an even greater opportunity. Changes in code requirements in 1980 and 1992 have served to reduce the indoor water use of a three bedroom home by 35% over the last 30 years. Old toilets and showerheads can use up to three times more water than current available models.

Addressing existing housing, particularly old showerheads, can be a very cost effective way of reducing water use. Additionally, in order to achieve deep reductions in the amount of water used in homes, strategies must be developed to reach the 7,500,000 existing single family homes and the 13,000,000 total housing units in the state.







Lastly, the single largest use of water in the United States is by electric power plants. By continuing to improve the energy efficiency of homes, California home builders are indirectly helping to reduce nationwide water consumption.

Table of Contents

Water Use in the United States

Water is becoming an increasingly important resource throughout California and the United States. The largest single use of water use is in the cooling towers of power plants, followed by water used to irrigate for agriculture. Combined, these two uses account for over 80% of all domestic water use. The largest remaining segment of water use is that of Public Water Supplies. As of the year 2000, 85% of the national and 89% of California's population received their drinking water from public supplies; the remainder relies on self supplied water sources, generally ground water wells. Figure 1 below shows the national breakdown of water uses.

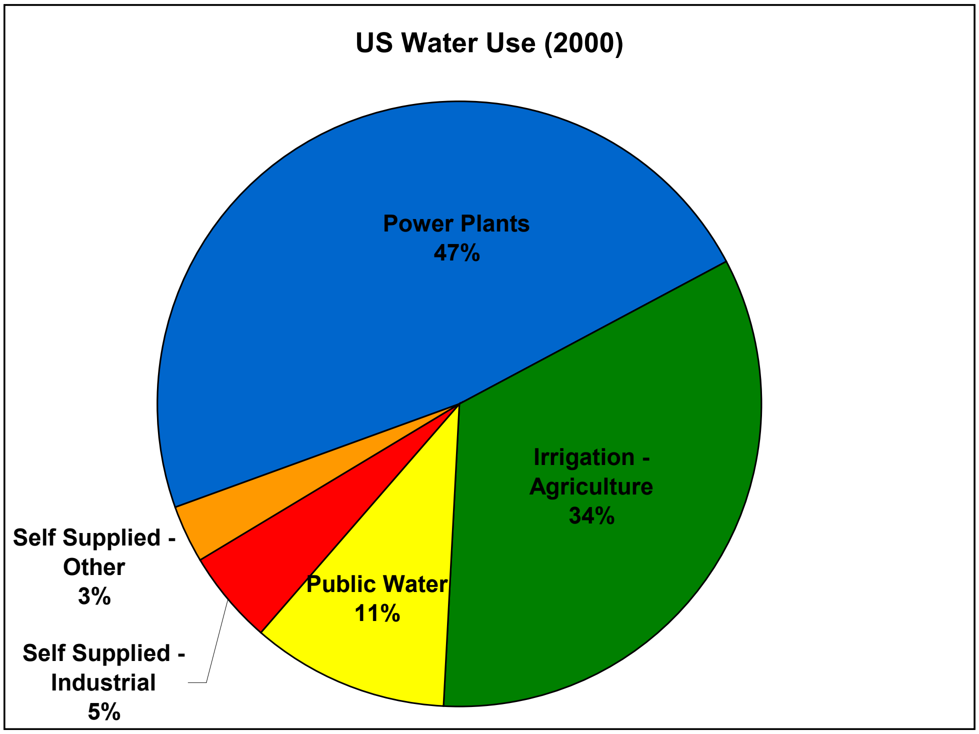


Figure 1: Total United States Water Use[1]

Public water supplies are often measured in gallons per capita per day (GPCD.) This is nothing more than the average daily supply divided by the service population. The national average for public water supplies is 179 GPCD, the California statewide average is 203 GPCD. California has the 15th highest per capita public water consumption in the country. Generally, the states with the highest water consumption are in the south and west, where there is a year round growing season and larger average home sites.

[1] http://pubs.usgs.gov/circ/2004/circ1268/htdocs/text-total.html

Water Use in the Home

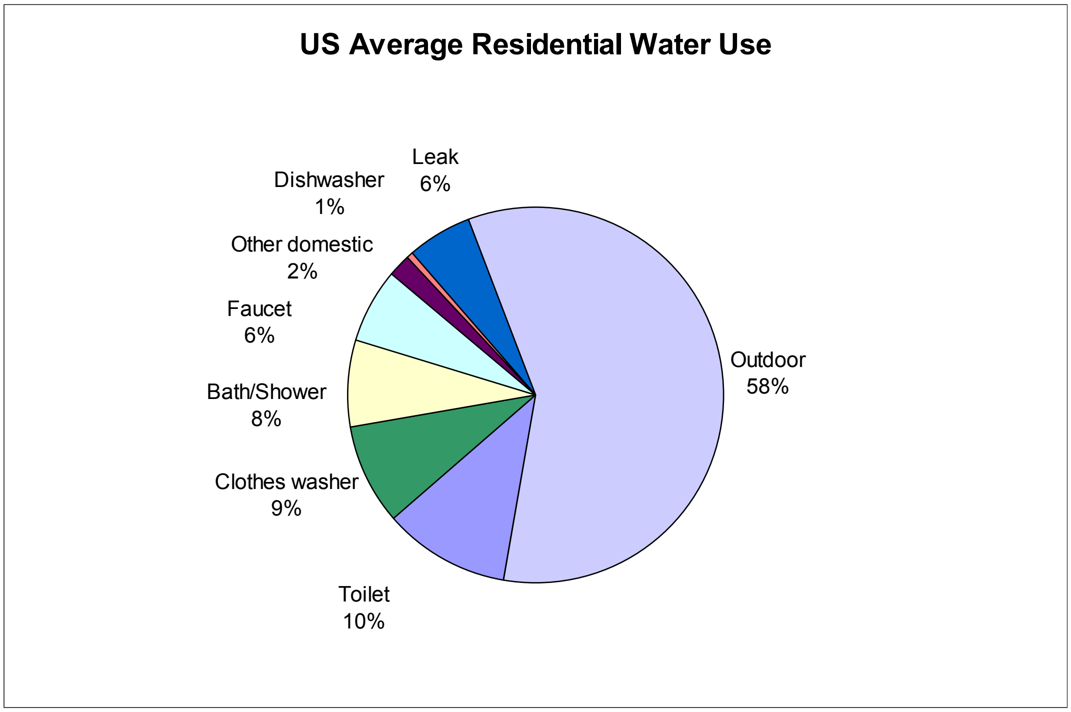


Figure 2: Average US Residential Water Use[2]

In the United States, residential water use is typically dominated by landscape water use and California is no exception. Figure 2 above shows the relative importance of various water uses throughout the home. There is a wide amount of variability in the above percentages. How much water an individual home will use is largely dependent on four factors: the number of residents; the types of fixtures (toilets, showerheads, faucets); the size of the home lot, and the type of landscaping (turf and pools using the most water.)

Indoor Water Use

The 2008 California Green Building Standards Code (CGBSC)[3] sets new standards for the flow rate of fixtures in new construction. The standards come into effect in 2011 and will call for a 20% reduction in indoor water use. The code also includes guidance on how to calculate the "baseline" indoor water use for a current new single family home. Table 1 lists the fixture flow rates and usage amounts assumed in the code for present day construction. The current fixture flow rates were set by the Federal Energy Policy Act of 1992, which became effective in 1994. Before that time, flow rates for these fixtures were much higher. In California, the 1980 plumbing code set showerhead flow rates at 2.5 gallons per minute (gpm) and toilet flow rates at 3.6 gallons per flush (gpf.) Before 1980, those values were typically 3.5 gpm and 5.0 gpf respectively. Table 2 shows the historical flow rates of showers, faucets, and toilets, as well as the flow rates which will become effective in 2011. Low flow faucets and showerheads should not add to the cost of the home. Currently, there is an approximately $50 premium on low-flow toilets, but that price has dropped dramatically over the past two years.

[2] http://www.aquacraft.com/Publications/resident.htm
[3] http://www.documents.dgs.ca.gov/bsc/2009/part11_2008_calgreen_code.pdf

FIXTURE TYPE	FLOW RATE[2]	DURATION	DAILY USES	OCCUPANTS[3, 4]
Showerheads	2.5 gpm @ 80 psi	8 min.	1	X
Showerheads residential	2.5 gpm @ 80 psi	8 min.	1	X
Lavatory faucets residential	2.2 gpm @ 60 psi	.25 min.	3	X
Kitchen faucets	2.2 gpm @ 60 psi	4 min.	1	X
Replacement aerators	2.2 gpm @ 60 psi			X
Wash fountains	2.2 [rim space (in.) / 20 gpm @ 60 psi]			X
Metering faucets	0.25 gallons/cycle	.25 min.	3	X
Metering faucets for wash fountains	.25 [rim space (in.) / 20 gpm @ 60 psi]	.25 min.		X
Gravity tank type water closets	1.6 gallons/flush	1 flush	1 male[1] 3 female	X
Flushometer tank water closets	1.6 gallons/flush	1 flush	1 male[1] 3 female	X
Flushometer valve water closets	1.6 gallons/flush	1 flush	1 male[1] 3 female	X
Electromechanical hydraulic water closets	1.6 gallons/flush	1 flush	1 male[1] 3 female	X
Urinals	1.0 gallons/flush	1 flush	2 male	X

Fixture "water use" = flow rate × duration × occupants × daily uses

1. Except for low-rise residential occupancies, the daily use number shall be increased to three if urinals are not installed in the room.
2. The flow rate is from the CEC Appliance Efficiency Standards, Title 20, *California Code of Regulations*; where a conflict occurs, the CEC standards shall apply.
3. For low rise residential occupancies, the number of occupants shall be based on two persons for the first bedroom, plus one additional person for each additional bedroom.
4. For nonresidential occupancies, refer to Table A, Chapter 4, 2007 *California Plumbing Code*, for occupant load factors.
5. Use worksheet WS-1 to calculate base line water use.

Table 1: Table 603.1 of the 2008 California Green Building Standards Code

Fixture and Appliance Standards Over Time					
	1975	1980	1992	2009	2011
Shower (gpm)	3.5	**2.5**	2.5	2.5	**2.0**
Toilets (gpf)	5.0	**3.6**	**1.6**	1.6	**1.28**
Faucets (gpm)	2.5	2.5	2.5	**2.2**	**1.8**
Clothes Washers (gal/cu. Ft.)	15	15	15	**8.5**	**6**

Table 2: Flow Rates of Fixtures Over Time

The CGBSC, however, only covers showers, faucets, and toilets. The code does not provide baseline guidance for outdoor water use, nor does it provide guidance for clothes washer water use, which, as shown in Figure 2, is significant.

An average top loading clothes washer uses between 40 and 45 gallons per wash[4]. A horizontal axis washer can use between 15 and 30 gallons. Appliance standards currently effective in California limit the amount of water to 8.5 gallons per cubic foot of capacity. In 2010 this number will drop to 6 gallons per cubic foot. The average clothes washer capacity is 3 cubic feet, meaning a new clothes washer will average 18 gallons per wash. Studies have shown, the average household does between 300 and 400 loads of laundry per year[5]. Table 3 combines the fixture assumptions provided by the CGBSC with the assumptions on clothes washer usage to determine the estimated indoor water use for a new three bedroom home. Table 4 compares the water use of homes built prior to 1980, prior to 1994, the present day, and after 2011.

[4] http://www.allianceforwaterefficiency.org/Residential_Clothes_Washer_Introduction.aspx
[5] http://www.consumerenergycenter.org/home/appliances/washers.html,

Total Indoor Water Use, New Three Bedroom Home					
Fixture Type	**Flow Rate (gpm or gpf)**	**Duration (mins.)**	**Daily Uses**	**# of Occupants**	**Gallons/Year**
Showerheads	2.5	8	1	4	29,200
Lavatory Faucets	2.2	0.25	3	4	2,409
Kitchen Faucets	2.2	4	1	4	12,848
Toilets	1.6	---	3	4	7,008
Fixture Water Use					51,465
	Loads per Year		Gallons per Load		
Clothes Washers	300		25.5		7,650
Total Indoor Water Use, New Three Bedroom Home					**59,115**

Table 3: Indoor Water Use for a New Three Bedroom Home

Annual Water Use (gallons) for Family of Four

	1975	**1990**	**2009**	**2011**
Shower (gpm)	40,880	29,200	29,200	23,360
Toilets (gpf)	21,900	15,768	7,008	5,606
Kitchen and Lavatory Faucets	17,338	17,338	15,257	12,483
Clothes Washer	12,000	12,000	7,650	5,400
Total Water Use	**92,118**	**74,306**	**59,115**	**46,849**
Reduction		19%	20%	21%

Table 4: Indoor Water Use Over Time

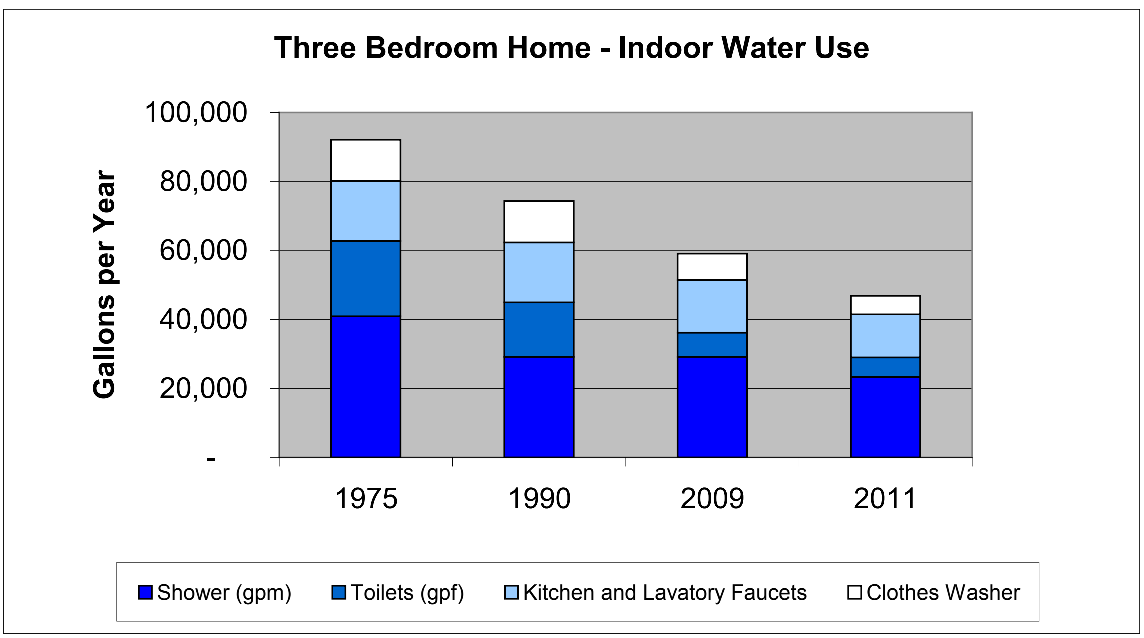


Figure 3: Indoor Water Use Over Time

Outdoor Water Use

The methods detailed in the California Department of Water Resources' recently published Model Landscape Ordinance[6] will be used to estimate outdoor water usage. The ordinance provides the formula listed in Equation 1 in order to determine the water needed by a given landscape.

$$LandscapeWater = (ETo)x(0.62)x(Area)x(ETAF)$$

Equation 1: Outdoor Water Use

In Equation 1, ET_o is the reference evapotranspiration. This is the amount of water, in inches, a specific species of grass requires in a specific climate. This number varies from city to city throughout the state, and the numbers are published in the Model Ordinance. The ET_o for Sacramento is 52 inches; for Monterey, which is much wetter and cooler, the ET_o is 36 inches. Needles, on the Arizona border, has the highest ET_o in the state at 92 inches. The median ET_o for the state is 50 inches. The complete list of the ET_o for all cities in California is available in Appendix A.

The number .62 is a conversion factor needed for the equation to output the water needed in gallons. The "Area" is the square footage of landscaping. For the purposes of this report, the average landscaped are of a single family home will be assumed to be 4000 square feet[7].

ETAF stands for evapotranspiration adjustment factor. This is a number that incorporates the specific plant type as well as the irrigation efficiency of the system[8]. The Model Ordinance uses a default value of 0.8 for the average existing California landscape. Given the assumptions made above, the landscape of an average single family home in California will require just shy of 100,000 gallons per year. Landscapes designed under the ordinance must have an ETAF of 0.7 or lower. This is accomplished through the greater use of plants that require less water. These landscapes will need 87,000 gallons of water per year, on average, a savings of 13,000 gallons. Meeting the requirements of the Model Ordinance should not add much cost to the installation of landscaping. However, there may be additional costs due to the time needed to calculate the water use of the landscaping in order to determine compliance.

It is rarely the case, however, that a landscape gets exactly as much water as it "needs"; more often than not, homeowners over water their lawn. One of the most detailed studies on the watering habits of homeowners was conducted by the Irvine Ranch Water District[9] (the ET_o for Irvine is conveniently right at the state average, making it well suited to evaluating landscaping water use).

The study concluded there was a savings potential in excess of 43 gallons per household per day, or roughly 16,000 gallons per year, if residents would not over water their lawn. The study examined two methods of changing homeowner behavior: mailing homeowners periodic postcards that carried suggested watering schedules; and installing weather based irrigation controllers (WBIC) that automatically adjust the irrigation system depending on current weather conditions (turning the sprinklers off after it has just rained). Mailing out the watering schedules captured 30% of the potential

[6] http://www.water.ca.gov/wateruseefficiency/landscapeordinance/
[7] http://www.epa.gov/WaterSense/docs/app_b508.pdf
[8] ETAF is the Plant Factor (PF) divided by the Irrigation Efficiency (IE.) Most turf grass has a PF of 0.8 or higher, while drought tolerant shrubs have a PF of 0.3 or lower. The PF numbers for specific plants can be looked up in the Water Use Classification of Landscape Species (WUCOLS) database, published by the University of California Cooperative Extension, the Department of Water Resources and the Bureau of Reclamation, 2000. Irrigation Efficiency is the percentage of water that leaves the sprinkler or irrigation device and actually lands on plants that need watering. Poorly designed spray head irrigation can have an IE of less than 0.6.
[9] http://www.irwd.com/Conservation/FinalETRpt[1].pdf

savings, 4,800 gallons per year. The WBICs captured 85% of the savings, 13,600 gallons per year. Because of their efficacy, WBICs are included in the Model Landscape Ordinance, and are likely to be added to the CGBSC. WBICs range on price from $150 to $350 dollars compared to a standard irrigation controller which is generally less than $50. Many water districts, however, provide rebates or incentives for the installation on WBICs.

When factoring in over watering, an "average" California landscape will consume approximately 115,000 gallons per year, a home which meets the requirements of the Model Landscape Ordinance will use approximately 89,000 gallons per year. This represents a savings of 26,000 gallons per year.

Combining the outdoor water savings with indoor water savings, a home built in 2011 will use 38,000 gallons of water less per year.

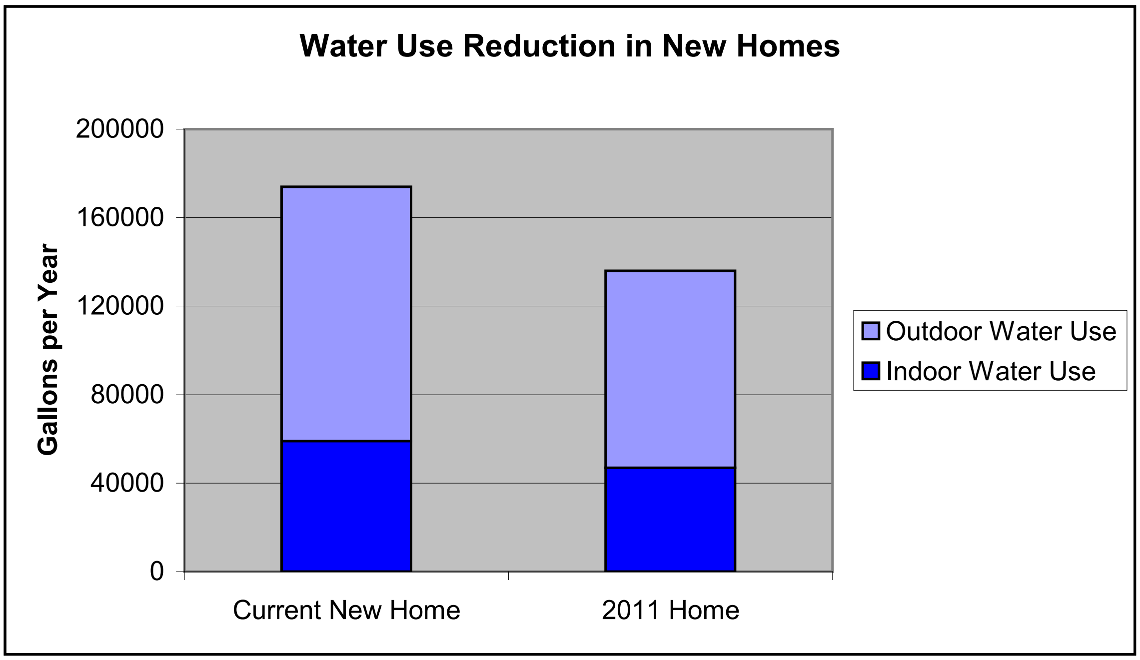


Figure 4: Water Use for New Three Bedroom Home

Wasted Water

Every morning, millions of gallons of water are wasted as homeowners wait for hot water to reach their showers. Studies have shown the average home with a conventional plumbing system uses an extra 10,000 gallons per year waiting for hot water[10]. Two systems which greatly reduce this waste are recirculation systems and parallel piping systems. A recirculation system is a pump that moves hot water through the pipe system so that it is ready when the fixture is tuned on. Recirculation systems come in three main varieties: always on; timer controlled, where the pump is set to run every day at specified times (at 6:15 am if you normally shower at 6:30;) and on demand, where the homeowner manually activates the pump. Recirculation systems eliminate nearly all the water loss while waiting for hot water. They cost approximately $500 to install, and do use additional energy, especially recirculation systems that are always on.

Parallel piping is a plumbing system that uses smaller diameter plastic pipes to run directly from the hot water fixtures to the water heater. Because these pipes have a smaller diameter, they hold a smaller volume of water that needs to be cleared before hot water arrives. These systems save on average, 7,000 gallons of water per year. There is an additional materials cost to installing a parallel piping system, but this is often negated by lower labor costs as the installation is generally easier than a traditional structured plumbing system.

Savings Potential

California currently has over 7,500,000 single family homes, more than half of these homes were built before 1980, when the first plumbing standards came into effect. While many of these homes have likely had their fixtures updated at some point, others have not. These older homes represent a large source of potential water savings.

Year Built	Number of Units	Avg. Indoor Water Use	Avg. Outdoor Water Use
pre 60s	2,392,460	92,118	115,088
60s	1,143,459	92,118	115,088
70s	1,162,924	92,118	115,088
80s	1,135,153	74,306	115,088
90s	826,346	59,115	115,088
00s	889,181	59,115	115,088
Total	7,549,523		

Table 5: Homes Built by Year

Table 6 Provides the savings potential of various retrofit measures discussed above. Water numbers are in gallons per year.

Year Built	Number of Units	Avg. Indoor Water Use	Avg. Outdoor Water Use	Fixture Replacemet	Toilet Replacement	WBIC	Water Schedules	Recirculation System
pre 60s	2,392,460	92,118	115,088	22,375	16,294	13,491	4,762	10,000
60s	1,143,459	92,118	115,088	22,375	16,294	13,491	4,762	10,000
70s	1,162,924	92,118	115,088	22,375	16,294	13,491	4,762	10,000
80s	1,135,153	74,306	115,088	10,695	10,162	13,491	4,762	10,000
90s	826,346	59,115	115,088	8,614	1,402	13,491	4,762	10,000
00s	889,181	59,115	115,088	8,614	1,402	13,491	4,762	10,000
Total	7,549,523							

Table 6: Savings Potential of Retrofit Measures

[10] http://www.toolbase.org/PDF/CaseStudies/hot_water_distribution_TN_California_2004_paper.pdf

The costs of retrofitting existing home could vary widely. The following assumptions (Table 7) are made to determine the cost of retrofit packages.

	Cost/unit	Units/Home	Total Cost
Fixture Replacemet	$ 50	3	$ 150
Toilet Replacement	$ 250	3	$ 750
WBIC	$ 250	1	$ 250
Recirculation System	$ 500	1	$ 500

Table 7: Retrofit Package Costs

Replacing old showerheads is by far the most cost effective water conservation measure available. The new code requirements are also fairly cost effective. The cost increase for a new home to meet the 2011 standards is estimated to be $350: $50 for three toilets, and $250 for additional landscape design. However, the total savings potential for the new code is only applicable to new construction, which accounts for less than 2% of the total housing stock.

Upgrade Measure	Annual Savings per Dollar (Gal.)
Replacing 5 gpm Showerheads	224
Replacing 3.5 gpm Showerheads	107
New Code Requirements	95
Replacing 2.5 gpm showerheads	86
Installing WBIC	54
Replacing 5 gpf Toilet	22
Install Recirc. System	20
Replacing 3.6 gpf Toilet	14
Replacing 1.6 gpf toilet	2

Table 8: Water Savings Cost Effectiveness

Appendix A – Reference Evapotranspiration for California Cities

Eureka	27.5	Santa Monica	44.2	Modesto	49.7	Lamont	54.4
Ferndale	27.5	San Juan	44.2	Los Banos	50	Chino	54.6
Crescent City	27.7	Chula Vista	44.2	Farmington	50	Gerber	54.7
Fort Bragg	29	Windsor	44.2	Los Angeles	50.1	Pine Valley	54.8
Point Arena	29.6	Yountville	44.3	Monrovia	50.2	Angwin	54.9
Fort Ross	31.9	Bennett Valley	44.4	Turlock	50.2	Beaumont	55
Hal Moon Bay	33.7	Los Alamos	44.6	Nicolaus	50.2	Elsinore	55
Garberville	34.9	Moraga	44.9	Oakdale	50.3	Kesterson	55.1
Weed	34.9	Ravendale	44.9	Otay Lake	50.4	Firebaugh	55.4
San Francisco	35.1	Carpenteria	44.9	Raymond	50.5	Gerber Dryland	55.5
Happy Camp	35.1	Hollister	45.1	Fair Oaks	50.5	San Bernardino	55.6
Soda Springs	35.4	Fairfield	45.2	Auburn	50.6	Esparto	55.8
Tahoe City	35.5	San Jose	45.3	Lindcove	50.6	Warner Springs	56
Hoopa	35.6	Pittsburg	45.4	Corning	50.7	Riverside UC	56.4
San Rafael	35.8	Lower Lake	45.4	Visalia	50.7	McFarland/Kern	56.5
Monterey	36	Solvang	45.6	Williams	50.8	Blackwells Corner	56.6
Mt Shasta	36	Gonzales	45.7	Crestline	50.8	Orange Cove	56.7
Castroville	36.2	Carneros	45.8	Coalinga	50.9	Temecula East II	56.7
Truckee	36.2	Pajaro	46.1	Putah Creek	51	Winchester	56.8
Santa Cruz	36.6	Valley of the Moon	46.1	Winters	51	Lost Hills	57.1
Salinas North	36.9	Camarillo	46.1	Thousand Oaks	51	Corcoran	57.1
Watsonville	37.7	Pleasanton	46.2	Bryte	51	Cathedral City	57.1
San Simeon	38.1	Walnut Creek	46.2	Durham	51.1	Hastings Tract	57.1
Salinas	39.1	Webb	46.2	Fresno	51.1	Panoche	57.2
Yreka	39.2	El Dorado	46.3	Santee	51.1	Patterson	57.3
Portola	39.4	San Diego	46.5	Red Bluff	51.1	Bakersfield/Bonanza	57.9
Oakland Foothills	39.6	Lodi West	46.7	Kerman	51.2	Bakersfield/Greenlee	57.9
Sierraville	39.6	Yuba City	46.7	Taft	51.2	Twitchell Island	57.9
Petaluma	39.6	McArthur	46.8	Manteca	51.2	Big Bear Lake	58.6
Long Beach	39.7	Fremont	47	La Grange	51.2	Lake Arrowhead	58.6
Novato	39.8	Rio Vista	47	Dinuba	51.2	Stratford	58.7
Torrey Pines	39.8	Miramar	47.1	Friant	51.3	Westlands	58.8
Morro Bay	39.9	Livermore	47.2	Reedley	51.3	Belridge	59.2
Arroyo Grande	40	San Benito	47.2	Willows	51.3	Cuyama	59.7
Weaverville	40	Camino	47.3	Claremont	51.3	Pearblossom	59.9
Hay Fork	40.1	Badger	47.3	Clovis	51.4	Kettleman	60.2
Quincy	40.2	Nevada City	47.4	Chowchilla	51.4	FivePoints	60.4
Benicia	40.3	Santa Maria	47.4	Denair	51.4	Santa Clarita	61.5
Blue Canyon	40.5	Brownsville	47.4	Oroville	51.5	Piru	61.5
Markleeville	40.6	Pomona	47.5	Hanford	51.5	Mendota	61.7
Santa Barbara	40.6	Groveland	47.5	Madera	51.5	Caruthers	62.7
Green Valley Rd	40.6	Sonora	47.6	Merced	51.5	Independence	65.2
Cloverdale	40.7	Soledad	47.7	Kingsburg	51.6	Palmdale	66.2
De Laveaga	40.8	Oakville	47.7	Ramona	51.6	La Quinta	66.2
Healdsburg	40.8	Colfax	47.9	Alpaugh	51.6	Victorville	66.2
Hopland	40.9	Courtland	48	Woodland	51.6	Lower Haiwee Res.	67.6
Ukiah	40.9	Grass Valley	48	Chico	51.7	Ripley	67.8
Burney	40.9	Goleta	48.1	Lemoore	51.7	Palo Verde II	68.2
Guadalupe	41.1	Santa Ana	48.2	Burbank	51.7	Bishop	68.3
Lompoc	41.1	Brentwood	48.3	Buntingville	51.8	Oasis	68.4
Downieville	41.3	Suisun Valley	48.3	Gridley	51.9	Calipatria/Mulberry	70.7
Yosemite Village	41.4	Isabella Dam	48.4	Arvin	51.9	Mecca	70.8
Oakland	41.8	Tracy	48.5	Sacramento	51.9	Lancaster	71.1
Martinez	41.8	Santa Ynez	48.7	Lincoln	51.9	Palm Springs	71.1
Fall River Mills	41.8	Shanandoah Valley	48.8	Parlier	52	Westmoreland	71.4
Santa Rosa	42	San Andreas	48.8	Buttonwillow	52	Blythe	71.4
Glenburn	42.1	Coulterville	48.8	Delano	52	Rancho Mirage	71.4
Oxnard	42.3	Redding	48.8	San Fernando	52	Meloland	71.6
Redondo Beach	42.6	Jackson	48.9	Orland	52.1	Yuma	71.6
Lakeport	42.8	Mariposa	49	Shafter	52.1	Palm Deser	71.6
Redwood City	42.8	San Ardo	49	Nipomo	52.1	Salton Sea North	71.7
Oceanside	42.9	Paso Robles	49	Dixon	52.1	Barstow NE	71.7
Los Gatos	42.9	San Miguel	49	Porterville	52.1	Inyokern	72.4
Tule lake FS	42.9	MacDoel	49	Roseville	52.2	Thermal	72.8
Black Point	43	Sanel Valley	49.1	Pasadena	52.3	China Lake	74.8
Point San Pedro	43	Long Valley	49.1	Bakersfield	52.4	Lucerne Valley	75.3
Bridgeport	43	San Juan Valley	49.1	Gorman	52.4	Seeley	75.4
Palo Alto	43	Stockton	49.1	Davis	52.5	Newberry Springs	78.2
Modoc/Alturas	43.2	Betteravia	49.1	Arroyo Seco	52.6	Death Valley Jct	79.1
Laguna Beach	43.2	Sisquoc	49.2	King City-Oasis Rd.	52.7	El Centro	81.7
Concord	43.4	Newman	49.3	Colusa	52.8	Twentynine Palms	82.9
Port Hueneme	43.5	Winters	49.4	Hollywood Hills	52.8	Oasis	83.1
Ventura	43.5	Grapevine	49.5	Zamora	52.8	Indio	83.9
Gilroy	43.6	Greenfield	49.5	Tehachapi	52.9	Brawley	84.2
Glendale	43.7	Rancho California	49.5	Browns Valley	52.9	Holtville	84.7
Atascadero	43.7	Woodside	49.5	Famoso	53.1	Baker	86.6
San Luis Obispo	43.8	Morgan Hill	49.5	Glendora	53.1	Coachella	88.1
Susanville	44	King City	49.6	Delano	53.6	Desert Center	90
St Helena	44.1	Irvine	49.6	Fresno State	53.7	Needles	92.1
Union City	44.2	Goleta Foothills	49.6	Escondido SPV	54.2		