Residential Water Conservation in Australia and California

Ryan Cahill[1] and Jay Lund[2]

Journal of Water Resources Planning and Management, in press 2012

Abstract

In much of the Western United States, reducing residential water use is a major source of water conservation, especially as population growth urbanizes agricultural land. While estimates of the potential of conservation are useful, the experience of Australia provides a realistic target for residential water conservation. Although reliability of urban water use data is often questionable, it is clear that Australians use less water than Californians, with a similar climate, economy, and culture. Per-capita usage is compared, and explanations for use differences are offered. If California had the same residential water use rates as Australia, it could have reduced gross urban water use by 2,600 GL (2.1 million acre-feet) in 2009 and potentially saved 1,800 GL (1.5 million acre-feet) for consumptive use by others.

Introduction

Urban residential water conservation has been discussed as early as 1910 (Van Hise 1910, Hazen 1920). Nevertheless, residential water use still has significant potential for conservation, especially as urban growth displaces agricultural lands (Gleick 2003). Although estimates abound on how much water can be conserved from the residential sector (Gleick 2003, CALFED 2006, DWR 2010), these numbers are projections, based mostly on theory and assumptions. However, Australia provides an example that has recently undergone substantial sustained reductions in urban residential water use. This paper compares residential water use in Australia and California, identifying realistic residential conservation behavior and objectives based on urban water use in Australia. California, and perhaps other regions, may be able to "see their future" in water conservation by looking at the Australian experience.

Australia makes for an excellent comparison with the Western US, particularly California. Population, economic development, culture, and hydrologic patterns are similar. The populations of California and Australia have the same order of magnitude: 37 million and 22 million people respectively (World Bank 2010). Australia's 2008, per-capita GDP was $46,500 AUD (Australian Bureau of Statistics (ABS) 2008) compared to California's per capita GSP (gross state product) of $48,600 (Bureau of Economic Analysis 2010). Average annual rainfall in New South Wales (Australia's most populous state) is about 51.8 cm (20.4 inches) with a standard deviation of 11.4 cm (4.5 inches), while California has an average annual rainfall of 56.6 cm

---

[1] Master's Degree Candidate, Dept. of Civil and Environmental Engineering, Univ. of California-Davis, Davis, CA 95616. E-mail: rjcahill@ucdavis.edu

[2] Ray B. Krone Professor of Environmental Engineering, Dept. of Civil and Environmental Engineering, Univ. of California-Davis, Davis, CA 95616. E-mail: jrlund@ucdavis.edu

(22.3 inches) with a standard deviation of 16.3 cm (6.4 inches) (National Oceanic and Atmospheric Administration (NOAA) 2010, Australian Bureau of Meteorology (ABM) 2010). Rainfall variability is also similar; both California and Australia have large weather swings, rather than a predictable, temperate rainfall pattern. California's climate is a bit more variable than southeast Australia's; the coefficient of variation was 4.5 in California and 3.5 in New South Wales over the past 100 years (NOAA 2010, ABM 2010). Residential lot sizes are also similar: the average lot size in Australia is 740 m^2 (8000 ft^2), while the average lot size in California is 840 m^2 (9,000 ft^2) (ABS 2005, Hanak & Davis 2006).

First, a comparison is presented of actual water use in each region, followed by a brief discussion of how Australia reached its lower levels of residential water use.

Comparison of Australian and Californian use

Before undertaking a comparison, some discussion of data availability and reliability is in order.

Data Reliability

The California Dept. of Water Resources (DWR) acknowledges that "easily retrievable, standardized, and comprehensive baseline urban water use data are not available in California" (DWR 2009). Although surveys are completed by water utilities each year (called Public Water System Surveys, or PWSS), consistent, reliable urban water use data are not published regularly (DWR 2005). PWSS results provide a statewide estimate, although its accuracy is questionable due to voluntary self-reporting without auditing. The other main sources of information about usage in California are Urban Water Management Plans (UWMPs), which are required every five years (California Water Code 2002). UWMPs include use data, but they are not compiled annually into a statewide database. This paper follows the example of California DWR, using the population and usage estimates from the PWSS results (DWR 2010, see Appendix A).

In contrast, Australia has a consistent system for collecting urban water data. Almost every three years, the Australian Bureau of Statistics publishes a "water account" with summary water statistics, including urban water usage. The data comes from surveys, water utilities, and research papers, and broadly consolidates information about water use (ABS 2010). In addition to the water accounts, a National Performance Report has been released each year since 2005. All major water utilities provide information for the audited report, which standardized reporting categories (National Water Commission (NWC) and Water Services Association of Australia (WSAA) 2011). The National Performance Report would be analogous to an audited, expanded version of the PWSS results in California, if such a compilation existed.

With those caveats in mind, total per-capita residential and urban water uses are compared, along with available information on the end uses of water. Urban use includes residential, commercial, and industrial uses.

Per-Capita Residential Use

Examining per-capita residential water eliminates the effects of population size. Table 1 shows the historical per-capita residential water use in California and Australia.

Table 1: Historical comparison of average residential water use (in liters (gallons) per capita per day, or lpcd (gpcd)) in Australia and California, 1994-2009

Sources: ABS 1997, ABS 2000, ABS 2002, ABS 2004, ABS 2006, ABS 2010, NWC and WSAA 2011, DWR 2011

Year	California Residential Use, lpcd (gpcd)	Australian Residential Use, lpcd (gpcd)
1994	397 (105)	290 (77)*
1997	443 (117)	295 (78)*
2000	441 (117)	315 (83)*
2004	446 (118)	245 (65)
2005	421 (111)	238-282 (63-75)*
2006	425 (112)	248 (65)
2007	445 (118)	221 (58)
2008	417 (110)	198 (52)
2009	397 (105)	203-222 (54-59)*

Notes:

* From ABS Water Account

Australians, on average, used nearly 200 liters per capita per day (lpcd) (50 gallons per capita per day, gpcd) less water than their Californian counterparts in 2009 (DWR 2011, NWC and WSAA 2011). Not only did Australia have less per-capita residential use than California as a whole in 2009, but nearly every major city in Australia used less water per-capita than metropolitan areas in the Western U.S., as shown in Table 2.

Table 2: Water use in selected Australian and Western U.S. cities, 2005.

Sources: Portland Water Bureau (PWB) 2011, Albuquerque Bernalillo County Water Utility Authority (ABCWUA) (2010), Tucson Water 2008, Denver Water 2011, DWR 2011, San Francisco Public Utilities Commission (SFPUC) 2005, East Bay Municipal Water District (EBMUD) 2005, Los Angeles Department of Water and Power (LADWP) 2005, San Jose Environmental Services Department (SJ ESD) 2005, San Diego Public Utilities Department 2005, Sacramento Department of Utilities 2006, NWC and WSAA 2011

Location	Residential Use**, lpcd (gpcd)	Urban Use**, lpcd (gpcd)
Portland, OR	**219 (58)**	**390 (103)**
Albuquerque, NM	**282 (74)**	**587 (155)**
Tucson, AZ	**367 (97)**	**544 (144)**
Denver, CO	**393 (104)**	**604 (160)**
California	**394 (104)**	**568 (150)**
San Francisco	172* (46*)	295* (78*)
Oakland/East Bay	277*-316 (73*-83)	439*-469 (116*-124)
San Diego	277*-350 (73*-92)	490*-524 (129*-138)
San Jose	307-323* (81-85*)	489-519* (129-137*)
Los Angeles	345*-376 (91*-99)	450*-547 (119*-145)
Sacramento	428*-455 (113-120*)	642-667* (170-176*)
Australia	**204 (54)**	**318 (84)**
Melbourne	150 (40)	238 (63)
Brisbane	172 (45)	289 (76)
Canberra	191 (50)	288 (76)
Sydney	207 (55)	312 (83)
Perth	284 (75)	399 (106)

Notes: *From Urban Water Management Plan
**Does not include distribution system losses

Components of Residential Use

Total use estimates are helpful, but a breakdown of end uses by purpose can better identify saving potential. The most difficult data to estimate are outdoor residential use. DWR estimated outdoor water use accounts for 54% of all residential use in 2005 (DWR 2009). However, East Bay Municipal Utilities District (EBMUD 2005) estimated outdoor use at 32% in the same year. The most recent end use study in California found outdoor water use to be 53% (DeOreo et al. 2011). Australian estimates also vary widely. One study estimated outdoor water use as 44% of all use, while another estimate pegged outdoor water use for the city of Perth at 56% (ABS 2004, Loh and Coghlan 2003). The most recent study in Queensland estimates outdoor water use as only 12% of residential use (Willis 2009). However, the variations are small enough that per-capita outdoor residential use remains much less in Australia than California. Indoor use estimates are more reliable and consistent than outdoor use estimates (DeOreo et al. 2011). An increasingly popular technique to estimate indoor end uses of water is to install data loggers that record meter readings at short time intervals (5-10 seconds), and then apply signal processing software to disaggregate water use events by end use from the meter readings. Table 3 shows the results of studies using this approach to estimate end uses of water in Australia and California in

1999-2009. Table 4 (in the online supplemental material) highlights the differences in end uses between California and Australia.

Table 3: Californian and Australian residential end use measurement studies, 1999-2009
Sources: Mayer and DeOreo 1999, Loh and Coghlan 2003, ABS 2004, EBMUD 2005, Roberts 2005, Willis 2009, DeOreo et al. 2011

	California						**Australia**					
Location:	**United States**		**East Bay Area**		**California**		**Perth**		**Melbourne**		**Gold Coast**	
Source:	Mayer & DeOreo (1999)		EBMUD (2005)		DeOreo et al. (2011)		Loh & Coghlan (2003)		Roberts (2005)		Willis (2009)	
Sample Size:	n = 1188		n = 33		n = 735		n = 124		n = 100		n = 151	
End Use	Use, lpcd (gpcd)	% of total	Use, lpcd (gpcd)	% of total	Use, lpcd (gpcd)	% of total	Use, lpcd (gpcd)	% of total	Use, lpcd (gpcd)	% of total	Use, lpcd (gpcd)	% of total
Toilet	70 (19)	11%	76 (20)	21%	48 (13)	10%	34 (9)	9%	30 (8)	13%	20 (5)	13%
Shower/ Bath	48 (13)	7%	57 (15)	16%	49 (13)	10%	52 (14)	14%	55 (14)	24%	58 (15)	37%
Washing Machine	57 (15)	9%	53 (14)	15%	39 (10)	8%	41 (11)	11%	43 (11)	19%	30 (8)	19%
Faucets	41 (11)	6%	38 (10)	11%	42 (11)	9%	26 (7)	7%	27 (7)	12%	27 (7)	17%
Leaks	36 (10)	6%	19 (5)	5%	39 (10)	8%	7 (2)	2%	14 (4)	6%	2 (0)	1%
Other	16 (4)	3%	4 (1)	1%	7 (2)	1%	4 (1)	1%	2 (1)	1%	2 (0)	1%
Outdoor	382 (101)	59%	114 (30)	32%	252 (67)	53%	209 (55)	56%	57 (15)	25%	19 (5)	12%
Total	650 (172)	100%	360 (95)	100%	476 (126)	100%	373 (99)	100%	227 (60)	100%	157 (42)	100%

From the end use studies, the biggest differences between Australian and Californian residential water use are, in order of magnitude: outdoor water use, toilet use, leaks and faucets, washing machines, other, and shower/bath. Over half of the total difference in residential water use can be attributed to Australia's significantly lower rates of outdoor water use.

Contributing Factors to Australian Conservation

While California's per-capita use dropped about 10% from 2000-2009, Australia reduced per-capita use by about 35% (DWR 2011, NWC and WSAA 2011). Three actions contributing to Australia's reduced water use are the adoption of outdoor water restrictions, lower-flush toilets, and water pricing.

Outdoor Water Restrictions

Outdoor water restrictions are a major reason that Australian outdoor use is less than in California. Even when water is not in short supply, many Australian cities limit outdoor water use. In Melbourne, for example, outdoor watering is prohibited between 10:00am and 8:00pm (DSE 2010). If residents notice neighbors wasting water, they can call a hotline to report water wasters and impose steep fines up to $458 AUD (DSE 2010). Similar permanent restrictions exist in all major metropolitan areas in Australia. During droughts, restrictions can increase significantly. Such uncertainty about outdoor water reliability has encouraged residents to adopt less water-intensive landscapes or invest in rainwater tanks, which are exempt from restrictions and reduce demand on the water supply system (Australian Associated Press 2006). As of 2010, 43% of Australian dwellings had a rainwater tank, dwarfing the prevalence of such devices in California (ABS 2010 “Environmental Issues”). Although tanks with small storage capacity have modest effectiveness, rainwater tanks contribute to the lower outdoor use rates in Australia. Water drawn from wells is also exempt from restrictions and reduces demand on the municipal water system, but only 4% of urban Australian households use wells as a water supply source (ABS 2010 “Environmental Issues”).

California, in contrast, has no permanent water restrictions on residential uses. While temporary restrictions can be effective during droughts, they are usually the prerogative of the local water utility. Californians might object to the loss of personal freedoms such water restrictions would cause, but these restrictions have dramatically reduced outdoor water use in Australia.

Lower-Flush Toilets

As the largest indoor residential end-use before the 2000’s, toilets were a logical place to start conserving water in coastal areas. Australia has advocated dual flush toilets with a half flush option when a full flush is unnecessary. Caroma, the leading toilet manufacturer in Australia, developed a 3 and 1.5 gallon/flush toilet in 1981, compared to earlier 3.5 or 6 gallon/flush models (State Library of South Australia 2006). By 1984, the Victorian government required use of dual-flush toilets in all new construction; other Australian states followed similar paths (ABS 2004, “Australian Social Trends”). In 1994, Caroma succeeded in producing effective toilets using 1.6 gallons for a full flush and 0.8 gallons for a half flush (State Library of South Australia 2010). By 2001, 64% of all households had dual-flush toilets; adoption was 86% in 2010 (ABS 2004, “Environmental Concerns and Related Activities”; ABS 2010, “Environmental Issues: Water Use and Conservations).

California law mandated the installation of 3.5 gallons/flush in new construction after January 1, 1978. California’s lawmakers acted slightly earlier than the federal government in requiring ultra low flow toilets (ULFTs), which use 1.6 gallons/flush, in replacements and new construction after January 1992 (DWR 1998). Californians have not adopted the ULFTs as quickly as Australians. By 2000, only about 26% of toilets in California were ULFT, and roughly the same proportion was still 6 gallon/flush models (Gleick 2003). The earlier passage of laws in Australia requiring more water-efficient toilets than California combined with strong rebate programs have reduced residential water use.

Water Pricing

Water prices are difficult to compare, because water is often priced in a block rate scheme, where different prices are charged depending on consumption. The exchange rate further obfuscates the comparison—since the exchange rate between American and Australian currency has fluctuated in recent years, no attempt will be made to adjust for the exchange rate: all prices are given in native currencies. In April 2011, Australian and US currencies have almost equivalent value, but the Australian dollar was worth $0.80 US on average during 2006-2011 (OANDA 2011). Table 5 (in the online supplemental material) compares a single family residential monthly water bill at the average metropolitan consumption rate in 2005 and at a fixed household consumption rate of 145 gallons/day (5.9 CCF/month), by city in 2009-2011. Wastewater charges (applying only to indoor use) are not included in the comparison, although they are often a significant component of a monthly water bill. Since Australians use less water outdoors than Californians, wastewater bills are higher in Australia than California.

Table 5 shows Australians pay more for water than Californians, but this has not always been the case. Residents of Los Angeles paid about twice as much for water in 1993-1994 as residents of Melbourne (Horridge and Rimmer 1994, Mitchell 1994). The situation is reversed now, as Australians in nearly every major city pay more than Californians, despite their lower consumption rates. Per-unit consumption costs, rather than fixed costs, make up a larger proportion of the total water bill in Australia, but increasing rate block schedules are used in all metropolitan areas listed. The higher price of water in Australia likely has contributed to reduced water use. Because of the higher water rates, utility revenues per residential connection are similar between Australia and California despite the lower use rates in Australia.

Potential Savings in California

The translation of per-capita numbers into total numbers can give a sense of how much water could actually be saved from increased conservation. First, a distinction should be drawn between gross urban use reduction and "saved" water. Most water used indoors by upstream areas is returned to waterways after treatment for use downstream, so conserving indoors in inland areas does not reduce statewide net or consumptive use. Outdoor water use is mostly consumptive (due to evapotranspiration losses, assumed at about 80%), so reductions in inland outdoor water use make some water available for other uses (Hanak et al. 2011). Water used in coastal urban areas is not used by downstream areas, so all conservation in coastal areas reduces consumptive use. Therefore, "saved" water consists of total use reduction in coastal areas and roughly 80% of outdoor use reduction in inland areas.

If Californians had the same levels of residential use as Australians in 2009, gross use would have been less by about 190 lpcd (50 gpcd, see Table 1). This translates to a statewide residential use reduction of 2,600 GL (2.1 million acre-feet (maf)) in 2009. Since the average Californian uses 397 lpcd (105 gpcd, see Table 1), and California coastal areas (with 26 million consumers) use about 300 lpcd (79 gpcd, see Table 2), a simple mass balance shows inland areas (with 11 million consumers) have average use rates of 621 lpcd (164 gpcd). Coastal areas will save 96 lpcd (25 gpcd) by achieving Australian use rates of 204 lpcd (54 gpcd), translating to a volume savings of 900 GL/year (0.7 maf/year), all of which is consumptive use savings. For inland areas, not all water conserved contributes to net or consumptive use savings. If we assume inland indoor use rates at 269 lpcd (71 gpcd) (Mayer and DeOreo 1999), about 307 lpcd (81 gpcd) of outdoor use would need to be conserved to reach Australian use levels. Since 80% of outdoor use is lost due to evapotranspiration, the consumptive use saved is 246 lpcd (65 gpcd), translating to a savings of 950 GL/year (0.8 maf/year). When the inland and coastal savings are combined, the total savings is 1,850 GL/year (1.5 maf/year). In other words, 750 GL (0.6 maf) of the total 2,600 GL (2.1 maf) gross use reduction would become available for downstream uses and not actually "save" water statewide. For comparison, the total urban use in California in 2005 was 10,200 GL (8.3 maf), and the average annual total water use (including agricultural and urban uses) is 53,000 (43 maf) (DWR 2005, 2009). Figure 1 provides mass balance schematics for a coastal and inland area as they conserve to Australian use levels, neglecting modest levels of wastewater reuse in coastal areas.

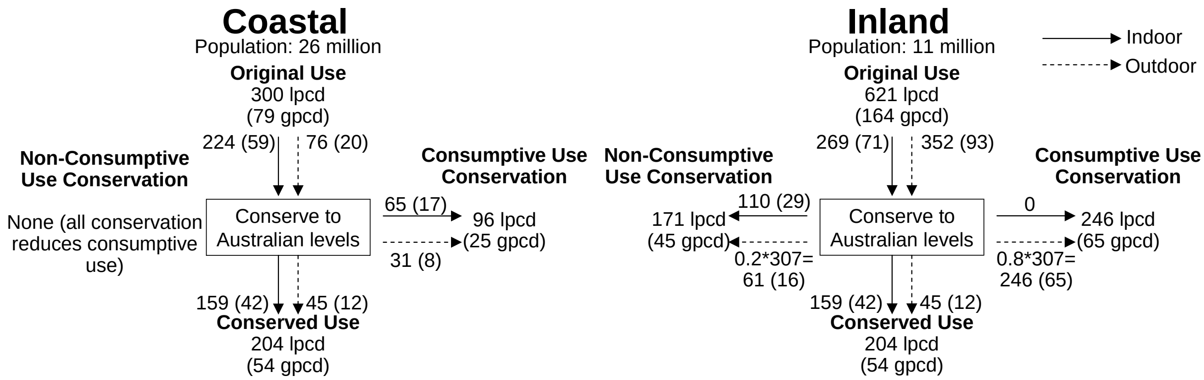

Figure 1: Mass balance schematics for coastal and inland areas after conservation to Australian use levels, 2009

Sources: United States Census Bureau 2011, DWR 2011, NWC and WSAA 2011, Hanak et al. 2011, Mayer and DeOreo 1999, DeOreo et al. 2011

As in Australia, such conservation would not come without cost and inconvenience. However, the change in water use in urban Australia, driven partly by drought and partly by longer-term conservation policies, is likely to pay dividends in terms of reducing water shortages for a long time.

Conclusions

Australia's progress in residential water conservation can be used to estimate realistic water conservation possibilities for California and elsewhere in the western US. Australia's path to water conservation has not been entirely smooth, but their experience proves that extensive residential water conservation is possible. Though California is making efforts to reduce consumption, there is room for more conservation. Australia offers several lessons for reducing residential water use, including outdoor water restrictions, substantial and accessible rebates for water-saving devices, and increased water prices. If California had used the same amount of per-capita residential water as Australia, the urban water use reduction would have been about 2,600 GL (2.1 maf) in 2009, with about 1,800 GL (1.5 maf) more water available for other uses.

Acknowledgements

Thanks to Dong Chen of California DWR for his help and patience in providing the PWSS data and to three anonymous reviewers for their helpful suggestions to improve the paper.

References

ABCWUA (2010), "Water Conservation Statistics for 2009".

Australian Associated Press (AAP) (2006), "Turf Industry Slams Water Rules", Herald Sun, November 6, 2006.

Australian Bureau of Meteorology (ABM) (2010), "Average Annual, Seasonal, and Monthly Rainfall", Data Online, http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp

Australian Bureau of Statistics (ABS) (1997), "1996 Census of Population and Housing: Selected Social and Housing Characteristics", Statistic 2015.0.

ABS (2000), "Water Account, Australia, 1993-1994 to 1996-1997", Statistic 4610.0.

ABS (2002), "Selected Social and Housing Characteristics, Australia, 2001", Statistic 2015.0.

ABS (2004), "Australian Social Trends, 2004", Statistic 4102.0.

ABS (2004), "Water Account, Australia, 2001-2002", Statistic 4610.0.

ABS (2004), "Environmental concerns and related activities", Statistic 4602.0.

ABS (2005), "Average size of new residential lots in capital cities", State of the Environment 2006, Indicator HS-30.

ABS (2006), "Water Account, Australia, 2004-2005", Statistic 4610.0.

ABS (2008), "Australia at a Glance 2008", Statistic 1309.0.

ABS (2010), "Water Account, Australia, 2008-2009", Statistic 4610.0.

ABS (2010), "Environmental Issues: Water Use and Conservation", Statistic 4602.0.55.003.

Bureau of Economic Analysis (2010), "Gross Domestic Product by State", U.S. Department of Commerce, <http://www.bea.gov/regional/gsp/> (Nov. 8, 2010).

California Department of Water Resources (CA DWR) (1994), Bulletin 166-4: Urban Water Use in California, Sacramento, CA.

CA DWR (1998), California Water Plan Bulletin 160-98.

CA DWR (2005), California Water Plan Bulletin 160-05.

CA DWR (2009), California Water Plan Bulletin 160-09.

CA DWR, et al. (2010), "20x2020 Water Conservation Plan".

CA DWR (2011), Public Water System Survey Data, 1994-2009.

California Water Code (2002), "Urban Water Management and Planning Act", Section 10610.

CALFED Bay-Delta Program (2006), "Water Use Efficiency Comprehensive Evaluation", Calfed Bay-Delta Program Water Use Efficiency Element, Final Report, Sacramento, CA.

Denver Water (2011), "Denver's Water Use", <http://www.denverwater.org/AboutUs/KeyFacts/> (Apr. 5, 2011).

DeOreo, W. et al. (2011), "California Single-Family Water Use Efficiency Study", Aquacraft Inc., Boulder, CO.

Department of Sustainability and Environment (DSE) (2010), "Water Restrictions", Our Water, Our Future, Melbourne, AUS, <http://www.ourwater.vic.gov.au/saving/restrictions> (Nov. 6, 2010).

East Bay Municipal Utilities District (EBMUD) (2005), "Urban Water Management Plan 2005", Water Resources Planning Division.

East Bay Municipal Utilities District (EBMUD) (2011), "Urban Water Management Plan 2010", Water Resources Planning Division.

Gleick, P. et al. (2003), "Waste Not, Want Not: The Potential for Urban Water Conservation in California", Pacific Institute.

Hanak, E. & Davis, M. (2006), "Lawns and Water Demand in California", *California Economic Policy*, Public Policy Institute of California, Vol. 2(2).

Hanak, E. et al. (2011), *Managing California's Water: From Conflict to Reconciliation*, Public Policy Institute of California, San Francisco, CA, 500 pp., February.

Hazen, A. (1920), "Water Use Variation in Completely Metered Systems", Engineering News-Recorder, 85(10), pp. 449-450.

Horridge, J. and Rimmer, M. (1994), “Water Pricing and Investment in Melbourne”, Centre of Policy Studies and the Impact Project.
Loh, M. and Coghlan, P. (2003), “Domestic Water Use Study in Perth, Western Australia 1998-2001”, Water Corporation.
Los Angeles Department of Water and Power (LADWP) (2011), “Urban Water Management Plan 2011”, City of Los Angeles.
Mayer, P. and DeOreo, W. (1999), “Residential End Uses of Water”, American Water Works Association Research Foundation (AWWARF), Denver, CO.
Mitchell, D. et al. (1994), “Setting Urban Water Rates for Efficiency and Conservation”, California Urban Water Conservation Council.
National Oceanic and Atmospheric Administration (NOAA) (2010), “California Precipitation September-August 186-2010”, U.S. Department of Commerce, <http://www.ncdc.noaa.gov/temp-and-precip/time-series/index.php?parameter=pcp&month=8&year=2009&filter=12&state=4&div=0> (Nov. 8, 2010).
National Water Commission (NWC) and Water Services Association of Australia (WSAA) (2011), “National Performance Report 2009-2010: Urban Water Utilities”.
OANDA (2011), “Historical Exchange Rates”, <http://www.oanda.com/currency/historical-rates/> (April 11, 2011).
Portland Water Bureau (PWB) (2011), “Demand and Consumption Information”, City of Portland, <http://www.portlandonline.com/water/index.cfm?c=29881&a=29952> (Mar. 25, 2011).
Roberts, P. (2005), “2004 Residential End Use Measurement Study”, Yarra Valley Water.
Sacramento Department of Utilities (2011), “2010 Urban Water Management Plan”, City of Sacramento.
San Diego Public Utilities (2011), “2010 Urban Water Management Plan”, City of San Diego.
San Jose Environmental Services Department (SJ ESD) (2011), “2010 Urban Water Management Plan”, City of San Jose.
San Francisco Public Utilities Commission (SFPUC) (2011), “2010 Urban Water Management Plan for the City and County of San Francisco”, City of San Francisco.
SFPUC (2010), “Water Conservation Report 2007-2010”, City of San Francisco.
State Library of South Australia (2006), “Innovations: Dual-flush toilet”, Government of South Australia, <http://www.samemory.sa.gov.au/site/page.cfm?u=318> (Mar. 26, 2011).
Tucson Water (2008), “2008 Update to Water Plan 2000-2050: Projected Water Demand”, Section 3, City of Tucson.
United States Census Bureau (2001), “Total Population”, Census 2000 Summary File 1, Matrix P1.
United States Census Bureau (2001), “Average Household Size”, Census 2000 Summary File 1, Matrix P17.
Van Hise, C. (1910), *The Conservation of Natural Resources in the United States*, The MacMillan Company, New York, New York.
Willis, R., et al. (2009), “Gold Coast Domestic Water End Use Study”, *Water*, Journal of the Australian Water Association, Vol. 36(6), pp. 79-85.
World Bank (2010), “World Development Indicators”, <http://data.worldbank.org/data-catalog/world-development-indicators?cid=GPD_WDI> (Nov. 8, 2010).