ERRATA

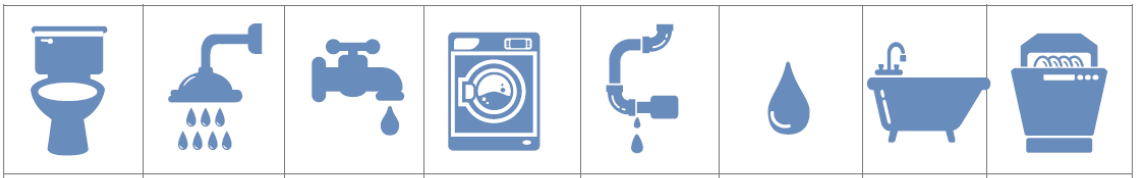
WRF Project #4309: *Residential End Uses of Water, Version 2*

WRF notes the following errors in the first printing of 4309A: *Residential End Uses of Water, Version 2: Executive Report*:

1) Page 2, inside front cover: City of Scottsdale Water Department was also a co-sponsor of this project.

2) Page 5: Several of the numbers in Figure 1 were incorrect. Figure 1 should appear as follows:

Figure 1. Indoor household use by fixture



Toilet	Shower	Faucet	Clothes washer	Leak	Other*	Bath	Dishwasher
24%	20%	19%	17%	12%	4%	3%	1%
33.1 gphd	28.1 gphd	26.3 gphd	22.7 gphd	17.0 gphd	5.3 gphd	3.6 gphd	1.6 gphd

* The "Other" category includes evaporative cooling, humidification, water softening, and other uncategorized indoor uses.

3) Page 6, paragraph 3, sentence 1: "To analyze outdoor water use, the estimated actual use was compared to the theoretical irrigation requirement - an equation estimation of water needs for residential and park landscapes."

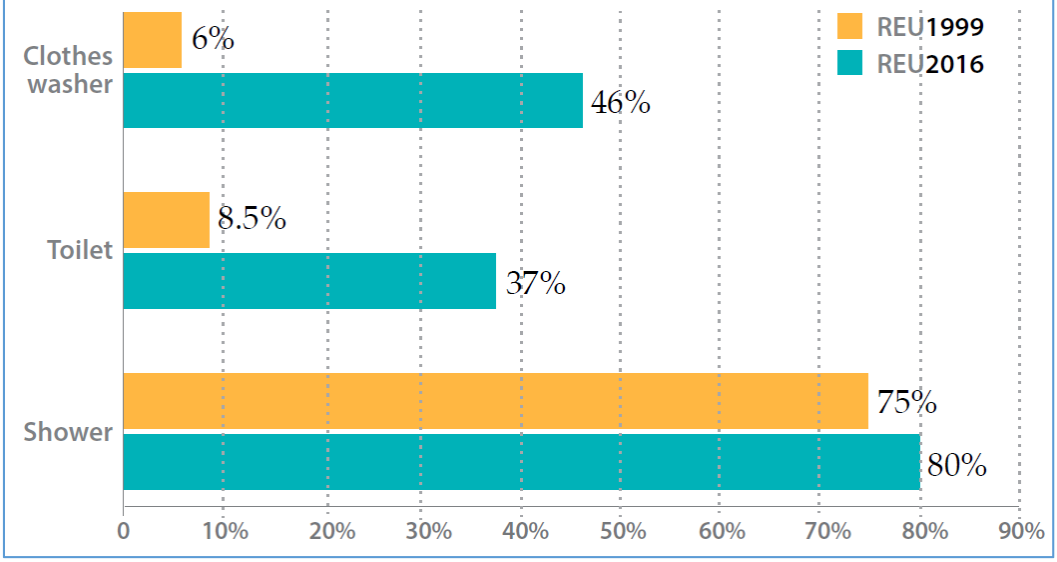
4) Page 6, paragraph 4, sentence 1: "The majority of study participants—72 percent—applied considerably less water than was theoretically required and were termed 'low/deficit' irrigators."

5) Page 9, last two sentences of "Toilets" section: "In REU1999, just 8.5 percent of the homes had average toilet flushes of less than 2.0 gpf. In REU2016, 37 percent of the homes had average toilet flushes of less than 2.0 gpf."

6) Page 10: The percentage of REU1999 homes with average toilet flushes < 2.0 gpf was 8.5%, rather than 5%. The corresponding change to Figure 6 is as follows:

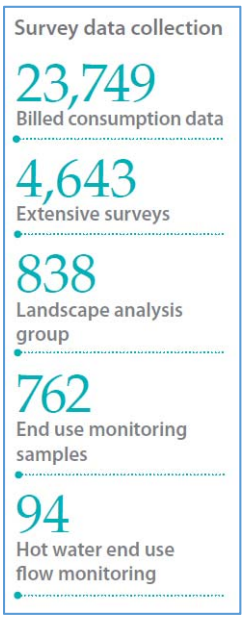
Figure 6. Percent of homes meeting efficiency criteria, REU1999 and REU2016

Efficiency criteria include: clothes washers <30 gal/load, toilets <2.0 gal/flush, showers <2.5 gal/minute.



7) Page 11, paragraph 1 of Outdoor Conservation Potential: "There are a number of common strategies to maximize outdoor efficiency. Utilities should target water efficiency programs at excess irrigators. Deficit irrigators (those using less than the theoretical irrigation requirement) should be prevented from increasing their irrigation in the future. Pricing programs and reduction in planting areas may achieve outdoor demand reductions beyond efficiency measures. For example, water reductions of 20-50% are estimated when using mild to aggressive landscape conservation programs."

8) Page 12: The "Survey data collection" graphic is incorrect, specifically, the number of extensive surveys. This graphic should appear as follows:



WRF notes the following errors in the first printing of 4309B: *Residential End Uses of Water, Version 2*:

1) Title Page: City of Scottsdale Water Department should have been listed as a co-sponsor of this project.

2) Page xxxiii: In Figure ES.2, the key reads "REU2015." This should be changed to "REU2016."

3) Page xxxiv: In Figure ES.3, the key reads "REU2015." This should be changed to "REU2016."

4) Page xxxvii: Change paragraph 3, sentences 1 and 2 to: "In REU1999, just 8.5% of the homes had an average toilet flush volume of less than 2.0 gal/flush. In REU2016, 37% of the homes had an average toilet flush volume less than 2.0 gal/flush."

5) Page xli: Change bottom paragraph, last sentence to: "The minimum household efficiency criteria used in these studies were:
    - Average clothes washer load < 30 gallons
    - Average toilet flush < 2.0 gallons
    - Average shower flow rate < 2.5 gallons per minute"

6) Page xli: In the footnote, "Nearly 100" should be changed to "Nearly 100%."

7) Page xlii: The REU1999 Toilet efficiency statistic in Figure ES.7 is incorrect. Instead of 5%, it should be 8.5%. Figure ES.7 should appear as follows:

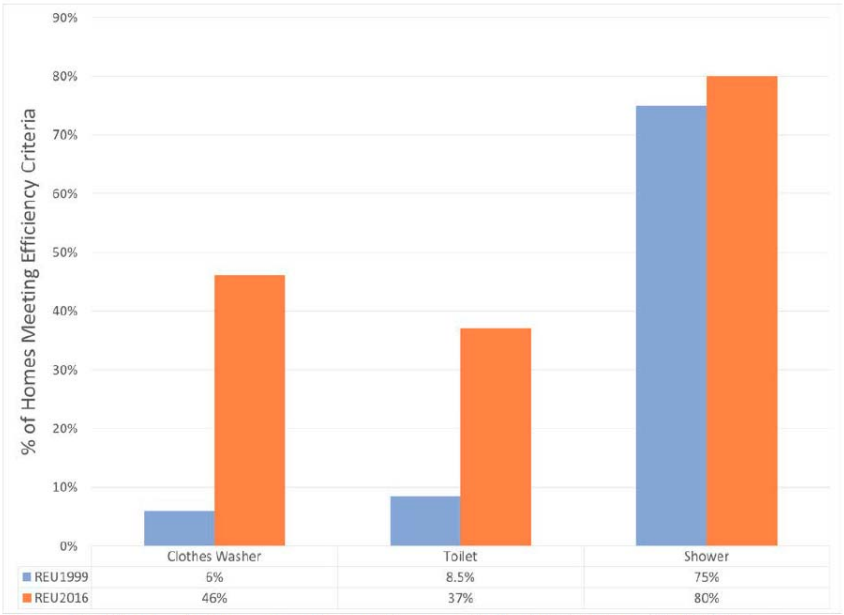


Figure ES.7 Percent of homes meeting efficiency criteria, REU1999 and REU2016

8) Page xlvi: Under **Factors that Influence Water Use**, the corrected text is as follows:

Creation of predictive mathematical models of indoor and landscape water use in single family households can show how variation in one set of parameters (called explanatory variables) is likely to impact the average daily household water use, for indoor purposes, and the average annual irrigation use, for landscape uses. Models are useful to the extent that they explain the variability in water use better than simple use of average values.

A model was created to evaluate the impacts of specific factors on indoor water use (Table 7.1). Some of the factors that have significant influence on increasing indoor water use are number of people residing in the home (large impact), presence of a home water treatment system, parcel size (proxy for income) and presence of a swimming pool. Some of the factors that have significant influence on decreasing indoor water use were the presence of efficient toilets (large impact), increased sewer rates, presence of a hot water recirculating system, and presence of efficient clothes washer. Additional models were created to examine individual end uses and conservation (see Tables 7.2 to Table 7.10).

Factors that were found to have significant influence on increasing outdoor water use in REU2016 were occurrence of excess irrigation (large impact), net ET (large impact), presence of an in-ground sprinkler system (large impact), irrigated area, and presence of a swimming pool. Factors that were found to have significant influence on decreasing outdoor water use was the cost of water. Additional models were created to examine conservation, see Table 7.14 and 7.15.

9) Page xlvii: Under **Indoor Water Use Will Continue to Decline in the Future**, the 2nd bullet should read:
    - The percentage of homes that have efficient toilets and clothes washers has increased substantially. In REU1999, only 6% of homes had average clothes washer loads of less than 30 gallons and in REU2016, this increased to 46%. In REU1999, only 8.5% of homes had average toilet flushes less than 2.0 gallons, and in REU2016 this increased to 37%.

10) Page 30: The first two full paragraphs should read as follows:

Each water use event in the flow trace is characterized by fixture type, flow rate, duration and volume. The analysis does not reveal the fixture or appliance's make, model, or the manufacturer's stated water use amount. The efficiency of devices like toilets, showers, and clothes washers is inferred from their measured volumes or flow rates. For example, there may be many "standard" showerheads that flow at less than 2.5 gpm (6 lpm). These would be classified as "high-efficiency showers" because they meet the EPAct 2005[7] criterion of rates of 2.5 gpm @ 80 psi.

Individual toilet flush volumes of less than 2.2 gpf (6 l) were classified in this study as "efficient" toilets, most likely due to the presence of an ultra-low flow[8] or high-efficiency toilet.[9] An old toilet modified to flush with less water might be classified as an efficient toilet, even though an auditor might classify it as inefficient because it was not stamped as a ULF of HET model. Conversely, ULF manufactured toilets may really have flush volumes as high as 3+ gallons because they are poorly adjusted or malfunctioning. Since this study monitored water use, these malfunctioning toilets would be considered as "not efficient." For more details, see page 116. A second efficiency criteria was set for the household level. Efficiency was assigned if houses had average clothes washer load less than 30 gallons, average shower flow rate less than 2.5 gpm, and average toilet flush volume less than 2.0 gallons.

11) Page 108: The final sentence on this page should read: "Figure 6.10 shows the average indoor per capita use grouped by the number of residents (from 1 to 10) in the homes for all <u>737</u> logged homes and fitted with an exponential curve."

Page 109: The 2nd full sentence at the top of the page should be amended as follows: "A linear model fits the data for the homes that report 1–7 residents, which is 733 of the 737 homes. A slightly better line fit can be achieved with the data in Figure 6.11 with power, exponential, or logarithmic curves."

12) Page 110: Figure 6.10 is incorrect. It should appear as follows:

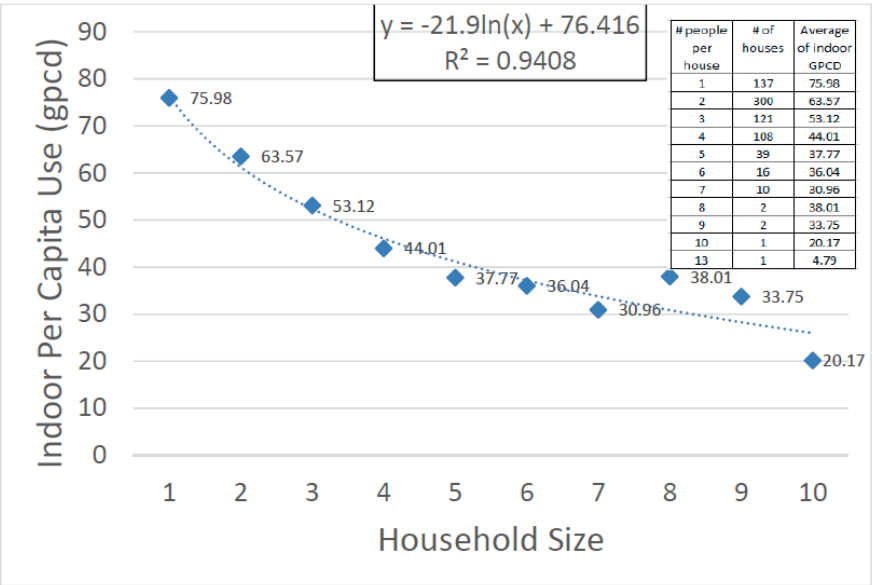


Figure 6.10 Per capita indoor use and number of residents (non-linear model)

13) Page 111: Figure 6.11 is incorrect. It should appear as follows:

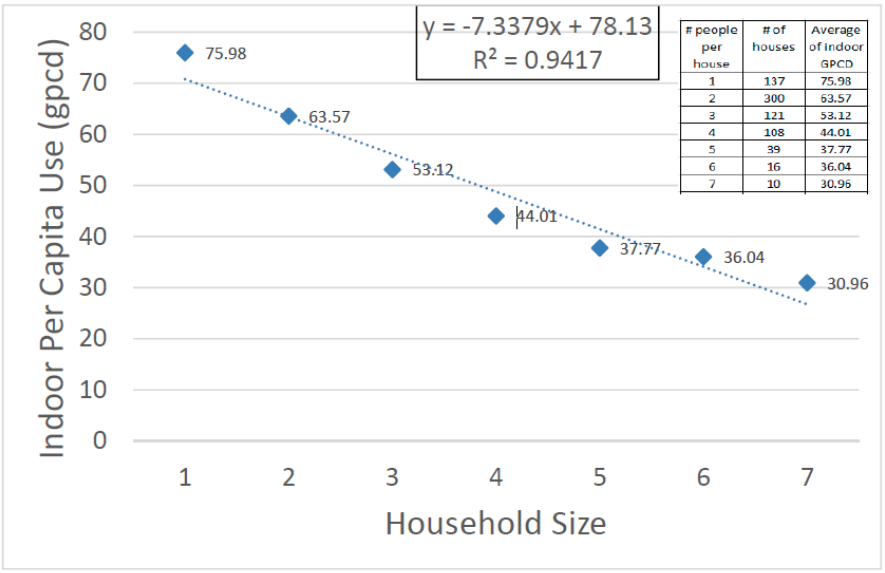


Figure 6.11 Per capita indoor use and number of residents (linear model)

14) Page 115: In Table 6.7, the 2nd to last row should appear as follows:

% Homes with average flush < 2.0 gal	37%	8.5%

15) Page 116: Under Figure 6.15, the two paragraphs of text should read as follows:

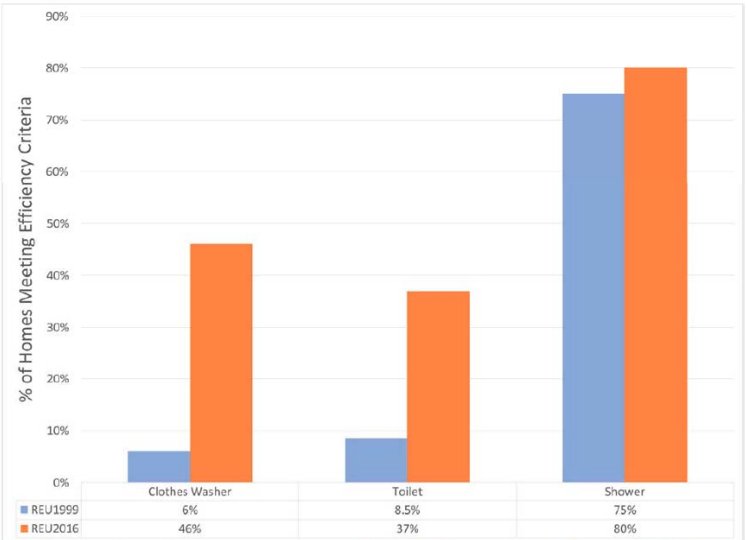
This study had two efficiency criteria related to toilets: the house's average toilet flush volume and individual flush volumes. Homes were characterized as efficient if the home's average toilet flush volume was less than 2.0 gpf (7.6 lpf). Individual flushes were also analyzed, but using 2.2 gpf (8.3 lpf). Homes often include multiple toilets and thus flush volumes, so no immediate household toilet efficiency demarcation line is apparent. The starting point for setting the efficiency criteria was the 1992 Energy Policy Act (EPAct) standard of 1.6 gpf (6.1 lpf). Some volume was added since these toilets often flush above the 1.6 gpf and sometimes the flow trace captures faucet flow in the flush. The 2.0 gpf efficiency criteria for the average household flush volume was chosen because it will label homes efficient if they exclusively have toilets that flush at 1.6 gpf, 1.28 gpf (4.8 lpf), or 1.1 gpf (4.2 lpf). Homes with a mixture of efficient and older toilets (with larger flush volumes) will probably not be deemed as efficient with the 2.0 gpf mark.

When examining individual flush volumes, a slightly wider margin in the flush variation was allowed. The efficiency criteria for individual flush volumes was allowed to rise to 2.2 gpf. This larger volume accounts for the range of actual flush volumes observed in toilets due to how they are installed and adjusted. Table 6.8 shows the percent of flushes in each study site that were found to be less than 2.2 gallons. This table shows that as a whole slightly less than half of the flushes measured in the study were in the efficient range. Note, in REU1999 report, 14.5% of flushes were less than 2.0 gpf. The 1999 study data were reanalyzed to determine that 16% of flushes were less than 2.2 gpf (see Table 6.7).

16) Page 134: Under **Occurrence Rates of Efficient Fixtures and Appliances**, the second sentence and bulleted list should read as follows: "The minimum household efficiency criteria used in these studies were:

- Average clothes washer load < 30 gallons
- Average toilet flush < 2.0 gallons
- Average shower flow rate < 2.5 gallons per minute"

17) Page 135: he REU1999 Toilet efficiency statistic in Figure 6.25 is incorrect. Instead of 5%, it should be 8.5%. This figure should appear as follows:



Note: The 6% clothes washer statistic was not presented in REU1999, but was calculated later using the REU1999 data.

Figure 6.25: Percent of homes meeting efficiency criteria for clothes washers, showers and toilets in REU2016 and REU1999

18) Page 135: The last sentence on this page should read as follows: "This comparison seems the most relevant parameter for judging the efficiency of the homes in the service area, but one should keep in mind that the percentage of houses with average flush volumes of less than 2.0 gpf is not the same as the percentage of toilets flushing at this volume, which would be higher than the percent of homes."

19) Page 136: Table 6.21 is incorrect. This table should appear as follows:

Table 6.21 Changes in household occurrence rates over time

Study Location	Data year	Percent of Homes Complying with Efficiency Criteria			References
		Clothes washer < 30 gpl	Showers < 2.5 gpm	Toilets < 2.0 gpf	
Various sites in North America (REU1999) (n=1,188)	1997	6.1%**	75.4%	8.5%	Mayer et al. (1999)
Albuquerque Bernalillo County Water Utility Authority, NM (n=204)	2009	45.5%	81.0%	35%	Aquacraft (2011a)
Various sites in California (n=729)	2007	29.5%	79.1%	30%	Aquacraft (2011b)
Various sites in North America (REU2016) (n=762)	2012	46.0%	80.0%	37.0%	WRF (2016)

**This result was not presented in REU1999, but was calculated later based on REU1999 data.

20) Page 136: A sentence should be added to the paragraph in the middle of the page so that it reads as follows:

The increase in the penetration of high efficiency fixtures and appliances are necessarily based on a uniform standard, which in this case are the 1992 Energy Policy Act standards, which were the original water fixture efficiency standards enacted at the Federal level. Keeping the same evaluation criteria over time establishes a baseline against which progress can be measured. Using the same standard allows the percentage of homes that have met the standard to be tracked over time. Using data from Table 6.21, the rate of change in household efficiency is about 2–3% per year for toilets and clothes washers. Presumably, homes that upgrade later also are more likely to meet whatever standard is in place at the time. The changes in occurrence rates reflect both active conservation measures (such as rebates offered by utilities) and passive conservation.

21) Page 230: Under "4) Indoor Water Use Will Continue to Decline in the Future," the 2nd bullet should read as follows:

- The percentage of homes that have efficient toilets and clothes washers has increased substantially. In REU1999, only 6% of homes had average clothes washer loads of less than 30 gallons and in REU2016, this increased to 46%. In REU1999, only 8.5% of homes had average toilet flushes less than 2.0 gallons, and in REU2016 this increased to 37%.

22) Page 232: Under "8) Factors That Influence Water Use Include Demographics, Fixtures, and Pricing," the text should read as follows:

- The regression models in REU2016 show that the most important predictor of indoor water use is the number of persons residing in the home. A model was created to evaluate the impacts of specific factors on indoor water use (Table 7.1). Some of the factors that have significant influence on increasing indoor water use are number of people residing in the home (large impact), presence of a home water treatment system, parcel size (proxy for income) and presence of a swimming pool. Some of the factors that have significant influence on decreasing indoor water use were the presence of efficient toilets (large impact), increased sewer rates, presence of a hot water recirculating system, and presence of efficient clothes washer. Additional models were created to examine individual end uses and conservation (see Tables 7.2 to Table 7.10).
- Factors that were found to have significant influence on increasing outdoor water use in REU2016 were occurrence of excess irrigation (large impact), net ET (large impact), presence of an in-ground sprinkler system (large impact), irrigated area, and presence of a swimming pool. Factors that were found to have significant influence on decreasing outdoor water use was the cost of water. Additional models were created to examine conservation, see Table 7.14 and 7.15.