

Project Title: **Individual Water Reduction in Accordance with California State Water Mandate**

Participants: Arena, Brian
Becker, Jake
Karabinos, Brian
Smith, Kyle

Section: A02

Abstract

California Governor Jerry Brown issued an executive order that requires all urban water use be decreased by twenty-five percent. For residents, it may not be clear what a twenty-five percent reduction in water use might translate to in their everyday lives. Many students might not have lawns they tend to personally or they may already be limiting outdoor water use to their absolute minimum. Therefore, we will focus this project on indoor water consumption.

Our project goal is to pool data from our own individual experiences together to come up with some examples of what reducing our water use by twenty-five percent might look like on an individual basis. We will be able to convert this into how many minutes of a faucet running, how many toilet flushes, how many minutes in the shower, or how many dish or laundry cycles equate to a twenty-five percent reduction in consumption. In addition, we will consider the effects of installing flow regulators to see how that affects our water consumption.

We believe this information will be not only pertinent to current events, but also informative and helpful for those who want to know how they should be reducing their water use according to the governor's decree. The findings from our research could be used to determine effective policy tools to reduce residential consumption as well as provide education for those interested in how efficient their personal conservation efforts are.

Introduction

On April 1st, 2015, California Governor Jerry Brown issued Executive Order B-29-15 proclaiming a state of emergency due to an ongoing drought and all potable water use in California be reduced by twenty-five percent. The Executive Order mandates that municipalities and water agencies throughout the state reduce water usage by amounts ranging from eight to thirty-six percent based on the average water use per capita. The State Water Resources Control Board determined mandated cuts by analyzing historical water use per capita rates of municipalities and water agencies. This is the first time in California's history that mandatory water reductions were put in place. The plan reflects the effects of the ongoing drought affecting much of the southwestern United States. State and federal regulators are forced to make decisions about how and when to allocate water to both the environment and the large agriculture industry. They are charged with balancing short term economic impacts on a growing population and agriculture industry against long term harm to ecosystems and wildlife.

Water use in California is shared across three main sectors; environmental use, agriculture, and urban. Environmental water use comprises roughly fifty percent of the state's water budget, agriculture averages roughly forty percent of the budget, and urban use comprises just over ten percent (PPIC, 2015). Urban water use is broken up into indoor use and outdoor use. Indoor use consists of roughly half of all urban water use (ConSol 2010).

Despite exponential population growth and urban expansion throughout the state, total urban water use has remained constant. Per capita water use for the state was roughly 178 gallons per day in 2010, down from 232 gallons per day in 1990 (PPIC, 2015). Despite substantial efforts to reduce water usage through economic incentives and mandatory water meters, there is potential for further water savings in reducing indoor water use. Water agencies and water users alike need to find ways to decrease their water use in order to become compliant with state mandates. Significant savings could necessitate behavioral changes, not just the adoption of water saving technology.

Objective

The objectives of this report include: (1) addressing the problem of complying with a mandated water reduction at the individual level, (2) determining and providing a description of average daily indoor water use for students in Davis, California, and (3) analyzing the effectiveness of proposed conservation methods. Our general research question is as follows; can individuals reduce personal indoor water use consumption by twenty-five percent using conservation methods rather than increasing water supply efficiency?

In order to effectively answer our research question, three main tasks must be completed. First, individual water use data will be compiled by four team members working on this project. Consumption data will be recorded for weekdays and weekends in order to prevent intermittent bias. Second, individual water consumption data will be compiled in order to achieve average daily usage for a number of common household water sources. The average daily use will be determined using three weekdays and two weekend days. Finally, the data will be analyzed to determine which uses are most individually consumptive and propose a number of individual conservation methods that can be used to reach a twenty-five percent reduction in water use. Conservation methods will be tested to analyze their effectiveness and aggregated across all users.

When analyzing how individuals can reduce their water consumption by twenty-five percent, the ease of water reduction should be of paramount concern. Individuals are not mandated by the state to decrease their water consumption, however, water agencies are subject to state mandates. As such, water agencies should be able to offer relatively simple and cost effective methods for water reduction to their users in order to obtain significant conservation.

Students tend to have a unique schedule when compared to someone with a nine to five work day. A stable schedule is not often something a student can rely on, and we may take advantage of campus amenities, such as showering facilities or water bottle refill stations. Therefore, we believe this study will be particularly useful for our fellow students who would like to know how they can do their part to meet this twenty percent reduction. Therefore, our unique strategy of pooling data will provide students with realistic water use data that they can relate to their own lives. This project's findings might also prove useful to cities planning to adopt their own water savings goals.

Hypothesis

The hypothesis for this research is that a twenty-five percent reduction in individual water use can be attained utilizing water conservation methods rather than increasing water supply efficiency. Conversely, the null hypothesis is that individuals are not able to reduce their water consumption in accordance with state mandate by using only water conservation methods.

The concept of water efficiency is defined as the extent to which improved technologies and practices exhibit the characteristic of equal or better service with less water. For example, water efficiency measures include reducing the total amount of water supplied, reducing water

pressure, or decreasing the amount of energy requires to deliver the same amount of water to users. The concept of water conservation is defined as the extent to which water use exhibits the characteristic of being curtailed by using less water. For example, water conservation methods include minimizing the amount of water supplied to lawns or not filling up swimming pools or water fixtures.

Data Sources

Our individual data will come from five typical indoor sources: toilets, showers, faucets, dishwasher cycles, and washing machine cycles. Factory water rates for all fixtures and appliances will be gathered as well as the total number of minutes, cycles, or flushes per day. We will average our usage over 3 weekdays and 2 weekend days. We will utilize a shared spreadsheet for each individual group member to enter their own data. This spreadsheet will calculate numerous statistics to paint a clear picture of how our water is used in each of our households as well as by the group as a whole. All data for this project is entirely driven by individual use and data entry into the group spreadsheet.

Methods and Assumptions

This research will utilize a natural design to determine whether individuals can decrease their water use in accordance with state mandates through conservation methods. Data will be gathered quantitatively and tested for summary statistics in order to provide breadth and depth to an informed conclusion. Using summary statistics, we will be able to understand the degree to which individual consumption can be decreased across the population.

This research may be disposed to systematic and random error. Systematic error may exist in two forms; (1) using a small data set to generalize a large population may not be accurate, and (2) data gathered for factory fittings and appliance consumption rates may not be accurate to physical operation. Random error exists because water use measurements and record keeping may not be accurate. Also, some group members might spend the majority of weekdays on campus, which underestimates our average use. This is why we are including a weekend day, assuming that we are more likely to be home studying. Accurately estimating time used is not something that our water meters or any appliance can do, as such timing will be measured with stopwatches. While we can accurately come up with the number of times we have run a dishwasher cycle, laundry cycle, or flushed the toilet, our number estimates for shower use and faucet use are indeed estimates rounded to the nearest minute.

The independent variables for this research are individual water use and consumption rates for fittings and appliances. In order to determine an average consumption rate, data will be aggregated from four students at the University of California, Davis. The dependent variable is individual daily water consumption.

By the end of our data collection period, we should have a good understanding of our indoor water use. Once we have this information, we can utilize our shared spreadsheet to reflect and suggest ways to reduce our water consumption. Having numerous individuals enter their data into several categories of use will provide us the ability to formulate graphs or charts comparing how each of us use water indoors, and some of the variables that might lead to differences in our use. We'll also create an aggregate use chart to represent the average student's indoor water use. We may also find statistics for local city averages, such as Davis or Sacramento. This will also us to compare our results with citywide averages and identify discrepancies between students and other citizens.

Calculations and Results

Our individual usage was gathered into a community spreadsheet (see Figure 1) in which we each entered our own individual appliance consumption rates and personal daily use. Laundry and dishwasher consumption was measured in gallons per cycle (gpc), faucets and shower were measured in gallons per minute (gpm), and toilets were measured in gallons per flush (gpf). Participant data over the five-day period will be averaged for each appliance and then multiplied by the standard consumption rate for that appliance to obtain a 5-day average use (see Figures 2 & 3). These averages were then summed for each user to come up with an individual total indoor water use measurement in gallons per day (gpd).

Figure 1: Shared Data Collection Sheet

Individual Water Reduction

Arena, Becker, Karabinos and Smith

Baseline Data for Kyle Smith (has HE apps)		Standard Consumption		Avg Daily Use		Indoor Wat. Use		Day 1 Use	Day 2 Use	Day 3 Use	Weekend Day 1	Weekend Day 2	5-Day Average
Residential Water Use (gpd/person)		Quantity	Unit	Quantity	Unit	5-Day Avg (gpd)	(%)	4/19/15	4/20/15	4/21/15			
Laundry	9.1	gpc*	0.8	cycle	7.28	22.41%		1	0	2	0	1	0.8 cycles
Dishwasher	5.8	gpc*	0.8	cycle	4.64	14.28%		1	1	1	1	0	0.8 cycles
Faucets	0.5	gpm**	16.8	minutes	8.4	25.86%		16	13	17	21	17	16.8 minutes
Shower	1.25	gpm	4.2	minutes	5.25	16.16%		4	5	4	4	4	4.2 minutes
Toilet	1.28	gpf***	5.4	flushes	6.912	21.28%		4	6	4	6	7	5.4 flushes
Total Indoor Water Use (gpd/person)						32.482							
Baseline Data for Brian Arena		Standard Consumption		Avg Daily Use		Indoor Wat. Use		Day 1 Use	Day 2 Use	Day 3 Use	Weekend Day 1	Weekend Day 2	5-Day Average
Residential Water Use (gpd/person)		Quantity	Unit	Quantity	Unit	5-Day Avg (gpd)	(%)	4/20/15	4/21/15	4/22/15	5/9/15	5/10/15	
Laundry	10.9	gpc*	0.6	cycle	6.54	12.28%		0	0	1	0	2	0.6 cycles
Dishwasher	5.5	gpc*	0.4	cycle	2.2	4.13%		0	1	0	1	0	0.4 cycles
Faucets	1.8	gpm**	15	minutes	27	50.69%		23	17	14	10	11	15 minutes
Shower	1.7	gpm	7.6	minutes	12.92	24.25%		11	9	10	8	0	7.6 minutes
Toilet	1.28	gpf***	3.6	flushes	4.608	8.65%		4	4	3	3	4	3.6 flushes
Total Water Use (gpd/person)						53.266							
Baseline Data for Jake B		Standard Consumption		Avg Daily Use		Indoor Wat. Use		Day 1 Use	Day 2 Use	Day 3 Use	Weekend Day 1	Weekend Day 2	5-Day Average
Residential Water Use (gpd/person)		Quantity	Unit	Quantity	Unit	5-Day Avg (gpd)	(%)						
Laundry	11	gpc*	0.4	cycle	4.4	13.56%		0	0	1	0	1	0.4 cycles
Dishwasher	5	gpc*	0.6	cycle	3	9.25%		1	0	1	0	1	0.6 cycles
Faucets	2.2	gpm**	10	minutes	22	67.80%		8	10	7	12	13	10 minutes
Shower	2.5	gpm	0.4	minutes	1	3.06%		0	0	0	1	1	0.4 minutes
Toilet	1.28	gpf***	1.6	flushes	2.048	6.31%		2	2	1	2	1	1.6 flushes
Total Water Use (gpd/person)						32.446							
Baseline Data for Brian K		Standard Consumption		Avg Daily Use		Indoor Wat. Use		Day 1 Use	Day 2 Use	Day 3 Use	Weekend Day 1	Weekend Day 2	5-Day Average
Residential Water Use (gpd/person)		Quantity	Unit	Quantity	Unit	5-Day Avg (gpd)	(%)						
Laundry	11	gpc*	0.4	cycle	4.4	10.46%		0	0	0	0	2	0.4 cycles
Dishwasher	5.5	gpc*	0.2	cycle	1.1	2.61%		1	0	0	0	0	0.2 cycles
Faucets	2	gpm**	10.2	minutes	20.4	48.48%		9	7	11	11	13	10.2 minutes
Shower	1.9	gpm	5.2	minutes	9.88	23.48%		6	5	5	0	10	5.2 minutes
Toilet	1.5	gpf***	4.2	flushes	6.3	14.97%		4	3	5	4	5	4.2 flushes
Total Water Use (gpd/person)						42.08							
Results (Will update automatically from entered values above. All are taken from 5 days of data and averaged.)													
Group Averages		Quantity	Unit	Quantity	Unit	Quantity	Unit						
Average Group Water Use	40.0695	gpd/person											
Average Group Laundry Cycle	10.5	Cycles	0.55	Cycles	6.5	16.22%	Water reduction by replacing only faucet fitting						
Average Group Dishwasher Cycle	5.45	Cycles	0.5	Cycles									
Average Group Faucet	1.625	Minutes	13	Minutes									
Average Group Shower	1.8375	Minutes	4.35	Minutes									
Average Group Toilet	1.335	Flushes	3.7	Flushes									
25% Reduction in Water Use Goal		10.017375	gpd/person	30.052125	gpd/person								
This would mean an average of		0.9540357	Fewer Laundry Cycles per Day										
		or 1.8380505	Fewer Dishwasher Cycles per Day										
		or 6.1645385	Fewer Minutes of Faucet Use Per Day										
		or 5.4516327	Fewer Minutes of Shower Use Per Day										
		or 7.5036517	Fewer Toilet Flushes Per Day										

Figure 2: Individual Data Calculation pt. 1

Baseline Data for Kyle Smith (has HE apps)	Standard Consumption		Avg Daily Use		Indoor Wat. Use	
Residential Water Use (gpd/person)	Quantity	Unit	Quantity	Unit	5-Day Avg (gpd)	(%)
Laundry	9.1	gpc*	0.8	cycle	7.28	22.41%
Dishwasher	5.8	gpc*	0.8	cycle	4.64	14.28%
Faucets	0.5	gpm**	16.8	minutes	8.4	25.86%
Shower	1.25	gpm	4.2	minutes	5.25	16.16%
Toilet	1.28	gpf***	5.4	flushes	6.912	21.28%
Total Indoor Water Use (gpd/person)					32.482	

Figure 3: Individual Data Calculation pt. 2

Day 1 Use	Day 2 Use	Day 3 Use	Weekend Day 1	Weekend Day 2	5-Day Average
4/19/15	4/20/15	4/21/15			
1	0	2	0	1	0.8 cycles
1	1	1	1	0	0.8 cycles
16	13	17	21	17	16.8 minutes
4	5	4	4	4	4.2 minutes
4	6	4	6	7	5.4 flushes

For results, five-day averages for each individual were summed and then divided by four in order to come up with a group average for daily use (see Figure 4).

Figure 4: Total Group Averages

Group Averages	Avg. Consumption	Avg. Daily Use	Unit
Average Group Water Use		40.0695	gpd/person
Average Group Laundry Cycle	10.5	0.55	Cycles
Average Group Dishwasher Cycle	5.45	0.5	Cycles
Average Group Faucet	1.625	13	Minutes
Average Group Shower	1.8375	4.35	Minutes
Average Group Toilet	1.335	3.7	Flushes

Once the group averages were obtained, we could then multiply consumptive values by .25 in order to obtain the consumptive use reduction goals (see Figure 5).

Figure 5: Goal Reductions

25% Reduction in Water Use Goal		10.017375	gpd/person	for a total goal of	30.052125	gpd/person
This would mean an average of		0.9540357143	Fewer Laundry Cycles per Day			
	or	1.838050459	Fewer Dishwasher Cycles per Day			
	or	6.164538462	Fewer Minutes of Faucet Use Per Day			
	or	5.451632653	Fewer Minutes of Shower Use Per Day			
	or	7.503651685	Fewer Toilet Flushes Per Day			

From our results (Figures 4 & 5), we found that nearly half of our total indoor water use as a group came from our faucets. Each user had varying consumptive values for our faucets, ranging from 0.5 gpm to 2.2 gpm. From this, we utilized the same group spreadsheet to figure out how much we could reduce our indoor water consumption by simply installing flow restrictors in each of our faucets to make them all 0.5 gpm. By installing the flow restrictors, we found that we could enjoy a total of 36% reduction in daily consumptive use, exceeding our goal and state mandate of twenty-five percent reduction in daily water consumption (see Figure 6).

Figure 6: Faucets with Flow Restrictors Meet Goals

	gpm	Avg. Daily Use			
Average Group Faucet (Before)	1.625	13 Minutes		21.125	
Average Group Faucet (If we all had 0.5 gpm faucets)	0.5	13 Minutes		6.5	
				14.625	Gpd Difference
				36%	Reduction from the 40.0695 gpd avg

Parties of Interest

As UC Davis students, we feel our data represents the behavior of the common young adult with a busy daily schedule. With that said, the priority of saving water should be adopted by all California residents. The main reason we decided to analyze our own data was to quantitatively remind us of how much water we’re using. We encourage all residents of

California to monitor and quantify their water use the same way we have. The act of timing or keeping track of one's usage will allow a better understanding of where (which appliance) conservation measures should be addressed, and every type of person has the power to do this.

Conclusion

Our main findings from our indoor water use opened our eyes to the excess water use predominantly coming from our faucets. Through the use of flow restrictors and water efficient appliances, the 25% water use reduction goal is more than possible to attain. If Californians are willing to abide by these changes, this water conservation technique can be spread to other states as well as nations with major droughts. Many of our initial water conservations came from using water efficient appliances and on campus facilities, such as showers and toilets. Some of our data was skewed due to the fact that we are college students on the move, and not household dwellers using home facilities consistently. Knowing this has introduced the excessive water use that is occurring in households across the state, that are most likely more substantial than a college student's water use. A reduction in California's household water use will require education programs, statewide water conservation campaigns, and water department programs to offer cheaper and more efficient water appliances for the public.

Works Cited

ConSol. "Water Use in the California Residential Home." 2010. Web. 25 April 2015.

<http://www.cbia.org/go/cbia/?LinkServID=E242764F-88F9-4438-9992948EF86E49EA>

Public Policy Institute of California (PPIC). "Water Use in California." 2015. Web. 26 May

2015. http://www.ppic.org/main/publication_show.asp?i=1108