Urban Water Conservation in the Sacramento, California Region during the 2014-2016 Drought

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Historic 2014 weather and water supply conditions in California prompted Governor Brown to issue Executive Order B-29-15, introducing the state's first mandated conservation targets aimed at over 400 urban water suppliers. The Sacramento region, home to 2 million residents, collectively reduced water use by 19%, 30%, and 25%, from 2014-2016, respectively. This thesis catalogs and analyzes supply and demand management actions implemented in the region in the context of the state's developing drought policies. Primary activities such as reducing outdoor watering and increasing public outreach are explored along with the related roles of media and water related energy saving during drought. Looking forward, the thesis explores recommendations for urban water suppliers and the State to prepare for the next drought, including available revenue recovery mechanisms for urban water suppliers, reduced roles of rebate programs as a drought response, and appropriately scaled drought response tasks for state, regional, and local entities. The thesis also summaries and analyzes recent drought and conservation related legislation (Senate Bill 606 and Assembly Bill 1668) approved in 2018 to establish long term budget-based efficiency targets for urban water suppliers, setting the stage for the next phase of drought management and water efficiency in the state.

I. Chapter 1: Introduction

A. Definition of Drought

Drought can be defined in many ways (conceptual, operational, and geographical) and is seen from many different perspectives (e.g., farmers, urbanites, water professionals, environmental advocates, and politicians). A generic definition of drought is "a deficiency of precipitation over an extended period of time--usually a season or more--resulting in a water shortage for some activity, group, or environmental sector" (NDMC, 2014). However, the severity and impacts of water shortages can vary within a particular region based on internal geographic characteristics (e.g. weather, land use, topography, and demographics), water source, time (duration and timing), and water demands. Drought also can be defined by its cumulative effects on urban, agricultural, and environmental values, products, and processes. Urban water use restrictions, the temporary disappearance of green lawns, stifled recreational opportunities, economic losses, fallow agricultural fields, land subsidence, and reduced habitat for fish and wildlife are the more visible results from large reductions in precipitation. Drought is important, not for the lack of precipitation, but rather for its effects on humans, society, and the environment. Drought reveals the fragility of our lifestyle, economy, water management systems, and ultimately, our underlying dependence on nature.

Nowhere is this fragility and dependence more hidden than in urban environments. In *Concrete and Clay*, Gandy explains:

> It is paradoxically in the most urban of settings that one becomes powerfully aware of the enduring beauty and utility of nature. It is the reshaping of nature that has made civilized urban life possible. Nature has a social and cultural history that has enriched countless dimensions of the urban experience. The design, use, and meaning of urban space involve the transformation of nature into a new synthesis (Gandy, 2002).

In this sense, nature (water) has been "produced" for urban settings (Smith, 2008). The act of bringing water to urban centers has a complex history of infrastructure, engineering, cultural and landscape domination, social justification, creation and growth that is different for each location. Drought affects how urban spaces function (or dysfunction) and the activities that are allowed (and not allowed) because of the established dependence and availability of fresh water.

Another way to describe this relationship is through the term "urban metabolism" as described in Robbins's book, *Political Ecology*.

> In this understanding of the city, powerful actors and interests (like the state, agriculture, large urban cities) bend and funnel natural materials and forces into place in order to increase rents, develop property, fuel growth, and control citizens. At the same time, however, these objects and forces enact their own tendencies or interests in surprising ways, as rivers flood neighborhoods, insects thrive in tenements, and heat waves bake local residents, all with further implications for investment, social action and urban politics. Urban metabolism is a powerful metaphor for political ecology, which reminds us that cities are fundamentally natural, in that they are populated by human and non-

> human residents, formed from earth material, and supported by ecological processes. It also means, however, that these residents, materials, and processes are always politicized in cities and no technical solution or ecological analysis can free them from the struggle of interests that make up the life of the city (Robbins, 2012).

To simply define drought as a lack of precipitation does not do the topic justice nor does it fully capture the influences that contribute to drought conditions experienced in urban areas. Regardless of how it is defined, the frequency and severity of droughts in California will likely increase in the future (Diffenbaugh, 2015). This increase is from several interrelated factors including compounding changes in precipitation and temperature patterns, urban water use trends, increasing water development costs, decreasing reliability of current water supplies due to water scarcity, and landuse development patterns, many of which are discussed in more detail elsewhere (Hanak, et al. 2011). These factors combine to create water scarcity conditions like drought.

B. Thesis Topic and Brief Literature Review

This thesis examines one example of local and regional drought experience and evaluates policy and program solutions to mitigate future droughts and improve water supply reliability. The focus will be on urban droughts, although drought impacts all developed (urban, rural, and agricultural) and natural (forests, grasslands, water bodies, etc.) areas. This thesis uses California's 2014-2016 drought to evaluate the State's drought response framework, while highlighting the Sacramento region's drought response to that framework to explore the following topics: state mandated conservation targets, realized water and energy savings, drought response measures, drought-related legislation and regulation, and recommendations to improve future state, regional, and local drought response. The analysis extends through 2018 to explore the State and region's drought recovery and recent legislation intended to help the State prepare for future drought and climate change.

A large body of research already exists on drought and, specifically, on California drought. Drought in California, in itself, is a broad topic with research ranging from tree ring analysis of past droughts to the economic impact of drought on agriculture (Meko, 2005; Howitt et al., 2015). California urban drought research is somewhat limited in terms of assessing actual major events. Furthermore, what research is available is somewhat repetitive with its recommendations and observations, suggesting slow or stunted integration into society. Perhaps the infrequency of truly impactful droughts (about one per generation) has led to apathy and limited implementation of recommendations after droughts end (Lund, et al., 2018). However, if droughts increase in frequency as expected in the future, there may be more opportunities for tangible policy and management efforts (and evaluation) and perhaps a more willingness of elected officials and other leaders to prioritize drought preparation and mitigation efforts.

Decades ago federal and State agencies provided valuable insight into urban drought through a series of published reports. The United States Army Corps of Engineers (USACE) Institute for Water Resources summarized lessons learned from the 1987-1992 California drought as part of a larger National Study of Water Management During Drought. The lessons include the need to regulate land use to manage urban growth, water markets as a way to reallocate restricted water supplies, the positive role of mass media in drought response and local and regional interconnections among water systems (USACE, 1993). At the state level, the California

Department of Water Resources (DWR) produced, *The 1976-77 California Drought: A Review* in 1978 outlining several lessons for future urban droughts including:

- The importance of starting conservation efforts early to mitigate multiyear droughts;
- the concept of water use rebounding after a drought, but not returning to pre-drought consumption levels;
- the relationship between revenue loss and rate increases from drought; users paid more for water during and after the drought;
- acknowledgement that major infrastructure expansion opportunities are limited and that management of existing supplies is necessary;
- additional benefits of promoting activities that save both water and energy;
- potential of substantial savings from outdoor water use reductions;
- the value from increased interconnection of urban and agriculture supplies and users;
- the need to diversify water supply sources;
- and that groundwater will be more important in future droughts (via increased groundwater banking and conjunctive use programs).

Many of the observations and recommendations from these two reports reappear and are incorporated throughout this thesis.

Furthermore, some researchers and water industry professionals have made the comparison between drought in Australia and California, citing similar climates, economy, development patterns, and vulnerability to climate change (Cahill and Lund, 2011). While drought is a local issue, research and lessons learned from Australia's Millennial Drought (1997-2009) have been incorporated into California's drought policy discussions, referenced by State agency officials, and published at the national scale (Mount et al., 2015; Kasler, 2015; Turner et al, 2016). Australia's long Millennial Drought required more stringent drought measures than are typically seen in the United States. For example, the city of Melbourne set wastewater targets with a goal of a 20% reduction encouraging water users to divert wastewater onsite for outdoor water use. Other actions include trading approximately 40% of annual water allocations among water users to mitigate the drought's worst year, and reducing per capita water use by half (Grant, 2013; AghaKouchak et al., 2014).

More recently, the 2014-2016 drought inspired a new round of analysis resulting in informative publications like the Public Policy Institute of California (PPIC)'s *Building Drought Resilience in California's cities and suburbs* report. This report focuses on urban water, summarizes relevant past state and local policies, defines a common drought language, and develops broad policy changes to better cope with future droughts based on the input from 173 urban water suppliers throughout the State (Mitchell et al., 2017). The general conclusion was that urban water suppliers were largely prepared to respond to the recent drought. However, there could be some improvements including better coordination of water shortage contingency planning and implementation, fostering water system flexibility and integration, improving water suppliers' fiscal resilience, addressing water shortages in vulnerable communities and ecosystems, and balancing long term water use efficiency and drought resilience. Expanding beyond the PPIC report, Lund et al. 2018 summarized relevant water supply conditions, major problem areas, water accounting and water rights administration, economic impacts, and the potential for water markets for the same drought. Conclusions included: droughts encourage improvements in management; a diversified economy buffered the economic impacts of drought; diversified supply systems help mitigate drought and climate change; ecosystems were most impacted by the drought; small rural systems are especially vulnerable to drought; and every drought is different.

Building on previous work, this thesis provides insights into urban drought at the state and regional level regarding drought response programs and policies, associated savings, and the interconnected influences of government, water suppliers, customers, and media. Similar research for other regions of the State would help illustrate the staggering diversity of water and drought management throughout California and the growing realization that these regions need to collaborate closely to complement their strengths and weaknesses for more effective regional and statewide water management.

C. Thesis Structure

This thesis has seven chapters. Chapter 1 introduces the topic and relevant research. Chapter 2 describes the Sacramento region's water supplies and use. Chapter 3 summarizes California's 2014-2016 state level drought conditions and outlines the State's drought policies and response. Chapter 4 provides an analysis of 2014-2016 drought response for the Sacramento region. Chapter 5 evaluates the State's drought response framework through the lessons learned in the Sacramento region. Chapter 6 summarizes state level drought recovery and evaluation of the recent drought motivated legislation and regulatory efforts. Chapter 7 summarizes recommendations for the implementation of the recent legislation and recommendations for state, regional, and local agencies to mitigate future droughts and improve water reliability.

II. Chapter 2: Sacramento Region Water Supplies and Use

A. Water Suppliers

For this thesis, the Sacramento region is defined as the Regional Water Authority (RWA)'s member water suppliers. RWA was formed as a joint powers authority in June 2001 "to serve and represent the regional water supply interests, and to assist members in protecting and enhancing the reliability, availability, affordability, and quality of water resources." RWA includes 21 water suppliers in Sacramento, Placer and El Dorado counties and the cities of West Sacramento (Yolo County) and Yuba City (Sutter County). The region's water suppliers include cities, counties, special districts, mutual water companies, investor-owned suppliers, and community service districts covering 1,032 square miles (560,500 acres) and serving approximately 2 million people (Figure 1). Water supplier service areas range from 1 square mile to 100 square miles. Table 1 summarizes the population, number of customer connections, 2018 annual water use, and type for each Sacramento region water supplier.

Figure 1: Water Supplier Service Areas in the Sacramento Region. Source: RWA, 2018.

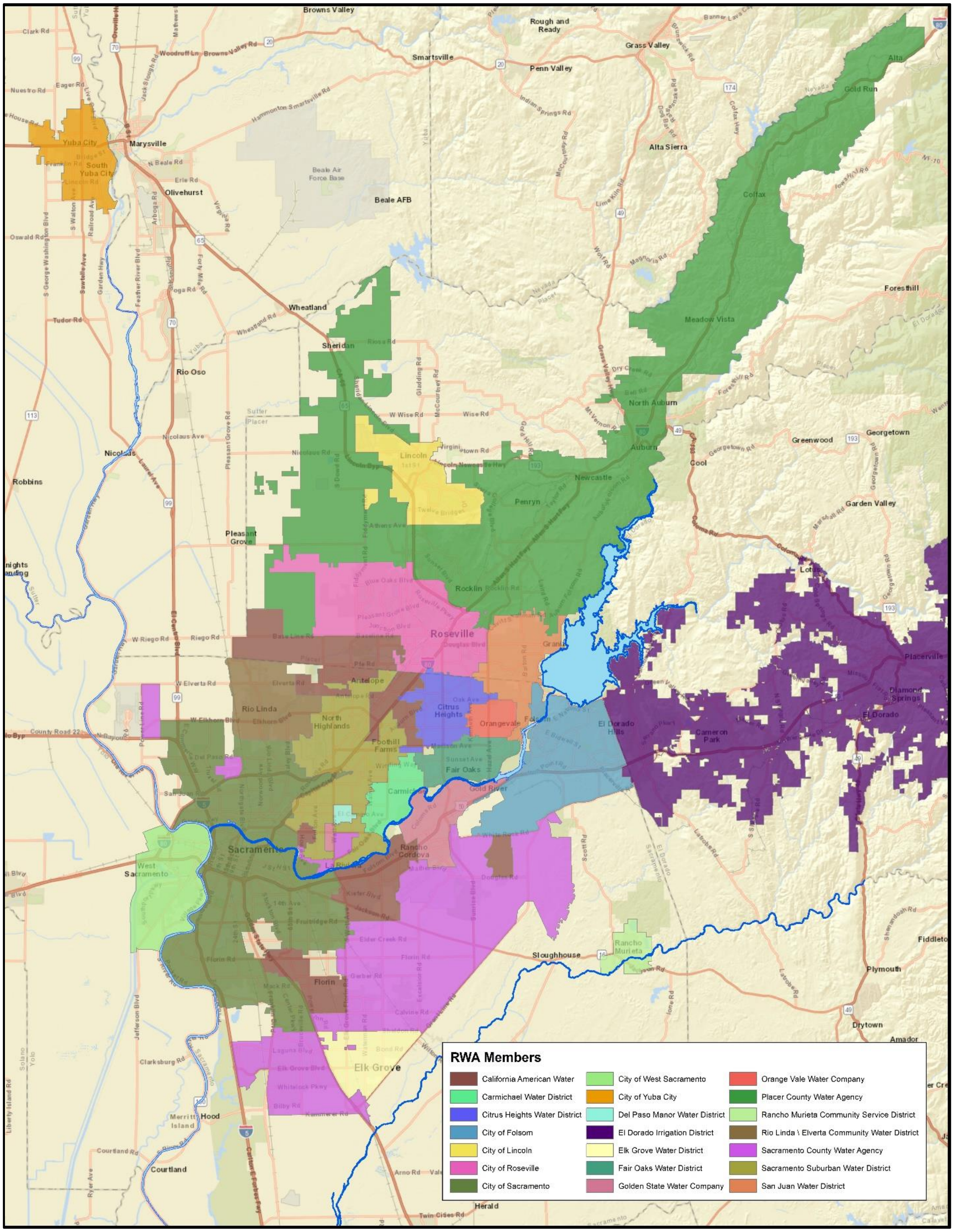


Table 1: Urban Water Suppliers. Source: RWA, 2019.

Water Supplier	Population	Total Connections	2018 Annual Water Use (MG)	Supplier Type
California American Water	203,851	59,946	8,926	Investor Owned
Carmichael Water District	37,897	11,871	2,730	Special District
Citrus Heights Water District	65,093	19,513	3,848	Special District
City of Folsom	67,323	19,040	3,323	Municipal
City of Lincoln	47,339	17,768	6,267	Municipal
City of Roseville	129,262	39,452	3,052	Municipal
City of Sacramento	493,025	137,800	9,220	Municipal
City of West Sacramento	53,082	13,480	29,525	Municipal
City of Yuba City	73,202	18,732	3,644	Municipal
Del Paso Manor Water District	5,000	1,797	399	Special District
El Dorado Irrigation District	110,950	39,891	10,867	Special District
Elk Grove Water District	44,874	12,302	2,105	Special District
Fair Oaks Water District	36,226	13,817	3,157	Special District
Golden State Water Company	53,893	16,891	4,473	Investor Owned
Orange Vale Water Company	16,754	5,531	1,293	Mutual
Placer County Water Agency	101,530	44,242	8,780	Special District
Rancho Murieta Community Services District	5,488	2,614	499	Special District
Rio Linda/Elverta Community Water District	14,102	4,615	816	Special District
Sacramento County Water Agency	182,603	54,872	12,067	County
Sacramento Suburban Water District	179,031	46,661	10,054	Special District
San Juan Water District	29,551	10,365	3,658	Special District
Regional Total	**1,950,076**	**591,200**	**132,391**	

B. Water Sources

The Sacramento region is served by surface water, groundwater, and recycled water. Two-thirds of the region's water supply is directly from surface water sources. The Lower American and Sacramento rivers are the region's primary surface water sources with additional water from the Bear, Feather, and Consumnes rivers. Folsom Reservoir (Lake) releases into the Lower American River and is the region's largest local reservoir with a 975,000 acre feet storage capacity. Shasta Reservoir, 175 miles north of Sacramento, releases into the upper Sacramento River and has a 4.5 million acre feet storage capacity. Both reservoirs are managed by the United States Bureau of Reclamation (USBR) through the Central Valley Project (CVP) and serve multiple functions including local water supply, flood control, power generation, recreation, environmental needs, and water quality requirements. For example, on average, only 10% of Folsom Lake's supply serves municipal demands for local residents and businesses (RWA, 2016). Most American River water is used for other functions, mostly outside the local region. The region's surface water supplies are managed through a variety of contracts, rights, and entitlements. In addition to local water rights, nine water suppliers receive water from the federally operated CVP and state operated State Water Project (SWP). Water delivered through these two projects varies from year to year based on current water supply conditions, applicable water rights, and water contracts (RWA, 2018).

The remaining approximate one-third of the region's water supply is groundwater. The North American Subbasin within the Sacramento Valley Groundwater Basin is the region's primary groundwater source. The subbasin is managed locally and serves as the region's underground reservoir. The subbasin has 208 public groundwater wells classified as "active" or "standby" (RWA, 2018). The region's aquifers are considered stable and sustainable in terms of potential overdraft. The sustainable status of the subbasin is in part a result of the historic Water Forum Agreement signed in 2000, which created management institutions like the Sacramento Groundwater Authority to address systemic issues in the region and implement projects and programs to address those issues. For example, more than 200,000 acre feet of surplus water has been stored in the North American Subbasin since 1998 (SGA, 2018). These actions were taken before passage of the Sustainable Groundwater Management Act (SGMA) in 2014. SGMA is the State's new framework for sustainable groundwater management that "requires governments and water suppliers of high and medium priority basins to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge" (DWR, 2018). Under new law, the Sacramento region's North American subbasin is classified as a low priority basin. The Sacramento region also includes 600 agriculture and 8,700 domestic private wells in Sacramento County alone (RWA, 2018). Private well use is beyond the scope of this thesis.

Finally, several water suppliers produce and deliver recycled water for agricultural and residential irrigation. Recycled water use is somewhat limited in the region due to relatively inexpensive water supplies and consistent surface water and groundwater. Recycled water averages 3% of the region's total annual water use. Detailed information for each water suppliers' surface, groundwater, and recycled supplies is in Table 2. Regional water deliveries for groundwater and surface water for 2011-2018 are in Table 3. During the height of the drought (2014-2015), groundwater use increased as a percent of total supply; however, the overall volume of groundwater actually decreased due to the large reduction in total water use (both groundwater and surface water) during the drought.

Table 2: Water Supplier Water Sources. Source: RWA, 2019.

WATER SUPPLIER[1]	CVP Contract[2]	CVP Settlement[3]	SWP Contract[4]	Groun dwater	Surface Water[5]	Recycled Water
California American Water				X	X	
Carmichael Water District				X	X	
Citrus Heights Water District				X	X	
City of Folsom	X				X	
City of Lincoln				X	X	X
City of Roseville	X			X	X	X
City of Sacramento		X		X	X	X
City of West Sacramento	X		X		X	
City of Yuba City			X		X	
Del Paso Manor Water District				X		
El Dorado Irrigation District	X				X	X
Elk Grove Water District				X	X	
Fair Oaks Water District				X	X	
Golden State Water Company				X	X	
Orange Vale Water Company					X	
Placer County Water Agency	X			X	X	
Rancho Murieta CSD					X	X
Rio Linda/Elverta CWD				X		
Sacramento County WA				X	X	X
Sacramento Suburban WD				X	X	
San Juan Water District	X				X	

[1] Notes: WA= Water Agency, WD=Water District, CWD=Community Water District, and CSD=Community Service District

[2] Central Valley Project (CVP) Contracts – These water suppliers have a contract directly with the U. S. Bureau of Reclamation (USBR), which is managed by the Mid-Pacific Region of the USBR.

[3] CVP Settlement Contracts – These water suppliers have a USBR contract that specifies a quantity of water that can be diverted free of charge (Base Supply) and water they must pay for (Project Water). Their Base Supply stems from senior water rights on the Sacramento River prior to authorization of the CVP.

[4] State Water Project (SWP) Contracts - The California Department of Water Resources (DWR) administers long-term water supply contracts with local water suppliers for water service from the SWP.

[5] Local Surface Water – Rights include diversions from the American, Sacramento, and Cosumnes Rivers; plus local contract water, including but not limited to, water obtained through direct CVP contracts and interagency contracts.

Table 3: Annual Regional Water Supply by Source from 2011-2018. Source: RWA, 2019.

	Groundwater (MG)	Surface Water (MG)	Total Production (MG)	Groundwater %	Surface Water %
2011	48,840	107,491	156,330	31%	69%
2012	50,599	113,870	164,469	31%	69%
2013	53,360	115,570	168,931	32%	68%
2014	50,927	87,955	138,882	37%	63%
2015	42,650	77,882	120,532	35%	65%
2016	36,734	90,170	126,903	29%	71%
2017	37,901	98,707	136,608	28%	72%
2018	39,412	96,968	136,380	28%	71%

C. Conjunctive Use

Some suppliers can access only surface water or groundwater; however, about half of the region's water suppliers can access both, making them more suitable for conjunctive use. Conjunctive use is when a water supplier or group of water suppliers effectively align their water supply withdrawals with current water supply conditions. For example, in a wet year, with plentiful surface water, a water supplier with access to surface water and groundwater will use less groundwater when surface water is more available, effectively "saving" groundwater for later use. That same water supplier, in a dry year, will minimize surface water withdrawals and rely more on groundwater. Over time a supplier or group of suppliers avoid overstressing any one source, but instead use each source based on current supply conditions to optimize longer term total supply availability.

The Sacramento region is hydrologically advantaged both in its physical water and legal availability through a variety of historic water rights. Both are needed for effective local water supplier conjunctive use. A third factor, interconnection, also is needed for regional or joint conjunctive use. The region's water suppliers have been working to create interties or interconnections among neighboring water suppliers for this purpose.

Conjunctive use is especially useful during drought for suppliers that solely depend on surface water for deliveries. The 2014-2016 drought accelerated several proposed projects that could "expand the region's ability to move water to areas most impacted by drought" (RWA, 2016). RWA and the region's water suppliers identified $30 million in priority projects and received $9.7 million in grant funding for 17 projects including:

- Lower American River Pipeline (7,400-foot long, 24-inch diameter) to connect Carmichael Water District to Golden State Water Company. Project Cost: $5.1 million. Grant Award: $775,000.
- Sacramento River Pump Station Modifications to design and construct vortex breakers for Sacramento's intake pumps, so the intake and treatment plant can continue to operate at low water levels in the river. Project Cost: $200,000. Grant Award: $135,000
- Antelope Booster Pump Station Expansion to install a series of high-capacity booster pumps to pump groundwater uphill from Sacramento Suburban Water District to San Juan Water District and its wholesale water customers, who all primarily rely on surface

water supplies from Folsom Reservoir. The new pump station delivery capacity is 10,000 gallons of groundwater per minute. Project Cost: $3.9 million. Grant Award: $720,000.

Overall the grant funded a variety of projects, from interties between neighboring water suppliers, well upgrades, and urban and agricultural water efficiency programs. Although not all infrastructure projects were built in time to directly respond to the 2014-2016 drought (conditions improved greatly for the Sacramento region in 2015), they are completed now and will be in place for the inevitable next drought.

Beyond drought, conjunctive use can "create" additional supply for beneficial uses like environmental use, water transfers, and groundwater banking. The Sacramento region's water suppliers are participating in several planning processes including a Reliability Plan and Drought Contingency Plan that are exploring water transfers within the region and with downstream users. Several RWA member water suppliers worked on a limited "proof of concept" water transfer to test the physical and legal transfer system. The transfer was coordinated through the Sacramento Groundwater Authority (SGA), a joint powers authority formed in 1998 to manage the groundwater basin underlying Sacramento County north of the American River. The following water suppliers participated in the transfer either by providing surface water for delivery to buyers (Kern County Water Agency and Dudley Ridge Water District) and/or pumping and delivering groundwater in lieu of pumping surface water to meet local demands, to make surface water available for transfer:

- City of Sacramento-*Seller and groundwater pumper*
- Carmichael Water District-*Seller and groundwater pumper*
- Citrus Heights Water District-*Groundwater pumper*
- Fair Oaks Water District-*Groundwater pumper*
- Sacramento Suburban Water District-G*roundwater pumper*
- San Juan Water District-*Seller*

The transfer took place from July 2018 through September 2018, with a total transfer volume of approximately 12,000 acre feet of surface water, which sold for $300 per acre foot. All 61 wells involved with the transfer were monitored monthly during the transfer period and continue to be monitored after the transfer to evaluate potential impacts in coordination with RWA and SGA. Additionally, all wells are municipal supply wells and all are meeting the Title 22 water quality requirements as administered by the State Water Resources Control Board (State Water Board) Division of Drinking Water (Sac, 2018; RWA, 2018).

The success of this transfer could facilitate more transfers in the future. The region is also exploring the creation of a regional water bank to officially "save" water in the region's aquifers to respond to supply interruptions, like drought. A water bank must be approved by the State and must closely monitor water deposits and withdrawals by its participating partner water suppliers. A small portion of the water moving through the water bank is kept in the bank (like a bank fee) to slowly build capacity over time. Furthermore, while the Sacramento region's water suppliers have some of the necessary infrastructure to successfully operate a regional water bank, additional funding will be needed to expand capacity. Collaborating with neighboring and other interested water suppliers can help collectively fund this additional infrastructure to benefit all parties. Water banks, like those established in California in 1977 and 1991, have been used to help respond to drought conditions (Israel and Lund, 1995). However, water banks of the present (like the Kern Water Bank and Willow Springs Water Bank) and future may be operated in a broader range of situations (not just purely shortage) as part of the implementation of integrated water management practices in response to shifting water supply conditions, like the timing and volume of snowpack runoff.

D. Delta Considerations

The Sacramento metropolitan area is built around the confluence of the Sacramento and Lower American rivers and is upstream of a larger land area known as the Sacramento-San Joaquin Delta (Delta), often referred to as the "heart of California's water system" (DWR, 2019). This Delta is a predominately freshwater tidal estuary formed when sea level rise drowned the confluence of the Sacramento and San Joaquin rivers. The Delta supplies water to two-thirds of California's population and millions of acres of farmland from runoff from 40% of the State's land area before mixing with salt water in San Francisco Bay (DWR, 2018). In addition to supplying most of the State with water, the Delta is also the largest estuary on the West Coast, providing habitat for many fish and wildlife in this transition zone between ocean and fresh water. Today agriculture is the Delta's primary land use. The Delta's varying needs and functions, both natural and developed, exist in a small portion of the State at 1,150 square miles (<1% of the State's total area) and present an endless challenge to balance its complex and interrelated needs. Management issues in the Delta have been broadly researched (Dettinger and Cayan, 2014; Norgaard, 2008; Burton and Cutter, 2008; Lund et al., 2008), planned (Bay Delta Conservation Plan, Delta Stewardship Council's Delta Plan, California Water Action Plan, California Water Fix, etc.) and argued over for about a century. The Sacramento region's water supplies are intricately linked to the Delta. Three main water supply related activities in the Sacramento region directly impact the Delta: water exports, return flow, and water quality management.

Exports: Water is exported from the Sacramento region through the Delta via the Lower American and Sacramento rivers to downstream users in the San Francisco Bay, central, and southern areas of California. Roughly 30 million acre-feet of water move through the Delta watershed per year on average. Of this, the Sacramento region uses on average between 350,000 and 500,000 acre feet per year (RWA, 2018). While water used by RWA's water suppliers originates from the region's watershed, the timing and amount of exported water can affect how water is used locally in the region especially as plans for managing the Delta are potentially implemented over time.

Return flow: The Sacramento region sits in the larger Sacramento valley of the Sierra Nevada with some water suppliers in the foothills. The region's water suppliers' service areas are either adjacent or directly in the headwater watersheds that serve it, meaning the region is in a relatively unique position in California to both withdraw and return water to the same watershed. Although several treatment plants process wastewater in the region, 15 of the region's water suppliers, representing 68% of the region's average annual water supply are connect to the large Regional San centralized wastewater treatment plant in south Sacramento. On average, about 47% of the water supplied in the Regional San service area is returned as effluent (treated discharged wastewater) to the Sacramento River before continuing to travel downstream to the

Delta for other water users (Table 4).[6] Annual effluent discharge reached a five year low in 2015 due to the 30% reduction in potable water use during the drought from indoor and outdoor conservation actions. Furthermore, Table 5 shows monthly effluent data (proxy for indoor water use) for 2015-2017 as a percent of total monthly water production (labeled Regional San) compared to (production-only) indoor water use estimates calculated using the minimum month method (detailed in Chapter 3). Indoor water use estimates between the two methods show the biggest differences (-69% to 25%) during the winter/spring months (September through May) when precipitation runoff enters the Regional San system, muddling the indoor estimate. The comparison shows the smallest differences (-6% to 13%) during summer (June through August), when the region receives little to no precipitation.

[6] Annual Effluent Discharged to River calculations can also include runoff from precipitation from areas with combined sewer systems (wastewater and stormwater) and other sources.

Table 4: Regional Return Flow. Source: Regional San, 2018.

	Annual Effluent Discharged to River (Million Gallons)	Water Use in Regional San Service Area (Million Gallons)	Effluent Percent of Water Use (%)
2013	43,296	116,423	37%
2014	41,802	138,882	44%
2015	38,672	81,539	47%
2016	41,447	86,874	48%
2017	52,036	92,745	56%
		Annual Average Percentage	47%

Table 5: Wastewater and Production Data for Indoor Water Use Estimates. Source: Regional San and RWA, 2019.

		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Regional San	2015	73%	80%	55%	51%	44%	35%	33%	33%	35%	42%	63%	76%
% Indoor	2016	90%	77%	98%	57%	43%	31%	22%	28%	32%	50%	71%	89%
	2017	147%	169%	114%	104%	50%	36%	27%	28%	31%	35%	65%	70%
Minimum Month	2015	92%	100%	71%	68%	60%	52%	47%	47%	51%	59%	87%	98%
% Indoor	2016	95%	100%	94%	71%	53%	41%	36%	36%	42%	59%	87%	92%
	2017	85%	100%	82%	79%	42%	36%	30%	31%	36%	42%	72%	79%
% Difference[7]	2015	18%	20%	13%	14%	12%	**13%**	**10%**	**10%**	11%	13%	25%	24%
	2016	1%	23%	-8%	6%	3%	**2%**	**7%**	**1%**	4%	3%	12%	-1%
	2017	-63%	-69%	-31%	-28%	-14%	**-6%**	**-1%**	**-1%**	0%	2%	6%	7%

[7] Percent Difference is the difference between the Regional San percent indoor estimate and the Minimum Month percent indoor estimate.

Although the water is treated before being discharged, effluent water often has lower water quality. To improve the quality of discharged water, Regional San is now required to treat the effluent to tertiary treatment levels by 2021-2023 (Regional San, 2018). Known as the EchoWater Project, these upgrades will reduce current ammonia discharge by 95% and also reduce nitrate. The project will cost $2.1 billion to build and $50 million a year for ongoing maintenance and operation. The project will increase the water quality of the discharges to the Delta benefiting downstream users and the environment. The remaining average 53% of potable water supplied in Regional San's service area is considered consumptive use (does not directly return to the source river) and is likely primarily outdoor landscape irrigation uses.

Water Quality: Water quality in the Delta is closely monitored and regulated. A major issue affecting water quality is the ever-changing boundary between ocean and fresh water, which is a natural occurrence in estuarine delta systems. However, in the highly altered Sacramento-San Joaquin Delta, seawater boundaries need to be maintained or fresh water supplies for urban and agriculture demands could be at risk. If salt water enters pumping areas for fresh water supplies, the salinity of the water increases and can make the water supply unsuitable for irrigation, human consumption, or urban treatment. This issue is managed by maintaining a substantial flow of freshwater to "push back" seawater. Regulation of upstream freshwater flow is primarily from Shasta, Oroville, and Folsom reservoirs. Folsom Reservoir is often the "first responder" to maintain Delta water quality standards as it takes only about one day for water released from Folsom to reach the Delta compared to three days from Oroville and five days from Shasta (SWRI, 2005). Releasing additional water from these reservoirs has significant potential to impact fall-run Chinook salmon and steelhead because of fluctuations in river flows and increases in river water temperature.

Releases also have significant potential impacts to public water supply. For example, in 2015, Folsom Reservoir was preferentially called on to deliver additional flow downstream for Delta water quality. Folsom releases were preferred to maintain cold water in Shasta to protect fall-run species on the Sacramento River. Despite the substantial demand reductions, Folsom Reservoir saw its lowest ever storage level, since its completion in 1956, at near 135,000 acre-feet in early December 2015 (CDEC, 2015). Considering the drought conditions at the time, the water released for water quality could have been maintained in the reservoir to provide a larger buffer of supply. Balancing the multiple functions of these reservoirs now and in the future is a challenge. Water supply availability will continue to be affected by this water quality need, especially with rising sea levels tending to drive seawater further into the Delta (Logan, 1990).

E. Water Use

Water use or the amount of water produced and treated in the Sacramento region in the last 6 years ranged from 167.8 to 118.2 billion gallons or 515,000 to 360,000 acre feet a year. While many factors cause use fluctuations between years, the seasonality of the region's demand is well defined and is affected by changes in temperature and precipitation.[8] Water use doubles or triples in the summer (June – September) from the winter (December – March). This monthly variability is from greater outdoor water use in summer due to higher summer temperatures and

[8] Another significant influence on water use for this data set was the 2014-2016 drought. More historical water use from 2000-2012 ranged from 558,000 to 459,000 acre feet a year with the lowest use year in 2011 and the highest use year in 2004. Source: RWA, 2018.

little to no precipitation. Table 6 and Figure 2 show water use by month from 2013 – 2018. Figure 3 shows average monthly temperature and precipitation for the region.

Table 6: Regional Monthly Water Production in Million Gallons (2013-2018). Source: RWA, 2019.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2013	6,953	7,232	10,094	12,105	17,472	19,483	22,413	20,855	17,311	14,848	10,649	8,430
2014	7,528	5,724	6,741	8,034	12,069	15,536	16,196	14,996	13,357	11,201	7,201	6,090
2015	6,714	6,179	8,781	9,282	10,536	12,419	13,789	13,866	12,560	10,759	7,131	6,217
2016	6,154	5,900	6,354	8,435	11,413	15,136	17,257	17,190	14,696	10,357	6,910	6,407
2017	6,285	5,407	6,620	6,943	13,232	15,858	18,870	18,398	15,765	13,454	7,710	6,998
2018	6,456	6,469	6,627	8,129	13,031	15,947	18,141	17,497	14,947	12,981	9,440	6,716

Figure 2: Regional Monthly Water Production (2013-2018). Source: RWA, 2019.

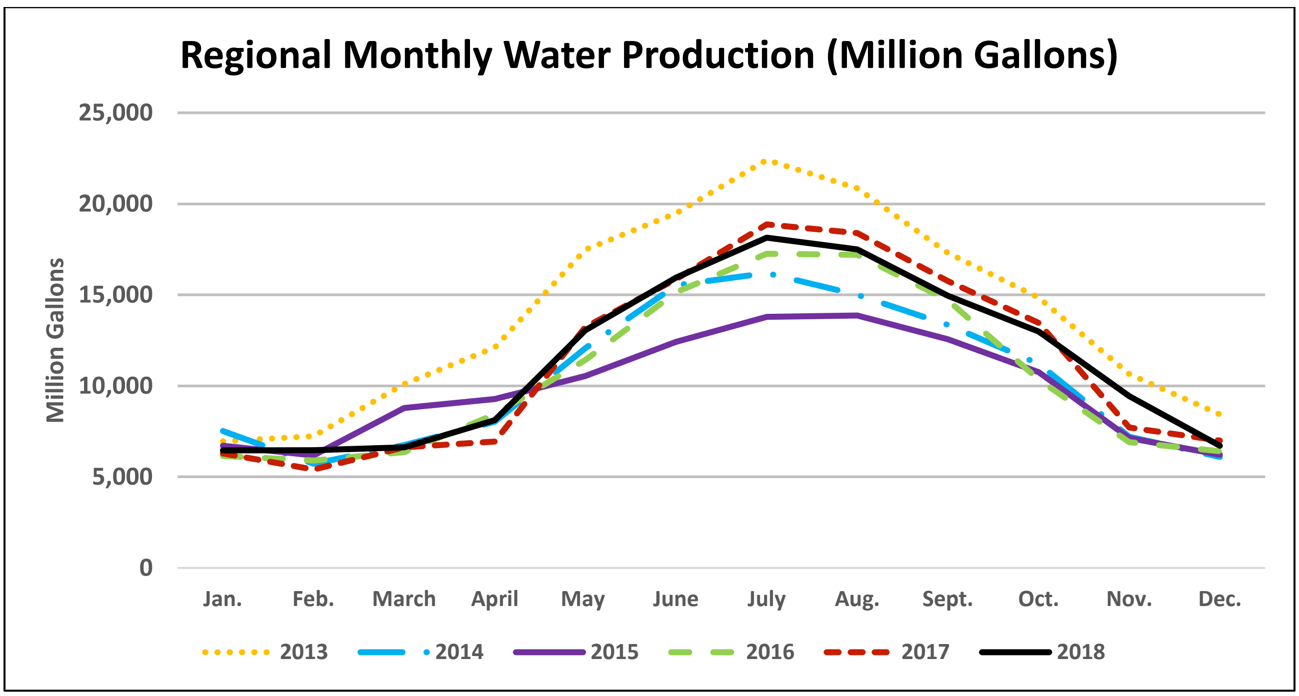
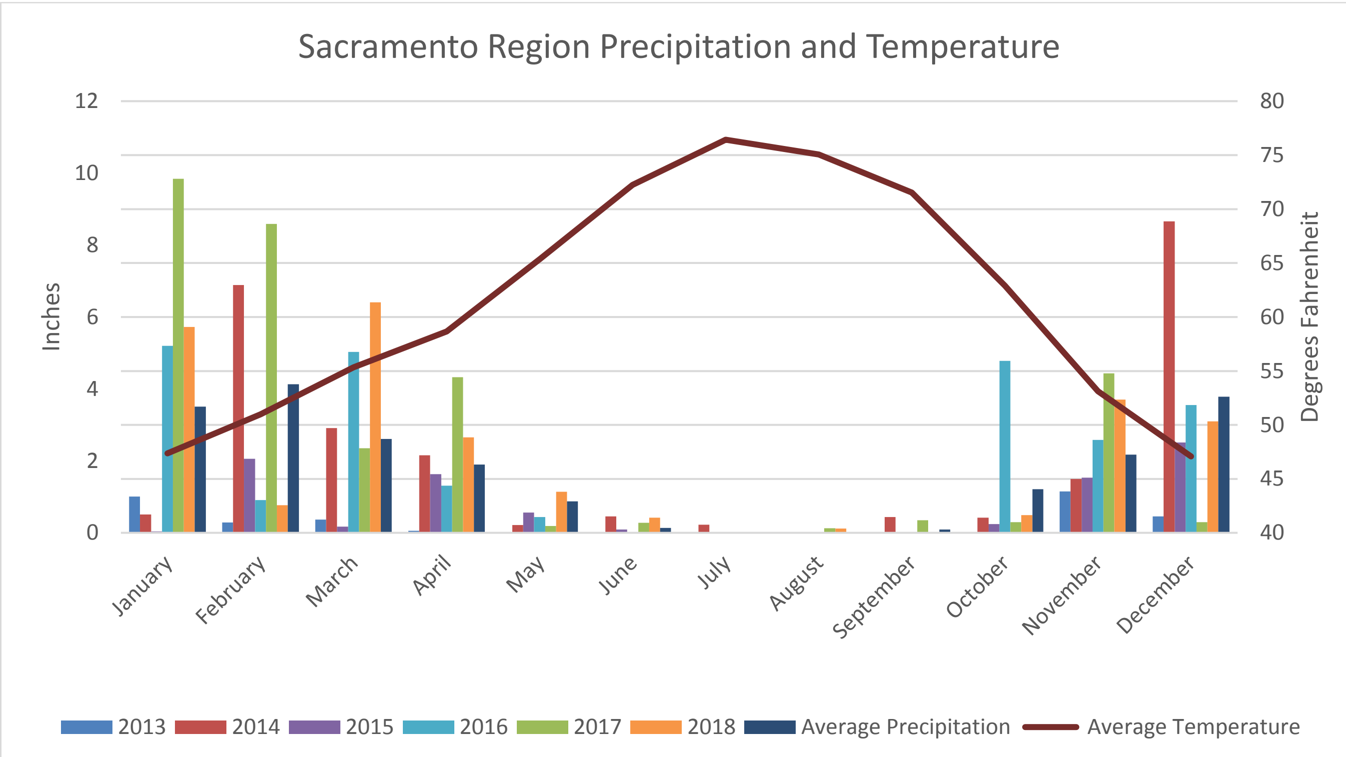


Figure 3: Sacramento Region Precipitation and Average Temperature (2013-2018). Source: California Irrigation Management Information System (CIMIS), Station 131, 2019.

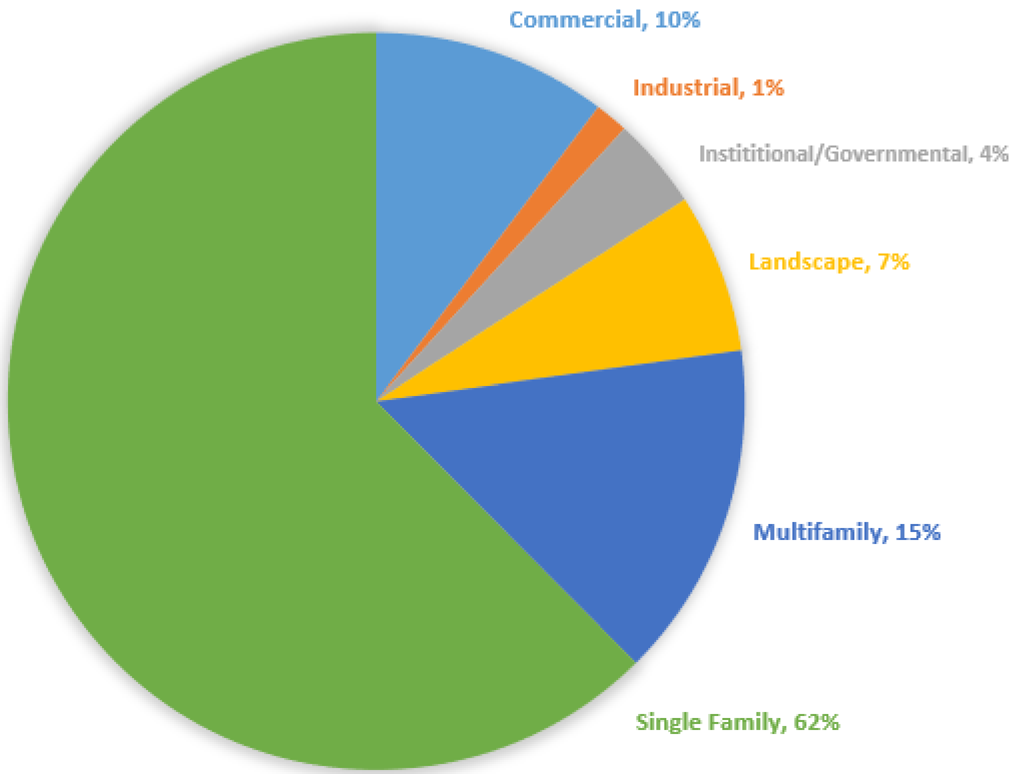


Water Use by Sector

Water demand, or volume of water used by customers, is generally split across residential (both single- and multi-family), dedicated landscape, and commercial, industrial, and institutional (CII) (Figure 4).[9] Single family household water use is most water use supplied by urban water suppliers in the Sacramento region.

[9] Several categories are excluded from this figure including agricultural, water losses and other. 2015 data is the most recent available data; however, historical demand patterns are consistent with 2015 proportions between sectors.

Figure 4: 2015 Regional Water Use by Sector. Source: 2015 State Drinking Water Information System Data.



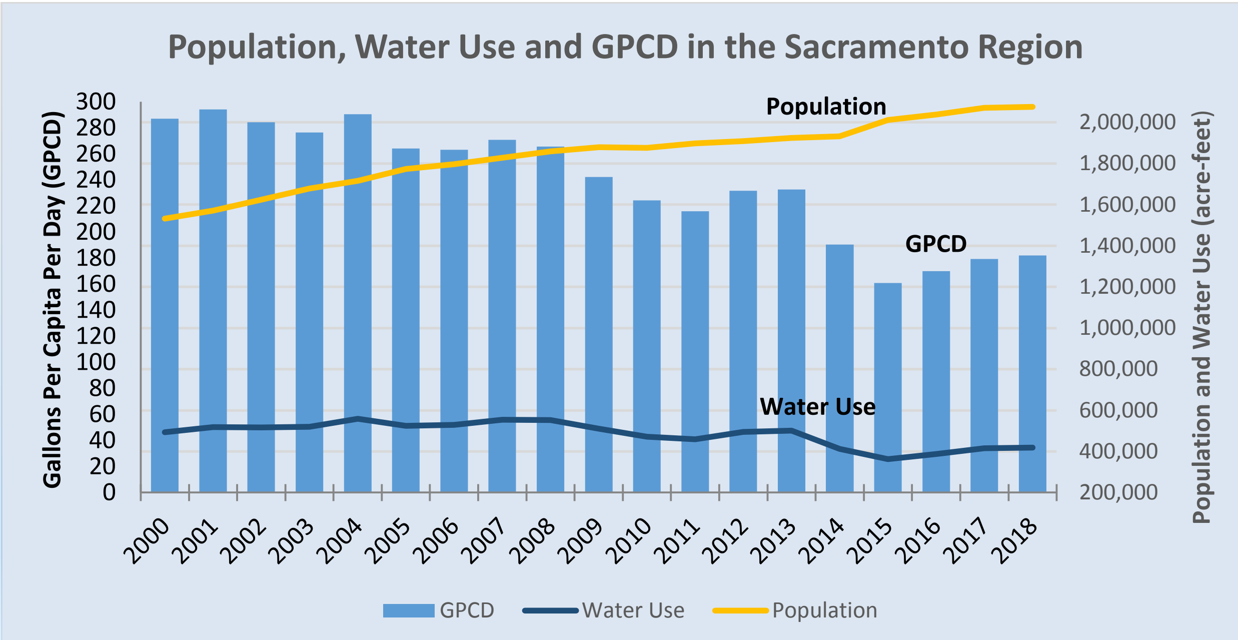
<u>Per Capita Water Use</u>

Another way to view water use is through daily per capita use, usually expressed as gallons per capita per day, or GPCD. GPCD is the water supplier's average daily water production divided by the population served. This metric is used by water suppliers and the State to assess water use trends. Several factors influence a water supplier's GPCD, including rainfall, temperature, evaporation rates, population growth, population density, socio-economic measures such as lot size and income, economic activity, and water rates. GPCD should not be used as the sole metric to evaluate a water supplier's water use or water efficiency, but should be considered with other metrics. Overall, per capita water use has diminished as population has grown, especially since the passage of the Energy Policy Act of 1992, which mandated increased efficiency of water related fixtures like toilets and clothes washers (Vickers, 1993). From 2000-2013, water use in the Sacramento region decreased, despite a roughly 25% increase in population, shown in Figure 5, resulting in a decreasing GPCD.[10] Effects of the drought can be seen with additional decreases in water use in 2014 and 2015. Recovery in GPCD from the drought also can be seen with water use and GPCD slightly increasing in 2016 and 2017, but still below pre-drought levels. People are using less water per person now than in the past. Any overall demand

[10] 2014-2018 GPCD estimates were not included in the factoid because they were drought influenced and not as applicable for evaluating long-term trends.

increases depend partially on how many more people move into the service area. Other considerations for increased demand include new CII accounts.

Figure 5: Sacramento Region GPCD, Population, and Water Use. Source: RWA, 2019.



In November 2009, California enacted Senate Bill X7-7 requiring that urban water suppliers increase water use efficiency through GPCD targets. The overall goal of the legislation was to reduce urban GPCD by 20% by December 2020 with each urban water supplier having a custom target.[11] An interim target for 2015 was also established, pursuant to the legislation (Water Conservation Act of 2009).

As shown in Table 7, urban water suppliers in the Sacramento Region have all met and exceeded their 2015 GPCD targets, due in part to additional water conservation during the drought. At this time, the water suppliers have also met their 2020 GPCD targets. Meeting the interim and final targets ensures a water supplier's eligibility for state funding opportunities. With the recent end of the extended drought, water demands are partially rebounding as seen in 2016-2018, which may also bring rebound in water suppliers' GPCD values. To ensure that GPCD values stay below their 2020 GPCD targets, the region's water suppliers must continue to implement water efficiency practices beyond the recent drought to minimize rebounding demand.

<u>Residential Per-Capita Water Use:</u>

Whereas GPCD considers all of a water supplier's production from all sectors, residential gallons per capita per day or R-GPCD was developed as an additional metric by the State in 2015 to better understand how much water the average resident is using at home. R-GPCD is residential water demand divided by the service area population. R-GPCD will always be smaller than GPCD and serves as a more precise estimate of average household water use. R-GPCD data

[11] An urban water supplier is a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually. Source: California Water Code Section 10617.

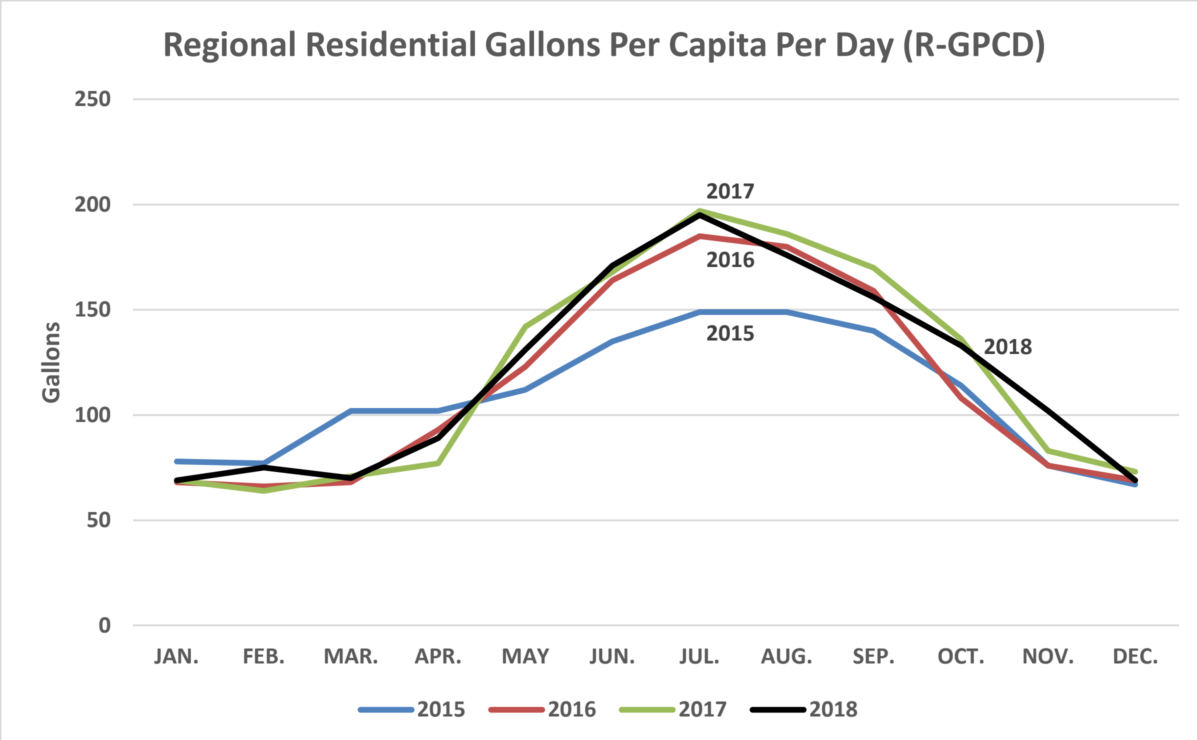
was collected by the State from urban water suppliers during (required in 2015 and 2016) and after (voluntary in 2017 and 2018) the drought. Figure 6 shows average R-GPCD data for the Sacramento region's water suppliers from 2015-2018. As expected, average residential water use per person follows a similar seasonal trend as GPCD at the water supplier level, with residential use tripling in the summer months.

Table 7: Water Supplier GPCD Baseline and Targets. Source: 2015 Urban Water Management Plans.

Water Supplier[12]	Baseline GPCD	2015 Interim Target	2015 Actual GPCD	Supplier Met 2015 Target	2020 Target GPCD
California American Water	216	195	130	Yes	173
Carmichael Water District	296	266	168	Yes	237
Citrus Heights Water District	286	257	137	Yes	229
City of Folsom	440	396	261	Yes	352
City of Lincoln	241	217	149	Yes	193
City of Roseville	309	278	165	Yes	247
City of Sacramento	282	253	158	Yes	225
City of West Sacramento	293	264	183	Yes	234
City of Yuba City	240	216	163	Yes	192
Del Paso Manor Water District	NA	NA	NA	NA	NA
El Dorado Irrigation District	301	271	187	Yes	241
Elk Grove Water District	239	215	111	Yes	191
Fair Oaks Water District	348	314	207	Yes	279
Golden State Water Company-Cordova	400	360	235	Yes	320
Orangevale Water Company	301	271	176	Yes	241
Placer County Water Agency	322	292	203	Yes	261
Rancho Murieta Community Services District	NA	NA	NA	NA	NA
Rio Linda/Elverta Community Water District	226	204	127	Yes	181
Sacramento County Water Agency	295	265	153	Yes	236
Sacramento Suburban Water District	257	232	142	Yes	206
San Juan Water District	516	464	293	Yes	413

[12] * Del Paso Manor Water District and Rancho Murieta Community Services District are not considered urban retail water suppliers and, therefore, are not required to have GPCD targets, represented by the label NA for "not applicable" in this table.

Figure 6: Regional Residential Gallons Per Capita Per Day (R-GPCD). Source: RWA, 2019.



Indoor versus Outdoor Use:

The primary driver of seasonal variation in R-GPCD is outdoor water use, resulting in double or triple R-GPCD values in summer compared to winter months. Between 42% and 54% of an average household's daily water use is outdoors in the Sacramento region (a higher percentage of total use in summer, less in the winter) leaving 58% to 46% of use for indoor tasks like laundry and showers (MWM, 2014). This indoor/outdoor split is relatively consistent with statewide estimates. Save Our Water (SOW), California's statewide public outreach campaign, estimates that 30-60% of a resident's water use is outdoors (SOW, 2018). Lastly, a study of over 700 single family homes within 10 water supplier service areas throughout California estimated that 53% of water use is outdoors versus 47% indoors (DeOreo, 2011).

However, the Sacramento region deviates from the State in the intensity and volume of outdoor water use. Most of the State's population lives in the southern and coastal areas, where temperatures and precipitation are relatively consistent throughout the year. The Sacramento region's weather is highly variable between seasons, with a long hot summer. Regions with a hot and dry climate and cultural norm of the household lawn/garden (such as the Sacramento region) generally use more water outdoors compared to areas with more moderate climates. A residential focus group was facilitated in the Sacramento region in February 2018 in which participants were asked how they decide when to water their lawn. Most participants explained that they adjust the duration and frequency of watering cycles based on weather and visual cues that their lawn and plants need water (PVR, 2018). Detailed comments include:

- “If plants are droopy and look dehydrated then I water. I try not to go more than two weeks. I just keep it going between rains. It’s been sunny for longer periods.”
- “Usually when it heats up for consecutive days we turn it back on.”
- “You can just tell by looking at your grass and vegetation if it’s dry.”

Table 8 shows San Diego and Sacramento’s average monthly temperature and precipitation. San Diego is in coastal southern California and Sacramento is inland Central Valley California. The standard derivation calculations for each locations’ temperature and weather reveal that Sacramento’s variations are double those of San Diego’s meaning Sacramento has more variable (more extreme) weather patterns, which partially explains its higher variability in seasonal water use.

Table 8: Average Precipitation, Temperature, and Evaportranspiration from 2003-2017. Source: CIMIS, 2018.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Standard Deviation
San Diego (#184) Precipitation	1.4	2.12	1.05	0.79	0.37	0.31	0.18	0.03	0.15	0.6	0.76	1.52	0.64
Fair Oaks (#131)[13] Precipitation	2.99	3.25	2.83	2.01	0.66	0.16	0.02	0.01	0.08	1.29	2.07	4.03	1.44
San Diego (#184) Temperature	55.91	56.35	58.21	59.77	60.26	64.66	68.66	70.52	69.66	65.44	60.51	55.28	5.50
Fair Oaks (#131) Temperature	47.59	51.28	55.69	58.86	65.59	72.49	77.09	75.15	71.53	62.97	53.15	47.1	10.81
San Diego (#184) Evaportranspiration	2.24	2.61	3.82	4.48	4.85	4.94	5.42	5.25	4.47	3.36	2.42	1.95	1.26
Fair Oaks (#131) Evapotranspiration	1.14	1.78	3.23	4.39	6.35	7.39	7.92	7.03	5.18	3.29	1.62	1.06	2.54

[13] The Fair Oaks Station #131 is used to represent the Sacramento region including the city of Sacramento as it is the closest fully operational station. Fair Oaks is a community located approximately 15 miles southeast of Sacramento.

Another way to understand how temperature and precipitation affect plant watering needs is through the concept of evaportranspiration (ET). ET is "the loss of water to the atmosphere by the combined processes of evaporation (from soil and plant surfaces) and transpiration (from plant tissues)" (CIMIS, 2019). This loss, expressed as inches of water per time period, represents how much supplemental water a plant needs to be healthy in a specific location. To standardize ET, the concept of reference evaportranspiration (ETo) was developed, which uses well-watered turf grass maintained at 12 centimeters as the reference plant to determine ET losses in specific locations (Allen et al., 1998). Turf grass is used for ETo because it is the most common landscape plant and is the reference crop of California Irrigation Management Information System (CIMIS) weather stations commonly used throughout the State and managed by DWR. Table 8 also shows average ETo for San Diego and Sacramento, which like temperature and precipitation are double/half of each other. For a broader perspective, Figure 7 shows ETo values for the State of California, organized by Reference ETo Zones. ETo ranges from 33 inches to 71.6 inches per year and provides evidence that biologically plants need different amounts of water depending on location-based factors like weather.

However, the biological need for water is only one factor influencing water use on landscapes. Landuse patterns and water rates also influence outdoor water use. In the Sacramento region, aside from agriculture, residential housing is the predominate developed land use (Land IQ, 2016). Residential lots in the region tend to be larger than in other parts of the State (Table 9). Larger lots generally have larger yards, which generally means more water is used to maintain the yard (especially considering the local climate). Local landuse codes still allow for predominate turf grass landscapes, although codes are evolving to include text discussing lower water use plantings and sustainable design principals like Sacramento County's Development Standards (Sacramento County, 2015). However, from a practical standpoint, most people still enjoy their lawns and wish to maintain them (PVR, 2018).

Table 9: General Residential Mean Lot Size. Source: County Assessor Data, 2017 and Census Data, 2010.[14]

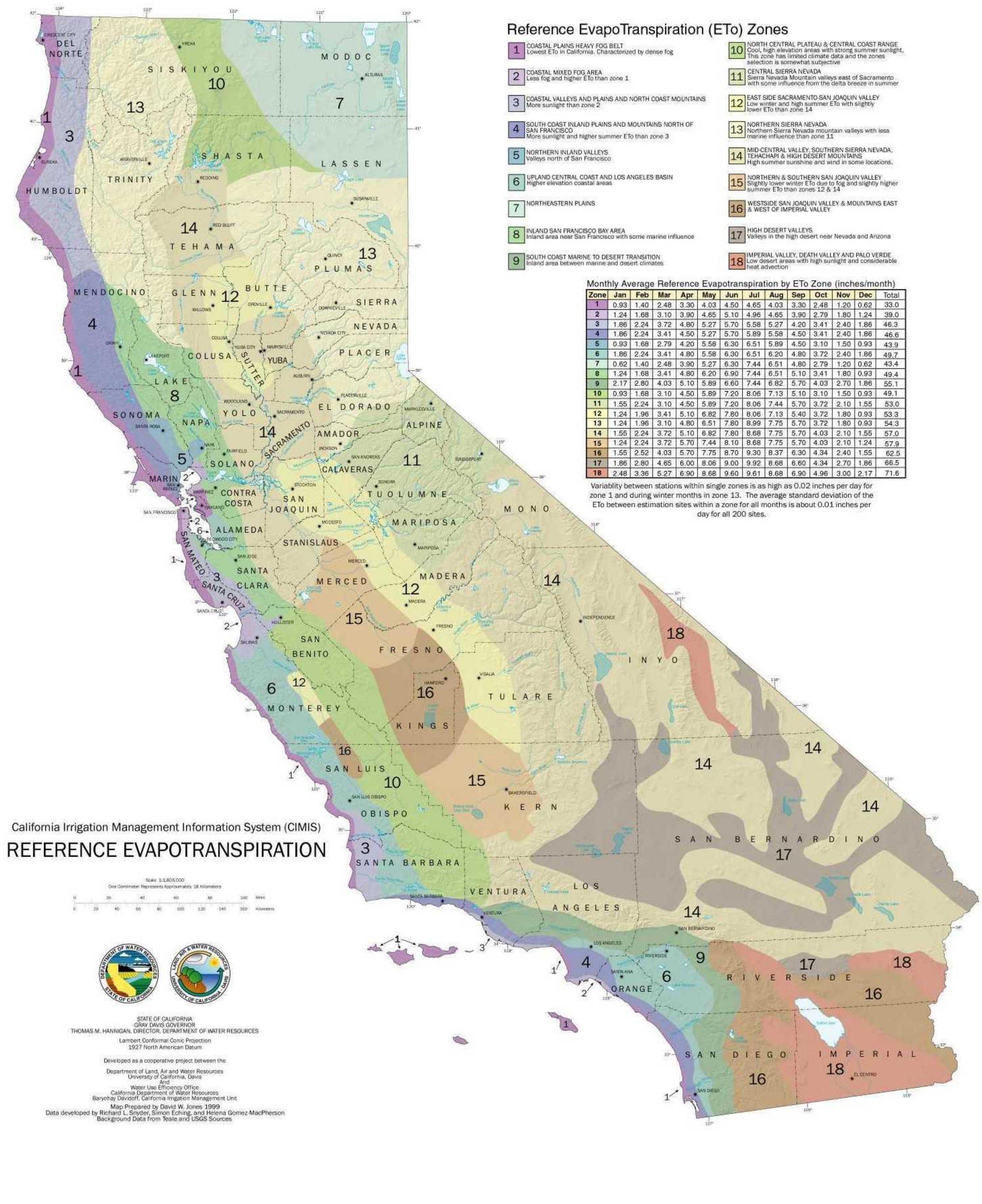
County	California Region	Mean Residential Lot Size (Acres)	County Land Area (Square Miles)	Population per Square Mie
Sacramento County	Sacramento	0.33	964	1,471
Placer County	Sacramento	1.08	1,407	248
El Dorado County	Sacramento	4.28	1,707	106
Los Angeles County	South Coast	0.71	4,057	2,420
San Francisco County	Bay Area	0.07	47	17,179

In addition to the lot size, the mix of land uses within each water supplier's service area affect water demand and GPCD/R-GPCD values because land use drives water use. For example, if a water supplier has more multifamily units than single family units but similar populations, the same number of people will be incorporated into the GPCD/R-GPCD figures but without additional outdoor water use from single family lots. Or if a water supplier has primarily industrial water use with a small population, GPCD/R-GPCD figures could be higher than

[14] General residential data was used because not all counties have single family residential data categorized. This is not ideal but the purpose is to show variation of lot sizes throughout the state. Additionally, the data represents lot size, which includes both structures and vegetation.

surrounding water suppliers. Table 10 a sample of water suppliers' service areas from Sacramento and Placer counties broken down by land use type, displayed in percentage. The large majority of the region's land use is classified as residential.

Figure 7: Reference Evaportranspiration Zones in California. Source: CIMIS, 1999.



Monthly Average Reference Evapotranspiration by ETo Zone (inches/month)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	0.93	1.40	2.48	3.30	4.03	4.50	4.65	4.03	3.30	2.48	1.20	0.62	33.0
2	1.24	1.68	3.10	3.90	4.65	5.10	4.96	4.65	3.90	2.79	1.80	1.24	39.0
3	1.86	2.24	3.72	4.80	5.27	5.70	5.58	5.27	4.20	3.41	2.40	1.86	46.3
4	1.86	2.24	3.41	4.50	5.27	5.70	5.89	5.58	4.50	3.41	2.40	1.86	46.6
5	0.93	1.68	2.79	4.20	5.58	6.30	6.51	5.89	4.50	3.10	1.50	0.93	43.9
6	1.86	2.24	3.41	4.80	5.58	6.30	6.51	6.20	4.80	3.72	2.40	1.86	49.7
7	0.62	1.40	2.48	3.90	5.27	6.30	7.44	6.51	4.80	2.79	1.20	0.62	43.4
8	1.24	1.68	3.41	4.80	6.20	6.90	7.44	6.51	5.10	3.41	1.80	0.93	49.4
9	2.17	2.80	4.03	5.10	5.89	6.60	7.44	6.82	5.70	4.03	2.70	1.86	55.1
10	0.93	1.68	3.10	4.50	5.89	7.20	8.06	7.13	5.10	3.10	1.50	0.93	49.1
11	1.55	2.24	3.10	4.50	5.89	7.20	8.06	7.44	5.70	3.72	2.10	1.55	53.0
12	1.24	1.96	3.41	5.10	6.82	7.80	8.06	7.13	5.40	3.72	1.80	0.93	53.3
13	1.24	1.96	3.10	4.80	6.51	7.80	8.99	7.75	5.70	3.72	1.80	0.93	54.3
14	1.55	2.24	3.72	5.10	6.82	7.80	8.68	7.75	5.70	4.03	2.10	1.55	57.0
15	1.24	2.24	3.72	5.70	7.44	8.10	8.68	7.75	5.70	4.03	2.10	1.24	57.9
16	1.55	2.52	4.03	5.70	7.75	8.70	9.30	8.37	6.30	4.34	2.40	1.55	62.5
17	1.86	2.80	4.65	6.00	8.06	9.00	9.92	8.68	6.60	4.34	2.70	1.86	66.5
18	2.48	3.36	5.27	6.90	8.68	9.60	9.61	8.68	6.90	4.96	3.00	2.17	71.6

Variablity between stations within single zones is as high as 0.02 inches per day for zone 1 and during winter months in zone 13. The average standard deviation of the ETo between estimation sites within a zone for all months is about 0.01 inches per day for all 200 sites.

Table 10: Land Use Type by Water Supplier in Sacramento and Placer Counties. Source: Land IQ, 2016.

Water Supplier[15]	Commercial	Industrial	Institutional	Landscape	Other	Residential	Total Acres
California American Water	10%	5%	6%	0%	1%	79%	16,532
Carmichael Water District	5%	1%	7%	0%	1%	87%	3,895
Citrus Heights Water District	10%	0%	4%	1%	2%	84%	6,059
City of Folsom	19%	2%	8%	0%	3%	68%	5,713
City of Lincoln	19%	5%	7%	1%	0%	68%	4,675
City of Roseville	22%	5%	8%	2%	0%	63%	11,135
City of Sacramento	11%	10%	7%	1%	1%	70%	31,533
Del Paso Manor Water District	9%	0%	6%	0%	0%	85%	416
Elk Grove Water District	4%	4%	5%	0%	1%	86%	4,821
Fair Oaks Water District	4%	0%	3%	0%	1%	91%	4,576
Golden State Water Company	24%	8%	5%	0%	4%	58%	4,425
Orange Vale Water Company	6%	1%	6%	0%	0%	87%	2,506
Placer County Water Agency	4%	2%	3%	1%	0%	90%	48,175
Rancho Murieta CSD	28%	1%	0%	0%	34%	36%	1,305
Rio Linda/Elverta CWD	2%	4%	2%	0%	0%	92%	6,689
Sacramento County WA	5%	5%	2%	0%	0%	86%	26,970
Sacramento Suburban WD	12%	6%	8%	0%	1%	73%	14,312
San Juan Water District	5%	0%	3%	0%	0%	91%	7,354
Average	11%	3%	5%	0%	3%	78%	

[15] CSD=Community Service District, CWD=Community Water District, WA=Water Agency, and WD= Water District.

Water rates in the Sacramento region also are lower than in other parts of the State. This is partially explained by the requirement to comply with Proposition 218, which requires that a water supplier cannot charge more to a customer than it costs to deliver water to that customer (Salt, Best Best & Krieger, 2016). Since water is relatively plentiful in the Sacramento region, water rates are relatively low. The California Nevada American Water Works Association's 2017 Water Rates Survey shows relative average charges and total water bill by hydrologic region (Figure 8 and Figure 9). The Sacramento hydrologic region is solidly in the middle of the State's regions for total bill cost and is at the lower end of average bill service charge in the State. Water suppliers can adopt rate structures that further encourage conservation, while still complying with Proposition 218; however, this topic is beyond the scope of this thesis. Three factors in the region (hot, dry weather; large residential lots and relatively inexpensive water rates) combine to increase total annual and summer water use.

Figure 8: Average Monthly Water Charge (Dollars) Per Connection. Source: AWWA, 2017.

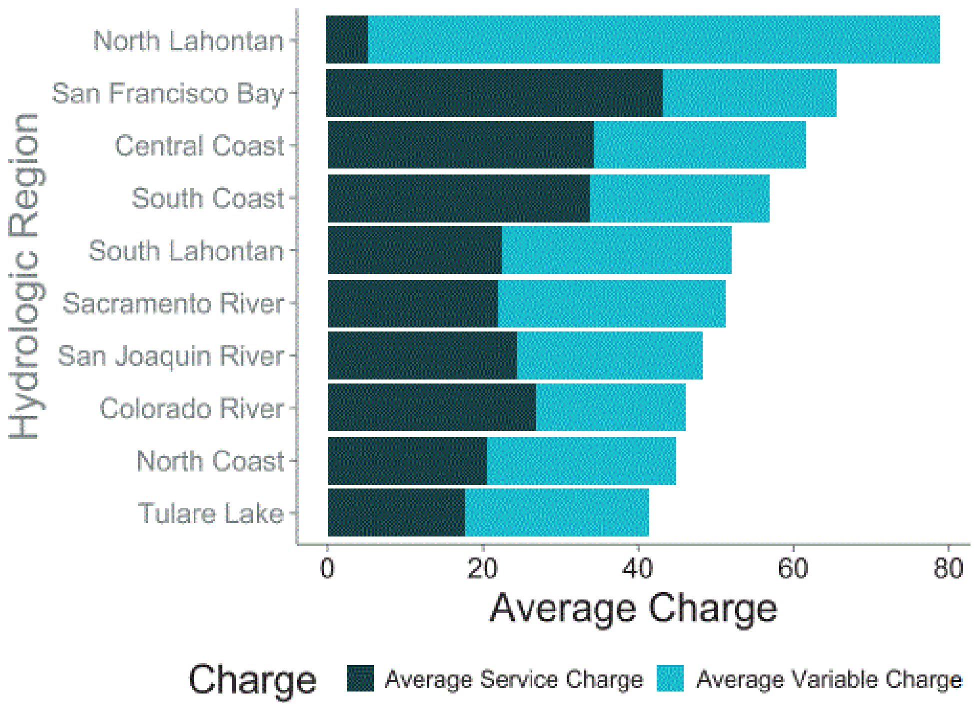
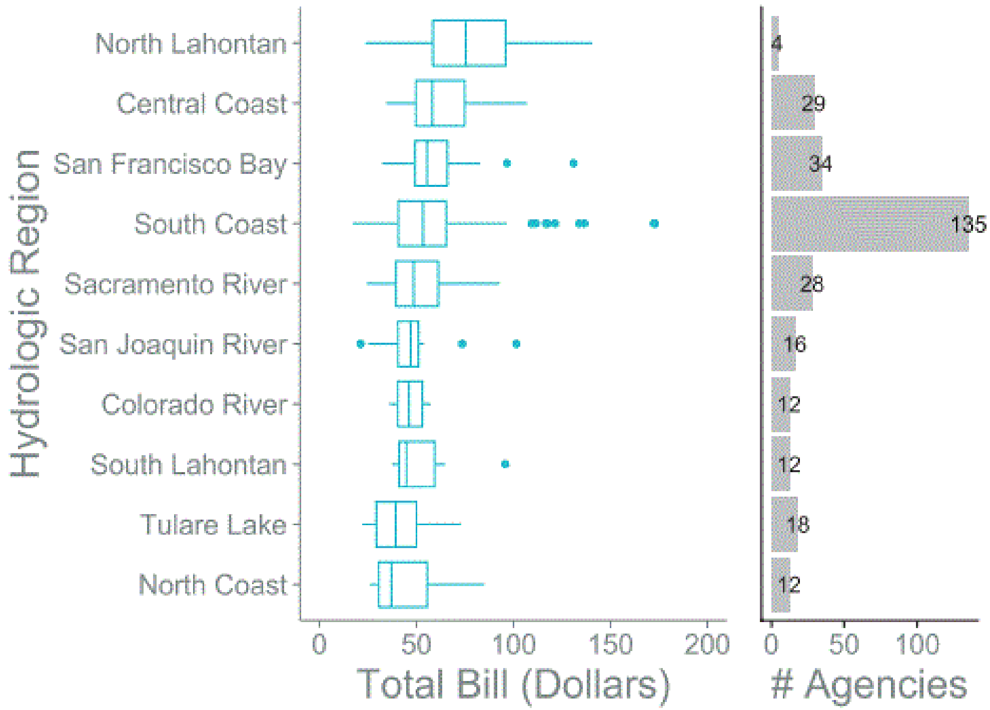


Figure 9: Average Monthly Total Water Bill Amount (Dollars) Per Connection. Source: AWWA, 2017.



With a better understanding of why overall summer water use increases, a more detailed look at average per capita outdoor use can be estimated. Water suppliers and the State do not know precisely how much water is used indoors versus outdoors because households lack separate indoor and outdoor meters. Residential water bills are calculated on reads from one meter. Technology is helping to fill in the gaps. Water suppliers are replacing older meters with Automatic Meter Reading (AMR) and Advanced Metering Infrastructure (AMI) meters and technology that can read water use at smaller hourly time intervals. These newer "smart" meters can help estimate outdoor water use by observing daily water use patterns. Indoor water use is generally from 7 a.m. and 10 p.m., with a relatively consistent use pattern (DeOreo, 2011). Outdoor water use appears in water supplier data as a huge spike in water use typically very early in the morning (3:00 a.m. to 6:00 a.m.), when indoor uses are unlikely (people are sleeping) (DeOreo, 2011).

One method to estimate outdoor water is the minimum month method. 2018 R-GPCD data is used as the base for this method because it most accurately represents residential water use and is the most recent annual data relatively removed from the 2014-2016 drought conditions (in terms of demand reductions and precipitation/temperature). The minimum month method works by selecting the lowest water production month of the year (usually December, January, or February), assuming that all this use is indoor use, and that this indoor use is constant across all other months. Then the lowest month's production is subtracted from every other month's production to estimate outdoor water use (all remaining gallons for a particular month). Monthly outdoor use estimates are then added together to estimate the year's outdoor water use. As with any method, there are some errors, such as the probability that people take more showers in summer, which could underestimate actual indoor water use during those months and inflate outdoor water use during the same time. Other methods like the summer-winter method which split the year into 2 seasons and compared water use do not work for places like the Sacramento region because outdoor watering occurs during most of the year including some month's that are considered "winter" months elsewhere in California and the United States. The Table 11 shows 2018 monthly R-GPCD data by water supplier. Tables 12 and 13 show estimated indoor and outdoor water use per person by month and annually respectively based on regional average 2018 R-GPCD using the minimum month method.

Table 11: 2018 Residential Gallons Per Capita Per Day (R-GPCD). Source: RWA, 2019. [16]

Water Agency	2018 Residential Gallons Per Capita Per Day (R-GPCD)													
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Minimum	Maximum
California American Water	62	65	65	76	103	127	139	127	113	103	81	61	61	139
Carmichael Water District	85	97	87	115	194	251	294	261	249	174	147	88	85	294
Citrus Heights Water District	77	85	79	100	156	209	253	231	200	154	122	81	77	253
City of Davis	59	68	61	80	111	128	147	139	125	116	90	58	58	147
City of Folsom	80	94	86	112	178	223	244	238	198	170	126	81	80	244
City of Lincoln	61	75	57	85	121	184	202	200	175	159	118	62	57	202
City of Roseville	54	61	54	63	109	154	174	181	181	127	115	69	54	181
City of Sacramento	62	65	66	77	119	138	165	133	113	107	78	62	62	165
City of West Sacramento	70	79	58	81	105	157	164	173	125	110	95	67	58	173
City of Woodland	55	62	48	61	88	113	118	121	109	92	85	50	48	121
City of Yuba City	69	81	75	90	129	153	164	157	143	122	102	71	69	164
El Dorado Irrigation District	97	93	99	111	183	260	324	207	239	166	145	89	89	324
Elk Grove Water District	58	62	59	68	106	138	159	152	135	117	95	60	58	159
Fair Oaks Water District	75	94	81	113	198	265	316	316	268	199	151	83	75	316
Golden State Water Company	84	90	88	102	155	201	216	210	195	161	134	93	84	216
Orange Vale Water Company	79	93	83	116	210	286	325	303	270	160	148	82	79	325
Placer County Water Agency	68	71	63	106	151	203	223	215	208	138	129	69	63	223
Rancho Murieta CSD	102	104	77	116	203	263	299	350	297	218	178	110	77	350
Rio Linda/Elverta CWD	91	102	74	84	146	204	231	212	179	146	107	76	74	231
Sacramento County WA	80	89	78	112	143	176	192	188	165	140	108	77	77	192
Sacramento Suburban WD	66	69	68	84	85	151	170	155	109	142	82	60	60	170
San Juan Water District	91	136	102	175	362	477	553	NR	NR	NR	NR	NR	91	553
Sacramento Regional Average	**69**	**75**	**70**	**89**	**131**	**171**	**195**	**176**	**156**	**133**	**102**	**69**	**69**	**195**
Minimum	54	61	48	61	85	113	118	121	109	92	78	50		
Maximum	102	136	102	175	362	477	553	350	297	218	178	110		

[16] The cities of Davis and Woodland are included in the R-GPCD analysis for the Sacramento region because their wholesale supplier, Woodland-Davis Clean Water Agency, was a RWA member for a portion of the drought period, when R-GPCD data was first collected. Notes: WD=Water District, WA=Water Agency, CWD=Community Water District and CSD=Community Service District. San Juan Water District's R-GPCD is estimated using 2017 data for regional calculations because it was not reported to RWA during certain months (NR=Not Reported).

Table 12: 2018 Estimated Monthly Indoor and Outdoor Water Use. Source: RWA, 2019.

Minimum Month Method	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Regional Average 2018 R-GPCD	**69**	**75**	**70**	**89**	**131**	**171**	**195**	**176**	**156**	**133**	**102**	**69**
Number of days in the month	31	28	31	30	31	30	31	31	30	31	30	31
Gallons per person per month	2,139	2,100	2,170	2,670	4,061	5,130	6,045	5,456	4,680	4,123	3,060	2,139
Outdoor use per person per month	39	0	70	570	1,961	3,030	3,945	3,356	2,580	2,023	960	39
Indoor use per person per month	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
% outdoor use per person by month	1.8%	0.0%	3.2%	21.3%	48.3%	59.1%	65.3%	61.5%	55.1%	49.1%	31.4%	1.8%

Table 13: 2018 Estimated Annual Indoor and Outdoor Water Use. Source: RWA, 2019.

Water Use[17]	Regional Average R-GPCD	Average Annual Gallons per Person	Total Average Annual Percentage
Total	120	43,773	100%
Outdoor	51	18,573	42%
Indoor	69	25,200	58%

[17] Note: Indoor and outdoor water use splits vary from year to year. This is a sample of one year.

To provide context for indoor/outdoor use throughout the State, a similar analysis (based on 2017 R-GPCD) has been done for San Francisco, Fresno, Riverside, Santa Rosa, Los Angeles Department of Water and Power, and Sacramento (Table 14). Winter water use is similar between all the cities whereas summer water use varies. The results are in line with the data provided in Table 12 and are in line with the observed differences in seasonal water use (i.e., outdoor water use) presented earlier in this chapter. The goal of this comparison is to reinforce that this are seasonal water use differences throughout the State (as also eluded to by varying ETo values presented in Figure 7 and Table 8) when observing monthly (ETo and production) values instead of annual values, which better explain local water use patterns. Comparisons between regions and states will continue, but should be provided within proper context to avoid incomplete conclusions and inapplicable recommendations for improvement. For example, the 2011 California Single Family Water Use Efficiency Study showed that outdoor water waste does occur but is smaller that often thought (DeOreo, 2011). Most households are watering relatively efficiently or deficit irrigating. The study shows that most use and waste resulted from a small portion of customers. This is an opportunity to further tailor drought related restrictions in the future.

Table 14: Minimum Month Method for Sample California Cities.[18] *Source: State Water Board, 2018.*

Minimum Month Method	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
City of San Francisco R-GPCD	**41**	**42**	**39**	**41**	**40**	**47**	**43**	**43**	**47**	**44**	**43**	**40**
Number of days in the month	31	28	31	30	31	30	31	31	30	31	30	31
Gallons per person per month	1,265	1,175	1,207	1,240	1,247	1,425	1,323	1,335	1,399	1,357	1,292	1,255
Outdoor use per person per month	91	0	32	65	72	250	148	160	224	182	117	80
Indoor use per person per month	1,175	1,175	1,175	1,175	1,175	1,175	1,175	1,175	1,175	1,175	1,175	1,175
% Outdoor use per person by month	7.2%	0.0%	2.7%	5.2%	5.8%	17.5%	11.2%	12.0%	16.0%	13.4%	9.1%	6.4%

Minimum Month Method	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
City of Fresno R-GPCD	**83**	**70**	**101**	**95**	**149**	**182**	**200**	**194**	**169**	**136**	**107**	**90**
Number of days in the month	31	28	31	30	31	30	31	31	30	31	30	31
Gallons per person per month	2,561	1,949	3,122	2,858	4,621	5,466	6,207	6,016	5,084	4,225	3,203	2,799
Outdoor use per person per month	612	0	1,173	908	2,672	3,517	4,257	4,067	3,135	2,276	1,254	850
Indoor use per person per month	1,949	1,949	1,949	1,949	1,949	1,949	1,949	1,949	1,949	1,949	1,949	1,949
% Outdoor use per person by month	23.9%	0.0%	37.6%	31.8%	57.8%	64.3%	68.6%	67.6%	61.7%	53.9%	39.2%	30.4%

Minimum Month Method	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
City of Riverside R-GPCD	**57**	**57**	**85**	**107**	**120**	**139**	**149**	**141**	**131**	**124**	**105**	**102**
Number of days in the month	31	28	31	30	31	30	31	31	30	31	30	31
Gallons per person per month	1,767	1,596	2,635	3,210	3,720	4,170	4,619	4,371	3,930	3,844	3,150	3,162
Outdoor use per person per month	171	0	1,039	1,614	2,124	2,574	3,023	2,775	2,334	2,248	1,554	1,566
Indoor use per person per month	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596
% Outdoor use per person by month	9.7%	0.0%	39.4%	50.3%	57.1%	61.7%	65.4%	63.5%	59.4%	58.5%	49.3%	49.5%

[18] California Regions/Locations: San Francisco (North Coastal), Fresno (Central Inland), Riverside (South Inland), Santa Rosa (North Inland), LADWP (South Coastal), and Sacramento (North/Central Inland).

Minimum Month Method	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
City of Santa Rosa R-GPCD	**49**	**49**	**43**	**56**	**69**	**76**	**98**	**73**	**97**	**78**	**48**	**47**
Number of days in the month	31	28	31	30	31	30	31	31	30	31	30	31
Gallons per person per month	1,519	1,372	1,333	1,680	2,139	2,280	3,038	2,263	2,910	2,418	1,440	1,457
Outdoor use per person per month	186	39	0	347	806	947	1,705	930	1,577	1,085	107	124
Indoor use per person per month	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333
% Outdoor use per person by month	12.2%	2.8%	0.0%	20.7%	37.7%	41.5%	56.1%	41.1%	54.2%	44.9%	7.4%	8.5%

Minimum Month Method	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
LADWP R-GPCD	**53**	**50**	**61**	**68**	**71**	**76**	**74**	**77**	**80**	**68**	**69**	**72**
Number of days in the month	31	28	31	30	31	30	31	31	30	31	30	31
Gallons per person per month	1,649	1,411	1,885	2,040	2,201	2,280	2,294	2,387	2,406	2,108	2,070	2,220
Outdoor use per person per month	238	0	474	629	790	869	883	976	995	697	659	808
Indoor use per person per month	1,411	1,411	1,411	1,411	1,411	1,411	1,411	1,411	1,411	1,411	1,411	1,411
% Outdoor use per person by month	14.4%	0.0%	25.1%	30.8%	35.9%	38.1%	38.5%	40.9%	41.3%	33.1%	31.8%	36.4%

Minimum Month Method	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
City of Sacramento R-GPCD	66	58	74	74	127	145	163	150	129	112	71	67
Number of days in the month	31	28	31	30	31	30	31	31	30	31	30	31
Gallons per person per month	2,046	1,624	2,294	2,220	3,937	4,350	5,053	4,650	3,870	3,472	2,130	2,077
Outdoor use per person per month	422	0	670	596	2,313	2,726	3,429	3,026	2,246	1,848	506	453
Indoor use per person per month	1,624	1,624	1,624	1,624	1,624	1,624	1,624	1,624	1,624	1,624	1,624	1,624
% Outdoor use per person by month	20.6%	0.0%	29.2%	26.8%	58.8%	62.7%	67.9%	65.1%	58.0%	53.2%	23.8%	21.8%

Some irrigation controller companies are creating devices (e.g., Rachio's Wireless Flow Meter) to meter outdoor water use through their controllers. A customer could, in theory, use their controller and obtain their outdoor water use in gallons and then subtract their outdoor water use from their total water bill consumption during the same timeframe to calculate indoor water use. While it is unlikely that the average customer would go through this process, the technology is available at the household level.

F. Water Related Energy Use

It takes energy to produce water and water to produce energy. This relationship is often referred to as the "water energy nexus" and it is especially relevant in California because energy to collect, convey, treat, distribute, heat, and use water consumes 19 percent of the State's electricity, 30 percent of its natural gas, and 88 billion gallons of diesel fuel every year (CEC, 2005). Most of this water-related electricity and natural gas is used for residential and commercial water heating. Water-related energy use varies throughout the State and is a function of distance traveled from water source, water source type, water quality, and treatment type, as well as other factors. This relationship is commonly expressed as an energy intensity metric such as kilowatt hours of electricity per million gallons of water (kWh/MG). Table 15 shows energy intensity differences between northern and southern California. The driving factor of the variation in this case is distance and elevation traveled from water source as southern California imports about 50% of their water supply (from northern California and Colorado River) compared to the more local supplies of northern California (CEC, 2005).

Table 15: Energy Intensity (Kilowatts per Million Gallon) in Typical Urban Water Systems in Northern and Southern California. Source: California Energy Commission (CEC), 2005.

	Northern California Energy Intensity (kWh/MG)	Southern California Energy Intensity (kWh/MG)
Water Supply and Conveyance	150	8,900
Water Treatment	100	100
Water Distribution	1,200	1,200
Wastewater Treatment	2,500	2,500
Total	3,950	12,700

A more localized study was commissioned for the Sacramento region by Sacramento Municipal Utility District (SMUD), the primary local energy provider in the region, in partnership with the RWA. The study calculated energy intensities for water suppliers within SMUD's service area as well as water suppliers that provide water to water suppliers within SMUD's service areas to identify additional efficiency improvements and renewable energy projects to reduce overall energy use and greenhouse gas (GHG) emissions from water delivery. The average energy intensity of the region's water supply is approximately 1,062 kilowatt hours per million gallons with the individual water suppliers ranging from 312 kWh/MG to 2,370 kWh/MG (GEI Consultants, 2014). Figure 10 shows energy intensity by supplier based on 2007-2011 water and energy data. As expected, suppliers that primarily use groundwater or advanced treatment generally had higher energy intensities than suppliers using primarily surface water and standard water treatment. Also, as expected, peak energy use occurs in the same months as peak water use (Figure 11). Water production and electricity demand in Figure 11 are the collective use of all participating water suppliers. Based on this interdependent relationship, water and energy use should be more closely examined and tracked together to better understand current and future co-impacts from consumption of both resources.

Figure 10: Average Energy Intensity (kWh/MG) by Water Supplier. Source: GEI Consultants, 2014.

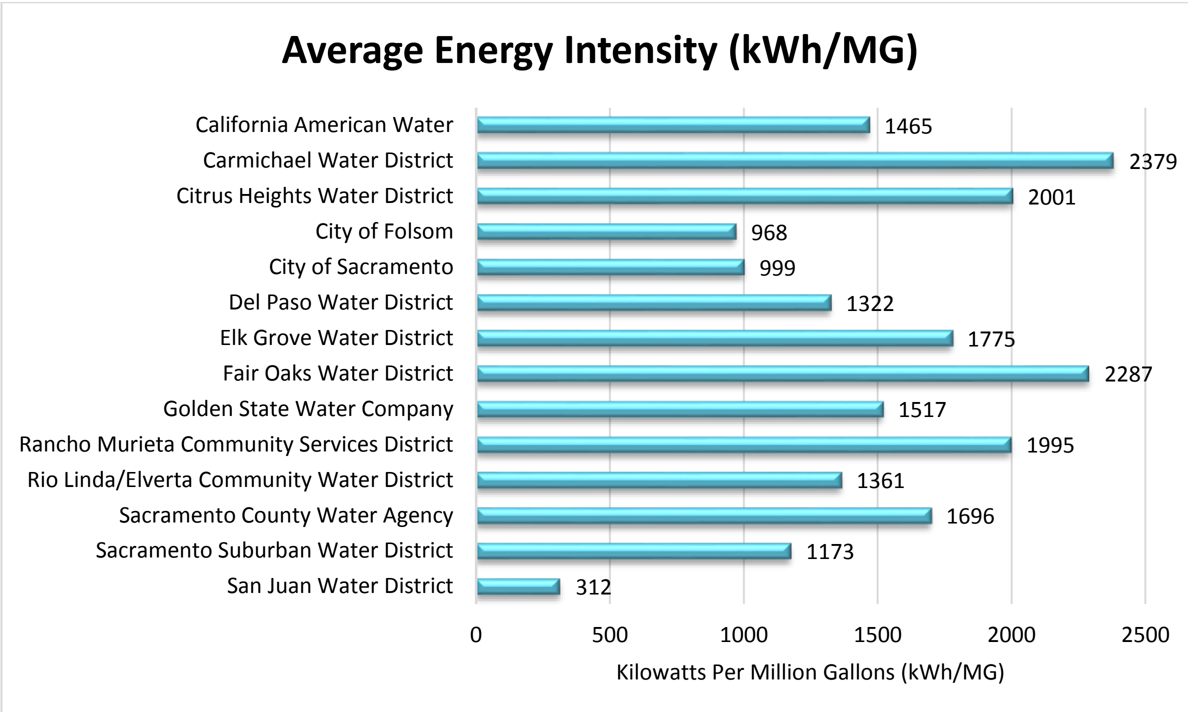
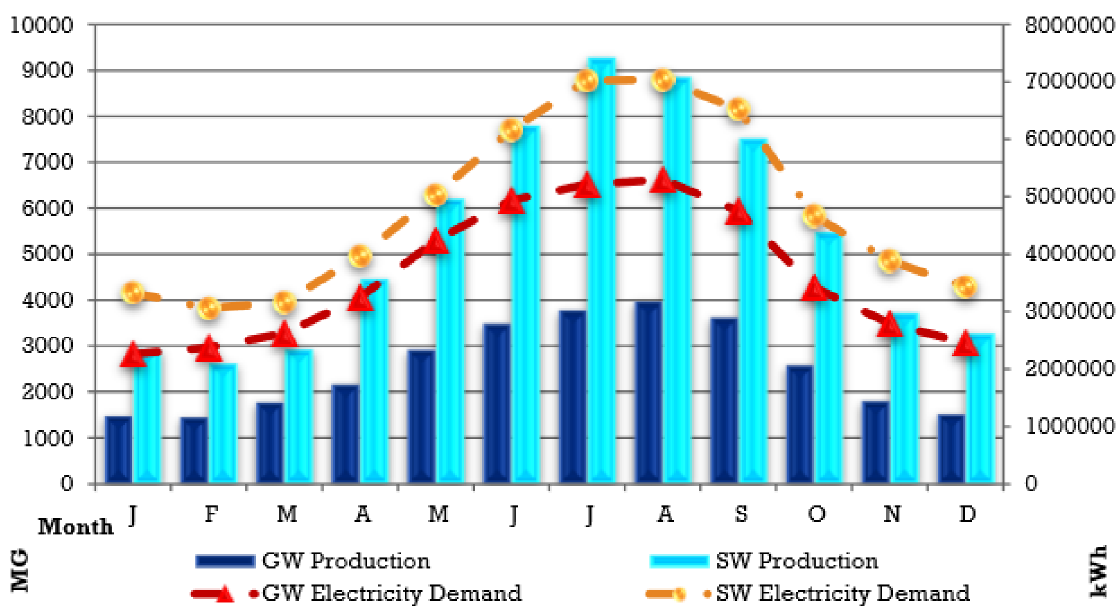


Figure 11: Total Average Monthly Water Production (Million Gallons) and Electricity Demand (kilowatt hours) by Groundwater (GW) and Surface water (SW). Source: GEI Consultants, 2014.



III. Chapter 3: 2014-2016 State Conditions and Actions

California is no stranger to water supply variations and shortages. Until the recent drought, the State had experienced nine multiyear large-scale droughts (based on statewide runoff) since 1900: 1918-1920, 1923-1926, 1928-1935, 1947-1950, 1959-1962, 1976-1977, 1987-1992, 2000-2002 and 2007-2009. The 1928-1935 "Dustbowl" drought established future storage and reservoir operation criteria and led to the construction of the Central Valley Project (DWR, February 2015; CalCAN, 2014). The 1976-1977 drought showcased water conservation as a successful demand management measure to combat water shortages in 1977, one of the driest years on record (DWR, 1978). Drought in California has a history of being catalyst for change.

A. 2014 Executive Orders and the Emergency Regulation

California's tenth large-scale drought was officially declared a state of emergency through an Executive Order (B-17-2014) on January 17, 2014 by Governor Edmund G. "Jerry" Brown, Jr. (Brown, 2014). The emergency declaration was based on historically low snowpack (Figure 12), the driest calendar year on record (Figure 13), record high temperatures (Figure 14), and historically low storage levels throughout the State (Figure 15) (Brown, 2014). Additionally 2014 conditions may have been exacerbated by the relatively dry conditions of the previous several years.

Figure 12: Sierra Nevada Snowpack in 2013 and 2014. Source: NASA.

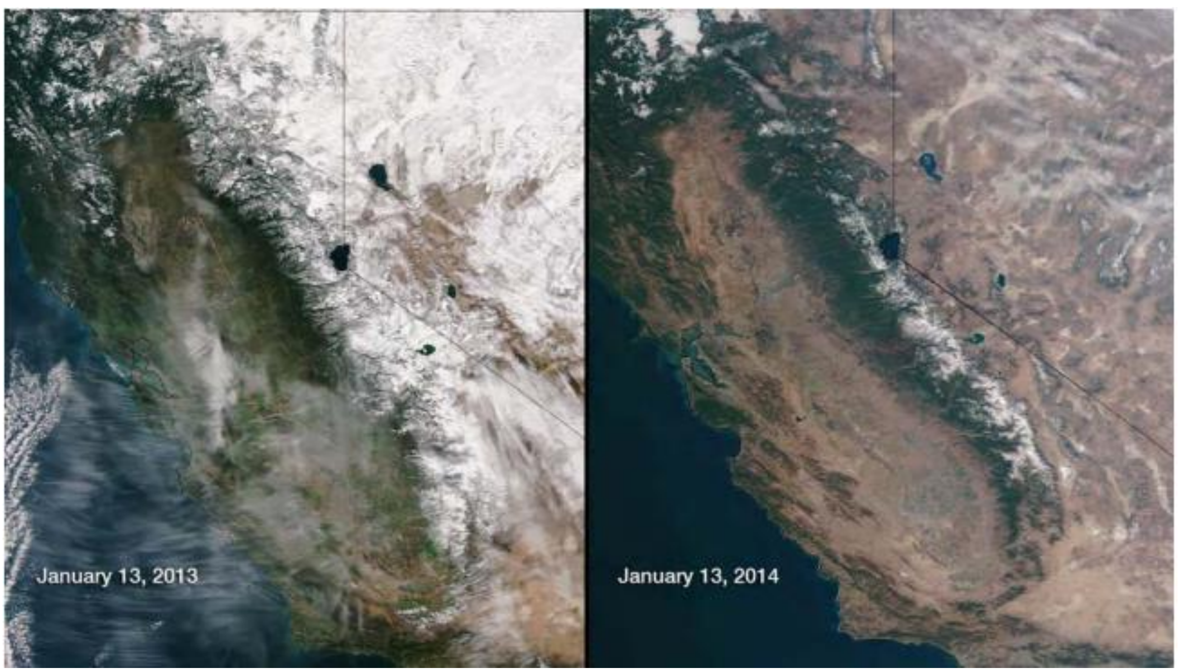


Figure 13: Governor Brown demonstrating historically low precipitation for 2014. Source: Justin Sullivan, Getty Images.

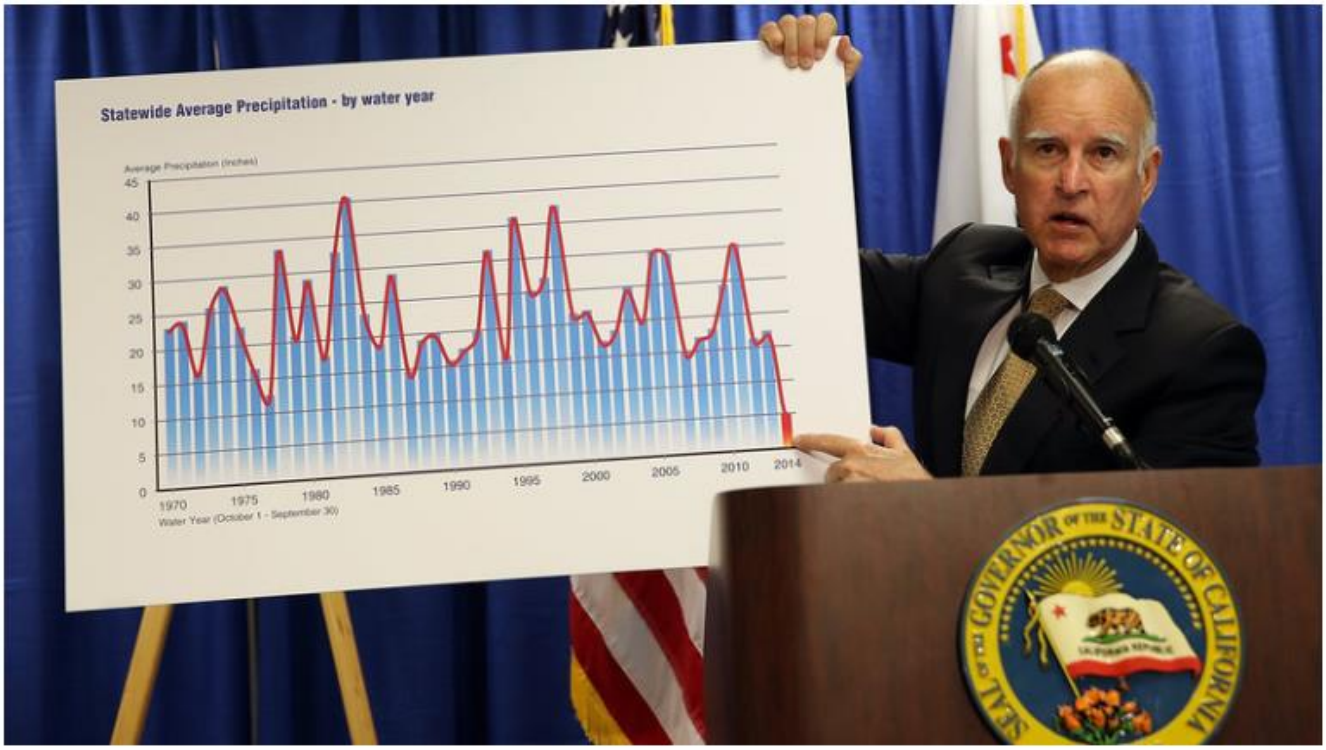


Figure 14: Annual Average Precipitation and Temperatures. Source: DWR, 2015.

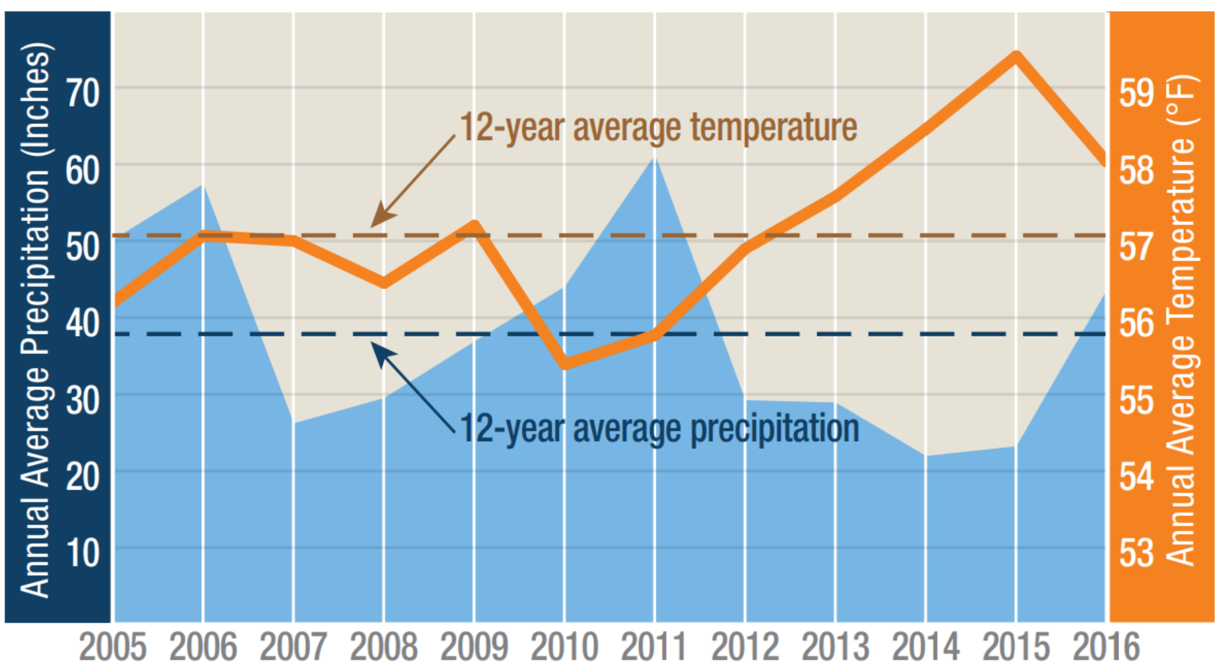
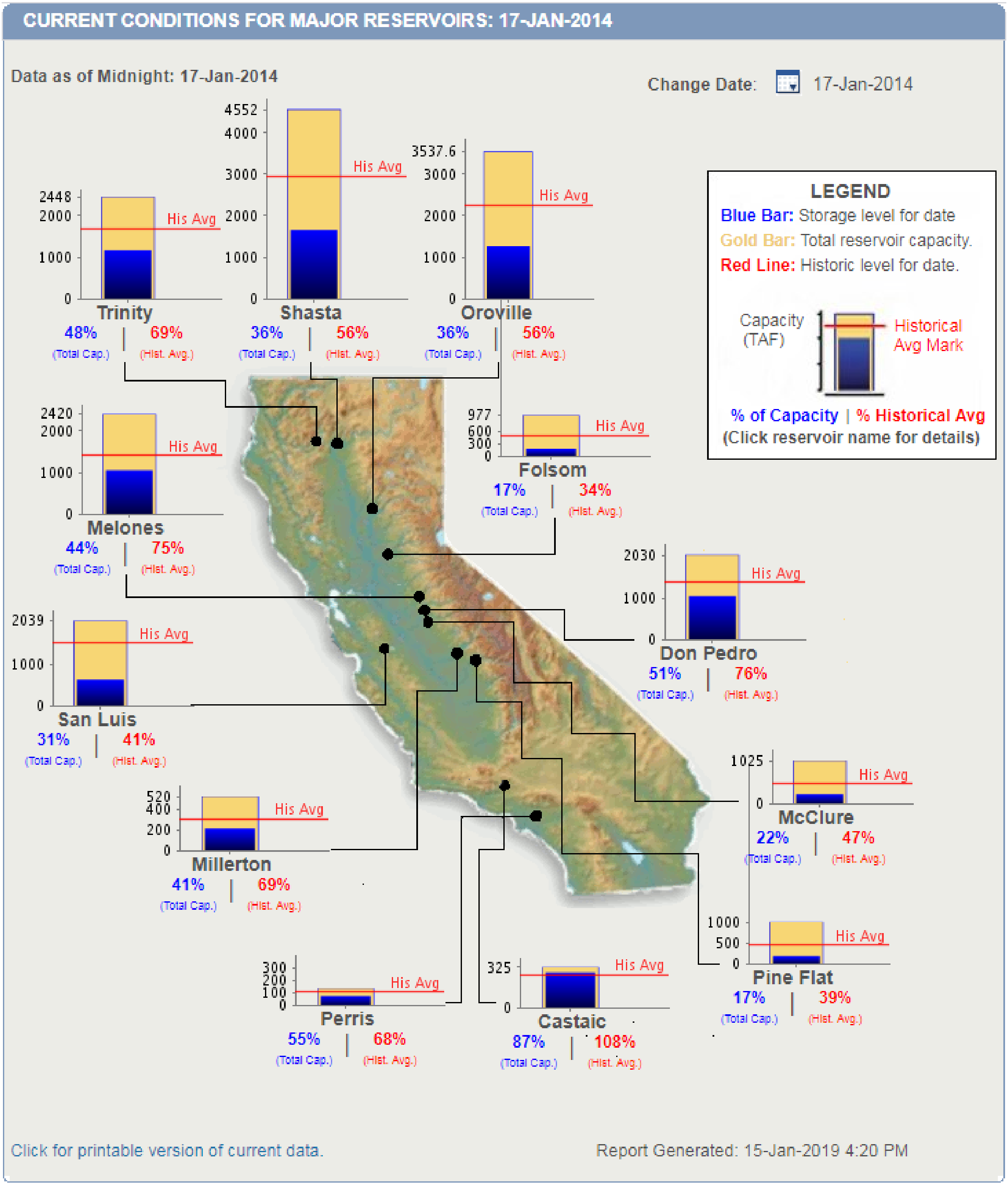


Figure 15: Statewide Reservoir Levels for January 17, 2014. Source: CDEC, 2014.



An official state of emergency declaration typically triggers state funding to aid affected entities and residents. Within two months of the declaration, the Governor announced a $687.4 million drought relief package to provide "immediate funding for drinking water, food, housing, and assistance for water-conserving technologies" (Brown, 2014). However, most of this funding, $549 million, was already allocated through prior actions, but was to be expedited ahead of its current schedule to provide more immediate relief. There was relatively little "new" funding as a result of this declaration.

The emergency declaration also called for State agencies, led by the DWR to implement a public outreach campaign to educate about the drought and "encourage personal actions to reduce water use." The campaign called for all Californians to reduce water use by 20 percent. Local water suppliers and municipalities were directed "to implement their local water shortage contingency plans immediately in order to avoid or forestall outright restrictions that could become necessary later in the drought season." This direction was promoted by the State as voluntary, which was primarily interrupted by local water suppliers as a local decision based on current and projected local water supply conditions (Brown, 2014).

After the initial drought state of emergency declaration in January 2014, Governor Brown issued a second Executive Order (B-25-2014) on April 25th, which reinforced the severity of the drought by continuing the state of emergency and expanded options to address drought challenges including expediting requests for water transfers to areas of need, additional water waste recommendations including a maximum of 2 day a week watering, and targeted recommendations for homeowner associations, commercial establishments, and sports facilities (Brown, 2014). Additional monitoring and assistance actions were outlined for water suppliers with drinking water shortages, environmental flows, select groundwater basins, CAL FIRE, and wastewater reuse (Brown, 2014).

Executive Order B-25-2014 also directed the State Water Board to ensure that urban water suppliers were working with customers to limit outdoor irrigation and other wasteful practices. To assist with this effort, the Governor offered the State Water Board the option to adopt and implement a statewide emergency regulation pursuant to Water Code Section 1058.5, if deemed necessary. Empowered by this Executive Order, the State Water Board approved an Emergency Regulation (Office of Administrative Law File No: 2014-0718-01 E) on July 15, 2014 to increase urban water conservation, which became effective on July 29, 2014. The Emergency Regulation would remain in effect for 270 days (until April 25, 2015) unless retracted or extended. The adopted emergency regulation had two main components, one aimed at all Californians and the other aimed at the State's urban water suppliers (roughly 411 large suppliers).

The Emergency Regulation prohibited the following actions statewide: the use of potable water to wash sidewalks and driveways, runoff when irrigating with potable water, hoses with no shutoff nozzles to wash cars, and the use of potable water in non-recirculating decorative water features. A possible fine of $500 per day may be issued by water suppliers or the State for not complying. The enforcement portion of the emergency regulation provided additional support to urban water suppliers that were not also municipalities with the associated existing enforcement powers.

The Emergency Regulation required urban water suppliers to do two actions: to enact their local water shortage contingency plans to a stage that includes restrictions on outdoor irrigation and report monthly water production starting in August 2014 with the addition of R-GPCD reporting starting in October 2014. Urban water suppliers without a water shortage contingency plan and smaller water suppliers (under 3,000 connections or delivering under 3,000 acre feet per year) were required to mandate only two day a week watering or watering restrictions with similar savings. Monthly reporting was needed to better understand water use throughout the State and to begin tracking water saving (using 2013 data collected at the same time as the baseline). The data was collected via an online portal and was posted on the State Water Board website each month, providing transparency to the public and requiring accountability for reporting from each water supplier. However, given the diversity of reporting methods and inconsistency of billing frequency between water suppliers, among other issues, the collected data provided a bird's eye estimate of monthly conservation progress at best. The State Water Board's actions could be compared to the role of Frontinus (first century Rome), who gathered information on water supplies throughout the city to show prowess and authority through management oversight, rather than a genuine attempt to provide aid (Frontinus, 97 A.D.).

Two other related Executive Orders were issued in September 2014 (B-26-2014) and December 2014 (B-28-2014). The September Executive Order made funding available through the California Disaster Assistance Act for families with drinking water shortages and created prohibitions on water price gouging during the drought, among other actions (Brown, 2014). The December Executive Order extended waivers for the California Environmental Quality Act (CEQA) and Water Code section 13247 for some activities that may affect water quality (Brown, 2014).

B. 2015 Executive Orders, the Emergency Regulation, and the Conservation Standard

Governor Brown issued another Executive Order (B-29-15) on April 1, 2015, the same day the DWR administered April snow survey was released documenting the lowest snowpack ever recorded in the State (Brown, 2015). With this Executive Order and for the first time in state history, the Governor directed the implementation of mandatory water conservation targets. Governor Brown tasked the State Water Board with achieving a cumulative 25% water savings from the State's urban areas (compared to 2013 water production) from June 2015 through February 2016.[19] Water conservation at the state level has historically been led by the DWR, which employs full-time staff to further water conservation and efficiency planning and implementation in the State with limited regulatory oversight. The State Water Board has

[19] The 25% savings was strictly assigned to the state's urban water use, which accounts for 10% of the state's water use for human purposes. Agriculture accounts for the 40% of water use for human purposes (i.e., developed water), while only accounting for 2% of the state's gross state product (Mount and Hanak, 2016). While the statewide agriculture community has also been affected by the drought, the majority of these losses in revenue, jobs and water were focused in the San Joaquin Valley, where groundwater supplies had issues before the drought and will likely continue to have issues after the drought (Howitt et al., 2014). This thesis focuses on drought response in urban areas but cannot ignore the relatively limited urban water use and, therefore, limited water savings potential when considered in the larger context of the state's water use portfolio. Securing ample water supply for all users in the state is a shared burden and benefit. Ensuring equity among all the state's water users in this endeavor remains a challenge, especially in times of drought.

historically led regulatory enforcement of water rights and water quality regulations but had little staff capacity in water conservation at the time. State officials expressed the expectation that DWR and the State Water Board would coordinate to successfully implement Executive Order B-29-15.

To meet the Governor's 25% reduction, the State Water Board approved an updated Emergency Regulation on May 5, 2015 that created a conservation standard that was used to assign mandated conservation targets for the State's 411 urban retail water suppliers. The updated Emergency Regulation (Office of Administrative Law File No. 2015-0506-02-EE) was approved by the Office of Administrative Law and effective on May 18, 2015. Over the regulation period from June 2015 through February 2016, the State Water Board estimated the conservation standard, if fully implemented, would produce 1.2 million acre-feet or 336,000 million gallons of water savings, equating to a 25% savings as directed by the Governor.

Furthermore, the Executive Order stated, "These restrictions should consider the relative per capita water usage of each water suppliers' service area and require that those areas with high per capita use achieve proportionally greater reductions than those with low use" (Brown, 2015).[20] As a result, the State Water Board organized the 411 urban water suppliers by their R-GPCD and assigned conservation targets that ranged from 4%-36% (tiers increased by 4% increments) based on "lower" to "higher" per capita per day water use. For example, a water supplier with 80 R-GPCD would receive a 16% conservation target while a supplier with 130 R-GPCD would receive a conservation target of 28%. The reasoning behind this sliding scale method, as provided by the State, was "that communities that have been conserving water will have lower mandates than those that have not conserved this past year and/or over the last decades since the last major drought" (SWRCB, October 2015). Chapter 2 challenges this reasoning by showing some complexities with using R-GPCD as an efficiency metric. Regardless of the reasoning, the State, through the use of R-GPCD, prioritized reducing outdoor water use to meet the State's conservation target. One assumption for this prioritization choice could be that indoor use is thought to be more uniform by some and urban water suppliers with "higher" R-GPCD simply use more water outdoors and/or were more wasteful with outdoor water use. The assigned conservation targets based on this method for all of the State's urban water suppliers is available on the State Water Board's website. Table 16 shows the final standard that determined each urban water supplier's conservation target. Each supplier's R-GPCD value was calculated based on data collected from July 2014 through September 2014, which captured the peak of summer outdoor water use, as designed. Each supplier was required to report monthly water production to the State Water Board, which was used to calculate monthly conservation savings and compared to the supplier's conservation standard. Suppliers were expected to reach their conservation standard at the end of the regulation period (February 2016), recognizing savings vary from month to month. However, conservation progress was calculated and reported on a monthly basis by the State. All data were posted online on the State Water Board website.

[20] The term "restrictions" refers to the conservation standard created by the State Water Board. Additionally, the terms conservation standard, conservation reduction, and conservation target were sometimes used interchangeable by state and local water suppliers and used similarly in this thesis.

Table 16: Mandatory Conservation Tiers. Source: State Water Board, 2014.

Tier	R-GPCD Range		# of Suppliers in Range	Conservation Standard
	From	To		
1	Reserve		5	4%
2	0	64.9	27	8%
3	65	79.9	23	12%
4	80	94.9	42	16%
5	95	109.9	61	20%
6	110	129.9	44	24%
7	130	169.9	81	28%
8	170	214.9	61	32%
9	215	612.0	67	36%

C. Limitations of the Conservation Standard

Many stakeholders, including urban water suppliers, acknowledged the aggressive timeline the State Water Board was under when this method was developed. However, several concerns contributed to it being replaced in 2016. First, this method does not account for the varying climates and resulting variable monthly water use patterns in the State. For example, the Sacramento region's summer water demand is typically two to three times its winter use due to temperatures often above 100 degrees F and lack of rainfall during the summer. This issue is less prominent in coastal areas, where water demand is flatter throughout the year and temperatures remain moderate. Increases in water use due to weather could be seen as water waste or it could be seen as water needed to keep the same plants alive in different climates. Should homes in hotter climates not have grass because it requires more water than at the coast? Admittedly, some plants are more adapted to some areas than others. Redwood trees are poorly suited for Sacramento's climate. However, attempting to address long term landscape planting decisions during a drought can be difficult and ineffective. Water suppliers were more concerned with meeting immediate local conservation targets set by the State, than changing longer term land use policies.

Second, this method does not account for varying lot sizes and development densities across the State and resulting impacts on water use. Lot size decisions are often not controlled by local water suppliers, unless the water supplier is also a municipality. Larger lots generally have larger outdoor areas, which means more outdoor water use with higher R-GPCD. Larger urban lots are more common in areas with lower land values like Sacramento compared to the smaller higher value lots of San Francisco. Development density also influences water use. Higher density housing tends to have less outdoor space per person equating to lower water use per person. This conservation target method took components of local land use policies (lot size and landscape type) and assigned the outcomes of those land-use decisions as a responsibility of local water suppliers to manage during the drought. This takes the simple idea of reducing outdoor use as a drought response and created equity problems by not considering local factors. The end result of using R-GPCD alone (and excluding local factors such as weather and land use) to realize outdoor water savings was the inadvertent prioritization of outdoor water use conservation of some subpopulation in the State compared to others.

Third, this method assumes that most people use (or should use) the same amount of water indoors and that outdoor water use is nonessential in a drought. While the State estimates that most water is used outdoors in the residential sector, the exact split between outdoor and indoor varies throughout the State (Table 14) and can be influenced by household income, home value, density, and marginal cost of water among other factors (Dziegielewski, 2009).

The State Water Board acknowledged all these factors affect R-GPCD prior to their approval of the R-GPCD based comparative mandated conservation standards on their website (Figure 16) and clearly stated R-GPCD figures should not be compared between suppliers. This issue did not end after the initial approval of the standards but was repeatedly brought back to the attention of the State Water Board and staff by water suppliers and other interested parties during their monthly State Water Board meetings throughout 2015.

Figure 16: Factors that can affect per capita water. Source: State Water Board, 2015.

Factors that can affect per capita water

It is not appropriate to use Residential Gallons Per Capita Day (R-GPCD) water use data for comparisons across water suppliers, unless all relevant factors are accounted for. Factors that can affect per capita water include:

- **Rainfall, temperature and evaporation rates** – Precipitation and temperature varies widely across the state. Areas with high temperature and low rainfall need to use more water to maintain outdoor landscaping. Even within the same hydrologic region or the same water supply district these factors can vary considerably, having a significant effect on the amount of water needed to maintain landscapes.
- **Population growth** – As communities grow, new residential dwellings are constructed with more efficient plumbing fixtures, which causes interior water use to decline per person as compared to water use in older communities. Population growth also increases overall demand.
- **Population density** – highly urbanized areas with high population densities use less water per person than do more rural or suburban areas since high density dwellings tend to have shared outdoor spaces and there is less landscaped area per person that needs to be irrigated.
- **Socio-economic measures** such as lot size and income – Areas with higher incomes generally use more water than areas with low incomes. Larger landscaped residential lots that require more water are often associated with more affluent communities. Additionally, higher income households may be less sensitive to the cost of water, since it represents a smaller portion of household income.
- **Water prices** – Water prices can influence demand by providing a monetary incentive for customers to conserve water. Rate structures have been established in many districts to incentivize water conservation, but the effectiveness of these rate structures to deter excessive use and customers sensitivity to water prices vary.

D. Adjustments to the Conservation Standard

Due to the continued below average precipitation during the 2015/2016 winter season, the State entered its second round of Emergency Regulation. With the support of the Governor, on February 2, 2016, the State Water Board approved extending the Emergency Regulation until October 2016. This extended Emergency Regulation became effective February 13, 2016 and was largely based on the May 5, 2015 regulation text and carried much of the same language. For example, the statewide 25% water savings goal was extended, as is, original spanning from June 2015 to February 2016 but now with an updated deadline of October 2016 to match the extended Emergency Regulation timeframe (savings are still compared to 2013).

However, there were some notable changes and additions. The extended regulation updated water supplier conservation targets by incorporating several adjustments. The first adjustment addressed climate and seasonal demand impacts. The State Water Board based this climate adjustment on evapotranspiration (ETo) zones. ETo zones were eligible for adjustments based on their deviation from the State average ETo from July through September. The further away from the State average ETo, the more percentage point reduction was awarded (Table 17), ranging from 2-4%, which was then applied to a water supplier's conservation target.

Water suppliers within each ETo zone, as defined by California Department of Water Sources (DWR) ETo map, selected for adjustment by State Water Board staff automatically received the climate adjustment with no additional water supplier-provided justification to the State. Table 18 shows each ETo zone and the applicable climate adjustment and Figure 7 provides the zone map for reference. As expected, zones with higher ETo values received higher climate adjustments. In total, approximately 211 climate adjustments were given among some of all 411 suppliers (SWRCB, February 2016). Each water supplier in the Sacramento region received a 3% downward adjustment to their current conservation target (ETo Zones 13 and 14). Additionally, if a supplier wanted to make a case for an additional climate adjustment, they could submit in-lieu climate adjustment documentation to the State Water Board. Eleven suppliers received this type of adjustment.

Table 17: Climate Adjustment Standard. Source: State Water Resource Control Board, 2015.

Deviation from State Average ETo	Reduction in Conservation Standard
>20%	4%
10-20%	3%
5 to <10%	2%

Table 18: Climate Adjustment Target Reductions by ET Zone, Source: RWA, 2015.

Zone	July-September ET Average	Deviation from CA Average	Conservation Adjustment
1	3.99	-37.01%	No Change
2	4.50	-28.97%	No Change
3	5.02	-20.87%	No Change
4	5.32	-16.04%	No Change
5	5.63	-11.15%	No Change
6	5.84	-7.94%	No Change
7	6.25	-1.42%	No Change
8	6.35	0.16%	No Change
9	6.65	4.94%	No Change
10	6.76	6.68%	3%
11	7.07	11.46%	3%
12	6.86	8.25%	3%
13	7.48	17.98%	3%
14	7.38	16.35%	3%
15	7.38	16.35%	3%
16	7.99	26.03%	4%
17	8.40	32.49%	4%
18	8.40	32.44%	4%

The second and third adjustments address growth impacts on water demand and local drought-resilient sources of potable supply. The State Water Board required additional information from water suppliers to receive an adjustment in these areas. In total, 95 growth adjustments and 65 drought resilient supply adjustments were approved. The cap for all adjustments combined was 8% per supplier. Most suppliers were approved (either through the default climate adjustment or through supplier submitted documentation to the State) for one adjustment. Seventeen suppliers received approval for 2 adjustments and just one supplier received approval for all three adjustments. Among all these adjustment categories, the State Water Board denied 39 adjustment requests. Even though the extended Emergency Regulation provided some adjustments to improve equity among water suppliers and their customers, it was not sufficient as the entire conservation target methodology was built on an inequitable base metric, R-GPCD. Until the base of the method is refined, these adjustments provided a small and modest surface level fix. All adjustments took effect in March 2016 (SWRCB, January 2016).

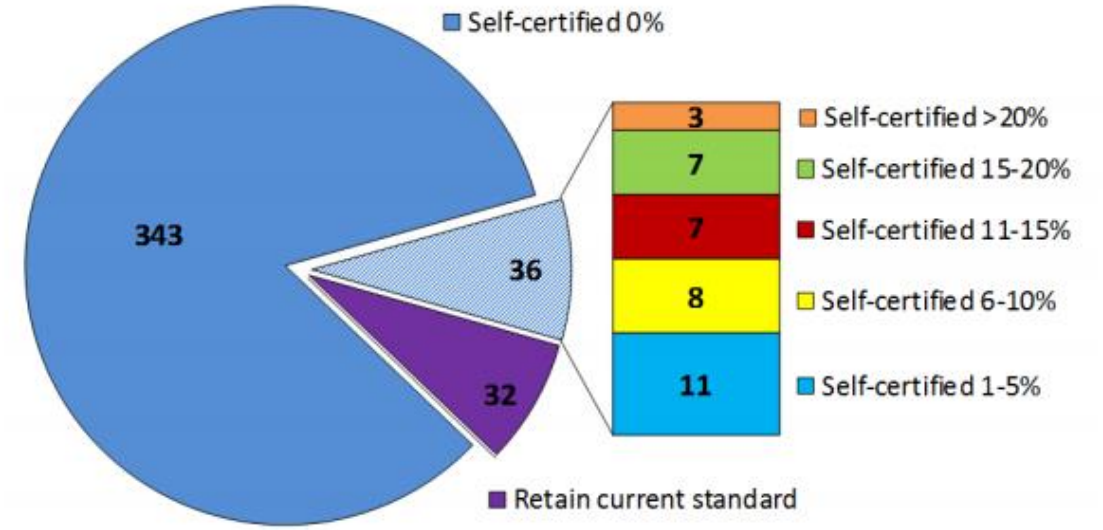
Unknown at the time, the opportunity for an entire overhaul of the method was around the corner. State Water Board staff monitored and evaluated available data on precipitation, snowpack, reservoir storage levels, and other factors in early 2016 and were directed to report back to the State Water Board in March and April 2016. And, if conditions warranted, they were also directed to bring a proposal for rescission or adjustment of the Emergency Regulation to the State Water Board in May 2016.

Water supply conditions continued to improve in the first half of 2016 compared to the last few years in parts of the State. The State Water Project, which supplies water to 29 public water suppliers serving 25 million people and about a million acres of irrigated farmland, had increased its allocation estimate to 30% of requests for 2016 (from 5% in 2014 and 20% in 2015). The increase was a result of winter storms building up Sierra Nevada snowpack (DWR, February 2016). In January 2016, snowpack was 115% of historical average, compared to 25% in January 2015 and 20% in January 2014. However, by March 1, 2016, snowpack had dropped to 83% of historical average thanks to February's hotter and drier weather. The March snowpack also had lower water content than normal for the time of year, which has implications for how much runoff was expected to fill nearby reservoirs during late spring and summer (DWR, March 2016). At the same time, Folsom Reservoir was spilling water for flood protection as a result of increased water availability from several storm systems. Early and mid-March storms looked hopeful for increasing snowpack in time for the April 1st snowpack measurement. DWR estimated that the State needed 150% of average winter precipitation (rain and snow) by April 1st to "significantly ease statewide conditions" for surface water supplies (DWR, February 2016). Ultimately the April 1st snowpack measurement was reported at 86% of average for that date, about half of DWR's estimated need, but an improvement from the previous few years. The resulting spring 2016 conditions made it less politically feasible for the State Water Board to continue the same level of conservation targets through 2016 as they did in 2015.

E. Transition to the Stress Test

Based on the improved 2016 water supply conditions, the State Water Board adopted an alternative method to replace the R-GPCD based conservation target approach at the May 18, 2016 State Water Board meeting. This alternative method, effective in June 2016, became known as the "stress test" and provided an additional option apart from the state mandated conservation targets. Water suppliers could choose to maintain their current state mandated conservation target or submit "stress test" documentation to receive a reduced conservation target based on evidence of sufficient water supply. The stress test was a step towards a more technically sound drought response, which incorporates current and projected water supply for each water supplier. To comply with the stress test, water suppliers self-certify they have sufficient supplies (for an assumed additional three dry years) by submitting a form to the State Water Board. The form included wholesaler and local supply information, estimated demand, and recognition of significant investments in alternative supplies such as recycled water and groundwater banking. If a water supplier could show sufficient supplies for three additional dry years, their updated conservation target would be 0%. If they could not show sufficient supplies, their updated conservation target would become the percent difference between available supplies and projected demand. This type of approach was consistent with water shortage contingency plans already required by the State for every urban water supplier. All but 32 of the 411 major urban water suppliers in the State chose the stress test option (Figure 17) (SWRCB, August 2016). Most of those suppliers, 343, that chose the stress test, certified at a 0% conservation target, meaning they had sufficient water supplies for current deliveries and for an additional three dry years. Only 36 suppliers that submitted for the stress test maintained some level of conservation target. In summary, by the middle of 2016, the large majority of the State's urban water suppliers showed they had sufficient supplies. However, the extended emergency regulation remained in effect until January 2017, so water suppliers continued to report monthly to the State Water Board on their conservation targets, water waste prohibitions, and enforcement activities.

Figure 17: Number of Water Supplier Stress Test Self-Certifications by Percent Reduction versus Current Standard. Source: State Water Board, 2016.



*The above results include one supplier new to reporting that also submitted "stress test" information, bringing the total number of urban water suppliers to 411.

F. Enforcement Efforts

To incentivize water suppliers to meet their conservation targets, the State Water Board set up an enforcement structure, authorized through the series of Executive Orders described above. The structure changed slightly throughout the 2014-2016 time period but in general is outlined below in Table 19 (SWRCB, 2019). While the enforcement structure is clearly defined in some ways (Table 19, description and details columns), it was unclear how the enforcement actions (warning letter, notice of violation, informational order, and conservation order) were linked to the monetary fine ($10,000 a day for noncompliance, referenced in the Executive Orders). The State Water Board had the authority to fine water suppliers but did not provide specific guidelines on how fines would be assessed. This lack of detail put water suppliers in the difficult situation of trying to justify to their rate payers and Boards the significant costs of additional public outreach efforts and water conservation programs needed to meet their targets versus the potential cost effectiveness of simply paying the fines. While water suppliers generally support using water efficiently, especially during droughts, supplier managers also felt a responsibility to balance conservation with the potential increases in operational costs that could increase rates for all customers. Most urban water suppliers in California are public agencies, relying on water rates to fund operations. Some water suppliers felt that incurring unnecessary costs that could raise water rates, especially when they had sufficient and available water supply, was irresponsible as a public agency.

Table 19: Compliance Priorities and General Enforcement Strategy from June 2015 - May 2016. Source: State Water Board, 2015.

Priority	Description	Details
1	More than 15 percentage points below standard	Each priority 1 supplier receives a Notice of Violation and Informational Order. Meetings are arranged with State Water Board staff to assess the circumstances preventing the supplier from achieving their conservation standard. Some of the suppliers will receive Conservation Orders.
2	5 to 15 percentage points from meeting standard	Each priority 2 supplier is sent a Notice of Violation and Informational Order. Priority 2 suppliers have two weeks to provide information on water production, water use, and water conservation efforts. Based on this information, Water Board staff assesses the need for a Conservation Order. If a Conservation Order is warranted, Water Board staff will meet with the supplier before issuing an order.
3	0 to 5 percentage points from meeting standard	Warning letters are sent to priority 3 suppliers.
0	Meeting Standard	The State Water Board congratulates the suppliers that met, or were within one percent of meeting, their conservation standard.

Despite this ongoing conundrum, water suppliers geared up to meet their targets by increasing water conservation programs, public outreach messaging, and water waste patrols. However, all of these actions came with costs. Water suppliers lost revenue from selling less water and also paid more for customer enforcement and conservation programs. An informal statewide survey by the Association of California Water Agencies (ACWA) and the California Municipal Utilities Association (CMUA) suggested a collective $528.5 million revenue loss from June 2015 through February 2016 for the 85 responding water suppliers. Extrapolating these losses to the rest of the State's water suppliers, the total statewide revenue loss was estimated to be more than $3 billion (ACWA, 2016).

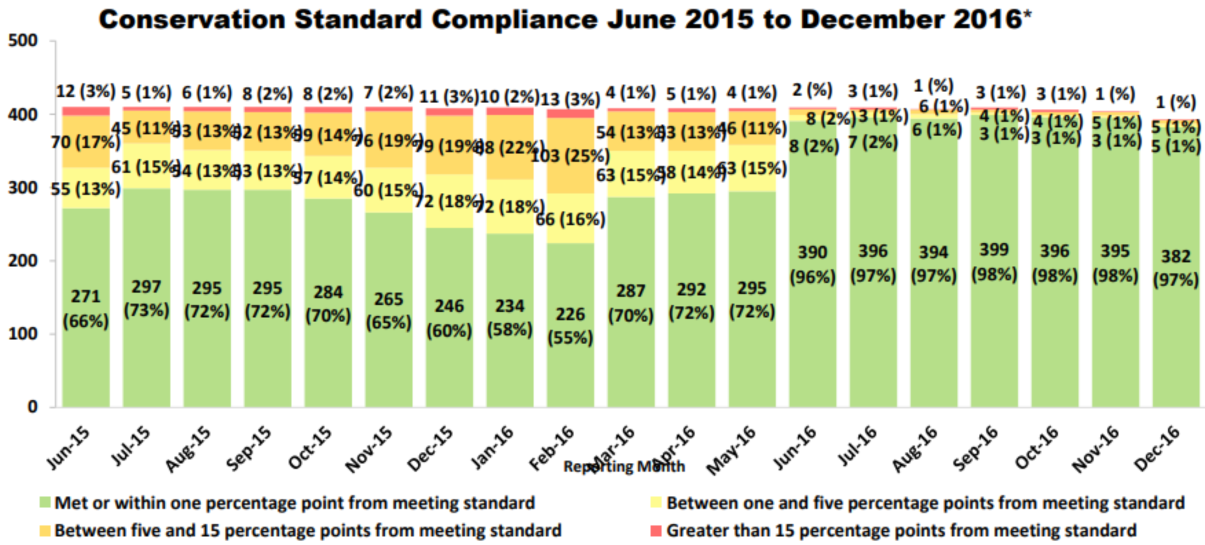
By the time the stress test was effective in June 2016, only 4 suppliers were fined for $61,000 each. Those suppliers were the cities of Beverly Hills, Indio, and Redlands, and the Coachella Valley Water District. They received fines because they "consistently failed to meet their water conservation goals" (SWRCB, October 2015). Ironically, the suppliers that were fined likely spent less money paying the fine than suppliers that met their targets through reduced revenues and increased conservation and enforcement costs. For example, the City of Sacramento lost $5.5 million in revenues and spent $1.8 million on conservation programs for January through September 2015 to help meet their target (RWA, 2015). From a fiscal responsibility perspective, the City of Sacramento would have lost less money doing nothing to conserve and paying the fine considering the city had ample water supply during and after this time period. Collectively, the Sacramento region alone lost an estimated $25 million in revenues primarily from reduced water sales from January through September 2015 (RWA, 2015). Without clearly defined enforcement rules, suppliers were unable to fully understand the costs and benefits of their decisions to rate payers regarding the conservation regulation.

Lastly, the State Water Board was authorized to enforce the State's adopted emergency regulation water waste prohibitions described above on individuals throughout the state. However, it's unclear if the State Water Board used this authority on a wide scale. The general understanding was that most enforcement on water waste prohibitions happened at the local water supplier level. The State Water Board did create a statewide water waste reporting webpage to collect water waste complaints and direct them to the appropriate local supplier. The webpage received limited use during the drought and was moved to the statewide public outreach Save Our Water website after the drought and has now been removed altogether. Local water suppliers generally already had an existing water waste reporting process in place prior to the drought. Furthermore, local enforcement of water waste information transferred from the State website was difficult and at times not allowed to be used in a formal citations as some water suppliers require photo documentation of water waste for sufficient legal coverage to issue a citation or violation.

In terms of communication of enforcement efforts, the State Water Board staff gave monthly presentations to the State Water Board during their Board meetings on the status of statewide and regional conservation savings, number of suppliers reporting, and number of suppliers meeting their targets among additional information for several years.[21] Figure 18 shows an example of a graphic included in those monthly updates. A notable trend in Figure 18 is associated with the stress test. The stress-test based regulation period began in June 2016 and resulted in many suppliers having a zero percent conservation target. With 393 water supplier reports submitted for December 2016, 382 suppliers (97 percent) met or were within one percentage point of their conservation standard; five suppliers (1 percent) were between one and five percentage points of meeting their conservation standard; five suppliers (1 percent) were between five and 15 percentage points of meeting their conservation standard, and one supplier was more than 15 percentage points from their conservation standard. Compliance increased as targets decreased, as expected. Another perspective on this trend was that the stress test more accurately represented the number of suppliers that, from a supply standpoint, actually needed to conserve, which were much fewer in number than with the previously mandated targets.

[21] A full collection of monthly Board presentations, fact sheets, and more materials is available here. https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/emergency_regulation.html

Figure 18: Supplier Compliance with Conservation Targets. Source: State Water Board, 2017.



* Includes suppliers under alternative compliance orders. Alternate compliance orders do not substitute for individual conservation standards, however, suppliers meeting the terms of their alternate compliance orders are not priorities for enforcement.

G. Effectiveness of the Conservation Standard

After all of this effort from the State, local water suppliers, residents, and businesses, did California actually save water? Were the conservation standards effective?[22] The simple answer is yes. Statewide water savings from June 2015 through May 2016 (the beginning and ending of the State assigned mandatory targets) was 24.5% (compared to 2013) or 524,000 million gallons, just shy of the State mandated savings of 25% (SWRCB, July 2016). At the state level, cumulative urban savings as of December 2016 were holding steady around 22.5% through the end of the year, which is impressive considering the lack of State mandated conservation targets since June 2016 (Figure 19). As expected, savings differed between regions, as did the State mandated conservation targets, and statewide and regional savings remained steady as well through the end of 2016 (Table 20). Furthermore, the net water saved varied throughout the State based on water sources, location, and return flows to local waterways (consumptive versus non-consumptive use). In summary, the State mandated and achieved significant urban water savings during the peak of the drought with the assistance of numerous state, regional, and local entities and actions. To better understand how local suppliers achieved those savings, Chapter 4 summarizes the drought related response activities of the Sacramento region and its 21 water suppliers.

[22] For this purpose, effectiveness means did the actions of the state and local water suppliers produce the desired effect, which in this case was to save 25% compared to 2013. It's debatable if the method used to obtain the savings was an efficient method.

Figure 19: Statewide Water Reductions. Source: State Water Board, 2017.

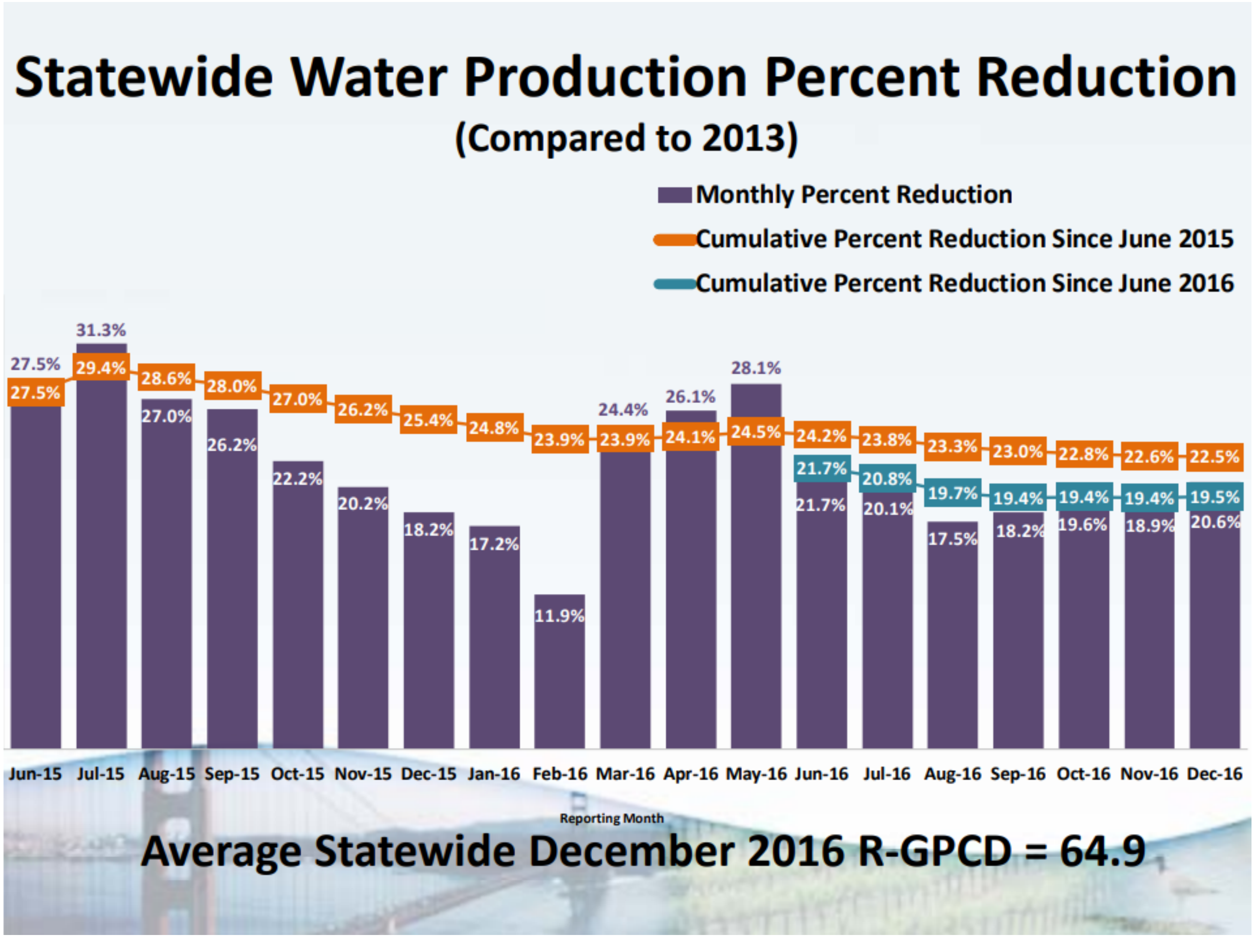


Table 20: Conservation Percentages by Hydrologic Region, compared to 2013. Source: State Water Board, 2017.

Hydrologic Region	Jun 15	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15	Jan 16	Feb 16	Mar 16	Apr 16	May 16	Jun 16	Jul 16	Aug 16	Sep 16	Oct 16	Nov 16	Dec 16
Central Coast	30.6%	31.9%	28.1%	26.9%	24.1%	27.3%	24.7%	19.2%	20.7%	30.4%	29.0%	31.5%	24.7%	26.4%	25.2%	24.9%	26.8%	29.1%	29.1%
Colorado River	25.2%	34.0%	24.7%	17.4%	24.4%	21.3%	10.8%	28.5%	18.0%	17.6%	30.2%	29.3%	23.8%	23.7%	15.1%	7.2%	11.1%	20.6%	11.7%
North Coast	16.0%	32.5%	19.7%	20.0%	16.8%	18.0%	20.3%	19.5%	14.4%	13.6%	27.7%	29.5%	8.9%	23.5%	15.5%	11.7%	21.8%	24.0%	19.2%
North Lahontan	29.8%	32.4%	25.0%	16.2%	10.0%	12.9%	18.8%	27.7%	23.2%	18.4%	30.7%	42.7%	19.5%	13.9%	10.6%	7.6%	16.4%	16.6%	18.7%
Sacramento River	36.3%	37.4%	34.5%	28.0%	25.5%	31.3%	24.6%	13.4%	20.6%	36.6%	30.4%	35.4%	23.4%	23.6%	18.6%	15.3%	30.6%	35.5%	23.4%
San Francisco Bay	32.3%	32.3%	30.5%	25.3%	23.3%	26.8%	23.5%	13.2%	18.1%	25.1%	28.8%	30.9%	22.5%	22.4%	21.1%	17.9%	26.0%	27.4%	22.8%
San Joaquin River	33.4%	34.7%	30.0%	26.7%	26.7%	31.2%	20.2%	15.4%	17.1%	35.2%	32.7%	34.3%	24.7%	24.3%	19.7%	19.2%	26.2%	29.3%	19.9%
South Coast	22.9%	28.2%	23.7%	26.7%	20.6%	14.1%	15.9%	18.0%	6.9%	20.9%	22.8%	24.2%	20.0%	17.0%	15.3%	19.5%	15.7%	12.3%	20.5%
South Lahontan	31.1%	35.9%	29.3%	25.8%	22.9%	18.8%	5.0%	18.4%	13.1%	27.8%	27.5%	25.3%	24.0%	17.0%	23.5%	13.4%	17.5%	15.2%	2.8%
Tulare Lake	29.4%	32.2%	28.0%	25.9%	22.1%	28.3%	21.7%	15.8%	17.2%	27.0%	30.1%	31.1%	24.2%	22.7%	18.6%	18.9%	15.5%	18.3%	19.1%
Statewide	27.5%	31.3%	27.0%	26.2%	22.2%	20.2%	18.2%	17.2%	11.9%	24.4%	26.1%	28.1%	21.7%	20.1%	17.5%	18.2%	19.6%	18.9%	20.6%

IV. Chapter 4: Analysis of Drought Response in the Sacramento Region

A. 2014 Regional Drought Perspective

While the 2014 drought year affected different areas of the State differently, the Sacramento region recognized local dry conditions as early as fall of 2013 and served as the 'canary in the coal mine' for the Governor's 2014 drought declaration. The Sacramento region builds from the confluence of the Sacramento and Lower American Rivers, which serve both local and statewide water users. Typically, the Sacramento region is less susceptible to drought because of its diverse water supplies (Table 2). However, the winter of 2013/2014 was an exception.

On November 20, 2013, Folsom Reservoir, which provides about half of the region's water supply, held 251,261 acre-feet of water or 53% of the historical average storage for that date (CDEC, 2014). This caused concern and action. On December 20th, water suppliers, environmentalists, and business leaders convened to create a regional action plan to minimize water supply and environmental impacts to the Lower American River, which is directly downstream of Folsom Reservoir. Solutions were further complicated because water releases from Folsom Reservoir are controlled by United States Bureau of Reclamation (USBR) for water supply for municipal, irrigation, industrial, power, fish and wildlife, and Sacramento-Bay Area Delta water quality as explained in Chapter 2. This water source must meet these multiple objectives even during drought.

On December 23, 2013, the City of Folsom became the first water supplier in the State to require a 20% reduction in water use from customers due to drought conditions. The city's sole water source is Folsom Reservoir. Shortly after on January 9, 2014 the RWA's Board of Directors, which represents 21 Sacramento area water suppliers, including the City of Folsom, passed a resolution to urge all member water suppliers to reduce water use by 20%. This action was taken eight days before the Governor officially declared a statewide drought on January 17th, calling for all Californians to reduce their water use by 20%.

By April 2014, most of the region's water suppliers were requesting or requiring at least a 20% reduction in use from their customers. By November 2014, fourteen water suppliers were requesting or requiring an "up to 20% reduction" and five water suppliers were requesting or requiring an "up to a 30% reduction." These reduction decisions were based on each water supplier's water shortage contingency plans, which contain a step-by-step guide to increasing water reductions in response to water shortage conditions and actions customers must take to realize those savings. The Sacramento region's water suppliers surpassed the Governor's 2014 request (not requirement) for a 20% reduction from the State's residents because there was a local need to save water due to local water supply conditions. From January 2014 through December 2014, the Sacramento region collectively reduced water use by 30,000 million gallons (92,000 acre feet) compared to the same period in 2013, an overall decrease in use of 19.3% (RWA, 2015).[23] Table 21 shows 2014 water savings, which represents cumulative monthly production of RWA's member suppliers plus the cities of Woodland and Davis.[24] The region's

[23] 2013 was chosen by the State as the baseline to compare current water production to calculate savings figures. The rationale provided was that it was the most recent year of data not influenced by drought conditions.

[24] The cities of Woodland and Davis are not RWA member suppliers but agreed to provide RWA with production data during the drought because they share water sources with many RWA suppliers. All water production and savings information provided in this chapter include Woodland and Davis data.

savings represented 20% of the State's total water savings from June through December 2014 despite having 5% of the population (SWRCB, February 2015).

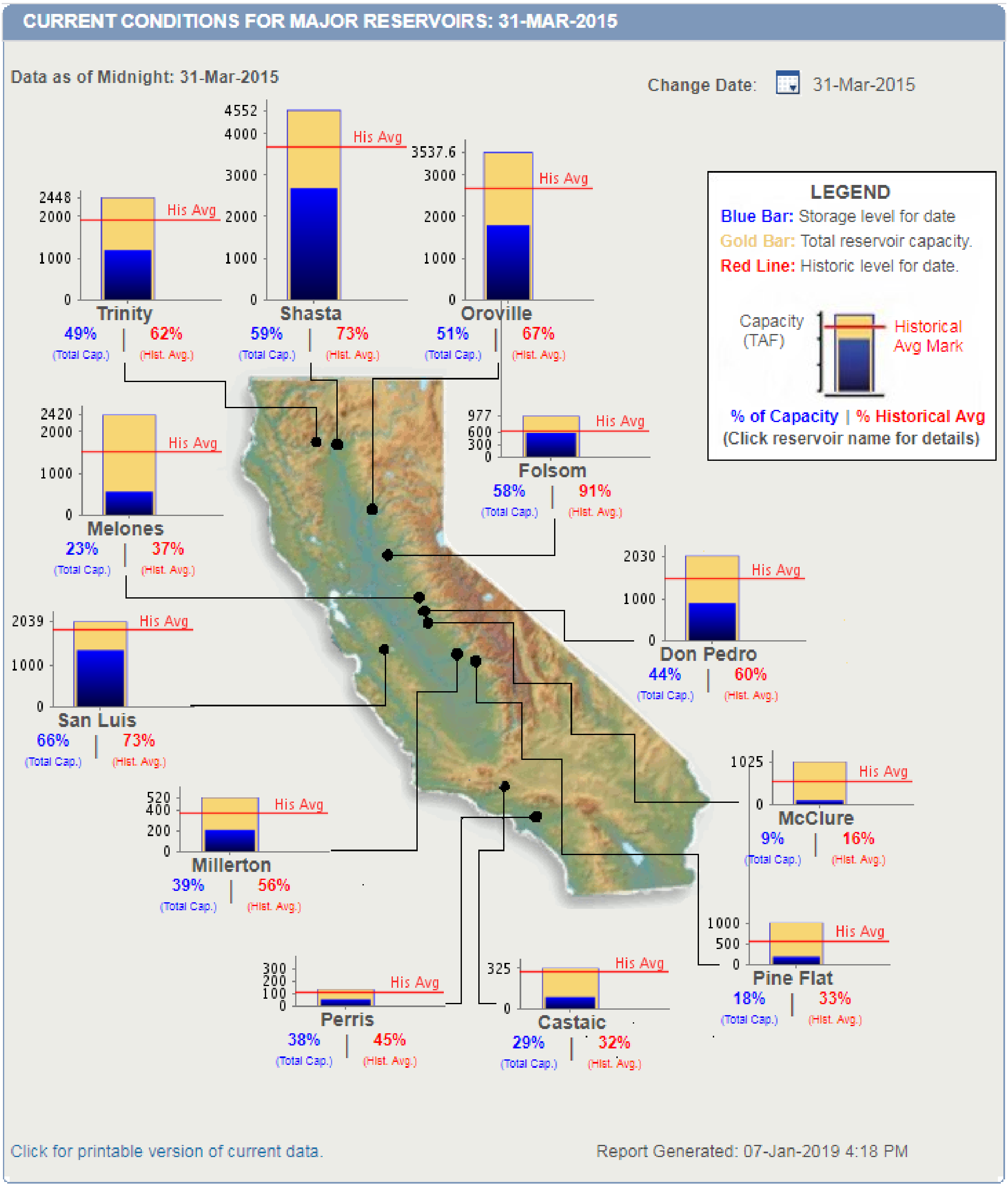
During 2014, the Sacramento region focused on coordinating conservation messaging, ramping up local conservation programs such as toilet rebates, hiring or reassigning local supplier staff for water waste enforcement, collaborating with neighboring water suppliers to provide alternative supply options, and meeting with local environmental groups to minimize the impacts of reduced flows from Folsom Lake on fish and wildlife. Most of these activities were implemented using existing local and regional funding and were locally implemented (with each supplier deciding what level of water use reductions, programs, and public outreach were needed for their service area) with regional coordination (regular meeting to share local activities, collective media buys, and consistent messaging) (RWA, 2014). The region succeeded in setting and meeting its own conservation targets in 2014.

Moving into 2015, State water supply conditions continued to be below normal, especially for the central and south coastal regions. However, locally the Sacramento region's water supplies recovered and were considered (at least hydrologically) no longer in drought conditions, with Folsom Reservoir's supply reporting at 91% of historical average (CDEC, 2015). Figure 20 shows State reservoir levels in at the end of March 2015.

Table 21: 2014 Sacramento Region Monthly Water Savings. Source: RWA, 2015.

2014 Regional Monthly Water Savings in Million Gallons													
	Jan	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total**
2014	7,528	5,719	6,741	8,034	12,069	15,554	16,196	14,996	13,357	11,201	7,216	6,090	124,702
2013	6,333	6,602	9,218	11,048	16,025	17,968	20,742	19,335	15,975	13,680	9,804	7,729	154,459
%	-18.9%	13.4%	26.9%	27.3%	24.7%	13.4%	21.9%	22.4%	16.4%	18.1%	26.4%	21.2%	**19.3%**

Figure 20: Statewide Major Reservoir Conditions, March 31, 2015. Source: CDEC, 2015.



B. State Mandated Conservation Targets and Water Savings

Facing increasingly dire water supply conditions from the statewide perspective, the State chose to manage the drought in 2015 using top-down conservation mandates, an approach typically exercised only by local water suppliers. Empowered by Governor Brown's Executive Orders, the State Water Board in coordination with the DWR, developed and mandated conservation target for each of the State's 411 large urban water suppliers based on current R-GPCD values. The method is described in more detail in Chapter 3. The targets were in place from June 2015 through May 2016.

Table 22 shows the State mandated conservation targets for the region's water suppliers as original assigned in June 2015, with adjustments (described in Chapter 3) as of March 2016, and suppliers' actual water savings during both the original mandate period (June 2015-February 2016) and the entire mandate period, June 2015-May 2016. Almost all water suppliers met their adjusted conservation targets by the end of the final mandate period. All suppliers were within 1% of their targets, even though the Sacramento region carried some of the highest conservation targets in the State.

Table 22: Conservation Targets and Savings by Water Supplier, Source: RWA, 2017.

Water Supplier	Initial Conservation Target June 15-Feb. 16	Water Savings June 15-Feb. 16	Adjusted Conservation Target* March 2016	Water Savings June 15-May 16**	Water Savings** Compared to Conservation Target*
California American Water	20%	34.2%	17%	35.6%	18.6%
Carmichael Water District	36%	33.2%	33%	34.8%	1.8%
Citrus Heights Water District	32%	33.9%	29%	34.6%	5.6%
City of Davis	28%	26.1%	25%	27.2%	2.2%
City of Folsom	32%	26.0%	28%	26.7%	-1.3%
City of Lincoln	32%	31.7%	28%	32.2%	4.2%
City of Roseville	28%	34.1%	25%	34.2%	9.2%
City of Sacramento	28%	28.4%	25%	29.2%	4.2%
City of West Sacramento	28%	31.3%	25%	31.1%	6.1%
City of Woodland	24%	29.8%	20%	31.9%	11.9%
City of Yuba City	32%	26.3%	28%	27.0%	-1.0%
Del Paso Manor Water District	25%	33.9%	25%	35.4%	10.4%
El Dorado Irrigation District	28%	29.6%	24%	31.9%	7.9%
Elk Grove Water District	28%	34.9%	25%	35.3%	10.3%
Fair Oaks Water District	36%	34.9%	33%	36.1%	3.1%
Golden State Water Company	36%	30.1%	32%	30.9%	-1.1%
Orange Vale Water Company	36%	36.5%	33%	39.7%	6.7%
Placer County Water Agency	32%	29.5%	28%	28.5%	0.5%
Rancho Murieta CSD	25%	25.6%	25%	28.3%	3.3%
Rio Linda/Elverta CWD	36%	32.3%	33%	33.0%	0.0%
Sacramento County WA	32%	34.4%	24%	33.9%	9.9%
Sacramento Suburban WD	32%	29.7%	29%	30.5%	1.5%
San Juan Water District	36%	35.0%	33%	36.0%	3.0%
Minimum	20.0%	25.6%	17.0%	26.7%	-1.3%
Maximum	36.0%	36.5%	33.0%	39.7%	18.6%

To track progress for the region as a whole, RWA collected water production data from all member water suppliers and the cities of Woodland and Davis and calculated and monitored an additional regional conservation target. The regional target was calculated from the State assigned conservation target for each supplier, multiplied by their 2013 use during the same time frame to produce a saving estimate in gallons, which is then totaled for all suppliers in the region. The regional target could then be compared to current production during the same time frame for all suppliers to assess if the region met the target. The regional target for June 2015 through February 2016 (first emergency regulation time period) was 29.67%. During this same time, the region achieved a 30.73% savings, effectively meeting the regional target, even though not all individual suppliers met their local targets (as shown in Table 22). For the full conservation target period (June 2015-May 2016) including the adjustments, the regional target dropped 44,000 million gallons and landed at 26.0% as compared to 2013. During this same time, the region achieved a 31.5% savings. Calculating a regional target was especially helpful for public outreach and media related inquires. Instead of a television station calling up 21 water suppliers in the region, they could report on a regional target as a proxy for conservation progress, which may have been more appropriate considering their audience of listeners spans multiple cities and counties.

Tracking savings was difficult during 2015 and 2016 due to the rapid adoption and extension of the emergency regulation (which included continuous modification of conservation targets) and the associated timelines and effective dates. To maintain a semblance of consistency, Tables 23 and 24 provide regional water savings by month for 2015 and 2016 for the Sacramento region, similar to the 2014 savings above.

In summary, from both local and regional perspectives, the Sacramento region overall reduced water deliveries by 19%, 30%, and 25% for 2014, 2015, and 2016 respectively. The large remainder of this chapter describes how the region's water suppliers met their targets through local supply and demand management measures. Coordinated regional demand management measures also are discussed.

Table 23: 2015 Regional Monthly Water Savings. Source: RWA, 2016. [25]

2015 Regional Monthly Water Savings in Million Gallons													
	Jan.	**Feb.**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total**
2015	6,714	6,179	8,781	9,282	10,536	12,419	13,789	13,866	12,560	10,759	7,131	6,217	118,233
2013	6,958	7,228	10,087	12,100	17,433	19,488	22,418	20,859	17,316	14,836	10,649	8,433	167,806
%	3.5%	14.5%	13.0%	23.3%	39.6%	36.3%	38.5%	33.5%	27.5%	27.5%	33.0%	26.3%	**29.5%**

Table 24: 2016 Regional Water Savings. Source: RWA, 2017.

2016 Regional Water Savings in Million Gallons													
	Jan.	**Feb.**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Total**
2016	6,154	5,900	6,354	8,435	11,413	15,136	17,257	17,190	14,696	10,357	6,910	6,407	126,210
2013	6,954	7,233	10,095	12,105	17,472	19,483	22,418	20,855	17,311	14,836	10,649	8,430	167,840
%	11.5%	18.4%	37.1%	30.3%	34.7%	22.3%	23.0%	17.6%	15.1%	30.2%	35.1%	24.0%	**24.8%**

[25]The baseline of 2013 usage varies slightly between 2014, 2015, and 2016 due to water suppliers refining data over time and the correction of reported errors.

C. Supply Management Efforts

Several supply management actions by water suppliers during the drought reduced water use from leak detection and repair, system pressure reduction, adoption of drought water rates, and limited conjunctive use. Accelerating leak detection and repair during drought allowed water suppliers to potentially save large quantities of water in a short time by dedicating more funding and staff. Increased surveying for leaks and fixing those leaks faster has potential to save more water than a supplier's water efficiency programs (Sturm and Thornton, 2007). Exact water savings were difficult to calculate for water loss activities and not undertaken by all suppliers. During the drought, at least three suppliers in the region accelerated water loss leak detection and repair (RWA, 2015).

Six water suppliers reduced their distribution system pressure for either all or parts of their service areas (RWA, 2015). Water distribution systems maintain a fixed level of pressure, typically at least 20 pounds per square inch (PSI), to ensure reliable water service to customers and sufficient pressure to respond to fires (Ghorbanian, 2016). A downside of continuous water service is that any leaks leak continuously. Reducing distribution system pressure even by a few PSI, reduces flow rates on all system leaks, and so reduces leakage volume. Pressure reduction is not an option for all suppliers. Some systems cannot reduce pressure for a variety of reasons including service area elevation or lack of elevation (flat service areas). Also, some systems with more variable topography have multiple pressure zones, so pressurization throughout the system is fragmented and more complex to manage. Regardless of the challenges, some suppliers did reduced pressure during the drought.

Several suppliers in the region triggered drought-based water rates to incentivize reduced water use and recover lost revenue. The City of Roseville triggered their drought rates in 2014. San Juan Water District and Citrus Heights Water District triggered drought rates in 2015, when the State's mandatory targets were implemented. Carmichael Water District and El Dorado Irrigation District had drought rates available but did not trigger them. Most of the region's water suppliers do not have a drought rate option as part of their rate structure; however, all water suppliers experienced revenue loss from decreased water sales. To balance budgets, the lost revenue must be recouped through drought rates, reserve funds, raising rates, or another strategy. In the Sacramento region, nine suppliers raised rates between January and October 2015; two suppliers planned and implemented rate increases in 2016. Although most increases were previously planned, two were directly attributed to drought revenue losses (RWA, 2015).

Lastly, the Sacramento region used conjunctive use to mitigate drought conditions throughout 2015. Several suppliers that predominately use surface water reduced diversions from the Lower American River and increased groundwater withdrawals during an 8-month period at the height of the drought. The impacts of those actions can be seen in Table 3, showing decreased percent surface water and increased percent groundwater for 2014 and 2015 compared to prior and future years. However, the region did not reach its full conjunctive use potential because water supply conditions improved for the region in the spring of 2015 making conjunctive use an option and less of a necessity, especially considering that groundwater is generally a more expensive to produce than surface water (assuming it's available).

D. Demand Management Efforts

Demand management actions including rebate programs, direct installation, audit services, and public outreach also were implemented. Unlike supply management actions, demand management relies on customer participation. While reductions can be large, demand actions require considerable staff time and funding and often ongoing commitment by customers to change behavior. A myriad of water conservation and efficiency programs were implemented during the drought by the region's water suppliers. Many programs were already in place before the drought but were expanded with additional staff or funding. Rebates and direct installation were among the most widely implemented programs.

Rebate programs provide incentives by covering some of the cost of purchasing a higher efficiency fixture like a toilet or clothes washer. The incentive varies by water supplier and program type. For example, toilet rebates in the region range from $30 to $150 (BWS, 2018). This is often a factor of available funding, partnership participation, supplier conservation/efficiency goals, and/or customer participation. Rebates also were provided for outdoor water efficient practices like "cash for grass" programs, which provided a $/square foot incentive (ranging from $0.50 to $3.00) to remove grass lawn that generally uses more water and replace the landscape area with native or low water plants like lavender.

Rebate programs are relatively cost-effective compared to other programs. A drawback of rebate programs is that while a water supplier knows that the new fixtures are purchased (customers generally must submit receipts), they don't know if the fixture was actually installed. Some water suppliers make a follow up visit to confirm installation, but this is usually only for a small subset of rebates issued due to staff constraints. Table 25 shows a sample of rebate programs in the Sacramento region during the drought and the number of participating suppliers for each program. Table 26 shows the number of rebates for each program reported to RWA through an online survey (n=16) (RWA, 2015).

Table 25: 2015 Rebate Program Supplier Participation. Source: RWA, 2015.

Rebate Program	Number of Participating Suppliers
Cash for Grass	7
Toilet Replacement	10
Clothes Washer Replacement	10
Irrigation Efficiency/Survey	12

Table 26: 2015 Rebate Programs-Reported. Source: RWA, 2015.

Rebate Program	Number of Rebates
Cash for Grass	926
Toilet Replacement	3,368
Clothes Washer Replacement	732
Irrigation Efficiency/Survey	587

Direct installation programs of water-efficient fixtures were also implemented, especially at the regional level. RWA managed several grant-funded direct installation programs from 2014-2016. Direct installation programs are similar to rebate programs in that they accelerate replacement of older less efficient fixtures. However direct installation programs fund both fixture purchase and installation. Table 27 shows the number of properties, type and number of fixtures and funding by year. Most participating properties were in areas considered Disadvantaged Communities (DACs) or served residents of DACs.[26] RWA has continued this program and more than doubled the number of toilet installations and units served post-drought, with an additional $2.5 million in funding in 2017 and 2018.

Table 27: 2014-2016 Direct Installations. Source: RWA, 2018.

Installations	2014	2015	2016	Total
Toilets	576	1,528	1,943	4,047
Showerheads	393	940	1,141	2,474
Aerators-Bath	504	743	1,162	2,409
Units	480	1,269	1,589	3,338
Properties	80	58	33	171
Funding	$146,800	$374,000	$492,200	$1,013,000

Water suppliers also provided a range of water efficiency related services including several water use audit programs geared toward residential, commercial, industrial and institutional (CII) audiences and large landscape surveys (Table 28). The audit services typically provide an in-person visit from a water supplier staff member (or consulting firm) to assess outdoor water use on the property and provide the customer with a custom watering schedule to optimize water efficiency and healthy landscape goals. In-home water use consultations or Water Wise House Calls are generally aimed at residential customers and provide a comprehensive assessment of indoor and outdoor water use, custom water savings tips, fixture replacement recommendations, and available rebates.

Table 28: 2015 Service Program Supplier Participation. Source: RWA, 2015.

Service Program	Number of Participating Suppliers
Residential Survey	13
CII Survey	12
Large Landscape Survey	11
Water Wise House Calls	13

[26] Disadvantaged Communities can be defined in many different ways. For the purpose of this thesis, the following definition is preferred and was directly linked to grant funding received by RWA. https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

Public Outreach Efforts
Drought related public outreach programs influence customer behavior to reduce water use by providing information about local conservation targets and related enforcement actions in the context of related state actions. During the drought, there were three distinct layers of public outreach campaigns in the Sacramento region: state, regional, and local.

At the state level, the Save Our Water (SOW) campaign had an active website (www.saveourwater.org) for customers to communicate water waste inquires, access statewide rebate programs for toilets and turf replacements, and learn water savings tips. The campaign produced ads, infographics, and videos that could be used at the local level with the addition of a supplier's logo. Additionally, SOW purchased billboard, online, and radio ad space throughout the State and encouraged partnerships with local water suppliers to join their media ad purchases with matching dollars. In non-drought years, the SOW campaign's budget is typically $1 million and is appropriated through the Governor's budget. During the drought, the SOW budget increased to $4 million in 2015-2016 and $5 million in 2016-2017 (LAO, 2015; LAO, 2016). After the drought, the budget returned to $1 million in the 2017-2018 budget (LAO, 2018). In a State of 39 million people, a budget of $0.03- $0.12 per person is small, especially considering the extensive and pervasive water supply challenges of California. Typically, local campaigns aim for $0.50/per person for budgeting purposes (Maddaus, 2014). However, in practice, this aspirational goal is rarely met, especially on a continuous basis.   All State media related efforts (Governor's Executive Orders, State Water Board, Department of Water Resources, etc.) during the drought promoted the SOW website and materials.   With such a limited budget, the campaign also relied on regional and local suppliers to adopt the campaign's ads and promote it within their own service areas. Figures 21 shows a 2016 SOW advertisement.

Figure 21: 2016 Save Our Water Campaign. Source: SOW, 2016.

Regional public outreach efforts during the drought were coordinated through the RWA's Water Efficiency Program (WEP), a regional program created in 2002 to increase water efficiency programs and outreach messaging in the Sacramento region. Most years the WEP public outreach budget hovers around $100,000 ($0.05 per person) but can increase 2 to 3-fold as grant funding is available. During the drought, the WEP public outreach budgets were $99,000 in

2014, $99,000 in 2015, and $123,000 in 2016 (RWA, 2015; RWA, 2016).[27] The public outreach budget was supplemented with DWR grant funding ($190,000) in 2016 (RWA, 2016). Additionally, in response to the mandated targets in 2015, the RWA member water suppliers raised an additional $150,000 to extend radio and online ads year round. Due to the program's limited funding, messaging is typically targeted for March through September of each year to coincide with peak seasonal water use.

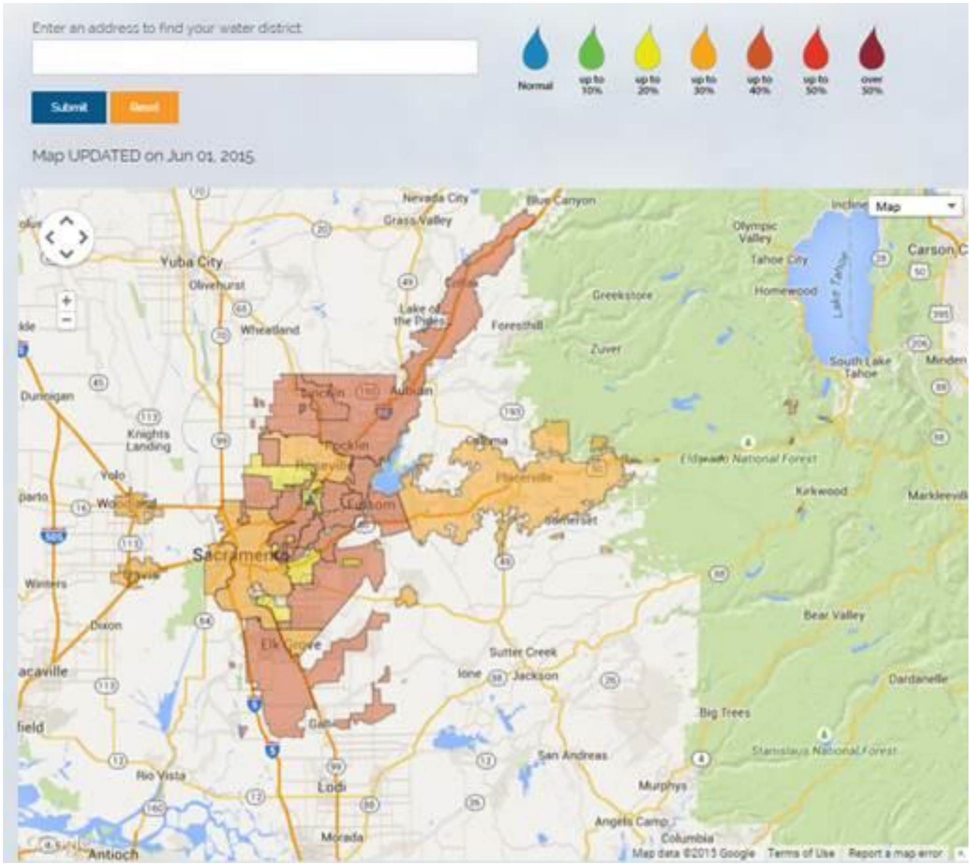
The public outreach program caters to two audiences: local water suppliers and the general public. For local water suppliers during the drought, the WEP provided templates for talking points for communicating with customers, social media posts, weekly editorial calendars, and customer newsletter text. The program also shared a photo gallery, top ways to save tips with associated water savings estimates, sample bill inserts, and table top informational cards for restaurants. Finally, the WEP also provided staff support for informational booths at variety of public outreach events throughout the region including Harvest Day and the Home and Garden Show.

For the general public, the WEP maintained a public facing website (Figure 22) for the region, www.bewatersmart.info, which contains a plethora of information including an interactive drought map that featured outdoor watering guidelines (Figure 23), water waste hotlines, and rebates for all member water suppliers. To further promote the Program's messages, the WEP program manager participated in 10-20 radio and television interviews a year during the drought. Furthermore in 2015, WEP partnered with ABC News 10 and their Chief Meteorologist, Monica Woods, to provide viewers with water conservation tips during her weather segments (Figure 24). WEP also partnered with the Sacramento River Cats, the region's semi-professional baseball team, to post advertising in the season programs and on the back of all the restroom stall doors in the stadium to take advantage of a "captive audience" (RWA, 2015).

[27] School education and landscape related budgets not included.

Figure 22: 2015 Homepage for bewatersmart.info. Source: RWA, 2015.

Figure 23: Interactive Drought Map. Source: RWA, 2015.



CITY OF SACRAMENTO

Water Source: Sacramento and Lower American Rivers, Groundwater

Landscape Guidelines:

- Currently, our winter watering schedule is in effect. Landscape watering limited to one day a week, either Saturday or Sunday (no watering Monday through Friday) between Nov 1st through February 28th.
- Between March 1st to October 31st, residents may water their landscape two days a week before 10 a.m. and after 7 p.m. (watering days for an odd numbered address is Tuesday and Saturday. An even number address is Wednesday and Sunday).
- New landscaping has a 30 day variance for watering, as long as there is no runoff into the gutters. Smart controller, hose watering, and hand watering exemptions began November 1, 2017.

Other General Guidelines:

- Car washing only permitted on landscape watering days.
- Provide information to customers on ways to reduce their water use.

Conservation Contact: William Granger Phone: (916) 808-1417
Water Waste Phone: (916) 264-5011
Website: www.sacwaterwise.com

Figure 24: Partnership with Monica Woods, News 10. Source: RWA, 2015.

The WEP public outreach program is based on one to two-year campaigns that focus on a jointly agreed upon theme or water savings tip, and then produces the related campaign images, online ads, radio ad text, and other types of related messaging. The Program purchases advertising space including newspaper ads, online website ads (weather websites, google, etc.), radio ads, and social media ads (Facebook, Twitter) to display the campaign. Figures 25, 26, and 27 show a sample of the program's 2014, 2015, and 2016 WEP campaign ads during the drought (RWA, 2016). For the 2014 campaign, the focus was on challenging residents to see how "low they can go" in achieving water savings, but also reminded them that there is a balance between savings and quality of life. For the 2015 campaign, the focus was on encouraging indoor savings during winter, which are the lowest water use months. The "Show Us Your Drought Face" campaign encouraged people to save water and not shave during the winter to proudly and boldly show off their support for saving water during the drought. The campaign ran a contest on Facebook asking residents to post photos of their drought faces. The top 3 winning photos were displayed on a billboard for a couple months near the Cal Expo on I-80. For the 2016 campaign, the WEP partnered with SOW and used their advertising materials with some regional modifications. Nearing the end of the drought (for the Sacramento region), the focus in 2016 was on rehabilitating residents' landscapes, asking them to rethink what their yard means to them, and encouraging the use of locally appropriate plants. Similar to 2015, the program hosted an online contest and displayed the winning low water use landscapes on billboards throughout the region. Lastly, the WEP has won numerous awards for their campaigns and educational efforts during the drought including Most Effective Social/New Media Category, Award of Distinction, California Association of Public Information Officials, "Show Us Your Drought Face!" Campaign and the National 2016 WaterSense® Excellence in Education and Outreach Award from the U.S. Environmental Protection Agency (EPA).

Figure 25: 2014 Outreach Campaign: How Low Can You Go?. Source: RWA 2014.

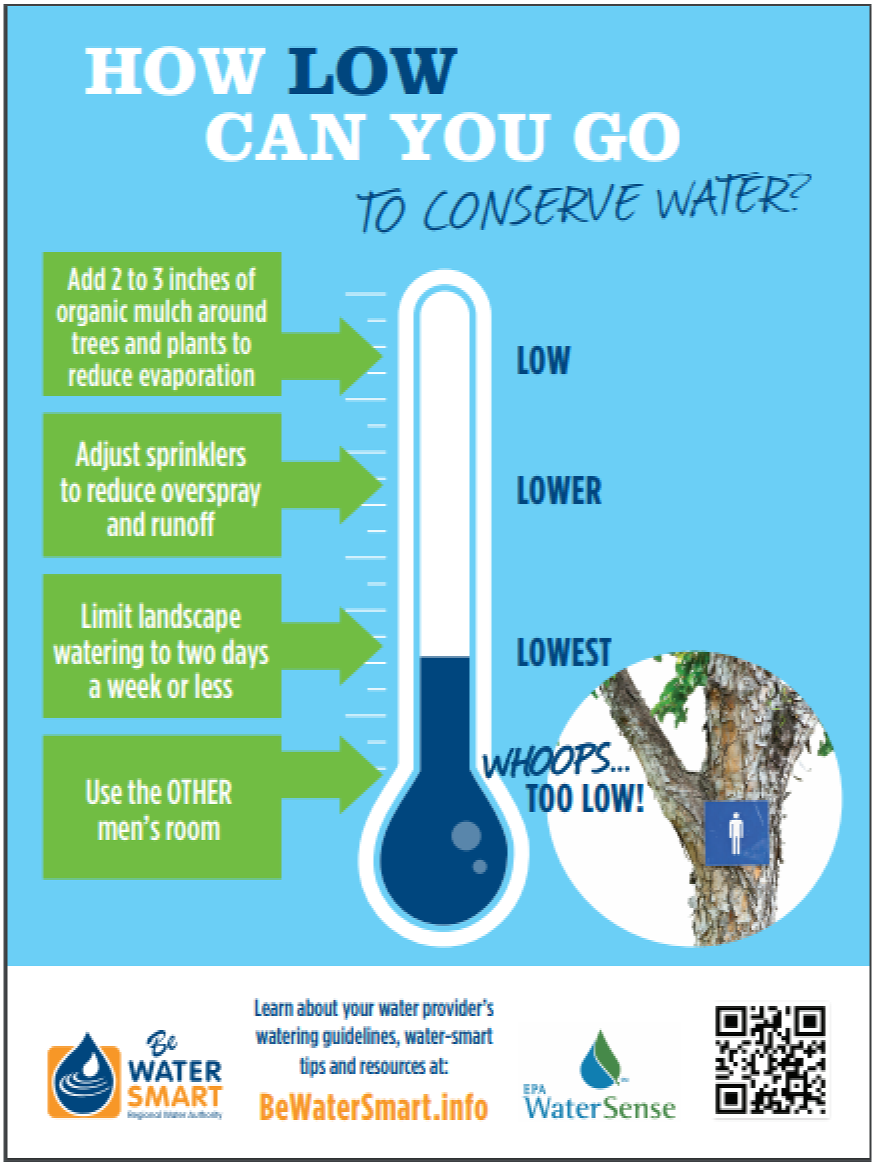
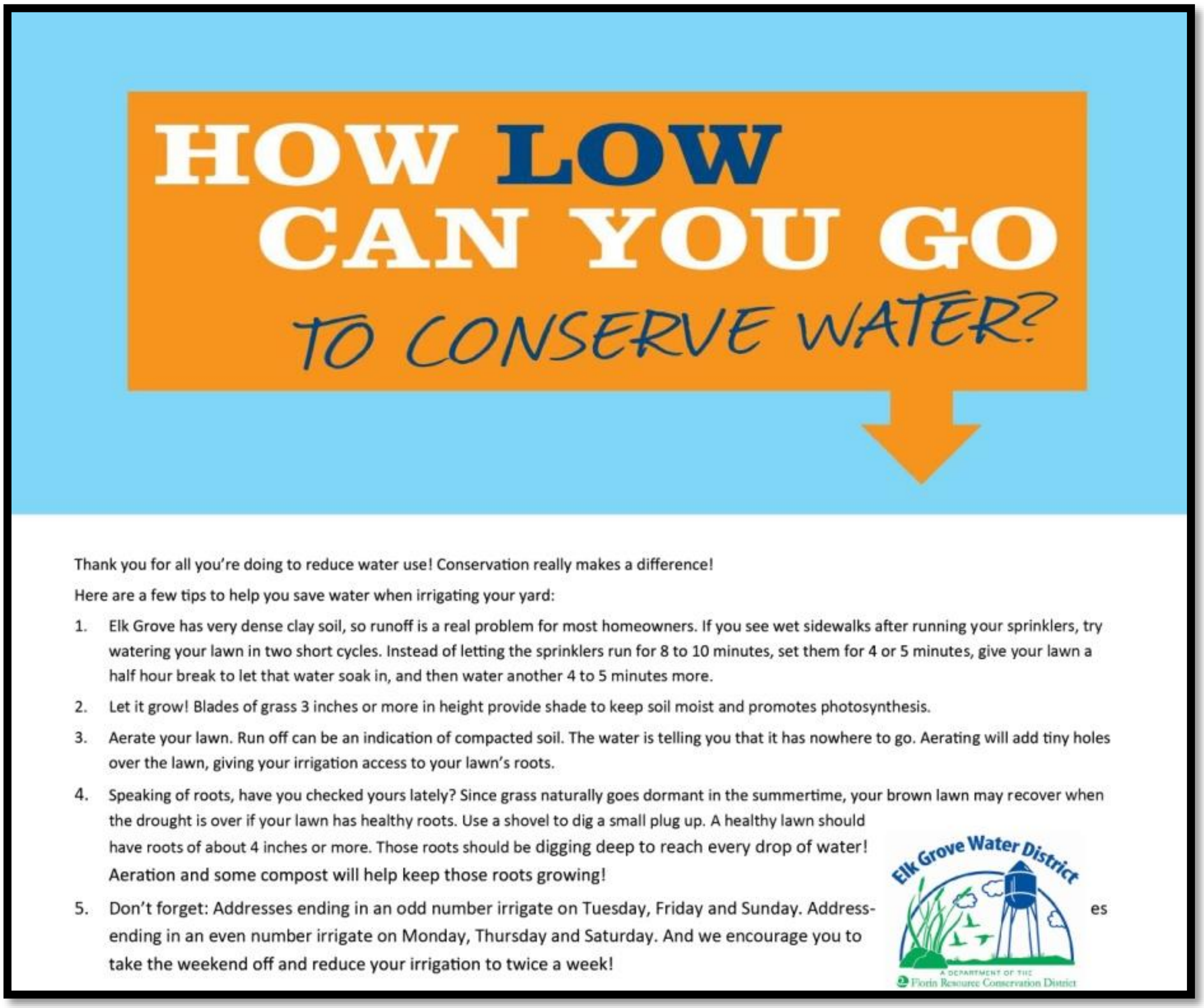


Figure 26: 2015 Public Outreach Campaign: Show Us Your Drought Face. Source: RWA, 2015.

Figure 27: 2016 Public Outreach Campaign: Rethink Your Yard. Source: RWA, 2016.

At the local water supplier level, public outreach programs during the drought varied greatly from supplier to supplier with annual budgets ranging from $1,000-5,000 to $250,000 at the high end (RWA, 2018). Some of the larger suppliers (more than 50,000 connections) developed their own standalone campaigns while smaller suppliers (less than 10,000 connections) primarily relied on RWA's WEP for their public outreach efforts. Other suppliers pursued a hybrid approach and used the WEP materials, but modified them to add their own local flavor. Local public outreach programs included many of the same activities implemented by the regional WEP including: purchasing advertising space on radio and online outlets, hosting booths at public events, creating customer newsletters, and maintaining a conservation focused webpage. Local suppliers coordinated their activities with the regional WEP to achieve wider customer reach. For example, if the regional program purchased radio ad space on Capital Public Radio then a local supplier may forgo that station and partner with another station to increase overall regional coverage and vice versa. Figures 28, 29, and 30 show examples of local public outreach program materials during the 2014-2016 drought.

Figure 28: Elk Grove Water District Bill Insert featuring WEP Campaign Design. Source: Elk Grove Water District, 2015.



HOW LOW CAN YOU GO
TO CONSERVE WATER?

Thank you for all you're doing to reduce water use! Conservation really makes a difference!

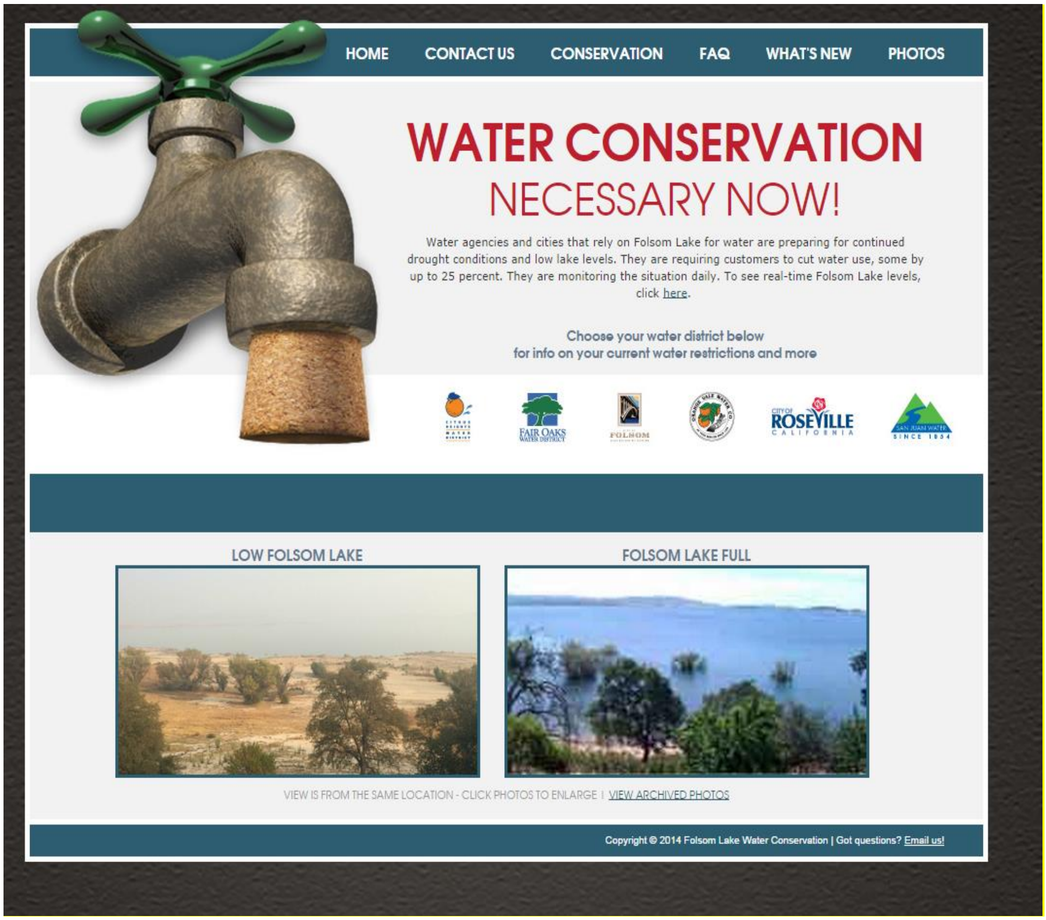
Here are a few tips to help you save water when irrigating your yard:

1. Elk Grove has very dense clay soil, so runoff is a real problem for most homeowners. If you see wet sidewalks after running your sprinklers, try watering your lawn in two short cycles. Instead of letting the sprinklers run for 8 to 10 minutes, set them for 4 or 5 minutes, give your lawn a half hour break to let that water soak in, and then water another 4 to 5 minutes more.
2. Let it grow! Blades of grass 3 inches or more in height provide shade to keep soil moist and promotes photosynthesis.
3. Aerate your lawn. Run off can be an indication of compacted soil. The water is telling you that it has nowhere to go. Aerating will add tiny holes over the lawn, giving your irrigation access to your lawn's roots.
4. Speaking of roots, have you checked yours lately? Since grass naturally goes dormant in the summertime, your brown lawn may recover when the drought is over if your lawn has healthy roots. Use a shovel to dig a small plug up. A healthy lawn should have roots of about 4 inches or more. Those roots should be digging deep to reach every drop of water! Aeration and some compost will help keep those roots growing!
5. Don't forget: Addresses ending in an odd number irrigate on Tuesday, Friday and Sunday. Address-es ending in an even number irrigate on Monday, Thursday and Saturday. And we encourage you to take the weekend off and reduce your irrigation to twice a week!

Elk Grove Water District
A DEPARTMENT OF THE Florin Resource Conservation District

Figure 29: City of Lincoln Watering Messaging. Source: City of Lincoln, 2015.

Figure 30: Website for Partnering Water Suppliers Dependent on Folsom Lake. Source: Folsom Lake Water Conservation, 2015.



The local public outreach programs and the water supplier staff that work on them were the backbone for the water savings during the drought. Local programs can communicate directly with customers (compared to State and regional campaigns) and more effectively educate customers on how to save water during the drought and beyond. Local supplier staff received water waste calls from customers to investigate. They also explained and administered local rebate programs, surveys, audits, and water wise house calls.

E. Drought Response Summary

Tables 29 and 31 summarize the demand management programs and outreach activities implemented during the drought through a 2015 RWA administered survey, organized by supplier size (n=15). Tables 30 and 32 show the possible demand program and outreach survey answer choices for local water supplier staff. The results are organized by supplier size to produce a more equitable evaluation based on the assumption that similar sized suppliers have more comparable staff and funding resources available to them. For these results, supplier size is defined by the following criteria: small (<12,000 connections), medium (12,001-20,000 connections), and large (>20,000). Data is self-reported by each participating water supplier.

Table 29: Demand Program Summary. Source: RWA, 2016.

Question	Small Suppliers (n=4)	Medium Suppliers (n=4)	Large Suppliers (n=7)
Most Cost Effective	Local Public Outreach Program	Water Wise House Calls	Irrigation Efficiency Rebates Cash for Grass
Most Staff Intensive	Cash for Grass Residential surveys Large Landscape survey	Cash for Grass	Cash for Grass
Most Popular	Residential surveys	Cash for Grass Water Wise House Calls	Cash for Grass
Most Savings	Local Public Outreach Program	Water Wise House Calls	Cash for Grass Irrigation Efficiency Rebates

Table 30: Demand Program Survey Response Choices. Source: RWA, 2016.

Demand Program Survey Response Choices	
Cash for Grass	Large Landscape Survey
Toilet Rebates	Residential Retrofit Kits
Clothes Washer Rebates	Pre-rinse Spray Valves
Irrigation Efficiency Rebates	Water Wise House Calls
Indoor Fixtures Direct Installation	Local School Education Program
Residential surveys	Local Public Outreach Program
CII surveys	

Table 31: Implemented Outreach Methods. Source: RWA, 2016.

Question	Small Suppliers (n=4)	Medium Suppliers (n=4)	Large Suppliers (n=7)
Implemented Outreach Method	Mailers Door tags Social media posts Supplier website	Mailers Door tags Social media posts Newspaper ads Supplier website E-blasts	Mailers Door tags Social media ads Social media posts Personalized conservation information reports Supplier website E-blasts

Table 32: Implemented Outreach Methods Survey Response Choices. Source: RWA, 2016.

Outreach Survey Response Choices	
Mailers	Newspaper ads
Door tags	Television ads
Online ads (weather.com, etc.)	Personal calls to select customer groups
Social media ads (Facebook, etc.)	Personalized conservation information reports
Social media posts (Facebook, twitter)	Supplier website
Billboards	E-blasts

Several observations can be made from these data. First, there is no magic bullet or combination of demand management measures that can guarantee savings. Every supplier, regardless of size, implemented their own mix of actions. However, some actions were more common among similar sized suppliers. For example, small suppliers tended toward less expensive and less staff intensive activities like mailers, door tags, social media posts, and supplier website for public outreach. As size increases, medium suppliers include paid advertising with newspaper ads. As size increases again, large suppliers supplement their efforts with more paid activities like social media ads and individual customer conservation reports. The trend continues with most savings results. Large suppliers reported that cash for grass and irrigation efficiency rebate programs save the most water of the programs listed. However, small and medium suppliers are less likely to offer programs like cash for grass in the first place due to limited financial and staff resources so their choice of answers are limited before they answer. If small suppliers had the full suite of programs like larger suppliers, they might respond differently to the savings question (or they may not).

Table 29 also shows results for the most cost-effective program. Public outreach programs received the most total votes. However, for medium sized suppliers, results were more diverse and there was no clear “winner.” One explanation for these results is that even though the suppliers may be of similar size, they may differ significantly in water sources portfolio, infrastructure design and layout, and operational costs, which influence the cost effectiveness of conservation and efficiency programs (typically based on the cost of the next unit of water). Furthermore, individual supplier administration and implementation of these programs can differ significantly, changing costs compared to neighboring suppliers.

Relationships between the different categories also can be identified. For example, the most popular program from a customer perspective (Table 29), cash for grass, was also reported as the most staff intensive program by suppliers. While customers might receive thousands of dollars to remove turf grass and replace it with lower water use plants, water supplier staff often have to make pre- and post- installation visits to the property to ensure the program was implemented as expected. This staff time is much more resource-intensive than processing mail-in rebate forms for other programs from the supplier office.

Table 33 provides additional information by supplier size to add context to the program and outreach efforts in Tables 29 and 31. Water savings from June 2015 through June 2016 (compared to 2013 monthly production) by supplier size were collected. Surprisingly the water savings percentages between different sized suppliers were relatively consistent despite the large diversity of programs implemented. One explanation could be because most mandated conservation targets were also in the same range (28% to 36%). Regardless, achieving water savings is not an exact science because it is largely based on human behavior, making the relative consistency of outcomes between different sized suppliers even more impressive. Perhaps the most eye-opening observation is that the water savings go far beyond what a supplier could expect based only on the number of rebates and services administered and their directly associated savings. During the drought, it was clear that rebate program participation alone only provided a small portion of water savings during the drought. It seems that public outreach programs, with influence from the media, provided the most significant portion of savings. Although this hypothesis is hard to quantify and prove, researchers at Stanford University are attempting to evaluate this assertion and have started analyzing public web searches as a metric for public outreach program impact (Quesnel and Ajami, 2017).

Table 33: Survey Water Supplier Details. Source: RWA, 2016.

	Small (n=4)	Medium (n=4)	Large (n=7)
Cash for Grass Rebates	0	0	918
Toilet Rebates	213	212	3135
Clothes Washer Rebates	63	30	635
Irrigation Efficiency Rebates	94	7	485
Water Wise House Calls	157	413	3839
Issued Water Waste Fines	2	3	4
Average Watering Days	2	2	2
Assess to Drought Pricing	2	1	2
Saving June 2015 - June 2016	33.8%	32.3%	30.7%

In addition to supplier size, water savings outcomes might be thought to vary by suppliers that are fully metered or partially metered. Five Sacramento region urban water suppliers are partially metered, meaning not all customer connections (mostly residential) have meters (Table 34).[28] The Pacific Institute, a California-based nonprofit that focuses on creating and advancing

[28] Note: Table 35 displays metering status as of 2015 and does not incorporate current metering progress (found in Chapter 2). Del Paso Manor Water District and Rancho Murieta Community Service District are not urban water suppliers and are not beholden to the 100% metered by 2025 legal requirement.

“solutions to the world’s most pressing water challenges” stated that meters are important to help customers use water efficiently and that metering can produce considerable water savings at the local level (Donnelly and Cooley, 2014). However, observed savings in the Sacramento region show similar savings regardless of customer metering status. Table 35 shows that metered (100%) and partially metered (less than 100%) suppliers achieved similar levels of savings during the drought. This table includes suppliers that have 100% Advanced Metering Infrastructure (AMI) deployment (i.e. “smart” meters), partial AMI and/or Automatic Meter Reading (AMR) deployment, and standard metering infrastructure. While not all factors can be accounted for with this high-level view of the data, the data suggest that meters were not a deciding factor in achieving savings. That said, water suppliers are in the process of extending metering to all connections to improve management, but also to meet the existing legal requirement that all partially metered urban water suppliers in the State need to be fully metered by 2025 (Assembly Bill 2572, Kehoe, September 29, 2004. California Water Code Section 527). Ninety percent of water connections in the Sacramento region were metered in June 2016. By the end of 2018, the percentage increased to 94%.

Table 34: Supplier Conservation Results and Metering Status. Source: RWA, 2017.

Water Supplier[29]	June 15-May 16 Reduction	Percent Metered in 2016
California American Water	34.2%	100%
Carmichael Water District	29.2%	100%
Citrus Heights Water District	31.1%	100%
City of Davis	31.9%	100%
City of Folsom	27.0%	100%
City of Lincoln	35.4%	100%
City of Roseville	31.9%	100%
City of Sacramento	34.8%	70%
City of West Sacramento	34.6%	80%
City of Woodland	35.3%	100%
City of Yuba City	36.1%	100%
Del Paso Manor Water District	35.6%	5%
El Dorado Irrigation District	30.9%	100%
Elk Grove Water District	39.7%	100%
Fair Oaks Water District	28.5%	100%
Golden State Water Company	26.7%	92%
Orange Vale Water Company	28.3%	100%
Placer County Water Agency	33.0%	100%
Rancho Murieta CSD	33.9%	100%
Rio Linda/Elverta CWD	30.5%	100%
Sacramento County Water Agency	27.2%	89%
Sacramento Suburban Water District	32.2%	94%
San Juan Water District	36.0%	100%

Table 35: Savings Comparison between Fully Metered vs Partially Meter Suppliers, June 2015-May 2016. Source: RWA, 2017.

Fully Metered Suppliers	% Savings	Partially Metered Suppliers	% Savings
Savings Average	32.5%	Savings Average	31.9%
Savings Median	31.9%	Savings Median	33.4%
Savings Minimum	27.0%	Savings Minimum	26.7%
Savings Maximum	39.7%	Savings Maximum	35.6%

[29] Notes: CWD=Community Water District, and CSD=Community Service District.

F. Volumetric Water and Energy Savings Summary

The absolute volume of water saved (compared to percentages in Tables 34 and 35) differed drastically among suppliers. As expected, volumetric savings for larger suppliers were proportionally greater than for smaller suppliers (Table 36). The Sacramento region saved approximately 53,000 million gallons between June 2015 and May 2016, with individual supplier savings ranging from 166 to 11,000 million gallons. The region's water savings equates to providing water to 477,000 average households in the region for a year, assuming 304 gallons per household per day (RWA, 2018). This savings represented 10% of the statewide savings of 524,000 million gallons during the same time period (SWRCB, July 2016).

While the volume of water savings from the drought is impressive, the accompanying energy savings is perhaps more impressive. The drought-related energy use reduction was one positive unintended consequence of the drought. Table 36 shows volumetric water and energy savings from June 2015-May 2016 for the Sacramento region. Where available, the local water supplier's unique energy intensity was provided. Where not available, the regional average energy intensity, 1,062 kilowatt hours per million gallon, was used (GEI Consultants, 2014). In total, the Sacramento region's drought related water savings of 52,860 million gallons saved 65,699,182 kilowatt hours (kWh) of electricity, equivalent to the average electricity used in 9,835 homes in California for a year (EIA, 2016).[30] Those energy savings can be translated into greenhouse gas (GHG) emission reductions, totaling 18,724 metric tonnes of carbon dioxide equivalents (MT CO_2e), equivalent to taking 4,070 passenger cars off the road for a year (EPA, 2018).[31]

A similar analysis was previously done to assess the electricity and greenhouse gas emission savings for the entire state based on the statewide drought water savings for 408 urban water suppliers for the same time period, June 2015 through May 2016. The results showed a total of 1,830,000,000 kWh in electricity savings and a GHG emissions reduction of 521,000 MT CO_2e was derived from 524,000 million gallons in water savings (Spang et al, 2018). The Sacramento region's electricity savings were only 3.5% of the State's savings. The study also evaluated the cost effectiveness of implementing water conservation programs to achieve electricity savings and GHG reductions (typically achieved from implementing energy efficiency programs by energy suppliers). The study concluded there is strong support for including water conservation in energy efficiency program portfolios and technology options.

[30] Assumes 6,680 kilowatt hours per household per year. 2016 data used for consistency with water savings data.

[31] Assumes 2015 emissions factor estimate for California electricity mix.

Table 36: Water and Energy Savings in Million Gallons (MG) and Kilowatt Hours (kWh). Source: RWA, 2018.

Water and Energy Savings in Million Gallons and Kilowatt hours (kWh)			
Water Supplier[32]	**Water Savings June 2015-May 2016 (MG)**	**Average Energy Intensity (kWh/MG)**	**Energy Savings June 2015-May 2016 (kWh)**
California American Water	4,226	1,465	6,190,775
Carmichael Water District	1,179	2,379	2,804,437
Citrus Heights Water District	1,680	2,001	3,362,148
City of Davis	1,093	1,062	1,160,614
City of Folsom	1,943	968	1,880,412
City of Lincoln	1,140	1,062	1,210,261
City of Roseville	3,809	1,062	4,044,880
City of Sacramento	11,134	999	11,123,230
City of West Sacramento	1,466	1,062	1,556,822
City of Woodland	1,268	1,062	1,346,831
City of Yuba City	1,508	1,062	1,601,570
Del Paso Manor WD	181	1,322	239,541
El Dorado Irrigation District	4,045	1,062	4,295,339
Elk Grove Water District	902	1,775	1,600,669
Fair Oaks Water District	1,443	2,287	3,300,840
Golden State Water Company	1,771	1,517	2,686,877
Orange Vale Water Company	665	1,062	706,096
Placer County Water Agency	2,834	1,062	3,009,249
Rancho Murieta CSD	166	1,995	331,747
Rio Linda/Elverta CWD	328	1,361	446,966
Sacramento County WA	4,489	1,696	7,613,804
Sacramento Suburban WD	3,837	1,209	4,638,949
San Juan Water District	1,754	312	547,126
Total	52,860	Not applicable	65,699,182
Minimum	166	312	239,541
Maximum	11,134	2,379	11,123,230

[32] Notes: CWD=Community Water District, CSD=Community Service District, WD=Water District, and WA=Water Agency.

G. Transitioning from Drought

In late 2016 through late 2017, the State received abundant rainfall, setting a new record of 95 inches compared to the long-term average of 50 inches, increasing the percent of average precipitation between October 2016 through September 2017 throughout the State (Figure 31) (DWR, CNRA, and CA, 2017). Additionally, DWR's April 1, 2017 snow survey showed snow levels at 163% of average (CDEC, 2017). These wet conditions drastically improved water supplies in 2017, including Folsom Reservoir's return to near average storage conditions (Figure 32).

Figure 31: Percent of Average Precipitation from October 1, 2016-September 17, 2017. Source: NOAA Climate Centers.

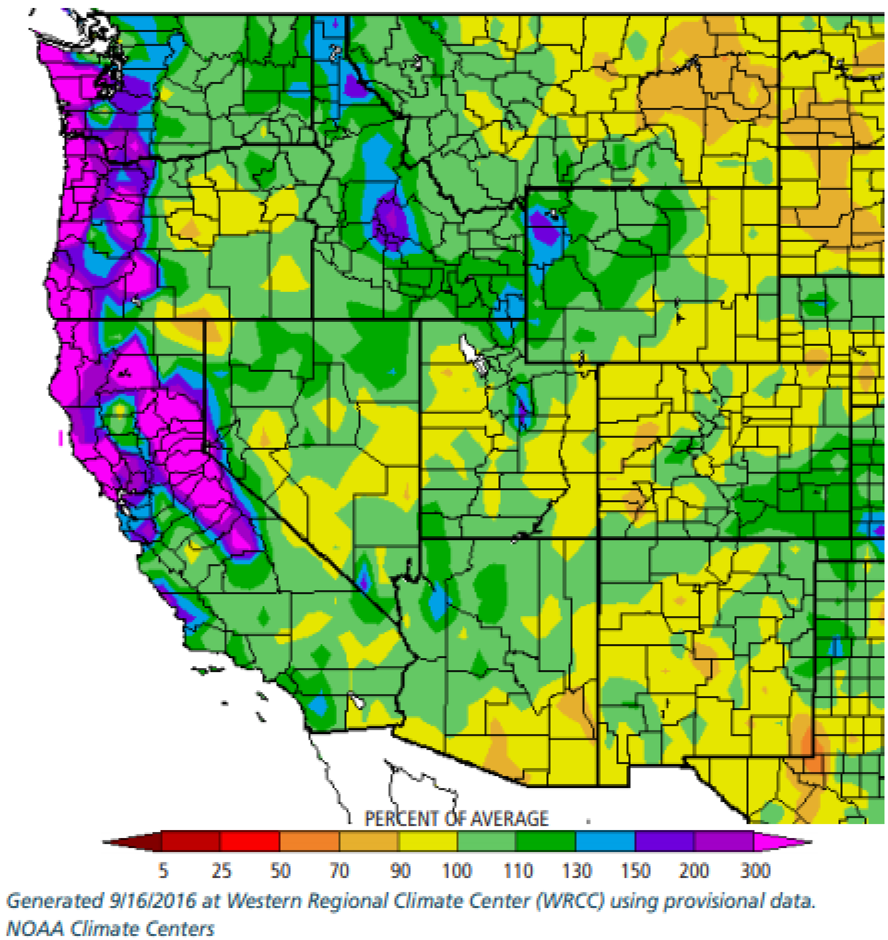
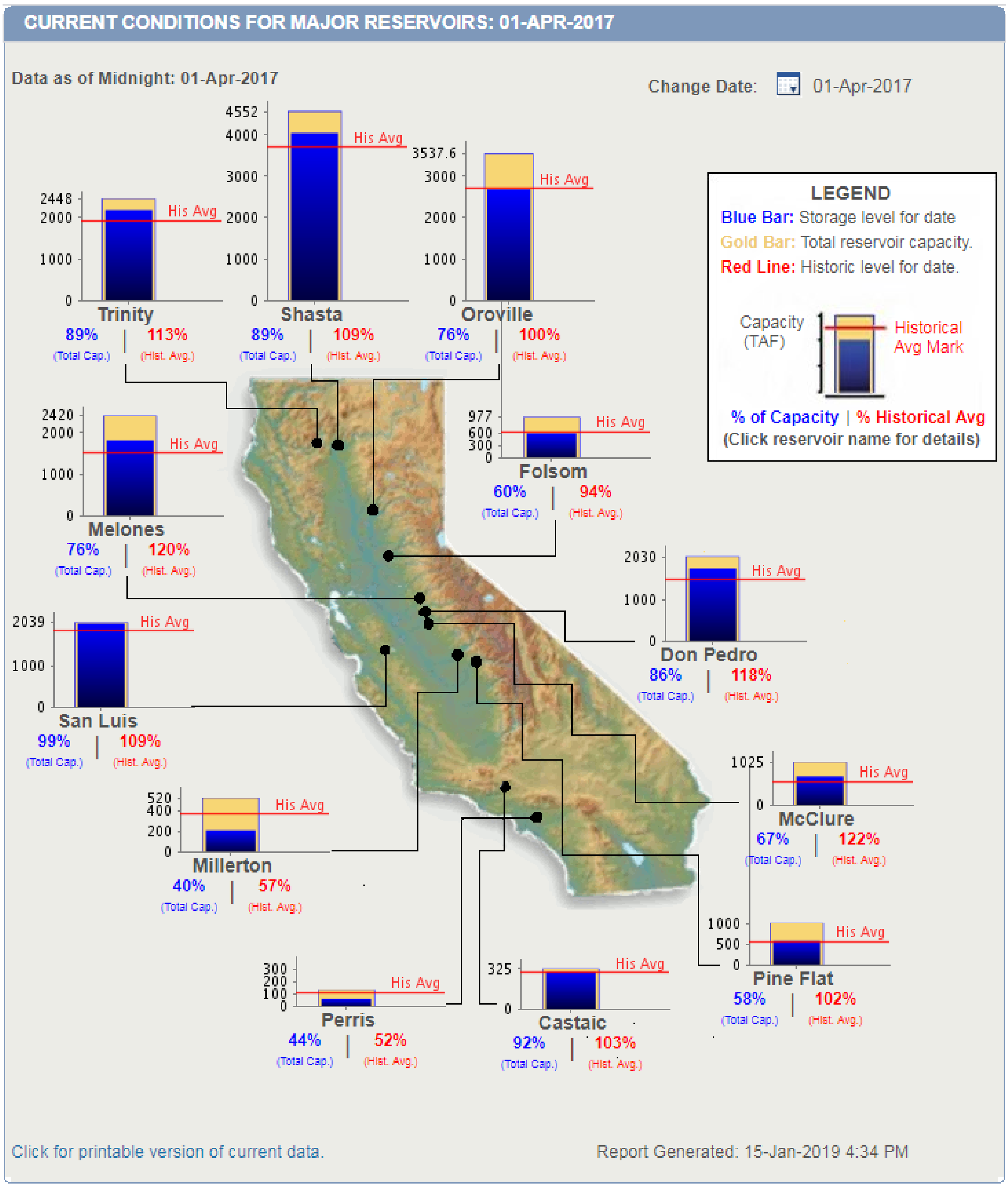


Figure 32: Reservoir Conditions as of April 1, 2017. Source: CDEC, 2017.



During the same time, water savings continued despite the end of state-mandated targets in June 2016 with a regional saving of 25% in 2016 and 20% in 2017, respectively, compared to 2013. Another way to look at the progressive decrease in savings is as water use rebound or recovery.

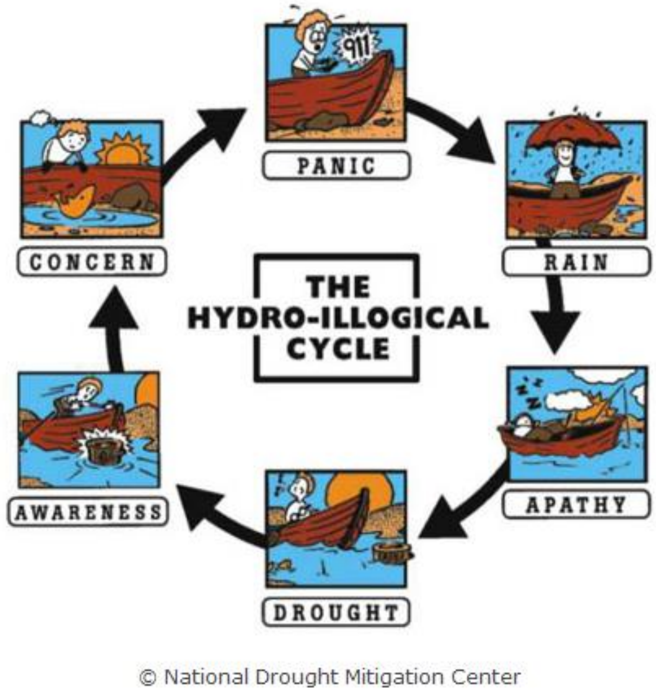
As water supply conditions improve and temporary restrictions are eliminated, the artificially constrained demand during drought returns back towards more normal levels. Although post-drought demand typically does not return to pre-drought levels, rebound post-drought is common, as shown through the statewide State Water Board data collected during and after the mandatory conservation period (SWRCB, 2019). For the Sacramento region, Table 37 shows estimated rebound both compared to the lowest use year 2015 and to the previous year.

Water use rebound has been interpreted differently. From a water supplier perspective, rebound is expected and often welcomed as revenue loss plagues most suppliers during drought. However, the State Water Board and media characterized the increase in production as "backsliding" from savings achieved during the drought (Bee staff and News Services, 2016). This approach assumes that water savings were to remain permanent after the drought, which misinterprets the distinctions between shorter-term water savings (drought) and longer-term water efficiency. There also was some fear that residents were falling victim to the so-called "hydro-illogical cycle" in which concern for the drought wanes after the rains come again, which prompts increases in water use until the next drought (Figure 33).

Table 37: Regional Production, Savings, and Rebound in Million Gallons, Source: RWA, 2019.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Savings from 2013	Rebound from 2015	Rebound from Previous Year
2013	6,953	7,232	10,094	12,105	17,472	19,483	22,413	20,855	17,311	14,848	10,649	8,430	167,844	N/A	N/A	N/A
2014	7,528	5,724	6,741	8,034	12,069	15,536	16,196	14,996	13,357	11,201	7,201	6,090	124,675	26.0%	N/A	-35.0%
2015	6,714	6,179	8,781	9,282	10,536	12,419	13,789	13,866	12,560	10,759	7,131	6,217	118,233	30.0%	N/A	-5.0%
2016	6,154	5,900	6,354	8,435	11,413	15,136	17,257	17,190	14,696	10,357	6,910	6,407	126,210	25.0%	6.0%	6.0%
2017	6,285	5,407	6,620	6,943	13,232	15,858	18,870	18,398	15,765	13,454	7,710	6,998	135,540	19.0%	13.0%	7.0%
2018	6,456	6,469	6,627	8,111	13,046	15,947	18,141	17,497	14,947	12,981	9,440	6,716	136,380	19.0%	13.0%	1.0%

Figure 33: "Hydro-Illogical Cycle"



Regardless of how it is characterized, water demand is rebounding, but remains significantly less than pre-drought levels. So, what does this mean for the future? As of end of 2017, the Sacramento region was still on track to meet the 20 X 2020 targets even with rebounding use from the drought (Table 7, Chapter 1; RWA, 2018). However, new legislation recently passed to surpass the 20 X 2020 targets in the next few decades, which will be discussed in Chapter 6. For now, it would be useful for the larger water community to accept the normalcy of drought, as a cycle with increases and decreases in water use according to water supply conditions (or State mandates) and related conservation efforts.

V. Chapter 5: Analysis of the State's Drought Policies

Now that the dust has settled from the drought, what lessons were learned? Looking back, several components of the State's drought policies worked and should be incorporated into the next statewide drought response. However, other components did not work, departed from basic water management, and inhibited creative responses and preparations by local and regional suppliers. Chapter 5 explores these dynamics, recognizing that no policy approach that satisfy all parties.

A. What Worked

This section focuses on four positive outcomes from the State's drought policies: prioritizing outdoor water use, improved reporting, elevating drought awareness, and coordination between water suppliers.

Prioritizing Outdoor Water Use

Focusing on reducing outdoor water use achieved significant savings, likely accounting for most of the residential water saved during the drought. Reducing outdoor water use in response to drought has been well documented (DWR, 1978; Mount et al., 2015) and is often preferred because it can be done quickly, has significant savings in most locations, and protects the lower volume indoor water uses that support public health and safety. Also, outdoor water use is always consumptive with little return to the system, unlike indoor use in much of the State that is treated and released (wastewater) for continued use. Especially important during drought (or any immediate and severe shortage), outdoor water savings can be instant. A person does not need to purchase and/or install anything, just change behavior, e.g., turn off or limit irrigation. There can even be positive aspects to reduced outdoor watering for the homeowner like less frequent mowing and healthier plants (Audubon, 2019). Furthermore, the average urban Californian uses 196 gallons a day (SOW, 2018). Outdoor water use is typically about half of urban use (from 30% to 60% based on location), with about 50% of that wasted from overwatering or evaporation (WaterSense, 2018). For these reasons, reducing outdoor water use was a logical focus for California's drought response in terms of quick and higher volume water savings.

However, for every action there is a reaction. Focusing on outdoor water use impacted the condition of urban landscapes during and beyond the recent drought (Hocker, 2019) Water starved lawns and trees are less functional as healthy landscapes, which provide a plethora of benefits to urban communities like reducing urban heat island effect, providing shade and energy savings for cooling homes, providing habitat for wildlife, carbon sequestration, improved air and water quality (STF, 2019; Nowak and Crane, 2002). Additionally, trees and shrubs can take decades to replace if lost during drought compared to grass. More research is needed to better understand the long term impacts of implementing this short term drought response.

Improved Reporting

Executive Order B-29-15 required water suppliers to report monthly information on water use, conservation achieved, and any related enforcement actions. The data was posted on the State Water Board website each month (for the previous month). However, public posting of data was a double-edged sword. It confirmed an open and transparent process by the State Water Board and held urban water suppliers accountable for their conservation efforts to customers, the State, and other interested parties. However, the data occasionally was misinterpreted by a third party and released as fact, often even citing the State Water Board as their source. This second-hand situation is unavoidable with dealing with publicity released data. Some examples of this issue include: miscalculating a water supplier's conservation savings, comparing usage to an outdated target, and prematurely extrapolating a water supplier's monthly variation in conservation savings percentages to predict overall savings. Furthermore, as with any self-reported data involving a significant number of users, there is sometimes error in the data. In the end, mandatory reporting during the drought provided more benefit to the State and the water suppliers than drawbacks in terms of transparency and accountability. Even the misrepresented data provided opportunities for media attention, which contributed to keeping public attention on the drought.

Elevating Drought Awareness

In addition to mandatory reporting, the State, the media, and community members created and maintained widespread attention on the drought. The State's actions, including the frenzy of drought related Executive Orders, associated Emergency Regulations, and press releases, while somewhat overwhelming at times, kept significant attention focused on the drought during 2014-2016. The State Water Board held Board meetings twice a month with drought as a standing agenda item, which included water savings and water supply updates by region. These meeting were attended by a plethora of water related organizations including water suppliers, non-profit organizations, business leaders, farmers, and others that provided the State Water Board and their staff with feedback on the regulations.

These State Water Board meetings were also attended by the media. At all major milestones during the drought, the media highlighted ongoing activities, often by interviewing State Water Board members and staff as well as other key industry leaders. Media coverage of the drought in the Sacramento region was intense and constant. In 2015 alone, the media collectively produced 163 stories on drought specifically focused on Sacramento region (IN Communications, 2016). Statewide media article coverage increased during the drought with peaks in coverage corresponding directly to political or significant weather events (Quesnel and Ajami, 2017). With this depth of coverage, the media served as a constant reminder that everyone needed to save water. In a 2015 public outreach survey conducted by the RWA, 90% of respondents demonstrated awareness that the State and region were in a drought (SCG, 2015). In a media environment ruled by short new story segments, the media collectively kept the drought fresh and exciting for several years. Unfortunately, this desire sometimes led to incomplete reporting and sensationalism. Regardless of the exact messaging, the attention the media gave to the drought helped communicate its importance and prompted people to conserve and to reach out to local water suppliers for more information. The media, triggered by State actions, elevated the drought to a higher level not possible by water suppliers alone.

The combined attention from water suppliers, the State, and the media contributed to customers' feeling engaged to help solve the drought. While it is highly unlikely (if not impossible) that every person in the region actively engaged in water conservation consistently during the drought, enough people did achieve significant savings. Most physical water savings resulted from the combined actions or inactions of the region's residents and businesses. All the above-mentioned activities, like the public outreach campaigns and rebates, can be seen as a necessary catalyst to achieve those savings. However, attention is only part of the solution and does not in itself physically save water, the public must turn attention into action.

Additionally, some customers moved beyond initiating savings for their households and took some responsibility for others. Local water supplier staff discussed the role of neighborhood peer pressure to follow drought watering guidelines at monthly RWA meetings. Neighbors were on the lookout for water waste and in some areas were not shy in reporting it. The social dynamic of drought response is important. The most direct example of this dynamic was the distribution of water use reports that compared one household's water use with "similar" nearby households (similar in terms of number of people, landscape area, etc.). Several water suppliers in the Sacramento area and many more throughout the State sent such reports to customers before, during, and after the drought. One could argue about the accuracy of the reports but they did motivate some customers to call water supplier staff to inquire about why they used more water than their neighbors. No one wants to be seen as using more water or wasting water; that's what their neighbors do. While the social dynamics of drought has not be extensively studied in the Sacramento region, this topic is becoming an important field of research and could influence how public outreach efforts and programs are designed and implemented. The few existing related resources on this topic have been insightful (CWEE, 2019; Slatford, 2017).

Water Supplier Coordination

The drought provided numerous opportunities for water suppliers throughout the State to work together (e.g., the development and implementation of the mandated targets, monthly drought updates at State Water Board meetings, and the associated public meetings). Water suppliers that in the past did not have an immediate reason to work together (e.g., no common water supplies, lack of proximity) found commonality through shared conservation targets, kindred feedback to the State on proposed regulations, and the necessity to expand public outreach campaigns and programs. Water suppliers with similar mandated targets throughout the State consulted with each other on how they were working to meet their targets. Inland suppliers from northern and southern California generally had higher conservation targets due to their higher R-GPCD. Coalitions were formed, often through the ACWA, to organize comments to the State Water Board on various components of the mandated targets including the adjustments mentioned above. The State Water Board would release draft regulation language and then the water suppliers would circulate draft response language to coordinate feedback to the State with the idea that the more streamlined and broadly supported the request, the more likely it would be accepted.[33] Finally, water suppliers shared their drought public outreach campaign materials (e.g. social media infographics, and slogans and strategies to reach customers), and program materials (e.g. guidelines, customer sign up processes, and savings figures) to help other suppliers quickly ramp up efforts. In the Sacramento region, one supplier came up with the idea of hiring a private security firm to patrol their service area at night for a fraction of the cost of paying water supplier staff overtime. This idea was brought up at a local RWA meeting, which resulted in several other suppliers hiring firms for similar tasks.

In a state that has a somewhat contentious water history with commonplace phrases like "southern California is taking all our water", water suppliers generally came together especially at the staff level, to support each other during the drought. The relationships built and deepened during the drought continued after the drought and in some cases extended into the state legislative world. For example, over 100 water suppliers signed onto a statewide coalition letter

[33] Sample of collaboration comment letter, December 2, 2015, Water Conservation Workshop. https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/comments120215/docs/richard_plecker.pdf

opposing a permanent water conservation budget trailer bill, which would later transition to the approved Senate Bill 606 and Assembly Bill 1668 discussed in Chapter 6.

B. What Did Not Work

As with any policy development, there are always tradeoffs between benefits and costs and these vary by stakeholder. In this case, several costs (monetary, time, social, etc.) experienced by water suppliers from implementing the State's drought policies originated from faulty policy design, including: approving a non-supply based conservation target method, discarding the effective use of alternative supplies and markets, ineffective communication, and the initial exclusion of formal regional compliance options.

Non-Supply Based Conservation Target

As described above, the State used a water supplier's R-GPCD to dictate their mandatory percent reduction to prioritize outdoor water use reductions. The assumption being that this saved/unused outdoor water would remain in surface water storage or aquifers to help relieve drought impacts regionally and statewide. However, this approach had little to do with current water supply conditions or addressing systems that suffered most during the drought.

For example, if a supplier had a lower R-GPCD but had severely distressed water supplies, according to the State they might receive a 12% reduction. However, if a supplier had a higher R-GPCD but ample water supplies, the State may have assigned a 32% reduction. In both cases the conservation percentage did not directly match actual local water supply conditions, leading to local imbalances. Suppliers with stressed water supplies could set a more stringent percent reduction than the State, but suppliers with ample local water supply could not relax their target. General Managers and staff in this situation were backed into steep water conservation targets and communicating that target to customers without an immediate water supply justification. This caused confusion among customers, which prompted questions like "If we have water, why do we have to save?" and "Where does the saved water go and who does it benefit?" The State's lack of a supply-based drought policy required water suppliers to motivate customers to reduce water use even when no local water supply issue existed. While this issue was of particular concern for the suppliers in the Sacramento region, it was not uncommon throughout the rest of the State. Furthermore, the stress test confirmed that most water suppliers in the State had sufficient supply. When the State transitioned from mandated conservation targets in May 2015 to the supply-based stress test in June 2016 only 68 of 411 large urban suppliers continued to have a conservation target, and only 32 of those suppliers continued with the State mandated target; the remainder reached their new percent reduction through the stress test method. During this transition, there was little improvement in State water supply conditions suggesting that the bulk of water suppliers' shift to a 0% reduction was a result of sufficient recent past and current supply. This is precisely why conservation targets are typically driven by water supply conditions, not water demand. Additionally a post-drought assessment of 173 urban water suppliers throughout the State confirmed that most urban water suppliers were prepared for the drought and that none lost the ability to provide water to their customers (Mitchell et al., 2017).

Required savings despite having an ample supply could potentially be justified if the conserved water was dedicated to a nearby water supplier in need, however, in most cases there was no identified beneficiary from the State for the water savings achieved. Areas like Santa Cruz and East Porterville had substantial water supply issues that required rationing or trucking in water during the drought and both had either isolated systems and/or had degraded water supply conditions prior to the drought (Bliss, 2015; Thompson, 2018). They physically could not benefit from other water suppliers' supplies even if the State would have identified their need. Messaging the need to conserve when there is no water supply issue and no direct, justifiable need to assist another supplier creates unnecessary concern for customers. Water suppliers should be able to preserve this request only when and if there is a real water supply issue to avoid a "crying wolf" outcome. This dynamic can make it harder for water managers to maintain credibility with their customers and potentially erodes trust in the State as well.

Furthermore, the conservation regulation focused on larger urban water suppliers (with generally sufficient supplies), when smaller systems were most in need. In the 2017 Pacific Institute Report, 132 of the 155 drought-impacted public water systems listed were systems of less than 1,000 connections (i.e., not urban water suppliers beholden to the mandated conservation targets) and were often disadvantaged communities (Feinstein at el., 2017). These systems also often are isolated and not connected to larger systems with more reliable supplies. Typical drought response policy matches a shortage in supply to a reduction in demand and is not solely based on current water use. The State's largest drought policy was not directed towards smaller systems most prone and vulnerable to shortage.

Discarding Alternative Supplies and Markets

The State's demand-based drought response policy also did not support the use of available (planned and unplanned) alternative potable supplies such as water banked specifically for water shortage conditions during the mandated target timeframe. Even though water suppliers like Irvine Ranch Water District had secured additional "drought proof" supplies (up to 50,000 acre feet in storage with ability to recover up to 17,500 acre feet per year), according to the State the banked water would still be counted as supply would count against their conservation target (IRWD, 2018). This decision disadvantaged suppliers that have undertaken extensive planning and infrastructure investments to secure reliable supplies. This policy could deter water suppliers and the Boards that govern them from developing secure supply investments in the future, which is maladaptive for climate change and a diversified water supply portfolio.

Water transfers were another underutilized practice during this drought. The State should have prioritized the facilitation of water transfers between suppliers with and without ample supplies. The ability to transfer water between suppliers and regions is the basis for a functioning water market. Water transfers do cost suppliers money, but this value exchange reduces the inequity of the mandated conservation targets because customers and water suppliers are getting a value from their prior investments, water rights, and water sources. Water suppliers needing additional water pay for the scarcity of supply through the market, which promotes both conservation actions and investments in alternative or additional supplies like recycled water. Transfers more accurately apply the concept of scarcity and its costs based on actual water availability rather than arbitrary mandated targets. While the State allowed for some transfers during the drought, their current policies and operating procedures can be improved. For example, ACWA's *Recommendations for improving Water Transfers and Access to Water Markets in California* 2016 Report lists 1) expand the timeframe for moving transfer water across the Delta and 2) facilitate water use efficiency-related transfers as two of eleven recommendations to improve the water transfer process in California (ACWA, 2016). California has just scratched the surface of the potential for water markets in the State, especially with the extensive network of water infrastructure. Reviewing and modifying transfer policies to increase access and reallocation of surplus water would be useful.

Ineffective Communication

The chain of communication from the State to the water suppliers, water suppliers to customers, customers back to water suppliers, and water suppliers back to the State was essential to the success the State achieved during the drought. However these multiple levels of active communication included numerous challenges including lack of common terminology and various iterations of the conveyance of inaccurate or incomplete information,

The first communication breakdown involved the lack of common terminology between the State, water suppliers, and the public regarding the concept of short-term versus long-term demand management and the terms water conservation and water efficiency and how they were applied in real life. Short-term means available for immediate drought response (within the year) and long-term means implemented over time to minimize effects of future droughts. An immediate short-term response to drought is water conservation or simply using less water. This can generally be thought of as a behavior change, such as practicing the "If it's yellow, let it mellow. If it's brown flush it down" approach to reducing toilet flushing. A short-term drought response can also be water efficiency, which uses less water to perform the same task, such as replacing a high water use toilet with a high efficiency toilet. A person does not flush the toilet any less (no behavior change), the toilet itself just uses less water per flush. Some behavior changes can be longer term, such as forming a habit of taking shorter showers that lasts beyond the drought. Some efficiency changes also can be longer term, e.g., putting a brick in the toilet tank to reduce flush volume (not recommended). Finally, if a customer installs a high-efficiency toilet during a drought, they use less water at the time of installation (short-term) and into the future (long-term). These changes combine for compounded savings, flushing less with a more efficient toilet. Similar examples exist for outdoor water use. Both water efficiency and conservation solutions are needed in water supply management but at different time periods (short and long term) to respond to current and future conditions. With all the different combinations of options and variation of definition interpretations, it is easy to understand how these terms can be confusing to customers, officials, supplier staff, the media and others.

One example of the discrepancy between short-term and long-term demand management was the State's $24 million lawn conversation rebate initiative to replace 10 million square feet of turf under the Save Our Water program. Focusing on lawn conversion originated from Executive Order B-29-15, in which a goal to replace 50 million square feet of turf was outlined. Lawn conversion (also known as "Cash for Grass") is a long-term measure with the potential to generate water savings for decades, as long as the low water use landscape is properly installed, irrigated, and maintained. However, if implemented in the middle of a drought, it can actually increase water use due to the increased watering needs for new plant establishment, reversing short-term water savings (Seapy, 2015). While replacing lawn during the drought could combat future drought conditions, it can harm current water savings. Although this dilemma seems minor, it caused confusion among water supplier staff and complicated communication between State and water supplier staff. The State's actions appeared to promote longer term water efficiency policies like permanent landscape change through the short-term emergency conservation regulation and mandated conservation targets. Furthermore, cash for grass programs are fairly new conservation programs with inconsistent savings, ranging from showing an increase in household water use to no change to a decrease (Seapy, 2015). However, some turf conversation programs in the State have brought substantial savings including additional savings from neighbors of households that received rebates becoming inspired to also change their landscapes without a rebate (Torpey, 2017; Johnson, 2017; Marx, 2016). Several local water suppliers in the Sacramento region also started cash for grass programs during the drought. Some added additional guidelines stating new planting could not occur until after the drought. Starting a new program (with mixed reviews on water savings) at the state level in the middle of drought is a heavy lift. Another option would have been to funnel the funding to existing regional and local programs with existing relationships to customers and vendors that could be scaled up to meet the additional funding.

A related example involved how the terms conservation and efficiency were interpreted by and communicated to customers. The U.S. Water Resources Council defined water conservation as activities designed to (1) reduce the demand for water, (2) improve efficiency in use and reduce losses and waste of water, and (3) improve land management practices to conserve water (WRC, 1980). Efficiency can be defined as "a measurement of the amount of water used versus the minimum amount required to perform a specific task" (AWE, 2019). Both conservation and efficiency actions reduce water use but efficiency is more specific with the technique to achieve savings.

For message consistency from the state to the local level, the term conservation was primarily used to describe any action that saves water to customers, which was appropriate during the drought but got confusing after the drought, when water suppliers switched back to promoting longer term water efficiency-based messaging and actions like toilet replacement and irrigation upgrades, while the State continued to use the term conservation. The term conservation was still prominent on the December 2018 Save Our Water website homepage and is central in the phase "Making Water Conservation a California Way of Life" which is the title of Executive Order B-37-16 and is used repeatedly in a wide range of post-drought related State released documents and plans. The RWA hosted a series of focus groups in February 2018 to gather information on how the public perceived the terms water conservation versus water efficiency. The overwhelming response from the focus group participants was that they perceived the term "conservation" as "punitive" imposing "limits" and "restrictions", whereas the term "efficiency" was perceived as "active" and "empowering." One participant stated "Conserve means going without, efficient means doing it in the proper way and savings as much as possible." This focus group provided valuable insight into how the public perceived the terms State and water suppliers use to communicate with customers (PVR, 2018).

The second communication breakdown was the conveyance of inaccurate or incomplete information in multiple situations. One prominent example was the pervasive use of the United States drought monitor map to represent urban drought water supply conditions. The map is produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln to represent the level of drought impact on dry farming practices throughout the United States (NDMC, 2018). It does not accurately represent urban water supply conditions, yet it was featured in nearly every monthly State Water Board drought update in 2016. Confusion arose when the California DWR reservoir map clearly showed normal conditions (Figure 34) in June 2016 but the drought monitor map still showed a significant portion of California was in severe, extreme, or excessive drought (Figure 35). Figure 35 shows the drought map as of June 7, 2016, right after the stress test took effort. The blue box highlights Sacramento County, shown as currently being in "severe drought" although all 15 urban water suppliers within Sacramento

County qualified for a 0% reduction under the stress test methodology. Admittedly, the map does provide an easy to understand image with some simplistic drought definitions, which makes it unfortunate that it didn't represent the urban drought supply conditions it was used to communicate. This inaccurate communication of current supply conditions was further disseminated through the media, which described State and local water supply conditions through a variety of outlets, and was then interpreted by water customers. This information, at times, contradicted local water supplier messaging leaving customers wondering what to believe. Hopefully, in the future, there will be a graphic that communicates statewide urban drought conditions more accurately.

Figure 34: Major Reservoir Conditions, June 7, 2016. Source: CDEC, 2016.

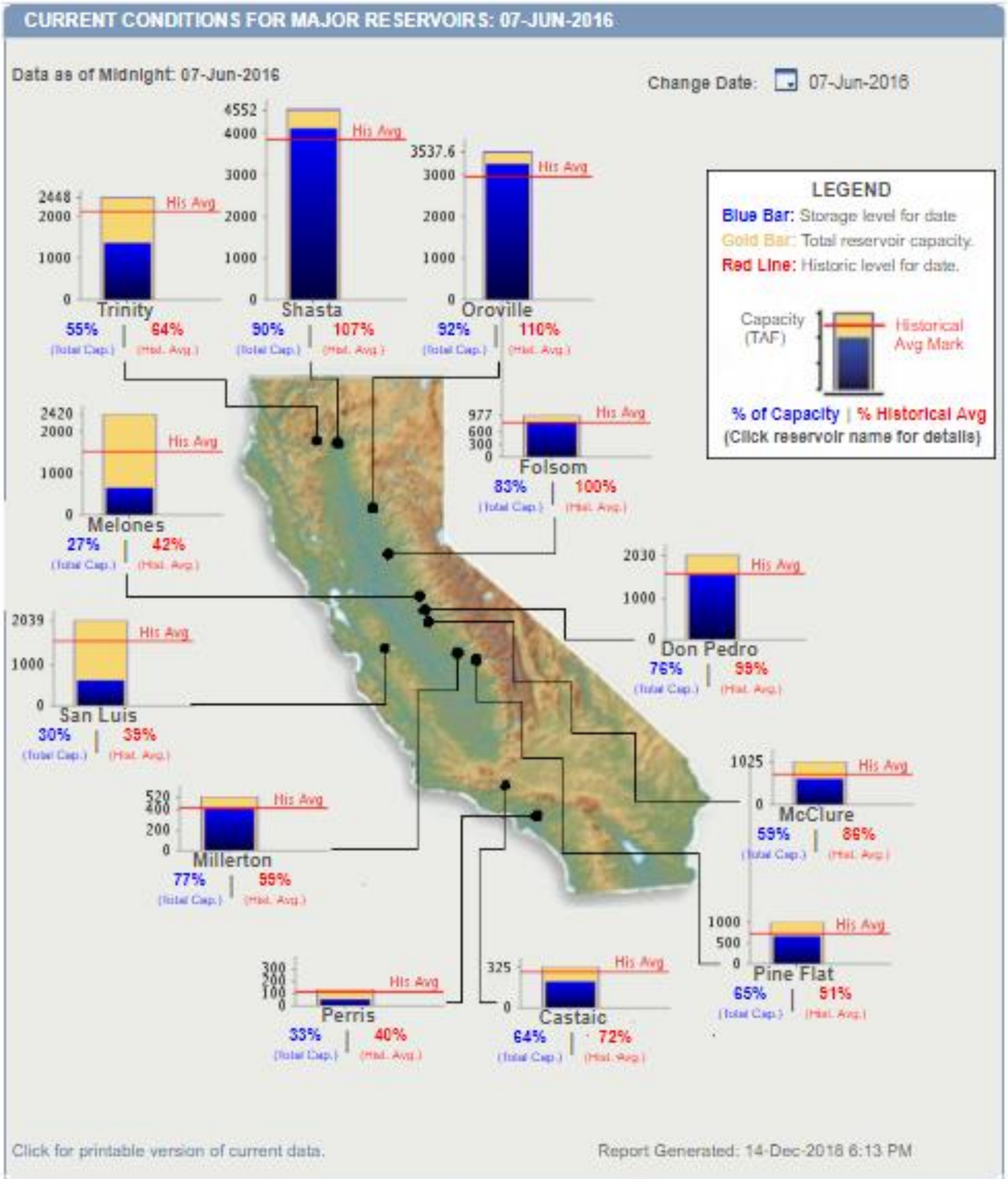
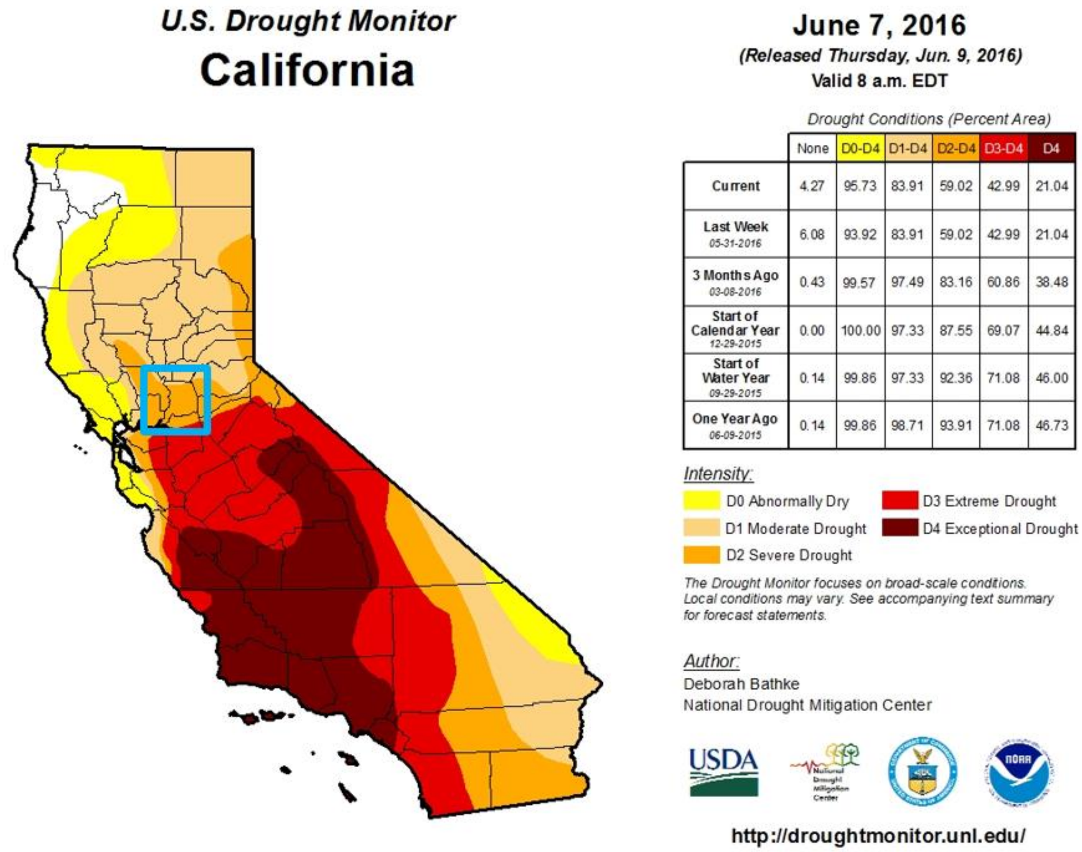


Figure 35: U.S. Drought Monitor Map, June, 7, 2016. Source: National Drought Mitigation Center, 2016.



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	4.27	95.73	83.91	59.02	42.99	21.04
Last Week 05-31-2016	6.08	93.92	83.91	59.02	42.99	21.04
3 Months Ago 03-08-2016	0.43	99.57	97.49	83.16	60.86	38.48
Start of Calendar Year 12-29-2015	0.00	100.00	97.33	87.55	69.07	44.84
Start of Water Year 09-29-2015	0.14	99.86	97.33	92.36	71.08	46.00
One Year Ago 06-09-2015	0.14	99.86	98.71	93.91	71.08	46.73

Another challenge was the media's effort to distill complex concepts and regulations down to clear and concise messages, but this is more of an issue of incomplete information rather than inaccurate reporting. The typical local television news story segment is short with a median length of 41 seconds (PRC, 2012). Explaining the how and why details of the drought in that short time while maintaining viewer's attention is difficult, especially with limited background knowledge. To address this concern, water supplier staff were challenged to convey the regulations, drought conditions, and local ordinance information in short, straightforward talking points when interacting with media outlets, hoping their messages would get aired. One prominent example was communicating a water supplier's watering days. One of the more complex watering days policies in the Sacramento region is the City of Sacramento's guidelines (Figure 36). The number of watering days changes from 2 days to 1 day based on the season and is has specific start/stop seasonal dates (Sections C and D). And there are exemptions to these watering day restrictions (Section E). If a customer has a smart controller, they can water any day of the week but that controller must be verified by the City of Sacramento. When forced to distill this information to a few key points for media purposes, residents do not absorb all details of the program and often reach only partially correct conclusions on how to implement the guidelines. Using the example above, the media may report simply that if you have a smart controller you can water any day or that the city has 2 day a week watering and to visit the city's website for more information. However, a customer may only hear the first parts of the message.

These unintentional omissions, abbreviated stories, and lack of follow up often added customer confusion during and after the drought.

Figure 36: City of Sacramento Outdoor Conservation of Water Code, Source: City of Sacramento, 2017,

13.04.870 Outdoor conservation of water.

A. No person shall use, or cause to be used, any city water to wash down sidewalks, driveways, or parking areas unless authorized by the director pursuant to section 13.04.940, except to alleviate immediate fire, health, or sanitation hazards, or to implement an integrated pest management program.

B. No person shall use, or cause to be used, any city water through a hose to wash a vehicle unless the hose is equipped with an automatic shut-off nozzle attachment, and the attachment is being used to shut off the flow of water at all times when the hose is not being used to wash the vehicle.

C. Beginning on March 1, and extending through October 31:

1. No person shall use, or cause to be used, any city water for landscape irrigation between the hours of 10 a.m. and 7 p.m., unless the director authorizes a different time limitation pursuant to section 13.04.940.

2. Residential and commercial locations bearing a street address ending in an odd number are permitted to irrigate with city water using conventional irrigation systems only on Tuesday and Saturday, and locations bearing a street address ending in an even number are permitted to irrigate with city water using conventional irrigation systems only on Wednesday and Sunday, unless the director authorizes a different irrigation pattern pursuant to section 13.04.940.

3. No landscape irrigation is allowed on Monday, Thursday, or Friday, unless authorized by the director pursuant to section 13.04.940.

D. Beginning on November 1, and extending through February 28, all residential and commercial locations are permitted to irrigate with city water only on one day per week, either on Saturday or Sunday, and landscape irrigation is prohibited on other days of the week, unless the director authorizes a different irrigation pattern pursuant to section 13.04.940.

E. The limitations specified in subsections C and D do not apply to:

1. Landscape irrigation using a low volume irrigation system;

2. The irrigation of container plants;

3. Hand watering with a watering can or using a hose without an automatic timer; or

4. The operation of irrigation systems solely for testing, maintenance, or repair.

F. The limitations specified in subsections C.2, C.3, and D do not apply to:

1. The irrigation of new landscaping in accordance with section 13.04.880;

2. The irrigation of a special landscape area;

3. Landscape irrigation using a smart controller that is properly installed and operated, as verified by the department;

4. Landscape irrigation during a heat wave period; or

5. Landscape irrigation conducted pursuant to an alternate method authorized by the director, on such conditions as the director may specify, if the director determines that the alternate method provides substantially equal water conservation benefits.

G. No person shall use, or cause to be used, any city water in a fountain or other decorative water feature unless it uses a recirculating system.

H. No person shall use, or cause to be used, any city water for landscape irrigation during and within 48 hours after measurable rainfall.

I. Upon declaration of a water shortage, the city council may impose revised and additional limitations on outdoor water use, as specified in section 13.04.910, and no person shall use, or cause to be used, city water in violation of those limitations while the water shortage remains in effect. (Ord. 2017-0062 § 3; Ord. 2017-0045 § 3; Ord. 2015-0011 § 8; Ord. 2009-050 § 1; Ord. 2009-026 § 1)

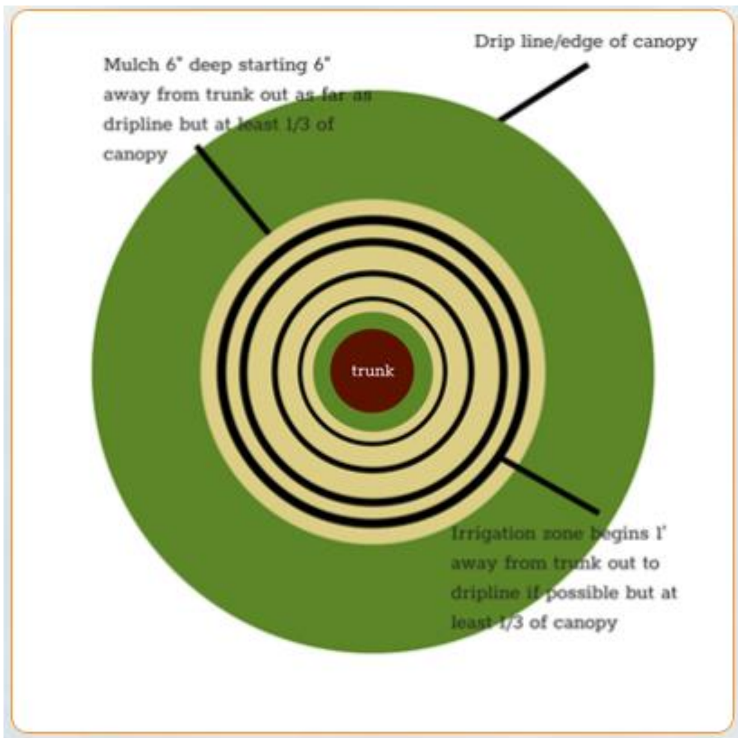
Lastly, the widely distributed public outreach message during the drought to reduce outdoor watering is another example of incomplete information. The intended message was to reduce watering turf grass but continue to water trees and shrubs. The average household’s lawn is primarily turf grass, which can go dormant during summer and recover in spring, so turf grass overall can survive reduced watering during the summer. However, shrubs and trees are established permanent plants that take decades to mature, are not as easily replaced, and generally do not go dormant in the absence of water. However, the over simplistic message of “stop watering your lawn” (without distinguishing between turf and perennials) was communicated widely by State, regional, and local entities (Figures 37 and 38).

Figure 37: Save Our Water-Brown is the New Green Lawn Sign. Source: SOW, 2015.

Figure 38: Save Our Water- Brown is the New Green Messaging. Source: SOW, 2015.

The sub-message of "but keep watering your trees" was a lost detail in the general public outreach messaging, although it was covered by the State during the State Water Board meeting drought update presentations. However, even if it had been added, it may have still been confusing because watering your trees means watering the tree canopy underneath the leaves, which is often turf grass (Figure 39). Therefore, the actual ideal message might be something like "stop watering your grass, except if it's grass under trees because how trees get water and we want to keep the trees alive." This multistep message is not as easy and catchy as more concise messages. Perhaps simply "only water your trees" would have worked better. Although there is no data to determine what outreach message contributed to actual household actions during the drought, urban tree mortality was observed and tracked. The City of Sacramento has an estimated 1 million trees spread out over 100 square miles. The city itself manages about 100,000 trees on public land. Based on Sacramento's climate, nearly all of the trees in the city of Sacramento were planted and rely on some form of irrigation to survive. During the drought, annual increases in tree removal were only observed by the city after the third year of drought. This suggests that tree mortality is not instant in drought but the result of prolonged irrigation deficits, which can occur before and after a drought is officially declared or ended. Furthermore, some tree species are better suited to handle rapid changes to irrigation than others (Hocker, 2019). Communicating these nuances about trees in drought is an area for improvement for State, water supplier, and media communicators. This example shows the importance of clear, accurate, and direct public outreach messaging.

Figure 39: How to Water Mature Trees Graphic. Source: Sacramento Tree Foundation, 2018.



Regional Compliance

The last critique of the urban emergency regulation was the exclusion of a regional compliance option to meet the mandated conservation targets. Regional compliance was a concept presented to the State Water Board in December 2015. It would have allowed a group of water suppliers to combine their conservation targets into one collective regional target and then manage complying to that regional target among the group. The idea behind regional compliance was that it would more efficiently use the group's resources including funding, conservation programs, and public outreach efforts and target them towards the areas with the most potential for savings within the group's service areas. The end result would be the same amount of water saved, most likely within the same location or watershed. Regional compliance is not a new concept to meeting conservation goals as it had already been approved to meet the State's long term 20 X 2020 legislation conservation targets.

Ultimately the State Water Board decided against approving the regional compliance option in 2015. State Water Board staff suggested that a regional compliance option would allow some water suppliers to not meet their targets while others in the group could exceed their targets, thereby allowing underperforming suppliers to escape potential State enforcement actions. While there were details still to be clarified with the proposed concept, the reasoning behind not adopting regional compliance showed a lack of trust in the water suppliers' ability to perform as a group. It was a missed opportunity to develop deeper regional collaboration among the water suppliers and could have set up another mitigation option for future droughts. Perhaps the State thought the risk to potential water savings was too high at the time.

In summary, the State's drought policies from 2014-2016, achieved the planned water savings almost exactly, which is quite impressive. However, there were tangible drawbacks to those policies that could have been handled better. It's debatable if similar water savings could have been achieved without such draconian actions. Out of the shadow of the drought, some lessons learned were already being integrated into permanent legislation to better prepare water suppliers for the next drought. This legislation is the focus of Chapter 6.

VI. Chapter 6: Drought Motivated Legislation and Regulation

Significant statewide water savings for 2015 (25.5%) and 2016 (22.5%) matched with the State's overall improved water supply conditions heading into 2017 helped pulled back some of the State's top-down drought mandates (State Water Board, 2017). By June 2016, state-assigned mandated conservation targets gave way to the water supplier focused stress test. The fall 2016 storms targeted the Sierra, where about 30% of the State's water supply originates (DWR, March 2016). The DWR's Northern Sierra 8-Station Precipitation Index (inches) showed 12.6 inches of precipitation for October 2016 or 420% of October average (3.0 inches) (CDEC, 2016). However, only three of the State's twelve primary reservoirs were at historic average levels by December 2016 (CDEC, 2016) (Figure 40). As the State headed into winter, there was still uncertainty on how effectively precipitation would translate into future supply, when a few storms can make or break a water year.

A. Executive Order B-37-16

This uncertainty and the State's dependence on fluctuating weather kept water conservation efforts alive and ready to respond to potential water supply shortfalls. In this context, the State and its suppliers used the drought to develop long term polices (Brown, 2016). Governor Brown issued Executive Order B-37-16 (EO) on May 9, 2016 tasked with "Making Conservation A California Way of Life." This EO and associated Final Report released in April 2017 outlined various proposed regulatory actions including expanded water supply planning efforts, permanent water use targets, and statewide water waste policies. The recommendations are organized into four categories: Use Water More Wisely, Eliminate Water Waste, Strengthen Local Drought Resilience, and Improve Agricultural Water Use Efficiency & Drought Planning. Figure 41 summarizes these four sections from the Final Report and ties each action to the appropriate section of the EO.

Figure 40: Major Reservoir Conditions, December 3, 2016. Source: CDEC, 2016.

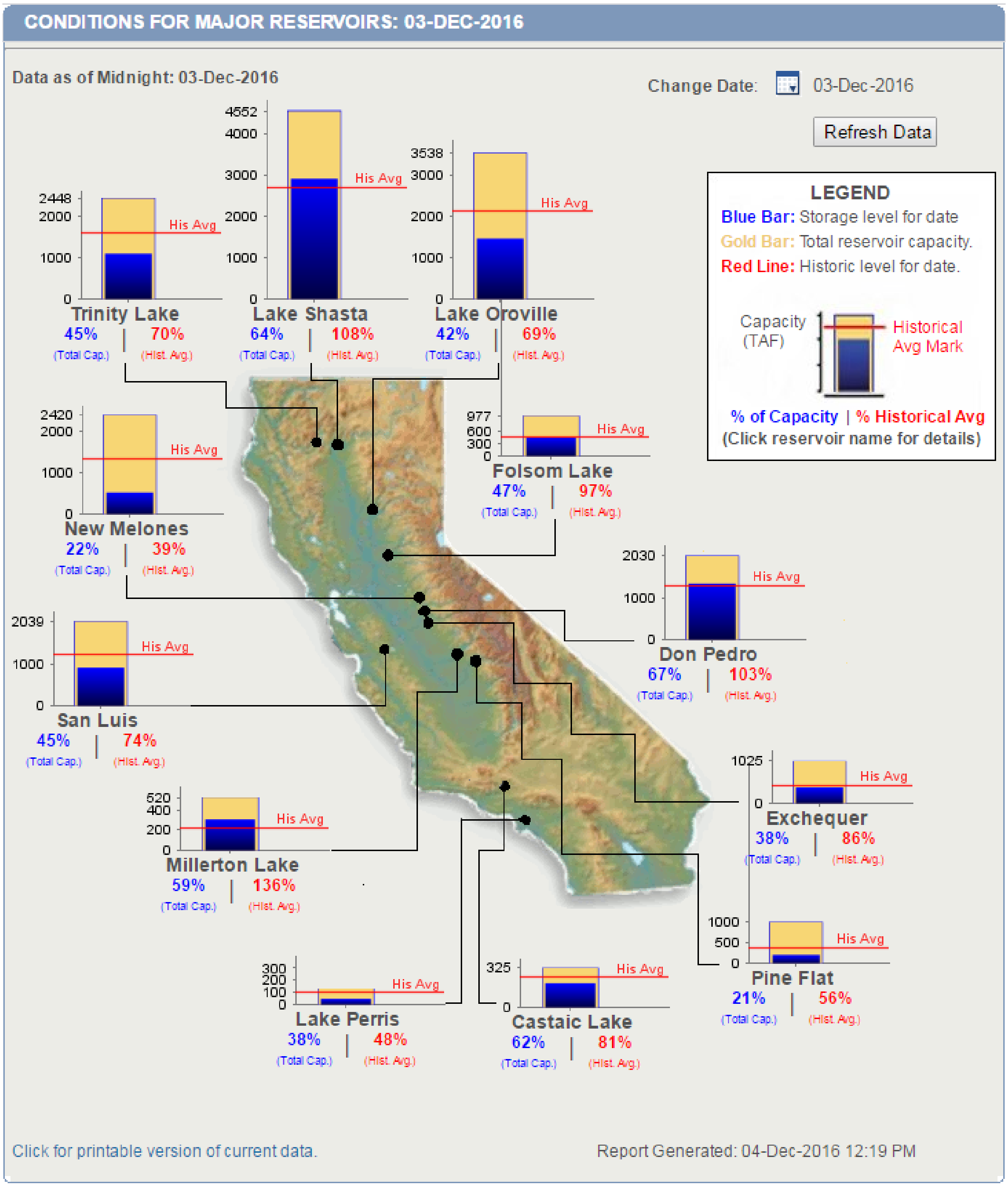


Figure 41: Summary of Final Report Sections. Source: ACWA, 2018.

Using Water More Wisely

Emergency Conservation Regulations (Executive Order Item 1): The State Water Resources Control Board (Water Board) will rescind the emergency requirement for a water supply stress test or mandatory conservation standard for urban water agencies, but, to provide a bridge to permanent requirements, it will continue to require monthly reporting and to prohibit wasteful practices (see below).

New Water Use Targets (Executive Order Items 2 and 6): Upon statutory authorization, the EO Agencies will adopt a new urban water use target methodology. Urban water suppliers would, in turn, be required to calculate their unique water use targets based on those standards and local conditions.

Permanent Monthly Reporting (Executive Order Item 3): The Water Board will open a rulemaking process to establish permanent monthly urban water reporting on water usage, amount of conservation achieved, and any enforcement efforts.

Eliminating Water Waste

Water Use Prohibitions (Executive Order Item 4): The Water Board will open a rulemaking process to establish permanent prohibitions on wasteful water practices, such as hosing down sidewalks and watering lawns after rain. This will build on the current prohibited uses in the emergency regulation.

Minimizing Water Loss (Executive Order Items 5 and 6): Senate Bill 555 (Wolk, 2015) requires all urban retail water suppliers in the state to submit a completed and validated water loss audit annually to the Department of Water Resources. The EO Agencies will take additional actions to accomplish the directives in that law related to reducing water supplier leaks. These actions include establishment of rules for validated water loss audit reports, water loss performance standards, and technical assistance for water loss audits and minimizing leaks.

Innovative Water Loss & Control Technologies (Executive Order Item 7): The California Energy Commission (CEC) is evaluating various options for certification of water loss detection and control technologies at utility, household, and appliance levels. The CEC is also making investments in research and funding programs for water saving devices and technologies.

Strengthening Local Drought Resilience

Water Shortage Contingency Plans (Executive Order Items 8, 9, and 6): Upon statutory authorization, urban water suppliers will be required to submit a Water Shortage Contingency Plan, conduct a Drought Risk Assessment every five years, and conduct and submit a water budget forecast annually.

Drought Planning for Small Water Suppliers and Rural Communities (Executive Order Item 10): The EO Agencies' recommendations focus on working with small water suppliers and rural communities to continue to develop more specific drought vulnerability assessments and supplier readiness and responsiveness during drought.

Improving Agricultural Water Use Efficiency and Drought Planning

Strengthened Agricultural Water Management Plan Requirements (Executive Order Items 11, 12, 13, and 6): Upon statutory authorization, the proposal described in this report would expand existing requirements to require agricultural water suppliers providing water to over 10,000 irrigated acres of land to prepare, adopt, and submit plans by April 1, 2021, and every five years thereafter.

The State held a series of public meetings before and after the release of the Final Report to explain the proposed regulatory actions and to solicit feedback. Successful implementation of this EO will require the collective effort of State agencies, water suppliers, land use agencies, environmental groups, businesses, public institutions, and residents over the next several decades and beyond. Each stakeholder brings a different perspective to the effort. Water suppliers were looking to comply with the proposed State mandates while still providing adequate and affordable water supply. Residents and businesses were trying to figure out what all of this means to them regarding the water waste prohibitions (i.e., "What days a week can I water?"), potential rate increases (i.e., "I'm saving water but my rates increased anyways."), and mixed public outreach messaging (i.e., "Are we in a drought or not?"). This EO shows a progression of State led post-drought actions and policies, starting with the building of the Central Valley Project in response to the "Dustbowl' drought, to the elevation of water conservation in response to the 1976-77 drought, to the mandated conservation targets in response to the current drought. The progression flows from supply augmentation through "hard" pipes and reservoir infrastructure, to "soft" demand management through behavior change to regulating behavior change (from engineering to management to regulation). However, the EO and Final Report alone lack regulatory power but did set policy direction. For these policies to be implemented locally, they need to become law.

While preparing language in the Final Report for insertion into the legislative process, the State declared the drought emergency was still in place; however, water supply conditions were still improving statewide. April 1, 2017 statewide snowpack was 163% of normal for that date and 9 out of the 12 major reservoirs in the State were at or above historical average (CDEC, 2018). Drought conditions were waning and the State needed to start backing off the declared drought emergency to maintain creditability, especially as new legislation to implement the EO was being created. Some water suppliers in the State had already declared the drought emergency over for their service area (PCWA, 2016).

Just as defining and declaring a drought are is ambiguous, so is declaring the end of a drought. There is still ongoing debate over the year that this drought started. It has been cited as starting as early as 2012 and as late as 2014 (Griffin and Anchukaitis, 2014; AghaKouchak et al., 2014). Furthermore, it is hard to end something that was not declared by clearly defined water supply metrics such as precipitation, snowpack, reservoir levels, groundwater levels, percent of imported supply, or State Water Project allocations. Some regions, such as the North Coast, never experienced drought conditions like the rest of the State as their water supply is isolated and their local conditions remained relatively normal during 2015-2017. This reinforces the conundrum of how different groups experience and define the same drought. That said, someone has to pull the trigger. With Executive Order B-40-17, Governor Brown officially declared the drought state of emergency over on April 7, 2017 for all California counties except Fresno, Kings, Tulare, and Tuolumne, due to continued emergency drinking water project implementation to address groundwater supply shortages (Brown, 2017).

Shortly after officially ending the drought emergency and in hopes of catching the residual support for water conservation in the State, the Governor introduced a budget trailer bill (identified as 810 Water Conservation as a California Way of Life on the Department of Finance website), which included a simplified version of the "Making Water Conservation a Way of Life" Final Report language (DOF, 2017). The intent of the budget trailer bill was to create authority to fully implement Executive Order B-37-16 including permanent water supplier level water targets and modified water shortage contingency plans. On May 3, 2017, the budget trailer bill was discussed in the Assembly Budget Subcommittee #3 on Resources and Transportation. Nearly 40 local water suppliers and ACWA provided testimony in opposition citing “the use of budget trailer bills to advance policy changes in state law” as a barrier to providing a “deliberative and transparent policy and fiscal committee” in which “adequate time for stakeholder comment and public input” would be allowed (ACWA, 2017). In the end, the budget trailer bill did not move forward for vote, but the intent of it lived on in two related bills introduced around the same time: Senate Bill (SB) 606 (introduced by Hertzburg) and Assembly Bill (AB) 1668 (introduced by Friedman)[34]

B. Senate Bill 606 and Assembly Bill 1668

After much discussion and over a year later, the two bills were signed by the Governor on May 31, 2018. These new laws will change how water conservation and water efficiency are implemented in California, and perhaps elsewhere. Figure 42 summarizes SB 606 and AB 1668, specifically focusing only on the urban water conservation, efficiency, planning, and enforcement components of the laws.[35] Table 38 shows the legislated implementation deadlines for tasks in the two bills. Figures 44, 45, and 46 show graphics used currently by local and regional water suppliers to communicate the bills intent to customers provided by the California Water Efficiency Partnership (CalWEP).

Figure 42: Summary of SB 606 and AB 1668. Source: ACWA, 2018.

Key elements of the new laws include:

- Requirements to establish water use objectives and long-term standards for efficient water use that apply to urban retail water suppliers. The objectives and standards are based on indoor residential water use, outdoor residential water use, commercial, industrial and institutional (CII) irrigation with dedicated meters, water loss due to leaks in water system pipes, and other unique local uses;
- Standards for indoor residential water use of 55 gallons per capita per day (GPCD) until 2025,

  52.5 GPCD from 2025 to 2030, and 50 GPCD beginning in 2030. This state per capita indoor water use standard is to be used to develop water supplier water use objectives on a service area basis, and the legislation DOES NOT require “rationing” or enforcement on a per person or per household basis;
- A process to develop standards for outdoor residential water use based upon a community’s climate and the amount of landscaped area;
- Incentives for water suppliers to recycle water;
- Requirements that both urban and agricultural water suppliers set annual water budgets and prepare for drought;
- A process to identify small water suppliers and rural communities that may be at

[34] Similar bills (AB 968 and AB 1654) were introduced by Rubio prior to these bills with the same intent, as an alternative to the budget trailer bill.

[35] Full language of both bills: https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB606 and https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB1668

risk of drought and water shortage vulnerability and provide recommendations for drought planning; and

- Provisions for progressive enforcement against urban water suppliers by the State Water Board, and fines of up to $1,000 per day during non-drought years and $10,000 per day during drought emergencies, if they do not achieve their water use objective by certain dates.

Contrary to some initial press and social media reports, the legislation does not provide for direct state regulation or fines for individual water customers that may not meet the indoor water use standard of 55 GPCD (or lower in future years).

URBAN WATER USE EFFICIENCY

The new water use efficiency laws build upon and essentially replace the current "20x2020" requirements for "urban water suppliers" (water agencies serving 3,000 or more connections or 3,000 or more acre feet) to have reduced water use by 20% from a prescribed baseline by the year 2020. The new laws still focus mostly on urban water suppliers, although some drought planning provisions apply to smaller water agencies, and some provisions apply to agricultural water suppliers (see separate discussion below). The new laws create a new structure for urban water suppliers to develop "annual urban water use objectives" for their service areas (also termed "targets") using a water budget approach. Once calculated, urban water suppliers are expected to manage their actual water use to meet or exceed their urban water use objectives. Local urban water suppliers would then implement new (and/or continue existing) supplier-specific strategies tailored to their circumstance and based on their decision-making authority to achieve the objectives. The water use objectives are to be based on a formula that includes the following components:

- Total estimated efficient indoor residential water use;
- Total estimated efficient outdoor residential water use and CII water use;
- Total estimated efficient water losses from leaks;
- Approved variances (if any); and
- Credits for qualifying potable reuse (if applicable).

INDOOR RESIDENTIAL WATER USE EFFICIENCY STANDARD

The indoor residential water use efficiency standard has been set by the Legislature and is to be multiplied by the service area population. The "provisional standard" is set at 55 gallons per capita per day (GPCD) until January 1, 2025, then it goes to 52.5 GPCD between January 2, 2025, and January 1, 2030; and then it becomes 50 GPCD after January 1, 2030. The legislation is explicit that DWR and the State Water Board may not revise these standards to be more stringent; only the Legislature may do so. However, DWR is required by January 1, 2021 to prepare and submit a report to the Legislature that recommends an alternative standard that more appropriately reflects best practices for indoor water use.

OUTDOOR RESIDENTIAL WATER USE EFFICIENCY STANDARD

The outdoor landscape standard is to be based on total "irrigable acres" (not just outdoor areas that are currently irrigated), and local climate conditions in the service area. The new laws direct DWR to provide water suppliers by January 2021 with data on the area of residential irrigable lands that should be included in their "total estimated efficient outdoor residential water use", but water suppliers are not required to use the data provided by DWR if they can meet specified criteria. DWR and the State Water Board are to jointly develop efficiency standards for outdoor water use by October 2021. The outdoor standards will incorporate the principles of the Model Water Efficient Landscape Ordinance (MWELO) and include provisions for swimming pools, spas, and other water features. This rulemaking is expected to include a robust stakeholder process, and ACWA staff foresee significant need for involvement by water agencies and outdoor landscape experts.

COMMERCIAL, INDUSTRIAL, AND INSTITUTIONAL WATER USE EFFICIENCY

Urban retail water suppliers will be expected to implement state performance measures to increase water use efficiency among their commercial, industrial, and institutional consumers (CII) by educating those water users regarding best management practices or conducting water use audits, among other things. These CII performance measures are to be developed through a stakeholder process. DWR must have this information available for use by June 30, 2022.

EFFICIENT WATER LOSSES

DWR will also set long-term standards for efficient water losses by June 30, 2022 based on the State Water Board's existing regulatory process to develop performance standards for urban retail water suppliers' volume of water losses under SB 555 (2015) (more detail is provided below).

RECYCLING INCENTIVE

The new legislation also includes a "credit" for qualifying potable reuse in the water use objective calculation. This is intended to avoid disincentivizing investments in potable reuse. Urban water suppliers that deliver potable reuse water from an "existing facility" may receive a 15% credit towards their efficiency objective. An "existing water recycling facility" includes a facility with existing plans and investment (defined a including a certified Environmental Impact Report by January 1, 2019 and production of recycled water suitable for potable reuse by January 1, 2022). Urban water suppliers bringing recycling facilities online after that time may receive a 10% credit.

VARIANCE PROCEDURE

The new legislation provides for a "variance" procedure that is intended to address special and unique circumstances (such as significant fluctuations in seasonal populations or extensive dependence on evaporative or "swamp" coolers). This procedure allows water suppliers to petition the State Water Board for adjustments to their urban water use objective, subject to the usual public process allowing for public review and comment.

DROUGHT CONTINGENCY PLANNING AND TECHNICAL ASSISTANCE

Water suppliers will also need to meet a number of new droughts contingency planning and reporting requirements as part of their Urban Water Management Plans. The State Water Board and the DWR are designated specific tasks and to provide technical assistance of various kinds and to developing regulations to implement these new programs.

ENFORCEMENT

Since the legislation includes many interdependent deadlines and a complex implementation process, it provides for a so-called "glide path" for enforcement over coming years. Initial water use objectives do not need to be calculated and reported to DWR and the State Board until November 1, 2023, and annually by November 1 thereafter. No fines may be imposed for non-compliance until November 2027.

Following are the main enforcement milestones:

- After November 2023 - Informational Orders may be issued by the State Water Board to urban retail water suppliers if they are not meeting their initial water use objective.
- After November 2024 - Notices of failure to meet urban water use objective may be issued by the State Water Board to urban retail water suppliers informing them that they are not meeting their water use objective or making reasonable progress. This notice may direct water suppliers to address areas of concern in their next annual report.
- After November 2025 - Conservation Orders may be issued by the State Water Board to urban retail water suppliers informing them that they are not meeting their water use objective or making reasonable progress. This order may include measures designed to assist water supplier in reaching their objective, including but not limited to DWR technical assistance or requirements to conduct various outreach and educational efforts.
- After November 2027 – Notice of violations may be issued by the State Water Board to urban retail water suppliers for failing to meet their water use objective or for violations of other regulations. Fines of $1,000 per day are authorized, which can be up to $10,000 per day if violations occur during emergency drought conditions.

Table 38: SB 606 and AB 1668 Implementation Deadlines. Source: ACWA, 2018[36]

When	Who	What	Code Section
June 1, 2019, and annually thereafter	Urban Water Supplier	Submit an annual water supply and demand (water shortage) assessment report to DWR.	§10632.1
No later than January 1, 2020	Department of Water Resources (DWR)	Coordinate with the State Water Resources Control Board (State Water Board) to identify small water suppliers and rural communities that may be at risk of drought and water shortage vulnerability.	§10609.42(a)
By January 1, 2020	DWR	Consult with the State Water Board to propose recommendations and guidance to the Governor and the Legislature relating to the development and implementation of countywide drought and water shortage contingency plans to address the planning needs of small water suppliers and rural communities.	§10609.42(b)
By January 1, 2020	DWR	Coordinate with the State Water Board to recommend to the Legislature the feasibility of developing and enacting water loss reporting requirements for urban wholesale water suppliers.	§10608.35(a)
By January 1, 2021	DWR	Coordinate with the State Water Board to conduct studies and investigations to report and recommend to the Legislature an alternative standard for indoor residential water use that more appropriately reflects best practices for indoor residential water use than the standard described in §10609.4(a).	§10609.4(b)(1)
By January 1, 2021	DWR	Provide each urban retail water supplier with data regarding the area of residential irrigable lands.	§10609.6(C)(b)
No later than October 1, 2021	State Water Board and DWR	Jointly conduct studies and investigations and recommend standards for outdoor residential use for adoption by the State Water Board.	§10609.6(a)(1)

[36] Table only includes deadlines pertaining to urban water use.

No later than October 1, 2021	DWR	Coordinate with the State Water Board to conduct studies and investigations and recommend standards for outdoor irrigation of landscape areas with dedicated irrigation meters or other means of calculating outdoor irrigation use in connection with CII water use for adoption by the State Water Board.	§10609.8(a)
No later than October 1, 2021	DWR	Coordinate with the State Water Board to conduct studies and investigations and recommend performance measures for commercial, industrial, institutional (CII) and large landscape water use for adoption by the State Water Board.	§10609.10(a)
No later than October 1, 2021	DWR	Coordinate with the State Water Board to conduct studies and investigations and recommend appropriate variances for unique uses for adoption by the State Water Board.	§10609.14(a)
No later than October 1, 2021	DWR	Coordinate with the State Water Board to conduct studies and investigations and recommend guidelines and methodologies for the board to adopt that identify how an urban retail water supplier calculates its urban water use objective for adoption by the State Water Board.	§10609.16
On or before April 30, 2022	DWR	Submit a report every five years that summarizes the status and evaluation of AWMP of agricultural water suppliers.	§10845(a)
By May 30, 2022	State Water Board	Identify the standards and potential effects on local wastewater management, developed and natural parklands, and urban tree health.	§10609.2(c)
On or before June 30, 2022*	State Water Board	Coordinate with DWR to adopt variances, guidelines, and methodologies pertaining to the calculation of an urban retail water supplier's urban water use objective.	§10609.2(e)
On or before June 30, 2022	State Water Board	Coordinate with DWR to adopt long-term standards for the efficient use of water.	§10609.2 (a)
On or before June 30, 2022	State Water Board	Coordinate with DWR and adopt performance measures for CII water use.	§10609.10(d)(1)
July 1, 2022, and every five years thereafter	DWR	Submit a report summarizing the status of 2020 plans and water shortage contingency plans (WSCPs) to the Legislature.	§10644(c)(1)(A)

By November 1, 2023, and annually thereafter	Urban Retail Water Suppliers	Deadline to calculate urban water use objective and report to DWR.	§10609.20(a)
By November 1, 2023, and annually thereafter	Urban Retail Water Suppliers	Deadline to calculate the previous years' actual urban water use and report to DWR.	§10609.22(a)
On and after November 1, 2023	State Water Board	Issue informational orders for water production, water use, and water conservation to urban retail water suppliers that do not meet their urban water use objectives.	§10609.26(a)(1)
On or before January 10, 2024	Legislative Analyst's Office	Provide to the appropriate policy committees of both houses of the Legislature and the public a report evaluating the implementation of the water use efficiency standards and water use reporting.	§10609.30
On and after November 1, 2024	State Water Board	Issue written notices to urban retail water suppliers that do not meet their urban water use objectives.	§10609.26(b)
By January 1, 2024	Urban Retail Water Suppliers	Submit to DWR a supplement to the adopted 2020 plan with a narrative that describes the water demand management measures that the supplier plans to implement to achieve its urban water use objective by January 1, 2027.	§10621(f)(2)
Beginning January 1, 2025	Urban Retail Water Suppliers	Abide by a standard for indoor residential water use of 52.5 gpcd.	§10609.4(a)(2)
On and after November 1, 2025	State Water Board	Issue conservation orders to urban retail water suppliers that do not meet their urban water use objectives.	§10609.26(c)(1)
On or around January 1, 2026	Chair, State Water Board & Director, DWR	Appear before the appropriate policy committees of both houses of the Legislature to report on the implementation of the water use efficiency standards and water use reporting.	§10609.32
After November 1, 2027	State Water Board	Impose fines for violations of long-term standards for efficient water use (from a minimum of $1,000/day to a maximum of $10,000/day in a drought emergency or critically dry year).	§1846.5(a)(1) & §1846.5(a)(2)
Beginning January 1, 2030	Urban Retail Water Suppliers	Abide by a standard for indoor residential water use of 50 gpcd.	§10609.4(a)(3)

Figure 43: CalWEP Social Media Indoor Example. Source: CalWEP, 2018.

Figure 44: CalWEP Social Media Combined Target Example. Source: CalWEP, 2018.

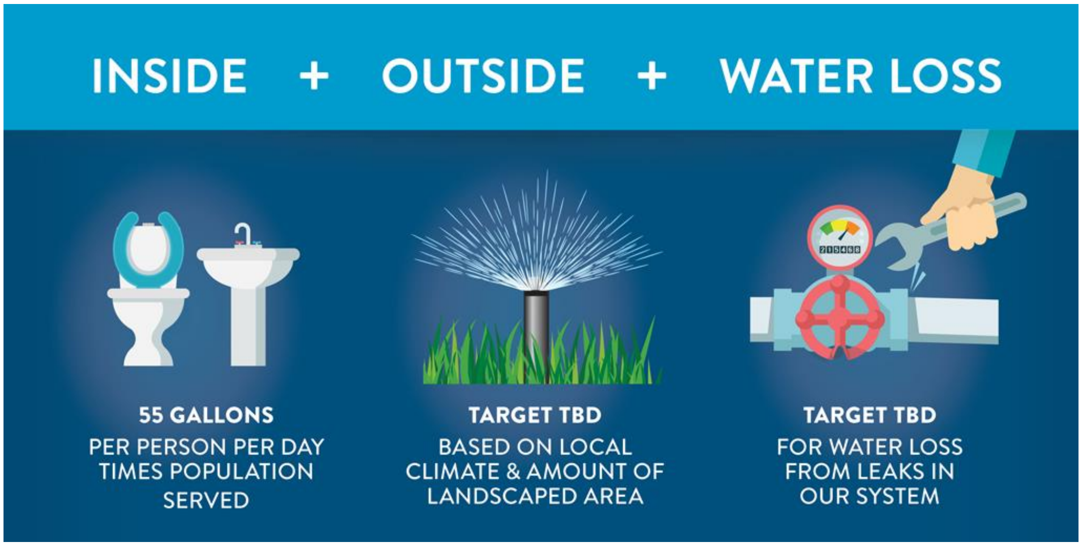
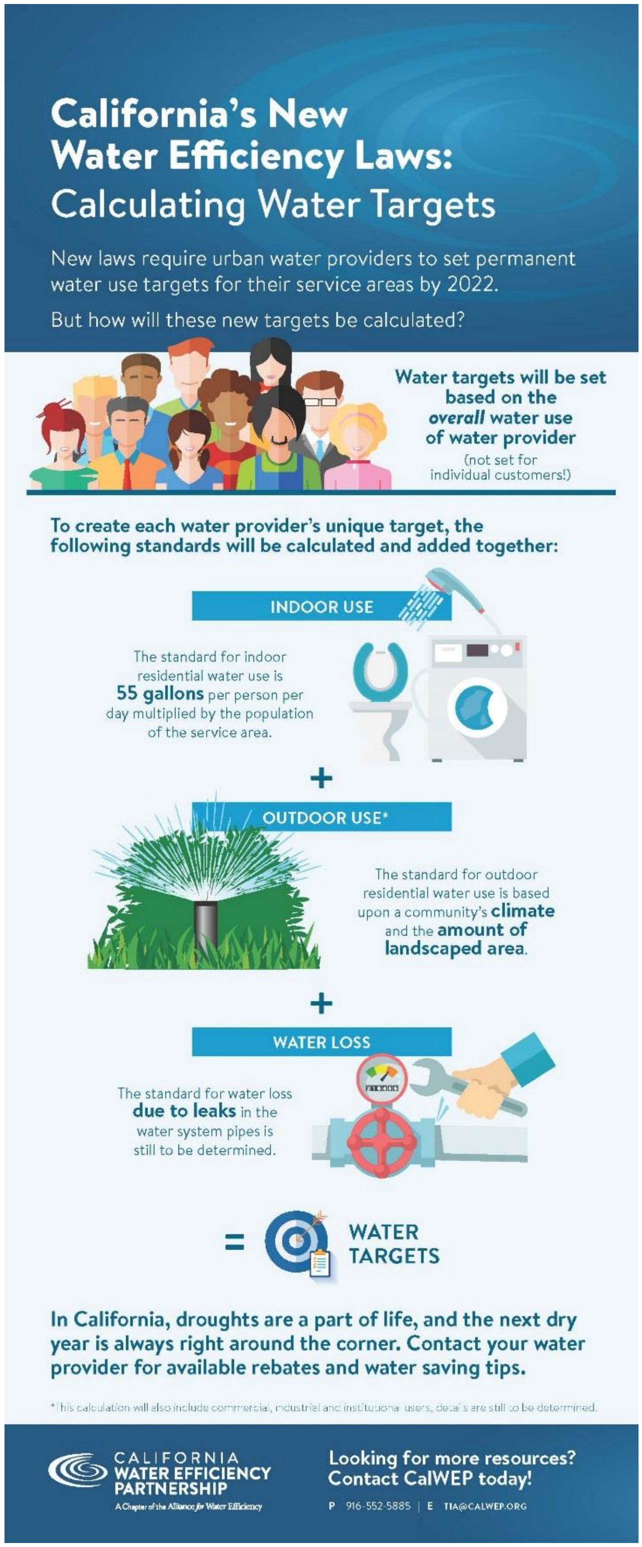


Figure 45: CalWEP Infographic for the New Water Efficiency Laws. Source: CalWEP, 2018.



C. Legislation Strengths

While expectations are high for these news laws, their details are important. Over the next the 4 years, State agencies (primarily the State Water Board and DWR), local water supplier staff, advocacy groups, and other interested parties will work together to translate the law's intent into implementable actions and will develop regulation rules to govern compliance. To prepare for these discussions, it is helpful to identify potential strengths and weaknesses from the legislative text. The strengths of the new legislation are 1) it attempts to prioritize a water budget-based approach to reducing water use versus the previous GPCD approach, 2) it provides for more robust and coordinated drought planning guidance and 3) regards of the details or outcome it will raise the priority of water efficiency within water suppliers, (hopefully) the public, and the State.

A major change from prior water conservation regulations was movement away from required percentage reductions (like those in the past SB X7-7 or 20 X 2020 legislation) to a water budget-based approach. The water budget-based approach is thought to equalize reduction requirements between water suppliers by incorporating differing local conditions such as climate, evapotranspiration rate, lot size, and land use patterns (discussed earlier) to regulate efficient water use. However, typically the water budget-based approach to managing water use is implemented locally, which entails calculating individual accounts or household water use budgets (in gallons) based on locally defined "appropriate" water use for the number of people in that household, estimated indoor water use, landscape area size, and weather. This approach is can be coupled budget-based rates, in which customers pay more or less if their water use is over or under their assigned household water budget. A few suppliers, Irvine Ranch Water District and Eastern Municipal Water District in southern California, already operate on budget-based rates but they are by far the exception in the State (IRWD, 2018; EMWD, 2017).

When the budget-based approach (even without the rates attached) is scaled up to the water supplier level, as required in SB 606 and AB 1668, equitably defining the necessary local details needed for this approach can be daunting considering the diverse set of over 400 large urban water suppliers. "Appropriate" water use is yet to be determined by the State. Finally, the budget-based approach responds to criticism by some water suppliers during the previous water conservation regulation (SB X7-7) that a GPCD base was not equitable because it neglects local conditions or prior conservation efforts. The equity intent of the budget-based approach is a strength in concept, however, the enormous addition of complexity with a statewide budget-based approach may become a major weakness in the long run.

A more universally agreed upon strength of the new laws is the deepening of drought response planning for all urban water suppliers and a more uniform structure for water shortage contingency plans. SB 606 expands the scope of drought planning projections from 3 to 5 years to accommodate the likelihood of longer droughts with climate changes and supply scarcity. Expanding the range of years will force suppliers to update their water supply models and provide additional information and insight about the limits of their water systems and response options.

Additionally, one criticism of water suppliers during the drought was the inconsistency of water shortage contingency plans within regions and the State. A water shortage contingency plan is a series of necessary percent reductions in demand and associated actions to achieve those reductions. These plans are typically arranged in numbered stages of increasing severity, individually tailored to each water supplier's needs. This tailoring led to a large variety of water shortage contingency plans throughout the State in terms of number of stages, percent reductions for those stages, and associated demand reducing actions.

In the Sacramento region alone, among the 21 RWA water supplier members, few plans were exactly alike.[37] Attempts in 2010 and 2015 to increase plan consistency among local suppliers in the Sacramento region resulted only in recommendations, not concrete movement forward (RWA, 2015). While differences among plans serve local purposes (and maybe rightfully so), they do little to aid region-wide and statewide public messaging. In 2015, the Sacramento region could not collectively communicate a consistent stage number and associated actions via regional media outlets because of plan variation. The new laws outline a consistent number of stages (1-6) for all water suppliers and consistent percent reductions (10% increase for each stage), which will help with regional and State assessment of future drought conditions and public outreach messaging. The demand reducing actions for each stage will be allowed to differ among water suppliers to maintain local effectiveness. For example, a 30% reduction in demand from reducing water days is more likely to be achieved in inland Sacramento than in coastal San Francisco that has less outdoor water use. Overall San Francisco will likely need different actions (a mix of indoor and outdoor) to achieve the same 30% reduction. The most recent water shortage contingency plans submitted via the State required Urban Water Management Plans for City of Sacramento and the City of San Francisco show differences in percentages (Figures 47 and 48) and actions (Figures 49 and 50) for each stage (Sac, 2015; SF, 2015).

[37] Only those plans with a common wholesaler, San Juan Water District, were similar.

Figure 46: City of Sacramento Water Shortage Stages. Source: City of Sacramento, 2015.

Table 8-1 Wholesale: Stages of Water Shortage Contingency Plan		
Stage	Complete Both	
	Supply Reduction[1]	Water Supply Condition (*Narrative description)*
1	Up to 20%	Water Alert
2	Up to 30%	Water Warning
3	Up to 40%	Water Crisis
4	Up to 50%	Water Emergency
[1] *One stage in the Water Shortage Contingency Plan must address a water shortage of 50%.*		
NOTES: The City does not have a separate WSCP specific to its wholesale customers. Each of the City's wholesale customers maintain their own WSCPs which will be reported in their respective UWMPs.		

Figure 47: City of San Francisco Water Shortage Stages. Source: City of San Francisco, 2015.

Table 8-3. Retail Water Shortage Stages of Action

[Standardized Table 8-3 Retail: Stages of WSCP – Consumption Reduction Methods]

Water Shortage Stage	Actions by SFPUC	Trigger Point (System-wide Shortage)	Target Water Use Reduction
1 – Voluntary	• Request voluntary rationing of customers • Alert customers to water supply conditions • Remind customers of existing water use prohibitions • Customers are alerted to water supply conditions • Increase education on, and possibly accelerate, incentive programs (e.g., toilet rebates)	10 – 20%	5 – 10%
2 – Mandatory	• Implement all Stage 1 actions • Assign all customers an "allotment" of water based on the Inside/Outside allocation method (based on base year water usages for each account) • Subject water use above the "allocation" level to excess use charges, installation of flow restrictor devices, and shut-off of water	21 – 50%	11 – 20%
3 – Mandatory	• Implement all Stage 2 actions with further reduced allocations	> 50 %	> 20 %

Figure 48: City of Sacramento Shortage Stage Details. Source: City of Sacramento, 2015.

Table 8-2 Retail Only: Restrictions and Prohibitions on End Uses			
Stage	Restrictions and Prohibitions on End Users	Additional Explanation or Reference *(optional)*	Penalty, Charge, or Other Enforcement?
1	Landscape - Prohibit certain types of landscape irrigation	Reduce irrigation of parks and cemeteries.	Yes
2	Landscape - Other landscape restriction or prohibition	Reduce irrigation of parks and cemeteries.	Yes
2	Other - Require automatic shut of hoses	Shut-off valves required on all hoses used for irrigation purposes, City parks, and other City facilities	Yes
2	Landscape - Limit landscape irrigation to specific days	Two day/week irrigation schedule	Yes
2	Landscape - Other landscape restriction or prohibition	The irrigation of new landscaping shall be subject to the same restrictions as existing landscaping (i.e. the provisions allowing irrigation of new landscaping for a period of 21 days after planting will no longer apply).	Yes
2	Landscape - Prohibit certain types of landscape irrigation	Irrigation of ornamental turf on public street medians with potable City water will be prohibited	Yes
2	Other	Prohibit all public water uses not required for health and safety	Yes
3	Landscape - Limit landscape irrigation to specific days	One day/week irrigation, manual only	Yes
3	Landscape - Prohibit certain types of landscape irrigation	Prohibit automatic sprinklers	Yes
3	Landscape - Limit landscape irrigation to specific times	Limit irrigation hours	Yes
3	Landscape - Prohibit certain types of landscape irrigation	Reduce irrigation of parks and cemeteries.	Yes
3	Other	Prohibit car washing	Yes
4	Landscape - Other landscape restriction or prohibition	Prohibit outdoor irrigation of residential turf	Yes
4	Landscape - Prohibit certain types of landscape irrigation	Reduce irrigation of parks and cemeteries.	Yes

NOTES:
Revised or additional prohibitions may be adopted by City Council Resolution.
The actions included in each stage are cumulative, meaning, for example, that if Stage 2 of the Water Shortage Contingency Plan is implemented, all of the measures in Stages 1 and 2 shall be implemented, unless altered by the City Council.

Figure 49: City of San Francisco Shortage Stage Details. Source: City of San Francisco, 2015.

Table 8-4. Water Use Restrictions

[Standardized Table 8-2 Retail Only: Restrictions and Prohibitions on End Uses]

Mandatory Restrictions	Applicable Water Shortage Stage(s)
Permanent[a]	
Water waste, including but not limited to, any flooding or runoff into the street, sidewalk or gutter	Not applicable
Using hoses for any purpose without a positive shut-off valve	Not applicable
Serving water at a restaurant, café, or food counter without waiting for a request by a customer or customers	Not applicable
Potable water was not to be used to clean, fill or maintain levels in decorative fountains.	Not applicable
Use of potable water for consolidation of backfill, dust control or other nonessential construction purposes if groundwater or recycled water is available and approved by the San Francisco Department of Public Health[b]	Not applicable
Use of single-pass cooling systems, fountains, and commercial car washes	Not applicable
Temporary (i.e., imposed during water shortage)	
Washing sidewalks, driveways, plazas and other outdoor hardscapes for reasons other than health and safety needs[c]	2, 3
Outdoor irrigation of ornamental landscapes or turf with potable water that is not reduced by at least the amount (percentage) specified in the drought response plan	2, 3
Watering outdoor landscapes with potable water during and within 48 hours after a rain event[c]	2, 3
Not providing guests the option to refuse daily laundering of towels and linens at hotels and motels, and not prominently displaying notice of this option in each guestroom[c]	2, 3
Irrigation with potable water of ornamental turf on public street medians[c]	2, 3
Use of additional water for new landscaping or expansion of existing facilities unless low water use landscaping designs and irrigation systems are employed[d]	2, 3
Water service connections for new construction not incorporating water-saving fixtures or devices into the plumbing system[d]	2, 3
Verified water waste as determined by the Water Department would serve as prima facie evidence that the allocation assigned to the water account is excessive; therefore, the allocation was subject to review and possible reduction, including termination of service[d]	2, 3
Use of supplies other than groundwater and/or recycled water for irrigation of golf courses, median strips, and similar turf areas[d]	2, 3
Use of potable water on golf courses outside irrigation of putting greens[d]	2, 3
Use of potable water for street sweepers/washers[d]	2, 3
The washing of all automobiles, motorcycles, RVS, trucks, transit vehicles, trailers, boats, trains, and airplanes outside of a commercial washing facility; unless required to clean windows on all vehicles and such commercial or safety vehicles for health and safety reasons[d]	2, 3
The filling of new swimming pools, spas, hot tubs, or the draining and refilling of existing pools, etc.[d]	2, 3

a Established in SFPUC Rules and Regulations Governing Water Service to Customers, Section E, Rule 12.

b Consistent with the Soil Compaction and Dust Control Ordinance, Ordinance 175-91 (San Francisco Public Works Code, Article 21, Sections 1100-1107).

c Imposed by the SFPUC per emergency conservation regulations adopted by the SWRCB in 2014 and 2015.

d Prescribed in the 1987-92 drought and/or specified in RWSAP; may be enforced during a future drought.

Additionally, any change to a water supplier's water shortage contingency plan may take significant public outreach effort to ensure that customers understand the new restrictions, especially with watering days, so that the intended savings are achieved and not "lost" in the confusion of messaging. For that reason alone, the middle of a drought is not the best time to change a supplier's plan. The legislation timeline gives water suppliers enough advance notice to anticipate and plan for the changes for a better chance at a smooth transition.

Lastly, regardless of the details or outcome of these regulations, their presence has already elevated water efficiency within water suppliers. The regulations are being discussed at the local Board level, staff are being directed to participate in State technical workgroups, suppliers are taking a closer look at their programs and billing systems to start preparing for whatever the final version of the regulations will be several years from now. Even if a water supplier is not supportive of the regulation, it is now part of the requirements for doing business in the State. Suppliers have a choice to work towards making these laws successful for their supplier or sit back and see if they can live with the outcome of the regulatory process.

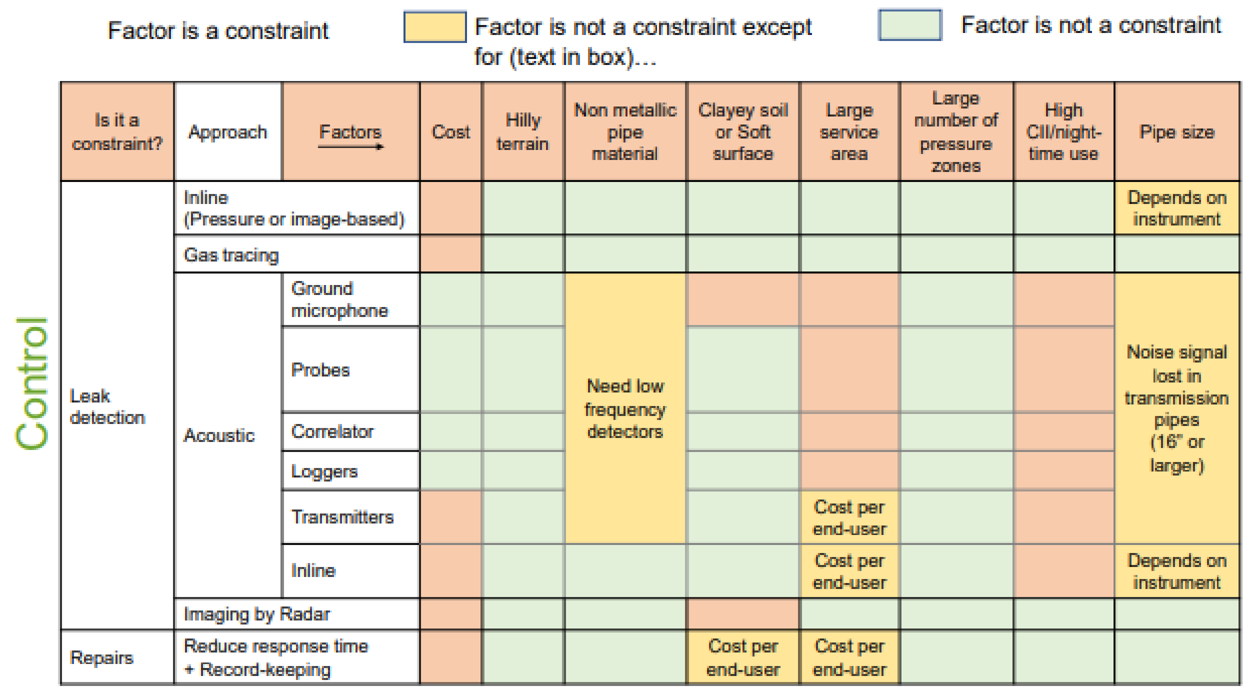
D. Legislation Weaknesses

There are several weaknesses in the legislation including 1) issues with scale and timing, 2) complications regarding the outdoor water use budget, 3) concern for cost effective water savings expected, and 4) overall uncertainty with finalizing target development.

The first weakness is a result of scale. The legislation is very detailed in some sections, which will require collecting local and water supplier data to assess and assign the water supplier specific targets. During the legislative process, water suppliers repeatedly sought targets that accurately reflect local conditions. To do this, local information is needed to make local assessments like what is already done when water suppliers implement their local water shortage contingency plans. There should be balance between considering locally appropriate targets and the scale at which they are implemented. Implementation at the state scale should be matched with the appropriate scale of data collection. Furthermore, the State would not be required to implement a regulation that over-incorporates local characteristics. The State should in response create a more generalized regulation that equally accommodates the diversity of water suppliers without over burdening water suppliers and the State with surplus data collection and analysis. This is not an easy task.

One example of this scale issue is the development of an acceptable volumetric water loss budget, which is one component of a water supplier's budget/target required in SB 606 and AB 1668. This volume will likely be derived from some component of a water provider's validated American Water Works Association (AWWA) Water Loss Audit spreadsheet. However as dictated in related legislation SB 555 approved in 2015, "the (State Water) board shall employ full life cycle cost accounting to evaluate the costs of meeting the performance standards." These performance standards are supposed to be incorporated into a water supplier's water use target, as required for SB 606 and AB 1668. To properly evaluate full life cycle costs in the context of a volumetric water loss performance standard, the State has to figure out how to determine if the supplier has done "enough" water loss management to be cost effective while maximizing water savings. This "sweet spot" is usually determined at the water supplier level with the internal knowledge of the system's strengths and weaknesses, future infrastructure plans, current water rates, and water reliability among other factors. As legislated, the State is required to try and duplicate this type of assessment at the state level to appropriately determine the acceptable level of loss for 411 urban water suppliers. Figure 51 shows the current data matrix the State is proposing to collect for all water suppliers to identify water loss control actions that might be appropriate/cost effective for each water provider (SWRCB, 2018). That the State is considering such detailed factors such as soil type for individual service areas indicates that the balance between being locally appropriate and overstepping into details best evaluated at the local level. Additionally, these water loss targets are produced on an annual basis (per the legislation), so, the level of water loss information requested from the State for water suppliers should match this relatively short timeline. Is there enough time to provide such a detailed analysis for all urban suppliers each year? The State is unlikely to understand the inner workings of 411 urban water suppliers when state regulators are so far removed for the day to day functions of water suppliers. How much detail is enough?

Figure 50: Proposed State Water Board Water Loss Control Data Matrix. Source: State Water Board, 2018.



Is it a constraint?	Approach	Factors	Cost	Hilly terrain	Non metallic pipe material	Clayey soil or Soft surface	Large service area	Large number of pressure zones	High CII/night-time use	Pipe size
Leak detection	Inline (Pressure or image-based)									Depends on instrument
	Gas tracing									
	Acoustic	Ground microphone			Need low frequency detectors					Noise signal lost in transmission pipes (16" or larger)
		Probes								
		Correlator								
		Loggers								
		Transmitters					Cost per end-user			
		Inline					Cost per end-user			Depends on instrument
	Imaging by Radar									
Repairs	Reduce response time + Record-keeping					Cost per end-user	Cost per end-user			

Factor is a constraint

Factor is not a constraint except for (text in box)…

Factor is not a constraint

Control

Is it a constraint?	Approach	Factors →	Cost	Hilly terrain	Non metallic pipe material	Clayey soil or Soft surface	Large service area	Large number of pressure zones	High CII/night-time use	Pipe size
Operational pressure	Pressure reducing valves			High elevation zones			Cost per end-user	Cost per end-user		
	Booster pumps						Cost per end-user	Cost per end-user		
Pressure surges	Flywheel pumps									
	Backup pump						Cost per end-user			
	Relief valves						Cost per end-user			
	Surge tanks						Cost per end-user			
	Start-stop practices						Cost per end-user			

The AWWA Water Loss Audit spreadsheet was developed for water suppliers to better manage water losses and prioritize areas of apparent losses for improvement over time, and was not originally intended to be used for regulation. Elevating this approach for regulation also assumes that a water supplier has reached sufficient data accuracy. The AWWA M36-Water Audit and Loss Control Programs (M36) manual does not recommend target and goal setting using the spreadsheet software until a supplier's data validity score is at least 50. If the data validity score is not high enough, the State may recommend some levels of acceptable loss or water loss mitigation actions based on inaccurate data, i.e., mistaking a data problem for a water loss problem. That said, this is not the first attempt to regulate water loss. Investor owned water suppliers in the California are already essentially regulated for water loss as part of a larger assessment of their systems. Several states like Georgia, Tennessee, and Texas also have some level of water loss regulation (AWE, 2018). The country of Denmark fines water suppliers that show losses over 10% of production (MEFDEPA, 2018).

The second weakness is the overall timing for water suppliers to receive their annual targets and reporting to the State on those annual targets. The State gives each supplier their water use target every year based on the previous year's water use. This means that a supplier will not exactly know their target until it is too late to make adjustments. For example, the water loss component of the target will at least partially be based on annual water production, which is not final until the end of that one-year period. Another example is the outdoor water use component. While evapotranspiration (a factor expected to be used in calculating outdoor water use) is relatively consistent year to year, slight changes near the end of the year cannot be anticipated, which will increase or decrease ability to achieve a target. Even if water suppliers assess their progress throughout the year, it will be nearly impossible to meet the water use objective exactly at the end of the year, if unexpected changes occur. The situation lends itself to the State permitting an allowed range of compliance for suppliers' target to account for the "wobble" of unexpectedness that could happen due to timing. For example, if in a supplier is within 5-10% of their target, they would still be in compliance. The good news is there are still opportunities in the coming years to incorporate changes to how the state will enforce water provider targets.

Reporting to the State on water use is another area of timing concern for water suppliers. The legislation requires reporting a supplier's water use target to the State by November 1st of each year starting in 2023. Also in the legislation, suppliers are required to conduct an annual water supply and demand assessment to evaluate potential supply shortages for that year by June 1st of each year, starting in 2020. Suppliers are separately required to submit production and demand data each year to the Drinking Water Information Clearinghouse (DRINC). Suppliers are also required to report their validated water loss audits from SB 555 on October 1st of each year starting in 2017. Due to the interrelatedness of the all these reported data: water loss, production, shortage information, target, etc., consolidating reporting dates, and streamlining content to the State would better ensure uniform quality data is used for assessing compliance with the numerous water supplier requirements, standardize time frames for the reported data and would also limit staff time commitments to this endeavor. Currently proposals are circulating among water suppliers in the State to achieve such objectives and limit reporting to the State to two times a year.

The third weakness is the calculation of landscape water budgets for residential (single and multifamily) households and commercial, industrial, and institutional (CII) properties with a dedicated irrigation meter. The calculation will be based on high resolution aerial imagery obtained by the State. Based on the imagery, "irrigable" areas will be defined, measured, and used to calculate a water budget (how much water should be applied to that area based on a combination of factors such as evapotranspiration and irrigation efficiency). The definition of irrigable is currently being specified by the State but will likely include those areas of a parcel that could be but may not be currently irrigated or have been irrigated in the past. This would exclude impervious surfaces like sidewalks, roofs, and driveways unless they are covered with tree canopy, which would be counted as irrigable. This method can become complicated easily, especially considering the diversity of water service areas in the State. What about water suppliers with large lots with irrigated areas near the house but natural areas on the perimeter of the property? What happens when land use data used by the State to identify residential parcels does not match the meter data for water suppliers?[38] How will growth within a water supplier's service area be accounted for if aerial imagery is not updated every year to match the annual targets? Possible complications abound.

To answer some of these questions, the State is in the process of piloting the residential landscape part of the supplier target. The State has already completed an initial pilot with two suppliers, the city of Santa Rosa and Padre Dam Water District. Several issues have already been identified such as misaligned parcel data, differing interpretations of what areas are irrigable, and the consolidation of tax assessor files used by the State to identify residential parcels. However, outdoor water use, like all components of the water use target, will be rolled up to the water supplier level, not parcel level. Therefore, the currently identified issues may only make a small impact on the overall supplier target or it could drastically change the target

[38] Some multifamily residential properties are categorized as commercial properties in water supplier records but may be categorized as a residential property according to the state. In this instance, the water supplier target would include the property in the supplier's target but it would not be included in the supplier's meter data to assess the target. This situation can work both ways.

for some suppliers. It is too soon to tell what the impact will be for each supplier. The State is now moving forward with additional pilots with more water suppliers in 2019. The City of Folsom in the Sacramento region will participate in the next pilot along with a diverse set of 16 other suppliers throughout the State.

The CII part of this target is still more complex and is solely focused on CII dedicated irrigation meters within a water provider's service area. However, unlike single family residential where it is standard to have one meter per parcel, CII customers may have multiple parcels per water supplier account and/or multiple meters per account. Most water suppliers do not have their CII dedicated irrigation data tied to spatial data. Therefore, it will be challenging for the State to calculate landscape budgets for those accounts. Is this something water suppliers are responsible for rectifying? If so, that may entail water supplier staff visiting each dedicated irrigation account location and mapping out where each meter's water goes on the landscape, taking extraordinary staff time and cost, especially for larger suppliers with 1,000's of dedicated CII irrigation accounts. Little is known at this time on how this component will be implemented, which has allowed for much speculation among water suppliers.

This uncertainty leads to the final weakness, will these new regulations be cost-effective for individual suppliers? Typically, water suppliers evaluate infrastructure maintenance/expansion and program costs to assess whether the funding spent will provide for a desirable return (either in water savings, cost savings, level of service improvements, increased customer service, etc.) to the supplier and its customers. With the water supplier water use target being mandated, how will cost effectiveness be accounted for? Does the State care that to meet a supplier's target, a supplier might have to spend millions of dollars beyond what is accepted as cost effective for that supplier's circumstances? Without all the details of the components of the target it is hard to respond to these questions. However, it continues to be a concern to water suppliers.

In an attempted to estimate potential costs for the calculation and reporting requirements of implementing AB 1668 and SB 606 (not counting the additional costs for public outreach efforts, water efficiency programs to achieve the savings, and capital infrastructure), a group of 19 water suppliers from the South Coast, Bay Area, and Sacramento regions estimated costs based on the information provided in the legislation text. Retail suppliers of various sizes, water sources, rate structures, development patterns, operational budgets, and water efficiency practices participated in an informal survey. Table 39 shows the combined calculating and reporting costs from the survey.

Table 39: AB 1668/SB 606 Calculating and Reporting Cost Estimate Ranges for 2020-2026. Source: Regional Water Authority, 2017.

Supplier Size	# of Suppliers	# of Connections	Low Cost Range	High Cost Range	Average Cost	Average Cost Per Connection
Small	5	3,000-10,000	$108,569	$645,340	$336,123	$41
Medium	8	10,001-39,999	$167,765	$683,342	$396,292	$20
Large	6	≥40,000	$427,693	$3,697,799	$1,311,815	$11
Note: Cost estimates are intended for the sole purpose of estimating expenditures related to the calculation and reporting requirements proposed in AB 1668 and SB 606. The estimate ranges reflect responses to the multiregional survey and are based on current available knowledge and best professional judgement. Detailed retail supplier estimates may differ as costs and implementation requirements may vary significantly by region.						

Tables 40 and 41 show the breakdown of calculation and reporting costs, respectively. Urban water use objective/target costs (Table 40) include costs of verifying and maintaining landscape imagery and analyses for outdoor residential landscapes and CII landscapes served by dedicated irrigation meters and the implementation of CII performance measures.[39] New planning and reporting requirement costs (Table 41) include costs for preparing urban water use objective reports, annual water supply and demand analysis, and the expanded Urban Water Management Plan development requirements, including updating water shortage contingency plans, extended drought risk assessments, and energy intensity reporting.

Table 40: Urban Water Use Objective/Target Cost Estimate Ranges for 2020-2026. Source: RWA, 2017.

Supplier Size	# of Suppliers	# of Connections	WU Low Cost Range	WU High Cost Range	WU Average Cost
Small	5	3,000-10,000	$30,463	$437,340	$217,582
Medium	8	10,001-39,999	$89,659	$486,546	$266,286
Large	6	≥40,000	$357,236	$3,166,999	$1,082,144
Note: Cost estimates are intended for the sole purpose of estimating expenditures related to the calculation and reporting requirements proposed in AB 1668 and SB 606. The estimate ranges reflect responses to the multiregional survey and are based on current available knowledge and best professional judgement. Detailed retail supplier estimates may differ as costs and implementation requirements may vary significantly by region.					

[39] The water loss component of the urban water use objective is not included in this analysis. CII performance measures were assumed to be audits for the top 100 CII accounts by volume.

Table 41: New Planning and Reporting Requirement Cost Estimate Ranges for 2020-2026. Source: RWA, 2017.

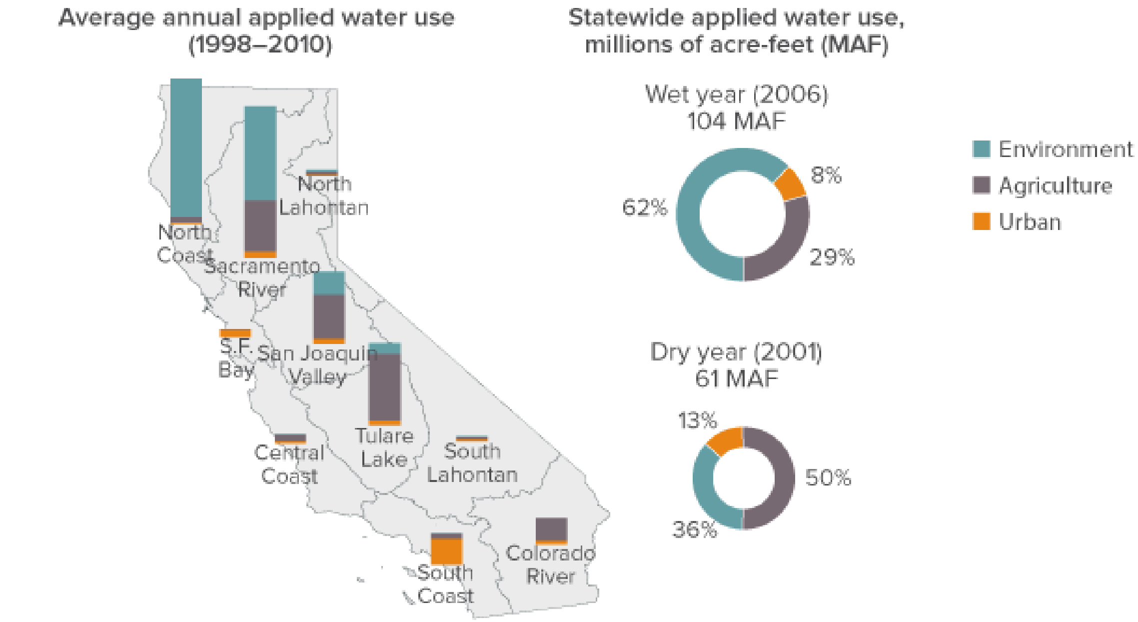
Supplier Size	# of Suppliers	# of Connections	Reporting Low Cost Range	Reporting High Cost Range	Reporting Average Cost
Small	5	3,000-10,000	$78,000	$208,000	$118,541
Medium	8	10,001-39,999	$78,106	$252,000	$130,006
Large	6	≥40,000	$63,700	$530,800	$229,671
Note: Cost estimates are intended for the sole purpose of estimating expenditures related to the calculation and reporting requirements proposed in AB 1668 and SB 606. The estimate ranges reflect responses to the multiregional survey and are based on current available knowledge and best professional judgement. Detailed retail supplier estimates may differ as costs and implementation requirements may vary significantly by region.					

Although it seems expensive at first glance, it is unclear if complying with these regulations will be cost-effective because the water use targets for water suppliers are still being developed. Some suppliers may require extensive actions to reach their target while others may already meet or exceed it and will simply continue their current practices and programs with potential minor adjustments and increased reporting.

E. Legislation and Water Savings

The water suppliers cannot substantially say how much water these new regulations will save or if these savings will be worth the cost. The success of the regulation will partly depend on customer participation and how the State's enforcement is organized. Of all runoff in California, average uses are 50% environmental, 40% agricultural and 10% urban. These percentages fluctuate locally and between dry and wet years (Figure 52), but urban water use is relatively small statewide and has declined for decades despite increasing populations (Mount and Hanak, 2016). Considering urban use is about 10%, with about half of that being residential and then half of that is outdoor water use and then the regulations will save a portion of that, maybe 10%, now the savings starts to look smaller and smaller on a statewide scale yielding a 1% savings statewide. Residential water savings (a primary focus of the EO) alone will not provide the State with substantial water savings. Other water management policies need to continue to be considered like supply augmentation/alternatives, fixture, and infrastructure improvements among others. This is not to say that water efficiency efforts should not continue and expand in the future. But it is reasonable to ask if the level of effort expended on reducing urban use would be better dedicated to something else to achieve the more fundamental objectives of water conservation.

Figure 51: Applied Water Use by Sector. Source: PPIC, 2016.



SOURCE: Department of Water Resources (2013). *California Water Plan Update* (Bulletin 160-13).

There is a place for legislation and regulation in the water industry, if done to solve a systemic and pervasive issue with a clear goal. Unfortunately, this is often not the case. At best, legislation can correct a deficiency in industry practices and create significant benefits for the industry as a whole, its customers, and the state. Only when the details for this particular regulation are complete will the State, the water suppliers, and water customers understand the impacts of these laws.

VII. Chapter 7: Conclusions and Recommendations

Focusing on the future, this last chapter summarizes recommendations to increase the effectiveness of water efficiency and conservation programs in the State regarding implementation of SB 606 and AB 1668 and recommendations to improve state, regional, and local responses for the next drought.

A. Recommendations to Increase Water Use Efficiency in California

These recommendations are directed at specific components of the new laws: Overall Goal, Reduction Method, Funding, and Compliance.

Overall Goal: The State should clarify its statewide water savings goal. Senate Bill 1668 states that the savings from the new regulations "would exceed the statewide conservation targets required", meaning it would exceed the current Senate Bill X7-7 also known as the 20 X 2020 targets set to achieve a statewide 20% reduction in urban use by 2020. However, it's not a direct "apples to apples" comparison because the methods are different and not all suppliers under the current statewide conservation targets are required to save exactly 20%, targets vary up to 20% depending on a number of factors. Does that mean that the new SB 606/AB 1668 targets will have to equal greater than 20% and from what baseline? Furthermore if most of the state's water suppliers are deemed "efficient" according to the new method, will the State change the definition of efficient use to meet the greater than 20% savings outlined in the legislation? This would compromise the newly provided equity among the water suppliers that was the reasoning for developing budget-based targets in the first place. Furthermore, what does the State intend to do with the water savings? What will the water be used for? The State needs to clarify the savings quantity and purpose prior to finalizing the budget-based method so water suppliers and the public have a clear goal to meet and, then, a defined path to get there (not the other way around).

Reduction Method: Outdoor water use reductions should be moderate. The State heavily focused on reducing outdoor watering during the most recent drought. While widely accepted in a drought emergency, continuously reducing landscape water use beyond levels of efficiency can harm other landscape functions like providing habitat, healthy soil, quality of life, tree health, and stormwater management (STF, 2019; Nowak and Crane, 2002). Currently the State does not know what efficient use is for different regions in the state. The landscape water budgets are an attempt to define efficient use but little "on the ground" verification of these methods exists for establishing efficiency. Only 4 of the 355 reported urban water suppliers in the State to date have officially attempted a water supplier level water budget approach to meet current conservation targets (Brostrom, 2015).

Broader research and evaluation of the effectiveness of the water budget approach, like the 2014 University of California-Riverside study, should be done before finalizing regulations (Baerenklau, 2014). Research should help define reasonable timeframes for implementing budget-based targets, especially considering the data-heavy nature of this approach. At what point does conservation conflict with quality of life and other landscape objectives? Is the State trying to redefine what residential landscapes look like? Max Gomberg with the State Water Board stated, "We're not saying everyone everywhere has to eliminate all turf, but if you live anywhere south of Eureka, that shouldn't be the dominant plant material of your landscaping" (Smith, 2016). If the State truly wants to "make conservation a California way of life," water savings actions should be implemented gradually and so people can integrate these practices into everyday life with a goal of long-term success. Additionally, if the State wants residential landscapes to have less turf, they should coordinate with local and regional land use agencies that regulate building codes and the types of plants included in landscaping. Lastly, simply changing plant materials in landscapes does not necessarily reduce water use. Modifying landscape irrigation and upgrading to more efficient irrigation equipment can more directly reduce water use consistently over time. To some extent, alternative supplies like graywater reuse can supplement these potable system supplies for landscaping. Some communities like San Francisco already provide guidance to residents and businesses for graywater reuse (SFPUC, 2019).

Reduction Method: **State driven water efficiency efforts should match expected savings.** Is the "juice worth the squeeze" for these regulations? The amount of time and funding needed to implement complex water supplier level water budget targets seems likely to exceed the potential benefits from resulting statewide water savings. Is saving 1% of a supplier's production worth paying for 3 full time employees and $5 million in conservation programs when they have ample supply? Perhaps such expense could be better devoted to more directly support conservation objectives.

Will the budget-based approach save the same amount of water than the less detailed 20 X 2020 approach? In that case the State could simply extend the 20 X 2020 targets to 30% by 2030, freeing up State and local staff and funding efforts to focus on other tasks with more water savings potential or to help areas with more urgent drought and water supply problems. Is the added (real or perceived) equity of the budget-based approach worth the costs to water suppliers and customers? No one knows for sure right now.

While incorporating local factors into State policy and regulation is important, there should also be a consideration for scale (local versus State). How can the State balance the need to customize targets as required by the legislation but not overly burden State and water supplier staff with data collection and analysis? Keeping in mind that every detail added here has an opportunity cost for the state and water suppliers to be active in other areas that may also achieve water savings and other water management objectives. The additional effort should generally not exceed the additional benefit.

Funding: **To aid implementation, energy efficiency funding should supplement water efficiency program budgets.** As shown during the drought, water efficiency also produced energy savings, at times more cost-effectively than energy efficiency programs (Spang et al., 2018). Local water and energy suppliers should continue to work together towards mutual savings goals. Water suppliers will benefit from funding from the energy sector, and energy suppliers benefit from a more diverse program portfolio and a shared administrative program. With a shared customer base and constrained customer outreach budgets, partnerships (assuming a positive cost benefit for both parties) can be helpful. However, in practice joint supplier partnerships often require significant coordination to set up and maintain and may not produce enough for both parties to continue partnership. However, the state should continue to help facilitate such partnerships and provide joint funding opportunities as part of a larger climate change adaptation strategy.

Compliance: **The State should allow for a compliance target range.** With many data details and potential for error designing and implementing these regulations, the State should allow some flexibility in enforcement. As discussed above, given the difficulty of timely reporting, complexity of landscape budgets, uncertainty with the CII measures, limited data to produce the water loss standard, changing customer behavior, organization of supplier meter data, and oscillating water supply conditions from year to year, it is unreasonable to expect water suppliers to exactly meet their targets every year. Enforcement should be based on the ability of a water provider to show progress toward improving water efficiency over time towards their target, recognizing that water efficiency is not an exact science and water demand is a function of many factors out of the control of the water supplier. While the state is working on reducing the errors inherent in the process, some errors will always exist and providing a range gives suppliers additional flexibility to meet the intention of the laws (without being overshadowed by error). This is especially important because water suppliers can be monetarily fined for non-compliance starting in 2027.

B. Recommendations to Improve State, Regional, and Local Drought Response

"Unfortunately, we tend to focus on drought when it is upon us. We're then forced to react -- to respond to immediate needs, to provide what are often more costly remedies, and to attempt to balance competing interests in a charged atmosphere. That's not good policy. It's not good resource management. And it certainly adds to the public's perception that government is not doing its job when it simply reacts when crises strike. To the contrary, we must take a proactive approach to dealing with drought. We must anticipate the inevitable -- that drought will come and go -- and take an approach that seeks to minimize the effects of drought when it inevitably occurs." -- James R. Lyons, Assistant Secretary of Agriculture for Natural Resources and the Environment, speaking at Drought Management in a Changing West: New Directions for Water Policy, a conference in Portland, Oregon, in May 1994.

California is constantly in a cycle of drought, response, and adjustment, similar to the principles of adaptive management (MFR, 2014; Lund et al. 2018). Each new drought brings a new chance for innovation and adjustment and this last drought is no different. Better to evaluate and make adjustments after the last drought than during the next one. Below are recommendations for State, regional, and local drought response improvements organized by implementation lead(s).

State:

Water use reductions should be linked to local water supply conditions. Drought is ultimately a local condition. Perhaps the biggest misstep from the 2014-2016 drought was the initial reaction of State-assigned conservation targets based on water use, not water supply. To the State's credit, this was rectified with the implementation of the more localized "stress test" near the end of the drought. Water suppliers must first respond to their immediate local need and responsibility to their customers. Then they can coordinate with partnering water suppliers to move water to other areas of need through water transfers and markets.

The State should support and fund additional climate change and drought adaptation actions. Suppliers should have the ability to swing from drought to flood years through utilizing a variety of management options including water markets, system infrastructure and treatment upgrades, supply augmentation, and regional water transfers and interconnections, among others. Having a portfolio of supply and demand options to maintain supply to customers is ideal. Water conservation and efficiency alone is not enough to respond to the current and anticipated impacts from climate change. If a person uses 10% less than the previous year, but there is still not enough water to deliver, the savings is insufficient. The state should continue to move forward with water efficiency efforts but keep in mind that similar efforts are warranted in other supply and infrastructure areas to create a well-rounded state strategy of options to assist water systems in need.

Regional:

Regional entities should identify and implement programs and projects that bring collective benefit to their regions. Regional entities exist to see beyond the individual needs of each local supplier and identify what programs or infrastructure projects that could help solve an overarching issue that would allow the local suppliers to better serve. For example, a regional water bank could provide water to a few suppliers in the region that are more prone to drought and could provide other suppliers in region funding from selling water to make infrastructure improvements to their own facilities. Regional entities are the connectors, the birds' eye view, to add value to local activities.

Local:

The residential lawn should be viewed as water conservation infrastructure in future droughts. Just as pipes and pumps carry water from a water provider to customers, collectively lawns throughout a water supplier's service area could be tapped to reduce residential water demand rapidly by up to 50% in some areas of the State. No other single action can deliver this reduction short of cutting off service, especially for suppliers with primarily residential use, like those in the Sacramento region. This concept was promoted during the last drought but in a less informed way. With the development of residential landscape water budgets via implementation of SB 606 and AB 1668, water suppliers can better estimate how much water is used on residential landscapes and more accurately estimate realistic water savings from a 10%, 20%, 30%, etc. reduction in residential outdoor water use. This additional knowledge could change how water suppliers organize their water shortage contingency plans including how they prioritize landscape type reductions (trees versus lawn) and the percentage of customers regularly above or below their budgets (to gauge potential savings).

Urban water suppliers should have a drought revenue recovery mechanism approved by the supplier's management and in compliance with Proposition 218 as part of their standing policies and/or rate structure. The mechanism could be a revenue recovery or "rainy day" fund, a specified "drought rate" or another option. Water suppliers should not be required by the State or any other entity to trigger the mechanism, but it should be available to the system in the event of a supply interruption, drought or otherwise. A drought revenue recovery mechanism option could be added to a supplier's regularly scheduled rate study.

State, Regional, and Local:

Drought management should be controlled locally, coordinated regionally, and overseen at a state level. State and regional actions should not disrupt suppliers from investing in reliability planning; instead it should recognize these investments' local, regional, and statewide benefits. Local water suppliers should maintain their own policies and response plans. Regional entities and/or wholesalers should coordinate with each other and help their local water suppliers identify areas of opportunity and challenges that could be solved regionally. The State should focus on removing barriers to implementing local and regional solutions and step in only when local and regional efforts fail. Senate Bill 606 requires urban water suppliers to conduct an annual water supply and demand assessment and submit it to the State with information about anticipated shortage. This submission to the State about local conditions should help avoid mandating blanket conservation targets to all urban water suppliers in the future. The information will allow the State to oversee local conditions with enough foresight to provide assistance directly to the subset of suppliers in need, prioritizing and more efficiently using limited State resources.

Rebate programs should be less of a focus during drought. As shown in the Sacramento region, rebate programs create little direct water savings, but expend staff time and funding. During drought, water suppliers should prioritize broader public and media outreach focused on reducing outdoor water use. During the drought, the State committed $30 million to funding toilet and cash for grass rebates, while the public outreach statewide Save Our Water Campaign had less than a 1/10 of that funding annually. As of January 2019, there was still funding available from the State's drought response cash for grass rebate program. Rebate programs provide visual pizazz but little substance from a drought response perspective, expending and distracting scarce staff time and funding. For immediate reductions in water use needed during a drought, public outreach is a better use of funding. Furthermore, even in normal water use years, some suppliers are sunsetting rebate programs thought to have reached customer saturation. The future of water efficiency will be move away from these general programs to a more targeted analysis of customer use accompanied with targeted solutions.

Local, regional, and State entities should work more closely with media outlets to accurately report water related information. Seemingly minor discrepancies can lead to widespread inaccurate reporting, such as recent reporting of a residential limit of 55 gallons per day, interrupted by some media outlets as residents "can't take a shower and do laundry in the same day" (Gomez, 2018). Staff at all three levels should have media training, updated communication plans, and media talking points/messaging available to facilitate ongoing relationships with State and local media. As shown, saving water during a drought largely depends on customer actions (or inactions) supported by statewide and local media reporting.

In closing, water management will always be a "wicked" problem, especially in California. It is unsolvable and never ends. Its "solutions" breed more issues. There are few "true" or "false" solutions, but mostly shades of grey between extremes. There are conflicting values among parties. And there is a degree of trial and error for solutions with multilayer consequences as everything is connected to everything else (Rittel, 1973). This makes water management both fascinating and frustrating. The recommendations presented here represent one perspective, which in no way encompass the diversity of perspectives in this field. However, they represent a perspective that genuinely believes in water efficiency as part of the solution to more effective water management. These recommendations are steps towards increasing the prominence of water efficiency and nudging it to reach its full capacity as a solution. The days of conservation and efficiency programs being just "stickers and bubblegum" are behind us. In the absence of implementing these recommendations, there is a fear that SB 606 and AB 1668 will be implemented in a way that actually deters increasing efficiency through unamenable and ineffective requirements that become more of a burden than a valuable investment. Furthermore, the drought policy recommendations have a goal of smoothing some of the harsher edges experienced in the last drought to improve response to the next drought.

In the meantime, the debate over how to manage water in California will continue in perpetuity at all levels of implementation. The State and water suppliers will keep trying, working toward their own perspective solutions in coordination with others. It is a give and take, a push and pull, even a power struggle at times that shapes and advances the field of water efficiency as part of overall water management. It could not be any other way.

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