Executive Order B-29-15
State of Emergency Due to Severe Drought Conditions
Economic Impact Analysis

Prepared for the State Water Resources Control Board

M.Cubed

Steven Moss, Project Manager

Richard McCann, Principal Investigator

David Mitchell, Principal Investigator

Elizabeth Stryjewski, Researcher

Roger Mann, RMann Economics, Principal Investigator

Thomas Wegge, TCW Economics, Principal Investigator

ERA Economics

Duncan MacEwan, Principal Investigator

Richard Howitt, Principal Investigator

May, 2015

EXECUTIVE SUMMARY

California is in the midst of what may be the worst drought since the arrival of European settlers. The first quarter of 2015, a period that has historically been the heart of the rainy season, was the driest on record. Now in the fourth drought year, there is a scientific consensus that record-high temperatures have exacerbated water scarcity, sapping moisture from soils and preventing snow from building up in the Sierras' frozen reservoir (Griffin and Anchukaitis, 2014). On April 1 the smallest Sierra snowpack on record was recorded, with water content estimated at just five percent of long-term averages. More than two-thirds of the state is in an "extreme" drought, with more than 40 percent in "exceptional" drought, the most dangerous category, according to the U.S. Drought Monitor.

It is within this context that on April 1, 2015 Governor Jerry Brown issued an executive order (EO) – B-29-15 – mandating statewide reductions in water use for the first time. The EO aims to reduce the amount of water consumed statewide in urban areas by 25 percent from 2013 levels – roughly 1.3 million acre-feet (AF) of water – through demand management and pricing policies, and heightened public awareness about the need to reduce water consumption. The State Water Resources Control Board (SWRCB or Board) is responsible for developing the regulatory framework to implement the EO. On April 18, 2015, SWRCB issued updated proposed regulatory instructions that grouped urban water suppliers into nine tiers, with conservation standards ranging from 8 percent to 36 percent.

At its Core, the EO is a Drought Insurance Policy for the State

No one knows how the future will unfold. While the state may return to "normal," or even above average, hydrologic water conditions in 2016, such an outcome is far from certain. The EO is intended to address potentially significant economic vulnerabilities - risks - rather than statistical or probabilistic expectations. If the drought and high temperatures continue in California, water saved as a result of the order will become increasingly valuable. Under these circumstances, costs estimated to be associated with the EO this year could be more than exceeded by greater adverse impacts next year if the EO had not been issued. That is, if there is a fifth, or even sixth, year of water scarcity the EO will have safeguarded the state's future water supplies, thereby forestalling potentially dramatic economic consequences. From this perspective the EO serves to reduce the long-term risk of even more significant water curtailments, a potentially valuable insurance policy. Said differently, the EO provides an "option value" of enlarging the scope for future actions to address the possibility of an ongoing drought.[1]

An example of the potential challenge facing California comes from Australia, which experienced persistent and severe drought across most of its continent between 2002 and 2012. Lasting 10 years, the "Big Dry" had profound impacts on Australia's economy.[2] Water curtailments imposed early in the drought, 2002-03, cut 1.6 percent from the gross domestic product (GDP) growth rate. Lower production in non-agricultural industries accounted for nearly 40 percent of the slowdown in GDP growth. Employment growth slowed by 0.8 percent, average wages fell by 0.9 percent, and exports dropped by 5 percent. Over the full course of the drought half a percentage point may have been shaved from Australia's GDP growth rate. A half-point reduction in GDP growth is significant: if this

---

[1] Quantifying the value of this option would require a deeper analytic assessment than is possible within the time frame provided for this economic analysis.

[2] Further discussion of Australia's drought impacts are in Appendix A.

were to occur in California, cumulative state output would be reduced by close to half a trillion dollars over the same 10-year span of time.

If wet and moderate temperature conditions return next year, the EO's water saving benefits will be less valuable. However, even in this circumstance some of the order's elements will increase water supply resiliency. For example, permanently replacing water-dependent landscaping with drought tolerant plots; retiring less water-efficient appliances and replacing them with water wise ones; and imposing new conservation-oriented water rate structures could serve to structurally reduce water demand, and create new tools to address water scarcity as it emerges. As stated by the World Wildlife Fund,

> *Tackling water scarcity in such a way that reduces long-term risks to a range of stakeholders can have multiple pay-offs in relation to a range of government policy priorities on poverty reduction, economic growth, food security and trade…*[3]

In addition, imposing statewide conservation requirements will forestall the adverse consequences of allowing agencies and water users to inadequately respond to water scarcity, and "free ride" on the actions of other more prudent agencies and water users. Quantifying the economic costs imposed by free riding on more prudent planning is beyond the scope of this analysis. However, based on experience from past droughts the potential impacts next year and in the future from failing to impose prudent planning could be quite large.

Drought Insurance Carries a Premium

There is no getting something for nothing in this world. Good insurance is not free; a premium must be paid. In the case of the EO, the premium to be paid is the forgone economic value of water conserved this year so that it may be available for beneficial uses in subsequent years.

A fair assessment of this cost requires segregating the adverse economic outcomes created by the drought itself from the additional impacts caused by the order. That is, EO impacts are related to *additional* reductions water suppliers will have to make. Many agencies had already sufficiently reduced demand in 2014 to meet their EO requirement, and would have likely done so again in 2015 even without the order. As a result, no additional costs or impacts for these suppliers should be attributed to the EO. In fact, many water suppliers would (and may already) have cut even deeper this year without the EO to comply with their own drought management plans. The extent of potential additional water supplier response in 2015 is unknown however. So for the purposes of this analysis the EO's effective conservation standard is defined as the difference between SWRCB's tiered conservation standards and the percentage of water already conserved by suppliers between June 2014 and February 2015 compared with 2013 water deliveries. Estimated impacts should be viewed as maximums in that full compliance is assumed and required reductions are allocated pro-rata over sectors, rather than being targeted to sectors that have lower added economic value per unit of water.

The economic cost of forgoing water consumption can be decomposed into two parts: (1) the net revenue reductions to urban water suppliers that eventually have to be recovered from ratepayers; and (2) the economic costs of forgoing productive uses of water. In the economics literature, the second

[3] WWF, "Understanding Water Risks," http://awsassets.panda.org/downloads/understanding_water_risk_iv.pdf, March, 2009.

part is referred to as the loss of consumer surplus.[4] That is, the EO essentially restricts water use, compelling businesses and residences to give up a good that has real economic value to them.

It is useful to decompose the economic cost in the above manner because the first part of the cost – the forgone net revenue – can be estimated with relative precision. The second part – the economic cost of forgoing productive water uses – entails significantly more measurement uncertainty. The important point is that both parts represent real economic costs that ultimately will be borne by water users.[5]

Nominally the EO will save roughly 1.3 million AF statewide. However, roughly half a million AF of this savings has already been realized through conservation actions undertaken in 2014. After accounting for 2014 conservation, the net reduction due to the EO will be about 800,000 AF assuming water utilities did not act further on their own. Statewide reductions in water utility net revenues are estimated to range between $500 and $600 million, equivalent to $14 to $17 per person. In addition, the economic costs of forgoing productive water uses is estimated to range between $500 and $700 million, equivalent to $14 to $19 per person. When combined, total economic costs to the state could range from $1.0 to $1.3 billion, or $28 to $36 per person. Table ES-1 summarizes the results of the analysis.

Table ES-1: 2015 EO Statewide Direct Costs

Statewide Impacts	
Total Statewide AF Savings Compared to 2013	1,300,000
Statewide AF Saved in 2014 by Local Actions	500,000
Statewide AF Saved by the EO	800,000
Public Agencies Net Revenue Loss	$425 to $510 million
Investor Owned & Mutual Water Companies Net Revenue Loss*	$75 to $90 million
Utility Net Revenue Loss*	$500 to $600 million
per Acre-foot	$625 to $750
per Capita	$14 to $17
Consumer Surplus Loss*	$500 - $700 million
per Acre-foot	$625 to $875
per Capita	$14 to $19
Total Cost*	$1,000 to 1,300 million
per Acre-foot	$1,250 to $1,625
per Capita	$28 to $36
* *Impacts rounded to nearest $100 million.*	

[4] The economic cost of forgoing productive uses of water—the consumer surplus loss—can be further divided between commercial and non-commercial water uses. In the case of commercial water uses, the economic cost translates into lost profits due to higher costs of production, lower demand for goods and services, or some combination of the two. In the case of non-commercial water uses, the economic cost is measured as the difference between what water users would be willing to pay (i.e. the value they place on water consumption) and what they actually pay (i.e. what the utility charges them for additional water). The concept of consumer surplus, which includes both components, represents the economic value that water users gain from the consumption of water above and beyond what they have to pay for it. This concept is discussed further in the Methodology and Economic Welfare Effects: Consumer Surplus Losses sections of the report.

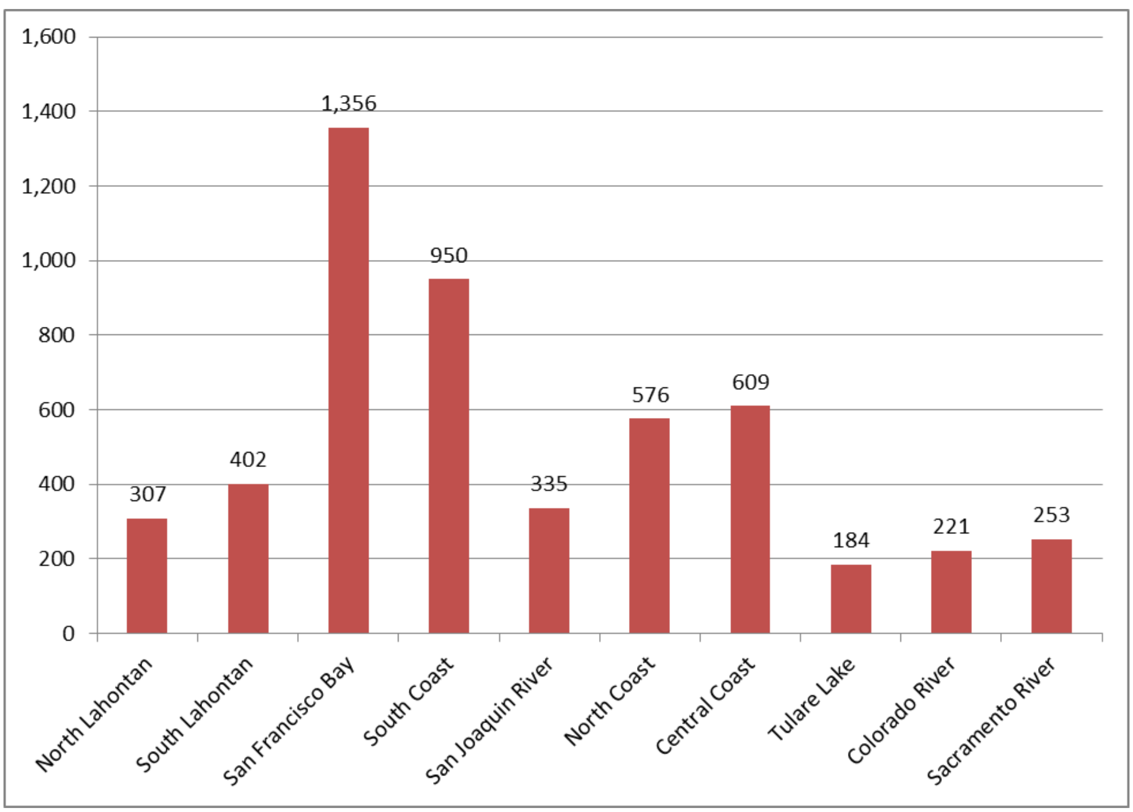
[5] This is not to say that revenue reductions are not consequential for water utilities; they are. Adjusting rates and service charges is not an easy task, particularly in the post-Proposition 218 era. Nonetheless, as noted in Sunding et al. (2014), water utilities in California recover sunk capital costs through volumetric prices such that rates are set above marginal cost. Only the marginal cost of producing water is avoidable. The sunk fixed costs must be recovered from water users, even when water is not delivered, to avoid a fiscal imbalance in the utility enterprise. In the end, ratepayers must bear the economic cost of the shortfall.

Net revenue impacts will vary significantly by district as a result of water use differences, conservation measures adopted in 2014, and water rates. Figure ES-1 summarizes the net revenue losses by major hydrologic region.[6] Impacts are highest in the San Francisco Bay Area and Southern California, reflecting both levels of water use and higher current water rates. The San Francisco and South Coast (Southern California) hydrologic regions are home to over 26 million residents, or 74 percent of the total population, and nearly 70 percent of statewide urban water use. In these regions the EO is estimated to cause net revenue losses of $950 to $1,350 per acre-foot, more than triple the average net revenue loss of $360 per acre-foot in all other hydrologic regions. Much of this difference arises due to the larger past infrastructure investment required to deliver water to these regions compared to the relatively water-rich but less populated areas.

Specific industries have been identified as particularly vulnerable to these restrictions, including landscaping, and recreation and tourism. Whether these industries incur economic losses is uncertain because outcomes will be largely determined by water use restriction decisions made by urban water agencies. Likewise, significant environmental benefits are likely to be prompted by the EO, related to higher stream flows and reservoir levels, with concomitant benefits associated with protecting California's fish and wildlife resources. However, these ancillary benefits are not quantified in this analysis.

Figure ES-1: 2015 EO Net Revenue Impact Summary by Hydrologic Region

Net Revenue Losses per Acre-Foot



[6] See Appendix D for a map of the hydrologic regions.

Table of Contents

INTRODUCTION

M.Cubed,[7] in collaboration with RMann Economics, TCW Economics, and ERA Economics, was asked by the State Water Resources Control Board to develop an analysis of the economic impacts of Executive Order (EO) B-29-15 and associated Board implementation requirements. The EO mandates that urban water suppliers reduce statewide potable urban water use by 25 percent from 2013 levels by February 28, 2016, beginning June 1, 2015.

To achieve this goal the State Water Resources Control Board proposes to establish a tiered system, in which urban water suppliers who serve more than 3,000 customers or deliver more than 3,000 AF of water per year – which account for more than 90 percent of urban water use – were each assigned a conservation standard. Of the state's 411 water agencies, 94 will have to reduce their use by 36 percent, the maximum amount, because they have the highest per capita water use. Twenty-three agencies fall into the second lowest reduction tier, 8 percent. The lowest tier, a 4 percent cut, could apply to a small number of communities that can demonstrate that they have sufficient surface water to last for several years and have had above-average rainfall.[8]

Table 1. Tiered Water Reduction Standards

Tier	Residential Gallons Per Capita Day Range	Number of Suppliers	Conservation Standard
1	Reserved	0	4%
2	0 – 64.99	23	8%
3	65 – 79.99	21	12%
4	80 – 94.99	42	16%
5	95 – 109.99	41	20%
6	110 – 129.99	51	24%
7	130 – 169.99	73	28%
8	170 – 214.99	66	32%
9	215 – 612	94	36%

Water suppliers serving fewer than 3,000 connections, and commercial, industrial, and institutional users with independent supplies, are required to achieve a 25 percent conservation standard or restrict outdoor irrigation to no more than two days a week. These smaller urban suppliers serve less than 10 percent of Californians. Enforcement of the supply cuts includes potential fines of up to $10,000 a day.

In addition to the supply reductions, the EO identifies a number of specific actions to achieve the reduction goal, including replacing 50 million square feet of lawns and ornamental turf with drought tolerant landscapes; imposing water efficiency measures on campuses, golf courses, and cemeteries; requiring urban water suppliers to develop conservation-inducing pricing mechanisms; and improving the efficiency of water-using appliances, among other measures.

[7] M.Cubed is a resource economics and policy analysis consulting firm with offices in Davis, Oakland, and San Francisco.

[8] The economic analysis presented here does not address or analyze the rationale for the different tier levels or the assignment of specific water purveyors to different tiers.

Water Scarcity Imposes Costs; Prompts Investment

Typically, natural catastrophes – such as hurricanes and earthquakes – result in immediate economic and fiscal losses, and a muffling of growth. Droughts impose less abrupt outcomes. Depending on the resiliency of the existing water supply system (e.g., conveyances, storage facilities, low- or no-cost conservation measures), there may be minimal adverse implications from water scarcity until the third or fourth year of dry conditions.

However, if a drought continues over multiple years the risk that it will trigger reductions in water availability will cause some households and businesses to defer or cancel water-intensive investments (e.g., a new lawn; a food processing plant), concomitantly dampening economic activity. When water scarcity prompts the need to reduce consumption hard costs start to accrue, in the form of the loss of water-dependent assets and activities (e.g., landscaping; pools), and/or the need to pay higher costs to maintain those assets and activities.

Responses to catastrophes, however, can also prompt greater economic activity, as the public and private sectors invests in addressing the "damage" and changing their behaviors. For example, replacing landscaping disrupts existing supplier relations, but creates new demand for alternatives. Likewise, subsidizing water efficient appliances prompts consumer purchases, and potentially reduces household utility bills while providing the same level of service. In summary, water scarcity causes economic costs, but the net effect on regional expenditures and economic impacts is less certain.

ECONOMIC BENEFITS ARE SUBSTANTIAL BUT DIFFICULT TO QUANTIFY

The EO focuses on equitably and efficiently coping with the water supply risks inherent in California's on-going drought. In the long run, the EO's value will be determined by weather conditions in 2016 and beyond. Significant uncertainties are associated with policies predicated on unknown futures. The EO is intended to address potential vulnerabilities, not probabilistic expectations.[9] While a return to a "normal," or even above average, hydrologic water conditions may occur in 2016, such an outcome is far from certain. For this reason, the EO must be evaluated against the reasonable possibility, not probability, of continued drought conditions.[10] In such a situation, imposing statewide conservation requirements addresses the important economic consequences of allowing non-compliant agencies and water users to "free ride" on the actions of other more prudent agencies and water users.[11] Quantifying the economic costs of such free riding on prudent planning is beyond the scope of this analysis. However, the potential impacts on the state next year and in the future from failing to impose prudent planning are known qualitatively to be quite large based on experience in past droughts. Australia lost

[9] "Whereas a distinct possibility exists that the current drought will stretch into a fifth straight year in 2016 and beyond;"

[10] Economists have recently focused more on balancing the costs of actions against events with large or catastrophic outcomes for which assigning probabilities are difficult. Techniques such as robust decision making, used in recent California Water Plans, assess preferred strategies to avoid "black swan" events that occur outside of our collective experience. The 2008 financial crisis is considered one such "black swan" event not well anticipated by the financial industry. Weitzman (2011) examines how the cost-benefit methodology should be modified to assess actions in the face of another potential environmental catastrophe, global climate change. This approach is applicable here as well.

[11] In economic parlance, "free riding" is considered an "externality." An externality is an economic cost or benefit imposed by one party on another external to any direct economic transaction. In other words, the cost or benefit is not internalized to the transaction itself. Externalities muddle the market price signals that can lead to more efficient resource allocation; economists generally recommend addressing externalities by better defining property rights or imposing regulations or taxes.

up to a 0.5 percent off its gross domestic product (GDP) during a 10-year drought.[12] That would be equivalent to almost $500 billion to the California economy.

If the drought and high temperatures continue, water saved as a result of the order will become increasingly valuable. Under these circumstances, estimated 2015 costs would be offset by similar or even greater avoided costs next year. That is, if there is a fifth, or even sixth, year of water scarcity the EO will have safeguarded the state's future water supplies, thereby forestalling potentially dramatic economic consequences. From this perspective the EO serves to reduce the long-term risk of water curtailments, a valuable insurance policy. As a result, the EO provides the significant "option value" of enlarging the scope for future actions. Quantifying the value of this option would require a deeper analytic assessment than is possible within the time frame provided for this economic analysis. Nevertheless, the value of acting now is likely to be significantly larger than the value of waiting for more information given the magnitude of the potential consequences from a delay.

If wet and moderate temperature conditions return next year the EO's water saving benefits will be less valuable. However, even in this circumstance some of the order's elements may increase water supply resiliency. Resiliency is a characteristic of ecological systems that has been applied to engineering and economic systems. It is broadly defined as the ability to reduce the magnitude, duration or cost of disruptive events. The effectiveness of a resilient system is defined by its ability to anticipate, absorb, adapt to, or recover from a potentially disruptive event. In engineering parlance, the shorter the 'return time,' the more resilient the system. Water systems are often designed to have resiliency in their supply side, which frequently takes the form of reserve supplies in reservoirs to maintain service through drought periods. California's groundwater supplies also play this role for both urban and agricultural water systems.

With most conventional supply side sources of resilience exhausted in the current drought, demand side resiliency could be augmented by actions prompted by the EO. The compulsory reductions in water deliveries to water agencies and individual users will force them to critically examine and prioritize their uses, and in some cases, provide an incentive for innovative changes in water demand. If successful, this increase in demand resilience will be embedded in physical infrastructure and, more importantly, in the institutional structure where the majority of adaptation and change will take place, given the EO's short-run nature.

Resiliency can also be enhanced by the ability of a system to adapt and reach a different steady-state after the disruptive event. This alternate definition reflects the system's capacity to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks. Once an urban water agency has been forced to adjust to meaningful cuts in deliveries, as required by the EO, it is likely that the same mechanisms will remain in place when water supplies return.[13] This adaptation will leave the urban water agencies more resilient for the inevitable future droughts.

For example, permanently replacing water-dependent landscaping with drought tolerate plots; retiring less water-efficient appliances and replacing them with water wise ones; and imposing new conservation-oriented water rate structures could serve to structurally reduce water demand, and create new tools to address water scarcity as it emerges. Likewise, the EO's mandated cuts in water

---

[12] See Appendix A for a review of impacts on the Australian economy from its long-running drought.

[13] A number of studies have found downward, sustained shifts in water demand after previous droughts in 1976-77 and 1987-92.

deliveries by urban water agencies may induce investment in infrastructure and innovative institutions that will reduce the costs of future drought periods.

METHODOLOGY FOR MEASURING ECONOMIC COSTS

The analytical approach on which this report is based is founded on the standard fiscal and welfare analysis of public resource allocation. In this context, the economic effects of mandatory shortage are largely determined by water prices and willingness to pay for water as reflected by end-use demand functions. Demand functions reflect the disutility (unhappiness) and costs of actions taken by residential, commercial and industrial customers; public sector water users; and others, required to reduce water use. For residential customers, these costs might include less enjoyment of water, shorter showers or brown lawns, for example, as well as the costs of more intensive management such as hand watering, or costs of water saving devices.

For commercial and industrial water customers the situation is more complex. These water customers could react in several ways, including temporarily incurring reduced production and profits, purchasing alternative water supplies, raising product/service prices, or changing their mix of production inputs to reduce non-water-related costs. Many industrial and commercial facilities have landscape irrigation in which water can be reduced. Most businesses would likely undertake a combination of these actions, depending on the proportion of an enterprise's overall costs that are attributable to water, the magnitude of mandatory shortage, and a business's ability to raise prices in the market environment in which it operates.

For institutional water users primarily composed of government agencies, the cause-and-effect response to mandatory shortage is not the same as for households or commercial and industrial customers. For many institutional users, landscape water use might be reduced. While agencies could lay off staff or reduce spending on other operational inputs in response to temporary shortage, the need for agencies to maintain staffing and service levels set through agency budgeting processes suggests that the short-term economic effects of shortage would be limited. Additionally, public sector agencies are often unable to reduce payroll or staff levels, and may be more likely to run temporary budget deficits or to seek a temporary budget augmentation to offset cost increases.

All of these decisions and responses are incorporated implicitly in the analytic framework presented herein. The measure of consumer surplus for all types of water users, including residential, commercial, industrial and institutional, accounts for how those water users would likely change their basket of purchases, resulting in changes in the amount of water consumed, at different shortage levels.[14] The economic analysis does not, and need not, account for each individual decision, but rather focuses on

[14] The economic cost of forgoing productive uses of water -- the consumer surplus loss -- can be divided between commercial and non-commercial water uses. In the case of commercial water uses, the economic cost translates into lost profits due to higher costs of production, lower demand for goods and services, or some combination of the two. Any business that relies on water as an input to production – for example, a golf course -- potentially will be affected by the EO. Likewise, any business whose demand depends on others access to and cost of water – for example, a landscape contractor -- potentially will be affected by the EO.

In the case of non-commercial water uses, the economic cost is measured as the difference between what water users would be willing to pay (i.e. the value they place on water consumption) and what they actually pay (i.e. what the utility charges them for additional water). The concept of consumer surplus which includes both components represents the economic value that water users – whether they be commercial or non-commercial -- gain from the consumption of water above and beyond what they have to pay for it. This concept is discussed further in the section, Economic Welfare Effects: Consumer Surplus Losses.

the aggregate water revenue loss and the marginal willingness-to-pay for water as reflected by water demand functions.

EO Impacts Are Net of What Would Have Occurred without the Regulation

The EO was issued as a result of the severe drought conditions prevailing throughout California, and the West. In response to water scarcity, Governor Edmund G. Brown, Jr. proclaimed a State of Emergency on January 17, 2014. Prior to EO issuance most urban water suppliers had taken steps to reduce their water consumption, including by raising wholesale prices, mandating conservation measures, and prohibiting specific uses. It is quite likely that, absent the EO, additional urban water suppliers would have similarly acted to lower their water consumption, while those who had already done so would work to achieve deeper, or maintain already achieved, reductions. In this respect, the EO and associated implementation requirements are intended to avoid the potentially more catastrophic consequences of an uncoordinated response, or lack thereof, devised by a diverse set of suppliers under uncertain timelines.

From this perspective, the baseline for this analysis is the economic consequences that would have occurred in absence of the EO.[15] That is, the framework for this analysis was not to estimate the adverse impacts of water scarcity as a result of the drought, nor the outcomes associated with independent actions taken by urban water suppliers whether or not the Governor had acted, but rather the economic and fiscal consequences that would likely emerge because of implementation of the EO's particular policies.

In addition, there are significant fixed costs associated with the state's water supply infrastructure. That is, while water consumption will decline under the EO, water pipes and personnel, billing infrastructure and administrative functions, still need to be paid for. In the short-term this means that water savings do not necessarily translate into immediate dollar savings.

Data and Calculations

The baseline for this analysis is the effective water conservation percentage for each urban supplier in 2015 assuming continued conservation at 2014 levels. This change in effective water use causes two effects: fiscal and welfare, and taken together, the total economic impact. The fiscal effect is dominated by shortfalls in water agency net revenues due to the effective conservation requirements. This net revenue shortfall is assumed to be uncompensated by an increase in charges to water users. Price increases or service charges would be required to ensure the water agency remains revenue neutral. Given the inelastic demands for water used in this report, if water price increases were used to obtain conservation, the price increases needed to hold the agency revenue neutral might not be large enough to meet the conservation goals; some additional rationing or mandatory conservation would still be required.

Eventually, to raise money to pay fixed costs, debt service, overhead and similar expenses, utilities would pass the net revenue loss onto their customers. At this time, consumer's discretionary income might be reduced.

[15] The baseline for tracking water use reductions in 2013. The Governor issued a state of emergency due to the drought in January 2014; the SWRCB issued its first set of emergency regulations in July 2014. Note that a 2013 baseline does not account for economic growth that has occurred since then.

The economic welfare effect, as opposed to economic impacts, is the lost value to Californians due to the inability to purchase water supplies they would have otherwise used. The total cost includes the lost net revenue of water utilities, plus the lost consumer surplus of end-users.

The analytic approach relies on the following logic:

1. Calculate 2015 effective water conservation percentage for each water agency, defined as the mandated conservation percentage relative to 2013, less the percent conservation achieved in 2014 relative to 2013.
2. The additional quantity of water savings required times the retail commodity rate, less variable costs of potable water production is the loss in water net revenue. This is a fiscal impact and an economic cost.[16]
3. Calculate the resulting loss in consumer surplus; this is an economic cost with uncertain fiscal effects. Some of this loss represents consumer costs paid to reduce water use, but some is also the disutility or unhappiness of consumers who must sacrifice some of their enjoyment of their water.

To undertake these analytical steps, SWRCB data was used on the amount of water savings achieved by suppliers from June 2014 to February 2015, compared to 2013, for the same period.[17] That is, the EO's economic effects do not include savings achieved in 2014 relative to 2013, based on the assumption that the 2014 savings levels would continue in 2015 even without the EO. These data do not include March through May production, and it is assumed that the EO will end March 31, 2016.

It was assumed that without the EO, savings achieved by water suppliers in 2014 would have continued into 2015. As a result, the EO's impact would be the "Conservation Standard" less the "Percent Saved (Jun-14 - Feb-15, compared to 2013, gallons)." The analysis did not include any additional water supply cuts, beyond the "Percent Saved (Jun-14 - Feb-15, compared to 2013, gallons)" that would be caused by the drought in June 2015 through March 2016, even without the EO.[18]

Additional information on expected 2015 use, and sector-specific consumption, was extracted from the California Department of Water Resources' Urban Water Management Plans (UWMP) database, which includes sector data for 363 agencies – for which costs by sector can be calculated – with no sector data available for 48 agencies. There are 11 agencies in the UWMP database that are not on the Board's list; some of these are wholesale providers.

[16] In mandatory shortages lost revenues are equal to reduced end user water expenditures. End users do not pay the cost of water they are not allowed to use, but they also do not receive the benefit of the water they would have bought. Therefore the net welfare effect is the lost water revenue plus the lost consumer surplus of end users. However, since most water utilities are public agencies, they will be made fiscally whole at some future date to be determined by those individual agencies. Even investor-owned utilities, which in California operate under a revenue adjustment mechanism designed to maintain revenue neutrality, are likely to recover the lost revenues in future rates.

[17] California Water Boards, "Urban Water Suppliers and Proposed Regulatory Framework Tiers to Achieve 25% Use Reduction"; http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/emergency_regulations/urban_water_supplier_tiers.pdf

[18] It is probable that some water suppliers would have undertaken more conservation in 2015 than they did in 2014. Water supplier drought management plans typically are defined in terms of stages of use restriction. Stages of use restriction are triggered by prevailing supply and storage conditions. Given the lack of rainfall this winter it is reasonable to expect that some water suppliers (perhaps even many) would have moved into a higher use restriction stage this summer, regardless of the EO. However, it was not possible to assess this within the timeframe of this study.

The analysis also relied on Black and Veatch (B&V) 2006 water rate data, which provided typical commodity charges and monthly service costs. If a supplier had no commodity charge it was assumed to be $1 per hundred cubic feet (CCF). [19] These rates were updated to 2015 dollars using the nominal rate increase factors from Table 2 below. For agencies for which no B&V rate data were available the following default water prices were used.

Table 2: Default Rate Increases and Water Prices by Region

	Nominal rate increases, 2006 to 2014	Default price, $/AF
San Francisco Bay	2.00	$1,500
South Coast	1.80	$1,200
Central Coast	1.80	$2,000
Others	1.14	$500

Water rate data for some more-affected agencies were obtained directly from their rate structure information. The agencies with current data in the analysis are:

- Carlsbad Municipal Water District
- Coachella Valley Water District
- Contra Costa Water District
- City of Corona
- Cucamonga Valley Water District
- Desert WA
- Eastern Municipal Water District
- Elsinore Valley Municipal Water District
- City of Fullerton

The revenue loss is adjusted to remove variable cost savings assumed to be $200 per acre-foot in most regions, and $250 per acre-foot in the South Coast, Central Coast and Bay Area. These cost savings are reduced energy and operating expenses associated with not conveying, pumping, treating and distributing the water. The resulting net revenue loss is equal to the product of the amount of required savings and the water price less variable cost. It is unaffected by the shape of the demand curve for water, i.e., how responsive water demand is to changes in rates does not affect this calculation.

The estimated loss of consumer surplus, on the other hand, is sensitive to the shape of the demand curve, as measured by price elasticity[20], and several other assumptions. In particular, the consumer surplus loss estimates are subject to the following caveats:

1. **Elasticity of demand for water.** Demand elasticity is critical to determine the size of consumer surplus losses. Less price-responsive demand ("inelastic" demand) will translate to larger economic welfare effects, all else being equal.

[19] A CCF is the standard "billing unit" used by most urban water agencies, equal to 748 gallons.

[20] Price elasticity is a parameter that measures the percentage change in demand given a one percent change in price. For normal goods where demand is downward sloping the price elasticity is a negative quantity. If the price elasticity is less than one in absolute magnitude, demand is said to be inelastic, which means a one percent change in price would result in less than a one percent change in demand; consumers are unwilling or inelastic to change purchase patterns when prices change. Conversely, if the price elasticity is greater than one in absolute magnitude, demand is said to be elastic, which means a one percent change in price would result in more than a one percent change in demand. Urban water demand in California is price inelastic, with price elasticities typically measured in the range of -0.2 to -0.3.

2. **Constant elasticity demand (CED) function.** This analysis uses a constant demand elasticity function for urban water, along with short-run demand elasticities for residential, commercial, landscape, government/institutional and industry. The form of this demand function is

$$Q = aP^{Ed}$$

where *Q* is the quantity of demand, *a* is a scaling coefficient, and Ed is the elasticity of demand. With data on Q, P and Ed, the coefficient "a" can be calculated, the demand function is specified, and marginal and total willingness-to-pay can be calculated. The CED function results in a constant elasticity of demand over the entire price (water rate) range. In practice, water users' demand is typically more elastic as prices increase. In this report, consumer surplus losses are a linear approximation.

3. **Water rates.** 2015 water rates have been updated from the 2006 B&V water rate data using a constant escalator for most water agencies.

Consumer Demand for Water

The elasticity of demand is critical for the constant elasticity of demand function and determining the economic welfare costs of the EO. Two competing factors may affect the appropriate demand elasticity to use in this analysis. First, this is a short-run analysis, and short-run response by water users is typically less elastic than the long-run; that is consumers are less able to change demand immediately than if they have time to make investments or other lasting changes. Countering this short-run effect is the fact that the EO is now in place, and has reinforced widespread publicity about the drought and associated supplier-adopted restrictions, which tend to make demand more elastic.[21] A similar response occurred in 2001 to the "Flex Your Power" program prompted by the electricity crisis arising from California's industry restructuring effort. In addition, in 2014 it is likely that demand hardened due to conservation; the easiest savings have already been taken. In this study, consumer surplus losses are calculated given demand elasticities ranging between -0.25 and -0.3 for residential and between -0.3 and -0.4 for nonresidential water users.

Residential Demand Elasticity

Three studies were relied on to determine elasticities to reflect residential urban water demand.[22] These reports found summer short-run single family dwelling elasticities as follows:

- Renwick and Green: -0.2;
- Olmstead et al.: -0.33 to -0.58; and
- Klaiber et al.: -0.13 to -0.35.

[21] Mary E. Renwick and Richard D. Green. 2000. "Do Residential Water Demand Side Management Policies Measure Up? An Analysis of Eight California Water Agencies'" *Journal of Environmental Economics and Management* 40,37-55.

[22] Renwick and Green (2000); Olmstead, Sheila M., W. Michael Hanemann, and Robert N. Stavins, "Water demand under alternative price structures," *Journal of Environmental Economics and Management*, September 2007, 54 (2), 181–198.; H. Allen Klaiber, V. Kerry Smith, Michael Kaminsky, and Aaron Strong. 2011. *Measuring Price Elasticities for Residential Water Demand with Limited Information*. Working Paper.

Accordingly, this analysis uses a range of residential demand elasticities of -0.25 to -0.3. This spread is largely consistent with estimates used in the November 2013 Bay Delta Conservation Plan Public Draft.[23]

Industrial Demand Elasticity

Renzetti (1992) identified a consensus for industrial water use elasticities of between -0.15 and -0.59.[24] This range is supported by other studies of industrial firms,[25] which find an elasticity of -0.77, and Reynaud (2003) who identifies an elasticity of -0.29. Accordingly, this study uses an industrial demand elasticity of -0.37.[26]

Commercial Demand Elasticity

A review of the literature on short run commercial water demand elasticities finds a range of -0.12 to -0.48. Lynn et al (1993) reported a range of -0.48 to -0.12.[27] These results are supported by studies by Schneider and Whitlach (1991) who find elasticities ranging from -0.4 to -0.36, and by Williams and Suh (1986) who estimate an elasticity of -0.23 for short-run commercial water use.[28] Accordingly, this analysis uses the mid-point value of -0.3 for commercial water use demand elasticity. The demand elasticity for landscape and institutional/governmental use is set equal to the commercial elasticity of -0.3.

Estimates Likely Overstate Impacts Because Many Agencies Would Have Conserved More Even without the EO

As discussed above, most urban water suppliers have drought management plans. The actions detailed in those plans are divided into stages, which are triggered by supply conditions. It is quite likely that higher stages would have been triggered this summer for many urban suppliers, and as a result they would have implemented more stringent water use restrictions. In other words, the EO most likely is non-binding on many water utilities. The EO simply places a floor on suppliers that may not have such plans, or whose plans were not as aggressive.

Because of this dynamic, the analysis overstates the EO's impact for agencies that were going to move to higher restrictions any case. The analysis assumes more costs for consumers served by those utilities than would actually be the case, since they would have incurred some of those costs even without the EO. For a community such as Livermore, for which SWRCB designated a 20 to 24 percent reduction, the EO simply reinforces what the supplier would likely have done anyway—what it did in 2014, when it cut

[23] This study indicted a range is -0.15 to -0.32, with a simple average is -0.24. BDCP. November 2013 Draft. "Appendix 9.A Economic Benefits of the BDCP and Take Alternatives."

[24] Renzetti, S. 1992. "Estimating the Structure of Industrial Water Demands: The Case of Canadian Manufacturing." *Land Economics* 68(4): 396– 404.

[25] Dupont, D.P., and S. Renzetti. 2001. *Water's Role in Manufacturing. Environmental and Resource Economics* 18(4): 411– 432.

[26] Reynaud, A. (2003), "An econometric estimation of industrial water demand in France," *Environ. Resour. Econ.*, 25,213–232.

[27] Lynne, G.D.; Luppold, W.G.; Kiker, C. (1993): "Water Price Responsiveness of Commercial Establishments". *Journal of the American Water Resources Association*, 14, pp. 719-29.

[28] Schneider, M. and Whitlach, E. (1991): "User-Specific Water Demand Elasticities". *Journal of Water Resources Planning and Management*, 117, pp. 52-73.

its use by 27 to 31 percent.[29] The analysis estimates that the EO does not cause any additional costs for Livermore. For other agencies, if they did not reduce use much in 2014, the analysis tends to show larger losses, but these agencies might have been forced to conserve more even without the EO.

On the other hand, selected suppliers in specific hydrologic regions would not have had higher stages triggered and probably would have continued on their current consumption path. For example, the EO, and concomitant SWRCB action, will force Chico to cut use by 32 percent even though it has ample groundwater supplies. Reducing its consumption beyond the 16 percent it executed in 2014 may not be beneficial for their future supply outlook.

Noteworthy, though difficult to capture in the time for this analysis, is SWRCB's regulatory clause allowing water suppliers to request a modification in their total water use or to be placed in a lower conservation tier:

- Urban water suppliers delivering more than 20 percent of their total water production to commercial agriculture may be allowed to modify the amount of water subject to their conservation standard. These suppliers must provide written certification to the Board to be able to subtract the water supplied to commercial agriculture from their total water production for baseline and conservation purposes.
- Urban water suppliers that have a reserve supply of surface water that could last multiple years may be eligible for placement into lower conservation tier. Only suppliers meeting the eligibility criteria will be considered. These criteria relate to the source (s) of supply, precipitation amounts, and the number of years that those supplies could last.[30]

If effectively triggered, these clauses could reduce potential economic impacts.

Factors that would tend to overstate economic costs of the EO relative to the results reported here are:

- The additional conservation agencies would have required of themselves even without the EO.
- Reduced mandatory shortages under the regulatory clauses noted above.
- Agencies might shift reductions among their customers to avoid the largest costs.
- If demand is more flexible (less inelastic) than assumed.
- The CED function assumes a constant demand elasticity

Factors that would tend to understate economic costs of the EO relative to the results reported here are:

- Without the EO, some agencies might be unable to maintain the conservation achieved in 2014.
- If demand is less flexible (more inelastic) than assumed.
- If enforcement costs, which have not been examined, are significant relative to revenue and consumer surplus losses.
- If some commercial and industrial customers respond to the EO by locating out-of-state

---

[29] A more precise and perhaps more accurate analysis would require an examination of agencies individually. Even regional level calculations would require a substantial amount of data gathering unavailable under the project schedule.

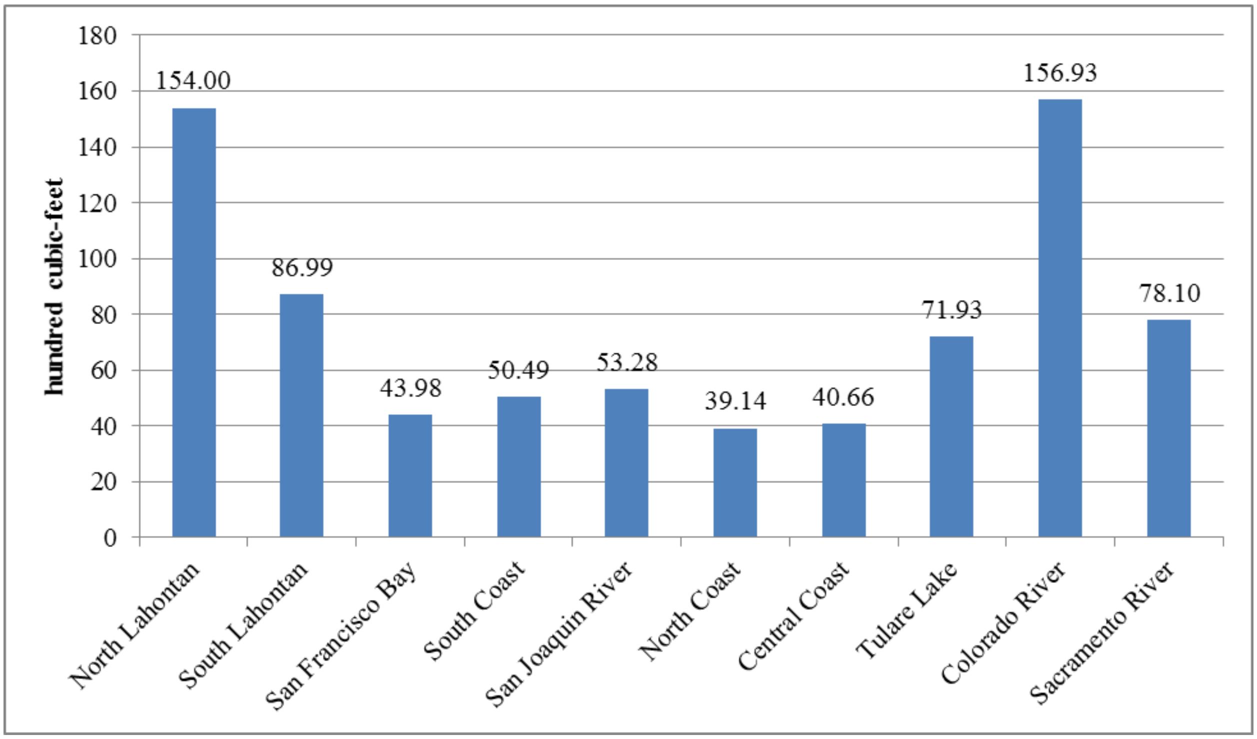
[30] http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/emergency_regulations/fact_sheet_implementing_25.pdf

URBAN WATER USE BASELINE

In 2013, California's urban water use averaged just under 7.5 million AF per year, which is below the 2000-10 annual average use of 8.3 to 9 million AF. Approximately half of California's urban water use is for outdoor irrigation purposes and landscaping, including filling pools, washing cars, and outdoor cleaning. Of this outdoor use, more than three-quarters is used by residential, single and multi-family dwellings. Commercial, government, and industrial water use is approximately 20 percent of total urban water use.

Figure 1 illustrates statewide annual single and multi-family water use per capita for water agencies with sector-specific data.[31] Residential water use per capita is highest in the North Lahontan and Colorado River hydrologic regions, at about 150 CCF per year. The more populous hydrologic regions, including the San Francisco Bay, Central, and South Coast, have per-capita water use ranging from 39 to 53 CCF per year. The statewide average single and multiple family water use is 77 CCF per capita per year.

Figure 1: Water Use per Capita Summary by Hydrologic Region (CCF/Year)

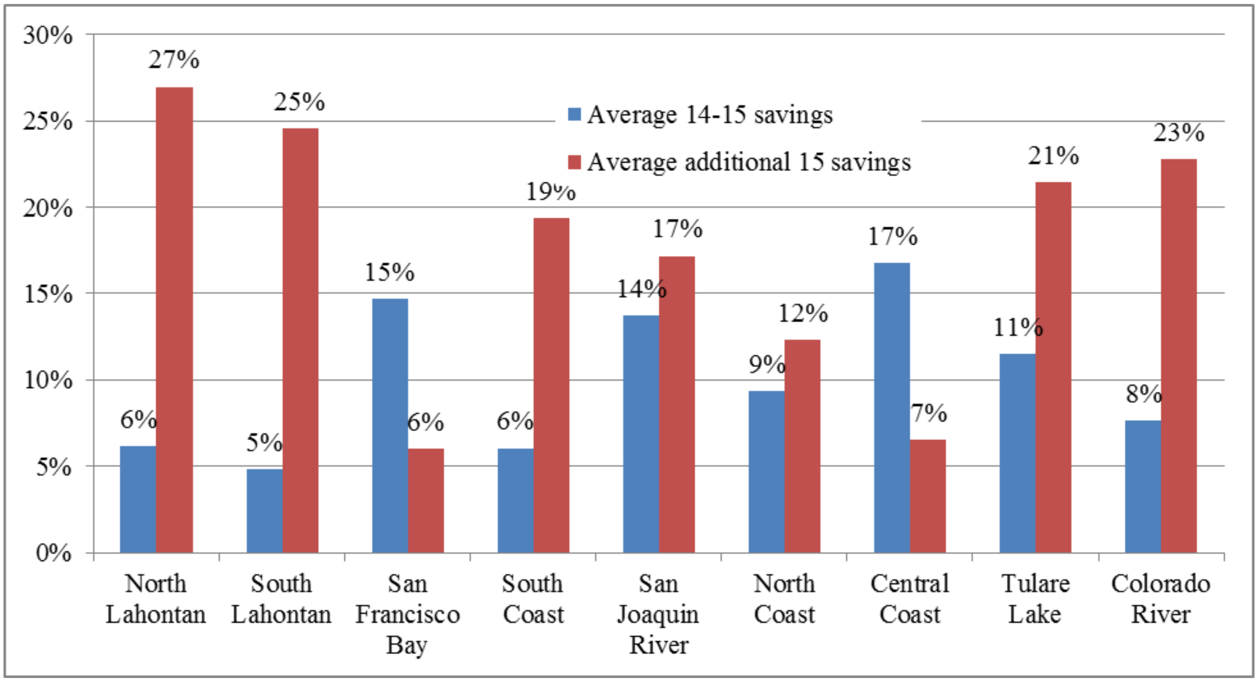


As discussed previously, most water agencies in California have already implemented conservation measures in 2014. This analysis considers these savings to calculate the effective water conservation percentage mandated under the EO. Figure 2 illustrates conservation standards with 2014 conservation actions by hydrologic region. The San Francisco Bay Area, Central Coast, and San Joaquin Valley regions realized the highest water savings in 2014 of 15, 17, and 14 percent relative to the 2013 baseline, respectively. Southern California (South Coast) realized relatively less water conservation, with 6 percent relative to the 2013 baseline. The statewide average conservation in 2014 was 10 percent. Figure 2 also illustrates the required effective conservation in 2015, having accounted for the savings in 2014. Areas such as Southern California with relatively little conservation in 2014 will need to conserve

[31] An additional 250,000 AF per year is included in water agencies with no sector-specific information.

more in 2015 to meet the total conservation targets in the EO, thus the effective conservation for these regions is higher.

Figure 2. 2014 Conservation and 2015 Effective Conservation by Hydrologic Region



ESTIMATED EO ECONOMIC AND FISCAL COSTS

As discussed previously, the impacts attributable to the EO principally consist of (1) lost net revenue caused by reduced water sales by urban water districts; and (2) economic welfare effects prompted by the lost value associated with an inability of Californians to buy water supplies they otherwise would have purchased, as measured by consumer surplus loss. Net revenue impacts represent real financial costs to water utilities and their ratepayers in the state; consumer surplus measures potential welfare loss by water users.[32]

Fiscal Impacts: Urban Net Revenue Losses

The EO's fiscal impact is the net revenue losses incurred by water agencies due to the effective percentage reduction in deliveries. The net revenue loss is equal to the product of the amount of required savings and the water price less variable cost. The net revenue losses would be absorbed by water suppliers as fiscal deficits in the short run, but would ultimately be passed along to water customers through higher service charges and rates. Table 3 summarizes the net revenue loss estimate. For purposes of analyzing impacts on public agencies separately from corporate and mutual companies, the impacts on those two groups are shown separately, and then summed for the overall economic impacts. SWRCB data on water sales shows that public agencies delivered about 85 percent of water sold in 2013 and revenues have been allocated proportionately on usage.

[32] A survey of previous economic impact studies for different regions in California is included in Appendix B.

Table 3. 2015 Statewide Net Revenue Impacts

Statewide Impacts	
Total Statewide AF Savings Compared to 2013	1,300,000
Statewide AF Saved in 2014 by Local Actions	500,000
Statewide AF Saved through the EO	800,000
Public Agencies Net Revenue Loss	$425 to $510 million
IOU & Mutual Co. Net Revenue Loss*	$75 to $90 million
Utility Net Revenue Loss ($)[1]	$500 to $600 million
Net Revenue Loss per Acre-foot	$625 to $750
Net Revenue Loss per Capita	$14 to $17
[1] Impacts rounded to nearest $100 million.	

Economic Welfare Effects: Consumer Surplus Losses

The concept of "consumer surplus" is used to measure lost economic welfare or benefits prompted by the forgone value associated with an inability of Californians to buy water supplies they otherwise would have purchased. Consumer surplus losses are driven by the effective percentage reductions in water deliveries under the EO. Consumer surplus is a measure of consumer benefits forgone, rather than a direct financial cost. For non-residential customers these can represent lost business profits. Total surplus losses for businesses include the added profits by enterprises increasing sales as well as those that lose.

Consumer surplus, which includes both residential and commercial components, represents the extra value that consumers derive from a product or service above and beyond what they have to pay for it. When a market has no restrictions on supply or consumption, a consumer will chose to purchase a good like water until the value of the last unit purchased – the marginal unit – equals the price of the good. When the demand curve is downward sloping, as it is for municipal water service, the value the consumer places on the inframarginal units – i.e. the units consumed before the last or marginal unit -- will exceed the price paid. The amount of extra or "surplus" value the consumer reaps depends on whether the demand curve is steep or flat (i.e., whether the willingness to pay for inframarginal units is much or little higher than the marginal one), which generally comes down to the how essential the good is and the availability of affordable substitutes for it. The steepness or flatness of a demand curve can be empirically measured by observing how demand for the good changes with its price and the price of substitutes. This study uses empirically-based evidence on the slope of the demand curve for municipal water service to estimate potential consumer surplus losses due to the EO.

Table 4 summarizes the estimated consumer surplus loss for the range of price elasticity used for this analysis.

Table 4. Sensitivity of Statewide Welfare to Demand Elasticity

Statewide Impacts	
Total Statewide AF Savings Compared to 2013	1,300,000
Statewide AF Saved in 2014 by Local Actions	500,000
Statewide AF Saved through the EO	800,000
Consumer Surplus Loss[1]	$500 - $700 million
Consumer Surplus Loss per Acre-foot	$625 to $875
Consumer Surplus Loss per Capita	$14 to $19
[1] Impacts rounded to nearest $100 million.	

Total Economic Impacts

Both the net revenue losses and the consumer surplus losses ultimately will be borne by water users, since water utilities will have to adjust their service charges and rates over time to recover the forgone net revenue.[33] This revenue would have gone to pay fixed enterprise costs. Municipal water service is extremely capital intensive and the majority of revenue is used to pay the fixed costs of plant, equipment, and workforce. Because most urban water suppliers in California recover a significant percentage of their fixed costs through their volumetric rates, a reduction in the sale of water will create a fiscal imbalance unless service charges and rates are adjusted to recover the forgone net revenue.

When combined, total economic losses to the state could range from $1.0 to $1.3 billion, or $28 to $36 per person. Table 5 summarizes the results of the analysis.

Table 5. Summary of Fiscal and Consumer Surplus Losses

Statewide Impacts	
Total Statewide AF Savings Compared to 2013	1,300,000
Statewide AF Saved in 2014 by Local Actions	500,000
Statewide AF Saved	800,000
Utility Net Revenue Loss ($)[1]	$500 to $600 million
Net Revenue Loss per Acre-foot	$625 to $750
Net Revenue Loss per Capita	$14 to $17
Consumer Surplus Loss[1]	$500 - $700 million
Consumer Surplus Loss per Acre-foot	$625 to $875
Consumer Surplus Loss per Capita	$14 to $19
Total Cost	$1,000 to 1,300 million
Total Cost per Acre-foot	$1,250 to $1,625
Total Cost per Capita	$28 to $36
[1] Impacts rounded to nearest $100 million.	

[33] The forgone revenue would have gone to pay fixed enterprise costs. Municipal water service is extremely capital intensive (Hanemann, 2005) and the majority of revenue is used to pay the fixed costs of plant, equipment, and workforce. Because most urban water suppliers in California recover a significant percentage of their fixed costs through their volumetric rates, a reduction in the sale of water will create a fiscal imbalance unless service charges and rates are adjusted to recover the forgone net revenue. This fiscal reality is what generates the ubiquitous newspaper headline during droughts: "Utility rewards customers for saving water by raising its rates."

Potential Impacts on Vulnerable Sectors

Landscaping

Implicit in relying on consumer surplus to estimate economic impacts is the assumption that water is a primary input to production, constraints on the supply of this input would limit production, with concomitant implications to employment and payroll. This is a reasonable way to describe how water shortages impact water-intensive industries and businesses. For example, a chemical manufacturer uses water in its processes, as well as for cooling, heating, and sanitation. In the short-run, the ability to substitute other inputs for water in the production process may be limited; reductions in water supply may thus require changes in output and employment levels.

However, not all industry sectors considered vulnerable to water shortages follow this general model. Water shortages do not affect the landscape services sector's ability to supply its customers. Rather, water shortages may reduce the demand for landscape services. Put another way, water shortages impact the landscape services sector indirectly through changes in demand. These indirect impacts are not accounted for in the EO drought cost estimates presented earlier in this report.[34]

The landscaping services sector is dominated by small businesses; roughly 80 percent of landscaping firms have gross sales of less than $1 million.[35] Droughts and concomitant water shortages tend to reduce demand for these services. For example, between 1990 and 1991 – a period in which California experienced both a recession and a drought – the landscaping service sector payroll fell by $217 million, of which 11 percent, or about $23.9 million, was attributable to the drought alone.[36] That is, the drought alone was estimated to reduce 1991 landscaping service sector forecast payroll by 1.7 percent.

In this respect, it seems likely that absent a policy response the state's landscaping service sector payroll (e.g., employment) will shrink somewhat as a result of the current drought. It is notable that the EO does not direct the Department of Water Resources to allow 50 million square feet of lawns and ornamental turf to go without water, but rather that this vegetation should be affirmatively replaced:

> *The Department shall lead a statewide initiative, in partnership with local agencies, to collectively replace 50 million square feet of lawns and ornamental turf with drought tolerate landscapes.*

A number of factors will influence the economic implications of this EO element. Individuals and businesses facing the loss of their existing lawns and turf due to water scarcity, or who are subject to particularly high water prices imposed by their water supplier or as a result of the EO will be most apt to agree to transform their landscapes into drought tolerant plots. While they may lose a prized amenity, unless the water scarcity was directly caused by the EO its forfeiture cannot be attributed to the order.

[34] Appendix C contains a survey of previous studies on how drought affects the landscaping industry.

[35] Chuck Bowen (2012), "State of the Industry," *Lawn and Landscape,* http://www.slideshare.net/fullscreen/cb102102/2012-lawn-landscape-state-of-the-industry-report/8, October 2012.

[36] Spectrum Economics, Inc., "Preliminary Report: The Impact of Drought on California's Green Industry." Report to State Water Contractors and Metropolitan Water District of Southern California. WRINT SWC Exhibit Number 20, 1992.

Installing drought tolerant landscapes can cost from $2 to more than $5 per square foot,[37] suggesting that the EO will trigger from $100 million to $250 million in expenditures on landscaping, to the benefit of that sector.[38] The majority of this spending will take place in Southern California, which has the state's largest concentration of landscaping and groundskeeping workers.[39] While a portion of these dollars will come directly from households or businesses – reflecting a transfer from either savings or away from an alternative purchase – a significant amount will be provided through rebates offered by water suppliers. In some cases rebate amounts will be sufficient to include cash payments to households for agreeing to remove their lawn.[40]

In the long run participants in the initiative seem likely to maintain their newly drought tolerant landscapes – as opposed to returning to more water-thirsty vegetation – barring the reappearance of consistently wet weather and mild temperatures. As a result, the initiative will have the effect of permanently retiring the amount of water used for the previous landscaping, enabling those supplies to be directed to other economically beneficial uses.[41] It will also help catalyze a new, drought-oriented, sub-sector of the landscaping services sector, thereby creating new employment, as well as, over time, likely reducing prices for this type of amenity.

Recreation and Tourism Industry

According to the California Travel and Tourism Commission, tourism related travel during 2013 generated approximately $101.8 billion in visitor spending in California and directly supported an estimated 931,000 jobs.[42] With more than 215 million person-trips to and through California in 2012, recreation and tourism activity contributed substantially to the State economy and many local economies.

The recreation and tourism industry in California is a labyrinth of business sectors that produce and sell goods and services to visitors. For this assessment, the business sectors that comprise the recreation and tourism industry include those from a study of statewide travel impacts in California.[43] These business sectors include:

- Accommodations (includes hotels and motels, campgrounds, private homes, and vacation homes)
- Food and Beverage Service

---

[37] Southern Nevada Water Authority, Frequent Questions - Water Smart Landscapes, http://www.snwa.com/rebates/wsl_faq.html; Carolyn Said, "Artificial Lawns Gain Popularity, Draw Criticism," *San Francisco Chronicle*, April 21, 2015. For an analysis of lawn-related water demand and concomitant water saving polices, see Ellen Hank and Matthew Davis, "Lawns and Water Demand in California," *California Economic Policy*, Public Policy Institute of California, Volume 2, Number 2, July 2006.

[38] Home services site Thumbtack.com reported a doubling of requests for artificial-turf installations the week the EO was issued.

[39] U.S. Bureau of Labor Statistics (2014), Occupational Employment and Wages, May 2014: 37-3011 Landscaping and Groundskeeping Workers, http://www.bls.gov/oes/current/oes373011.htm.

[40] Dana Bartholomew, "L.A. company saving water by offering drought-tolerant lawns for free," *Los Angeles Daily News*, June 29, 2014

[41] There will be a number of "free-riders" on this initiative; i.e., households and businesses that would have replaced their landscaping even without it.

[42] California Travel and Tourism Commission. Information on the economic impacts of travel and tourism in California. http://industry.visitcalifornia.com/Why-Travel-Matters/Must-Know-Research/, accessed April 21, 2015.

[43] Dean Runyan Associates, California Travel Impacts by County, 1992-2012. May 2014. California Travel and Tourism Commission: *http://www.deanrunyan.com/doc_library/CAImp.pdf*

- Arts, Entertainment and Recreation
- Retail Sales (includes gasoline)
- Ground Transportation (includes car rental)
- Air Transportation

Economic Contribution of Outdoor Recreation to the Tourism Industry

An important component of the travel and tourism industry in California is outdoor recreation activities. Based on a 2008 study of the economic impact of outdoor recreation on public lands (federally managed wildlife refuges, parks, and recreation lands; state parks; local and regional parks; and private lands that support outdoor recreation activities such as hunting and fishing) in California, visitor expenditures associated with activities on these lands were estimated at $20.8 billion,[44,45] representing about 20 percent of total travel-related tourism spending in 2013.[46]

One outdoor recreation activity that could be impacted by urban water use restrictions from the EO is golfing. Maintaining large, turf-dependent golf course landscapes typically requires relatively substantial amounts of water. According to the California Golf Course Owners Association, the more than 900 golf courses that this association represents are responsible for the employment of over 128,000 California residents, with wages in excess of $4 billion and a statewide economic impact exceeding $13 billion.[47]

Vulnerability to Water Use Restrictions for Recreation and Tourism

The large and interwoven structure of the recreation and tourism industry in California suggests varying levels of vulnerability to water use restrictions imposed by the EO. As described above, the "industry" is a labyrinth of business sectors, driven primarily by the needs and demands of visitors. Certain business sectors in one region, or even the entire tourism-related industry, could be negatively affected by water use restrictions, whereas the same sectors in a different region might avoid (or even benefit from) changes in consumer demand driven by water use restrictions elsewhere. Key determining factors are the extent (or magnitude) of the water conservation targets to be achieved and how water agencies decide to impose restrictions.

For example, the Coachella Valley Water District (CVWD) has been identified by the SWRCB as a Tier 9 urban water agency. This designation means that the District must achieve a 36 percent reduction in water consumption within the District service area between June 2015 and February 2016, as compared to water consumption levels between June 2013 and February 2014.

The CVWD's service area includes 124 golf courses in world-renowned resorts such as Palm Springs, which are estimated to use about 1,000 AF of water (the equivalent of 325 million gallons) per golf

[44] BBC Research and Consulting. (2010) *California Outdoor Recreation Economic Study: Statewide Contributions and Benefits*. California State Parks. http://www.parks.ca.gov/pages/795/files/ca%20outdoor%20rec%20econ%20study-statewide%2011-10-11%20for%20posting.pdf

[45] Although this study is several years old, Dean Runyan Associates (2014) contends that the tourism industry just recovered to pre-recession levels in 2013, indicating that 2008 estimates of expenditures may not be far off from current levels.

[46] Information on participation levels in outdoor recreation activities on private lands in California is limited.

[47] Comment letter from Marc Connerly, Executive Director of the California Golf Course Owners Association (CGCOA) on Section 865 of the Proposed Emergency Regulations. Letter dated March 11, 2015 and accessed on the SWRCB website (http://www.waterboards.ca.gov) on April 21, 2015.

course.[48] Although most golf courses in the CVWD service area pump groundwater from wells, some also receive either Colorado River supplies or use reclaimed sewer water for landscape irrigation needs. Water conservation efforts have been underway since at least 2009 to get golf courses connected to recycled water; however, as of late 2013, only 19 of the 124 golf courses were as yet receiving recycled water for irrigation purposes.

According to information on CVWD's website, meetings are scheduled for April 28 and May 12, 2015 to discuss options for achieving the water conservation goals established for the District.[49] Presumably, similar discussions are being carried out statewide by many if not most of the more than 400 urban water agencies to decide how water use restrictions from EO-B29-15 will be imposed.

Potential Effects of Urban Water Restrictions on the Recreation and Tourism Industry

As indicated for the assessment of the landscape sector, potential economic impacts on businesses in the recreation and tourism industry are considered *indirect* effects, and therefore have not been accounted for in the estimated costs of water use restrictions presented earlier in this report. These economic impacts potentially include changes (mostly decreases but some increases) in net revenues to businesses associated with a corresponding change in operations (i.e., changes in revenues less changes in operating costs). If the impacts on more directly affected businesses are sufficiently large, the regulations also could spill over to affect the net operating revenues of other complimentary businesses, both within and outside the recreation and tourism industry.

In addition to regions that appear at higher risk of experiencing economic impacts, businesses in certain recreation and tourism sectors of the broader industry also are considered at higher economic risk. Assuming that urban water agencies decide to impose water use restrictions across all economic sectors and types of water users, businesses comprising the recreation and tourism industry that would appear to be most vulnerable would be those that depend on intensive water use, such as turf-dependent golf courses and water parks, and other outdoor recreation areas with major water features. Reducing the overall demand for recreation and tourism-related goods and services will affect a wide array of businesses; however, businesses in hotel and lodging accommodations; food and beverage service; the arts, entertainment and recreation services; tourism-dependent retail sales, including gasoline; ground transportation, such as car rentals; and air transportation sectors are particularly expected to be economically impacted.

Also, businesses (and communities) in regions where the recreation and tourism industry is a relatively large and important part of the local economy may be particularly vulnerable, because of the interrelatedness of many sectors within the industry and the potential magnification of effects across the wide swath of tourism-dependent businesses. Some communities in Southern California (e.g., lower desert communities) and along the Central Coast (e.g., Monterey) where golf is a relatively important recreation and tourism attraction are examples of tourism-dependent communities. Regions that benefit economically from visitors recreation at regional parks and other large-scale tourist attractions also would likely be vulnerable, again depending on how water restrictions are imposed by local water agencies.

---

[48] Ian, James. "Coachella Valley Water District looks to speed efforts to take golf courses off groundwater." *The Desert Sun*. March 19, 2014.

[49] http://www.cvwd.org, accessed on April 25, 2014.

Businesses that support the recreation and tourism industry such as accommodations and food service businesses that cater to visitors participating in outdoor recreation activities, especially water-dependent activities like boating and fishing in freshwater areas, also could be vulnerable, although the overall net effect of potential economic impacts is more ambiguous. To the extent that certain businesses can substantially reduce water-consumption operating costs (e.g., hotels, in which expenses for services such as laundry can account for a relatively large share of total operating costs), or might benefit from the displacement of visitors from other, more impacted regions, could actually benefit from the water use restrictions (e.g., beach communities have seen increased visits this winter while ski resorts have closed early). Sectors comprised of businesses that are not water intensive, such as retail and ground transportation, or that are located outside of urban water service boundaries (e.g., national and state parks or other public recreation areas), would appear to have low vulnerability to the water use restrictions.

In the short-run, when the ability of affected businesses to substitute other inputs for water in the production process is more limited, water use reductions likely will result in net negative effects in economic output, employment and earnings. From a regional perspective, the regions that are most vulnerable to economic effects include those with a relatively large share of the population, primarily the South Coast region but secondarily the San Francisco and Sacramento regions. Also, regions where the estimated water savings achieved by urban water agencies are disproportionately large relative to the population, such as in the South Coast and Colorado River regions, would be expected to be more economically impacted. Businesses in tourism-dependent communities within these four regions (South Coast, San Francisco, Sacramento, and Colorado River) have the greatest potential for being economically impacted, depending however on how water agencies decide to impose water use restrictions.

In summary, the overall, statewide effect on the recreation and tourism industry is expected to be negative, based on the expectation that California's reputation for providing high quality tourism-related services likely will be tarnished by the water use restrictions and would negatively affect overall levels of tourism; however, at the regional and local levels, there would be pockets of "winners and losers" within the many and diverse communities that comprise the recreation and tourism industry. For example, winter skiing has decreased, negatively impacting the Tahoe area, but a sunny winter increases beach visits in Santa Cruz and Monterey counties. Accurately predicting, however, which tourism-related businesses in specific communities would be either negatively or positively affected is considered speculative, especially in light of the uncertainty with how urban water agencies will impose water use restrictions.

APPLIANCE REBATE/WATER ENERGY TECHNOLOGIES PROGRAMS

The EO directs the State Water Board to work with the California Energy Commission (CEC) and DWR to implement

> *…a time-limited statewide appliance rebate program to provide monetary incentives for the replacement of inefficient household devices.*

and

> *…a Water Energy Technology (WET) program to deploy innovative water management technologies for businesses, residents, industries, and agriculture.*

Neither the precise funding level, nor source, for these initiatives is yet known, though it seems quite likely that monies will come from the CEC's existing budget, possibly supplemented by DWR. In any event, it is unlikely that these sets of measures will result in any adverse impacts; they are more likely to result in economic benefits. Past studies of similar programs have suggested mixed outcomes, including inducing "free riders," both delaying and accelerating appliance purchases,[50] and triggering long-run increases in productivity as a result of technological breakthroughs and increased cost-effectiveness.

ANCILLARY BENEFITS TO THE ENVIRONMENT FROM THE EO

Increasingly, the economic values of aquatic ecosystems are being evaluated using an ecosystem services analytical framework. Although the challenges of quantifying and monetizing ecosystem services are widely recognized[51] and even considered insurmountable by some from a monetization perspective.[52] This analytical approach is considered to be useful in understanding the social and economic importance of aquatic ecosystems.

As noted by Boyd (2010), ecosystems support more than species and biological functions; they also support the provision of socially valuable services.[53] Ecosystems can purify water, reduce flood and fire risks, support recreation, provide beauty, improve nearby agricultural output, sequester carbon, and enhance air quality.[54] Ecosystems provide both marketable and nonmarketable goods and services. The nonmarketable services that ecosystems provide, such as nutrient recycling, contributing to the quality of water supply aquifers, and regulating flood risk, are becoming increasingly recognized as critical functions that society depends on.[55] When ecosystems are changed or damaged, the social and/or economic value of the services provided by those ecosystems also changes.

Economics normally focuses on determining the value of services provided by an asset.[56] In applying measurement techniques to ecosystems, ecological endpoints are typically identified and then an accounting system is built around them.[57] Ecological endpoints are characterized by their biophysical qualities or characteristics; by being concrete, tangible, and measurable; and by being directly, intuitively connected to human wellbeing.

Applying ecosystem services measurement techniques to estimate potential environmental benefits and associated economic values of water savings from implementing the EO is beyond the scope of this assessment; however, this conceptual framework helps to explain the relationships between potential

---

[50] Joseph Aldy, Sebastien Houde, Hasan Nazar (2013), "Did the Stimulus Benefit the Environment? New Evidence from Cash for Appliances," Working Paper, http://web.stanford.edu/group/SITE/SITE_2013/2013_segment_6/2013-segment_6_papers/houde.pdf, August 9.

[51] Turner et al. (2003). *Valuing nature: lessons learned and future research directions*. Ecological Economics. Vol 46 (2003). pp. 493-510.

[52] MacNair, Doug (2013). *Ecological value of water*. Posted on http://growingblue.com/blog/economics/ecological-value-of-water/ accessed on April 24, 2015.

[53] Boyd, James (2010). *Biomass to Energy: forest management for wildfire reduction, energy production, and other benefits*. CEC-500-2009-080-A. January 2010.

[54] Daily, G.C. (1997). "Introduction: What are ecosystem services?" in *Nature's Services: Societal dependence on natural ecosystems*, G.C. Daily (ed.) Washington, D.C.: Island Press. pp. 1-10.

[55] National Research Council. 2005. *Valuing ecosystem services – toward better environmental decision-making.* The National Academies Press. Washington, D.C. .

[56] Ibid

[57] Boyd, James. 2010.

environmental benefits and economic values from restricting urban water use during the 2015-16 water year. Regardless, these benefits are only ancillary to the main objective of the EO to coordinate management of the state's water supply infrastructure across its many water purveyors.

The additional water in the streams and reservoirs that are part of California's water delivery system would be expected to contribute to the protection of aquatic ecosystems throughout the State. Although the importance of higher streamflows and reservoir levels associated with these water savings is uncertain, it would appear that the water savings would have a positive economic value in terms of protecting California's fish and wildlife resources and avoiding likely environmental costs.

APPENDIX A: SEVERE DROUGHT CONDITIONS THREATEN THE CALIFORNIA ECONOMY: LESSONS FROM AUSTRALIA[58]

Between 2002 and 2012 Australia experienced persistent and severe drought across most of the continent. Termed the "Big Dry," the drought affected different regions at different times and to differing degrees. By April 2007 – five years into the drought – the situation was so dire that it prompted then Prime Minister John Howard to appeal to higher powers; "We should all pray for rain," he said. At that moment, 65 percent of all viable land in Australia was in drought. Major water storage reservoirs were at just 25 percent of capacity.

By 2010 the drought had considerably eased in parts of Australia. It was officially declared over in 2012. Lasting 10 years, the Big Dry had profound impacts on Australia's economy, particularly those parts of the economy linked to the agricultural sector.

The drought did not just devastate farming, though that sector bore the greatest impacts. All parts of Australia's economy were affected. Modeling of economic impacts associated with the 2002-03 water supply curtailments indicates that in that year alone growth of gross domestic product (GDP) was slowed by 1.6 percent, employment growth slowed by 0.8 percent, average wages fell by 0.9 percent, and exports fell by 5 percent.[59] Reduced production in non-agricultural industries accounted for nearly 40 percent of the GDP decline.

The largest employment losses occurred in non-agricultural sectors. Half a percentage point may have been shaved from Australia's GDP growth over the course of the drought.[60] A half-point reduction in GDP growth is significant: if this level of economic decline occurred in California, cumulative state output would be reduced by close to half a trillion dollars over the same span of time. At its peak, the Big Dry was estimated to have reduced Australia's GDP by 1.6 percent. A 1.6 percent hit to California GDP would reduce state output by more than $30 billion. [61]

The Big Dry also threatened to disrupt Australia's electricity supply.[62] During the drought's peak in 2007, water supply for power plant cooling and hydropower generation was increasingly uncertain.[63] Electricity futures nearly doubled as the market anticipated the possibility of skyrocketing electricity costs and shortages. The Sydney Futures Exchange ranked it as one of the biggest commodity price increases the exchange had ever seen, stating it was not driven by market speculation but rather "the

[58] This analysis was originally developed under the auspices of the California Water Foundation.

[59] Horridge, M., Madden, J., & Wittwer, G. (2005). The impact of the 2002–2003 drought on Australia. *Journal of Policy Modeling , 27*, 285–308.

[60] Pearson, T., Rodrigues, M., & Toth, J. (2006). *Impact of the Drought 2006-07: Outlook for Australian Agriculture and the Economy.* Economics@ANZ.

[61] The difference between the single and multiple year estimates is created by compounding. The Australia drought shaved about half a point off GDP growth. If this were to happen in California over a 10 year period it would amount to about half a trillion dollars cumulatively. At its worse, Australia's GDP fell by about 1.5 percent in a single year, which is roughly $30 billion at current levels of state GDP.

[62] Australian Associated Press. (2007). *Drought Puts Pressure on Electricity.* Retrieved May 21, 2012, from The Age: theage.com.au. May 19.

[63] Since October 2011 California ratepayers spent $1.4 million more for electricity than in average years because of drought-induced shift from hydropower to natural gas. In the same period, hydropower's share of the electricity market dropped from 18 percent in average years to less than two percent, according to the Pacific Institute.

convergence of several negative trends, dominated by the water shortage".[64] According to one report, water scarcity contributed to the doubling of wholesale electricity costs in 2007.

Pressed by water scarcity, urban regions imposed increasingly stringent restrictions on domestic water use. For example:

- From 2006 to 2008 Canberra banned the use of automatic sprinklers and lawn watering. It restricted hand watering of plants to alternating days in the morning or evening. It prohibited the filling and topping off of swimming pools, and restricted car washing to commercial establishments only. It banned window washing.
- From 2005 to 2007 Sydney banned the use of sprinklers; limited hand watering to twice weekly; prohibited pool filling without a permit; and banned hosing of hard surfaces and car washing.
- From 2007 to 2010 Melbourne prohibited lawn watering and sprinkler irrigation; limited hand watering to twice weekly; banned filling of swimming pools; and limited car washing to windows, mirrors, and lights.

As indicated in the table below, Australia and California are alike in many respects. Populations are of similar magnitude, and are massed primarily along the coast, with agricultural hinterlands stretching into a much drier interior. Agriculture is economically important, but not dominant.[65] Both places have strong, technologically advanced economies. Their climates are similar, especially in the coastal zones. In both places, weather patterns are heavily influenced by El Nino and La Nina events.

Table A-1. Australia and California Climates

	California	Australia
Population	37,691,912	22,299,000
Landmass	163,695 square miles	2,941,299 square miles
Annual Rainfall	22.20 inches	18.31 inches
Average Annual Runoff	71 million acre feet	196 million acre feet
Desert	25,000 square miles	529,346 square miles

In Australia's major metropolitan regions – Sydney, Melbourne, Brisbane, Adelaide, and Perth – the drought added about half a percent to unemployment. At its peak, the Big Dry was estimated to have reduced employment by 0.8 percent. A 0.8 percent decrease in employment in California translates to approximately 114,000 jobs. Hydropower supplies roughly 15 percent of California's electricity. In a drought like the Big Dry, much of this energy supply would be lost to the region, resulting in potentially significant impacts to electricity prices and reliability.[66]

64 Ibid

65 Agricultural production accounts for about 1.5 percent of gross domestic product in California and about 3 percent in Australia.

66 Hydropower in neighboring states would also likely be negatively impacted; further impacting California's economy.

During the Big Dry, Queensland residents reduced their per capita water use to a Spartan 34 gallons per capita per day. That's less than half the consumption of California's most water efficient cities, and just 7 percent of the statewide average.[67]

[67] Nelson, Barry. "World Water Day – California's Embarrassment of Water Riches?" National Resources Defense Council. http://switchboard.nrdc.org/blogs/bnelson/world_water_day_californias_em.html

APPENDIX B: REVIEW OF OTHER ECONOMIC IMPACT STUDIES

The M.Cubed team identified six studies that have estimated or examined the impact of water shortages on business activity, as follows:

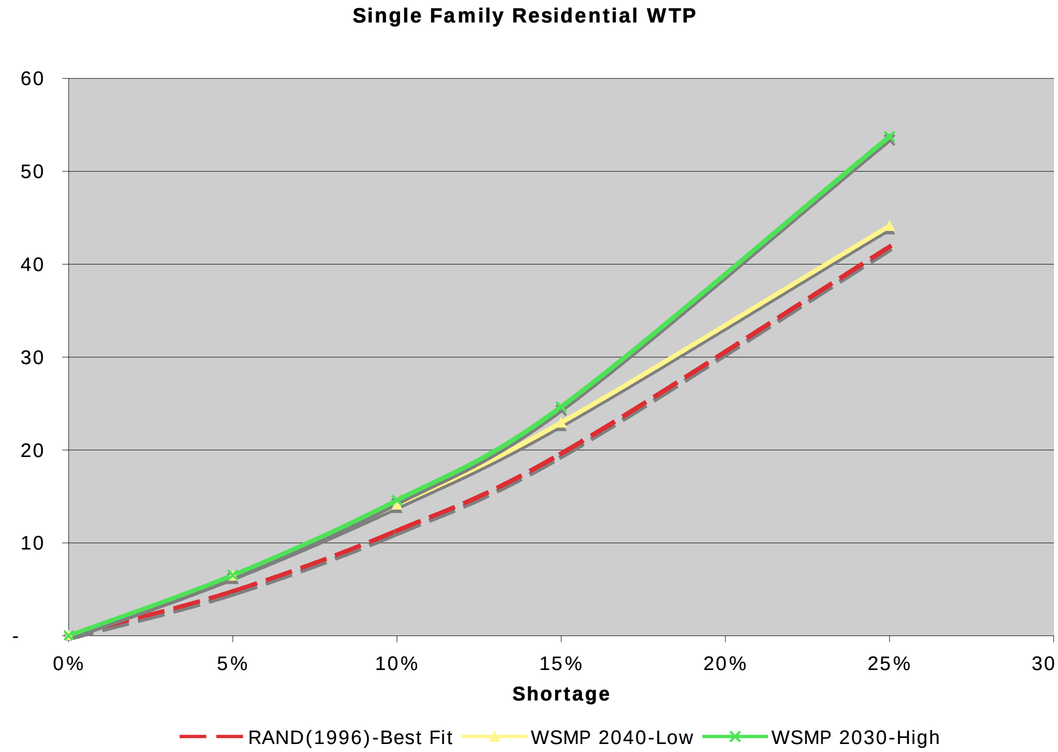
- Spectrum Economics (1991). "Cost of Industrial Water Shortages: Preliminary Observations." Hereafter referred to as Spectrum (1991).
- Center for Regional Economy (2006). "East Bay Water Sources and a Pilot Study of User Response to a Potential Supply Disruption." Hereafter referred to as St. Mary's (2006).
- San Francisco Public Utilities Commission (2007). "Measures to Reduce the Economic Impacts of a Drought-Induced Water Shortage in the SF Bay Area." Hereafter referred to as SFPUC (2007).
- MHB Consultants, Inc. (1994). "The Economic Impact of Water Delivery Reductions on the San Francisco Water Department's Commercial and Industrial Customers." Hereafter referred to as MHB (1994). SFPUC (2007) utilized some of the results from MHB (1994) in its analysis.
- Brozovic, Nicholas, et al. (2006). "Estimating Business and Residential Water Supply Interruption Losses from Catastrophic Events." Hereafter referred to as Brozovic (2006).
- RAND (1996). "Drought Management Policies and Economic Effects in Urban Areas of California, 1987-1992."

An Estimate of Residential Impacts

RAND (1996) calculated demand functions for single family residential accounts served by the Alameda County Water District and used them to estimate the direct statewide economic impacts of water shortages to households for the period July 1991 to June 1992. This study provides the most comprehensive and rigorous statistical examination of the economic impacts of the 1987-1992 drought available. The statistical models were estimated using 10 years of bi-monthly consumption data for a randomized sample of 599 single-family accounts. Consumption and price data were combined with data on house size, lot size, precipitation, temperature and other variables that drive household water use.

The direct economic impact derived from the demand function estimated for single-family accounts was compared to the M.Cubed team's preliminary estimates to determine if they were of similar order of magnitude. The results are shown in Figure 1. The estimates are similar in size, though the M.Cubed team estimates are approximately 5% to 35% higher for shortages in the range of 15% to 25%. The results suggest that the methodology used herein to estimate direct shortage costs to customers is consistent with empirical findings from California's last major drought cycle.

Figure B-1. Single Family Residential WTP



Estimating Impacts to Business Output, Income, and Employment

The underlying data used for Spectrum (1991) is at least 25 years old (1987 base data and older industrial water use data from 1979). It also looks at only a 30 percent reduction scenario for a year, and respondents were told to ignore any measures they had instituted for the then-current drought (in 1990). This survey was primarily examining impacts from permanent changes in Delta pumping requirements, not drought planning. The results are not directly applicable for the EO.

St. Mary's (2006) attempted to update the Spectrum (1991) study. It added four scenarios, of which two or three are applicable to the EO, with 15 and 35 percent reductions for six months and three years. Unfortunately the report provides only a qualitative discussion of potential impacts. The study's author indicated that they received only a handful of survey responses and were unable to conduct any analysis. As a result this report is not usable for estimating shortage costs.

SFPUC (2007) and MHB (1994) estimated changes in output and payroll using output and payroll elasticities derived from survey responses from industrial and commercial customers. Elasticities for aggregated commercial water industrial water use were estimated. Elasticities for specific industries or business were not calculated. The elasticities estimate the percentage change in output (or payroll) for a one percent reduction in water supply to the industry, and can be used to estimate impacts of water shortage on output and payroll.

Brozovic (2006) calculated business output responses to reductions in water supply using estimates of business sector resiliency. The methodology closely follows that of Chang, et al. (2002), but employs a more refined business output response function. The resiliency factors used by Brozovic (2006), however, were taken directly from Chang et al. (2002). The business resiliency factors in Chang et al.

(2002) relied on data from the 1994 Northridge and 1995 Kobe earthquakes. Resiliency factors were estimated at the two-digit NAICS level of industrial classification, enabling more disaggregated impact estimates than SFPUC (2007). The output resiliency functions can be used to estimate impacts of water shortages on output. The methods used by SFPUC (2007) and Brozovic (2006) could be transferable to the EO using data on business output (sales) and payroll from the U.S. Economic Census.

However, change in output is not a good measure of regional impact because it does not account for imports of factors of production and intermediate goods into the region. Value-added, defined as the sum of regional labor, proprietor, and other income plus indirect business taxes, provides a better gauge of regional impact. Value-added is the basis for the familiar gross domestic product (GDP) and gross state product (GSP) often reported in the press as a measure of national and state economic growth.

Figure 2 shows the percent reduction in baseline output for increasing levels of water shortage using the SFPUC (2007) and Brozovic (2006) methods. Commercial and industrial impact estimates under Brozovic (2006) are very similar, so only one curve is presented. Figure 3 shows the percent reduction in baseline payroll for increasing levels of water shortages using the SFPUC (2007) method. Note that the shortage levels in the figures and table refer to the sector rather than the system-wide shortage. This is important to keep in mind, since system-wide shortages may not be allocated proportionally across water customer classes.

Figure B-2. Water Shortage Output Losses

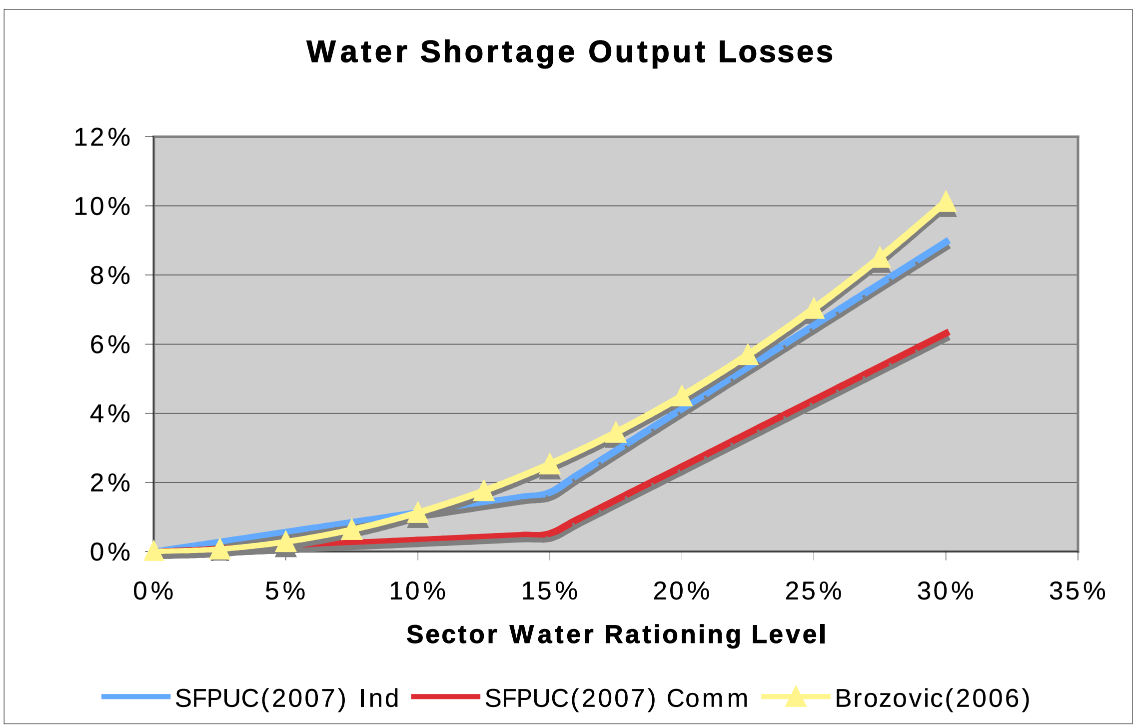
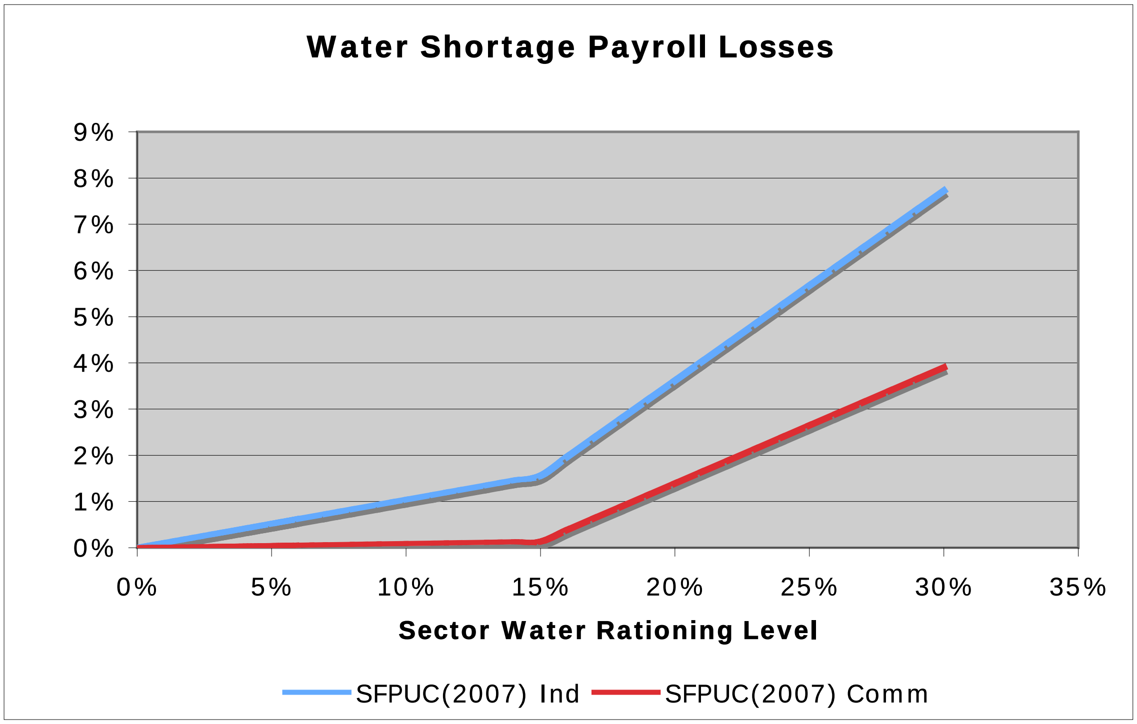


Figure B-3. Water Shortage Payroll Losses



Industrial and Commercial Payroll: 1987-1991

RAND (1996) examined industrial and commercial water use over the period 1987-1991. As hypothesized by the SFPUC (2007) and Brozovic (2006) models, the study found a positive correlation between industrial water use and industrial payroll during the drought, shown in Figure 4, though changes in payroll were much less than proportional to changes in water use. Additionally, the latter part of the drought coincided with a broad economic recession, which also negatively impacted industrial payroll. While industrial water use in 1991 decreased by about 15 percent from the previous year, industrial payroll decreased by only 4 percent; most of this decrease probably was due to the economic recession, as U.S. manufacturing employment declined by 3.5 percent in 1991.[68] The SFPUC (2007) model estimates that industrial payroll would decrease by 1.6 percent given a 15 percent reduction in industrial water use. Given that most of the reduction in industrial payroll between 1990 and 1991 probably was attributable to the recession, this estimate appears plausible.

The SFPUC (2007) predicts negligible impacts to commercial payroll for shortages of up to 15 percent. This appears consistent with changes in commercial payroll observed between 1987 and 1990 (Figure 5). During this period, while commercial water use decreased by about four percent from its 1986 level, commercial payroll continued to grow. Between 1990 and 1991 commercial water use fell by roughly 11 percent while commercial payroll decreased by about 2.6 percent. As with industrial payroll, given that

[68] U.S. Census Bureau, *Statistical Abstract of the United States, 1993*, Table No. 647.

the economic recession may account for much or most of this decrease the SFPUC (2007) payroll impact estimates appear plausible.

Figure B-4. Industrial Water Use and Payroll

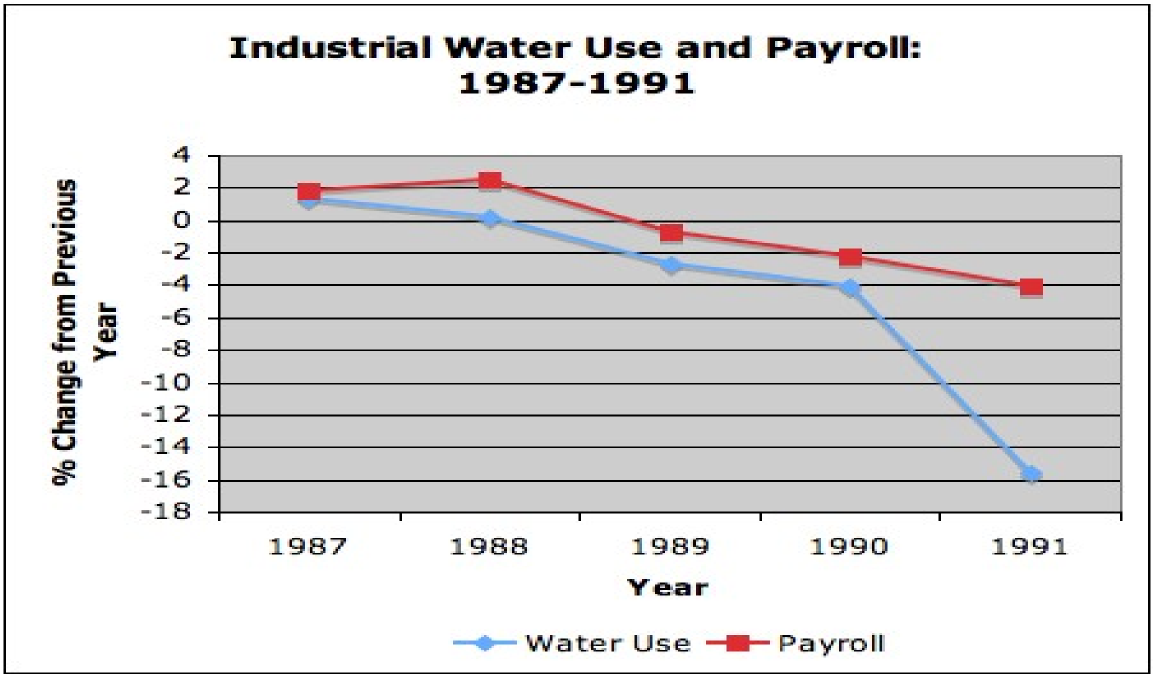
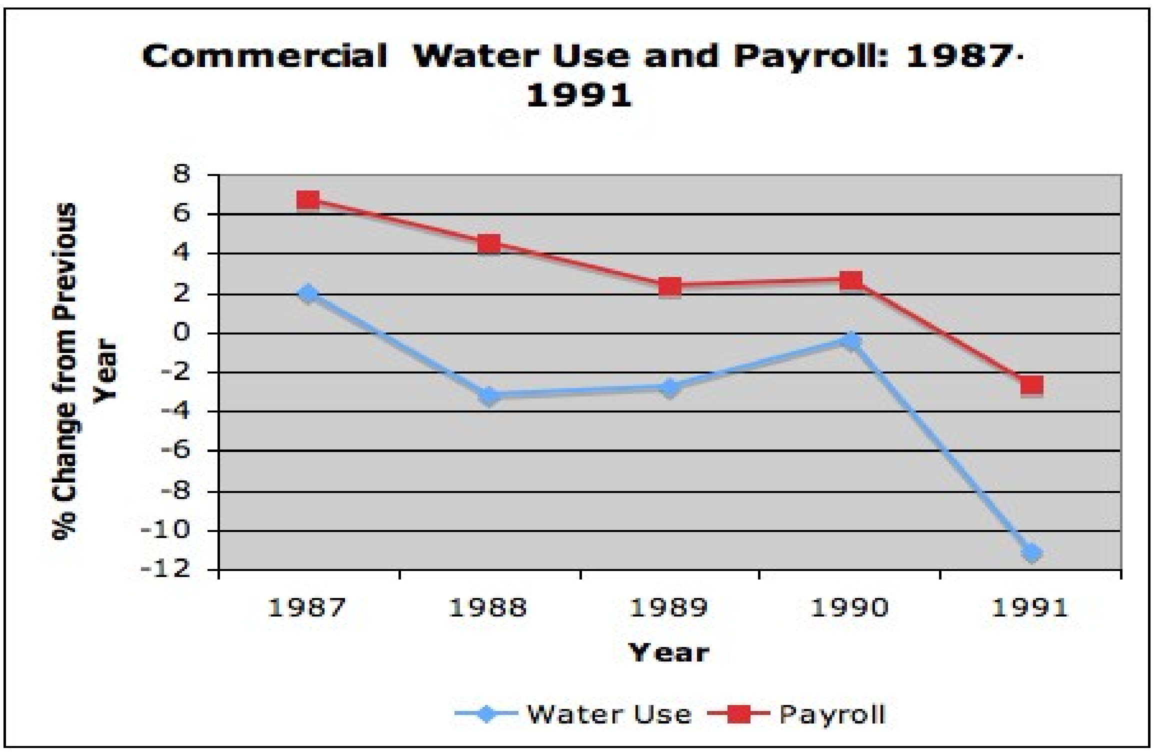


Figure B-5. Commercial Water Use and Payroll: 1987-1991



APPENDIX C: PREVIOUS ESTIMATES OF LANDSCAPING INDUSTRY IMPACTS

Limited information on how water shortages impact the landscape services sector is available. M.Cubed has identified two studies, sponsored by the State Water Contractors (SWC) and by Metropolitan Water District (MWD), which examined drought impacts on California's landscape services sector. The SWC study examined how the combination of drought and recession impacted statewide payroll and employment within the landscape services sector in 1991. Through a survey of landscape service sector employers, the MWD study estimated how much of the total impact could be attributed to the drought alone, the recession alone, or was not separable.

Results are summarized in the following table. The SWC study estimated that between 1990 and 1991 California's landscape service sector payroll fell by $217 million and that 11%, or about $23.9 million, was attributable to the drought alone. That is, the drought alone was estimated to reduce 1991 forecast payroll by 1.7%.

RAND (1996) estimated that water shortages in California's urban areas averaged 14% in 1991, implying a payroll elasticity of 0.12.[69]

Table C-1. 1991 Statewide Landscape Services Sector Payroll Impact (Million $)[70]

1991 Forecasted Payroll	1991 Actual Payroll	Difference	% Drought Related	Drought Related $	1991 Statewide Urban Shortage	Implied Payroll Elasticity
$1,421.5	$1,204.5	-$217	11%	-$23.9	-14%	0.12

In 2008, this approach was used to assess the potential impacts for the East Bay Municipal Utility District's *2040 Water Supply Management Plan*. The following table shows the size of the landscape services sector in Alameda and Contra Costa counties, as reported in the 2002 Economic Census.

Table C-2. Landscape Services in Alameda and Contra Costa Counties, 2002

County	No. Establish.	Sales ($1,000)	Ann. Payroll ($1,000)	Employees
Contra Costa	306	$203,747	$63,166	2,593
Alameda	262	$338,827	$131,079	4,557
Total	568	$542,574	$194,245	7,150

The next table shows the potential impact to annual payroll, employment, and value added for 10, 15, 20, and 25 percent shortages. These impacts are for all of Alameda and Contra Costa Counties, which includes impacts that fall outside of the EBMUD service area.

[69] Payroll elasticity is defined at the percentage change in landscape sector payroll given a one percent change in urban water supply. An elasticity of 0.12 means that a 10% urban shortage would reduce landscape sector payroll by 1.2%.

[70] RAND 1996. "Drought Management Policies and Economic Effects in Urban Areas of California, 1987-1992.

Table C-3. Landscape Services Impacts in Alameda and Contra Costa Counties, 2002.

Water Shortage	Employment	Payroll (Mil. $)	Value Added (Mil. $)*
10%	71	$2.3	$3.3
15%	107	$3.5	$5.0
20%	143	$4.6	$6.6
25%	179	$5.8	$8.6

* Based on ratio of value added to payroll for IMPLAN sector 458 “Services to Building and Dwellings,” which includes NAICS 5617 “Landscape Services.”

APPENDIX D: HYDROLOGIC REGIONS

REFERENCES

Australian Associated Press. (2007). *Drought Puts Pressure on Electricity.* Retrieved May 21, 2012, from The Age: theage.com.au. May 19, 2007.

Bartholomew, D (2014) "L.A. company saving water by offering drought-tolerant lawns for free," *Los Angeles Daily News*, June 29, 2014

BBC Research and Consulting (2010) *California Outdoor Recreation Economic Study: Statewide Contributions and Benefits*. California State Parks. http://www.parks.ca.gov/pages/795/files/ca%20outdoor%20rec%20econ%20study-statewide%2011-10-11%20for%20posting.pdf

Black & Veatch (2006). *2006 California Water Rates Survey.* Los Angeles, California. May.

Bowen, Chuck (2012). "State of the Industry." *Lawn and Landscape*. http://www.slideshare.net/fullscreen/cb102102/2012-lawn-landscape-state-of-the-industry-report/8. October 2012.

Boyd, James (2010). *Biomass to Energy: forest management for wildfire reduction, energy production, and other benefits*. CEC-500-2009-080-A. January 2010.

Brozovic, N., D. Sunding, and D. Zilberman (2006) "Estimating Business and Residential Water Supply Interruption Losses from Catastrophic Events." University of Illinois at Urbana-Champaign, November 20, 2006.

California Department of Fish and Wildlife (2015). State and federally listed endangered and threatened animals of California. http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf accessed on April 25, 2015.

California Golf Course Owners Association (2015). Comment letter from Marc Connerly, Executive Director of the CGCOA on Section 865 of the Proposed Emergency Regulations. Letter dated March 11, 2015 and accessed on the SWRCB website (http://www.waterboards.ca.gov) on April 21, 2015.

California Travel and Tourism Commission (2015). http://industry.visitcalifornia.com/Why-Travel-Matters/Must-Know-Research/, accessed April, 2015.

California Water Boards (2015). Draft Regulations: Implementing 25% Conservation Standard Fact Sheet. http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/emergency_regulations/fact_sheet_implementing_25.pdf

Chang, S.E., W.D. Svekla, and M. Shinozuka (2002) "Linking Infrastructure and Urban Economy: Simulation of Water-Disruption Impacts in Earthquakes." *Environment and Planning B: Planning and Design*, 29:281-301.

Coachella Valley Water District (2015). Public Notice. http://www.cvwd.org, accessed on April 25, 2015.

Courtney, R., W. Perkins, and W. Halpin (2006) "East Bay Water Sources and a Pilot Study of User Response to a Potential Supply Disruption." Center for the Regional Economy, St. Mary's College, Moraga, CA.

Daily, G.C (1997). "Introduction: What are ecosystem services?" in *Nature's Services: Societal dependence on natural ecosystems*, G.C. Daily (ed.) Washington, D.C.: Island Press. pp. 1-10.

Dean Runyan Associates (2014) California Travel Impacts by County, 1992-2012. California Travel and Tourism Commission. http://www.deanrunyan.com/doc_library/CAImp.pdf

Dixon, L., N. Moore, and E. Pint (1996) "Drought Management Policies and Economic Effects in Urban Areas of California: 1987-1992." RAND, Santa Monica, CA.

Dupont, D.P., and S. Renzetti (2001) *Water's Role in Manufacturing. Environmental and Resource Economics* 18(4): 411– 432.

Foster Associates, Inc (1994) "The Impact of Water Shortage and Recession on California's Green Industry." Report to Metropolitan Water District of Southern California and Council for a Green Environment. August 8, 1994.

Griffin, D. and K.J. Anchukaitis (2014). "How unusual is the 2012–2014 California drought?" *Geophysical Research Letters*, Volume 41, Issue 24, pages 9017–9023. 28 December 2014

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

Hanemann, W.M (2005). "The Economic Conception of Water." Working Paper No. 1005, Department of Agricultural and Resource Economics and Policy. University of California, Berkeley.

Horridge, M., J. Madden, & G. Wittwer, (2005). "The impact of the 2002–2003 drought on Australia." *Journal of Policy Modeling , 27*, 285–308.

Ian, James. *Coachella Valley Water District looks to speed efforts to take golf courses off groundwater.* The Desert Sun. March 19, 2014.

Klaiber, H. A., V.K. Smith, M. Kaminsky, and A. Strong (2011). "Measuring Price Elasticities for Residential Water Demand with Limited Information." Working Paper.

Lynne, G.D.; Luppold, W.G.; Kiker, C (1993): "Water Price Responsiveness of Commercial Establishments". *Journal of the American Water Resources Association*, 14, pp. 719-29.

MacNair, Doug 2013. "Ecological value of water." http://growingblue.com/blog/economics/ecological-value-of-water/ accessed on April 24, 2015.

MHB Consultants, Inc (1994) "The Economic Impact of Water Delivery Reductions on the San Francisco Water Department's Commercial and Industrial Customers." June 29, 1994.

Morse, Harry (2015). "Fish and Game Commission Approves Emergency Fishing Closure on Part of Upper Sacramento River." California Department of Fish and Wildlife. http://ca.gov/drought/new/story-83.html accessed April 24, 2015.

National Research Council. 2005. "Valuing ecosystem services – toward better environmental decision-making." The National Academies Press. Washington, D.C. .

Nelson, B., (2010) "World Water Day – California's Embarrassment of Water Riches?" National Resources Defense Council. http://switchboard.nrdc.org/blogs/bnelson/world_water_day_californias_em.html

Olmstead, S.M., W.M. Hanemann, and R.N. Stavins (2007). "Water demand under alternative price structures," *Journal of Environmental Economics and Management*, September 2007, 54 (2), 181–198.

Pearson, T., M. Rodrigues, & J. Toth, (2006). *Impact of the Drought 2006-07: Outlook for Australian Agriculture and the Economy.* Economics@ANZ.

RAND (1996) "Drought Management Policies and Economic Effects in Urban Areas of California: 1987-1992." RAND, Santa Monica, CA.

Renwick, M and R.D. Green (2000) "Do Residential Water Demand Side Management Policies Measure Up? An Analysis of Eight California Water Agencies'" *Journal of Environmental Economics and Management* 40:37-55.

Renzetti, S (1992) "Estimating the Structure of Industrial Water Demands: The Case of Canadian Manufacturing." *Land Economics* 68(4): 396– 404.

Reynaud, A (2003) "An econometric estimation of industrial water demand in France," *Environ. Resour. Econ*., 25,213–232.

Said, C (2015) "Artificial Lawns Gain Popularity, Draw Criticism," *San Francisco Chronicle*, April 21, 2015.

San Francisco Public Utilities Commission (2007) "Measures to Reduce the Economic Impacts of a Drought-Induced Water Shortage in the SF Bay Area." May 3, 2007.

State Water Resources Control Board. Water consumption data. http://www.water.ca.gov/urbanwatermanagement/2010_Urban_Water_Management_Plan_Data.cfm.

Sunding, D., et al (2014). "Economic Benefits of the BDCP and Take Alternatives." *Bay Delta Conservation Plan*. Public Draft. Appendix 9.A.

Schneider, M. and Whitlach, E (1991): "User-Specific Water Demand Elasticities". *Journal of Water Resources Planning and Management*, 117, pp. 52-73.

Spectrum Economics, Inc (1991) "Cost of Industrial Water Shortages: Preliminary Observations." April 11, 1991.

Spectrum Economics, Inc (1992) "Preliminary Report: The Impact of Drought on California's Green Industry." Report to State Water Contractors and Metropolitan Water District of Southern California. WRINT SWC Exhibit Number 20.

Turner et al. 2003. Valuing nature: lessons learned and future research directions. Ecological Economics. Vol 46 (2003). Pps 493-510.

U.S. Census Bureau, *Statistical Abstract of the United States, 1993*, Table No. 647.

U.S. Environmental Protection Agency. 1994. "Regulatory impact assessment of the final water quality standards for the San Francisco Bay/Delta and critical habitat requirements for the Delta smelt." With the technical assistance of Jones & Stokes Associates. San Francisco, CA. December 15, 1994.

Vogel, Nancy and Ted Thomas. “Drought Triggers Need for Installation of Emergency Salinity Barrier on Delta Channel.” California Department of Water Resources. http//ca.gov/drought/topstory/top-story-31.html. accessed April 24, 2015

Williams, M. and B. Suh, (1986). “The Demand for Urban Water by Customer Class.” *Applied Economics*, 18: 1275-1289. December

Weitzman, Martin L (2011). “Fat-Tailed Uncertainty in the Economics of Catastrophic Climate Change.” *Review of Environmental Economics and Policy*. 5:2. Summer. pp. 275–292.