CONSERVATION STRATEGIES FOR THE SONOMA COUNTY WATER AGENCY

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EXECUTIVE SUMMARY

The Sonoma County Water Agency's water supply is constrained by limits on its withdrawals from the Russian River and by its surface water storage capacity. The Agency's 2005 Urban Water Management Plan (UWMP) assumes that the Agency will expand its rights to withdraw water from the Russian River by 2016 in order to meet projected increases in water demand. However, the Agency is not currently pursuing plans to expand its water rights, and such an expansion might be difficult given various regulatory limitations on the Russian River. Without increased supply, projections in the 2005 UWMP suggest that the by 2020 the Agency's supply will fall 13,166 ac-ft short of its contractors' demand for water.

In addressing projected shortfalls, SCWA's options are limited by its need to raise enough revenue to cover both its fixed and variable costs. The Agency is also constrained by being a water wholesaler; it does not interact directly with the end users of water.

The most cost-effective solution to addressing projected water deficits will likely involve both supply expansion and demand reduction. This report analyzes demand reduction options that the Agency could pursue. Further analysis would be necessary to determine to what extent projected water shortfalls can be addressed through supply expansion and what the most cost effective mix of supply expansion and demand reduction is. Reducing water demand has the additional benefit of reducing energy required to pump and treat water, which will help SCWA meet its goal of making its water supply and transmission system operations carbon-free.

In order to continue operating during a 2009 drought, SCWA obtained permission from the State Water Resources Control Board (SCWRB) to reduce downstream Russian River flows below normally allowable levels. As part of the agreement with the SCWRB, the Agency reduced its diversions from the Russian River by over 25% through conservation programs and increased use of local supply. However, having less water to sell resulted in a significant revenue loss for the Agency. While long-term conservation can reduce the frequency and severity of short term supply shortages by reducing baseline water use and maintaining higher storage levels, they will still likely occur.

Based on the above factors, we recommend that SCWA:

1. Focus non-price conservation programs on increasing the saturation of high efficiency toilets and on changing water use behavior;
2. Implement a seasonal tiered pricing structure to encourage conservation during the peak period of water use;
3. Negotiate a protocol for a short-term, immediate price increase at the onset of a temporary shortage.

We evaluated the non-price conservation programs already utilized by SCWA and its contractors, including indoor retrofit rebates, landscaping rebates, and education and outreach. We estimate that these programs already conserve approximately 10,000 ac-ft/yr, and significantly reduce SCWA's energy use and greenhouse gas emissions. We also estimate the maximum potential future conservation that could be achieved with these methods if 100% saturation of efficient equipment and landscaping is attained. We project that, at most current programs could conserve an additional 8,000 ac-ft/yr, insufficient to balance anticipated future supply and demand. Additionally, non-price conservation programs require funding, and, if implemented without a price increase, reduce agency revenue as they reduce water demand.

Accordingly, we consider four different pricing structures that might be used to maintain revenue and encourage conservation: flat wholesale rate (currently used by the Agency), seasonal rate, tiered rate, and two-part tariff. We evaluate the rate structures based on whether they would send a strong conservation price signal, how well they would maintain Agency revenue stability, and how likely the public would be to accept them. The two-part tariff is the most revenue stable, as a high fixed charge always allows the Agency to recover fixed costs, regardless of the volume of water sold. However, this benefit is outweighed by the fact that the two-part tariff would reduce the per-unit charge for water use, sending a weaker conservation price signal than the current tariff. We argue that the seasonal and tiered structures should be combined into a seasonal tiered rate that will send a strong price signal and give revenue stability in the long run. A seasonal tiered rate is also more equitable because the highest price is charged when the water system is under the most strain.

Additionally, we suggest a strategy to address temporary water shortages. Mandating water conservation during a shortage and then later increasing price to recover lost revenue is unpopular with customers who comply with inconvenient mandatory water use restrictions and then see themselves being punished with a price increase. Increasing water rates at the onset of a temporary shortage would allow for efficient water conservation by motivating reduction of the least valued uses of water and maintains revenue throughout the shortage.

STRUCTURE OF THE REPORT

Section I presents the motivations for SCWA to encourage conservation.

Section II provides a description of SCWA's water supply, its contractors, and its regulatory and environmental constraints.

Section III is a detailed discussion of the projected deficit between the Agency's water supply and its contractors' demand, and why conservation will likely be necessary to close that deficit.

Section IV analyzes current non-price conservation methods, estimates their effectiveness, and projects the potential for future non-price conservation. Section IV also compares the revenue stability and conservation incentive of four pricing structures: flat wholesale rate, seasonal rate, tiered rate, and two-part tariff.

Section V suggests an immediate price response to temporary shortages.

Finally, Section VI summarizes our conclusions and recommendations.

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ABBREVIATIONS

ac-ft	acre-feet (an acre-foot is the volume required to cover one acre of area a foot deep)
ac-ft/yr	acre-feet per year
BMP	Best Management Plan
CUWCC	California Urban Water Conservation Council
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
NMFS	National Marine Fisheries Service
PG&E	Pacific Gas and Electric
SCWA (or "the Agency")	Sonoma County Water Agency
SWRCB	State Water Resources Control Board
UWMP	Urban Water Management Plan

I. CONSERVATION IS INTEGRAL TO SCWA'S LONG-RUN GOALS

The Sonoma County Water Agency's water supply is constrained by limits on its withdrawals from the Russian River. The region's growing population will cause water demand to pass the Agency's current supply. In addition to supply expansion, the Agency should pursue strategies to reduce the quantity of water demanded by its contractors. Reducing water demand will also help SCWA pursue its goal of providing carbon free water by 2015. Currently, the Agency is pursuing energy efficiency and renewable energy projects to reduce the carbon emissions associated with water production. Reducing water demand will reduce energy use in the distribution and wastewater treatment process, making it easier for the Agency to meet its 2015 goal. Demand reduction strategies must fit within the economic and political constraints that the agency faces and will likely include price and non-price approaches.

II. DESCRIPTION OF SCWA AND THE REGULATORY ENVIRONMENT

A. SONOMA COUNTY WATER AGENCY

The California Legislature created the Sonoma County Water Agency (SCWA) in 1949. Although SCWA is a separate legal entity from Sonoma County, with independent revenue and taxation powers, its Board of Directors is the Sonoma County Board of Supervisors and the Agency shares some of its officers with Sonoma County. SCWA has the power to levy property taxes and receives a portion of the general Proposition 13 property taxes. SCWA also collects fees for the services it provides, which may only be used for the purpose for which they are collected. Since the 5 members of the Sonoma County Board of Supervisors are elected from districts within the county, SCWA is ultimately responsible to county residents. The network of regulations and entities that guide SCWA's decisions are presented in Figure 1.

SCWA is a wholesale water supplier that provides water to nine cities and special districts in Sonoma County (contractors), which in turn supply residents with drinking water (Map 1). SCWA is also responsible for managing the county sanitation zones and districts, which are in charge of wastewater collection and treatment. The Agency also plays a role in flood protection. SCWA has worked with federal agencies to help build a flood protection strategy for the community.

Table 1 provides key information about SCWA's major contractors. Contractors are charged a flat per-acre-foot water charge that differs based on the distribution pipe that serves them. They also vary widely in size, both in terms of population and water demand. Most contractors have alternate water sources that can be used in addition to SCWA water, including local storage and groundwater, though all but Marin Municipal Water District and the Town of Windsor rely on SCWA for the majority of their water. Other customers, including Forestville Water District and the towns of Kenwood and Penngrove, constitute only a minor portion of total SCWA deliveries.

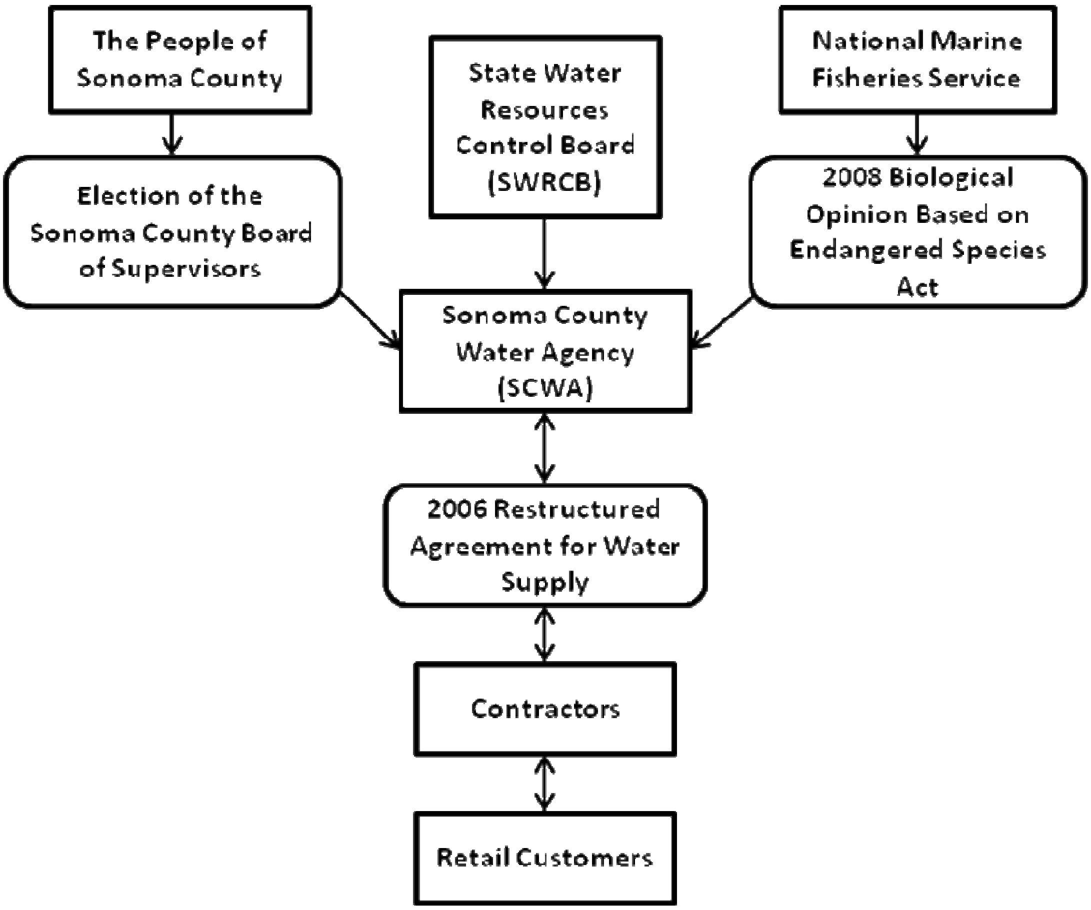
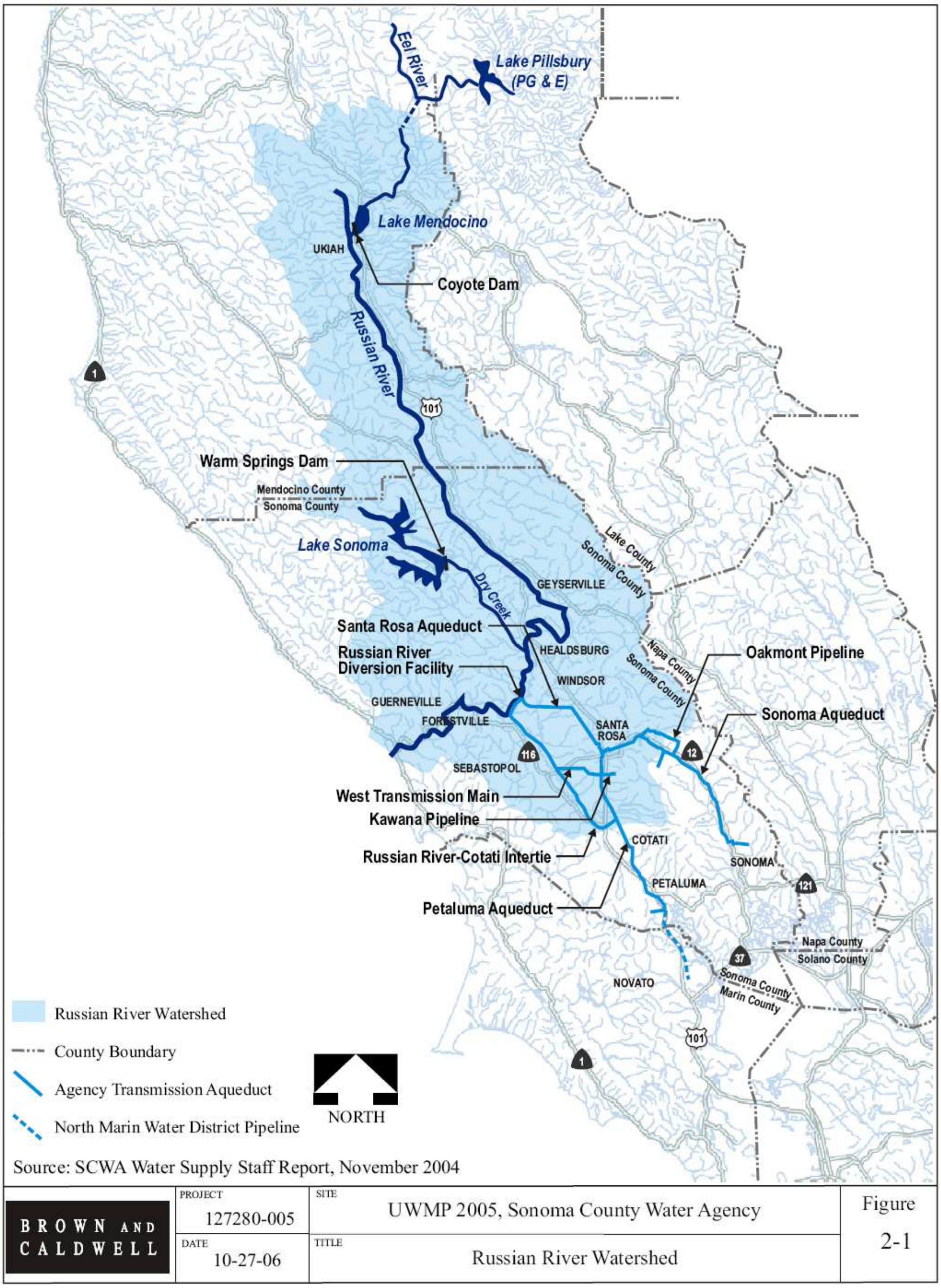


Figure 1: SCWA's position as a wholesaler makes it subject to the authority of state and federal regulators. SCWA supplies water to multiple contractors who in turn distribute it to retail customers. The rounded rectangles represent agreements, processes or rulings that govern the relationship between SCWA and other actors.



Map 1: Sonoma County Water Agency Service Area

Source: "2005 Urban Water Management Plan." Sonoma County Water Agency. 2006.

Table 1. SCWA Contractor Statistics

Contractor	Populationa (2005)[a]	Charge/ac-ft (2009)[b]	SCWA Water Deliveries, ac-ft (2007)[c]	SCWA Water Deliveries, ac-ft (2008)[c]
City of Cotati	7,105	$564.78	849	649
Marin MWD	-	$699.81	8,138	6,901
North Marin WD	58,816	$611.90	8,342	8,186
City of Petaluma	57,277	$564.78	9,682	9,529
City of Rohnert Park	41,640	$564.78	4,254	4,088
City of Santa Rosa	153,790	$564.78	23,214	22,253
City of Sonoma	10,733	$622.11	2,319	2,357
Valley of the Moon WD	22,685	$622.11	2,935	2,905
Town of Windsor	22,909	$677.74	528	509

a: "2005 Urban Water Management Plan." Sonoma County Water Agency. 2006. The population of Marin MWD was not included in this report.

b: "Sonoma County Water Agency Rates for Water Deliveries in FY 09-10" (scwa.ca.gov/water-rates/)

c: Open System KWh-acft study 2007-2008.xls (provided by SCWA)

B. WATER SUPPLY IN SONOMA COUNTY

Surface water

SCWA gets most of its water supply from a Russian River diversion facility near Forestville. The Agency is a part of the Russian River managed system. Originating in Mendocino County, the Russian River is approximately 110 miles long and consists of five main tributaries: the East Fork of the Russian River, Big Sulphur Creek, Mark West Creek, Maacama Creek, and Dry Creek. Decision 1610, made by the State Water Resources Control Board (SWRCB) in 1986, requires the Agency to maintain minimum flows in the Russian River downstream of its diversion facilities to preserve the ecology and recreational value of the river. The Agency uses reservoir releases along the system to control river flows. If water levels are low, SCWA supplements the supply by releasing water stored in the reservoirs to augment the natural flow of the river.

Groundwater

Groundwater plays an important role in Sonoma County. It provides water to most of the unincorporated part of the county and is a primary source for agricultural water use. Approximately 5% of SCWA's supply comes from groundwater, and several of the Agency's contractors also have local groundwater supplies. There are four main groundwater basins in Sonoma County: Sonoma Valley, Alexander Valley, Santa Rosa Valley, and Petaluma Valley. The Department of Water Resources has not classified any of these basins as in overdraft. Overdraft is a condition where the amount withdrawn by pumping exceeds the amount of water recharging the basin during a set period of time.

C. WATER DEMAND IN SONOMA COUNTY

The majority of water supplied by SCWA goes to residential and commercial use, with a very small fraction going to irrigation. Santa Rosa, the largest contractor, delivered approximately 70% of its water to residential customers (Santa Rosa 2005) and Rohnert Park delivered over 90% of its water to residential customers in 2005 (Rohnert Park 2005). Other contractors are similar, with residential use generally accounting for at least half of water demand, and irrigation accounting for no more than 10%. Across major contractors, 83% of water use is residential, 3% is irrigation (including large landscape and agriculture), and 14% is commercial or industrial. Although agriculture uses a substantial amount of water in Sonoma and Marin Counties, it is primarily supplied by sources other than SCWA and its contractors.

Table 2. SCWA Contractor Water Use by Sector in 2005 (acre-feet)

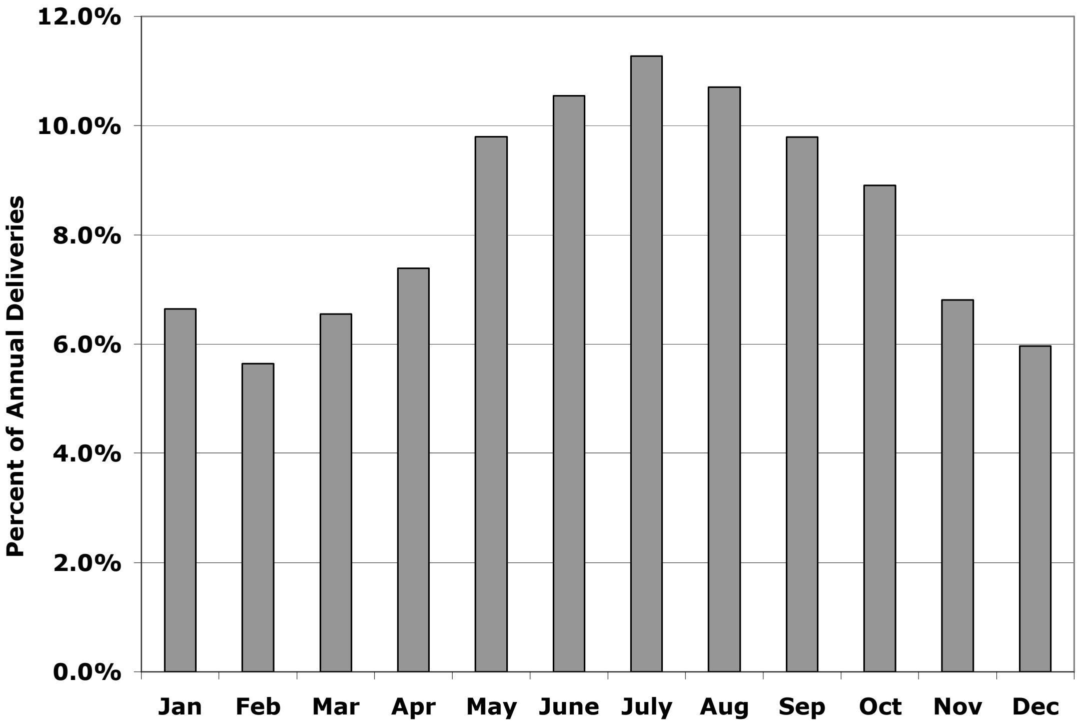
Contractor	Residential	Irrigation	Commercial / Other	Total
City of Sonoma	1,609	194	--	1,803
City of Petaluma	6,914	--	3,360	10,274
City of Santa Rosa	17,232	2,807	4,363	24,402
City of Rohnert Park	8,259	--	648	8,907
City of Cotati	801	187	1,489	2,477
Marin MWD	55,525	--	5,715	61,240
Sector Total	90,340	3,188	15,575	109,103
% of Total	83%	3%	14%	100%

Source: Contractor 2005 Urban Water Management Plans

Notes: Plans could not be obtained for North Marin WD, Valley of the Moon WD, or City of Windsor, but the above table includes the majority of SCWA deliveries. Total water use for some districts includes water from sources other than SCWA.

Water demand among SCWA contractors varies substantially by month. As there is little need to irrigate lawns and other landscape during the rainy season, winter water use primarily represents indoor uses, such as faucets, toilets, and showers. Peak water use occurs during the summer, between June and September, when temperatures are highest and there is generally no rain. Water use is least during the winter and early spring, between December and February.

Chart 1. Monthly Percent of Total Annual Water Deliveries, 2005-2008 Average



D. KEY PLAYERS INFLUENCING SCWA'S ACTIONS

The State Water Resources Control Board grants water rights

The State Water Resources Control Board (SWRCB) aims to ensure the "highest reasonable quality" of water in the state. It also has the primary responsibility for allocating water across users according to their beneficial use. The Water Board has five members appointed by the Governor and confirmed by the Senate.

National Marine Fisheries Service

Three fish species found in the Russian River and its tributaries, Central California Coast steelhead, Central Coast Coho salmon, and California Coastal Chinook salmon, are listed as threatened in the federal Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS) is charged with ensuring that the Agency's actions comply with the ESA. Central California Coast Coho salmon are also listed as endangered by the California ESA. This gives the California Department of Fish and Game authority to oversee management of the Russian River watershed as well.

Contractors

SCWA's direct customers are the nine contractors who purchase its water. The 2006 Restructured Agreement for Water Supply, a multiparty agreement between SCWA and its contractors, governs the sale of water to the contractors. Unless amended, the Agreement will be in effect until 2040. The annual water delivery limit that the Agreement sets for a contractor can be changed with that contractor and the Agency's consent, if notice of the change is given to all other contractors. Other than delivery limit changes, SCWA and the eight contractors who signed the original agreement must agree upon all amendments to the Agreement. SCWA also supplies water to the Marin Municipal Water District, but those deliveries are subject to more limitations under the terms of a Supplemental Water Supply Agreement.

While the Restructured Agreement does not set specific water rates, which will clearly change over 40 years, it lays out how those rates will be calculated and structured. The Agreement calls for a "uniform annual charge per acre foot." A change to SCWA's rate structure to include tiered rates or seasonal rates would likely require an amendment to the Agreement. The Restructured Agreement also commits the signing contractors and SCWA to become members of the California Urban Water Conservation Council (CUWCC) and follow the Council's conservation Best Management Practices (BMPs).

Voters of Sonoma County

Unlike investor-owned utilities in California, SCWA is not regulated by the CPUC. Instead, it is responsible to its Board of Directors, which is the Sonoma County Board of Supervisors. Since the Board of Supervisors is elected by Sonoma County residents, SCWA is ultimately responsible to its contractors' end-use customers.

III. REDUCING WATER DEMAND WOULD HELP CLOSE PROJECTED WATER DEFICITS

By requiring contractors to follow the CUWCC conservation BMPs, the Agency is already making efforts to reduce or slow the growth of its customers' water demand. Based on projected water supply and demand, we recommend that the Agency explore further demand reduction measures. SCWA's 2005 Urban Water Management Plan (UWMP) assumes the Agency will increase its Russian River diversion rights by 26,000 ac-ft/yr by 2016. However, SCWA no longer plans to petition for this increase (Seymour 2010). Without increased diversions, by 2020 SCWA will be unable to meet water demand projected by the 2005 UWMP (Table 3). Supply shortfalls of 13,166 ac-ft, 21,442 ac-ft and 25,999 ac-ft are projected for 2020, 2025, and 2030. Based on this analysis, we conclude that the Agency must close these deficits either by expanding supply or reducing demand.

While the Agency's Russian River supply is constrained by regulatory limits, particularly during drought years, options are available to increase or more efficiently manage water supply in order to meet higher demand. However these options would almost certainly come at a cost. Projecting the cost of supply expansion is not within the scope of this report. We assume, however, that an effective management strategy will also include at least some demand reduction. Further analysis would be required to determine what the most cost-effective mix of demand reduction and supply expansion will be.

This section first analyzes SCWA's 2005 UWMP, the assumptions it makes, and how the Agency's water supply outlook has changed since 2005. Next, we look at the case of the 2009 water shortage, which was caused by a drought and regulatory limitations on SCWA's management of the Russian River. The events of 2009 show that the Agency must improve its ability to meet water demand during drought years in a sustainable manner.

Table 3 Projected SCWA Supply and Demand

Supply and demand projections (ac-ft/yr)	2010	2015	2020	2025	2030
Supply with increased diversion	78,870	78,870	104,870	104,870	104,870
Supply without increased diversion	78,870	78,870	78,870	78,870	78,870
Demand	77,511	78,853	92,036	100,312	104,869
(Supply - Demand) without increased diversion	**1,359**	**17**	**(13,166)**	**(21,442)**	**(25,999)**

**Supply with increased diversion and demand projections are from the 2005 UWMP. For supply without increased diversion, we assume the Agency will maintain the same supply after 2016 as it had before. The 2005 UWMP gives the same 2010 and 2015 supply projections for normal years and drought years, thus we assume these figures are valid for all years.*

A. 2005 URBAN WATER MANAGEMENT PLAN

SCWA's 2005 UWMP, published in December 2006, projects annual water demand and supply through 2030. Accounting for single drought years and three-year drought periods, the UWMP predicts that supply will meet demand through 2020. The UWMP predicts that demand will also be met from 2020 to 2030, with the exception of a one-year drought, in which case supply would fall 15% short of normal demand. While the 2005 UWMP projects that the Agency will be able to meet future water demand, it is based on several assumptions:

- **New Facilities:** Regulators will not prevent the Agency from building and operating the facilities planned in its Water Supply, Transmission, and Reliability Project.

- **Potter Valley Project:** Pacific Gas and Electric's (PG&E) Potter Valley Project (PVP) will continue to divert water from the Eel River basin to the Russian River. This diversion is controversial and could be limited by the Federal Energy and Regulatory Commission (FERC).

- **Threatened Fish Species:** The listing of three salmonid species as threatened or endangered under the federal Endangered Species Act (ESA) will not reduce the quantity of water the Agency is able to supply.

- **Expansion of Water Rights:** The SWRCB will give the Agency water rights to increase its Russian River diversions from 75,000 ac-ft/yr to 101,000 ac-ft/yr by 2016.

- **Conservation Measures:** Conservation measures currently being implemented by the Agency and its contractors will result in projected demand reduction.

Also, the UWMP makes its projections on an annual basis, not accounting for seasonal variation in supply and demand. Based on communication with Agency staff, high water demand during the summer months, when supply is most constrained, is a major challenge (Jeane, Lesko, Seymour 2010). Thus, the Agency could face seasonal water shortages not predicted by the UWMP.

Some, but not all 2005 UWMP assumptions will be realized, resulting in less water supply than the UWMP predicts

- **Potter Valley Project:** SCWA does not anticipate the flows from the PVP to change in the near future. PG&E is licensed by FERC to operate the project through 2022 (Jeane 2010).

- **Threatened Fish Species:** A September 2008 NMFS Biological Opinion regarding salmonid species protected by the ESA gives SCWA 15 years to implement measures to protect fish that are impacted by its water supply and flood control operations. The Agency is implementing enhancement projects on Dry Creek tributaries and the mainstream of Dry Creek (Restoration and Fish Passage Projects 2010). If these projects are effective in enhancing salmon habitat, the Agency will be in compliance with the 2008 Opinion. If not, the Agency may have to reduce flows in Dry Creek and construct a bypass pipeline that would convey water from Lake Sonoma to the Russian River to meet water demands in the lower Russian River without sending all of the flow through Dry Creek (Seymour 2010).

- **Expansion of Water Rights:** The Agency is not currently moving forward with plans to increase its water rights to divert more water from the Russian River system. Consequently, after 2016 the Agency will not have the right to the additional 26,000 ac-ft/year from the Russian River than the 2005 UWMP contemplated (Seymour 2010).

- **Conservation Measures:** The 2006 Restructured Agreement for Water Supply between the Agency and its contractors obligates the contractors to implement California Urban Water Conservation Council (CUWCC) best management practices (BMPs).

Options for increasing supply exist, but most involve infrastructure improvements and are likely costly

The 2005 UWMP acknowledges that all of its water supply assumptions may not be realized. The UWMP mentions several possibilities for addressing such unanticipated supply shortages:

- Petition to the SWRCB for a change in the in-stream flow requirements in the Agency's water rights permits.

- Construct a pipeline between Warm Springs Dam and the Agency's water diversion facilities.

- Construct a water treatment facility.

- Implement an aquifer storage and recovery project.

- Participate as a member of a regional consortium in a project to increase the water supply storage capacity of Lake Mendocino.

- Acquire, either individually or as a member of a regional consortium, the Potter Valley Project.

- Establish "conservation" hatcheries for listed salmonid species.

- Implement other actions or projects to enhance salmon habitat that were proposed by a 2004 Biological Assessment prepared for the Agency and the U.S. Army Corps of Engineers (ENTRIX, INC.).

Increasing the use of recycled wastewater would conserve water, but impacts would be limited

In 2020, the UWMP projects that sanitation districts within the Agency's coverage area will collect and treat 56,972 ac-ft of wastewater. Most of that wastewater is put to beneficial uses, such as groundwater recharge, wetland habitat and restoration, agricultural irrigation and urban irrigation to offset potable water demand. However, the UWMP projects that in 2020 18,421 ac-ft of the wastewater, 12,891 ac-ft of it having received tertiary treatment, will be discharged into local bodies of water. Some of that water could be recycled to offset potable water demand. Some contractors already make use of recycled wastewater, and the UWMP takes local use of recycled water into account. Additional water reuse would require users to purchase the recycled water and a means of transmitting the water to those users. Nevertheless, in addition to supply expansion, increased water reuse is another option to reduce the Agency's projected water deficits.

B. CASE STUDY: 2009 WATER SHORTAGE SUGGESTS THAT THE AGENCY'S ABILITY TO MEET DEMAND DURING SUMMER DROUGHTS IS LIMITED

In 2009, the Agency projected that if it continued to maintain required flows downstream of its Russian River diversion facilities, its Lake Mendocino reservoir would be dry by September, 2009. This shortage was partially caused by reduced flows into the Russian River from PG&E's PVP, which were mandated in 2004 by FERC. To address the projected shortfall, the Agency applied for a temporary urgency change from the SWRCB. The temporary urgency change allowed the Agency to release less water down the Russian River. The SWRCB approved the Agency's request. The SWRCB order approving the temporary urgency change in minimum in-stream flow required the Agency to reduce its diversions from the Russian River by 25% from April 6 to October 2, 2009 (as compared to diversions during the same months of 2004), impose a prohibition of irrigation of commercial turf unless managed with a water budget, and develop a plan to engage agricultural and municipal Russian River water users in conservation efforts. The SWRCB had issued a similar temporary urgency change for the Agency in 2007 (Sonoma County Water Agency 2009).

In accordance with the SWRCB order, the Agency and its contractors implemented conservation programs. These measures, combined with contractors' increased reliance on their local surface and groundwater supplies, resulted in about a 35%reduction in the Agency's Russian River diversions. However, the reduced water sales cut the Agency’s revenues by $2.6 million (Term 16 Water Conservation Status Report 2009). While producing less water reduced the Agency’s variable costs, its fixed costs, such as administration, capital, and payroll did not drop by nearly as much. Sudden, drastic conservation measures, like those implemented in 2009, can be problematic for the Agency’s bottom line.

Future water shortages, resulting from Sonoma and Marin Counties’ limited water supplies being stressed by drought conditions, will likely have negative economic consequences. One study estimates that a 10% water supply shortfall in relation to demand would result in the loss of 1,595 jobs and $218 million in economic output in Marin and Sonoma Counties (Eyler 2009). Based on the example of 2009, and the possible economic consequences of future shortfalls, the Agency should improve its ability to reliably meet water demand, even during drought conditions.

C. THIS REPORT FOCUSES ON DEMAND REDUCTION

While supply expansion or water reuse could help reduce the Agency’s projected water deficit, this report focuses on gains that can be made from demand reduction. The 2005 UWMP presents several options for supply expansion that are probably still viable. However, most involve new infrastructure, which might be costly. Increased water reuse would allow the Agency’s supply to cover more demand, but more water reuse would require customers willing to purchase the recycled water. We think that demand reduction will likely be a part of a cost-effective strategy to address the Agency’s projected gap between supply and demand. Demand-reduction options should be considered to the extent that they are more cost-effective than expanding supply and increasing water reuse. Water conservation will also help the Agency achieve its goal of making its water supply and transmission system operations carbon-free.

It is not within the scope of this report to examine the cost-effectiveness of supply expansion and water reuse or to determine the most cost-effective mix of supply expansion, water reuse and demand reduction to address the Agency’s projected water deficit. Our objective is simply to examine what might be accomplished through demand reduction.

IV. CONSERVATION STRATEGIES

In practice, multiple conservation approaches will likely be used together (e.g. wholesale price increase, public information campaign, implementation of stricter landscape ordinances). However, it is useful to look at each method separately to determine which to apportion resources to. Interactions between strategies also need to be considered, as some may reinforce or counteract others. For example, the literature suggests that implementing a price increase after a mandatory use restriction leads to an overall water use reduction less than sum of the independent impact of a price increase or use restriction (Howe 2002). This suggests that we must consider the order in which conservation strategies are implemented as well.

Water agencies currently use price and non-price methods to encourage conservation. In general, increasing price is a more cost-effective means of reducing water demand compared to non-price conservation programs. However, price increases meet with significant public resistance, and non-price conservation is more commonly used by water utilities throughout the country. Non-price conservation programs include restrictions on quantities of water per customer, bans on certain types of water use like car washing, and water efficiency incentives (Olmstead 2007). Another option for encouraging conservation, but one that has not been well tested, is to introduce a system of conservation credits.

As the Agency implements conservation measures, it will be constrained by its position in the water supply chain and its operating costs. Since the Agency does not sell water directly to consumers, non-price conservation programs must be implemented through its contractors. Its position as a wholesaler also affects the Agency's ability to implement price-based conservation. As a water wholesaler, the Agency cannot directly control the rates that consumers face. The Agency can only control the rate at which it sells water to its contractors, which may or may not be passed down entirely to consumers. We contacted all of SCWA’s primary contractors to ask them how they would react to a wholesale rate change. Santa Rosa’s Senior Water/Wastewater Planner indicated that any future SCWA wholesale rate increase will be passed through to Santa Rosa’s tiered retail rates. Santa Rosa was the only contractor to respond, and we assume that they are representative of how all contractors would react to a rate change.

Any change in the Agency's rate structure must be approved by the Agency and eight of its contractors, a process that can take a few years, even for small changes (Jeane 2010). Conservation strategies will only be effective if they are implemented with the cooperation of the Agency's contractors.

In implementing both price-based and non-price conservation, the Agency must maintain sufficient revenue to cover its fixed operating costs. Otherwise, revenue shortfalls like the one experienced during the water shortage of 2009 could result.

A. ANALYSIS OF SCWA NON-PRICE CONSERVATION METHODS

Non-price conservation strategies will decrease net revenue by decreasing the amount of water sold. The non-price conservation strategies target different types of water use and will each be associated with a different cost to SCWA. The decrease in net revenue from a non-price conservation strategy will depend on the amount of conservation it induces and the costs SCWA avoids by not supplying or treating the amount of water conserved. Since the 2005 UWMP already takes into account implementation of CUWCC BMPs, the potential savings estimated in this section are an upper bound for what can be achieved with current non-price conservation.

We focus on residential non-price conservation methods, since residential use makes up 83% of SCWA's demand. Since similar methods could likely be applied to industrial, commercial and irrigation water use, we assume that the same proportional demand reduction could be achieved in those areas as well. For instance, if increasing the prevalence of indoor and outdoor residential conservation methods could result in a 10% reduction in residential water use, we assume that analogous programs could result in a 10% reduction in industrial, commercial and irrigation water use.

The potential savings estimated in this section are calculated based on a 100% saturation of efficient equipment in the SCWA service area. This is certainly the eventual goal of SCWA, but is not expected to be achieved in the near future. However, considering the additional savings from reaching 100% saturation allows us to estimate the remaining potential of non-price conservation programs and to demonstrate the value of combining price and non-price conservation incentives.

Supplying, distributing, and treating water consumes a significant amount of energy. The primary economic value of water conservation to SCWA is the energy cost avoided. Additionally, reducing energy consumption brings SCWA closer to meeting its goals of making its water supply and transmission system operations carbon-free.

Current Non-Price Conservation Methods

Rebates encourage the adoption of high efficiency equipment

As with other indoor water efficiency improvements, increasing the stock of high efficiency toilets and showerheads will reduce the volume of wastewater that must be treated. In Northern California, wastewater treatment accounts for an average of 56% of water agency energy use and costs (Trask 2005), so any sizable reduction in wastewater generation will likely significantly reduce SCWA's energy costs.[1] If a viable carbon market emerges in California, reductions in SCWA energy use will produce additional

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[1] SCWA does not own all of the wastewater treatment plants that it uses. Therefore, although the Agency will benefit from reduced energy costs, some of the savings will go to other facilities like the Santa Rosa Subregional treatment plant.

revenue, possibly offsetting any revenue loss from decreased water demand. Table 4 presents typical rated water use of low and high efficiency water-using equipment.

Table 4. Rated Water Use of Low and High Efficiency Equipment

Equipment Type	Low Efficiency	High Efficiency
Toilet	3.5 gallons per flush	<1.28 gallons per flush
Urinal	1 gallon per flush	<0.125 gallons per flush
Faucet aerator	2.2 gallons per minute[1]	<1.5 gallons per minute
Showerhead	2.5-5.5 gallons per minute[1]	<1.5 gallons per minute

source: 2009 TUCP Term 16 Conservation Report (http://www.scwa.ca.gov/lower.php?url=stateboard2009)
[1]source: http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13050

Use restrictions can effectively reduce outdoor water use in the short term

Empirical analysis has shown that use restrictions have significantly reduced water demand in the San Francisco Bay Area (Corral 1999). Restrictions on the irrigation of turf grass and car washing are the most common forms of this conservation method. Alternatively, outdoor water use may only be allowed on certain days of the week; however, this may simply encourage people to use excess water on the approved days to make up for the days in between when they cannot water their yards. Use restrictions are more appropriate for emergency situations than long-term conservation strategies.

Information programs improve customers' understanding of the value of water

Empirical analysis has shown that information programs have substantially reduced water demand in the San Francisco Bay Area (Corral 1999). Other studies have also highlighted the conservation effectiveness of making water use and per-unit water cost readily apparent on residential water bills (Olmstead 2007).

Estimated Impact on Water and Energy Use Vary by Conservation Strategy

Indoor Conservation Retrofits

In SCWA's service area, indoor water use accounts for approximately 66% of total residential use. On average, high efficiency toilets are rated to use only 37% as much water as low efficiency toilets use, and high efficiency faucets and showerheads are rated to use 68% and 27-60% as much water respectively as their low efficiency counterparts (2009 TUCP Term 16 Conservation Report). A study that measured pre- and post-retrofit indoor water use found that after the installation of efficient equipment households used 62% as much water for clothes washing, 42% as much for flushing toilets, 96% as much for showers, and 87% as much for faucets as they did before (DeOreo 2001). We use the values from the DeOreo field study to provide a conservative estimate of the potential water savings from indoor retrofits, as increased intensity of use (double-flushing of toilets or longer showers) can result in a smaller actual decrease in water use than projected by efficiency ratings. If the discrepancy between theoretical and actual water use savings is not as large in SCWA service area, the water savings from indoor conservation retrofits may be greater than we predict using the DeOreo values.

Indoor conservation retrofits have the additional benefit of reducing the volume of wastewater that must be treated, thus reducing SCWA's energy costs. The amount of energy used in wastewater treatment differs among SCWA’s facilities, ranging from 1000 kilowatt hours per acre-foot (kwh/ac-ft) to 5,000 kwh/ac-ft. In this preliminary analysis we use the average value of 1,300 kwh/ac-ft, though the energy savings may be significantly higher depending on which water treatment facility a retrofitted house is connected to. Additionally, because SCWA does not own all of the wastewater treatment plants that it uses, the Agency would not see the full energy savings.

The City of Santa Rosa’s Senior Water/Wastewater Planner informed us that of the end users in Santa Rosa, 61% have high efficiency toilets and approximately 80% have high efficiency faucets and showerheads, based on the records of their rebate programs. As all contractors offer similar conservation incentives and we received no response from other contractors, we use these values to estimate the remaining potential for indoor water savings.[2] Based on current assumptions we estimate that indoor retrofits have already saved 6,718 ac-ft/yr, and if applied to the remaining households, could produce additional water savings of 3,785 ac-ft/yr. The greatest reductions can be achieved by replacing the remaining low efficiency toilets.

Outdoor Conservation Retrofits

Limiting turf area, switching to native or climate-appropriate plants, grouping plants by their need for water, and limiting irrigation to the minimum amount necessary can significantly reduce outdoor water use compared to current average landscape irrigation demand. A survey of water conservation studies suggests that switching to efficient landscaping and irrigation can reduce outdoor water use by 10-43% (Barta 2004). Due to similarities in landscape efficiency program structure, but climatic differences, we estimate that outdoor conservation in SCWA's service area will result in a decrease in water use between the 10% reduction reported in a landscape efficiency study in Seattle, WA, and the 33% reduction reported in a similar study in the Mojave Desert. We evaluate outdoor conservation in SCWA service area assuming a 21.5% reduction due to conservation retrofits. Because most SCWA contractors already offer turf grass replacement rebates and SCWA already offers the Qualified Water Efficient Landscaper program,[3] we consider the impact of retrofitting the landscaping of 50% of the existing

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[2] Santa Rosa’s rebate programs have been in place longer than those of other districts, so saturation rates of efficient equipment in Santa Rosa may be higher than in the service areas of other SCWA contractors.

[3] Qualified Water Efficient Landscaper (QWEL) training is a U.S. Environmental Protection Agency WaterSense approved training program for landscapers that provides an educational foundation based on principals of proper plant selection for the local climate, irrigation system design and maintenance, and irrigation system programming and operation.

houses served by SCWA.[4] With our current assumptions, we estimate that efficient landscaping has already saved 2,350 ac-ft/yr, and that full conversion to efficient landscaping could produce additional water savings of 2,350 ac-ft/yr.

Education and Outreach

Education and outreach include advertisement, seminars and lectures, training for landscapers and contractors, and making water use and per-unit water cost readily apparent on residential water bills. These programs aim to change the water use behavior of end users, which is inherently difficult to do. Education and outreach can effectively reduce demand during a temporary shortage, but often have only a slight impact on water demand in the long run.

A survey of non-price conservation programs suggests that public education alone can reduce water consumption by approximately 5%, primarily through outdoor water conservation (Barta, 2004). Assuming that water users served by SCWA's contractors react to outreach similarly to the populations studied in our literature review, we estimate that education and outreach have already reduced water consumption by 975 ac-ft/yr. Further conservation through education will most likely require expanding SCWA's outreach efforts; maintaining current programs may maintain current conservation levels, but is not expected to increase conservation indefinitely. The following case study discusses expanding education and outreach by adding a Block Leader program.

[4] Accordingly, we assume 50% current saturation rate of efficient landscaping. Santa Rosa responded to our question about landscape conservation with an estimate of average EtO, rather than saturation rate. Estimated water and energy savings for other saturation rates can be calculated using the framework set out in Appendix 1.

CASE STUDY: EDUCATION THROUGH BLOCK LEADERS

Common public education and outreach programs used across the country include flyers, billboards, radio advertising, and events to raise conservation awareness at schools. The "Block Leader" program is an innovative approach used by the Town of Cary, North Carolina, which utilizes the framework of earlier grassroots recycling efforts to spread water conservation information to customers in its service area (Platt 2001). A similar program has also been successfully implemented in Allen, Texas.

Block leaders are environmentally conscious community members who volunteer to become educated on the town's water conservation needs and spread this information among their friends and neighbors. Each spring new and experienced block leaders attend training sessions to become familiar with the town's summer water conservation campaign, including the status of projects and the expected supply and demand for water. These training sessions endow block leaders with the necessary information to advise others and provide printed materials to disseminate in their neighborhoods. Block leaders also receive more in-depth workshops on leak detection and repair, landscaping, and conservation techniques, building a wealth of knowledge in the community.

A study of the Town of Cary's conservation programs projects annual water savings from public education of 0.5 million gal per day, or a 6% decrease in water use, at a program cost of approximately $60,000 per year. This includes reduction in both indoor and outdoor water use. Assuming several potential splits between indoor and outdoor water use reduction, we estimate the impact of a similar program on SCWA water deliveries.

POTENTIAL ENERGY, ENERGY COST, AND GHG SAVINGS OF BLOCK LEADERS PROGRAM

Scenario	Water Saved (acre feet)	Energy Saved (MWh)	Energy Cost Savings (thousand $)	GHG Reduction (tons)
Assuming 50% of reductions were indoor	1,721	2,783	$242	954 tons
Assuming 20% of reductions were indoor	1,391	1,661	$140	587 tons

Due to differences in community culture, this type of program may not be as effective in SCWA's service area as in the Southern cities where it has already been implemented. In areas with strong neighborhood sentiments and community spirit, a block leader program could help to achieve water conservation. An additional consideration is the intensity of previous conservation efforts by the agency. The Town of Cary has a history of conservation awareness and outreach, but if SCWA has already exhausted easy sources of conservation, a block leaders program may be less effective than predicted.

Table 5 summarizes the estimated annual water, energy, and green house gas savings already achieved by conservation programs currently in place. These estimates are based on the assumed efficiency improvements and saturation rates discussed above.

Table 5. Impacts of Conservation in SCWA's Service Area

	Water Savings (ac-ft)	Energy Savings (thousand $)	GHG Savings
Indoor retrofits	6,718	$2,387 (13,759 MWh)	4,631 tons
Outdoor retrofits	2,350	$145 (1,833 MWh)	687 tons
Public education	975	$60.3 (761 MWh)	285 tons

Table 6 summarizes the projected water, energy, and green house gas savings that could be achieved by reaching 100% saturation of high efficiency equipment and landscaping in SCWA's service area. The associated reduction in agency revenue due to decreased water sales is also projected, based on current contractor water prices.

Table 6. Maximum Potential Additional Savings from Non-Price Conservation Methods

	Impact on Agency Revenue	Water Savings (ac-ft)	Energy Savings (thousand $)	GHG Savings
Indoor retrofits	-$2.73 million	3,785	$1,345 (7,753 MWh)	2,609 tons
Outdoor retrofits	-$1.70 million	2,350	$145 (1,833 MWh)	687 tons
Public education*	-$1.24 million	1,721	$242 (2,783MWh)	954 tons

*Assuming implementation of a block leaders program or similarly effective expansion of education and outreach programs, targeting indoor and outdoor use equally.

Non-Price Conservation Conclusions and Recommendations

The Agency's 2005 UWMP water use projections already assume that many current conservation programs will continue and that new construction will meet low impact development standards. Because projections of Agency water demands already assume some increase in the saturation of efficient equipment and landscaping, and 100% saturation is not likely to be reached soon, the potential future water savings estimated above are an upper bound estimate of the role that these types of non-price conservation can play in reducing the anticipated future water supply deficit. In reality, saturation will probably still be well below 100% in 2020. Thus, while non-price conservation measures will continue to help SCWA reduce energy use and associated GHG emissions, other measures will have to be taken to ensure that future demand will not exceed future available supply.

After efficient equipment and landscaping have high or full penetration rates, the remaining options for conservation are to search out additional higher-efficiency end-use equipment, to invest more heavily in reuse (possibly in-home reuse), or to change behavior. Changing behavior is difficult, particularly creating long-term changes toward a water-efficient lifestyle. One way to target long-term behavior is to emphasize efficiency and environmental awareness in schools. This way water-saving behavior becomes incorporated into habits at an early age, rather than having to try to reprogram habits at a later age.

Price also has a significant influence on water use behavior. A visible increase in price causes people to evaluate their water use and find ways to conserve regardless of what equipment they have in their homes. Given the potential 13,000 ac-ft/yr supply shortfall anticipated by 2020, current non-price conservation methods alone are unlikely to balance future water supply and demand. Price-induced conservation will play a vital role, both by providing funding for improvements to non-price programs and by motivating conservation through changes in water use behavior.

NON-PRICE CONSERVATION RECOMMENDATIONS

1) Continue rebate incentives, particularly for high efficiency toilets due to their effectiveness and the relatively low current saturation rate.

2) Emphasize programs that will improve water use behavior.

3) Consider instituting a block leaders program to capitalize on the community's interest in protecting the environment.

B. PRICE-BASED CONSERVATION METHODS

We analyze four ways that wholesale rates could be changed: a flat wholesale rate increase, a tiered rate structure, a seasonal rate structure, and a two-part tariff. The Agency could implement one of these methods individually or a combination of them could be used. Changing rate structures is feasible, but would take several years to implement and would require SCWA to renegotiate its water supply agreement with contractors.

The impact of SCWA rate changes will depend on the price elasticity of demand for water. Reviewing the literature, we find reported values of the price elasticity of demand for water ranging between -0.1 and -0.4, meaning that a 10% increase in the price of water will result in a 1 to 4% reduction in water consumption (Howe, 1982; Weber, 1989; Kiefer and Dziegielewski, 1991). The price elasticity range represents the end user's response to the price that they face. In what is referred to as "demand hardening" price elasticity will likely go down as consumers conserve. Our rough estimates of the effects of price increases, assume fixed values for price elasticity, a lower bound and an upper bound.

Retail water districts will likely pass along any increase in SCWA's wholesale rate to the retail customers (residents and businesses). In response to our questionnaire, Santa Rosa stated that “Santa Rosa will begin to pass through any wholesale water increase when it is enacted.” However, because Santa Rosa has its own operational and fixed costs incorporated in the rates it charges end users, “if SCWA increases its rates by 7.4% in 2010/11, Santa Rosa’s customers will see a 3% usage charge.” The price signal of SCWA’s rate increase will be reduced by half by the time it reaches the end user of the water. Although we have not received responses from all contractors, we assume that their responses to a SCWA rate increase would be similar. This effect must be considered in conjunction with price elasticity to project the water demand impacts of a wholesale price increase.

Using -0.1 and -0.4 as the upper and lower limits for our calculations, we estimate the price increase that would be required to meet the potential shortfall of 13,000 ac-ft/yr in 2020. In each case, we assume that non-price methods described above *will not reach 100% saturation* and will meet at most 6,000 ac-ft of this need. Therefore, we calculate the price increase *necessary to meet a projected 7,000 ac-ft deficit in 2020.*

Criteria used for price-based strategy evaluation

Maintaining revenue stability

The price strategies are designed to either maintain revenues when water use decreases or to increase revenues while motivating conservation. Either of these effects would allow SCWA to implement further non-price conservation measures without adverse financial impacts.

Integrity of price signal / Effectiveness at promoting conservation

To effectively promote conservation through pricing strategies, the end consumer must face a high marginal cost of water. Price signals sent by SCWA may be partially offset if the contractors simply switch to other water supplies. The demand for SCWA water would indeed be reduced, but so would the benefits of reduced water and energy use to the region as a whole.

Public Acceptance

A change in SCWA’s wholesale water pricing would directly impact its contractors’ water pricing decisions. To that end, a pricing scheme that disproportionately impacts larger contractors compared to smaller contractors, for example, would impact the political feasibility of implementing the new pricing scheme.

Increase in wholesale rates would lead contractors to pass the higher costs on to consumers

Efficient water management requires a clear price signal. To the extent that water demand is elastic, SCWA can induce water conservation by increasing the wholesale rate it charges contractors. Contractors in turn would pass these higher rates on to end-use consumers in one form or another. Table 7 calculates the projected wholesale rate increase needed in 2020 reduce demand by 7000 ac-ft.

Table 7. Projected Wholesale Rate Increase

	Inelastic demand (e = -0.1)	Elastic demand (e = -0.4)
Projected 2020 water deficit (ac-ft)	7,000	7,000
Current unit price of water ($/ac-ft)	619	619
Needed rate increase (%)	76%	19%
Needed rate increase ($/ac-ft)	**$1160**	**$290**
Total price of water after increase ($/ac-ft)	**$1779**	**$909**

A seasonal rate structure would allow SCWA to account for peak summer demand

The water needs of SCWA's contractors vary significantly by season. SCWA has plenty of water in the winter, but in the summer, when demand is particularly high, water supply is more constrained. A pricing scheme that raises water rates during the summer months would help to alleviate excess demand and would more accurately reflect the higher costs of providing water during the summer.

Contractors facing higher wholesale rates during the peak summer months would likely pass that increase on to consumers, who would reduce consumption. A significant portion of summer water use is landscape irrigation, which is more elastic consumption than indoor use, suggesting that customers will be more responsive to the price increase. Contractors could also react at a higher level by shifting a portion of their summer use of SCWA water to the winter. For instance, they could pump more from local groundwater supplies during the summer, when SCWA prices are high, and use less groundwater during the winter. Such a strategy would require contractors to increase groundwater pumping capacity and then let it go unused during the winter, but a large enough summer-winter price differential could cover the costs of those changes.

In considering how to implement a seasonal rate, there are several approaches. The first involves creating two specific rates – a peak and an off-peak rate – which would be in effect during the respective peak and off-peak seasons. The second method involves maintaining a uniform rate structure, but specifying a threshold of consumption during the peak period, beyond which point the contractor would face a higher on-peak rate. Seasonal rate structures can also be combined with a tiered rate structure.

Seasonal pricing is most effective when there is substantial variation in demand between peak and off-peak periods. This could be due to increased consumption during peak periods, or a seasonal fluctuation in the number or types of customers served. When moving to a seasonal wholesale rate, the Agency can minimize large rate shocks to contractors (and consumers) and allow for adequate time to adjust consumption patterns, by making the initial peak/off-peak rate differential relatively small. The price differential can be gradually increased over time in order to achieve the needed demand reduction.

Up until now, SCWA has had sufficient resources to meet peak summer demand. However, it is now reaching a point where it will need to make decisions regarding building new infrastructure to increase capacity to handle peak summer flows. The Agency could implement a seasonal rate structure to help mitigate future increases in summer demand. When considering a switch to a seasonal rate, SCWA should keep in mind the varying customer bases served by each of its contractors. If there is great variability in water usage between seasons by the different types of customers, a seasonal rate would disproportionately affect some contractors. Certain types of customers, for example, may have greater flexibility in adjusting their consumption patterns than others.

Implementation of seasonal rates elsewhere

Seasonal rates are most common for natural gas and electric utilities. They have been less widely implemented for water utilities, mostly because water utilities have historically been able to supply adequate water at affordable costs. Water utilities have started to implement seasonal rates in some areas where there is particularly high demand for irrigation during the summer, or where there are significant seasonal resort activities.

Southern Water, a water utility in Great Britain, recently employed a seasonal rate structure. They add a 6% surcharge to the rate for water consumed between June and September and discount the rate for the rest of the year by 2%. The measure is designed to encourage less water use in the summer, when water is scarce, without affecting consumers' overall annual bill (Wallop 2010).

Revenue Stability:

- In switching to a seasonal rate, SCWA may see some revenue volatility as contractors react to the peak use price differential. A high summer rate may lead some contractors to shift away from summer use to winter use, which would also shift SCWA’s revenue stream.

Price Signal:

- A seasonal rate would send a strong message to conserve during peak summer months when supply is the most constrained and water demand is the most elastic.

Public Acceptance:

- Those contractors most responsible for higher peak-demand costs are charged for those higher costs. They will be disproportionately affected by a seasonal price increase.

- Some of this will be offset by customers who have relatively low peak-demand and who will therefore see a reduction in their water bills. Additionally, in the long run, seasonal rates may reduce the cost of water to all consumers. If higher on-peak rates lead consumers to reduce peak demand, the utility may be able to put off constructing additional supply projects.

A tiered rate structure would give more flexibility to SCWA

A tiered rate structure, also referred to as a "block" rate structure, changes the unit price of water at different consumption levels. When a utility wants to send a strong conservation message to its customers, it can implement an increasing tier rate.

Customers are charged a higher per-unit price for water consumed beyond a certain level, creating a disincentive to consume beyond that level. Tiered rate programs are often most effective when accompanied by an education campaign so that customers understand that the more water they use, the higher the price becomes.

A tiered rate program could work in a similar manner for a wholesaler like SCWA, with wholesale rates for contractors set at tiered levels. Depending on how tiers are structured compared to current water use, this could have an impact similar to the impact of a flat wholesale rate increase. An increasing block rate structure would allow SCWA to send a clear conservation signal to its contractors without collecting too much or too little revenue.

Implementation of tiered rates elsewhere:

In 1991, the Irvine Ranch Water District in southern California implemented a five-tier increasing tiered rate structure to reward water efficiency. The thresholds at which each customer's rate increases are set individually based on landscape square footage, number of residents, any special customer needs, and daily evapotranspiration rates. In the year the new rate structure was implemented, water use declined by 19%. Surveys showed that 85% to 95%of customers approved of the rate structure (U.S. Environmental Protection Agency 2002).

Revenue Stability:

- An increasing block rate structure would allow SCWA to adjust rates in order to recover its full costs.
- Increasing block rates would result in short-term revenue volatility, until the appropriate levels for the tiers are established.

Price Signal:

- Increasing block rates send a strong conservation signal.

Public Acceptance:

- Block rates are somewhat complex to design and require information about water sales for each of the blocks of consumption. There would also be discretion on the part of SCWA in determining how many blocks to include, as well as in determining at what point the price level increases (the size of the block) and by what increment the price increases. Public acceptance would likely depend on the specific design of the tiered system.

In Table 8, we look at the effect of a tiered rate combined with a seasonal rate. Specifically, we calculate the tiered rate increase needed in order to reduce demand by 7000 ac-ft in 2020. We first consider a scenario where the contractor does not change its own rate structure, but responds to the tiered wholesale rate with a flat summer rate increase. We then consider a scenario where the contractor adopts a tiered rate structure similar to that of SCWA. Because a seasonal rate would target summer water use, we use elasticities of –0.3 and –0.4, which reflect the more elastic summer demand.

Table 8. Seasonal Tiered Rate Price Increase

	Scenario 1: Contractors do not adopt a tiered retail rate structure		**Scenario 2: Contractors adopt a tiered retail rate structure**	
	Inelastic demand (e=-0.3)	Elastic demand (e=-0.4)	Inelastic demand (e=-0.3)	Elastic demand (e=-0.4)
Projected 2020 water deficit (ac-ft)	7,000	7,000	7,000	7,000
Estimated retail rate ($/ac-ft)	$1,526	$1,526	$1,526	$1,526
Current SCWA wholesale rate($/ac-ft))	$619	$619	$619	$619
Needed retail rate increase (%)	42%	31%	42%	31%
Needed rate increase ($)	**$1,758**	**$1,318**	**$634**	**$476**
SCWA wholesale rate after increase ($/ac-ft)	**$2,377**	**$1,937**	**$1,253**	**$1,095**

Two-part tariff would help SCWA recover its costs amidst conservation but would also discourage conservation

Revenues are variable while many costs are fixed

As is the case with many water utilities, many of SCWA's costs are fixed in the short run, meaning that they do not vary with how much water the Agency sells. Revenues, on the other hand, are completely variable. The vast majority of the Agency's revenues are derived from a per-acre-foot charge for water. As a result of this, the Agency loses money if it sells less water, since its revenues drop more quickly than its costs do. That was the case in 2009, when the Agency reduced its water sales and lost $2.6 million in revenues (Term 16 Water Conservation Status Report 2009). This situation results in a fiscal disincentive for the Agency to promote conservation.

Decoupling separates revenues from water sales

For conservation to be fiscally feasible, the Agency's rate structure must allow it to cover its operating costs even if sales decline. This separation of revenues from sales volume, which can take on different forms, is known as decoupling. Recently, the California Public Utilities Commission (CPUC), which regulates investor-owned water utilities, has considered allowing for decoupling of water rates (CPUC 2005).

The two-part tariff

There are multiple ways to decouple revenues from sales. Perhaps the most intuitive is the two-part tariff, which would divide the rate charged to customers into a fixed fee, charged regardless of how much water is used, and a variable per-acre-foot fee. For instance, if fixed costs are currently 50% of total costs, a contractor who currently purchases 1,000 ac-ft/yr at $500/ac-ft would pay a fixed charge of $250,000 plus a variable charge of $250/ac-ft. By including a significant fixed portion, this rate structure would conform better to the Agency's cost structure. In the context of conservation, the problem with this form of decoupling is that it reduces the marginal cost of water. Now, instead of paying an additional $500 for using an additional acre-foot of water, a contractor only pays $250, since the $250,000 fixed charge is a sunk cost. This reduces the incentive to conserve water. In the context of electricity pricing, Friedman and Weare argue that the two-part tariff can be implemented while still maintaining incentives for conservation. They say that the negative externalities of pollution caused by electricity generation should be internalized through taxes on pollution rather than inflated variable electricity rates, since some forms of generation are cleaner than others. However, this argument might not hold here, since SCWA has no simple way to internalize the negative impacts of increased water use other than to directly discourage increased water use.

Increasing rates to cover increasing average costs

Another way for the Agency to retain fiscal solvency while promoting conservation would be to simply raise rates to cover increasing average costs as sales volume decreases. Since the 2006 Restructured Agreement for Water Supply allows SCWA to set rates to cover its costs, such rate increases are currently feasible. When it raised rates after the 2009 water shortage, the Agency was in effect pursuing a form of decoupling. Since this form of decoupling is already used by the Agency, we do not discuss it further here. However, in Section V, we do discuss how the Agency could better use rates to manage short-term water shortages in the future.

Revenue Stability:

- A two-part tariff would ensure that SCWA recovers its full fixed costs, despite any fluctuations in water demand from its contractors. A two-part tariff would produce the greatest revenue stability of the four pricing structures that we examine.

Price Signal:

- A two-part tariff would send a weak conservation price signal. By switching to a two-part tariff, the marginal cost of water may actually be lower in the short-run and cause contractors to increase consumption rather than reduce consumption.

Public Acceptance:

- A two-part tariff would need to be accompanied by an educational campaign by SCWA to inform contractors of the new rate structure and reduce the negative implications (namely, a potential increase in water use) of a weak price signal.

- Smaller contractors with overall lower water deliveries may face fixed costs that are a disproportionately larger share of their total costs.

PRICE-BASED CONSERVATION RECOMMENDATIONS

- SCWA should consider implementing a seasonal, tiered rate structure. A tiered rate during peak summer use will send a strong conservation signal. This will be especially important as summertime water supply becomes more constrained.
- A seasonal rate would also reflect the higher relative cost to the system of supplying water during peak use.
- While initially a seasonal tiered rate may lead to some revenue volatility as SCWA determines the correct price level for the different tiers, in the long run revenue collected under the new rate scheme should be relatively stable.

V. PRICE RESPONSE TO A TEMPORARY WATER SHORTAGE

Due to variability in rainfall and potential regulatory droughts, short-term supply shortages cannot be avoided entirely. Long term conservation through improved water use efficiency of the equipment stock and behavior modification helps prepare for supply shocks by reducing the baseline demand on the water system. Without switching to a two-part tariff pricing system, a decrease in water use necessitates an increase in price to maintain necessary revenue to meet fixed costs. In 2009, conservation was first mandated, then prices increased the subsequent year to recover lost revenue.

This sequence of conserving first, then increasing price creates short-term budget deficits. Revenue from future price increases cannot be used immediately to cover current fixed costs. It is also unpopular with customers who complied with inconvenient mandatory water use restrictions and then see themselves being punished with a price increase.

Increasing water rates at the onset of a temporary shortage would both signal the need to conserve water and maintain revenue throughout the shortage. Price increases allow for efficient water conservation by motivating reduction of the least valued uses of water. Mandated use restrictions, on the other hand, do not allow people to choose how they conserve. A restriction on car washing, for example, does not account for people who may place a high value on keeping their car clean, but be willing to reduce their use of water for other purposes. Additionally, when the mandated restriction is on a type or time of use, people may find ways to cheat unless a lot of effort is put into enforcement. If a price increase is implemented in combination with a use restriction, the price increase will reduce the incentive to ignore a mandated restriction. One disadvantage of conservation through simple price increases is that it disproportionately affects low-income customers, unless a reduced rate is charged to low-income customers. A tiered rate structure, in which enough water to fulfill a customer's basic needs could be purchased at the previous low rate, would alleviate these effects.

The Restructured Agreement for Water Supply currently allows SCWA to change its water rates annually in order to cover its costs. The Agency should negotiate with contractors to establish a protocol for immediate price increases in supply crisis situations. The temporary high conservation price would both maintain Agency revenue and encourage conservation, while allowing end users to choose methods of water use reduction. To avoid adversely affecting low-income customers, the high conservation rate should only apply to “luxury” water use above a certain basic allocation. Due to the relatively low price elasticity of water use, even of luxury water use, a price increase may not be enough to induce sufficient conservation. However, the price increase can be used in conjunction with use restrictions and other conservation incentives, and will help the Agency to cover its fixed costs.

Any rate increase is likely to be unpopular. The Agency would need to properly educate contractors and their customers about the reason for the price increase. Even though per-unit rates would increase, overall water costs would go down for customers who used less volume.

CASE STUDY: ENERGY SAVINGS OF 2009 WATER CONSERVATION

During 2009, SCWA and its contractors implemented all of the above-mentioned non-price conservation methods, along with the following emergency measures: education and flyers, home water surveys, mulching of turf grass, and limited irrigation days. Major contractors reduced water demand by approximately 10,000 ac-ft during the summer of 2009. While this combination of conservation measures proved effective at reducing water demand, SCWA revenues dropped by $2.6 million during the implementation period. This combination of conservation measures cannot be used as a long-term solution to SCWA's projected water deficits. SCWA needs to target conservation measures that prevent the growth of demand, or that significantly reduce SCWA energy costs to ensure that water conservation is achieved in a financially sustainable way.

To estimate the water savings achieved with this combination of conservation measures, we calculate the difference between summer 2004 and summer 2009 water deliveries by SCWA. The summer of 2004 serves as an estimate of the baseline water use without conservation because water supply conditions in 2004 were similar to those of 2009, but no emergency conservation measures were taken and reservoir storage and stream flow dropped to dangerously low levels.

Estimated energy, energy cost, and GHG savings achieved by 2009 conservation

Scenario		Energy Saved (MWh)	Cost Savings ($)	GHG Saved (tons)
Assuming all reductions in outdoor water use		7,820	$620,000	2,899
Assuming 20% of reductions were indoor		10,434	$867,000	3,717
Savings net of increased contractor use of local sources	All outdoor	6,908	-	2,516
	20% indoor	9,522	-	3,334

source: 2009 TUCP Term 16 Conservation Report

(http://www.scwa.ca.gov/lower.php?url=stateboard2009)

The City of Santa Rosa estimates that it cost approximately $100,000 to pay for the staffing and outreach required to achieve a 3,500 ac-ft reduction in water use in the summer of 2009. Assuming other contractors' additional conservation measures cost a similar amount per acre-foot conserved, the total cost of achieving the water use reduction is approximately $300,000. Though revenues in 2009 significantly dropped due to conservation, this impact is partially offset by the benefit of reduced energy cost, and safe stream flow and storage levels were maintained. After accounting for increased administrative costs, conservation-induced energy savings still contribute positively to Agency finances.

VI. CONCLUSIONS AND RECOMMENDATIONS

Regulatory limitations on diversions from the Russian River limit SCWA's water supply. Projections in the Agency's 2005 UWMP indicate that by 2020 the Agency's current supply will not be sufficient to meet increased contractor demand. A cost-effective strategy to close this projected deficit will likely include improved water supply management and demand-reduction strategies. This report focuses on how demand-reduction strategies could result in water savings.

Analyzing the Agency's non-price conservations programs, including indoor equipment retrofits, outdoor landscaping retrofits and education programs, we conclude that increased non-price conservation could result in further demand reduction. To increase the impact of its non-price programs, **we recommend that the Agency 1) Continue rebate incentives, particularly for high efficiency toilets, 2) Emphasize programs that will improve water use behavior, and 3) Consider instituting a block leaders program.** While more can be achieved with non-price conservation, savings will not be enough to cover the Agency's projected water deficit. Additional non-price conservation programs also will require funding from the Agency.

To encourage more conservation and fund its non-price programs, the Agency could change its rate structure. We evaluate four possible changes to the Agency's rate structure: a flat increase in wholesale rates, a seasonal rate structure, a tiered rate structure and a two-part tariff. To send a strong conservation price signal and discourage water use during the summer, when the Agency's supply is most limited and demand is highest, **we recommend the Agency implement a seasonal tiered rate structure that charges contractors a higher rate for excess summer water consumption.**

While long-term conservation can improve the Agency's ability to avoid short-term supply shortages caused by droughts, such supply shortages still may occur. The Agency reacted to the 2009 supply shortage by implementing water use restrictions without changing its rates. Reduced water sales resulted in a revenue shortfall, making it difficult for the Agency to cover its fixed costs. **When faced with future supply shortages, we recommend that the Agency raise rates initially, to send a conservation price signal and to ensure that it will recoup its operating costs despite selling a lower volume of water.** To allow for short-term drought price increases, the Agency will likely need to renegotiate the water supply agreement it has with its contractors.

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APPENDIX 1: NON-PRICE CONSERVATION IMPACT ESTIMATION

This Appendix describes the estimation procedures for non-price conservation impacts. Because of the number of factors taken into account (7 contractors; 3 types of water-using equipment; different prices for delivery energy, treatment energy, and water cost by contractor) some of these equations have been simplified, but they are still representative of the logic used for the estimates.

To divide SCWA water demand into indoor and outdoor use, we assume that water demand in the month of the year with the least demand represents the indoor use rate, and that demand in excess of that in other months is outdoor use. Using data from 2005 to 2008, we estimate that 34% of SCWA water demand goes to outdoor use and 66% goes to indoor use. We use these values in the conservation impact estimation. All estimates refer to annual values.

A. IMPACT FACTOR

The calculation of the conservation impact of high efficiency equipment and landscape retrofit includes a conservation "impact factor." The impact factor, an estimate of the current effectiveness of each type of conservation improvement, is calculated as follows:

Impact Factor = (Saturation of high efficiency) X (High efficiency water use / Low efficiency water use) + (Saturation of low efficiency)

Consider the example of high efficiency toilets, with an impact factor of 0.65. This implies that because of the efficiency gains from installing high efficiency toilets and their saturation rate in SCWA's service area, only 65% as much water is used for toilets compared to having no high efficiency toilets installed. An impact factor of 1 would imply that no conservation has been achieved. The lower the impact factor, the more water conservation is being achieved.

B. INDOOR RETROFITS

We estimate the impact on water demand from the current saturation of high efficiency water-using equipment, as well as the potential decrease in water demand that could be achieved by increasing the saturation of high efficiency equipment to 100%.

Additional information for these calculations comes from the Microsoft Excel file "Open System KWh-acft study 2007-2008.xls", obtained from SCWA Energy Efficiency Intern, Cary Roberts.

Table A1. Data for Indoor Retrofit Estimation

	Toilet	**Shower**	**Faucet**
% of indoor use[a]	26%	18%	15%
(high eff. water) / (low eff. water)[b]	42%	97%	87%
Saturation rate[c]	61%	80%	80%
Remaining potential[d]	39%	20%	20%
Impact factor for current saturation rate	0.65	0.97	0.90

a: "Energy Down the Drain: The Hidden Costs of California's Water Supply."NRDC and the pacific Institute. 2004.

b: DeOreo, William B., Allan Dietermann, Time Skeel, Peter W. Mayer, David M. Lewis, and Jenna Smith. "Retrofit Realities." American Water Works Association Journal, 93(3): 58-72. 2001.

c: Santa Rosa Senior Water/Wastewater Planner, 2010.

d: 1 – (saturation rate)

We estimate the current total annual water use of each equipment type:

Current toilet water use = (Indoor water volume) X (Toilet % of indoor water)

Current faucet water use = (Indoor water volume) X (Faucet % of indoor water)

Current Shower water use = (Indoor water volume) X (Shower % of indoor water)

We then estimate the amount of water that would be used by each equipment type if no high efficiency units were installed:

All low-eff. toilet water use = (Toilet water use) / (Current toilet impact factor)

All low-eff. faucet water use = (Faucet water use) / (Current faucet impact factor)

All low-eff. shower water use = (Shower water use) / (Current shower impact factor)

The estimated total water savings from currently installed high efficiency indoor water-using equipment, summing over equipment types, is:

$$CurrentIndoorSavings = \sum_{i=1}^{3} AllLowEfficiencyWaterUse - CurrentWaterUse$$

To estimate potential water savings, we first calculate the amount of total current water use due to low efficiency equipment:

Low efficiency toilet water use = (Remaining potential) X (All low-eff. toilet water use)

Low efficiency faucet water use = (Remaining potential) X (All low-eff. faucet water use)

Low efficiency shower water use = (Remaining potential)X(All low-eff.shower water use)

From these values, we estimate the potential savings that could be achieved, summed over all equipment types:

$$PotentialIndoorSavings = \sum_{i=1}^{3} (LowEfficiencyEquipmentWaterUse) * \left(1 - \frac{HighEfficiencyWaterUse}{LowEfficiencyWaterUse}\right)$$

Based on the amount of water conservation estimates described above, we estimate the current and potential avoided energy consumption (Mwh and million dollars) and greenhouse gas emissions.

Energy savings = (Indoor water savings) X (Delivery energy + Treatment energy)

Energy cost savings = (Indoor water savings) X ([Delivery energy x Delivery energy price] + [Treatment energy x Treatment energy price])

GHG savings = (Indoor water savings) X (Delivery GHG + Treatment GHG)

Finally, revenue reduction from reaching 100% saturation is estimated:

Revenue Loss = (Water rate) X (Potential Indoor Savings)

C. OUTDOOR RETROFITS

We estimate the impact of current landscape efficiency programs, as well as the potential savings that could be achieved by reaching 100% saturation of efficient landscaping. We consider current efficient landscaping saturation of 50%.

Table A2. Data for Outdoor Retrofit Estimation

	Landscaping
Saturation rate	50%
Remaining potential[a]	50%
(high eff. water) / (low eff. water)[b]	79%
Impact factor	0.893

a: Barta, Rachel. "Stretching Urban Water Supplies in Colorado: Strategies for Landscape Water Conservation." Colorado Water Resources Research Institute. 2004.
b: 1 – (saturation rate)

We estimate the amount of water that would be used if no landscape efficiency improvements had taken place, then subtract this value from current total outdoor water use to estimate the current savings:

All low-eff. landscape water use =
(Current outdoor water use) / (Landscape impact factor)

Current outdoor savings = All low-eff. landscape water use – Current outdoor water use

To estimate potential water savings, we first calculate the amount of total current water use due to low efficiency landscaping. We then calculate potential outdoor savings from achieving 100% saturation of efficient landscaping:

Current low-eff. landscape water use =
(Remaining potential) X (All low-eff. landscape water use)

Potential outdoor savings =(Current low-eff landscape water use) X $\left(1 - \frac{HighEfficiencyWaterUse}{LowEfficiencyWaterUse}\right)$

Current and potential landscape efficiency conservation impacts on energy consumption, energy cost, greenhouse gas emissions, and agency revenue are estimated as described for indoor efficient water-using equipment, though no wastewater treatment energy or greenhouse gas emissions are included.

D. PUBLIC EDUCATION

We estimate the impact of current public education by assuming that outdoor water use in decreased by 5%. To do this, we use the same procedure described above for landscape efficiency impacts.

Our estimate of potential conservation due to public education assumes that a program like the block leaders program will be instituted, with similar results to those achieved in Cary, NC. We assume a 6% reduction in total water use current water use, under two scenarios: split evenly between indoor and outdoor, or 20% indoor and 80% outdoor. This estimation combines the methods described for indoor and outdoor retrofits.

APPENDIX 2: PRICE-BASED CONSERVATION IMPACT ESTIMATION

A. WHOLESALE RATE CHANGE

We estimate the flat wholesale rate increase needed to reduce water demand by 7000 ac-ft/yr. To do so we use project 2020 water sales of 92,000 ac-ft. We assume a lower bound water demand price elasticity (e) of -0.1 and an upper bound elasticity of -0.4. We first calculate the percent change in retail price (the price charged to the end user) needed to create a reduction of 7000 ac-ft:

$$(1)\quad \begin{aligned} e = -0.1: &\quad \frac{7{,}000 \text{ ac-ft}}{92{,}000 \text{ ac-ft} \times 0.1} = 76\% \\ e = -0.4: &\quad \frac{7{,}000 \text{ ac-ft}}{92{,}000 \text{ ac-ft} \times 0.4} = 19\% \end{aligned}$$

Water contractors' retail rates are based on their own operating costs and on the wholesale rates they pay to SCWA. Using information from Santa Rosa Municipal Utility District, we estimate what portion of their retail rate is to cover water purchase costs. For the purposes of this analysis, we assume that Santa Rosa is representative of SCWA's other contractors. For a hypothetical 7.4% increase in SCWA wholesale rate in 2010, Santa Rosa told us they would need to raise their retail rates by 3% to pass on the cost increase. Given a current SCWA wholesale price of $619/ac-ft, we estimate the current total price of retail water (including contractor operation costs):

$$(2)\quad \begin{aligned} &\frac{\text{\% Change in retail rate}}{\text{\% Change in wholesale rate}} = \frac{3.0\%}{7.4\%} = \text{Wholesale rate makes up 40.5\% of retail rate} \\ &\frac{\$619 \text{ /ac-ft wholesale rate}}{0.405} = \$1526\text{/ac-ft retail rate} \end{aligned}$$

From equation (1) we calculated the necessary retail price increase. Combining the necessary percentage retail price increase from equation (1) with the current retail price estimated in equation (2), we calculate the price increase (in dollars) needed to induce 7,000 ac-ft/yr of conservation. This increase is both the necessary retail price increase and the necessary wholesale price increase:

$$\begin{aligned} &e = -0.1: \quad (76\%) \times (\$1526\text{/ac-ft}) = \$1161\text{/ac-ft} \\ &e = -0.4: \quad (19\%) \times (\$1526\text{/ac-ft}) = \$290\text{/ac-ft} \\ &\text{Total SCWA wholesale rate after increase:} \\ &e = -0.1: \quad \$1161\text{/ac-ft} + \$619\text{/ac-ft} = \$1779\text{/ac-ft} \\ &e = -0.4: \quad \$290\text{/ac-ft} + \$619\text{/ac-ft} = \$909\text{/ac-ft} \end{aligned}$$

B. SEASONAL TIERED RATE CHANGE

Using the same method as for a flat wholesale rate increase, we calculate how large of a seasonal tiered rate increase would be necessary to induce 7,000 ac-ft/yr of conservation. Based on 2005-2008 SCWA water deliveries, average winter (November through April) is 5,981 ac-ft/month. Average summer (May through October) is 9,358 ac-ft/month. Under a seasonal tiered rate structure, the Agency would charge its current rate for winter water use and for summer water use below the winter base use rate of 5,981 ac-ft/month. For all summer use above 5,981 ac-ft/month, the Agency would charge a higher rate.

It is unclear how contractors would react to a seasonal tiered wholesale rate. We analyze two alternatives, which could be considered best- and worst-case scenarios for how much conservation would be induced by the seasonal tiered wholesale rate. First, we consider what would happen if contractors treat the seasonal rate as a simple cost increase for summer water and raise all of their summer rates accordingly, without changing their rate structure to make it more tiered. This scenario would induce less conservation (or require a larger rate increase to induce the desired 7,000 ac-ft/yr of conservation) because end users would not be facing the increasing block rate that the Agency built into the wholesale rate.

Second, we consider what would happen if contractors pass the seasonal tiered rate structure on to their customers, charging a higher marginal rate for summer use in excess of base winter use. If we assume that no customers will be able to reduce their summer use below the average winter use, then all customers would face the higher marginal cost of water and would conserve accordingly. This scenario would induce more conservation, and not require as large of a rate increase in excess summer use to achieve the desired goal of 7,000 ac-ft/yr of conservation.

Scenario 1: Contractors don't change rate structure

Assuming that contractor rate structures are not tiered, or at least that they will not be tiered any more progressively as a result of the change in wholesale rate structure, we calculate the necessary increase in the summer water retail rate to induce 7,000 ac-ft/yr of conservation:

(1)
$$e = -0.3: \quad \frac{7{,}000 \text{ ac-ft}}{9{,}358 \text{ ac-ft/month} \times 6 \text{ months } \times 0.3} = 42\% \text{ increase in summer retail rate}$$
$$e = -0.4: \quad \frac{7{,}000 \text{ ac-ft}}{9{,}358 \text{ ac-ft/month} \times 6 \text{ months } \times 0.4} = 31\% \text{ increase in summer retail rate}$$

Using the estimated retail rate of $1526 /ac-ft from previous section, we calculate the necessary summer retail rate increase (in dollars):

$$e = -0.3: \quad (42\%) \times (\$1526/\text{ac-ft}) = \$634/\text{ac-ft}$$
$$e = -0.4: \quad (31\%) \times (\$1526/\text{ac-ft}) = \$476/\text{ac-ft}$$

With the seasonal tiered rate, the increased wholesale rate would only apply to summer use in excess of base winter use. This rate increase would have to be large enough to cause the desired overall rate increase when spread across all summer use:

$$\text{Total summer use} = 9,358 \text{ ac-ft/month}$$

$$\text{Base summer use} = 5,981 \text{ ac-ft/month}$$

$$\text{Excess summer use} = 9,358 \text{ ac-ft/month} - 5,981 \text{ ac-ft/month} = 3,377 \text{ ac-ft/month}$$

$$\text{Excess summer use} = \frac{3,377 \text{ ac-ft/month}}{9,358 \text{ ac-ft/month}} = 36\% \text{ of total summer use}$$

$$e = -0.3: \quad \text{To increase total summer retail rate by \$1902/ac-ft}$$

$$\text{we must increase wholesale rate on excessive summer use by}$$

$$\frac{\$634/\text{ac-ft}}{36\%} = \$1,758/\text{ac-ft}$$

$$\text{New summer excess use rate} = \$619/\text{ac-ft} + \$1,758/\text{ac-ft} = \$2,377/\text{ac-ft}$$

$$e = -0.4: \quad \text{To increase total summer retail rate by \$476/ac-ft}$$

$$\text{we must increase wholesale rate on excessive summer use by}$$

$$\frac{\$476/\text{ac-ft}}{36\%} = \$1,318/\text{ac-ft}$$

$$\text{New summer excess use rate} = \$619/\text{ac-ft} + \$1,318/\text{ac-ft} = \$1,937/\text{ac-ft}$$

Scenario 2: Contractors also implement a seasonal tiered rate structure

As with Scenario 1, to induce 7,000 ac-ft/yr of summer conservation, customers will need to see a summer retail rate increase of 42% (e = -0.3) or 31% (e = 0.4). However, if the contractors react to the tiered summer wholesale rate by implementing their own higher retail rate for excess summer use, and we assume all end customers continue to consume enough water to be affected by the high excess use rate, then conservation will be driven by this new higher marginal cost. Rather than increasing the average summer rate by $634 /ac-ft (e = -0.3) or $476 /ac-ft (e = -0.4) we now only have to increase excess use rate by that much.

$$e = -0.3: \quad \text{To increase the excess-use summer retail rate by \$634/ac-ft}$$

$$\text{we must increase wholesale rate on excessive summer use by \$634/ac-ft}$$

$$\text{New summer excess use rate} = \$619/\text{ac-ft} + \$634/\text{ac-ft} = \$1,253/\text{ac-ft}$$

$$e = -0.4: \quad \text{To increase total summer retail rate by \$476/ac-ft}$$

$$\text{we must increase wholesale rate on excessive summer use by \$476/ac-ft}$$

$$\text{New summer excess use rate} = \$619/\text{ac-ft} + \$476/\text{ac-ft} = \$1,095/\text{ac-ft}$$