California Public Utilities Commission

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What Will Be the Cost of Future Sources of Water for California?

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Executive Summary

California has been in a drought for several years, and it is expected that traditional sources of water will remain constrained even after its inevitable conclusion. Additional water supplies will come from non-traditional sources, including conservation, recycling, and desalination. Some additional supplies for urban consumption are coming from reallocation of water previously used for other purposes. And additional supplies may come from new sources or methods that are still in development and have not been commercialized, such as capture from the air. It is expected that all these additional water supplies will cost more than traditional water supplies.

This paper provides nearly 20 examples of the costs of various sources of water, including examples from such traditional sources as the State Water Project and from the latest updates on San Diego County's desalination project. The costs range from as little as $25/Acre-Foot[1] for certain water from the US Bureau of Reclamation to recycling and desalination projects with projected costs greater than $5,000/Acre-Foot. The extremes are misleading. By looking at several examples and by taking averages, it is possible to see the pattern: Although even some traditional sources of water are now priced above $1,000/Acre-Foot, clearly, the new sources are more expensive, quite a bit more expensive. The Summary Table below shows that, compared to the average among a few examples of traditional sources of water, the process of conserving water is about two-thirds more expensive, about $1,300 compared to about $800. Recycling water is nearly four times as costly as traditional sources of water. And desalination, seen in the few examples in our state, is more than four times the cost of traditional sources. Of course, that is to be expected, for if the new sources were less expensive, then we would be rushing to them first instead of examining them carefully for potential future use.

Summary Table - New Sources are Generally More Expensive than Traditional Sources

	Traditional Sources	Conservation	Recycling	Desalination
Lowest Cost Example	$25	$137	$396	$2,367
Average of Examples	$793	$1,335	$2,869	$3,389
Highest Cost Example	$1,456	$4,580	$5,800	$5,100
Dollars Per Acre-Foot				

The paper also presents information about provision of urban water from agricultural land management and water-use efficiencies. Finally possible future sources of water are discussed briefly, including harvesting it from air. Those sources may or may not be feasible in the future.

The overall finding is one of higher costs for new sources of water. Even though the bulk of water delivered to customers comes from traditional sources, water utilities will have to rely increasingly on new sources in the future. The cost of water from those new water sources, including conservation as

[1] An Acre-Foot is the amount of water required to cover an acre of ground to a depth of one foot. It is equal to 43,560 cubic feet or 325,851 gallons.

well as recycling and desalination, is higher than the cost from traditional sources. The inevitable result is that the overall cost of water will be rising in the future. We should expect water rates to rise in the future as well.

Introduction

California has been in a drought for several years, and it is expected that traditional sources of water will remain constrained even if our current drought is eased by plentiful rain in this upcoming winter of El-Nino. On November 13, Governor Brown issued an executive order that calls for additional actions to build on the state's ongoing response to record dry conditions and assist in recovery efforts from this year's devastating wildfires.[2]

California's State Water Resources Control Board (SWRCB) has issued many curtailment notices, and maintains a place on its web page under "Water Issues."[3] Californians have valiantly cut back on the use of water at their homes.[4] The latest California Water Boards Fact Sheet indicates that "residential gallons per capita per day" is trending downward to an average of 97.3 in September, with an overall savings rate of 26.1-percent.[5] It is likely that our current drought will one day end. Even so, there have been long periods of drought in the past, and we need to be prepared for long and continuing droughts in the future.[6]

In the future, Californians will continue to find new ways to use less water, and we will continue to rely on our traditional sources of water for the bulk of our usage. But Californians are also looking for new solutions, not only to the current drought, but to protect ourselves for the future. For that, we are looking to new sources of supply to meet our needs. Unfortunately, new sources come with heavy price tags.

This paper is an informational document that provides a comparison among the costs of a few selected new water sources. Production costs for new water generally exceed the costs of existing traditional supplies, such as traditional ground-water pumping or surface water. Numbers presented in this paper are general and not specific to any particular part of California or to any specific project. This paper compares the cost of water from our traditional sources to three new, or non-traditional, sources: Freed-up supplies from Conservation/efficiency actions; Water produced from recovery; and Desalination. Each of these sources comes at a cost that is higher than the cost of traditional sources.

- In this document water production costs are denominated in ***dollars per acre-foot***, a measure often used in wholesale transactions in the United States. An Acre-foot is the amount of water

[2] State of California Executive Order B-36-15. The announcement is on the Governor's web site here. The Governor's web site is https://www.gov.ca.gov/home.php.
[3] State Water Resources Control Board. The home page is: http://www.waterboards.ca.gov/ The notices for the 2015 water year are shown here.
[4] The State Water Resources Control Board maintains a web page called the Water Conservation Portal.
[5] California Water Boards Fact Sheet, "September 2015 Statewide Conservation Data," October 29, 2015.
[6] California Department of Water Resources, California's Most Significant Droughts: Comparing Historical and Recent Conditions, February 2015.

required to cover an acre of land to a depth of one foot. It is equal to 43,560 cubic feet or 325,851 US Gallons. For those more familiar with the metric system, it is approximately 1,233.5 cubic meters. If a typical Californian uses about 100 gallons per day (as indicated in the California Water Board Fact Sheet noted earlier), an acre-foot would serve about nine average Californians for a year.

The Costs of Traditional Sources of Water

California's CPUC-jurisdictional water utilities traditionally have purchased water from agencies such as the California State Water Project and the Metropolitan Water District (MWD, or Metropolitan), and many have their own sources based on water rights.

Many of California's jurisdictional water utilities have their own water sources and rights. The costs vary from source to source, and most are not catalogued here. This paper provides only an example from California-American Water Company (Cal-Am). The Company's Monterey Water Supply has been in critical shortage. Cal-Am's Groundwater Begonia Plant is an example of precisely the issue associated with all traditional supplies of water: The Begonia plant provides water at about $200/Acre-Foot, a fraction of the cost of most other supplies.[7] Production from Begonia is limited by the supplies available. According to Cal-Am, groundwater production at Begonia is limited to about 3,000 Acre-Feet per year, a small fraction of the total needed for Monterey. All consumers would be delighted to receive all of their water service from low-cost traditional sources such as Begonia Plant. But supplies of such low-cost sources are fully used already. The following are other major supplies of traditional water sources.

The California State Water Project (SWP) is one of the world's largest water, power, and conveyance systems. In the past decade, it has conveyed an annual average of 2.9 million acre-feet of water. The most recent Bulletin[8] describes the 2011-2012 water year, a time when the drought had already begun. The report provides estimates of unit water charges for 2019 that range from as little as $197/Acre-Foot for the San Juaquin Area to as much as $1,456/Acre-Foot for the Coastal Area, based on the assumption that in 2019 the SWP will be able to deliver the entire amount of water requested by each water agency with which it contracts.[9]

The Metropolitan Water District (Metropolitan or MWD) is a customer of the SWP. It is a regional wholesaler that delivers water to 26 member public agencies, which in turn provide water to more than 19 million people in Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties. To supply the more than 300 cities and unincorporated areas in Southern California with reliable and

[7] California-American Water Company, Monterey Supply Project Scenarios, a presentation at a public Workshop meeting related to the Monterey Peninsula Water Supply Project, Application A12-04-019, organized by the CPUC, December 11-13, 2012.
[8] California State Water Project, Bulletin 132-13, "Management of the California State Water Project, published April 2015." It is available for Download here.
[9] Bulletin 132-13, Table 14-12, "Estimated Unit Water Charges for 2014 and 2019, by Service Area (in dollars per acre-foot," page 281.

safe water, Metropolitan owns and operates an extensive water system including: the Colorado River Aqueduct, 16 hydroelectric facilities, nine reservoirs, 819 miles of large-scale pipes and five water treatment plants. It is the largest distributor of treated drinking water in the United States. Metropolitan delivers an average of 1.7 billion gallons of water per day to a 5,200-square-mile service area. Metropolitan's water rates have been rising steadily over the years. The 2016 rates for full-service treated water are $942/Acre-Foot for Tier-1 and $1,076 for Tier-2.[10] Tier 1 refers to the amount contracted for by the water agency, with additional supplies being charged at the higher rate. Because quantities are limited overall, there may be limits on the amount available even at the Tier-2 rate, and additional supplies may be charged at even higher rates. These numbers are about double the rates of a decade ago, when the rates were $453/Acre-Foot for Tier 1 and $549/Acre-Foot for Tier 2.

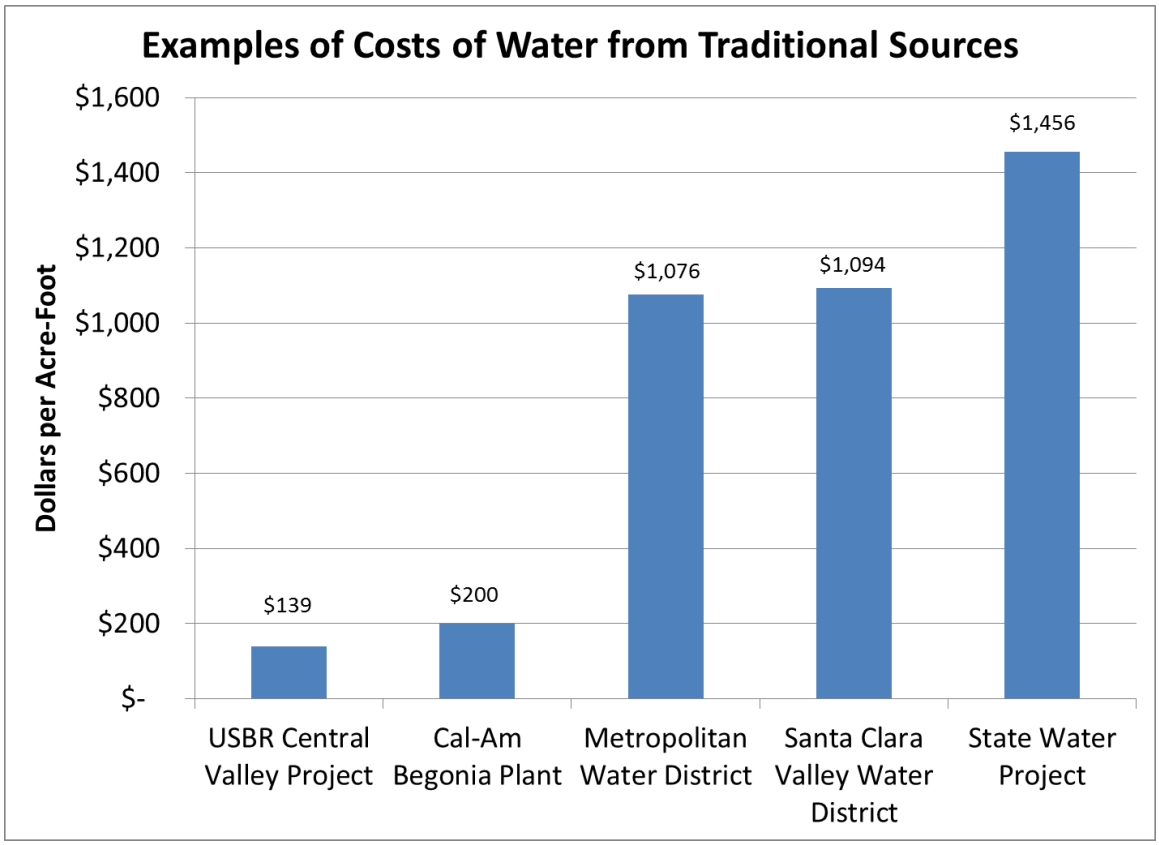
Like the Metropolitan, the Santa Clara Valley Water District serves 15 cities and 12 water retailers in Santa Clara County.[11] The District receives water from the State Water Project as well as from local sources. Santa Clara's current water charges for treated water are $994/Acre-Foot for Contracted water and $1,094/Acre-Foot for Non-contract water.[12]

The US Department of the Interior's Bureau of Reclamation, Central Valley Project web site provides a schedule of Municipal and Industrial Water Rates. The rates vary across 19 facilities and more than 50 contract receivers. The 2016 Central Valley Project rates vary from as little as $25.36/Acre-Foot to $139.63/Acre-Foot.[13]

The sources listed here are but a few among the thousands of sources relied upon by California's water utilities. Small mountain towns may have their own rights and their own wells or other sources. Even larger urban systems have many sources. These examples provide the flavor of the numbers, and they average about $800/Acre-Foot.

[10] Metropolitan Water District, Financial Information, Water Rates and Charges, as reported on the web site here.
[11] Santa Clara Valley Water District FY 2012-13 Annual Report.
[12] Santa Clara Valley Water District web site, water charges.
[13] This is US Department of the Interior, Bureau of Reclamation M&I 2016 Schedule A-1.

Summary of Traditional Sources' Costs



Cost of Conservation – Finding Ways to Use Less

In recent years, California water utilities have engaged in conservation programs to assist customers to use less water. Water thus saved can be considered "new" in the sense that it is freed up for other uses.

Conservation may be achieved by changing our habits and our lifestyles, such as through removing lawns and replacing them with other ground cover that requires less water, or even no water. It may be had from upgrading faucets, toilets, and other household devices. Householders may learn to be more efficient in their use of water indoors as well. Finally, conservation may come from tightening up the water systems, that is, reducing the amount of water that is lost through system leaks or other unaccounted for uses.

California's water utilities operate systems that must be kept in good working condition. All systems include a mix of pipes, including some new and some old. Some of those pipes, inevitably, will leak. In a 2009 Decision[14], the Commission recognized that by de-coupling revenue from water sales, it was

[14] California Public Utilities Commission Decision D.09-07-021, July 9, 2009, "Final Decision Authorizing Rate Increase in Monterey Water District and Toro Service Area."

reducing the incentive to avoid water losses. The Commission adopted an explicit means to provide a utility with "strong financial incentives to reduce unaccounted for water."[15] The decision adopted standards for unaccounted for water in several water districts of the California-American Water Company. The reward/penalty was set at $2,018.79/Acre-Foot.

The cost of water made available through conservation programs may be difficult to calculate, for there may be many costs that are unmeasurable. For example, the costs of new drought-tolerant plants for a garden are precisely measurable and may be very low. The labor cost of the gardener making the change also is measurable The administrative costs associated with the process, including the homeowner's time and the water utility's staff assistance may be more difficult to measure, but at least may be estimated. The cost of an educational program designed to educate customer about drought-tolerant plants and to convince them to make the change is measurable. The degree to which a customer is more or less pleased with the new garden would be very difficult to measure. Similarly, consider an enforced conservation measure such as a ban on outdoor washing of automobiles. The administrative and enforcement cost of the program may be negligible. But the degree to which customers are less pleased with a forced change in their habits may be very difficult to measure.

Cal-Am provided a rough estimate of water savings from conservation programs over the years from 2006-2011. The Company's Conservation expenses totaled approximately $3.4 million. In addition, the Company collected another $1.0 million as a pass-through on behalf of the Monterey Peninsula Water Management District for a total of approximately $4.4 million. Measurable conservation savings for the programs were found to be 957 AF. By simple division, Cal-Am calculated a cost of $4,580/Acre-Foot for the measurable savings.[16] Since this is a simple division, and it does not account for the continued savings that may result, it may overstate the total cost per unit.

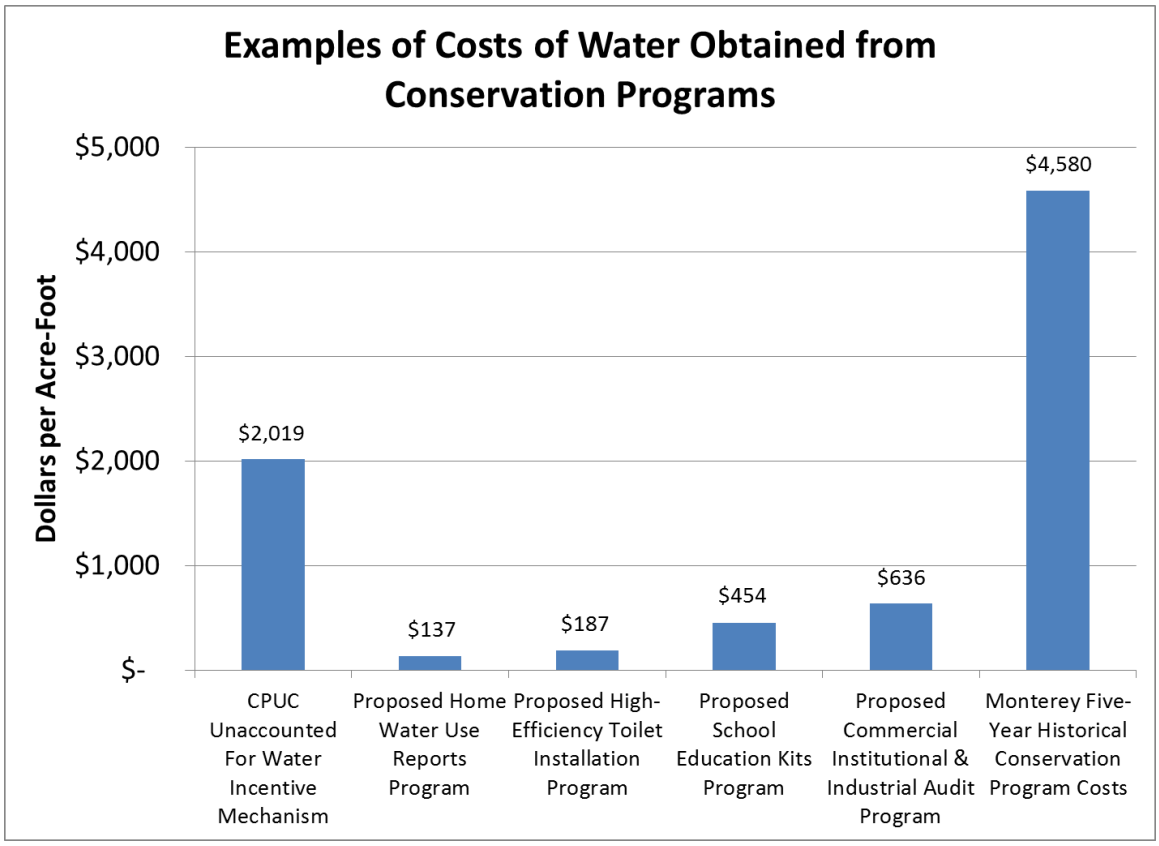
The Company also provided an estimate of the water savings available from a proposed program to retrofit residential household toilets in the area, about 35,000 according to the Company's estimate. The retrofit for each household was estimated to cost $280 and save approximately 4,000 gallons per year. With an estimated total cost of $280 million, the program could save 4,000 AF per year. The Company estimated that if the expenditures were capitalized over the expected life of the savings, the costs would be approximately $7,000/Acre-Foot saved.

In its current general rate case proceeding, San Jose Water Company has proposed four conservation programs to complement its programs already in place. The proposals have not yet been acted upon by the CPUC. A proposed Home Water Use Reports program would have discounted cost only $137/Acre-Foot. A High-Efficiency Toilet installation program for residential customers is estimated to have a discounted cost of $187/Acre-Foot over a ten-year period. A proposed School Education Kits Program is estimated to cost about $454/Acre-Foot with a ten-year analysis period. And a proposed Commercial,

[15] D.08-07-021, page 56.
[16] California-American Water Monterey Supply Project presentation, December 11-13, 2012.

Institutional, and Industrial Audit program is estimated to have a cost of $636/Acre-Foot over a five-year period of analysis. These numbers reflect ex-ante best estimates.[17]

Summary of Cost of Conservation Examples



Water Recycling – Collecting and Reusing Water

Water can be captured and recycled for new use. Many California water utilities are participating in development of water recycling programs. Water Recycling may be the holy grail of new water. It does not require customers to change their ways or invest in new technologies. Instead, it is the waste-water facilities that do the work. They capture the waste water from sewers and drain pipes, and then they clean it up and ship it off for reuse. In most cases, water is cleaned to tertiary treatment standards and is used as a substitute for potable water. In some cases, after being cleaned up to tertiary levels, it is pumped back into aquafers for future pumping for potable use. California is in the process of developing new standards for water reuse. California Senate Bill 918 of 2010[18] set up a process within the State Water Resources Control Board (SWRCB) to develop and adopt uniform water recycling criteria for

[17] San Jose Water Company, General Rate Case Application, A.15-01-002, Chapter 18, Water Conservation.
[18] An act to amend Sections 13350 and 13521 of, and to add Chapter 7.3 (commencing with Section 13560) to division 7 of, the Water Code, relating to water recycling. The text of the bill can be found here.

groundwater recharge, for surface water augmentation, and for direct potable reuse. The groundwater replenishment regulations became effective in 2014. In 2013, the legislature acted again through Senate Bill 322[19] to amend the process. Regulations for surface water replenishment are due soon. SWRCB maintains a web page for Recycled Water information.[20]

Recycling water through groundwater discharge involves pumping reclaimed and cleaned water to an aquifer from which it can be drawn later. This is an expensive process. Surface water augmentation involves pumping the reclaimed water to a reservoir or other place for dilution, and then for that water to be reused. This process may be more efficient and less costly than groundwater discharge. Ultimately, direct potable reuse, if it can be achieved, may be a less expensive process than either groundwater discharge or surface water augmentation.

The examples reported here are but a few of the many water recycling projects that are being developed across the state. California-American Water Company reported at a 2012 CPUC workshop that its Pacific Grove Recycled Water Project has production costs of approximately $2,105/Acre-Foot.[21] The Monterey Regional Water Pollution Control Agency groundwater Replenishment Project was estimated to develop water at between $2,500 and $3,000/Acre-Foot according to that same analysis. The Pacific Grove Satellite Recycled Water Treatment Project water production costs are between $2,624 and $3,042/Acre-Foot. In that presentation, Cal-Am estimated that its proposed Monterey Recycled Water Project would be able to deliver water at a cost of approximately $5,800/Acre-Foot.[22]

Two proposed projects not acted upon have much higher recycling costs: The Pacific Grove Stormwater Recycling project is estimated to cost approximately $10,400/Acre-Foot. And the Los Padres Dam Dredging project would cost on the order of $13,000/Acre-Foot.

The CPUC recently approved Golden State Water Company's request to add a Recycled Water Service agreement with Forest Lawn Memorial Parks.[23] That agreement provides for Golden State to transfer water from a recycling project of the City of Cypress to the Forest Lawn Memorial Park Cemetery in the City of Cypress. The cost of the water itself is provided at $0.91/CCF, a number that translates to just less than $400/Acre-Foot.

There may be many additional recycling opportunities in California. This paper provides just these few examples to show that the costs can be quite low, but are likely to be higher than the costs of traditional sources. The average among the methods shown is about $2,900/Acre-Foot, about two-and-one-half times more costly than the average for traditional sources.

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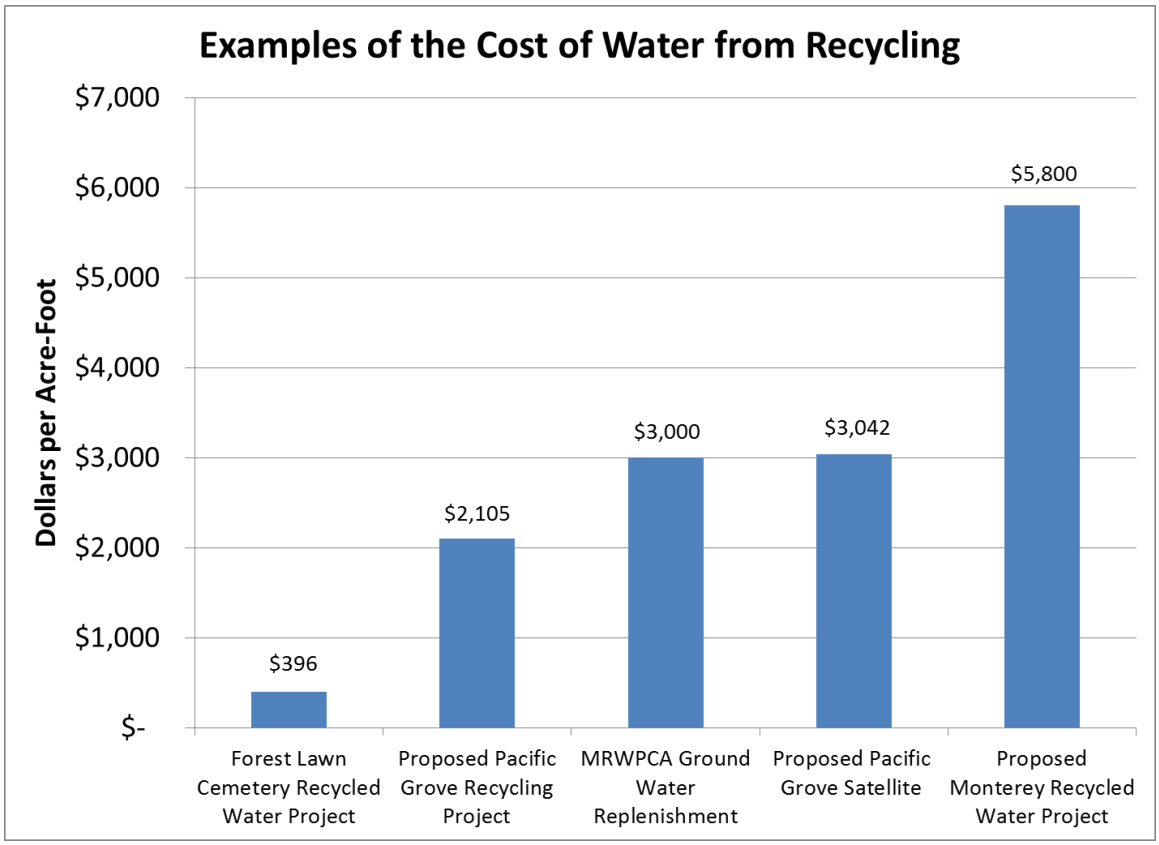
[19] An act to amend Sections 13563, 13564, 13565, and 13569 of the Water Code, relating to water recycling. The text of the bill can be found here.
[20] State Water Resources Control Board, Division of Drinking Water's Recycled Water Information, found here.
[21] California-American Water, "Monterey Supply Project Scenarios," CPUC Workshop associated with Application A.12-04-019, December 11-13, 2012.
[22] The CPUC proceeding A.12-04-019 is still under way, and no decision has been made about the project. Cost estimates have varied and changed over time.
[23] Golden State Water Company, Advice Letter No. 1635-W, filed on August 5, 2015.

Examples of the Cost of Water Recycling



Desalination – Treating Water from the Ocean

The ultimate water recycling program is desalination. The Pacific Ocean is a giant reservoir located just to the west of California, and the potential amount of water from this source is beyond any measure of our need.

California-American Water reported in 2012 that it expected its (as yet to be built) desalination plant in Monterey to have a production cost of about $5100/Acre-Foot.[24] The Sand City desalination plant is providing desalinated water to the Company at a rate of approximately $2,700/Acre-Foot.

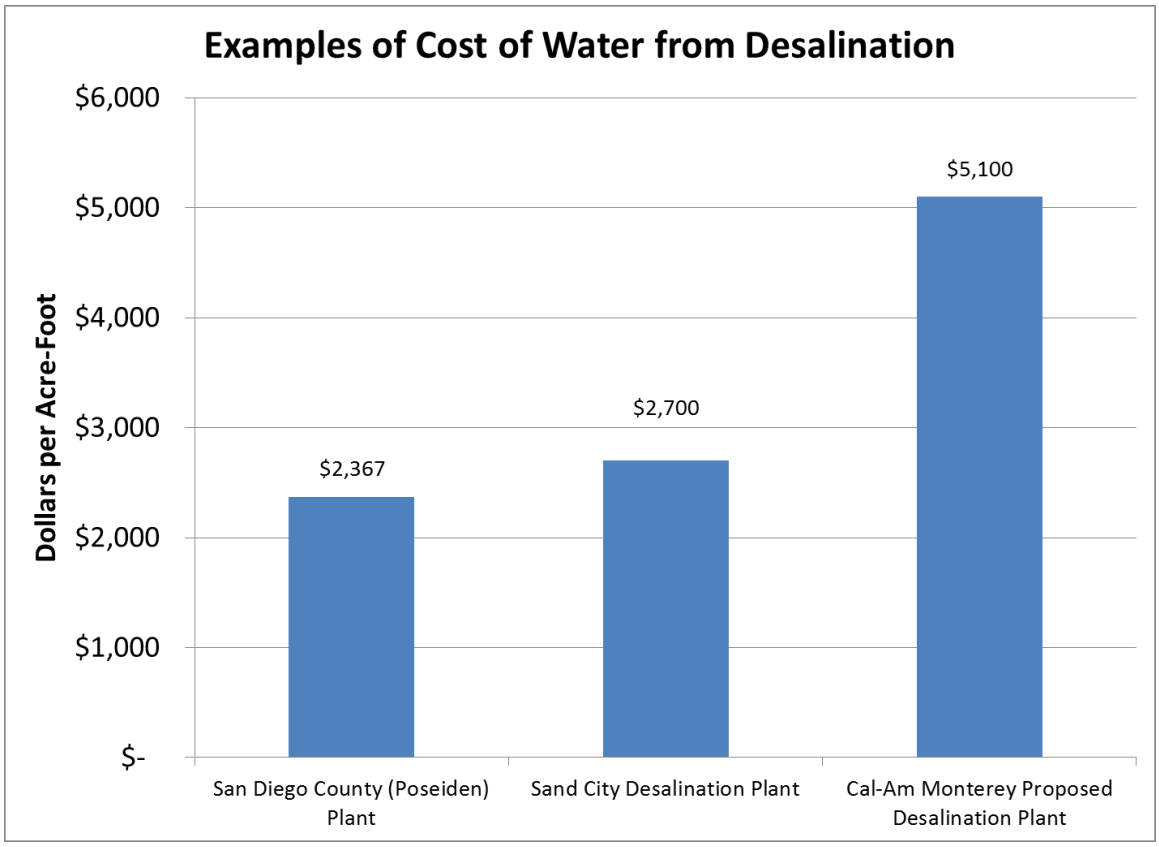
The San Diego County Water Authority is in the process of completing the Carlsbad Desalination Project, which includes the nations' largest, most technologically advanced, and energy-efficient seawater desalination plant, a 10-mile large diameter pipeline and improvements to Water Authority facilities for distributing desalinated water throughout San Diego County. The Authority reported in October that

[24] California-American Water, "Monterey Supply Project Scenarios," CPUC Workshop associated with Application A.12-04-019, December 11-13, 2012. The proceeding is still under way, and no decision has been made about the project. Cost estimates of the cost have changed with new assumptions and information.

the project is expected to produce drinking water in late 2015, and will be a major new drought-proof water supply that will meet about 7- to 10-percent of the county's water demands. Based on current electricity cost estimates, the Water Purchase Agreement sets 2016 the price of water at between $2,131 and $2,367/Acre-Foot, depending on how much is purchased annually.[25]

Desalination may be the ultimate source of water for a parched California; the supply of such water from the Pacific Ocean is virtually limitless! But the cost is high. Among the examples presented here, the average is about $3,400/Acre-Foot, more than four times the cost of water from traditional sources. Particular circumstances and costs will vary, but the availability is not in doubt.

Desalination Cost Examples



Other Ongoing Efforts to Develop and Supply Water

Already in California, there are agreements to let land be fallowed temporarily and to find efficiencies in agricultural use so that water may be made available for urban use. In addition, there are efforts ongoing to change the technology of water supply and to develop new ways to obtain water.

[25] San Diego County Water Authority, "Seawater Desalination, the Carlsbad Desalination Project." A Fact Sheet is available.

Conservation and Reallocation of Water

Most California water consumption is dedicated to agricultural use. Farmers are suffering as much from California's drought and tight water conditions as are urban water consumers. Still, some agricultural water users are finding ways to provide additional water for urban water consumption. Two California Irrigation Districts provide examples.

The Palo Verde Irrigation District (PVID), located in Riverside and Imperial Counties along California's Arizona border, in 2004 entered into an agreement with the Metropolitan Water District that helps local farmers while it provides a more reliable water supply for urban southern California. Under the Land Management Crop Rotation and Water Supply Program, Palo Verde farmers refrain from irrigating between seven- and 28-percent of the valley lands in any year at Metropolitan's request, making water that would have been used for farming those lands available to Metropolitan's urban water users. A fact sheet[26] indicates that this program, which is mutually beneficial to both the agricultural and the urban water users, can provide form 10 billion to 38 billion gallons of water each year to Southern Californians. Because there were initial payments as well as annual payments, and because the program is based on acres rather than acre-feet, a calculation of the cost of water per acre-foot is complex. Both PVID and Metropolitan find the program beneficial. PVID reports that in 2014, the latest year for which data are available, the program saved over 43,000 AF.[27]

The Imperial Irrigation District (IID or Imperial), similarly, is very interested in conservation programs.[28] In 1998, IID formed a Conservation-and-Transfer Agreement with Metropolitan under which MWD pays the costs of water conservation measures in exchange for conserved water estimated to be over 100,000 AF annually. Imperial formed a similar agreement with the San Diego County Water Authority which makes available between 130,000 and 200,000 AF of water annually through the development of efficiency and conservation projects. Because the programs involve long-term agreements and continuing financial obligations, the specific cost per acre-foot in any one year is a complex calculation. IID and both of its partners benefit from the increased efficiency of the water system and from the ability to consume the conserved water.

Recent headlines have revealed new ideas for alleviating our California's water shortage. While this research project has not made an effort to find new ideas, two recent headlines have brought new technologies to our attention.

A New Desalination Technology that may Hold Promise for Much Lower Cost

Engineers have developed a method to use electric current, instead of evaporation or reverse osmosis, as a way to desalinate water. Engineers at MIT have come up with a new desalination system that uses a shockwave to get the salt out of seawater.[29] The MIT professor, Martin Bazant, who developed the

[26] Palo Verde Land Management, Crop Rotation, and Water Supply Program at a glance, available for download here.
[27] Information provided by Paula Hayden, PVID Fallow Coordinator.
[28] The Imperial Irrigation District web page for water conservation is: http://www.iid.com/water/water-conservation.
[29] IEEE Spectrum, "Shocking Trick to Desalinate Seawater," Prachi Patel, November 12, 2015, found here.

idea, states that it is "a fundamentally new and different separation system."[30] If this process uses less energy than the currently available reverse osmosis technology, then it may reduce the cost of desalination.

A New Technology for Obtaining Water from Air

The 2015 Singularity University Impact Challenge,[31] presented in collaboration with California Lieutenant Governor Gavin Newsom, asked, "How do you positively impact the severe drought situation in California by leveraging new and exponentially growing technologies to increase water supplies available for California?" Prizes were offered to three start-ups, each of which is developing a technology to get water from the air.[32] The first-place winner, SunToWater, has developed a technology to pass air over a salt bed, according to a recent article in Fast Company.[33] The company estimates that water from this process would cost about 3.5 cents per gallon, which translates to about $11,400/Acre-Foot, significantly higher than the cost of desalination in the examples presented here. However, no ocean is necessary, and the technology has been able to operate in only 14-percent relative humidity.

Conclusion – New Sources are More Costly

This paper has shown that the costs associated with new water sources, including conservation programs, water recycling programs, desalination programs, and even future ideas that have not yet been demonstrated in commercial applications, are much higher than the costs of traditional sources of water. Even the traditional sources have been rising in cost and are expected to rise in the future. But the traditional sources are all spoken for. Any water manager naturally would search for the most cost-effective sources, and traditional sources, such as the State Water Project, are still the best.

Future water sources will come from conservation, which may result from squeezing greater efficiency out of current water use. Or it may result from increasing efficiency of water systems. It may even come from changing habits and usage patterns. Among the several examples shown in this paper, the average cost of conservation is more than $1,300/Acre-Foot, about 2/3 more expensive than the average of the traditional sources.

Recycling involves recapture of water that has been used, cleaning it up to high standards, and then finding uses for it, usually as a substitute for potable water, but ultimately, as potable water. The examples reported here average about $2,900/Acre-Foot, about two-and-one-half times more costly than the average of the traditional sources.

Desalination is the ultimate plentiful source, but it is very expensive compared to our traditional sources of water. At about $3,400 /Acre-Foot on average among the examples collected for this report, it is more than four times as costly as traditional sources of water.

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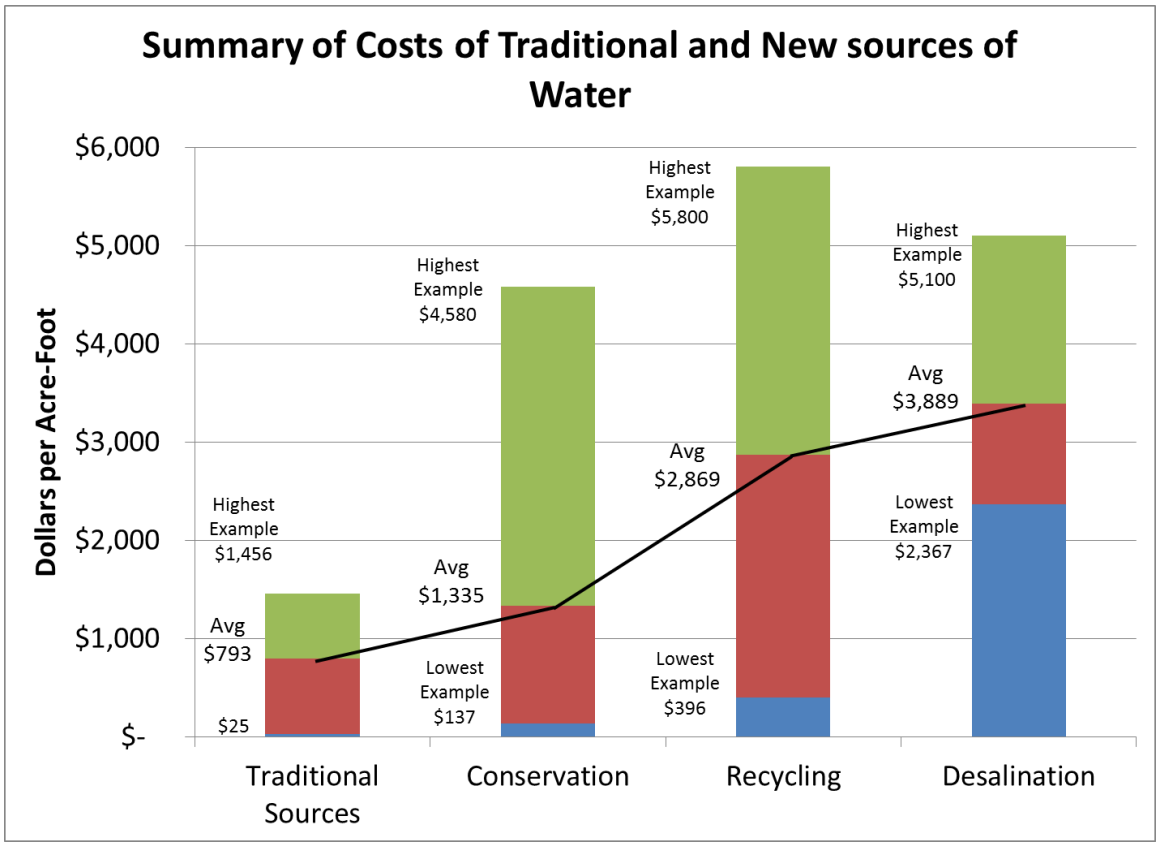
[30] MIT News, "Shocking New Way to Get the Salt Out," David L Chandler, November 12, 2015, found here.
[31] Singularity University Challenge, found here.
[32] Singularity University Challenge, "Finalists to Ease California Drought with Technology, found here.
[33] FastCoExist.com, "These 3 New Devices Can Suck Water From the Air to Solve Our Droughts, November 17, 2015, found here.

The future for Californians most likely will involve a combination of all of these non-traditional sources of water, and perhaps new sources that have not been developed in a commercial manner up to now. The inescapable conclusion is that water agencies will need to rely to a greater degree on new sources of water. The traditional and least costly sources are all fully subscribed, and new sources will be necessary to provide water to Californians. Even if the bulk of supplies still come from the traditional sources, the effect will be higher costs overall. We should expect that future costs for water service will rise as new sources are developed and their higher costs become part of the overall cost of service.

New Sources Are More Costly



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