Importance of Recycled Water to the San Francisco Bay Area

Prepared for
Bay Area Clean Water Agencies

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Executive Summary

Population growth and climate change are predicted to reduce the reliability and sustainability of the water supply that many of people in the Bay Area take for granted. The recently completed *San Francisco Bay Area Integrated Regional Water Management Plan* (Bay Area IRWMP) both highlights the growing imbalance between regional water supplies and demands and provides a blue print for improving the region's water supply reliability and meeting other water management objectives. This plan emphasizes the need for a multi-faceted approach to addressing regional water problems. A core strategy of the plan is increasing the amount of water recycling in the region.

Communicating the growing importance of recycled water to the Bay Area, its role in regional water management objectives, the regional economic benefits of recycled water, and ways to ensure its safety and allay public concern is an important task for managers of Bay Area water and wastewater agencies. This paper, commissioned by Bay Area Clean Water Agencies, provides a digest of factual information about the importance of water recycling in the Bay Area that water managers can utilize when participating in forums where recycled water is under discussion.

The paper is organized into three main topic areas: (1) the importance of recycled water to regional water management; (2) economic considerations of recycled water; and (3) recycled water implementation opportunities and challenges. The paper concludes with six key messages about recycled water in the Bay Area. This Executive Summary provides highlights and key findings from each of the paper's topic areas.

Putting Recycled Water into Context

Water recycling has been a part of California's water management picture for more than 100 years. California farmers are reported to have used recycled water as early has 1890 and by 1910 at least 35 communities were using recycled water for farm irrigation.[1] Today, recycled water use, estimated to be within a range of 450 and 580 thousand acre-feet per year, is becoming widespread in California.[2] Recycled water is primarily used for crop and landscape irrigation and industrial processes and cooling. But it is also being used for groundwater aquifer protection, environmental restoration, wastewater management, and indirect reuse.

[1] Recycled Water Task Force (2003). "Water Recycling 2030: Recommendations of California's Recycled Water Task Force." June 2003.
[2] Ibid.

Recycled water use can be planned or unplanned. Most indirect reuse of recycled water is unplanned and results from the upstream discharge of treated wastewater, which becomes part of river flows that are diverted downstream by farms and municipalities. For example, downstream diverters reuse about 90 percent of municipal wastewater discharged into the San Joaquin River.[3]

Direct uses of recycled water are generally planned, and involve delivering recycled water through pipes to the users of the water. Recycled water projects are designed to meet particular water management objectives and the intended uses of the recycled water determine the types and levels of wastewater treatment. Typical water management objectives that have led to the use of recycled water in California include:[4]

- A water supply to displace the need for other sources of water
- A cost effective means of environmentally sound treatment and disposal of wastewater
- A water supply for environmental enhancement
- Protection of groundwater resources threatened by seawater intrusion

Recycled water projects are not the only way to achieve these objectives, and typically proposed recycled water projects are evaluated alongside other water management alternatives to determine the most cost-effective approach. Water recycling can make the greatest impact on augmenting the State's water supply in regions like the Bay Area where treated wastewater has no opportunity to be reused downstream because it is discharged directly to bays or the ocean.

Importance of Recycled Water to Bay Area Water Management

Recycled Water Helps Address Growing Water Demands

Regional water supply reliability may be the toughest water management challenge confronting the Bay Area. Two-thirds of the Bay Area's water supply is imported into the region. While still capable of meeting regional demands during years of normal rainfall, imported water supplies are increasingly inadequate when rainfall is below normal. This problem will continue to worsen as more people and businesses move into the region and demand for water increases.

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[3] Ibid.
[4] Ibid.

The Association of Bay Area Governments (ABAG) predicts Bay Area population will increase by 1.7 million people by 2030. Regional water suppliers are forecasting water demands will increase by approximately 200,000 acre-feet by this time. The projected increase in demand is similar in magnitude to current demands for the entire service area of the East Bay Municipal Utility District (EBMUD), which serves 20 incorporated cities and 15 unincorporated communities, covers approximately 325 square miles, and serves 1.35 million people.

According to the Bay Area IRWMP, approximately 30 percent of the projected increase in 2030 regional water demands could be met with recycled water projects.

Recycled Water Reduces Dependence on Vulnerable Imported Water Supplies

The Bay Area's dependence on imported surface water makes it highly vulnerable to cyclical drought. On a cumulative basis, Bay Area imported water deliveries could decline by an average of 39 percent during a period of sustained drought down to 548,000 acre-feet, or about 61 percent of normal. A key regional benefit of recycled water is its imperviousness to drought. From the standpoint of the region's hydrologic cycle, it is 100 percent reliable. As a result, a "drought-proof" Bay Area supply of 60,000 acre-feet of recycled water is worth at least 100,000 acre feet of entitlements to imported water susceptible to drought reduction. To ensure the same level of drought supply through surface storage may require storage capacities that are three to five times the expected dry year yield.

Recycled Water Helps Mitigate Risks of Long-term Climate Change

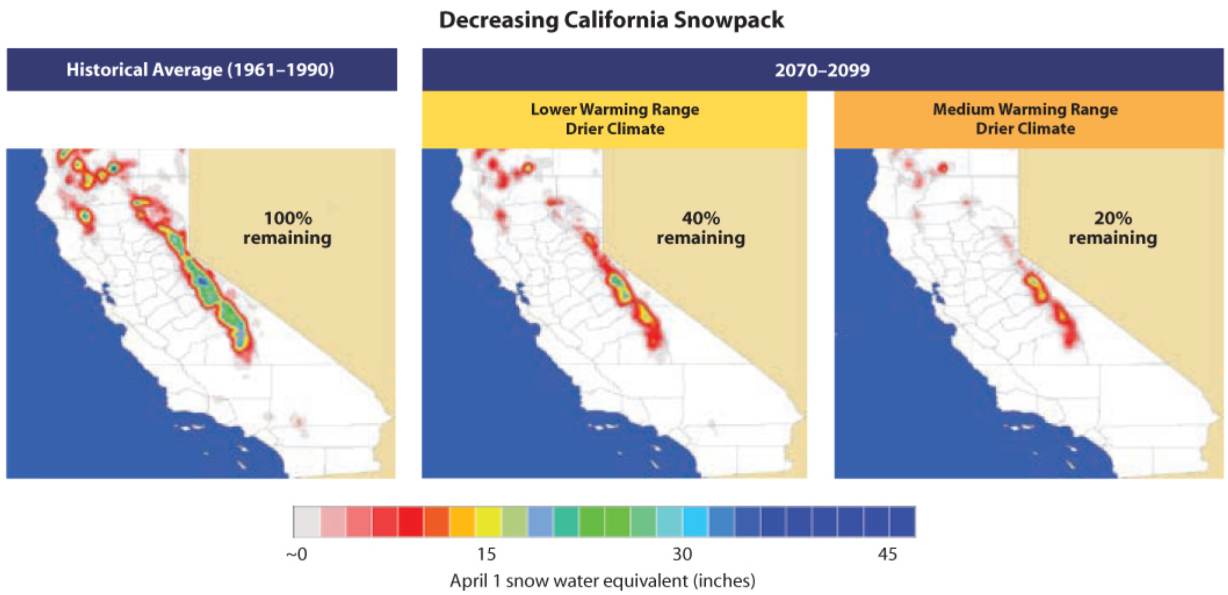
Long-term climate change poses substantial water supply risks to the Bay Area. While there is uncertainty and controversy surrounding climate change models and forecasts, the preponderance of available evidence strongly suggests the Bay Area's climate will get hotter and its primary source of water storage, the Sierra Nevada snow pack, will get smaller.

Absent the natural water storage provided by the Sierra Nevada snow pack, the imported water systems the Bay Area depend on for most of its water supply would be grossly inadequate. Figure E-1 shows predicted changes in snow pack for two climate change scenarios. Under these two scenarios the Sierra Nevada snow pack diminished by 60 to 80 percent within the next hundred years.

Climate change research also suggests an increased likelihood of critically dry years: up to 1.5 times more critically dry years under the lower warming scenario shown in Figure E-1; and 2-2.5 times more critically dry years under the medium warming scenario. Additionally, higher average temperatures and increased frequency of heat waves are expected to increase average water demands.

Even in the absence of climate change, the region will need to develop new water supplies to meet growing demands. With climate change, the need will be even greater. Water recycling provides an economically feasible and proven technology that can be deployed on a large scale within the region. Most importantly, however, the water supply it provides does not depend on weather or climate.

Figure E-1: Sierra Nevada Snow Pack for Two Climate Change Scenarios



Source: California Climate Change Center (2006), "Our Changing Climate – Assessing the Risks to California." July 2006.

Recycled Water has a Smaller Energy Footprint than Most Other Water Supply Options

All water supply options require significant amounts of energy and result in the release of greenhouse gases. The question is how does recycled water compare to other water supply options available to the region? According to the Natural Resources Defense Council, which described recycled water as a highly energy efficient water source, recycled water is less energy intensive than any physical source of water other than local surface water. Recycled water requires about an eighth of the energy required for seawater desalination; less than half the energy used by the SWP to bring water to the Bay Area; and haft to three-quarters the energy required to pump groundwater.

The Bay Area is Geographically Well Situated for Water Recycling

The Bay Area discharges over half a million acre-feet of water each year into the Bay and Pacific Ocean. This discharge represents a potential new source of fresh water supply to the region and to the State. Unlike recycling in inland regions, which often does not result in new supply because water discharged back into upstream water bodies is indirectly reused by downstream diverters, recycling in the Bay Area creates "new" fresh water supply. The Bay Area IRWMP recognized the potential of recycled to provide new water for the region. Of the 52 projects in the plan ranked highly for water supply reliability that could be permitted by 2010, 50 percent were recycled water projects. All of the projects ranked highly for water supply reliability in the plan that could be permitted by 2014 were recycled water projects.

Recycled Water Can Be Used to Simultaneously Address Multiple Regional Water Management Objectives

Few other water management options provide the diversity of possible uses and applications as recycled water. Bay Area water agencies are using water recycling to augment water supplies, reduce the impacts and costs of wastewater disposal, and restore and improve sensitive natural environments. Recycling by itself cannot solve the region's looming water crisis, but used in conjunction with other water supply and management options it can help the Bay Area continue to enjoy a safe and reliable water supply.

Economic Considerations of Recycled Water

Recycled water is often perceived to be an expensive water supply option. However, when the full range of benefits derived from recycled water projects are properly taken into account, most Bay Area projects turn out to be both affordable and cost competitive with other water management options.

Recycled Water is Cost Competitive with Other Supply Options

The State's Recycled Water Task Force convened in 2001 estimated that capital costs for recycled water averaged about $683 per acre-foot and O&M costs about $342 per acre-foot for a total unit cost of about $1,025 per acre-foot (updated to today's dollars). The Task Force report noted this cost was comparable to costs of other water supply options, including new dams and reservoirs or desalination. The Task Force's average unit cost estimate is very close to the average unit cost of 26 Bay Area recycled water projects evaluated in 2005. Collectively, the Bay Area projects had an average unit cost between $1,000 and $1,200 per acre-foot.

Perceptions about the relative cost of recycled water are frequently based on unequal comparisons. The cost of recycled water at the customer tap is frequently compared to the cost of other water supplies at their source, without taking into account the transmission, treatment, and distribution cost associated with moving water from a source to the customer tap.

Cost comparisons with other supply options commonly ignore differences in delivery reliability, which is of critical importance to the Bay Area. They also frequently ignore avoided costs of wastewater disposal and environmental impact.

Most Recycled Water Projects Proposed in the Bay Area Make Economic Sense

Bay Area recycled water projects make economic sense in most cases. Contrary to assertions that most recycled water projects are economic losers, regional studies involving detailed economic analyses of specific project proposals have concluded that the economic benefits would exceed costs of construction and operation over a broad range of implementation levels. Cost comparisons with other supply alternatives are generally favorable. This is not to say that all recycled water projects are sound economic investments. Each project must be able to stand on its own bottom line in terms of the benefits it produces for the Bay Area. Agencies must utilize rigorous benefit-cost tests as a part of project screening and prioritizing.

Recycled Water Implementation Opportunities and Challenges

While the Bay Area IRWP and BARWRP studies have shown tremendous potential for recycled water in the Bay Area, there are a number of implementation challenges the region must address in order to realize this potential. These challenges include securing state and federal participation in regional recycled water projects; coordinating local recycled water plans and projects for regional benefits; resolving jurisdictional constraints; improving public knowledge and understanding of recycled water; and addressing public health risk perceptions.

State and Federal Participation is Essential to Implementation of a Large-Scale Regional Recycling Program

Single-entity financing is often unsuited to financing large-scale recycled water programs in the Bay Area because of jurisdictional boundary issues. Economically beneficial recycled water projects are at risk of not getting implemented without state and federal participation. State and federal participation were instrumental in developing the Bay Area's water recycling regional master plan and State funding was instrumental in developing the Bay Area IRWMP. The State Recycled Water Task Force concluded there is a State and federal interest in regional recycling.

As noted by Congressman George Miller, "[i]t only takes a small federal investment in the Bay Area Water Recycling Program to yield massive dividends to [the] region over time."

Regional Implementation of Recycling Requires a Regional Recycling Program

BARWRP and the Bay Area IRWMP both stress the need for a regional recycled water program to address water agency jurisdictional boundary issues, inter-agency agreements, utility service duplication, and cost and revenue sharing agreements. Such a program would provide essential coordination functions, including:

- Prioritizing recycled water projects and activities;
- Identifying when, where, and how to interconnect the local recycled water projects to support the long-term interests of the region;
- Providing a forum to assist in balancing differences that may exist between local water or wastewater jurisdictions;
- Providing guidelines for recycled water project cost-sharing agreements;
- Developing and administering a regional program to facilitate transfers and exchanges of water among water entities and water recycling producers; and
- Developing and administering a regional water banking or wastewater discharge credit system.

Expanding Recycled Water Use in the Bay Area Requires Resources Devoted to the Public Understanding of Water Reuse

Public understanding of recycled water can be as complex as the engineering required to produce it and likewise requires a regional investment in public information. Public resistance to recycled water projects often derives from fundamental misunderstandings about the water cycle, upstream and downstream water reuse, and intended uses of recycled water. Regional recycling cannot move forward without public understanding of and confidence in the resource. Public confidence in the safe application of recycled water varies by type of use. When discussing the safety of recycled water, it is important to emphasize matching appropriate technology to intended use. There is a large body of research showing that recycled water can be made safe for all intended uses when paired with the appropriate treatment technologies.

Improving public understanding of water reuse will require informational programs designed to provide the public with:

- A better understanding of regional imported and locally derived water supplies; their respective reliability and sustainability; and the extent to which they are shared with other users within and outside of the region.
- More information about the various technologies that can be used in combination or alone to produce recycled water appropriate to specific circumstances or uses.
- Additional public information about risks of recycled water given appropriate pairings of treatment technology with intended uses, so as to avoid excessive investment in treatment technologies providing little or no additional risk reduction benefits for the intended uses of the water.

Moreover, meaningful public involvement must be incorporated into all phases of planning, development, and construction of recycled water projects. Responses to community concerns about public safety and environmental risks of recycled water must be addressed openly, using the best available science and information. To advance water recycling in the Bay Area water agencies and regional leaders must invest in general public awareness and understanding of how recycled water can be safely used to address some of the most pressing water issues confronting the Bay Area.

1 Introduction

The Bay Area is home to seven million people and one of the most vibrant economies in the world. It has the nation's largest concentration of national laboratories, corporate and independent research laboratories, and leading research universities; the highest density of venture capital firms in the world, with 32% of total U.S. venture capital funding invested in the region; more Fortune 500 companies than any region except New York; the most highly educated workforce in the nation, with the highest percentage of residents with graduate and professional degrees; a leading position in global trade, with exports larger than all but one U.S. state; and the highest economic productivity in the nation—almost twice the U.S. average.[5]

Most people in the region take for granted one of the key ingredients to making the Bay Area's economy so successful: water. A random sample of Bay Area residents would likely find few that could identify the source of water coming from their taps. Many would be surprised to learn the extent to which the region depends on distant watersheds for two-thirds of its water supply; or the extent to which the vagaries of weather or climate could reduce supplies from these distant sources and result in region wide water shortages. Few would be aware of the implications for regional economic growth of more frequent or severe cyclical water shortages.

Regional water suppliers, of course, are keenly aware of these issues and are working to address them. The recently completed *San Francisco Bay Area Integrated Regional Water Management Plan* (Bay Area IRWMP) both highlights the growing imbalance between regional water supplies and demands and provides a blue print for improving the region's water supply reliability and meeting other water management objectives.[6]

The Bay Area IRWMP emphasizes the need for a multi-pronged approach to addressing regional water problems. No one approach will suffice, whether it be higher levels of water use efficiency through recycling and conservation; desalination of bay or ocean water; increased capacity to import water from other regions, or any of the many other alternatives evaluated by the plan. What the Bay Area IRWMP clearly shows is that

[5] Bay Area Economic Forum. http://www.bayeconfor.org/baefregion.html
[6] The Bay Area IRWMP is a nine-county effort to coordinate and improve water supply reliability, protect water quality, manage flood protection, maintain public health, standards, protect habitat and watershed resources, and enhance the overall health of the bay. Readers can download the Bay Area IRWMP at www.bayareairwmp.net.

every alternative will be needed to some degree if the region is to continue to enjoy a safe and reliable water supply.

What is interesting is the frequency in which the Bay Area IRWMP identified recycled water projects as important parts to solutions for many water management problems, including improving regional supply reliability, restoring or protecting sensitive Bay Area natural environments, and reducing the discharge of pollutants into the bay and other impaired waters. In this regard, recycled water is somewhat unique in its ability to simultaneously address multiple water management objectives.

Despite these advantages, and also partly because of them, recycled water suffers from a number of implementation challenges that must be overcome if the Bay Area is to fully benefit from the potential for recycled water identified in the Bay Area IRWMP. Recycled water projects are often perceived to be expensive relative to other water sources, and the diffusion of recycled water project benefits can make financing more challenging. The general public has mixed feelings about recycled water. On the one hand, most people in the Bay Area are strongly in favor of using water as efficiently as possible, and the region has a strong recycling ethic. On the other hand, some people worry that recycled water poses risks to human health and safety and are uncomfortable with using recycled water for certain purposes and in sensitive locations such as schools or near play areas. To some degree, the public's mixed feelings result from incomplete knowledge, understanding, and education about water resource issues in general, and recycled water in particular. Finally, successfully implementing recycled water projects in the Bay Area will require overcoming legal and institutional constraints that can interfere with the formation of federal, state, and regional partnerships and coordination essential to implementation of water recycling on a large scale.

Communicating the growing importance of recycled water to the Bay Area, its role in regional water management objectives, the regional economic benefits of recycled water, and ways to ensure its safety and allay public concern is an important task for managers of Bay Area water and wastewater agencies. This paper provides a digest of factual information on each of these topics that water managers can utilize when participating in forums where recycled water is under discussion. The paper concludes by highlighting six key messages about recycled water that underscore its important role to the future of Bay Area water management.

2 Recycled Water's Importance to the Bay Area

Recycled water currently accounts for less than three percent of regional water supplies.[7] This diminutive share of current supply belies recycled water's growing importance to Bay Area water management. It is a statistic reflecting the region's historical dependence on imported water sources, rather than indicating how recycled water could contribute to regional water management objectives in the future.

The Bay Area IRWMP highlights that nearly all Bay Area water agencies use recycled water to supplement their other supplies and that future recycled water projects are expected to double the use of recycled water in the Bay Area by 2020.[8] It lists five important benefits of recycled water to the Bay Area:

- Provides a reliable, drought proof water supply
- Reduces regional dependence on imported water by providing a local supply under local control
- Helps direct high-quality potable water to its highest valued uses
- Helps reduce wastewater discharges to impaired waters
- Helps restore sensitive habitats and natural environments

In this section we summarize the evidence supporting each of these benefits of recycled water.

2.1 Recycled Water Improves Regional Supply Reliability

In many respects, regional water supply reliability is the toughest water management challenge confronting the Bay Area. Historically the region has counted on imported water to meet its needs. When originally constructed, the surface water projects bringing water into the region had capacities greatly exceeding regional demands. Growth in the Bay Area has been slowly chipping away at this excess capacity. Now, at the start of the 21st century, the region's imported water supplies, while still capable of meeting regional demands during years of normal rainfall, are increasingly less reliable when rainfall is below normal. This problem will continue to worsen as more people and businesses move into the region and demand for water increases. Moreover, it could worsen dramatically if climate change reduces the capacity of the state's largest water

[7] Bay Area IRWMP, Figure ES-3.
[8] Ibid., Page B-28.

storage system – the Sierra Nevada snow pack – upon which so much of the region's water supply depends.

Shoring up regional water supply reliability is likely to require lots of little actions rather than one big fix. Water transfers, groundwater conjunctive use and banking programs, desalination projects, recycled water projects, and increased investment in conservation all will have a role to play. Of particular advantage to the Bay Area will be new water supply projects whose yields either do not correlate or negatively correlate with the yields from imported water. The same basic principles of portfolio diversification that apply to financial assets also apply to water assets. New supplies from recycled water and desalination projects, for example, will help reduce the variability of the Bay Area's water supply and the risk of shortfall in dry years.

2.1.1 Recycled Water Can Help Meet Growing Regional Demands

Over the next 25 years the Association of Bay Area Governments (ABAG) predicts an additional 1.7 million people will call the Bay Area home. At current per capita rates of water use the projected population increase would raise regional water demand by almost 300,000 acre-feet per year.[9] To put this volume of water into perspective, it is approximately 20 percent greater than current demands for the entire service area of the East Bay Municipal Utility District (EBMUD), which serves 20 incorporated cities and 15 unincorporated communities, covers approximately 325 square miles, and serves 1.35 million people.

There is some reason to think that regional demand for water will grow more slowly than population. Over the past 15 years total regional demand for water has increased only slightly even though the Bay Area has added over a million new residents.[10] Average per capita water usage over this period has actually decreased. It is tempting to assign all the credit for this decrease to regional investments in conservation, but that would ignore other likely contributing factors such as (1) the residual effect on demand of the 1987-91 drought, (2) a shrinking industrial base and perhaps a shift away from some water intensive industries, and (3) a string of relatively wet years pushing down outdoor water demand. Over longer periods of time water demands have correlated closely with

[9] Calculation based on an average regional per capita use of 157 gallons per day (gpd), as reported in California Department of Water Resources (2005) *California Water Plan Update 2005: A Framework for Action, Volume 3*. Bulletin 160-05. December 2005.
[10] Bay Area IRWMP, Figure B-13.

population growth. It may be that the last 15 years represent a temporary deviation from this longer-term trend or it may be they signal a shift in water consumption patterns away from trend.

Most of the region's water suppliers are forecasting continuing growth in water demand by 2030. The Bay Area IRWMP estimated that regional demand for water could increase by about 17 percent by 2030, a smaller projected demand than would be anticipated given the projected and population growth due to improvements in water use efficiency. Nonetheless Bay Area water suppliers have forecast that regional demands will increase by approximately 200,000 acre-feet by 2030, a volume of water equivalent to all the water delivered to the Bay Area by the Mokelumne Aqueduct in 2000.[11]

Growing demand over the next 20 to 30 years could strain regional water supplies to the breaking point unless action is taken now. Addressing this challenge will require creative approaches to developing new supplies and tempering growth in demand. The Bay Area IRWMP sets forth the most promising strategies for the region. In addition to optimizing the use of imported water supplies, these strategies include aggressive levels of conservation, increased investment in groundwater development and banking, implementation of water transfers, expansion of desalination initiatives, and investment in recycled water.

According to the Bay Area IRWMP, the region could double recycled water production from roughly 60,000 acre-feet today to about 120,000 acre-feet by 2020.[12] This would address approximately 30 percent of the projected increase in 2030 regional water demands.

2.1.2 Recycled Water Reduces Dependence on Vulnerable Imported Water

The Bay Area's dependence on imported surface water makes it highly vulnerable to cyclical drought. Two-thirds of the Bay Area's water supply is imported from outside the region. Major projects bringing water to the Bay Area are summarized in Table 1, along with the amount of water each project supplied the region in 2000.

[11] DWR (2005) Bulletin 160-05, Table 3-1.
[12] Bay Area IRWMP, Figure D-2.

Yield from each of the water supply sources shown in Table 1 is highly variable. During periods of dry weather, project yields decrease. During drought periods, yields for many of the supplies listed in Table 1 can decrease precipitously. The Bay Area IRWMP estimated future reliability during significant droughts of several of the water sources shown in Table 1. Reliability percentages for these projects are shown in Figure 1. In decreasing order of reliability during significant droughts, CVP deliveries would be 75 percent of normal; deliveries from the Tuolumne River would be about 70 percent of normal; deliveries from the Mokelumne River would be about 60 percent of normal; and SWP deliveries would be about 40 percent of normal. Not shown in Figure 1 are reliability levels for the Russian River and local surface water supplies, which also are highly vulnerable to drought episodes.

Table 1: Bay Area Imported Water Projects

Facility	Water Source	Operator	Counties Served	Deliveries in 2000 (TAF)
Hetch Hetchy Aqueduct	Tuolumne River	SFPUC	San Francisco, San Mateo, Alameda, Santa Clara	259
Mokelumne Aqueduct	Mokelumne River	EBMUD	Alameda, Contra Costa	206
South Bay Aqueduct	Delta	SWP	Alameda, Santa Clara	119
Contra Costa Canal	Delta	CCWD/CVP	Contra Costa	117
San Felipe Unit	Delta	CVP	Santa Clara	89
North Bay Aqueduct	Delta	SWP	Solano, Napa	36
Putah South Canal	Lake Berryessa	CVP	Solano	35
Sonoma Petaluma Aqueduct	Russian River	SCWA	Sonoma County	33

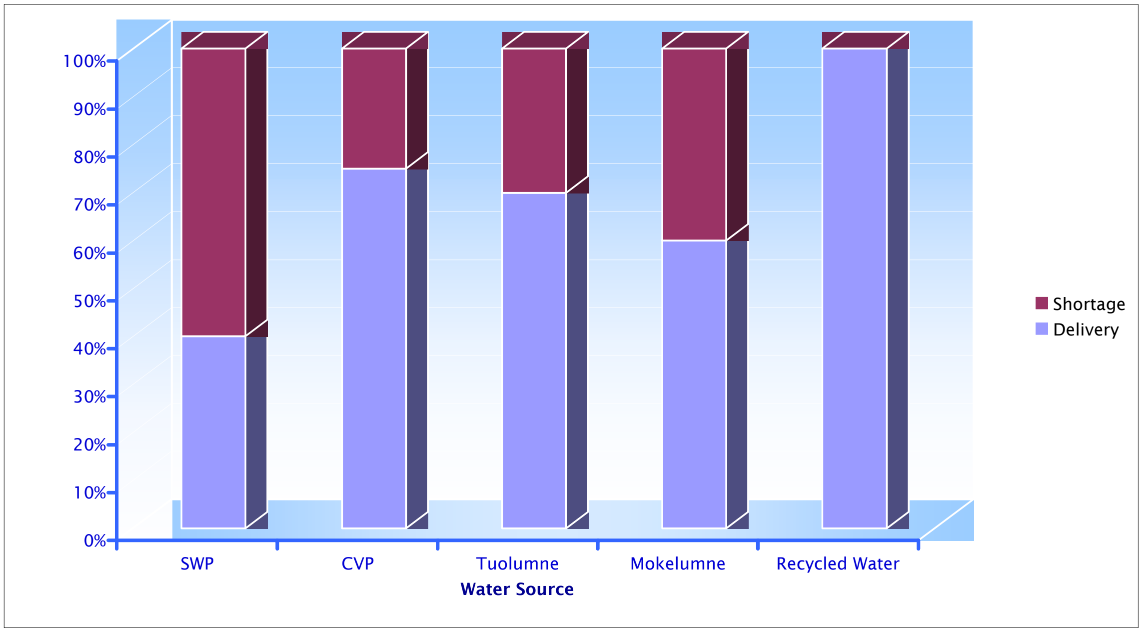
Source: Adapted from Table 3-1, DWR (2005), Bulletin 160-05.

The last bar in Figure 1 is for recycled water. Recycled water was placed in the figure to illustrate its reliability relative to the region's principal imported water sources. A key benefit of recycled water for the region is its imperviousness to drought. From the standpoint of the region's hydrologic cycle, it is 100 percent reliable.

It is useful to consider the extent to which imported water deliveries to the Bay Area listed in Table 1 could diminish during a period of severe drought by applying the reliability percentages from Figure 1. The yield from these water supply sources is highly variable and during periods of dry weather can drop to less than half of their normal amounts.[13] In 2000, a normal water year, Bay Area water agencies imported 894,000 acre-feet of water into the region. Under hydrologic conditions represented by Figure 1, imported water deliveries could decrease to about 548,000 acre-feet, or about 61 percent of actual delivery in 2000 – a 39 percent shortfall in imported water deliveries. An actual decrease under these conditions would likely be even worse because supply from the Russian River and local surface water would not be unaffected. It too would decrease. As a result, a "drought-proof" Bay Area supply of 60,000 acre-feet of recycled water is worth at least 100,000 acre feet of entitlements to imported water susceptible to drought reduction. To ensure the same level of drought supply through surface storage may require storage capacities that are three to five times the expected dry year yield.

[13] The CVP dry-year reliability estimate reported in the Bay Area IRWMP is optimistic. Under the USBR's Shortage Allocation Policy, deliveries to M&I CVP contractors could be cut by 50% or more provided these cuts do not pose risks to human health and safety.

Figure 1: Bay Area Drought Water Supply Vulnerability



Source: Bay Area IRWMP.

2.1.3 Recycled Water Helps Mitigate Risks of Long-term Climate Change

The foregoing discussion described the region's current vulnerability to historical weather patterns. It did not consider longer-term risks associated with climate change. These risks include decreased snowmelt runoff originating in the Sierra Nevada; increased water demands for cooling and irrigation; increased variability of weather and more frequent severe weather events; and increased frequency of droughts and critically dry years.[14] Each of these risk factors has important implications for Bay Area water management.

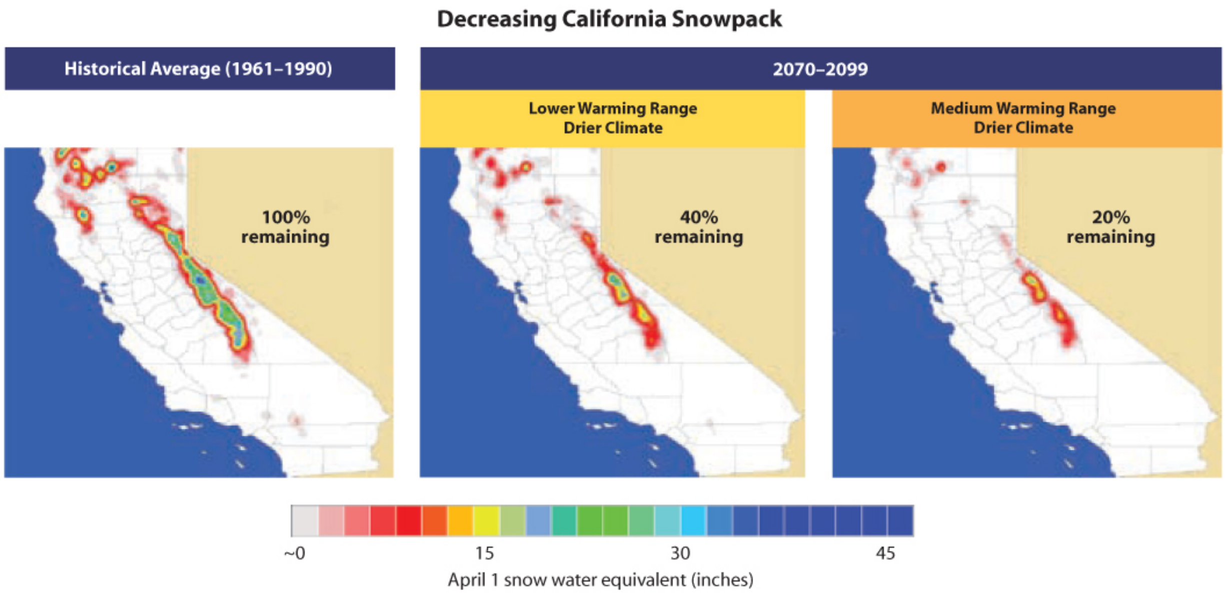
The majority of the Bay Area's water supply comes from snowmelt runoff originating on the western slope of the Sierra Nevada. The SWP, CVP, and the Mokelumne River and Hetch Hetchy water projects are each designed to store and divert snowmelt runoff through a series of storage reservoirs and aqueducts. Nature, however, provides the largest storage reservoir by far in the form of the Sierra Nevada snow pack. This snow pack holds winter and early spring precipitation and then releases it gradually through the later spring and summer months. Absent the natural storage provided by the snow

[14] California Climate Change Center (2006). "Our Changing Climate – Assessing the Risks to California." July 2006.

pack the human-constructed water storage systems the Bay Area depends on for most of its water supply would be grossly inadequate.[15]

Climate change research consistently indicates that a likely consequence of global warming is a decrease in the Sierra Nevada snow pack.[16] Figure 2 compares the historical average water content of the Sierra Nevada snow pack with two future climate change scenarios. The first scenario represents a 3-5.5 degree (F) increase in average temperature while the second scenario represents a 5.5-8 degree (F) temperature increase. In the first scenario, the snow pack as of April 1 holds 60 percent less water than its historical average. In the second scenario, it holds 80 percent less water.

Figure 2: Sierra Nevada Snow Pack for Two Climate Change Scenarios



Source: California Climate Change Center (2006), "Our Changing Climate – Assessing the Risks to California." July 2006.

Climate change research also suggests an increased likelihood of critically dry years: up to 1.5 times more critically dry years under the lower warming scenario; and 2-2.5 times more critically dry years under the medium warming scenario.[17] During critically dry

[15] Kiparsky, Michael and Peter H. Gleick (2003). "Climate Change and California Water Resources: A Survey and Summary of the Literature." July 2003.
[16] Ibid.
[17] California Climate Change Center (2006). "Our Changing Climate – Assessing the Risks to California." July 2006.

years, snow pack conditions could be expected to be even worse than depicted in Figure 2.

At the same time climate change is expected to decrease Bay Area water supplies it is expected to increase regional water demands.[18] Higher average temperatures will increase water demand for cooling and irrigation uses. The California Climate Change Center predicts under the lower warming scenario 2-2.5 times as many heat wave days in urban centers. Under the medium warming scenario, it predicts the number of heat wave days could increase by a factor of four. Increased water demand due to climate change would further compound the challenges already confronting the region of providing a reliable supply of water to a growing population.

Predictions of climate change and possible consequences are not universally accepted and substantial controversy and disagreement surrounds the topic. Much of the research into climate change relies on complex computer simulation models attempting to represent a vastly more complicated natural system that is not fully understood. As Nils Bohr, a Nobel laureate in Physics put it: “Prediction is difficult, especially if it’s about the future.” But the preponderance of available evidence strongly suggests the Bay Area’s climate will get hotter and its principal source of water storage, the Sierra Nevada snow pack, will get smaller. It would be reckless to ignore or disregard the possibility of this occurring.

Even in the absence of climate change, the region will need to develop new water supplies to meet growing demands. With climate change, the need will be even greater. Of the various supply options available to the region, recycled water has been described as an important and key water supply resource.[19] It is an economically feasible and proven technology that can be deployed on a large scale. Most importantly, however, the water supply it provides does not depend on weather or climate.

2.1.4 Recycled Water Has A Small Energy Footprint

Recycled water requires energy to produce, which in turn is likely to result in an increase in greenhouse gas emissions. However, all water supply options require significant amounts of energy and result in the release of greenhouse gases. The question is how

[18] Kistenmacher, Peter, et al., “Impacts and Opportunities of California’s Climate Change Initiative on Future Water Recycling Projects.” Undated.
[19] Ibid.

does recycled water compare to other water supply options available to the region? Many people are surprised to learn that recycled water uses less energy per acre-foot of water than most other water supply options. The Natural Resources Defense Council described recycled water as "a highly efficient water source … reusing water is far less energy intensive than any physical source of water other than local surface water."[20]

Table 2 compares the amount of energy to produce an acre-foot of water for several water supply processes.[21] The reader should note that energy requirements for SWP water in Table 2 are relative to delivery to Southern California, which involves substantially more pumping than delivery to the Bay Area. However, supposing SWP delivery to the Bay Area requires only one-third the energy shown in the table, it still would require more than twice the energy of recycled water production.

Table 2: Energy Intensities of Different Water Supply Processes

Water Supply Processes	Energy Intensity (kWh/AF)
Import Water – SWP	2900-3240[a,b]
Groundwater Pumping	570-950[b]
Desalination – Seawater	3260-5400[b,c]
Desalination – Brackish Groundwater	410-1700[b,c]
Water Treatment & Distribution	203-1260[b]
Recycled Water Production	400[b]

Notes:

a. SWP delivery to Southern California. Energy requirements for delivery to Bay Area are less because of less pumping requirements.
b. California's Water-Energy Relationship, CEC, November 2005
c. RMC San Benito and Marina Coast Projects

2.1.5 Recycled Water Diversifies Regional Water Supply

The Bay Area's current water supply systems cannot meet the challenges of population growth and climate change. The region needs to diversify its water supplies and reduce its dependence on imported water. Recycled water is one of the keys to diversification. It utilizes proven and economically feasible technologies, provides drought proof supply,

[20] Natural Resources Defense County (2004). "Energy Down the Drain – The Hidden Costs of California's Water Supply." August 2004.
[21] Adapted from Table 1 in Kistenmacher, Peter, et al., "Impacts and Opportunities of California's Climate Change Initiative on Future Water Recycling Projects." Undated.

has a smaller energy footprint than most other supply options, and can provide the region with tens to hundreds of thousands of acre-feet of new water supply.

In the course of development of the Bay Area IRWMP, hundreds of possible water management projects were evaluated and prioritized for implementation by the region's water agencies. Projects advanced to the IRWMP were divided into two cohorts: Cohort 1 projects are scheduled to have all applicable environmental documentation and permitting complete by 2010; Cohort 2 projects will have these activities completed by 2014. Of the 116 Cohort 1 projects included in the plan, 22 percent were recycled water projects. Of the 52 Cohort 1 projects ranked highly for water supply reliability, 50 percent were recycled water projects. 100 percent of the Cohort 2 projects ranked highly for supply reliability were recycled water projects.

Recycled water projects received such high rankings for water supply in the Bay Area IRWMP in part because of their suitability to the region. The Bay Area is at the tail end of a long water supply chain stretching eastward to the Sierra Nevada Mountains. As supply flows westward it is used many times over by different water users, who discharge back into rivers carrying the water westward. Essentially this water gets naturally recycled through the process of diversion and discharge. By the time it reaches the Bay Area, however, the final discharge point is into salt sinks (the Bay or Pacific Ocean). The Bay Area discharges over half a million acre-feet of water each year (617 million gallons a day) into these sinks.[22] This represents a potential new source of water supply to the region and to the State. Whereas recycling in inland regions will often not result in new supply because discharges are naturally recycled and used by downstream diverters, recycling in the Bay Area creates "new" fresh water supply.

2.2 Reducing Discharges to Impaired Waters

Most of the nine counties that surround the San Francisco Bay and discharge effluent into the Bay are urbanized and sewered. Residential wastewater, consisting of all waste flushed or washed down sinks and drains of residences and commercial establishments (e.g. stores, restaurants, and office buildings), is collected in sewers and flows to

[22] Bay Area Clean Water Agencies estimates the annual regional cost of the high level of treatment prior to discharge is in excess of $500 million. In most cases these fresh water discharges do not provide benefit to the receiving waters. Water recycling can convert non-beneficial discharges into a beneficial new water supply for the region.

secondary or advanced wastewater treatment facilities across the Bay Area. Much of the industrial wastewater produced throughout the region, following pretreatment, is also discharged to publicly owned sewers and subsequently transported to these publicly owned treatment works (POTWs). Currently, dry weather flows to the region's POTWs exceed 580,000 acre-feet per year.[23] By 2040, this has been projected to increase to 730,000 acre-feet per year.[24] Most of this flow is treated and discharged to the Bay.

Bay Area POTWs operate under permits issued by the San Francisco Regional Water Quality Control Board (RWQCB) following regulations established by the State Water Resources Control Board (SWRCB) and the Environmental Protection Agency (EPA). These permits are called National Pollutant Discharge Elimination System (NPDES) permits. These permits include limits on the concentration of various constituents in the wastewater (e.g. suspended solids, biochemical oxygen demand (BOD), and metals) as well as limits on the total amount of materials discharged into the receiving waters. In addition, many agencies are limited in the amount of water they are able to discharge to receiving waters at various times of the year. In both cases, using recycled water can help agencies meet their permit limits

2.2.1 Water Recycling Can Reduce Permitted Discharges

Concerned about the long-term impact of wastewater discharges into the environment, regulators are trending towards restrictions on the total pounds of constituents being discharged. By reducing the volume of wastewater discharged to the Bay recycled water projects may provide an effective way of meeting mass loading requirements. Additional benefits are obtained when certain constituents (e.g. trace metals) that are harmful to aquatic organisms serve as important plant nutrients when recycled water is applied for irrigation purposes.

Although less common than regulation of water quality, the quantity of treatment plant effluent discharged to a receiving body may also be limited by regulation. Such regulations may be continuous or seasonal. Recycling treated effluent often provides a

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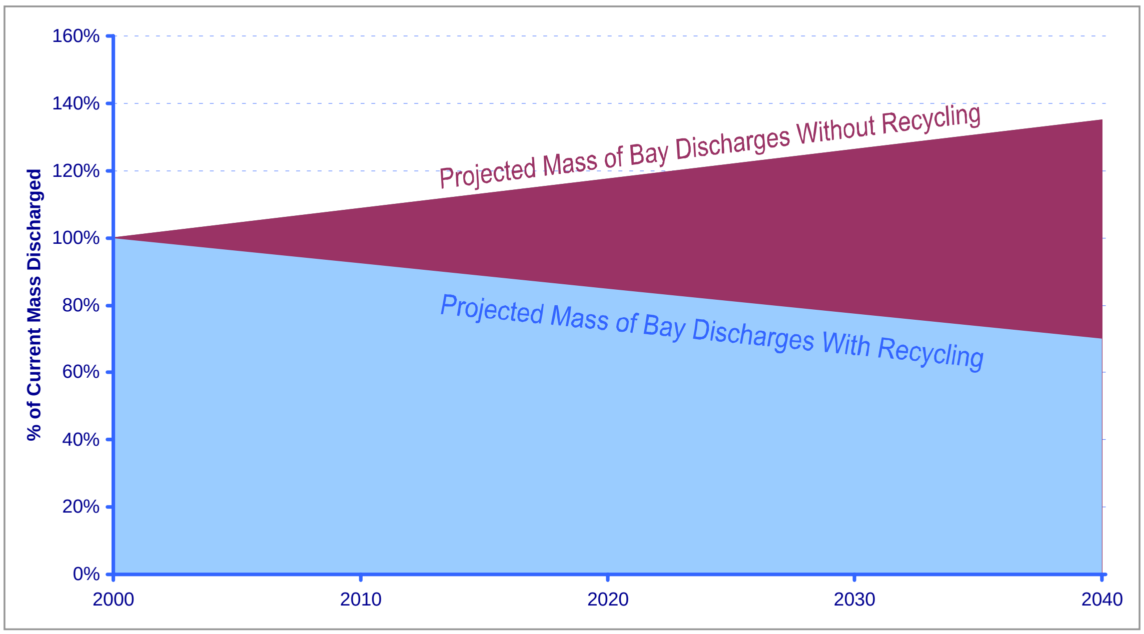
[23] Bay Area Regional Water Recycling Program (1999). San Francisco Bay Area Regional Recyling Program Recycled Water Master Plan." Table 5-1.
[24] Ibid

cost-effective alternative to storage or other disposal options, especially when flow restrictions correspond to period where recycled water is in demand.[25]

The San Francisco Bay Area Regional Water Recycling Program (BARWRP) evaluated the extent to which projected mass discharges to the Bay could be reduced by implementing the recycled water projects included in its Recycled Water Master Plan. Figure 3 depicts the results of this evaluation. It shows that by 2020 aggressive implementation of recycled water projects in the Bay Area could reduce mass discharges to the Bay by 28 percent. By 2040, discharges were projected to be 48 percent lower with recycling.

Figure 3: Recycled Water and Mass of Bay Discharges



Source: San Francisco Bay Area Regional Recycling Program Recycled Water Master Plan.

2.3 Restoring & Protecting Natural Environments

Recycled water projects also are being proposed for the restoration or protection of natural environments in the Bay Area. This paper has already discussed the indirect benefits to the Bay environment by reducing the volume of wastewater discharges through water recycling. This section presents examples of how recycled water can be used directly for environmental remediation of sensitive environments and habitats.

[25] USEPA "Guidelines for Water Reuse (EPA/625/R-04/108 (September 2004). Chapter 5, p.180.

2.3.1 Napa Salt Marsh Restoration

A prime example of using recycled water for environmental improvement in the Bay Area is restoration of the Napa Salt Marsh. In 1994, the State of California acquired all of the salt and bittern ponds in the North Bay and created the California Department of Fish and Game (CDFG) Napa-Sonoma Marsh Wildlife Area. The bittern ponds, located in the northern portion of the CDFG Napa-Sonoma Marsh Wildlife Area near Fly Bay and Coon Island, total 750 acres, and store an estimated 2.5 billion gallons of bittern. Restoring these ponds through levee breaching or other more common techniques is not feasible because of RWQCB restrictions on discharging bittern into the Bay. However, the RWQCB will consider discharge from these ponds if the compounds in the bittern are diluted to near background levels. To sufficiently dilute the quantity of bittern stored in the three ponds will require enormous amounts of fresh water.

A project to deliver approximately 3,000 acre-feet of tertiary-treated recycled water per year to the bittern ponds has been proposed by Sonoma County Water Agency in partnership with the Napa Sanitation District. Desalination of the bittern ponds is anticipated to take between 10 and 15 years. Upon completion of the restoration phase of the project, the recycled water would serve different agricultural areas in the region.

The Napa Salt Marsh Restoration Project will facilitate restoration of important salt marsh habitat located in the Napa-Sonoma Marsh Wildlife Area. The North Bay Marshes and San Pablo Bay provide habitat for chinook salmon, delta smelt, splittail, steelhead trout, green sturgeon, striped bass, and numerous species of migratory waterfowl, shorebirds, and wading birds.

2.3.2 South Bay Recycling Program

Water from inside most South Bay homes and businesses goes through the sanitary sewer system to the San Jose/Santa Clara Water Pollution Control Plant. The plant discharges over 100 million gallons of treated wastewater into the South San Francisco Bay everyday. The sheer volume of freshwater discharged from the Plant can alter South Bay salt marshes during the drier months. The wastewater discharge, which is not salty, dilutes the saltiness of the Bay water. This lessening of the saltiness of the water affects the type of plants growing in the salt marshes. One kind of plant, pickleweed, is needed for two endangered species to survive in the South Bay. These are the salt marsh harvest mouse and the California clapper rail.

In 1989, the USEPA and the State Water Resources Control Board determined that effluent discharges had the effect of reducing the salinity of salt marsh downstream of the Plant. Because the salt marsh provided habitat for two endangered species the EPA and the Board proposed to limit the flows from the plant during the dry weather period between May 1 and October 31. As lead agency for the eight cities and sanitary districts tributary to the plant, the City of San Jose evaluated a number of options to reduce or divert plant flow including water conservation, construction of a deep-water outfall and water reuse. After extensive study, the City adopted a plan combining water conservation and nonpotable water recycling to reduce discharge to the Bay.[26] The first phase of South Bay Water Recycling was completed in 1998 with construction of over 60 miles of pipe and four pump stations. In 2006, Silicon Valley communities reused 15 percent of wastewater and SBWR provided as much as 15 million gallons of nonpotable water per day to over 500 customers, keeping effluent flows well below target limits and contributing to the overall health of the South Bay ecosystem.

2.3.3 Wetland Habitat Enhancement

In addition to the two examples just cited, there are a number of other recycled water projects operating in the Bay Area that provide wetland enhancement benefits. Examples include the following:[27]

- Hayward Marsh, Hayward, California—Operated jointly by Union Sanitary District and East Bay Regional Parks District. Began operation in 1985.
- Mountain View Sanitary District wetlands, Martinez, California—Operated by Mountain View Sanitary District in conjunction with California Department of Fish and Game. Began operation in the 1980s.
- ITT Marsh, Palo Alto, California—Project operated by Palo Alto Regional Water Pollution Control Plant. Began operation in 1997.
- Pacifica Creek and Wetland Area Enhancement, Pacifica, California—Operated by Pacifica Water Pollution Control Plant. Began operation in 1998.

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[26] Rosenblum, E. "Selection and Implementation of Nonpotable Water Recycling in Silicon Valley (San Jose area) California," Water Science and Technology Vol 40 No 4 pp 51-58, IWA Publishing (1999)
[27] Bay Area Regional Water Recycling Program (1999). San Francisco Bay Area Regional Recyling Program Recycled Water Master Plan." Chapter 10.

Much more potential exists. BARWRP conducted a general evaluation of 16 potential wetland sites around the Bay Area. This evaluation allowed BARWRP to enumerate the potential benefits that could result from wetland creation and enhancement with recycled water. At the same time, it flagged the types of constraints and potential impacts that must be addressed for these types of habitat creation and restoration projects in general and at the proposed sites in specific.[28]

[28] Ibid.

3 Economic Considerations

Previous sections of this paper have discussed the multiple benefits of recycled water to the Bay Area. These benefits include providing the region with a reliable drought-proof water supply under local control; diversifying the region's water supply portfolio and reducing its dependence on imported water; reducing wastewater discharges to the San Francisco Bay; and using recycled water for environmental restoration and protection. Recycled water has been described as the "low hanging fruit" among water supply options for the region. And yet making the economic case for recycled water projects is not always straightforward.

This section of the paper addresses some common misperceptions about the economics of recycled water projects and discusses why financing recycled water projects remains a challenge. It compares the costs of recycled water to other water supply options and considers these costs in light of the multiple benefits recycled water projects can generate.

3.1 Some Common Misperceptions

For reasons to be discussed, not every recycled water project is able to generate sufficient sales revenue to cover the costs of installing and operating the required treatment processes and related infrastructure. People sometime misconstrue financial insufficiency as evidence that a recycled water project is a bad economic investment. Frequently, this is not the case. While it is relatively straightforward to tally all the costs associated with a recycled water project, it can be much more challenging to fully account for all the economic benefits. Often important benefits are excluded from consideration because they are difficult to quantify or overlooked, and this can bias decision making against recycled water projects. There is also a general misperception that recycled water is very expensive relative to other water supply options. When costs and benefits of alternative water supply options are properly considered, this often turns out not to be the case.

3.2 Why Economically Sound Projects May Still Be Difficult to Finance

From a social perspective, a recycled water project is a good investment if the societal benefits produced by the project outweigh the societal costs incurred to construct and operate it.[29] Even under this circumstance, however, it still may be the case that the financial assessment of the project appears unfavorable.[30] This apparent contradiction highlights the difference between a *financial* and an *economic* analysis.

A financial analysis of a recycled water project calculates the cash flows of expenses and revenues in and out of the utility operating the project. Recycled water projects can entail significant upfront and ongoing expenses to construct and operate. At the same time revenue potential of recycled water projects may appear low because recycled water is often priced at a discounted rate relative to the average cost-based rates charged for traditional potable supplies, which in turn may also be under priced, further compounding the problem.[31] Under these conditions, financial analyses often show that recycled water projects are unlikely to be financially self-sufficient from the perspective of the utility operating the project.

An economic analysis of a recycled water project tallies all of the costs to construct and operate the project and all of the benefits the project is expected to produce over the course of its useful life. It then converts these streams of costs and benefits into present value equivalents to ensure an "apples-to-apples" comparison. If benefits exceed costs, the project would be a good investment for the region because it would increase economic welfare. If costs exceed benefits, the project would be a bad investment for the region because it would decrease economic welfare.

A financial analysis of a recycled water project takes a much narrower perspective than an economic analysis. A financial analysis only considers one beneficiary of the project: the utility operating it. An economic analysis takes a much broader perspective and considers the full range of benefits and costs generated by the project, regardless of jurisdictional boundaries.

[29] Griffin, Ronald C. (2006). Water Resource Economics: The Analysis of Scarcity, Policies, and Projects. The MIT Press. Cambridge, MA.
[30] Raucher, Robert S. (2006). "An Economic Framework for Evaluating the Benefits and Costs of Water Reuse: Final Project Report and User Guidance." WaterReuse Foundation. Alexandria, VA.
[31] Ibid. Potable water supply is often found to be under priced relative to its full marginal costs because average system costs typically drive rates and because infrastructure renewal costs may not be fully embodied in cost recovery.

Figure 4: Illustration of Difference between Financial and Economic Analysis

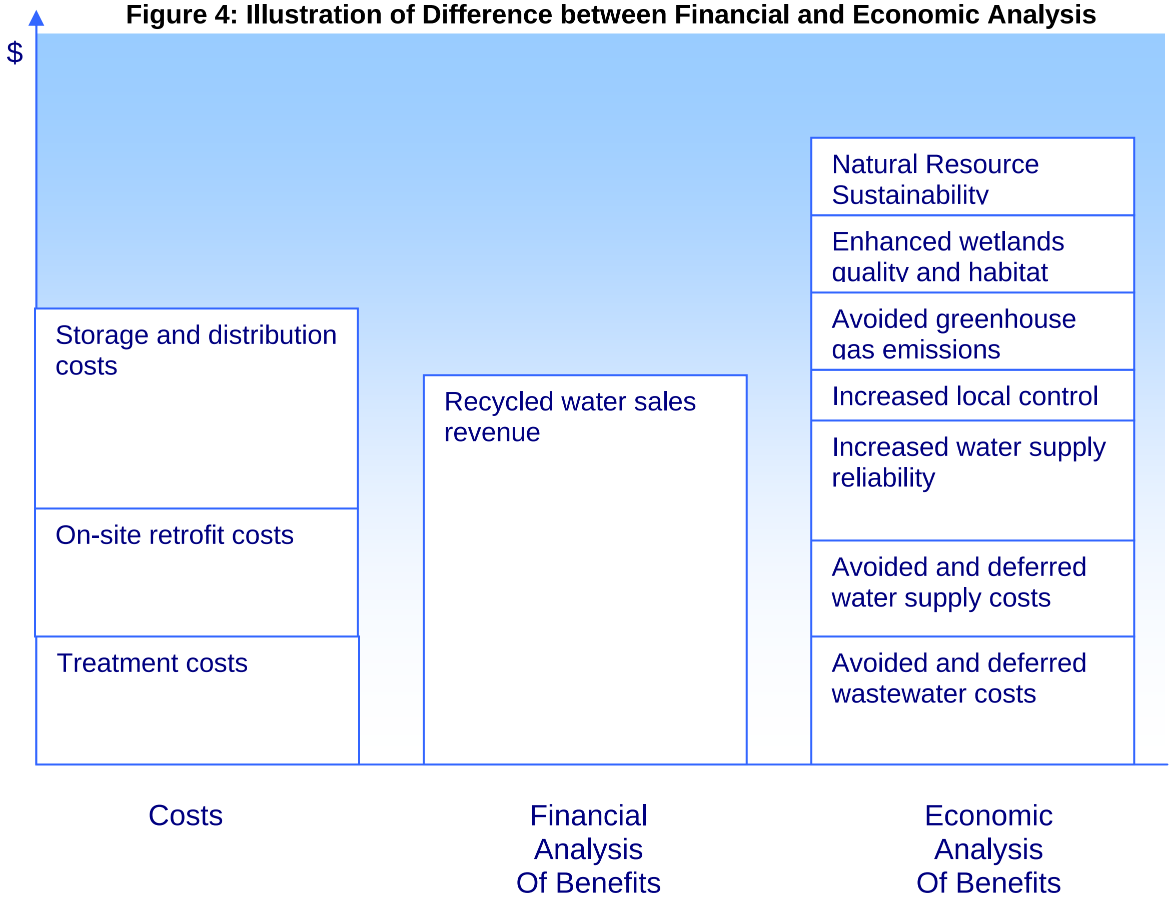

Figure 4 illustrates the difference between the two approaches and shows why projects considered good economic investments can also show bad financials.[32] Figure 4 shows a broad range of potential economic benefits typically not considered by financial analysis. Many of these benefits were discussed in previous sections of this paper. Quantifying them can be difficult. Even when they can be quantified, they may not be fully taken into account for a number of reasons:[33]

- Some benefits, such as environmental enhancement, are diffuse, crossing political or district jurisdictional boundaries. Recovering project costs from the people enjoying these benefits is not straightforward and may require broad taxation approaches beyond the reach of the project implementers.
- Some beneficiaries may not be engaged in the project deliberations and as a result these benefits may be given too little weight in the decision making process.

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[32] Figure 4 is adapted from Figures 2.1 and 2.2 in Raucher (2006).
[33] Adapted from Raucher (2006).

- Many benefits may not be realized until far into the future or may entail a high degree of uncertainty.
- Avoided costs resulting from the project may go unrecognized, be undervalued, or accrue to project beneficiaries other than the project implementer.

Because important benefits of recycled water projects are sometimes disbursed across political or district jurisdictional boundaries, recovering costs from project beneficiaries may require regional coordination, partnerships, and cost and revenue sharing agreements. Additionally, because some project benefits have the attributes of a public good, their associated costs may only be recoverable through the taxing authority of the state and federal governments. All of these considerations make single-entity financing of recycled water projects problematic.

3.3 Relative Cost of Recycled Water

Recycled water is often identified as an expensive water supply option. And it is true that for some recycled water projects the direct financial costs of installing and operating the required treatment processes and related infrastructure for recycled water projects can be large. For others they can be relatively modest. In fact, the cost of recycled water covers a wide range. The State's Recycled Water Task Force reported that annualized costs of individual projects "can vary from practically no extra cost to treat and deliver recycled water to over $2,000 per acre-foot of delivered water, including capital and operational costs."[34] The Task Force estimated that costs for recycled water averaged about $1,025 per acre-foot (updated to today's dollars), and noted this cost was comparable to other water supply options, including new dams and reservoirs or desalination.[35] Unit costs for 26 Bay Area recycled water projects were evaluated in 2005. Collectively, the Bay Area projects had an average unit cost between $1,000 and $1,200 per acre-foot, very close to the Task Force estimate of average unit cost for recycled water.[36]

Perceptions about the relative cost of recycled water as a water supply option are frequently based on unequal comparisons. The average costs of recycled water projects reported by the Recycled Water Task Force and for the Bay Area included costs of

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[34] Recycled Water Task Force (2003). "Water Recycling 2030: Recommendations of California's Recycled Water Task Force." June 2003.
[35] Ibid. Page 14.
[36] CDM, May 2005. Bay Area Water Quality and Supply Reliability Program, Appendix E3 - Recycled Water Concepts

treatment, delivery, and any retrofits or modifications needed by the recycled water customer to use the water. In other words, it is the full cost of getting the water to the customer's tap. Typically, other water supply costs when cited for comparison do not reflect the full cost of treatment and delivery to the customer. They also commonly ignore differences in delivery reliability, which, as discussed previously, is of critical importance to the Bay Area.

3.4 Avoided Costs

Avoided or deferred water supply and wastewater treatment costs are two of the benefits listed in Figure 4 for recycled water projects. Within the Bay Area, where water supply options are increasingly limited and wastewater discharge requirements are becoming more rigorous, the avoided costs realized through water recycling are significant.

For example, the Bay Area Regional Water Recycling Program (BARWRP) concluded that by implementing water recycling the San Jose-Santa Clara Water Pollution Control Plant (SJSC) could save approximately $320 per acre-foot (updated to today's dollars) by allowing it to avoid the cost of constructing a new outfall to meet more stringent wastewater discharge requirements.[37]

When considering the cost of recycled water supply relative to other sources, these avoided costs need to be taken into account. For example, suppose the cost of producing the recycled water was $1,000 per acre-foot (about the average cost of recently evaluated Bay Area projects) and an alternative water supply could be secured through a desalination project or storage project for about $800 per acre-foot. At face value, the desalination or storage projects appear to offer the better value for the region. However, once the avoided wastewater discharge cost is taken into account, recycled water becomes the least cost option.

BARWRP noted that "new water quality regulations may require that discharge into the San Francisco Bay of specific contaminants of concern, particularly copper and mercury, be significantly reduced. The wastewater agencies currently discharge very small amounts of these metals. Nevertheless, the current proposal for the Mercury TMDL requires a 40 % reduction of mass loads from Bay Area municipal wastewater within 20 years. This reduction can potentially be achieved with investment in tertiary treatment

[37] Bay Area Regional Water Recycling Program (1999). San Francisco Bay Area Regional Recycling Program Recycled Water Master Plan.". Page 8-8.

across the Region, A 2003 report by Larry Walker Associates and Applied Marine Sciences evaluated incremental treatment costs to meet proposed POTW limits for mercury discharged to the bay and estimated a mid-point cost of $900 per acre-foot (updated to today's dollars).[38] Other options available to the POTWs to reduce the mass loading of mercury and other pollutants to the Bay are an equitable and functional offset program or a more aggressive water recycling program. If water recycling is part of the solution to meet water quality attainment strategies, the incremental cost over an above the cost of treatment for discharge is small.

BARWRP evaluated near-term, mid-term, and long-term recycled water projects for the Bay Area. The mid-term projects are reflective of projects being considered today while the long-term projects are reflective of very aggressive investment in regional recycling. BARWRP concluded that the monetary benefits of avoided water supply and wastewater disposal costs would more than cover costs for mid-term projects and could cover costs for long-term projects under the assumption that wastewater discharge regulations become more restrictive. The results of the BARWRP evaluation are summarized in Table 3.

Table 3: BARWRP Evaluation of Avoided Cost Benefits of Bay Area Recycled Water Projects

	Mid-Term	Long-Term[b]
Supply (AF/Yr)	242,000	411,000
Cost (Mil. $)[a]	$3,800	$12,200
Cost ($/AF)	$900	$1,890
Avoided Costs (Mil. $)[a]		
Low	$5,200	$6,500
High	$9,600	$14,200
Net Benefits		
Low	$1,400	($5,700)
High	$5,800	$2,000

Notes:

[38] Grovhoug, Tom, et al. (2003). "Mercury Management By Bay Area Wastewater Treatment Plants: Approaches, Costs and Benefits of Alternative Scenarios for Implementing the San Francisco Bay TMDL Mercury in Municipal and Industrial National Pollution Discharge Elimination System (NPDES) Permits." Larry Walker Associates and Applied Marine Sciences, Inc. September 2003.

a. Costs updated to today's dollars and rounded to nearest hundred million.
b. BARWRP considered two long-term scenarios: conservative and visionary. Only the conservative scenario is represented in the table.

Source: BARWRP Table 8.3.

The average costs per acre-foot for the two recycled water scenarios shown in Table 3 are relatively high and may compare unfavorably with average costs for other water management options, such as conservation or water transfers. But this would be an incorrect comparison. Recycled water projects generate multiple benefits, not just water supply. Net benefits to the region provide the appropriate economic basis for comparison. Results from the BARWRP study indicate recycled water projects are likely to do well in such comparisons. This also illustrates the reason why support of the State and Federal grant programs is important, so that the regional benefits can be realized through a reduction of the local cost of the project.

3.5 The Value of Diversity

By dispelling common misperceptions about the economics of recycled water it is not this paper's intent to suggest or imply that recycled water programs should supplant other water management options available to the Bay Area. The Bay Area IRWMP clearly shows that the region will need to pursue a diverse mix of water management strategies in order to meet its water supply, water quality, flood protection, and environmental protection objectives. Recycled water by itself cannot provide a comprehensive solution. Used in conjunction with other water resource management tools, however, recycled water can contribute to a more diverse and robust regional water supply in an economically sound manner.

4 Implementation Challenges

While the Bay Area IRWP and BARWRP studies have shown tremendous potential for recycled water in the Bay Area, there are a number of implementation challenges the region must address in order to realize this potential. These challenges include securing state and federal participation in regional recycled water projects; coordinating local recycled water plans and projects; resolving jurisdictional constraints; addressing contaminants of potential concern; improving public knowledge and understanding of recycled water; and addressing public health risk perceptions.

4.1 Regional Recycled Water Projects Require State/Federal Participation

Single-entity financing of recycled water projects is problematic for the reasons enumerated in the previous section. Regional recycled water programs produce multiple benefits, some of which transcend local agency jurisdictional boundaries, and most of which contribute towards State and federal water policy objectives. The Recycled Water Task Force concluded there is a State and federal interest in regional recycling.[39] While various State and federal agencies within California administer funding programs for recycled water, each of these programs has a different application process and no requirements exist for agencies to coordinate their funding efforts.[40] Moreover, State and federal funds available for regional recycling have been highly variable from year to year, making it more difficult for regions such as the Bay Area to sustain the momentum of regional programs. For example, State and federal funding for BARWRP, a federal, state, and local agency partnership formed in the 1990s, has been eliminated. A federal bill, HR 1526, would authorize federal funding to this important Bay Area Program.

However, without federal funding through Title XVI of Public Law 102-575, and State participation through various loan and grant programs administered by DWR and SWRCB, many important Bay Area recycled water projects would not have moved forward. Moreover, State and federal participation were instrumental in developing the Bay Area's water recycling regional master plan and State funding was instrumental in developing the Bay Area IRWMP. Moving from planning to implementation also will require state and federal participation. As recently noted by Congressman George

[39] Recycled Water Task Force (2003). "Water Recycling 2030: Recommendations of California's Recycled Water Task Force." June 2003.
[40] Ibid.

Miller, "[i]t only takes a small federal investment in the Bay Area Water Recycling Program to yield massive dividends to [the] region over time."[41] The Recycled Water Task force reached a similar conclusion and recommended that the State increase funding available for regional water recycling projects.

4.2 Challenges of Moving from Local to Regional Implementation

Cooperation between water, wastewater, and, often other governmental agencies is essential to implementing large-scale recycled water programs, but not always easy to achieve. BARWRP identified several key issues that have constrained large-scale implementation of recycled water projects in the Bay Area, including the following:[42]

- The water and wastewater agencies implementing recycled water projects need to agree on how the recycled water will be delivered, wholesaled, and retailed in the service area. Without agreement on these issues, a recycled water project cannot be implemented.
- Differing needs drive water and wastewater agencies decisions on recycled water projects. Water agencies generally view recycled water as a water supply resource that can improve regional water supply reliability. Wastewater agencies, on the other hand, typically consider water recycling as a method of wastewater disposal in response to current effluent regulations, limitations on disposal capacity, and future effluent regulations. These differing viewpoints can affect each agency's decisions on the need, timing, and scale for a given recycled water project.
- Cost allocation can also be a difficult issue for water and wastewater agencies to resolve. Recycled water projects generate both water supply and waste disposal benefits in varying proportions. Regardless of what the specific circumstances are, water and wastewater agencies will both benefit from a recycled water project to some extent. However, determining the amount of benefit accruing to each type of service and relating this back to project costs often is not straightforward and can be a source of disagreement.

[41] http://www.house.gov/georgemiller/rel031607.html
[42] Bay Area Regional Water Recycling Program (1999). San Francisco Bay Area Regional Recycling Program Recycled Water Master Plan." Chapter 9.

- A wastewater agency implementing and funding a recycled water project on its own must still involve the affected water agency to comply with the Service Duplication Law. The Service Duplication Law states that when a public or private water supplier extends its water facilities into the service area of another utility with the same type service, such an act constitutes a taking of the property of the utility for a public purpose; to the extent that the utility is injured. The local governmental entity engaged in such activity must pay just compensation for the property taken. On the one hand, the Service Duplication Law compels cooperation between the water and wastewater agencies. On the other hand, it can be used to block or slow the implementation of recycled water projects.

BARWRP and the Bay Area IRWMP both stress the need for a regional recycled water program to address these and other local water and wastewater agency coordination challenges. Such a program would provide essential coordination functions, including:[43]

- Prioritizing recycled water projects and activities;
- Identifying when, where, and how to interconnect the local recycled water projects to support the long-term interests of the region;
- Providing a forum to assist in balancing differences that may exist between local water or wastewater jurisdictions;
- Providing guidelines for recycled water project cost-sharing agreements;
- Developing and administering a regional program to facilitate transfers and exchanges of water among water entities and water recycling producers; and
- Developing and administering a regional water banking or wastewater discharge credit system.

4.3 Trace Constituents in Water

Endocrine disrupting compounds (EDCs), personal care products, and pharmaceutically active compounds are part of a growing list of trace constituents being detected in some treated wastewater and drinking water supplies. They are not unique to the use of recycled water, but rather are ubiquitous to most water supply and wastewater sources. Generally they are detected in very low concentrations. Even though these compounds are ubiquitous to surface and groundwater supplies, the potential presence of trace

[43] Ibid.

constituents in recycled water is sometimes cited as a reason for opposing recycled water projects, and public perceptions of health and environmental risks may push the industry to adopt more advanced and more expensive treatment processes.

Current research suggests that the potential risks of EDCs are dose/potency related; that there is a "no-effects" exposure threshold.[44] Researchers suspect exposure to high concentrations of these substances may pose the greatest risks, while exposure to low or very low concentrations may pose little or no risk and may, for certain substances, result in beneficial effects.[45] Most research is focused on whether and to what extent exposure of aquatic species to high levels of EDCs affects their development and reproduction. Current research does not indicate a significant risk of adverse health effects to humans or wildlife at low levels of concentration.[46] Additionally, existing treatment technologies have been shown to be effective at reducing trace constituents to very low levels in treated water.[47]

4.4 Public Understanding of Recycled Water

Issues related to public understanding of recycled water can be as complex as the engineering required to produce it and require serious investment. Public resistance to recycled water projects often derives from fundamental misunderstandings about the water cycle, downstream water reuse, and intended uses of recycled water. There is also a strong psychological component to how people come to judgment about differing types of water reuse. For example, the greatest public opposition to recycled water is for potable purposes, yet most of the public does not voice similar concerns about its primary drinking water supplies, even though nearly all of us in the Bay Area are downstream from other water users, and much of our imported water has already been "recycled" at least once before reaching us.

Expanding recycled water use in the Bay Area will require devoting resources to the public understanding of water reuse. This educational component must address a range of topics, including:

[44] http://extoxnet.orst.edu/faqs/pesticide/endocrine.htm
[45] Ibid.
[46] Ibid.
[47] Ibid and Snyder, Shane A., et al. (2006). "Ozone Oxidation of Endocrine Disruptors and Pharmaceuticals in Surface Water and Wastewater." Ozone: Science and Engineering, 28:445-460.

- A better understanding of regional imported and locally derived water supplies; their respective reliability and sustainability; and the extent to which they are shared with other users within and outside of the region via natural recycling.
- More information about the various technologies that can be used in combination or alone to produce recycled water appropriate to specific circumstances or uses.
- Additional public information about risks of recycled water given appropriate pairings of treatment technology with intended uses, so as to avoid excessive investment in treatment technologies providing little or no additional risk reduction benefits.
- More effective methods for distributing information about recycled water to the public and working with different groups of stakeholders. Some fundamental principles of public involvement applicable to this last point are described in the next section.

4.5 Addressing Public Health Perceptions

Public acceptance of recycled water use is dependent on confidence that its use is safe. In general, public support for non-potable uses of recycled water has been strong. Controversy has focused mainly on indirect potable reuse projects, where recycled water would become part of the drinking water supply, either via groundwater or surface water reservoirs.[48] Proposed non-potable uses of recycled water generally raise fewer public health concerns, often limited to concerns about place of use and the possibility of cross-connection of recycled water distribution lines with drinking water distribution lines.

State law regulates the production and use of recycled water in California. Title 22 of the California Code of Regulations establishes water quality and public health requirements that recycled water use in California must satisfy. The Department of Health Services (DHS) is responsible for establishing these requirements and Regional Water Quality Control Boards are responsible for enforcing them. In addition, Title 17 of the California Plumbing Code establishes requirements to prevent cross connections between recycled water systems and drinking water systems. DHS and local health departments enforce these regulations.

[48] Recycled Water Task Force (2003). “Water Recycling 2030: Recommendations of California’s Recycled Water Task Force.” June 2003.

These laws and regulatory structures have been effective in ensuring that uses of recycled water in California protect public health and safety. Numerous research projects have also reaffirmed the public safety of recycled water when applied to its intended uses.[49] These findings, however, have not translated into universal public acceptance of recycled water. Public perceptions of the safety of recycled water use have become a growing factor in whether there is widespread community support or objection to proposed recycled water projects. For example, in a study of the safety of reclaimed water to irrigated parks, playgrounds, and schoolyards that evaluated 250 individual sites in nine states, Crook (2005) notes that "[w]hile there have been no reported adverse health effects to children or others resulting from reclaimed water use at any of the … sites …, public concerns over the safety of the practice occasionally arise."

A substantial amount of research has been done to understand public acceptance of recycled water.[50] This research has shown that public acceptance of recycled water is higher when:[51]

- The degree of human contact is minimal;
- Protection of public health is clear;
- Protection of the environment is a benefit of reuse;
- Promotion of water conservation is a benefit of reuse;
- The community has high awareness of water supply problems;
- The role of recycled water in the overall water supply is clear;
- The perception of the quality of the reclaimed water is high; and
- Confidence in local management of public utilities and technologies is high.

Communicating and having a dialog about these issues with the public in a forthright and honest way needs to be a part of every recycled water project.

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[49] See, for example, Crook, James (2005). "Irrigation of Parks, Playgrounds, and Schoolyards with Reclaimed Water: Extent and Safety." Sponsored and Published by WaterReuse Foundation. This report provides a long bibliography of studies addressing the safety of reclaimed water when applied to its intended use.
[50] Much of this research is reviewed in Hartley, Troy W. (2003). "Water Reuse: Understanding Public Perception and Participation." Water Environment Research Foundation.
[51] Ibid. Page 1-2.

The Recycled Water Task Force emphasized the importance of using community value-based decision-making models during the planning phase of recycled water projects. This recommendation has been echoed by other research as well.[52] Such models are based on the following general public participation principles:[53]

- Involve the public in all phases of project planning, including developing and selecting alternatives.
- Listen and respond to public concerns with respect and incorporate community values into the decision criteria. Acknowledge and validate fears and concerns and address them with accurate information and, if necessary, changes in project design.
- Disseminate adequate and understandable information about the proposed project and its role in regional water management to a broad array of public forums.
- Explain how the project contributes to fundamental community needs or desires, such as a safe and reliable water supply, prevention of water pollution, and environmental protection and enhancement.
- Incorporate concepts of environmental justice, fairness, and equity into the decision-making process.

[52] Ibid.
[53] Adapted from Recycled Water Task Force (2003). "Water Recycling 2030: Recommendations of California's Recycled Water Task Force." June 2003.

5 Advancing Recycled Water in the Bay Area

Recycled water holds great promise for Bay Area water management. This paper has reviewed a range of potential benefits of recycled water to the region as well as addressed issues of economics and challenges of implementation. Recycled water is a complex subject that touches on numerous aspects of water management, public finance, health and safety, and community involvement. During discussions about recycled water it is easy for important benefits to get short shrift or for valid concerns about affordability and safety to be too easily dismissed. Consistently communicating information about recycled water in terms of water management, water quality, environmental enhancement, regional planning, public finance, and public safety will be an important part of advancing recycled water in the Bay Area.

This paper concludes with six key messages about recycled water in the Bay Area. Each message relates to and is supported by the information presented throughout this paper.

5.1 Six Key Messages

1. The Bay Area's current sources of water are inadequate to meet the dual challenges of population growth and climate change. Expanding the region's recycled water resources is necessary to ensure an adequate and reliable supply of water into the future.

The Bay Area's current water supply systems cannot meet the challenges of population growth and climate change. The region needs to diversify its water supplies and reduce its dependence on imported water. Recycled water is one of the keys to diversification. It utilizes proven and economically feasible technologies, provides drought proof supply, has a smaller energy footprint than most other supply options, and can provide the region with tens to hundreds of thousands of acre-feet of new water supply. Recycled water is a core water supply reliability strategy of the Bay Area IRWMP.

2. Recycled water projects are unique in their ability to simultaneously address multiple regional water management objectives.

Bay Area water management agencies are using water recycling to augment water supplies, reduce the impacts and costs of wastewater disposal, and restore and improve sensitive natural environments. Few other water management options provide the diversity of possible uses and applications as recycled water.

3. Recycled water is affordable and cost competitive with other water supply options available to the Bay Area

Recycled water projects make economic sense in most cases. Contrary to assertions that most recycled water projects are economic losers, regional studies involving detailed economic analyses of specific project proposals have concluded that the economic benefits would exceed costs of construction and operation over a broad range of implementation levels. Cost comparisons with other supply alternatives are generally favorable. This is not to say that all recycled water projects are sound economic investments. Each project must be able to stand on its own bottom line in terms of the benefits it produces for the Bay Area. Agencies must utilize rigorous benefit-cost tests as a part of project screening and prioritizing.

4. State and federal participation is essential to implementation of a large-scale regional recycling program

Single-entity financing is often unsuited to financing large-scale recycled water programs in the Bay Area because of jurisdictional boundary issues. Economically beneficial recycled water projects are at risk of not getting implemented without state and federal participation. State and federal participation were instrumental in developing the Bay Area's water recycling regional master plan and State funding was instrumental in developing the Bay Area IRWMP. The Recycled Water Task Force concluded there is a State and federal interest in regional recycling. As noted by Congressman George Miller, "[i]t only takes a small federal investment in the Bay Area Water Recycling Program to yield massive dividends to [the] region over time."

5. Public safety of recycled water is paramount

California's laws and regulatory structures have been effective in ensuring that designated uses of recycled water in California protect public health and safety. Numerous research projects have also reaffirmed the public safety of recycled water within its designated uses. Regional recycling cannot move forward without public confidence in the resource. Public confidence in the safe application of recycled water varies by type of use. When discussing the safety of recycled water, it is important to emphasize matching appropriate technology to intended use. Given existing treatment technologies, recycled water can be made safe for all designated uses.

6. The Bay Area's Regional Recycling Program views recycled water as a local resource under local control and is committed to community involvement, understanding, and dialog

Recycled water is a local resource that must be developed in partnership with local communities. Meaningful public involvement must be incorporated into all phases of planning, development, and construction of recycled water projects. Responses to community concerns about public safety and environmental risks of recycled water must be addressed openly, using the best available science and information. To advance water recycling in the Bay Area water agencies and regional leaders must invest in general public awareness and understanding of how recycled water can be safely used to address some of the most pressing water issues confronting the Bay Area.