

**Analysis of Water Resources Management Strategies
for the Santa Ana River Watershed Region:
Water Reuse, Recharge and Use Efficiency**



Group Project Thesis
for the degree of
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for the
Donald Bren School of Environmental Science & Management
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By:
Nathan Adams
Heather Allen
Amy Burgard
Courtney Dietz
Po Chi Fung
Karl Rittger

Advisors:
Dr. Arturo Keller
Dr. Robert Wilkinson

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Nathan Adams

Heather Allen

Amy Burgard

Courtney Dietz

Po Chi Fung

Karl Rittger

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The Group Project is required by all students in the Master's of Environmental Science and Management (MESM) program. It is a three quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management and policy dimensions of a specific environmental issue. The final Group Project report is authored by MESM students and has been reviewed and approved by:

Dr. Arturo Keller

Dr. Robert Wilkinson

Dean Ernst von Weizsäcker

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ABSTRACT

In order to accommodate the water demands of a growing population and economy, water purveyors within the Santa Ana River Watershed Region (SARW) have become pioneers in developing local water management strategies in lieu of importing additional supplies of water. However, the region's population is forecasted to exceed 6.5 million people in 2025, an increase of 24% from 2005 population, and future supplies of imported water are beset with uncertainties. Therefore, the SARW Region must continue to develop water reuse, recharge, and use efficiency strategies to ensure future water reliability and local reliance.

The significance of this project is that we explore the interplay between alternative plausible future water demand and supply scenarios. The 2005 Urban Water Management Plans (UWMPs) for the region provide the baseline demand and supply projections and are contrasted with alternative future scenario projections in which we demonstrate the potential for the agencies within the region to reduce imported water supplies by 45,000-785,000 Acre-Feet by 2025, depending on the combination of demand and supply options.

Whereas baseline projections for 2025 forecast imports represent 36% of the total supply, there is the potential to reduce imports to only 3% of the total supply in 2025 if cost-effective water reuse, recharge, and use efficiency management strategies are aggressively pursued and implemented throughout the Region. Such a reduction would result in approximately \$1 billion in avoided imported water supply costs; savings which could fund the implementation of alternative demand and supply management strategies.

Executive Summary

Opportunity

In the semi-arid western United States, water suppliers and planners tasked with providing water to a growing population have historically procured supplemental water from afar, conveying the water through elaborate systems of aqueducts, pipes, pumps and reservoirs. In order to supply its 26 Southern California member agencies with water, the Metropolitan Water District of Southern California (MWD) imports water from Northern California via the State Water Project (SWP) as well as from the Colorado River. These sources of imported water are limited and fraught with numerous uncertainties regarding future water supply reliability.

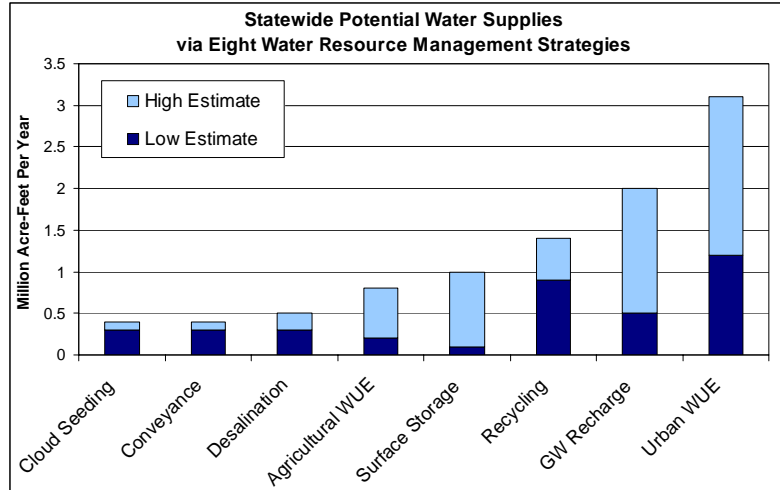


Figure ES- 1: Alternative management strategies for water resources identified by DWR in the State Water Plan 2005 Update. Combining water use efficiency with recharge and reuse can potentially supply approximately 6.5 million AFY of water to the State of California.

Both California and regional water agencies recognize the need to develop local water resources. For example, the Department of Water Resources (DWR) in its State Water Plan 2005 Update identified Water Use Efficiency (WUE), Groundwater Management and Recharge, and Water Recycling/Reuse as the top three management strategies (Figure ES-1). In this project we evaluate the potential for implementing the top three management strategies for each water agency within the Santa Ana River Watershed (SARW) Region by considering the interplay between plausible future water demand and supply scenarios.

Significance

In order to accommodate the water demands of a growing population and economy, the water agencies within the SARW Region have become pioneers in developing water reuse and recharge technologies and implementing policies and programs addressing water conservation. However, the SARW Region must continue to develop water demand and supply management strategies to ensure future water reliability and local reliance because the region's population is forecasted to be roughly 6.5 million in 2025, an increase of 24% from 2005 (MWD RUWMP, 2005).

In this project we explored the interplay between alternative plausible future demand and supply scenarios. We used the local and regional 2005 Urban Water Management Plans (UWMPs) to establish the baseline supply and demand projections for the SARW Region. By contrasting these baseline projections with alternative plausible future scenario projections we demonstrated the potential for the region to both reduce and replace imported water supplies with locally-derived sources of water, as shown in Figure ES-2.

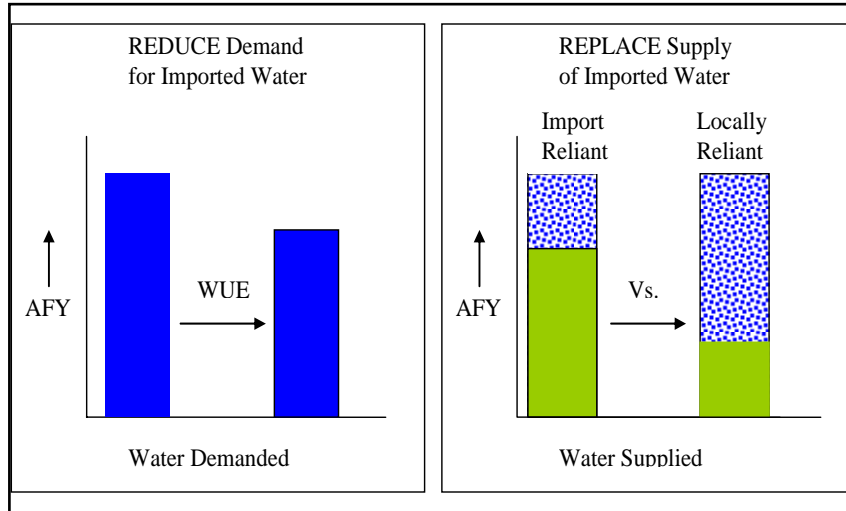


Figure ES- 2: WUE can result in reducing the amount of water Region and developing additional local water resources (via reuse and recharge) can make the region less reliant on imported supplies (AFY = acre-feet per year)

By varying the degree of aggressiveness of strategies for WUE, agencies can alleviate the region-wide pressure to develop and procure additional imported sources of water. Furthermore, if water agencies within the SARW Region continue to pursue the development of local water resources through reuse and groundwater recharge, they can replace imported supplies with the developed local resources.

Demand Management Strategies – Water Use Efficiency

There are multiple factors that influence the demand for water (e.g. weather, population, housing type, water use efficiency, etc.) for any given region. While it is possible to explore how changes in several of these variables alter demand, our analysis focuses on urban WUE intensity values. These values reflect policy options on the part of water agencies in which management strategies are used to affect the urban demand of water. Alternative demand scenarios developed for this analysis focused on altering the baseline scenario percentage of WUE intensity. This is accomplished by using the Water Scenario Evaluation Model (WASEM), which was developed to evaluate demand and supply scenarios (Groves et al. 2006). WASEM is based on the state-wide water demand scenario generator used to quantify three scenarios of water demand for the California Water Plan Update 2005 (Groves et al. 2005; DWR 2005) and used by the Pacific

Institute for their study “California Water 2030: An Efficient Future” (Gleick 2005).

We considered three alternative levels of efficiency: one from Pacific Institute’s *Waste Not, Want Not* report (Gleick et al. 2003) and two that we have tailored specifically for the SARW Region. These alternative demand scenarios were compared against the baseline demand scenario to explore how different management strategies can affect urban demand in the SARW Region.

The Pacific Institute’s 2003 study reported significant potential water savings attributable to new and emerging technologies, programs, and policies. For this reason, we have developed an alternative demand scenario that applies the potential water savings Gleick et al. 2003 report for the region. However, the Pacific Institute’s analysis did not include the following technologies and programs in its evaluation: Waterless urinals, Dual-Flush Toilets, ET-Based Irrigation Controllers, and California Appropriate Landscaping (CALscape). Thus, two scenarios were crafted specifically for the SARW Region which included these previously omitted programs and technologies. Figure ES-3 illustrates the plausible future demand projections that result from the different demand scenarios. Note how the baseline demand increased, whereas the alternative scenarios project stabilized or decreased demand by 2025.

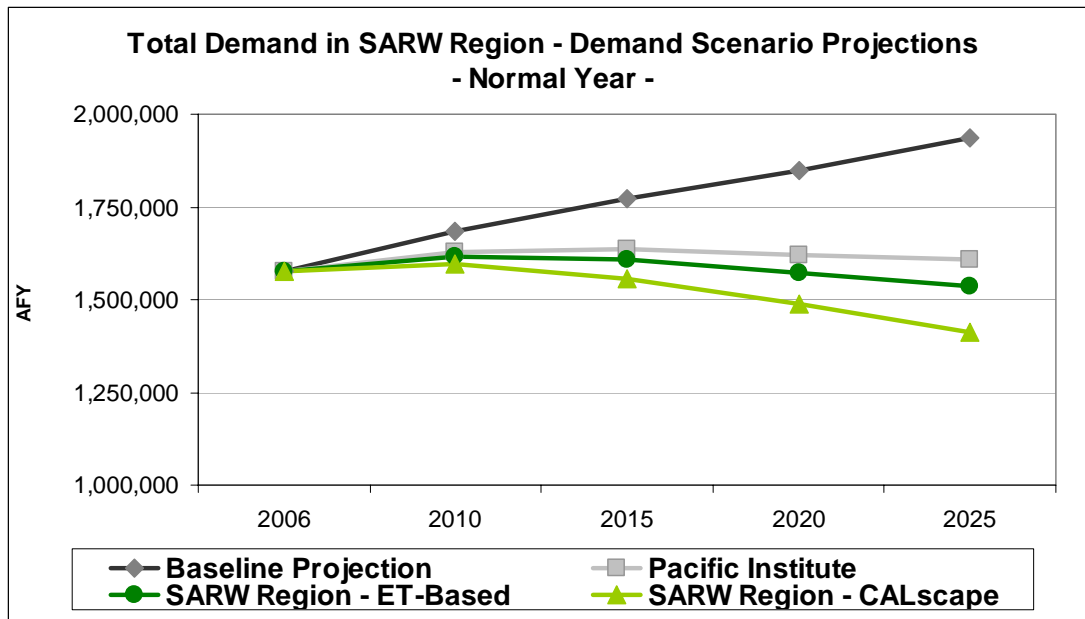


Figure ES-3: Plausible future demand projections if varying degrees of water use efficiency intensity is implemented, compared to baseline projections

Water Supply Strategies – Water Reuse & Groundwater Recharge

For this report, three alternative supply scenarios were created that feature increased levels of local resource development above and beyond what the SARW Region’s water districts UWMPs project and plan for. The three supply strategies are:

- 75% Maximum Reuse + Baseline Recharge Scenario
- 75% Maximum Reuse + Maximum Recharge Scenario
- Maximum Local Supplies Scenario

These alternative supply scenarios have been created such that they progressively develop additional local groundwater and municipal reuse supplies. Reuse is defined as the beneficial reuse of municipal treated wastewater. Often this water is treated to secondary standards, as required for discharge, but is then disposed of without any further use. For the Maximum Local Supplies Scenario, each water district in the region would be reusing 95% of their treated wastewater by 2025 and maximizing the sustainable safe yield of the groundwater basins that underlie each district through recharge. The parameter for reuse was taken from the fact that Inland Empire Utility Agency (IEUA) has projected that they will reuse 95% of treated wastewater. The 75% reuse scenarios result in each agency reusing 75% of their municipal wastewater that is treated to tertiary levels by 2025. Several agencies in the region are already reusing around 75% of treated wastewater, thus this level of future reuse is plausible.

Figure ES-4 illustrates the supply projections that result from the three alternative supply scenarios. By 2025, the maximum local supplies scenario is projected to increase total supplies about 260,000 AF (acre foot) over baseline projections¹.

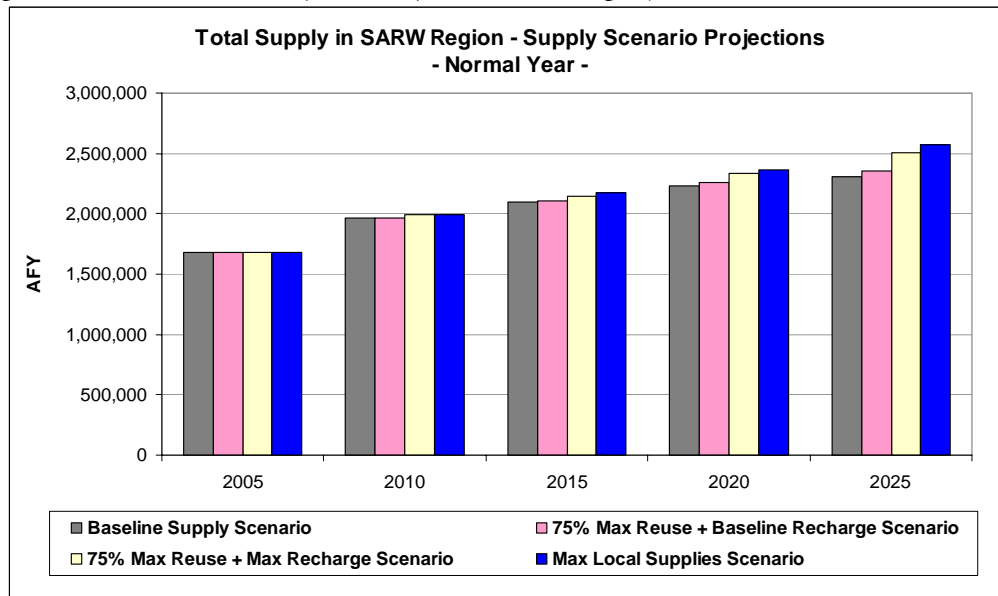


Figure ES-4: Plausible future supply projections compared to baseline projections if reuse & recharge management strategies are aggressively pursued

Plausible Future Scenario Evaluations

Water managers in the SARW Region are tasked with procuring, developing, storing, and delivering the requisite water resources to supply the growing demands of the region.

¹ An acre-foot of water is the volume of water that will cover one acre to a depth of one foot.

Thus, water managers must balance the delicate interplay between supplying the water demands of today while preparing a portfolio of supply options to meet a dynamic future demand. In our project, we examine plausible future supply and demand balances, or resource mixes, and the degree to which different scenarios result in the SARW Region becoming more locally-reliant in regards to future water supplies.

Using the methodology illustrated in Figure ES-2 of potentially reducing imported supplies through demand management strategies and replacing imported water with developed local supplies, the SARW Region has the opportunity to significantly increase its local-reliance with regards to water resources. By combining the various demand and supply scenarios, the potential exists to reduce imported supplies from 45,000-785,000 AF, as shown in Table ES-1. The potential reductions increase as one moves down the rows (Supply Scenarios) and across the columns to the right (Demand Scenarios).

Potential Decrease of Imported Supplies by Scenario (AF)				
Scenarios	Baseline Demand	Pacific Institute	SARW Region - ET Controller	SARW Region - CALscapes
Baseline Supply	-	330,000	403,000	525,000
75% Max Reuse + Baseline Recharge	45,000	375,000	448,000	570,000
75% Max Reuse + Maximum Recharge	195,000	525,000	598,000	720,000
Maximum Local Supplies	260,000	590,000	663,000	785,000

Table ES-1: Potential reductions range from 45,000-785,000 AF as the potential reductions increase as one moves down the rows (Supply Scenarios) and across the columns to the right (Demand Scenarios)

Approximately 785,000 AF of imported water may be potentially avoided in the Region if the SARW Region CALscape demand scenario is combined with the Maximum Local Supplies scenario.

Given this combination, it would be possible to reduce imported supplies significantly, such that imports would comprise only ~3% of the total supply by 2025 (Figure ES-5). Additionally, this scenario permutation would stabilize and decrease the supplies required to satisfy demands over time, so that by 2025 the resource mix only increases 6% over 2005 levels.

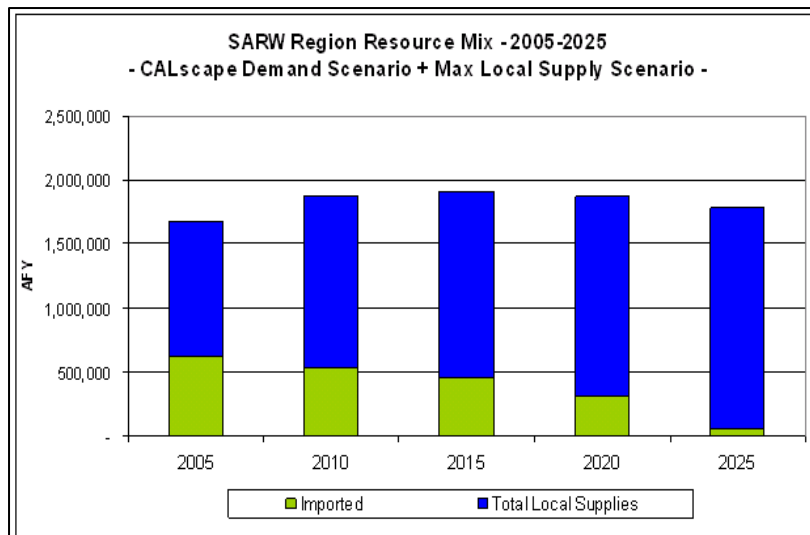


Figure ES-5: Resource mix resulting from aggressively implementing alternative management strategies in the SARW region

so that by 2025 the resource mix only increases 6% over 2005 levels.

Contrast this with the baseline resource mix in which imported water supplies constitutes 37% of the total supply in 2025 (Figure ES-6).

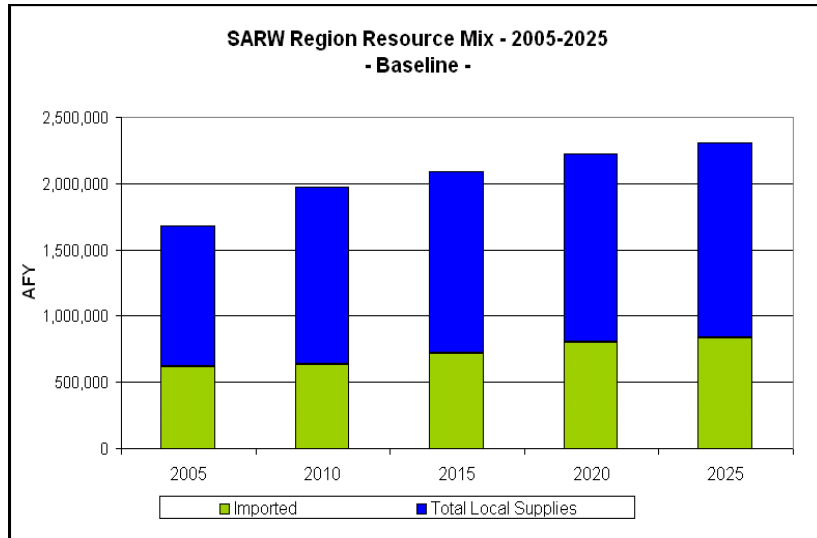


Figure ES-6: Resource mix resulting from the baseline supply and demand scenarios for the SARW region

Environmental Benefits of Increasing Local Reliance

Based on our assessment, the top three potential water resources that the DWR 2005 State Plan Update identifies are in fact quite significant for the SARW Region, if not underestimated. The significant reduction in imported supplies in the CALscape Demand + Max Local Supplies scenario would result in approximately \$1 Billion savings by 2025 in avoided costs associated with imported water (Figure ES-7).

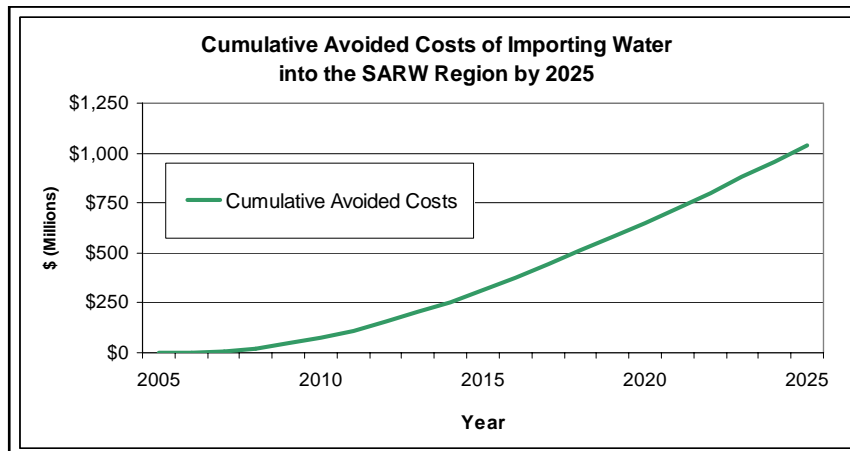


Figure ES-7: Approximately \$1 billion could be saved by 2025 in avoided costs associated with imported water if demand management and local resources development strategies are implemented

As a consequence of aggressively pursuing and developing local water management strategies the SARW Region would become less susceptible to water supply reliability problems related to limited and uncertain imported water supplies. Local ecosystems and riparian habitats would benefit from enhanced groundwater management and recharge as additional water would be present and available in the hydrologic system, raising in-stream water levels and protecting against seawater intrusion, even in drought conditions. Ecosystems such as the San Francisco Bay-Delta would also benefit as the burden to supply water resources to the SARW Region declines.

Summary of Barriers

This report has identified several barriers to implementation as identified below in order to help illuminate why these strategies have not been implemented.

Cost: Though water reuse, recharge, and use efficiency strategies are largely cost-effective, like other large scale projects, they often have high initial capital costs. The process of securing the initial capital can often be a challenge for water agencies and municipalities.

Land-Use Planning: Planning for the infrastructure requires effective and efficient land-use planning in order to implement water-saving measures in new development. For example, installing the pipelines for water reuse before a city has expanded significantly saves on the cost as opposed to retrofitting and trying to add the infrastructure once the city has already built out to an area.

Capitalizing on the Opportunities: Often a limitation is that people do not have full information as to what their opportunities actually are. For example, some consumers are unaware that dual-flush toilets are available, let alone the water savings that may be available to them. Furthermore, communication between the water districts themselves can be a barrier to implementation. Water district boundaries do not follow the natural boundaries of the watershed which decreases the collaboration between agencies. Agencies often benefit from working together in a region. A great example is the Orange County Water District which funded the formation of the Prado Wetlands, a natural treatment system completely out of Orange County, in order to more cost-effectively maintain water quality downstream in its own county.

Summary of Recommendations

Based on the analysis of this project, there are several recommendations provided to maximize the local water resources in the SARW Region. The recommendations are as follows:

- Maximize cost-effective urban water use efficiency technologies & programs
- Maximize the capture & recharge of stormwater
- Maximize reuse opportunities
- Increase regional cooperation between water agencies.

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ACRONYMS

AF	Acre-Feet
AFD	Acre-Feet per Day
AFY	Acre Feet per Year
AGWA	Association of Groundwater Agencies
AHHG	Area of Historic High Groundwater
APUD	Anaheim Public Utility Department
BEA	Basin Equity Assessment
BHV	Basin Cleaning Vehicle
BMP	Best Management Practice
BPP	Basin Pumping Percentage
CALscapes	California Appropriate Landscapes
DFG	California Department Fish & Game
CCF	100 cubic feet
CFS	Cubic feet per second
CII	Commercial, Industrial, and Institutional
CIMIS	California Irrigation Management Information System
CUWA	California Urban Water Agencies
CUWCC	California Urban Water Conservation Council
DDT	Dichloro-Diphenyl-Trichloroethane
DOF	California Department of Finance
DOHS	Department of Health Services
DWR	California Department of Water Resources
DYY	Dry Year Yield
EIR	Environmental Impact Report
EMWD	Eastern Municipal Water District
ET	Evapotranspiration
FSCWA	Family of Southern California Water Agencies
GAP	Green Acres Project
GPCD	Gallons per Capita Daily
GPCY	Gallons per Capita Yearly
GPF	Gallons per Flush
GSA	Geological Society of America
GW	Groundwater
GWR System	Groundwater Replenishment System
IDP	Irvine Desalter Project
IEUA	Inland Empire Utilities Agency
IRP	City of Los Angeles' Integrated Resources Program
IRWD	Irvine Ranch Water District
LACSD	Los Angeles County Sanitation District
LAWRP	Los Alisos Water Reclamation Plant
LTF	Landscape Task Force
M&I	Municipal and Industrial
MAF	Million Acre Feet

MF	Multi-Family
MGL	Million Gallons per Liter
MMWD	Marin Municipal Water District
MOU	Memorandum of Understanding
MRWPCA	Monterey Regional Water Pollution Control Agency
MWD	Metropolitan Water District of Southern California
MWDOC	Municipal Water District of Orange County
NAWQA	USGS' National Water-Quality Assessment
NRW	Non-Reclaimed Water Line
NTU	Nephelometric Turbidity Units
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
PBMP	Potential Best Management Practice
PFRD	Orange County Public Facilities and Resources District
RO	Reverse Osmosis
ROI	Return on Investment
RUWMP	Regional Urban Water Management Plan
RWIP	Regional Water Implementation Plan
RWQCB	Regional Water Quality Control Board
SAR	Santa Ana River
SARW	Santa Ana River Watershed
SAWPA	Santa Ana Watershed Project Authority
SBCFCD	San Bernardino County Flood Control District
SBVMWD	San Bernardino Valley Municipal Water District
SBVWCD	San Bernardino Valley Water Conservation District
SCAG	Southern California Association of Governments
SCCWRRS	Southern California Comprehensive Water Reclamation & Reuse Study
SF	Single-Family
SNWA	Southern Nevada Water Agency
SWP	State Water Project
TDS	Total Dissolved Solids
USDA	United States Department of Agriculture
UWCD	Santa Paula's United Water Conservation District
UWMP	Urban Water Management Plans
VOC	Volatile Organic Compound
WASEM	Water Scenario Evaluation Model
WBMWD	West Basin Municipal Water District
WMP	Water Management Plan
WMWD	Western Municipal Water District
WNWN	Pacific Institute's "Waste Not, Want Not" Report
WRP	Water Reclamation Plant
WUE	Water Use Efficiency
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Goals and Objectives

This project was proposed by Earth Resource Foundation, which is an environmental educational non-profit organization developed to empower the general public with the resources needed to make environmentally sustainable choices and changes. This project evaluates ways to both reduce water demand and increase local supply within the SARW Region in order to reduce reliance on outside water sources. To reduce demand, we focused on water use efficiency strategies, i.e. ways to accomplish the same tasks with less water. To increase local supply, we looked at ways to increase water recycling and water recharge. By combining water demand and supply strategies, we hope to provide a glimpse of what an alternative future for the region's water resources would look like.

Specifically, our objective was to complete the following:

- Identify the potential for alternative water resources management strategies in the region
- Identify plausible future water resources demand and supply scenarios for SARW Region by evaluating current literature and case studies
- Contrast baseline projections with these alternative future demand and supply scenarios
- Identify possible barriers within the region to implementing alternative water demand and supply management strategies
- Present analysis to the Santa Ana River Watershed Alliance, other stakeholders, and the local community

To achieve the objectives of this project, the three main themes addressed were:

- Water Use Efficiency
- Water Recycling & Reuse
- Water Recharge

1.2 Significance of project

In the semi-arid western United States, water suppliers and planners tasked with providing water to a growing population have historically procured water from afar, conveying the water through elaborate systems of aqueducts, pipes, pumps and reservoirs. An emerging trend over the last few decades has found water suppliers increasingly embrace water management strategies that develop local water resources and reduce water use to provide for both water supply and reliability. Whereas water suppliers once viewed water conservation as a short-term option in times of drought or water scarcity, water districts in California are now investing in long-term water supply portfolios which include aggressive water conservation and local supply management strategies that augment existing water supplies. While it is true that the growth of California's economy and population is linked to the availability and development of water supplies, continued dependence on imported supplies may prove to undermine and erode California's natural and physical resources, the foundation of California's viability and vitality.

The demand for water in California is immense as it has the highest population and largest economy in the nation. California's diverse economy results in a gross product in excess of 1.4 trillion dollars, which is 13.5% of the U.S. total economy (DWR, 2005). Such a large economy is fueled by a population that has increased from 30 million people in 1990 to 36.5 million currently and is projected to reach approximately 48 million by 2030 (DOF, 2005), an increase of over 31%.

Enhancing water conservation and developing local water supplies are of paramount importance to local and regional water suppliers if they are to protect themselves from the vicissitudes of imported sources of water. Currently, the State Water Project (SWP) supplies at least some portion of water demanded to two-thirds of the state's population and irrigates approximately 750,000 acres of agriculture, but it faces water reliability challenges due to growing uncertainties in water sources, conveyance, and demand (DWR, 2005). The Metropolitan Water District of Southern California (MWD) imports water from the SWP and from the Colorado River via the Colorado River Aqueduct for use throughout Southern California, as seen in Figure 1. These sources of imported water are fraught with uncertainties regarding water supply reliability issues, which include:

- Water quality (e.g. salinity & total dissolved solids)
- Legal disputes over water rights and allotments between States, Counties, Municipalities, and other public agencies
- Ecological health (e.g. San Francisco Bay Delta & Mono Lake)
- Climatic variability
- Seismic events and Delta levee failures (Mount & Twiss, 2005)
- Potential impacts of global warming to precipitation rates, frequency, and duration



Figure 1: Federal, State, and Local Water Projects

Source: DWR, 2005

The California Water Plan Update 2005 lists 14 recommendations to decision-makers throughout the state to help maintain and manage water resources for the next twenty-five years. Their number one recommendation is as follows:

“California needs to invest in reliable, high quality, sustainable, and affordable water conservation, efficient water management, and development of water supplies to protect public health, and to maintain and improve California’s economy, environment, and standard of living (DWR, 2005).”

In an effort to identify alternative supplies of water, the State Water Plan 2005 Update, issued by the California DWR, targeted eight alternative management strategies with a potential to generate water supply benefits, as shown in Figure 2. Of the eight management strategies, DWR identified urban WUE as having the highest additional annual supply potential, ranging from a low estimate of 1.2 million acre-feet (MAF) to a high estimate of 3.1 MAF, which is enough to supply between 2.4 to 4.8 million average households in California for a year (CUWCC, 2005). The second and third highest annual supply potential is provided through conjunctive management of groundwater recharge and municipal recycling of water, which combine to provide a projected high estimate of 3.4 MAF per year. Aggregating the high estimates together, WUE, groundwater recharge and municipal recycling can potentially provide water suppliers across the state 6.5 MAF per year of high-quality water. It is important to note that these management strategies are local or regional in nature as opposed to the multi-jurisdictional, inter-basin water projects that have typified some water management strategies in California.

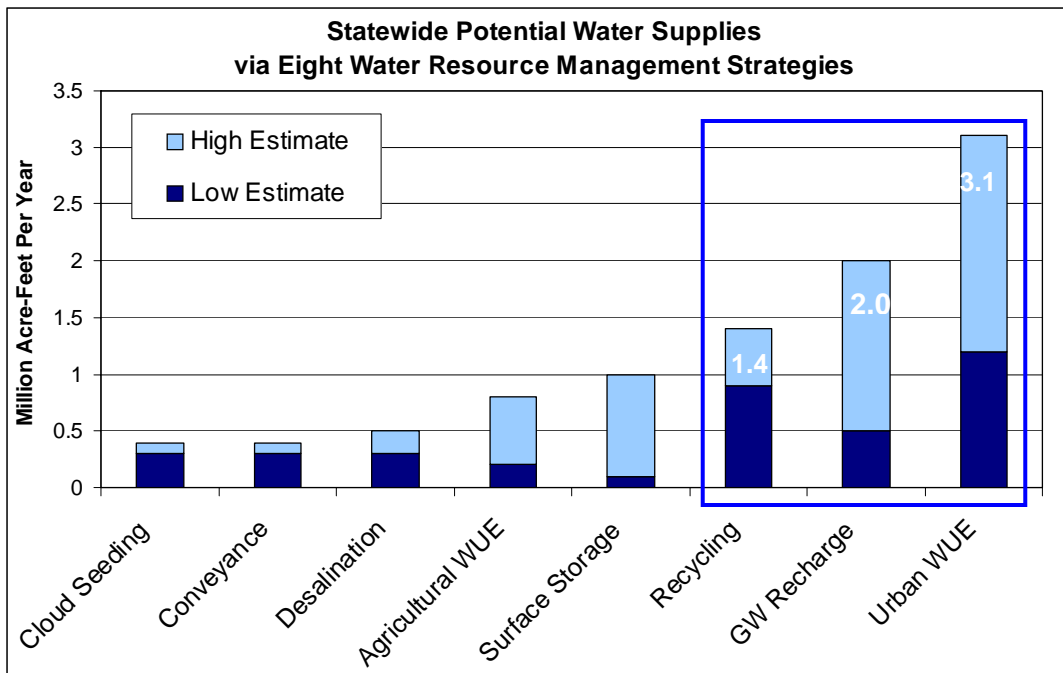


Figure 2: California state-wide water supply potential for top eight management options.
Source: DWR State Water Plan, Bulletin 160-05

The top three alternative water management strategies identified by DWR provide the impetus for our Master’s Group Project to analyze the efficacy and cost-effectiveness of such management strategies within the SARW Region in Southern California.

Providing alternative and innovative watershed management strategies for the SARW Region will affect one of the most populated and fastest growing areas in the nation, and therefore can have large positive effects on water resources and the environment in the

region as well as elsewhere. The results of this study have the potential for motivating similar areas to evaluate their current water savings and encourage improvements in policy in order to implement the necessary changes. The applicability of this study applies to all developed, urban areas particularly in arid regions where water resources management is challenged by extremely limited supplies. The importance of this analysis will likely become increasingly more valuable with the uncertainty of climate and the effects of global warming force more regions into states of limited water resources.

1.3 Background – Santa Ana River Watershed Region

1.3.1 General Description²

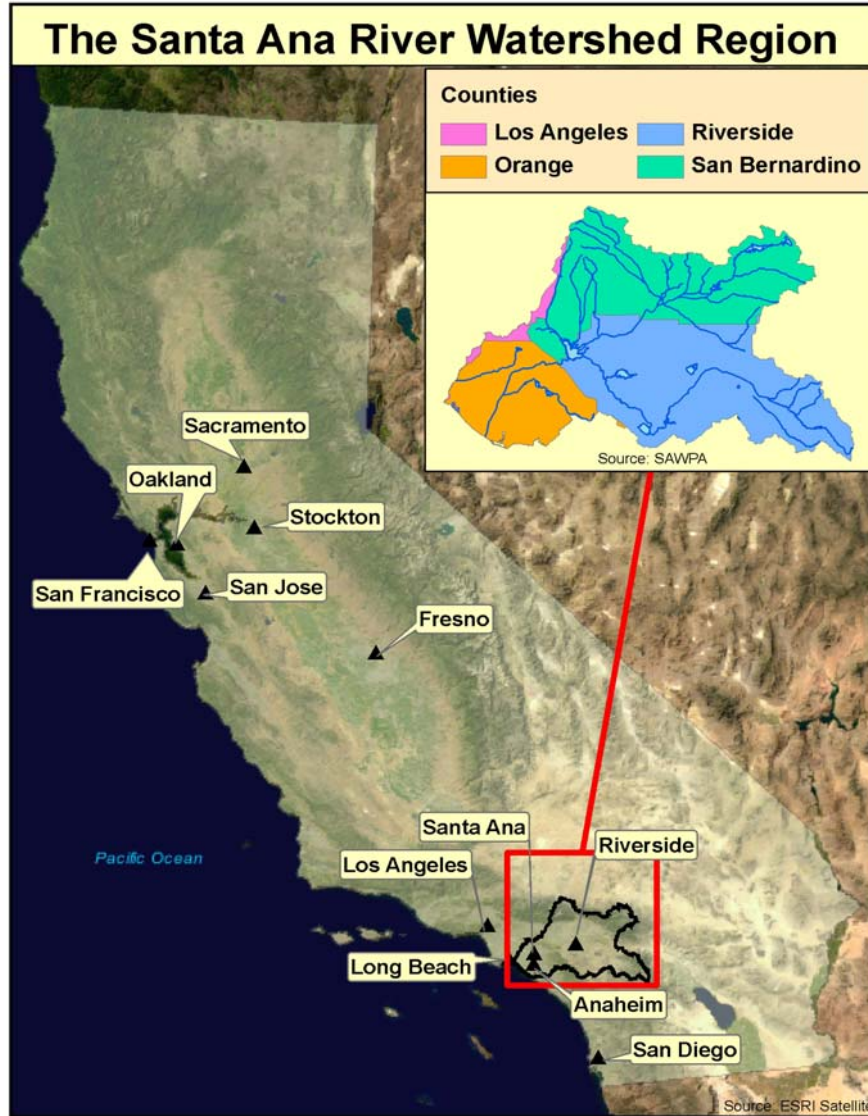


Figure 3: Location of the Santa Ana River Watershed Region in Southern California

The Santa Ana River is the largest coastal river system in Southern California, flowing over 100 miles from the San Bernardino Mountains to the Pacific Ocean and draining an area of approximately 2,800 square miles of mountains, foothills, and valleys. Containing portions of San Bernardino, Riverside, Orange, and Los Angeles Counties, the SARW

² This represents an aggregate view of the watershed. For a more detailed description of the individual water agency profiles, please refer to Supporting Research, Section A.

Region is home to more than 4.5 million people (Figure 3) (SAWPA, 2005). As the Santa Ana flows south it passes through the Seven Oaks Dam, the Prado Dam, and then into Orange County where it becomes largely channelized before discharging into the Pacific Ocean at Huntington Beach.

Political and water district boundaries do not overlap with the natural watershed boundaries, so our analysis focuses on the region comprised of the seven major water suppliers in the SARW Region. Water suppliers within the Region recently completed their 2005 Urban Water Management Plans (UWMPs), which provide the most current detailed water supply and demand projections for their service area. Map 1 at the end of this chapter shows the geographic context of the water supplier service areas within the SARW Region. Starting at the headwaters and working downstream, the following seven water suppliers and UWMPs were analyzed³:

- Eastern Municipal Water District (EMWD)
- Western Municipal Water District (WMWD)
- Inland Empire Utilities Agency (IEUA)
- City of Anaheim
- City of Fullerton
- City of Santa Ana
- Municipal Water District of Orange County (MWDOC)

1.3.2 Climate

Precipitation in the watershed varies depending on distance from the ocean, elevation, and topography. Note the orographic effect of the mountains affecting the average amount of precipitation. Average annual precipitation is about 20 inches, ranging from 11 inches at the coast to 40 inches in the headwaters in the San Bernardino Mountains. Map 2, Quadrant 2 at the end of this chapter shows average yearly rainfall throughout the Region. The Region has a Mediterranean climate with hot dry summers and cooler winter months during which most of the precipitation occurs. As a result, the Santa Ana River would normally run dry or intermittent in the dry summer months. Snow accumulation and storm water in the San Bernardino and San Gabriel Mountains at elevations above 6,000 feet can contribute significantly to runoff. Flooding from strong winter storms is a concern to the region. The Seven Oaks Dam reduces flooding potential and was filled to capacity for the first time after the high precipitation in 2005 (USACE, 2005).

³ Although San Bernardino Valley Municipal Water District is indicated in Map 1 in section 1.3.8, we have not included SBVMWD into our analysis as they did not produce an UWMP for 2005. Thus, our analysis includes those water districts and agencies that created 2005 UWMPs.

1.3.3 Population and Land Use

The Santa Ana Watershed includes the fastest growing region in Southern California, commonly referred to as the Inland Empire. This rapidly growing area includes the inland valleys of Riverside and San Bernardino counties, two of the fastest growing counties in the United States. Figure 4 illustrates the recent population growth this region is experiencing by water district service area.

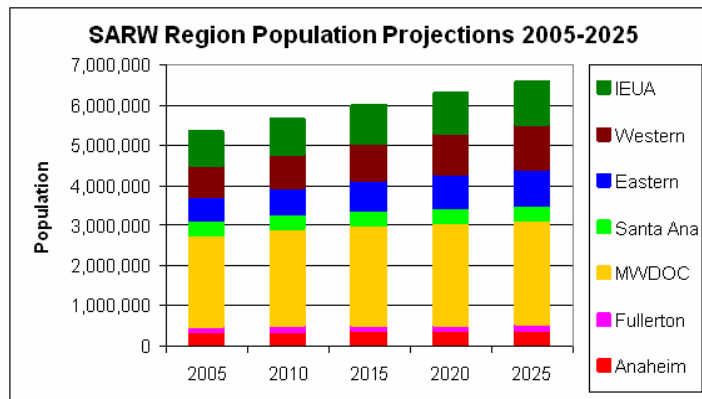


Figure 4: SARW population projections 2005
Source: MWD RUWMP, 2005

While the projected population is telling, it is also important to note the percentage growth projections within each service area (Figure 5) as these reflect the build-out capacity within certain regions. For example, while MWDOC has a large population, the region is close to build-out and is therefore experiencing a relatively small percentage growth increase; however, it should be noted that a small percent growth in MWDOC will continue to contribute a large amount toward the total population growth in the Region. The rapid population growth in the SARW Region is mainly driven by the service areas of Eastern, Western, and IEUA.

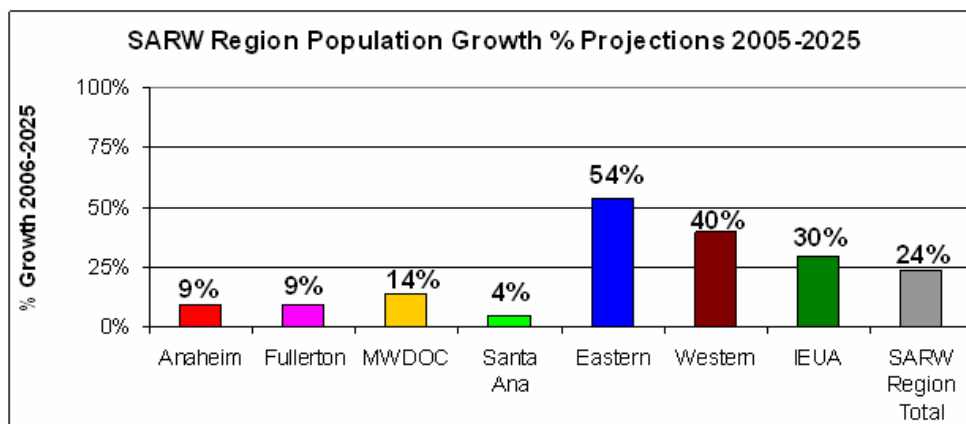


Figure 5: SARW Region Population Growth Percentage Projections 2005-2025.
Source: MWD RUWMP, 2005

Currently, urban development in the region is in the form of clusters, linked by freeways and commercial corridors with much of the development in San Bernardino and Riverside Counties occurring on unincorporated county land (SCAG, 2003). Major cities and highways in the region are shown in Map 2, Quadrant 1 at the end of this section. A large portion of the unincorporated land that is being converted to urban development is agricultural land, primarily dairies in the Chino Basin. Commercial development is also clustered along the major transportation corridors. The Inland Empire serves as a major hub for manufacturing industries, distribution centers, and warehouses because of the many interstates, highways, railroads, and airports that are in proximity to the region. The growth in these sectors has made the Inland Empire a distribution center for the region, state, and nation (ibid.). Land use can be seen in Map 3 at the end of this section.

1.3.4 Water Supply and Demand

Total Water Demand in the SARW Region

Demand data from the individual district level was not available; therefore, demand data obtained from MWD's 2005 Regional Urban Water Management Plan (RUWMP) was used as a proxy. Figure 6 provides the total demand projections for the SARW Region. Several trends that emerge are:

- Demand will increase over time, due in large part to the large increase in population the SARW Region is expecting to experience.
- The single-family sector drives demand in the SARW Region and is expected to increase due to the growing population.
- Agriculture in the SARW Region will decrease as agricultural lands are converted for urban development.
- Groundwater replenishment, or recharge, is expected to increase as agencies look to bank water in the groundwater basins to be used at a later date.

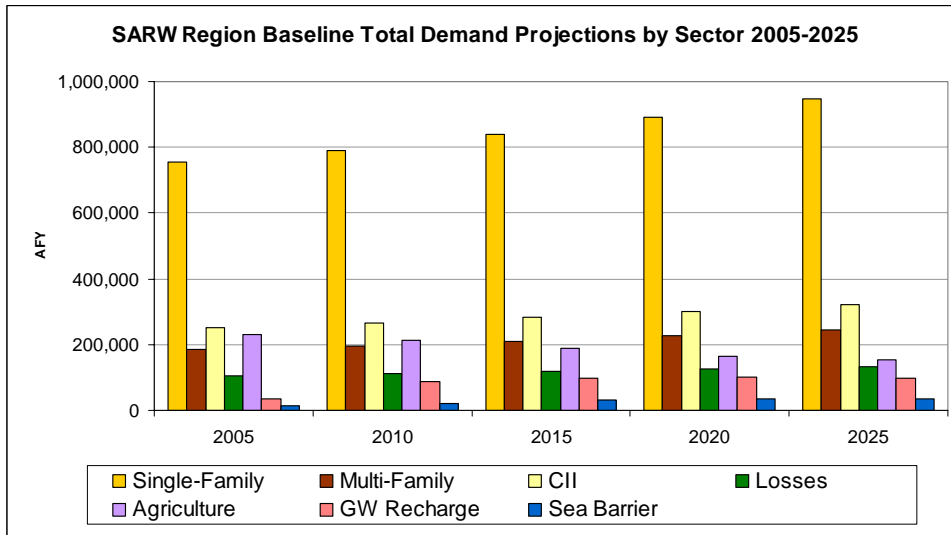


Figure 6: Total demand for SARW.
Source: MWD Demand Projections, RUWMP, 2005 ⁴

Map 4 at the end of this chapter illustrates per capita water use in the SARW Region which can be helpful when used in conjunction with demand projections to further illustrate how demand varies within the Region. Average per capita use in the SARW Region is around 200 gallons per capita per day (gpcd) in the coastal regions and about 250 gpcd in the inland areas. This is fairly high when compared to the per capita water use in other arid regions of the western U.S. In 2001 average per capita water use per day in other cities was as follows: Tucson- 107, Phoenix- 144, Denver- 159, Albuquerque- 135, Las Vegas- 230, and El Paso- 122 (City of Albuquerque, 2004).

Total Water Supply in the SARW Region

Aggregating the data from the seven water suppliers' UWMPs, we derived the SARW Region's total supply data. The current use is an approximate 60:40 mix of local supplies to imported supplies, of which groundwater makes up 36% of total supply. The regional UWMP's projections out to 2025 indicate that the SARW Region will maintain the 60:40 mix of local to imported supplies. The most notable change in the projected resource mix is the increase in recycled supplies from 5% to 14%. The projected supply portfolio in AFY is illustrated in Figure 7. Several trends that emerge include:

- The SARW Region has developed significant local supplies and forecasts to develop even more local supplies by 2025. Local supplies correspond to the blue bars
- Imported supplies of water are projected to increase by 35% in 2025 over 2005
- The SARW Region plans to increase the reuse of municipal treated wastewater, from 5% of the resource mix in 2005 to 14% in 2025

⁴ Sea barrier- refers to the water that is used to bar against sea water intrusion into the coastal aquifers. Losses- refers to water lost in system conveyance and/or infrastructure. CII- Commercial, Industrial, & Institutional

- Groundwater as a percentage of the resource mix is expected to remain constant, making up around 36% in both 2005 and 2025

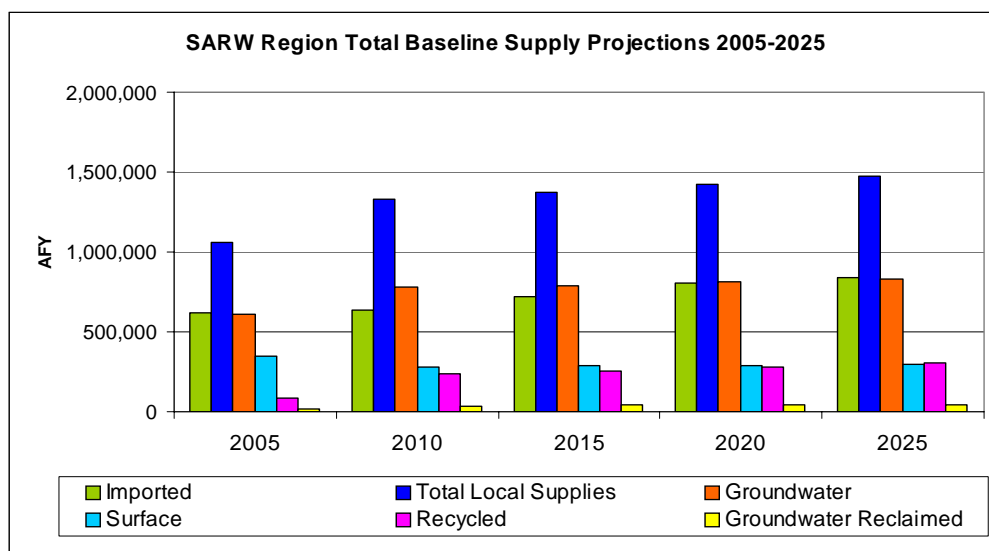


Figure 7: Water supply resource mix from 2005-2025. Total imported supplies indicated in green while total local supplies indicated in dark blue. Local supplies comprised of groundwater, recycled, and surface water sources.

Source: Water Agency UWMPs within SARW Region

1.3.5 Drainage, Geology, Hydrology

Drainage is controlled by geology and topography in the Santa Ana River watershed and influences hydrology, groundwater, and surface water flow. Other features that affect flow are faulting and the variable depth to bedrock. The watershed primarily slopes from northeast to southwest, while the San Andreas Fault trends southeast-northwest at the base of the San Bernardino Mountains. The natural water body within the region is Lake Elsinore with a surface area of 3,800 acres. The San Bernardino Mountains reach nearly 11,500 feet and the San Jacinto Mountains reach nearly 11,000 feet.

The width of the riverbed varies from 500 ft to 4,000 ft and is composed of mainly sand and gravel. Flow rates range from 0.15 cfs to 3445 cfs, with the highest runoff during the winter and spring (USACE, 2005). The steepest gradients occur at the top of the watershed where the headwaters are mountainous and this gradient declines in the lower portion of the watershed, forcing groundwater to the surface (USACE, 2005).

This soil profile of the Region is depicted in Map 2, quadrant 4 at the end of this section. Igneous (andesite) and metamorphic (granite) rock are near the surface and underlie the lower portion of the watershed (SAWPA, 2005). The combination of the high gradient and near-surface bedrock results in little percolation in the upper watershed. Broad unconsolidated alluvial fans cover the base of the mountains, and in the lower regions of the watershed the more permeable alluvium and sediment deposits can reach up to 1,000 feet in depth (USACE, 2005). The surface waters from the mountains replenish

groundwater in largely unconfined aquifers providing excellent quality recharge for the valleys. Storm runoff has high volume, especially in developed areas where impervious surfaces reduce groundwater percolation and create more runoff. There are 40 groundwater management zones in the Region, depicted in Map 2, quadrant 3 at the end of this section.

1.3.6 Water Quality

The upper reaches of the watershed are relatively undeveloped with high water quality; however, the lower reaches of the watershed have undergone many changes as a result of decades of urban growth and as a result water quality is impaired in much of this region (SAWPA, 2005). High-density residential, urban, and industrial development has replaced what used to be predominantly open space and agricultural land. With urbanization, the landscape is now characterized by an altered drainage network, storm flow patterns, and increased sediment and pollutant loading to the river channels and the Pacific Ocean. Due to continued population growth and increasing water demand, Southern California depends heavily on imported water. This reliance not only has detrimental effects on local ground water resources but also puts a huge strain on the Bay-Delta region of Northern California.

According to the Regional Water Quality Control Board for the Santa Ana Region, the main challenges in regards to water quality are the need to:

- “Reduce salts and nutrients in manure and wash water from dairy operations overlying the Chino Groundwater Basin that have severely degraded groundwater quality and threaten downstream water quality.
- Manage nonpoint sources of nutrients, silt, bacteria, metals, PCBs and the banned pesticide DDT that pose serious threats to Newport Bay.
- Control contaminated groundwater, which underlies many areas of the region, resulting from historic discharges of chlorinated solvents.
- Manage nonpoint sources of pathogens that continue to affect the quality of the Santa Ana River, thus rendering the river unsuitable for swimming (RWQCB, 2005).”

Though not within the scope of this analysis, various contaminants in the Santa Ana River pose potential concern for stakeholders. According to a report produced by the USGS’ National Water-Quality Assessment (NAWQA) Program, the SARW’s pollutants of concern are (USGS, 2004):

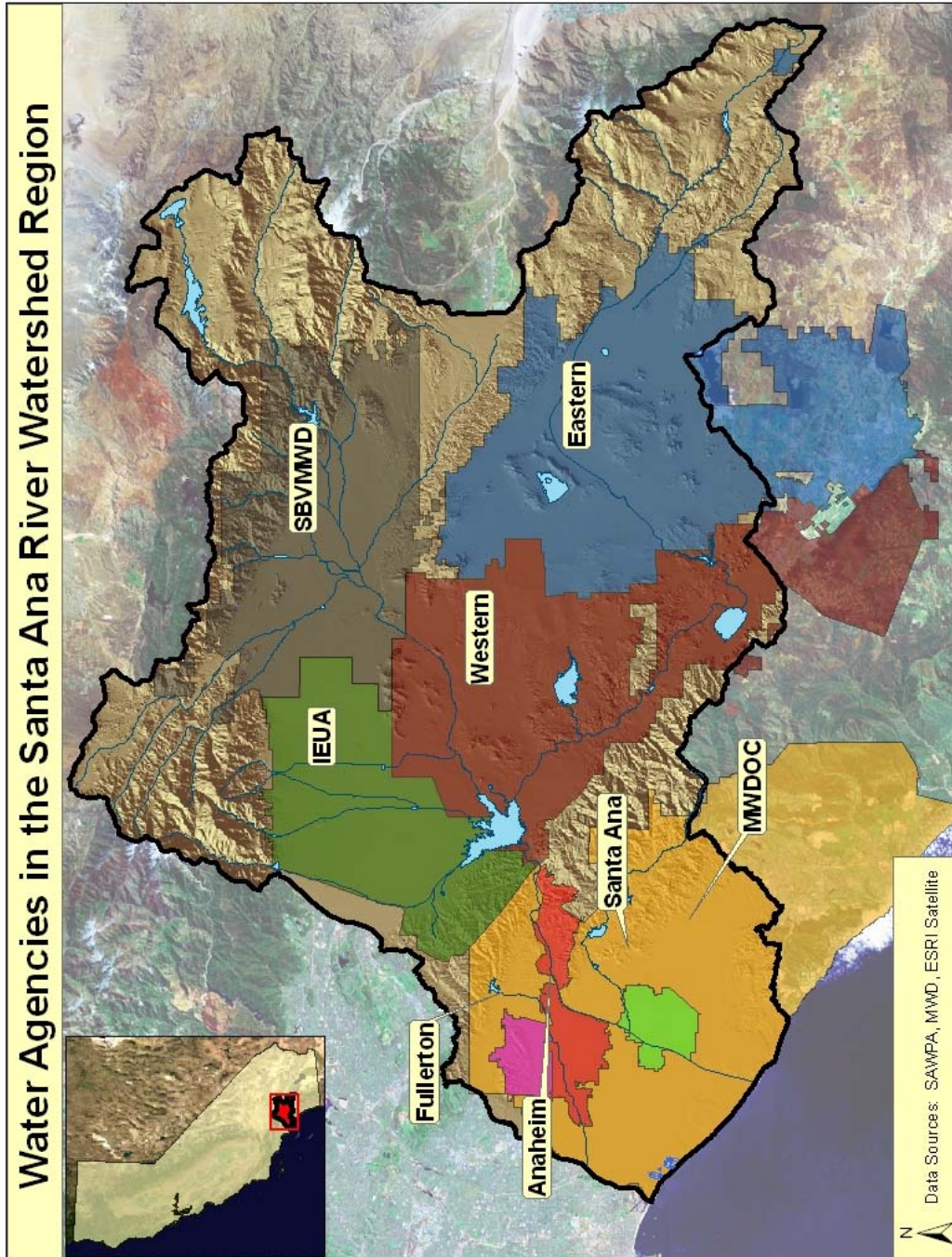
- Nitrates
- Dissolved solids
- Pesticides
- Trace elements (arsenic, radon, lead, zinc, etc)
- Volatile Organic Compounds (VOCs)
- Semi-volatile Organic Compounds (SVOCs)

1.3.7 Natural Resources

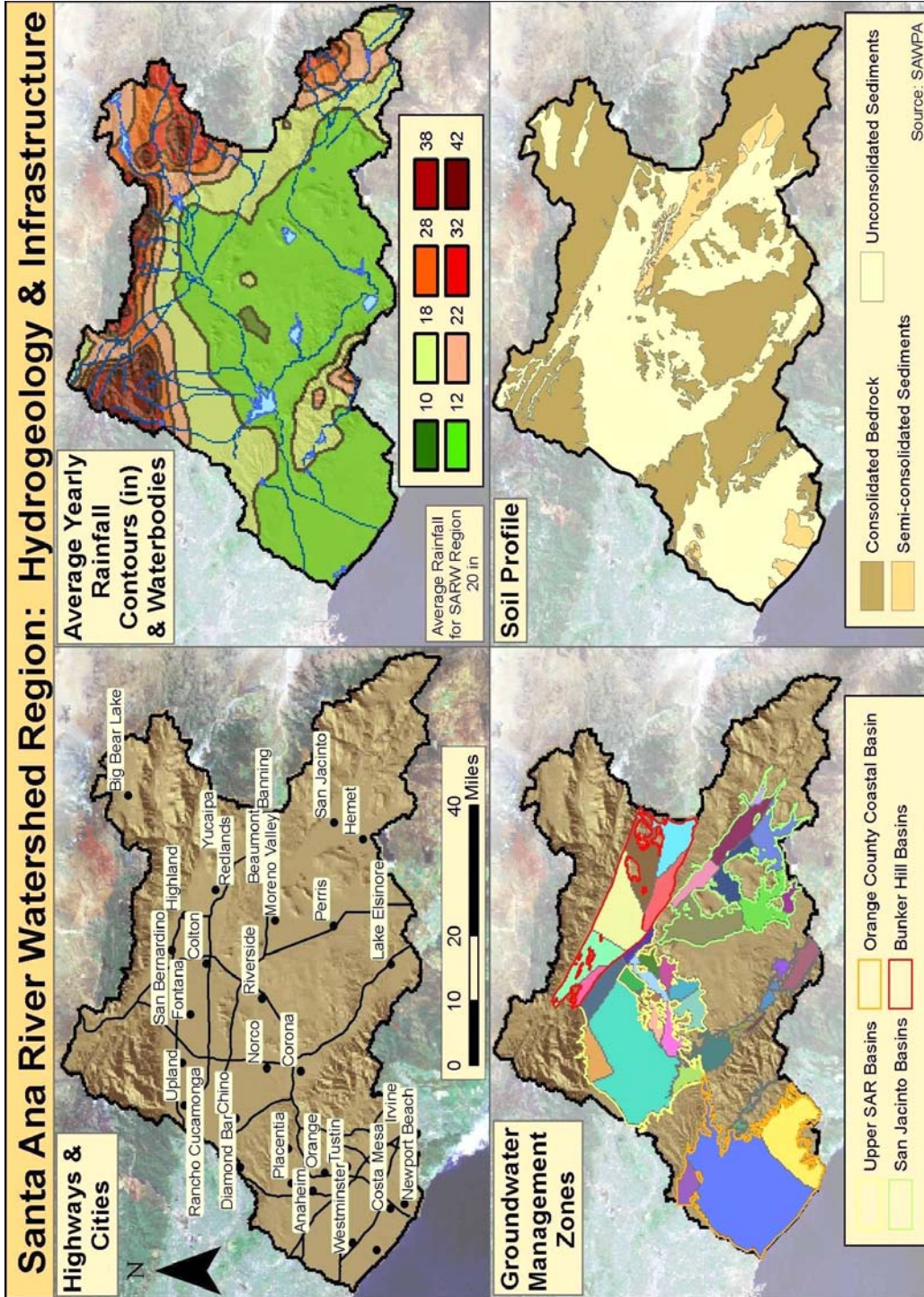
The SARW is experiencing many problems with habitat loss, degraded water quality and declining populations of wildlife and marine life due to the extensive urbanization in the area. The destruction of riparian habitat from development has led to several federally listed threatened and endangered species. Native habitat loss as a result of land development and invasive species is of special concern within the SARW. *Arundo donax* is an extremely prolific weed that chokes riversides and stream channels causing flood control problems as well as diminishing water supply available to other users. This invasive species requires more water than native vegetation, stressing the already limited water supply. In the watershed region, *Arundo* consumes 30,000 AF (9.8 billion gallons) of water every year (SAWPA, 2005).

To address concerns about natural resources, there are projects eradicating *Arundo* as well as numerous habitat mitigation projects throughout the watershed. There are efforts to protect the Least Bell's Vireo and Willow Flycatcher by trapping Cowbirds and restoring the endangered birds' natural habitat. The Riverside-Corona Resource Conservation District has constructed a native fish stream to augment native fish populations in the watershed including the Arroyo Chub (*Gila orcutti*), Speckled Dace (*Rhynchithys osculus ssp.*) and the Santa Ana Sucker (SAWA, 2005). Furthermore, the United States Geological Survey is working to restore Santa Ana Sucker populations.

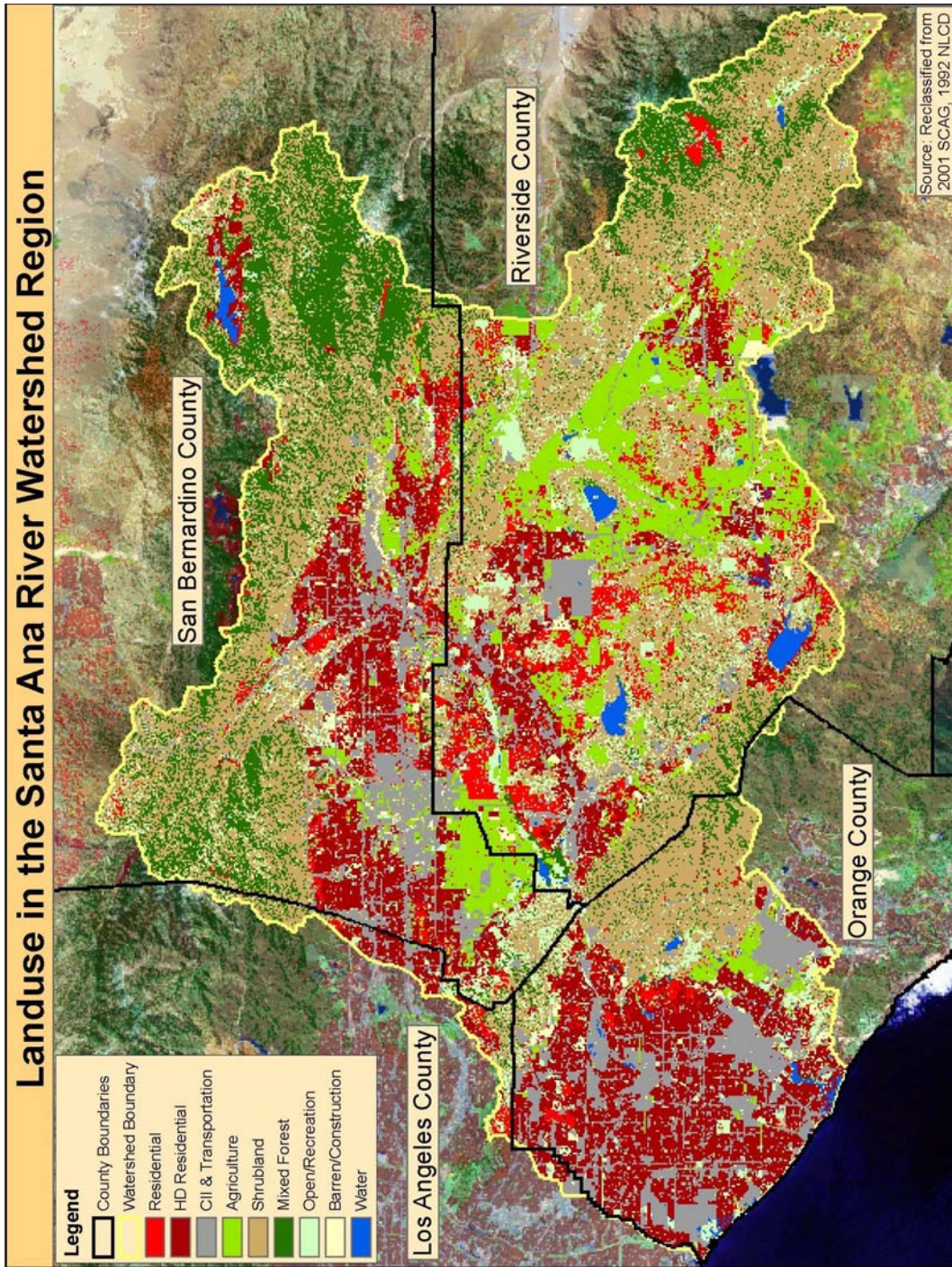
1.3.8 Maps



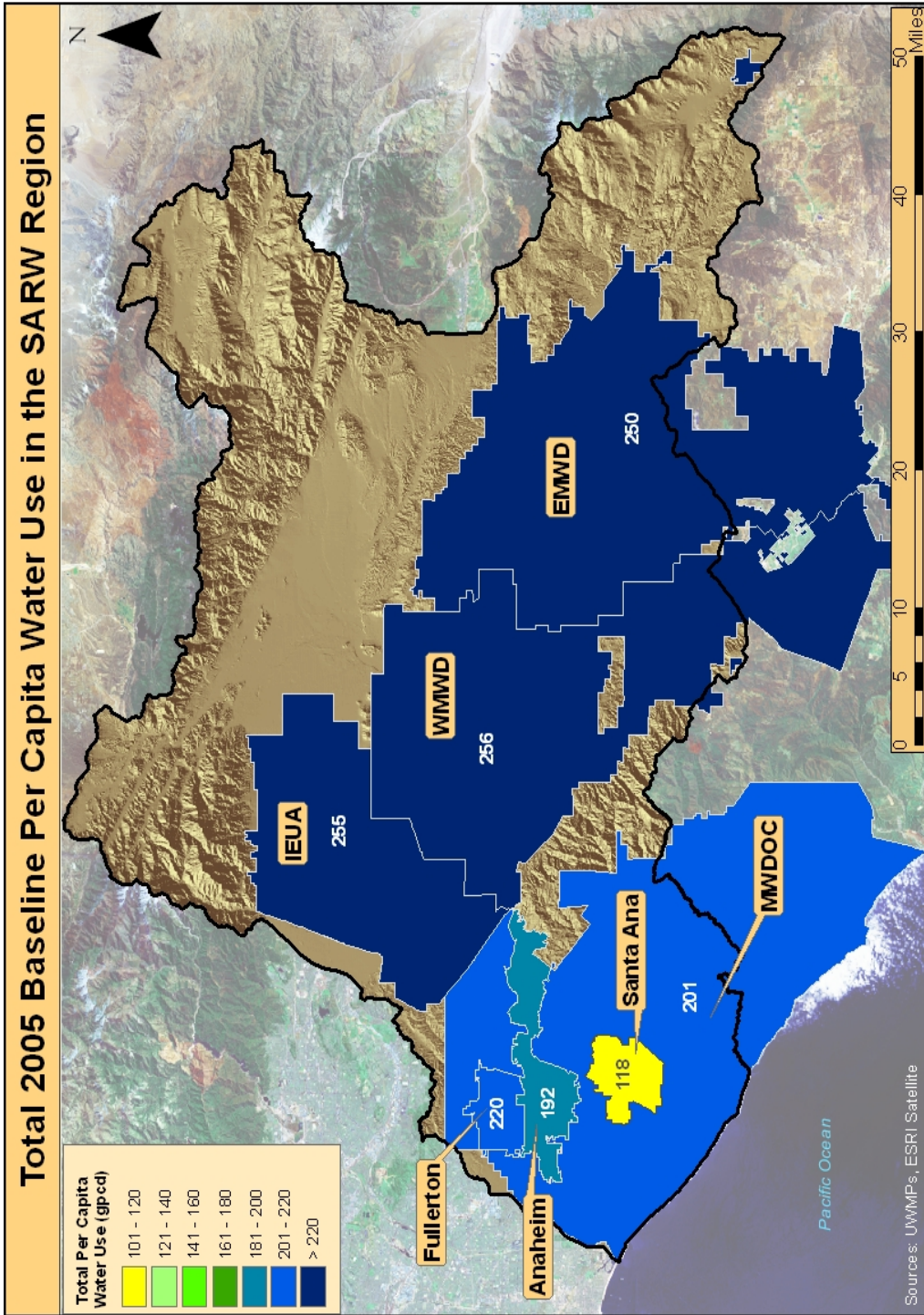
Map 1: Water agency service areas in the SARW Region



Map 2: SARW Region's Hydrogeology & Infrastructure- Quadrant 1: Highways & Cities, Quadrant 2: Average yearly rainfall, Quadrant 3: Groundwater management zones, Quadrant 4: Soil profile



Map 3: Land use in the SARW Region



Map 4: 2005 baseline per capita water use for the SARW Region

2 Approach

2.1 Background Research

Our project conducted an extensive literature review and examined the state water plan as well as UWMPs from the local and regional level. The UWMPs were published in 2005 and represent the most current and updated information for each agency. By closely considering these water management plans, our project was able to determine baseline information about the current and future water demand and supply projections in the SARW Region.

Plans reviewed:

- *Local UWMPs*: Metropolitan Water District of Orange County (MWDOC), Eastern Municipal Water District (EMWD), Western Municipal Water District (WMWD), City of Santa Ana, City of Fullerton, City of Anaheim, and Inland Empire Utilities Agency (IEUA).
- *Regional UWMP*: MWD 2005 Regional UWMP
- *State plan*: California Department of Water Resources State Water Plan 2005 Update [Bulletin 160-05]

2.1.1 Case studies

In order to identify additional management strategies, barriers to implementation, and solutions to overcome these barriers, this project looked at innovative programs within and outside the SARW Region. A review of current technology and programs within the fields of water use efficiency, reuse and recharge were evaluated to determine not only widely accepted measures but also those that may be more progressive and innovative. A description of each individual case study can be found in the respective sections for water use efficiency, reuse, and recharge. In addition, this project relied on communication with water managers throughout the Region to provide direction, insight, data and guidance in determining measures to evaluate as well as barriers to these measures.

2.1.2 Formulation of Scenarios

Scenarios utilizing varying water management strategies were created from our case studies and background research. The goal of this was to show the alternative water demand and supply projections that are plausible if the Region were to utilize the full potential of increasing water reuse, recharge and WUE.

2.1.2.1 Watershed Region Modeling-WASEM

WASEM Description

For this analysis we used a modified version of the water demand and supply scenario generator that was utilized in the State Water Plan Update 2005. This model, called *Water Scenario Evaluation Model (WASEM)*, has been tailored to the

South Coast region of California and can replicate MWD's 2005 RUWMP (2005) supply and demand projections and MWD's demand assessment of the seven major water districts in the SARW Region. WASEM can generate estimates of future water demand and supply scenarios based on specific external forces, conditions, and water management actions. A more detailed discussion regarding how WASEM was used for the State Water Plan Update 2005 and how it operates and can be utilized is described in Groves et al. (2005).

Model Inputs

While WASEM can generate demand and supply projections, this report will only rely on WASEM to determine plausible future demand projections for the SARW Region based on specific demand management strategies. Baseline future demand projections are based on MWD's 2005 RUWMP demand assessment for the seven principal water agencies in the SARW Region. Baseline future supply projections for the SARW Region are provided by aggregating together the seven individual water district's 2005 UWMP supply projections. For the purposes of this analysis, demographic data and other demand driver data were unavailable to us at the individual water district level, thus MWD demand projections from their 2005 RUWMP will serve as a proxy.

3 Solution Analyses

3.1 Water Use Efficiency

The Need for Water Use Efficiency

The fact that cities use about the same amount of water today as they did in the mid-1990's (DWR, 2005) speaks to the impact WUE and other water conservation strategies have made in alleviating urban water demand and augmenting urban water supplies. Further support and encouragement of WUE is so fundamental to managing water resources that the DWR's State Water Plan (DWR, Bulletin 160-05) has identified it as one of its three foundational actions for sustainability, as seen in Figure 8.

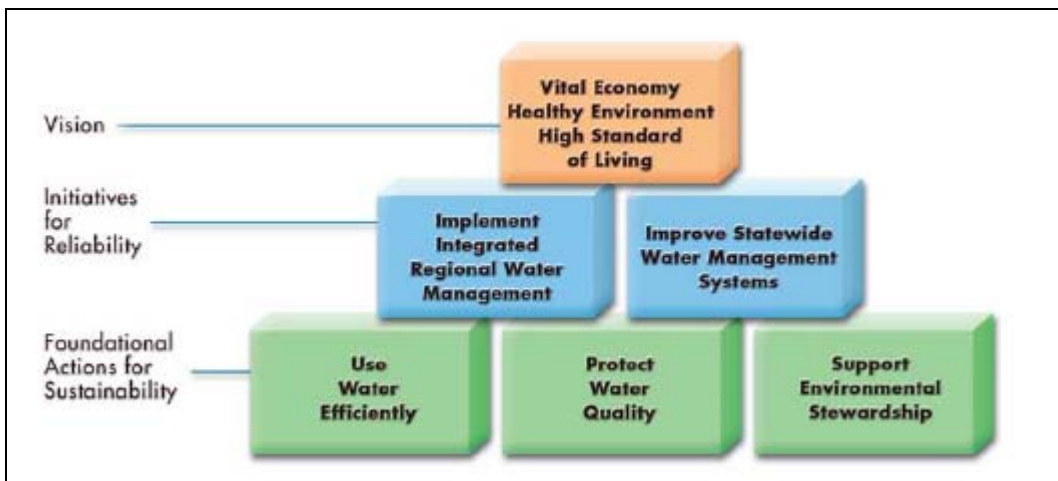


Figure 8: California Water Plan Update 2005's "Roadmap to 2030" lists Water Use Efficiency as a foundational action for sustainability and to ensure water supply reliability.

Source: DWR, 2005

Through the course of this analysis the terms "conservation" and "use efficiency" are both used. We recognize that in the past the word "conservation" has perhaps had a negative connotation and implied limitations to use, but we feel that this term has evolved with familiarity to mean that saving water in one area goes toward other beneficial uses elsewhere, often applying to environmental uses. Water use efficiency on the other hand refers to the ability of a particular volume of water to be used in such a manner as to increase its useful output.

Use Efficiency: The resourceful, non-wasteful use of water to decrease the volume of water needed for various end-uses without any change in the services provided.

Conservation: The reduction in total water use to save water for other uses deemed more valuable.

In addition, the literature differentiates between passive and active conservation as varying methods to achieve water use efficiency. Passive WUE would include such measures as code-based changes that affect the use of assorted technologies, such as plumbing fixtures. Active WUE measures include programs funded by water districts or other programs that can range from: plumbing retrofits, education programs, residential water audits, and landscape audits.

When dealing with water conservation and use efficiency, many water managers look to the California Urban Water Conservation Council (hereafter referred to as the Council or CUWCC) as pioneers for technology forcing and for promoting the active conservation programs in the water agency arena. The Council was created in 1991 as a means to address the need for efficient use of water and to create infrastructure to implement urban water conservation practices through partnerships with various agencies. In response, the Council created a Memorandum of Understanding (MOU) in order to establish proven cost-effective Best Management Practices (BMPs). This MOU was, and continues to be, agreed to by signatories that are then responsible for developing as well as implementing the management practices in their region. Currently there are 345 signatories to the MOU, including MWD, MWDOC, the City of Fullerton, and the City of Santa Ana (CUWCC, 2005). See Table 1 for current Best Management Practices.

Best Management Practices as Established By the California Urban Water Conservation Council	
<ul style="list-style-type: none"> ➤ BMP 1: Residential surveys ➤ BMP 2: Residential Plumbing Retrofits ➤ BMP 3: System Water Audits, Leak Detection & Repair ➤ BMP 4: Metering with Commodity Rates ➤ BMP 5: Large Landscape Conservation & Incentive Programs ➤ BMP 6: High Efficiency Clothes Washer Rebates 	<ul style="list-style-type: none"> ➤ BMP 7: Public Information Programs ➤ BMP 8: School Education Programs ➤ BMP 9: Conservation Programs for CII (Commercial, Industrial, Institutional) Accounts ➤ BMP 10: Wholesale Agency Incentive Programs ➤ BMP 11: Conservation Pricing ➤ BMP 12: Conservation Coordinator ➤ BMP 13: Wastewater Prohibitions ➤ BMP 14: Residential Ultra Low Flush Toilet Retrofit Programs

Table 1: Best Management Practices established by the California Urban Water Conservation Council
Source: CUWCC, 2006

As part of the MOU, the Council and its signatories also consider Potential Best Management Practices (PBMPs) that are water saving devices and/or technologies that have the potential to be efficient and cost-effective. While the PBMPs present many opportunities for future potential water savings, there may be other measures

that have been overlooked for political, economic, or other reasons and these are the measures that will be considered for this analysis.

Literature Reviewed to Drive WUE Savings Potential

In the course of this analysis various reports were consulted, but the following reports regarding the potential for urban water use efficiency have been relied on more significantly:

- California Urban Water Agencies 2004 update: “Urban Water Conservation Potential: 2003 Technical Update” (A&N Technical Services, 2004)
- The California Urban Water Conservation Council’s 2004 Annual Report: “Potential Best Management Practices” (Koeller et al., 2004)
- The Pacific Institute’s 2003 report: “Waste Not, Want Not: The Potential for Urban Water Conservation in California” (Gleick et al. 2003)
- The Pacific Institute’s 2005 report: “California Water 2030: An Efficient Future” (Gleick et al. 2005)

The last two reports represent the most current assessments of urban water use efficiency potential in California and were relied upon to generate alternative demand management scenarios for our analysis. In addition to the Pacific Institute reports, we have used the following studies to calculate our own urban water use efficiency potential savings that go above and beyond Pacific Institute’s water savings estimates:

- Southern Nevada Water Authority’s “Xeriscape Conversion Study: Final Report.” (Sovocool and Morgan, 2005)
- “Residential Weather-Based Irrigation Scheduling: Evidence from the Irvine ET Controller Study” (Hunt et al., 2001)
- MWDOC’s and IRWD’s “Residential Runoff Reduction Study” (2004)
- Canada Mortgage and Housing Corporation and Veritec Consulting, Inc., 2002. *Dual-flush Toilet Project*, by Veritec Consulting, April 2002.
- Aquacraft, Inc., 2000. Seattle Home Water Conservation Study: Evaluation of High Efficiency Plumbing Retrofits in Single Family Homes, Seattle Public Utilities and the U.S. Environmental Protection Agency, December, 2000.
- Pacific Northwest National Laboratory, 2001. *Oregon’s Save Water and Energy Education Program* (SWEEP). Prepared for the U.S. Department of Energy, May, 2001.

In total, this analysis considers the following three demand management strategy scenarios:

- 1 – Pacific Institute’s Water Use Efficiency Scenario
- 2 – SARW Region – ET Controller Scenario
- 3 – SARW Region - California Appropriate Landscapes (CALscape) Scenario

Pacific Institute’s Water Use Efficiency Scenario

Using a “bottom-up” approach, the Pacific Institute’s 2003 *Waste Not, Want Not* (WNWN) study quantifies the potential water savings of water conservation through cost-effective water-saving technologies, state and local regulations, economic policies, and education/awareness programs. This study breaks down water savings by the following sectors: Residential indoor; Residential outdoor; Commercial/Institutional; and Unaccounted-for water.

In 2005, *California Water 2030*, the Pacific Institute inputted the efficiency savings potentially quantified in *WNWN* into the same model (WASEM) that was used to derive the California Water Plan Update 2005 “Current Trends” baseline water demand scenario. WASEM will also be used in this report to assess the savings potential within the SARW Region. Pacific Institute concluded that the potential water savings in *WNWN* resulted in a reduction in water use intensity, derived for the SARW region, for residential interiors by 32.5%, residential exteriors by 27.5%, and 32.5% for commercial, industrial, and institutional sectors (over water use levels in 2000), as shown in Table 2 (Gleick et al. 2005). It should be noted that although this level of conservation was derived for state-wide application, our analysis will treat the SARW Region as a representative sample of state-wide averages and that implementation of *WNWN*’s efficiency standards would correspond to these percentage reductions.

Sector	Water conservation strategies	Statewide percentage reduction over 2000 water use levels
Indoor household use	-replace all remaining inefficient toilets, washing machines, showerheads, and dishwashers -reduce level of leaks	32.5%
Outdoor household use	- improved landscape maintenance and management practices - upgrading to available efficient irrigation technologies	27.5%
Commercial, industrial, and institutional use	- use of cost-effective water use practices and technology (varies by specific use)	32.5%

Table 2: Summary of water conservation opportunities quantified by the Pacific Institute and derived through the Water Scenario Evaluation Model (WASEM) for the SARW region.

Source: Gleick et al., 2003

SARW Region Water Use Efficiency Scenarios

Pacific Institute’s analysis in *Waste Not, Want Not*, and its subsequent demand-scenario projection in *California Water 2030*, did not include the following technologies, programs, and policies in its evaluation of potential water savings attributable to efficiency measures:

- Waterless Urinals
- Dual-Flush Toilets
- ET-Based Irrigation Controllers
- California Appropriate Landscape Conversions

Using the most current literature, research, and studies available to us, we have determined that the conservation measures listed above constitute a significant addition to the potential water savings Pacific Institute quantifies in *WNWN* and projects in *California Water 2030*. Waterless urinals offer tremendous water-savings in that they effectively eliminate the demand for water that now exists for such plumbing fixtures. Dual-flush toilets reduce the volume of water required per liquid waste by 50% (CHMC, 2002). Outdoors, ET-based irrigation controllers and California appropriate landscape conversions provide significant potential water savings through the efficient application of water to landscapes and reduction of the volume of water required by the landscape. While not evaluated for their water savings potential, market-based conservation measures, such as conservation-based water rate structures, effectively cut across all sectors of demand by sending price signals to inefficient consumers to conserve water.

These conservation technologies, programs, and policies, combined with those conservation measures outlined in *WNWN* and quantified in *California Water 2030*, are featured in the two SARW Region Water Efficiency Scenarios we have established for this analysis and provide water demand percentage reductions for the SARW region, as shown in Table 3.

Sector	SARW Region - ET Controller Scenario		SARW Region - CALscapes Scenarrio	
	Water conservation strategies	Efficiency % by 2030 from MWD Gross Baseline	Water conservation strategies	Efficiency % by 2030 from MWD Gross Baseline
Indoor Residential Use	Pacific Institute strategies + Dual-Flush Toilets	35.20%	Pacific Institute strategies + Dual-Flush Toilets	35.20%
Outdoor Residential Use	Pacific Institute strategies + ET-Based Irrigation Controllers	40%	Pacific Institute strategies + California Appropriate Landscapes	77%
Commercial, Industrial, and Institutional Use (CII)	Pacific Institute strategies + Waterless Urinals	37.10%	Pacific Institute strategies + Waterless Urinals	37.10%

Table 3: Water demand percentage reduction for the SARW Region scenarios

Section B in Supporting Research has more in-depth information regarding how we derive the SARW Region Scenario percentage demand projections. Current literature, including the aforementioned studies and each water district's UWMPs, provided the background required for evaluation of the savings potential and cost-

effectiveness of the conservation measures which we believe can make the SARW Region more water use efficient.

Barriers to Implementation

Though this study has determined that significant savings are attainable in the region, there are several barriers or limitations to implementation that exist and are likely part of the reason why these water savings measures have not been implemented. Some of the barriers that warrant discussion are capital costs, lack of information, and lack of implementation by developers.

To begin with, capital costs are often an issue because cities with already limited budgets rightly find it difficult to make a significant initial investment. Even when there is a return on investment, the funding for initiating these measures is often a serious limitation. This barrier also ties into the problem of insufficient information experienced by the retailer which can then be passed to the consumer. Districts may be operating without full information to make informed choices about their demand and supply portfolios. In addition, this lack of information can transfer to the consumer in ways that affect their use of water in and around the home. For example, a consumer may not know about the water savings involved in planting a landscape that is appropriate to California's climate and thus choose a much more water intensive landscape.

A third significant barrier is the lack of implementation by developers and urban planners in the area. The high rate of urbanization and development in the SARW Region leads to great opportunities for implementing many water savings measures into these new developments; however, developers do not always take advantage of these opportunities. Developers hold the opportunity for creating urban areas that implement interior savings devices such as dual-flush toilets while planting California appropriate landscapes and watering them with "smart" irrigation controllers. This implementation would be a type of technology forcing which in turn would help to educate the public about the water savings of these installed devices. Due to inadequate information developers may think that implementing these measures in their developments is more costly, but this is often not the case.

3.2 Water Reuse

“Every gallon of water that can be reused means that one more gallon can remain underground; or one more gallon doesn't need to be imported from Northern California or from the Colorado River” (EMWD, 2005).

The California Water Code defines recycled water as “water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur” (DWR, 2005).

For the purposes of this report, we will use the terms recycled, reused, and reclaimed interchangeably.

In the United States, uses for recycled water are typically non-potable, such as landscape irrigation, toilet flushing, industrial cooling, agriculture, artificial lakes, wetland augmentation, etc. With more advanced treatment systems, there is now an emergence in indirect potable uses, which according to the EPA, “refers to projects that discharge recycled water to a water body before reuse” (EPA, 2005).

Water reuse in the watershed

Water reuse is gaining significant acceptance as water agencies and consumers realize its many benefits. One major benefit of recycled water is that it is the only water supply that increases along with the population. In addition, the reliability and consistency of reclaimed water make it an increasingly appealing local resource supply option. The SARW Region’s burgeoning population has led to an escalating demand for water, which, combined with the recognition of limited local water resources and the uncertainty of future imported water supplies, has led to pioneering efforts in the field of water reuse by several agencies within the SARW Region. One such agency is OCWD, which is notable for its early start in water recycling with Water Factory 21 and the ongoing development of the Groundwater Replenishment System (GWR System), one of the largest purifying projects of its kind in the world. Another example is Irvine Ranch Water District (IRWD); whose progressive city planners recognized that aside from land, water is often the limiting factor for growth in Southern California and planned accordingly by installing recycled water infrastructure before much of the population spread into the region.

Although wastewater generated in the SARW Region is collected and treated, not all of it is treated to the requisite standards and criteria for reuse as set by the California Department of Health Services’ California Code of Regulations, Title 22, Chapter 4. In 2005, total wastewater flow through the Region was 457,000 AF, of which, 38% (175,000 AF) was treated to the Title 22 standards required for reuse. Only about half of this water, 87,000 AF, was actually reused (Figure 9). Based on projections for water reuse in 2025, the districts within the SARW region will treat 433,000 AF to recycled standards and the percentage reused will increase to 70%, for a combined district total of 303,000 AF of water reused for beneficial purposes (Figure 9). The difference between the total quantity treated to Title 22 standards and the amount

actually reused is a substantial portion of water that, although available for beneficial uses, will be discharged or disposed of.

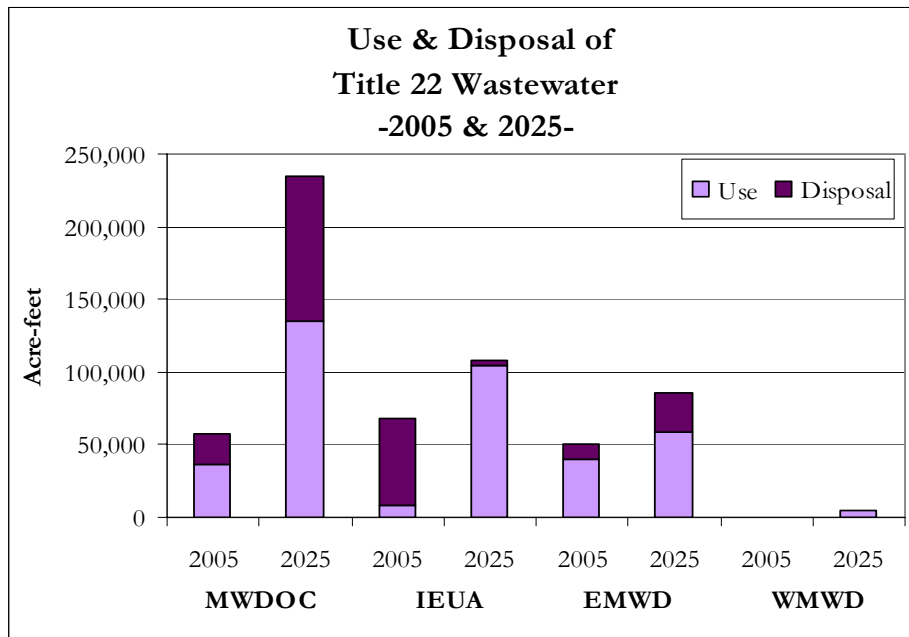


Figure 9: SARW Region Title 22 treated wastewater use and disposal for 2005 & 2025
Source: SARW Region water agency 2005 UWMPs

This additional available water supply presents an opportunity to replace a portion of imported water supplies. By reusing this water, the water agencies can further increase the local water supply, thus reserving higher quality potable water for other uses and augmentation of additional local supplies.

As mentioned previously, there are many water recycling pioneers within the SARW Region. This has resulted in a fairly high level of overall use of recycled water in the SARW Region. In 2005 recycled water made up 5% of total supplies, and is projected to increase to comprise 14% of the supply resource mix in 2025. It is important to note that the current and projected water reuse amounts vary from one water district to another. This variability in water reuse between water agencies can be attributed to a number of factors, such as the particular barriers present within each district, the differing reuse strategies, and the cost and availability of other supply sources. Understanding what districts are currently doing and are planning for is a crucial step in evaluating how best to maximize water reuse on a regional scale. Detailed information regarding water reuse within each district can be found in Supporting Research, Section C.

Scenarios

The data used to derive the water reuse portion of our scenarios was taken from the respective water districts' 2005 UWMPs. We utilized the information detailing each water district's current and projected amount of average wastewater flow, the quantity of water treated to Title 22 recycling standards, and the volumes of treated water projected for reuse and disposal. Keep in mind that for these scenarios we only considered water that is treated to the Title 22 standards for reuse, rather than considering total wastewater flow through the Region.

Our baseline scenario follows the UWMP projections of wastewater reuse by each district. As mentioned previously, in 2005 approximately half of the total treated wastewater was reused and by 2025 the water districts as a whole project to reuse a combined total of 70%. In addition to the baseline scenario, we derived two additional scenarios in which reuse increased by a given percentage. Scenario 2 examines the increase in water supply if each district were to reuse 75% of its treated wastewater by 2025⁵. Scenario 3 evaluates the increase in water supply if each district were to reuse 95% of its treated wastewater by 2025. The benchmark for this scenario came from IEUA's 2005 UWMP projection to utilize approximately 96% of its treated wastewater by 2025. This represents a dramatic jump, an increase of over 1000%, from the amount of treated wastewater reused in 2005. This projection by IEUA represents a commitment to maximizing water reuse and shows that a scenario under which maximization of water reuse is indeed possible.

In summary the three water reuse scenarios generated are as follows:

1. Baseline-Level of Reuse as projected by 2005 UWMPs
2. 75% Reuse of treated wastewater by 2025
3. 95% Reuse of treated wastewater by 2025.

Scenario	% of treated wastewater used			
	2010	2015	2020	2025
To reach goal of 75% by 2025	50%	60%	70%	75%
To reach goal of 95% by 2025	65%	70%	80%	95%

Table 4: Percentage increase through time to achieve reuse goals

To reach the scenario goals by 2025, increased projections were established every five years for the two different scenarios (Table 4). In years when districts project reuse amounts that exceed the percentage indicated with our progression, the districts' own higher projections were used.

⁵ For scenarios 2 and 3, in years when districts project reuse amounts that exceed the percentage indicated with our progression, the districts' own higher projections were used

As indicated in Figure 10, if all districts within the SARW Region increase their reuse of treated wastewater, an increase of 14% and 36% from the 2025 baseline scenario would be observed for the 75% maximum reuse and 95% maximum reuse, respectively. This represents a large quantity of water, 45,000 AFY for the 75% reuse scenario and 109,000 AFY for the 95% reuse scenario, which can dramatically increase local water supplies, and thereby replace imported water supplies.

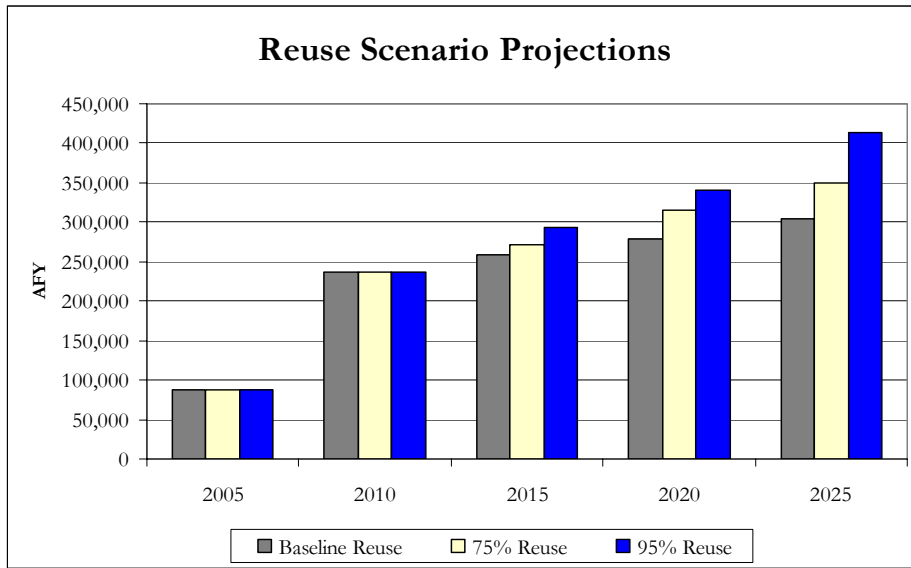


Figure 10: Reuse projections based on the three scenarios

To maximize water recycling, one must understand the barriers to reuse that water agencies are facing. In order to understand the barriers to reuse, and the strategies and innovations employed to cross these barriers, our project also looked at case studies of other recycling programs. The case studies explored were: Marin Municipal Water District, Los Angeles County Sanitation District, West Basin Municipal Water District, and Monterey Regional Water Pollution Control Agency (MRWPCA) outside the Region; and Orange County Water District (OCWD) and Irvine Ranch Water District (IRWD) within the Region. From our case studies, we learned that the four major and most common barriers to maximizing water reuse are: public perception, infrastructure, cost recovery, and lack of uses for recycled water.

Public perception is an issue that came up frequently as we explored case studies both within and outside the SAR watershed. This can present a barrier due to the fact that portions of the public may perceive the reuse of treated wastewater to be unclean and pose certain health risks. Within the SAR watershed, OCWD and IRWD both have a long history of using public outreach and education to keep the public well informed with accurate information about recycled water. OCWD is a great example of how the public perception barrier can be crossed. Since the mid-1970's water from OCWD's Water Factory 21 reclamation project has been injected

into the aquifer. OCWD is now constructing the GWR System, which will serve as a pioneering example of indirect potable reuse in the SARW Region as well as the nation. According to OCWD, the agency gives approximately 150 talks per year to the public, and has garnered support for the project through news publicity and outreach to every leader in Orange County. One important issue stressed by OCWD is that it is necessary to be relentless in order to reach out to the most possible consumers of recycled water, while remaining truthful and putting any risks into the correct context and perspective. This same attitude is demonstrated by IRWD, whose recycling program has been in operation for more than 20 years.

The *lack of infrastructure* is a major barrier for water agencies and municipalities that lack the treatment capacity to increase water reuse and the capital to increase capacity. Aside from treatment infrastructure, a lack of distribution infrastructure, such as a scarcity of dual piping in existing developments, can prevent districts from increasing the amount of water reused. This lack of infrastructure is partially related to negative public perception. With public support and the political will to increase water reuse, more channels will open up to increase funding for infrastructure. Aside from public perception, a way of increasing political will would be to increase the awareness of the true economic benefits of recycling water for the city or the water agency. Certain water districts and agencies have codified ordinances requiring reclaimed water use in certain instances. One example of this is IRWD's requirement for dual piping for all new developments of a certain size (IRWD, 2003). This strategy not only encourages recycled water use, but also reduces the future costs of having to retrofit developments for recycled water use.

Another problem for agencies is a *lack of uses* or extremely seasonal demand for recycled water. An example is the recycled water program at Marin Municipal Water District. Due to a combination of the northern California wet season and the fact that the service area is small, there is a lack of recycled water consumers, especially during the rainy months. As a result, the recycled water program is unable to recover its costs.

Cost recovery is often a barrier for water districts as they struggle to recover the costs for the construction, operation, and maintenance of a recycled water program. Infrastructure capital costs are often quite high with a long payback period which can decrease district incentives to invest in recycling expansion right away. For example, OCWD's GWR System has a construction time of around 6 years and a capital cost of approximately \$490 million; however nearly 20% of these costs will be offset through various grants (GWR, 2004). Cost recovery is also an issue for the many agencies who sell their recycled water at a reduced rate in order to encourage and incentivize water reuse.

The question remains: Why do districts continue to run recycled water programs if these programs do not recover their costs? According to several recycled water coordinators, these programs are considered a sound investment for the future.

They believe that water will undoubtedly become more expensive in the future as this resource becomes scarcer; therefore, every acre-foot of potable water saved from using recycled water to irrigate lawns or to flush the toilet is an acre-foot of water “banked” for the future. Though it can be seen as an investment, it is still necessary to understand the factors that are important to the development of a cost-recovering program. Some examples of recycled water programs that have been able to recover all costs are the Monterey Regional Water Pollution Control Agency (MRWPCA) and the West Basin Municipal Recycling Facility.

As mentioned above, one impediment to cost recovery is not having enough uses for recycled water. For the MRWPCA, the two major uses of recycled water are for the irrigation of crops and as a barrier against seawater intrusion. Farmers in the region irrigate 365 days a year, making this a fairly consistent use. Half of the water treatment costs are paid for by the tertiary water users (i.e. the farmers), while the other half is paid for by residents that benefit from the seawater intrusion barrier. Due to the high and relatively consistent demand for recycled water, MRWPCA is able to recover water recycling costs. Another example of successful cost recovery is the West Basin Municipal Recycling Facility. West Basin has several high-volume customers, the largest of which are refineries. Due to the reliability of recycled water, many of these large refineries have requested recycled water supplies over traditional sources of water. Since these customers are able to pay for large quantities of recycled water, they are helping West Basin achieve cost recovery and are therefore able to supply lower-volume users such as schools and parks. From these case studies, it can be seen that the number of users, amount of uses, and customer size, are all important factors to consider as a district looks at expanding its recycled water program. These case studies are discussed in further detail in Supporting Research, Section C.

While common barriers to water recycling face each water district, the degree to which any particular barrier presents an impediment to action varies depending upon the unique district characteristics. Supporting Research, Section C contains more in-depth information regarding each district’s approach to water reuse, information regarding specific barriers, and the methods used/proposed to overcome these barriers.

3.3 Groundwater Recharge

There are forty groundwater management zones in the SARW Region, as defined by SAWPA. The Association of Groundwater Agencies (AGWA) combines these forty zones into four major groundwater basins: the San Jacinto Basin, the Bunker Hill Basin, the Upper Santa Ana River Basins, and the Orange County Coastal Plain (see Figure 11). Maintaining groundwater levels in these basins is necessary to increase water supply reliability and to ensure sustainable water levels in drought years.

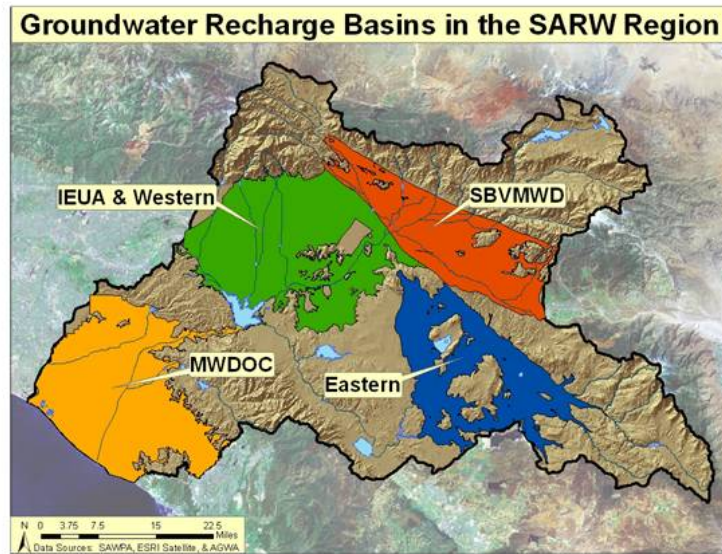


Figure 11: Groundwater management zones
Source: SAWPA, 2005

Current supply in the region is met though a heavy reliance on groundwater. Future scenarios with increased population and possible shortages on imported supplies will increase this reliance. Maintaining groundwater levels in these basins is necessary to increase water supply reliability and to ensure sustainable water levels in drought years. As a result, plans for water supplies must rely heavily on groundwater. Figure 12 shows that 36% of the supply from agencies in the SARW Region is provided by groundwater in 2005. By 2025, groundwater is estimated to comprise the same percentage, but will increase in yield to 223,000 AFY as a result of higher pumping rates.

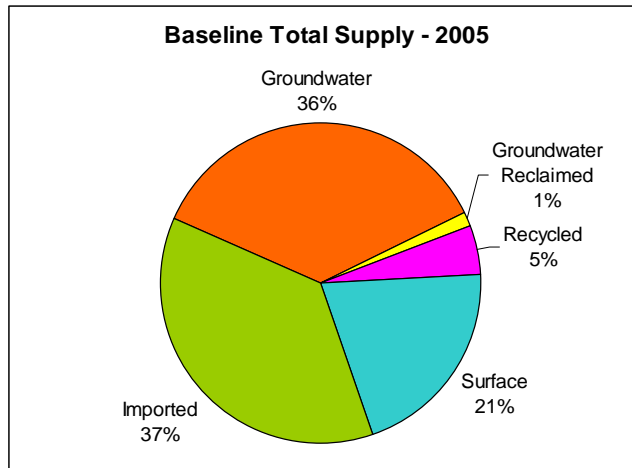


Figure 12: 2005 Baseline total supply for the SARW Region
Source: MWD, 2005

The primary method for increasing groundwater supplies is through conjunctive use. Conjunctive use is defined in this report as the planned and managed operation of a groundwater basin and a surface water storage system combined through a coordinated conveyance infrastructure. Water is stored in the groundwater basin for future planned use by heavily recharging the basin during above average wet years and using surface storage to capture and temporarily store stormwater. The three primary components of conjunctive use include:

- Recharging groundwater when surface water is available to increase groundwater storage
- Switching to groundwater use in dry years when surface water is scarce
- Maintaining an ongoing monitoring program to evaluate and allow water managers to respond to changes in groundwater, surface water, or environmental conditions that could violate management objectives or impact other water users (DWR, 2005).

When surface water supplies are abundant during periods of high precipitation the water is used to recharge groundwater basins. In times of drought, groundwater is used more extensively. Conjunctive use provides many advantages, but also introduces some disadvantages listed in Table 5 below. However, it is important to note that many of the disadvantages can be reduced or avoided through appropriate mitigation measures.

Advantages and Disadvantages of Using Groundwater Aquifers	
Possible Advantages	Possible Disadvantages
Water supply reliability	More difficult cost allocation
Decreased dependence on imported supply during dry years and emergencies	Greater power consumption to extract water
Ready integration with existing development	Increased need for diversion and/or conveyance of surface water during wet years
Storage plans can be phased	Less hydroelectric power through the avoidance of dam construction
Fewer drainage system improvements	Over-pumping may cause land subsidence
Better timing of water distribution	Liquefaction from shallow groundwater levels
Water quality improvements	May require active control of salt water intrusion
Less additional surface storage required	May cause contaminant movement
Low evaporative losses	Increased groundwater monitoring
Less threat from dam failure & Greater flood control	Increase in salt loading
Source: AGWA, 2000.	

Table 5: Advantages and Disadvantages to use of GW Aquifers
Source: AGWA, 2000

Methods for Recharge

Supporting Research Section D describes the various current and possible methods of recharge for the SARW Region (e.g. increasing pervious surfaces, bioswales, etc); however, this section will only discuss the importance of stormwater recharge as it relates to conjunctive use. Groundwater replenishment from rainfall is important due to the higher water quality as compared to imported sources of water and most blended water mixes. Additionally, stormwater recharge is not energy intensive and retaining water from rainfall in groundwater storage helps reduce flooding. The Santa Ana River Flow Impacts Report found that the driest rainfall year averaged 7.9 in. contributing 18,300 AFY of runoff; a typical year averaged 18.1 in. contributing 65,400 AFY; and the wettest period averaged 31.6 in., contributing 340,300 AFY of runoff (SAWPA 2004). Capturing and using water from rainfall can save large volumes of water; for example Inland Empire plans to recharge 44,000 AF annually of combined storm water and recycled water (IEUA, 2005). As development in the watershed continues, the areas of impervious surfaces will increase, thereby decreasing opportunities for natural recharge and increasing runoff. Replacing this water could be expensive if storm flow cannot be captured. Injecting or infiltrating a larger volume of high quality stormwater will allow more recycled water of lower quality to be mixed and recharged as well. Reducing storm water flows at or near the point of rainfall will also decrease sediment loading and decrease the distance water travels on the surface accumulating pollutants.

Recharge Scenarios

Two scenarios regarding groundwater recharge were generated for our analysis. The first scenario, called the Baseline Scenario, involved the aggregated groundwater yield as reported by the seven Water District’s (IEUA, MWDOC, Western, Eastern, Fullerton, Anaheim, and Santa Ana) UWMP. The second scenario, called the Maximum Recharge Scenario, was developed using the increase in available groundwater over the baseline with increased conjunctive use. Table 6 provides the total amount of additional local supplies due to conjunctive use for 2005 to 2025. Maximizing the conjunctive use of stormwater and surface water with the region’s groundwater basins can potentially increase the region’s sustainable safe yield by 150,000 AF over what is projected by the region’s water agencies. It is important to note that in the SARW Region, physical groundwater boundaries do not coincide with agency boundaries.

Scenario	2005	2025	Projected Increase
Baseline Projections (AF)	608,600	831,000	222,400
Maximum Recharge Scenario (AF)	608,600	981,000	372,400
<i>Difference (AF)</i>	-	-	<i>150,000</i>

Table 6: Additional Local Supplies

The amount of increased groundwater yield for the maximum recharge scenario was developed as a result of an assessment of conjunctive use performed by the Association of Groundwater Agencies (AGWA). Conjunctive use has been determined by numerous Water Agencies as the most effective method for recharge. The assessment looked at the potential for conjunctive use based on surveys and interviews with the managers of the individual groundwater basins in the SARW (AGWA, 2000). The report identifies the existing increase in basin yield from conjunctive use programs, the potential for dry year or long term storage, and the potential for enhancing the annual operational yield of groundwater basins from conjunctive use projects for each major basin (Groves, 2006).

Figure 13 shows the groundwater yield as well as the potential increase in safe yield for each district. These yields were aggregated (Figure 14) for the watershed region and show that the current annual safe yield from groundwater is 832,300 AFY. Conjunctive use can increase groundwater yield to 1,010,300 AFY and will provide the supply for the Max Recharge scenario.

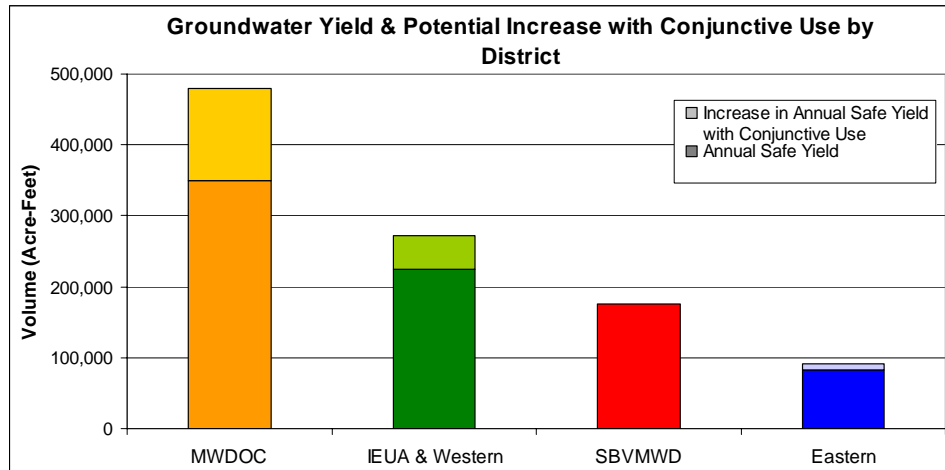


Figure 13: Groundwater Yield and Potential Increases with Conjunctive Use by Water Districts
Source: AGWA, 2000

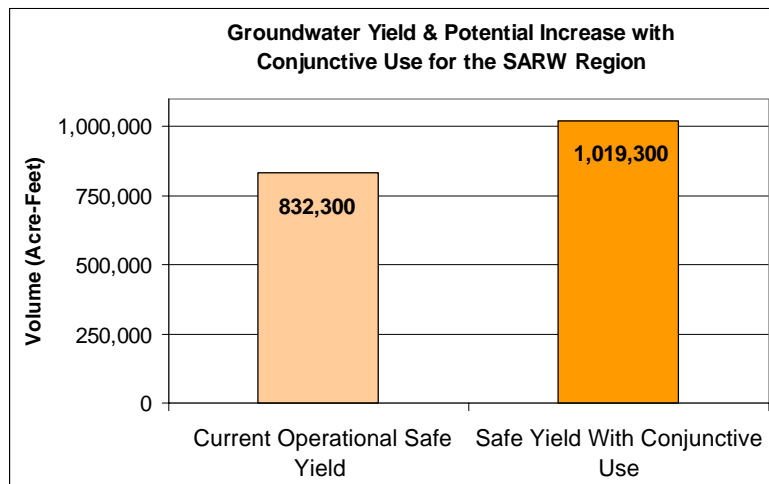


Figure 14: Groundwater Yield and Potential Increases with Conjunctive Use
Source: AGWA, 2000

Current and Proposed Groundwater Recharge Projects

Currently, surface water comprises the majority of artificial recharge (SAWPA, 2002). This source of recharge is expected to continue as the main supply over the next 50 years as more and more facilities are constructed to capture and store storm and river flows. In IEUA, stormwater is considered the primary source of water for recharge into groundwater basins. However in OCWD, recycled water is the primary source of water for the Groundwater Replenishment System. A short summary of OCWD’s and IEUA’s conjunctive use projects are described in the following section, however for more current and proposed projects please see Supporting Research, Section D.

Orange County Water District

The GWR System takes highly treated sewage water from the Orange County Sanitation District (OCSD) and purifies the water to state and federal drinking standards using a 3-step process of advanced membrane purification technology through the use of microfiltration, reverse osmosis, and ultraviolet light with hydrogen peroxide advanced oxidation treatment to treat the water. The water will then be used to recharge the Orange County Coastal Plain, in addition to expanding an existing underground seawater intrusion barrier. The GWR System consists of three different phases, the first of which will produce up to 72,000 AFY of recycled water for recharge to begin in 2007. The goal of the entire project is 140,000 AFY (OCWD, 2005). However, current recharge uses blended water whereas the GWR water's quality is much higher. OCSD treats and transfers the water to OCWD. This process may allow reduced reliance on imported water, which uses twice the energy needed for the GWR System to pump from northern California (OCWD, 2005). In addition, the higher quality of the replenishment water reduces mineral build up in groundwater basin, not to mention that the supply of treated wastewater will essentially be limitless. Ocean outfall will be reduced as a result of the GWR System and additional water will be available to combat salt water intrusion. Lastly, there will be no evaporation from groundwater aquifers.

Chino Basin Water Master

Groundwater currently produces 62% of water supplies for Inland Empire Utilities Agency (IEUA, 2005). Inland Empire, along with the Chino Basin Watermaster, is implementing the Regional Groundwater Recharge Program, the Chino Basin Desalter Program, and the Dry Year Yield (DYY) Program. The projects will significantly increase the overall yield of the Chino Basin in addition to improving the Basin's water quality. Groundwater production is expected to provide 68% of the area's water supply during normal years and 72% during dry years by 2025 (IEUA, 2005). The Groundwater Recharge Master Plan was developed in 2001 and identified sources of recharge water and improvements needed to existing recharge facilities to guarantee capture and percolation. As a result of the Plan, 100,000 AFY of recharge capacity was identified (IEUA, 2005). IEUA will use stormwater and recycled water in addition to imported water to fill the Basin. IEUA's Chino Basin Recharge Facilities Improvements project was completed in the spring of 2005. The project constructed two new basin sites and configured sixteen existing flood control basin sites for joint use as percolation basins, capable of percolating imported and stormwater. The Improvement project is expected to recharge 134,000 AFY (IEUA, 2005). The DYY requires the development of facilities to pump 33,000 AFY during dry years to utilize 100,000 AF of storage (IEUA, 2005). Additionally, all of the Water Districts participating in the DYY are obligated to reduce usage of imported water during dry years. As a result, the Districts will provide MWD with 33,000 AFY of water during dry years (IEUA, 2005). The facilities required for the DYY are scheduled to finish construction by 2008.

4 Results

4.1 Development and Comparison of Plausible Future Water Demand Scenarios

4.1.1 Water Scenario Evaluation Model

The Water Scenario Evaluation Model (WASEM) generates individual quantitative scenarios of future water demand and supply for various regions within Southern California. For this study, we focused the model on the seven major water districts in the SARW Region. WASEM's reference scenario is tuned to replicate the demand projections reported by MWD in their 2005 RUWMP and the supply projections reported by the water agencies comprising the SARW Region. Alternative scenarios of demand and supply can be easily generated by modifying key parameters that define demand and supply.

Although WASEM can generate scenarios of demand and supply, we used the model only to determine plausible future demand projections for the SARW Region based on specific demand management strategies. Baseline future demand projections were based on MWD's 2005 RUWMP demand assessment for the seven principal water agencies in the SARW Region. Baseline future supply projections for the SARW Region were prepared by aggregating together the seven individual water district's 2005 UWMP supply projections. Demographic data and other demand driver data were unavailable to us at the individual water district level, thus MWD demand projections from their 2005 RUWMP served as a proxy.

4.1.2 Demand

WASEM estimates future demand projections for each water district in the SARW Region by factoring together various demographic and management trends over a given time span. Future water use is derived by multiplying the different demographic units and their average water use. Water management trends, such as conservation efforts over time, are calculated from the demand data given by MWD. This provides a calculation of baseline demand from 2005-2030 which replicates the MWD projections for the SARW Region. Table 7 highlights the parameters used to define water demand for any given demand scenario:

Demand Parameters (by water district)
Population Growth Rate
Ratio of Single-Family and Multi-Family Households
Household Size
Income Growth
Commercial Business vs. Industry
Water Demand Response to Household Size & Income
Naturally Occurring Conservation

Table 7: Parameters defining water demand for each water district

Replacing the baseline parameter values with alternative values results in demographic and water demand estimates that deviate from MWD's baseline demand projections. Each parameter value carries with it uncertainties which intensify the further out demand projections are estimated. Water managers must deal with such uncertainties, such as population growth, when considering plausible future water demand projections. For the purposes of this analysis, baseline demographic values were held constant so that changes made to conservation, or water use efficiency levels could be made explicit. Future research opportunities exist to examine how uncertainties over future population and other demographic parameters may alter the interplay between future demand and supply projections.

WASEM was created to easily evaluate the effects of altering the level of water use efficiency for each specific water district within the SARW Region. Adjusting levels of water use efficiency is accomplished by varying the water use intensity in the following sectors: single-family (SF) interior, SF exterior, multi-family (MF) interior, MF exterior, commercial, industrial, and institutional (CII). The percentage savings are linearly applied from the outset to the end of the scenario time period, in this case from 2005-2030.

Baseline Demand Scenario Projections

For purposes of comparison, WASEM was used to first establish the baseline water demand for the SARW Region. This was accomplished creating a reference scenario based on MWD's 2005 RUWMP. Figure 15 illustrates the region's projected populations by water district and Figure 16 shows the projected population growth percentage from 2005-2025. The Region's population is projected to increase 24% over the next 20 years and is driven by growth in the Inland Empire (IEUA, Eastern & Western fall within the area referred to as the Inland Empire). The Region is forecasted to also experience a pronounced increase in housing units, particularly single-family units, as shown in Figure 17.

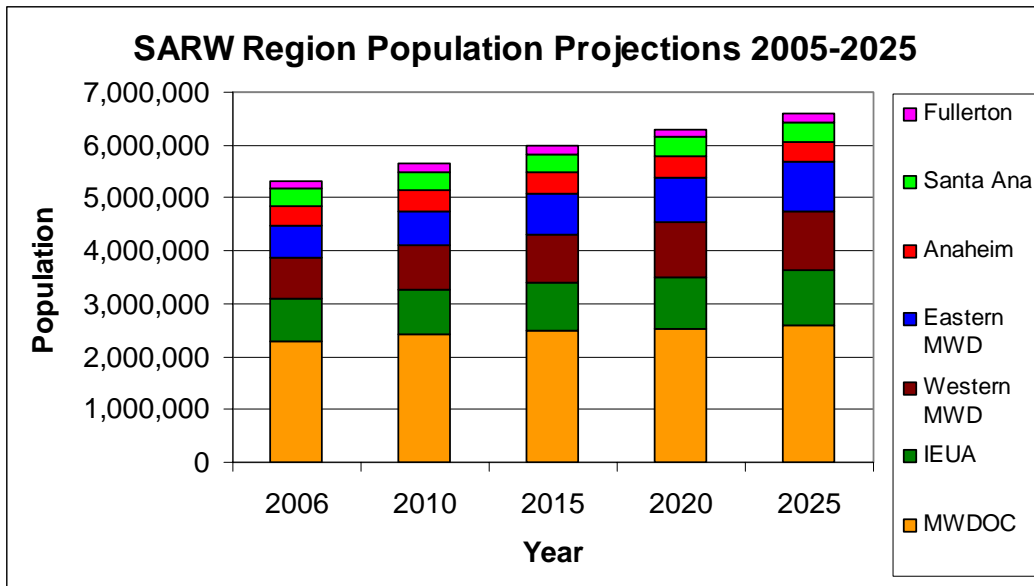


Figure 15: Baseline projections of population in the SARW Region.
Source: MWD RUWMP, 2005

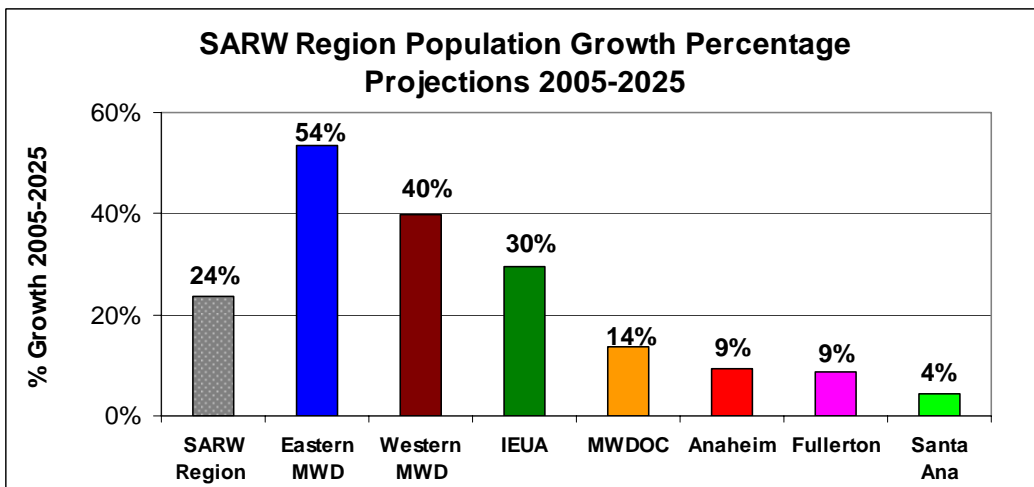


Figure 16: Population growth percentage projections,
Source: MWD RUWMP, 2005.

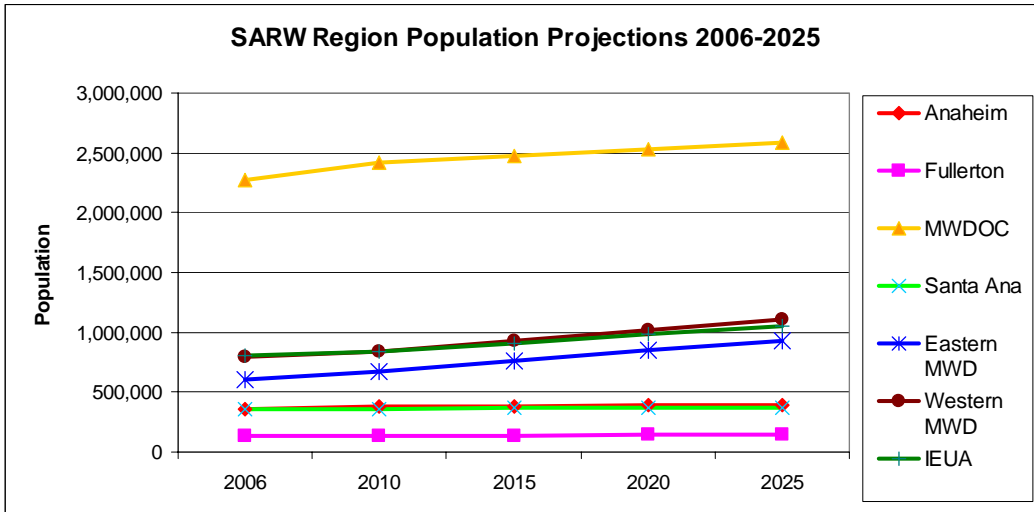


Figure 17: Single-family dwelling unit projections.
Source: MWD RUWMP, 2005.

The growth in population, single-family homes, and other urban water users will create higher future water demands in 2025 than currently exist in the SARW Region. Demand in all urban sectors is projected to increase by 2025, while agricultural demand is projected to decrease by 2025. Figure 18 shows that total annual demand in 2025 is projected to increase by over 275,000 AF an increase of 18% from 2006 estimates.

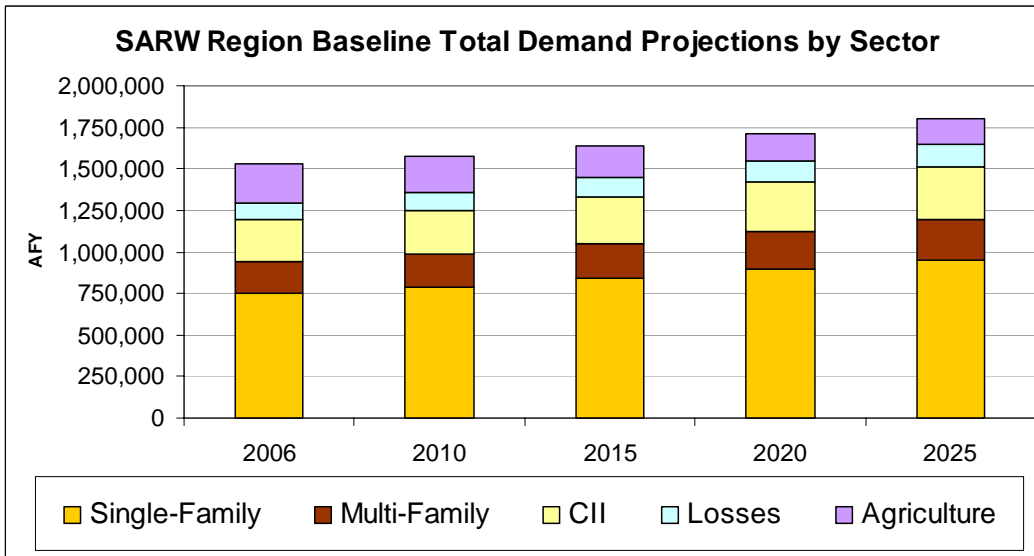


Figure 18: Baseline total demand projections by sector for the SARW Region.
Source: MWD RUWMP, 2005.

Alternative Demand Scenarios

While it is possible to modify multiple demand parameters in order to explore how water demand in the region changes, our analysis focuses exclusively on adjusting urban water use efficiency intensity values. These values reflect policy options on the part of water agencies in which management strategies are used to affect the urban demand of water. Thus, alternative demand scenarios are developed for this analysis by altering the baseline scenario percentage of water use efficiency intensity.

We consider three alternative levels of efficiency: one from Pacific Institute's *WNWN* report (Gleick et al. 2003) and two that we have created specifically for the SARW Region (see Section 3, Chapter 3.1). These alternative levels of efficiency establish the multiple demand scenarios that will be used in our analysis. These alternative demand scenarios will be compared against the baseline demand scenario to explore how different management strategies can affect urban demand in the SARW Region.

The baseline scenario does include conservation strategies, such as plumbing codes, to increase the urban water use efficiency, thereby decreasing demand; however, the efficiency gains are passive in nature. The three alternative demand scenarios utilize a suite of active demand management strategies, such as new appliances, technology, programs, and policies, to increase urban water use efficiency. The different demand scenarios and their respective management strategies and alternative efficiency percentages are summarized in Table 8

The Pacific Institute's 2003 report (Gleick et al. 2003) is viewed as the high-end of urban water use efficiency, as the study reported significant potential water savings attributable to new and emerging technologies, programs, and policies (Table 8). For this reason, we have developed an alternative demand scenario that applies the potential water savings Gleick et al. (2003) report to the SARW Region.

However, the report did not factor into its analysis the potential water savings attributable to dual-flush toilets, waterless urinals, ET-based irrigation controllers, and appropriate landscape plant designs. We have developed two alternative SARW Region demand scenarios that go above and beyond Pacific Institute's efficiency estimates. Both of these scenarios include the savings attributed to dual-flush toilets and waterless urinals, but differ by how aggressive residential outdoor efficiency measures are implemented and are therefore differentiated by their names: ET-Controller Scenario and CALscapes scenario (Table 9). Section B covers these technologies and programs in detail and provides our analysis for the potential water savings of such strategies for the SARW Region.

	MWD Baseline Scenario		Pacific Institute Scenario		SARW Region - ET Controller Scenario		SARW Region - CALscapes Scenario	
Sector	Water conservation strategies	Efficiency % by 2030 from MWD Gross Baseline	Water conservation strategies	Efficiency % by 2030 from MWD Gross Baseline	Water conservation strategies	Efficiency % by 2030 from MWD Gross Baseline	Water conservation strategies	Efficiency % by 2030 from MWD Gross Baseline
Interior Residential Use	Code-Based Strategies	11%	Replace all inefficient appliance and fixtures	32.50%	Pacific Institute strategies + Dual-Flush Toilets	35.20%	Pacific Institute strategies + Dual-Flush Toilets	35.20%
Exterior Residential Use		0%	Improved landscape maintenance and management with efficient irrigation technologies	27.50%	Pacific Institute strategies + ET-Based Irrigation Controllers	40%	Pacific Institute strategies + California Appropriate Landscapes	77%
Commercial, Industrial, and Institutional Use (CII)	Code-Based Strategies	7%	Use of cost-effective water use practice and technology	32.50%	Pacific Institute strategies + Waterless Urinals	37.10%	Pacific Institute strategies + Waterless Urinals	37.10%

Table 8 – Baseline Demand Scenario and the three alternative demand scenarios. Urban water use efficiency intensity increases from left to right.

<u>Scenario</u>	<u>Differentiation</u>
SARW Region – ET Controller Scenario	ET Controller + Pacific Institute Outdoor Efficiency Measures
SARW Region – CALscapes Scenario	CALscape Efficiency Measures

Table 9: Summary of strategies employed by each alternative demand scenario

Figure 19 illustrates how water demand in the SARW Region would change under the three different levels of efficiency holding all other factors constant. The dark grey bar to the far left indicates the MWD RUWMP baseline projection. The light grey bar corresponds to the level of demand projected under the efficiency levels determined by the Pacific Institute. The green bars represent the scenarios specifically created for the SARW Region with the dark green bar indicating the ET-Controller Scenario and the light green bar corresponding to the CALscape scenario.

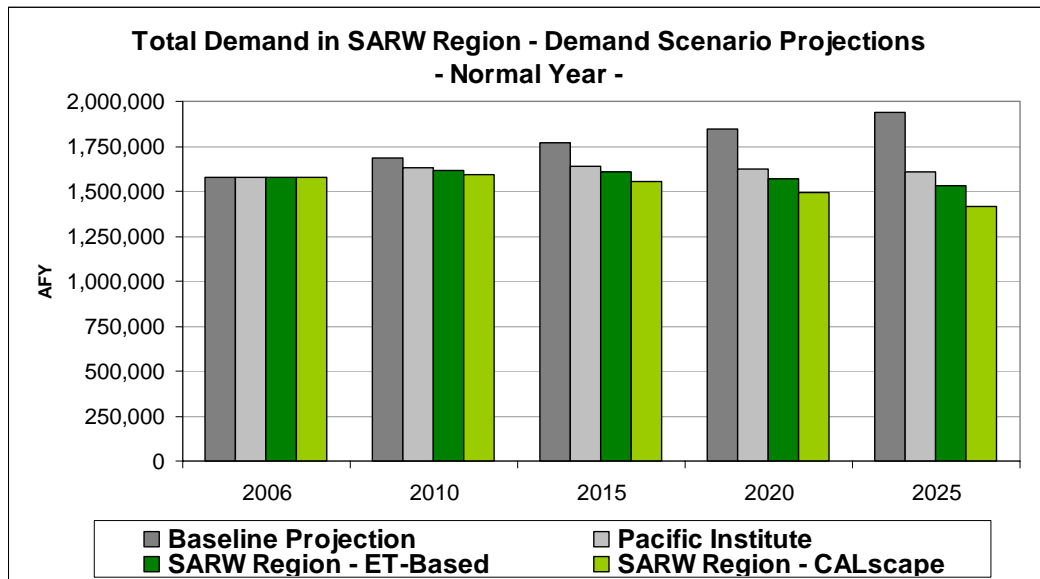


Figure 19: Plausible future demand projections of demand scenarios

There are several key findings indicated by these results:

- The baseline demand projections rise over time due to increases in specific demand drivers, such as population and housing trends.
- Implementing available and cost-effective efficiency technologies and programs can potentially stabilize water demand in the SARW Region.
- Water demand can potentially *decrease* over time by aggressively implementing demand management strategies, such as CALscapes and ET Controllers.
- If the entire SARW Region were to feature CALscapes, water demand could potentially decrease by approximately 525,000 AF in 2025 over the baseline demand projection, a decrease of 27%.

- Total per-capita water use can be reduced for the entire SARW Region and for each water district depending on which management strategies are utilized (Figure 20).

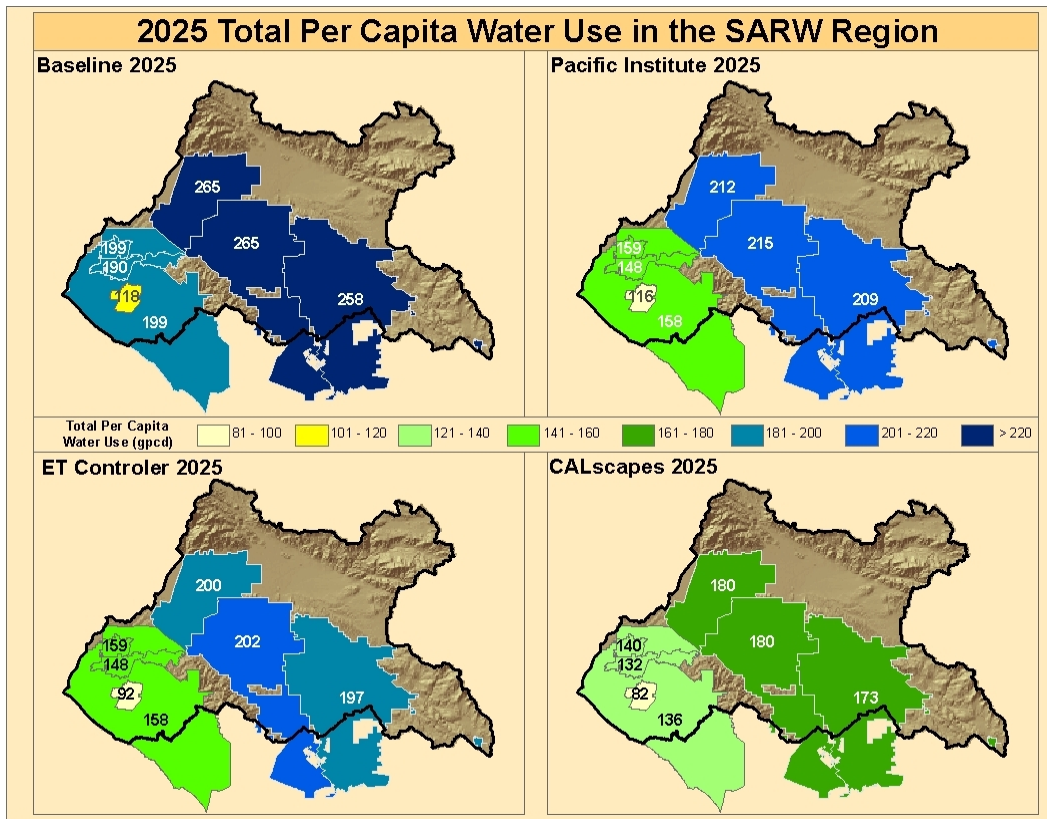


Figure 20: Total per capita water use in the SARW Region

4.1.3 Supply

The water districts within the SARW Region have been pioneers in developing local water resources, whether it is by reusing municipal wastewater, reclaiming non-potable groundwater to potable drinking standards or enhancing groundwater pumping safe yields with the conjunctive use of storm water. Many of the water districts in the Region have stated in their 2005 UWMP that they fully intend to continue implementing progressive strategies to develop even more local supplies over the next 20 years. Several notable plans and strategies that are either developed or are slated to be developed include: IEUA’s goal to recycle and reuse over 95% of its service area’s municipal treated wastewater by 2025; OCWD’s GWR System; and the inter-basin coordination and cooperation between the SAWPA agencies to handle groundwater, Santa Ana River base flow, and other hydrologic issues.

For the purposes of this analysis we wish to build upon the successes of the seven water agencies in developing local resources by identifying plausible future supply scenarios in

which local supplies are maximized using management strategies such as municipal wastewater reuse and the conjunctive use of freshwater to recharge the groundwater basins beneath the SARW Region. If the SARW Region's water resources can further become locally-reliant, how much can the region decrease its reliance on imported water supplies from the Delta, the Owens Valley, and the Colorado River?

Baseline Supply Scenario Projections

In order to evaluate and compare different supply management strategies and the local supplies they yield, a reference baseline supply scenario for the entire SARW Region was created. This was accomplished by aggregating the total water supplies, both local and imported, of the seven water districts together. Information regarding the types and quantities of water supplies at the district level comes from each district's 2005 UWMP⁶. For this analysis, unless otherwise stated, all reported supplies will be comprised of both direct and indirect supplies. Additionally, only supplies for normal or average years will be analyzed.

Direct and indirect supplies- Direct supplies imply that the water is targeted to supply direct uses of water, such as potable uses, industrial uses, landscape uses, agricultural uses, etc. Indirect supplies are generally targeted to supply non-potable uses such as groundwater replenishment, saline barriers, irrigation, agriculture, etc. It should be noted that some uses of water can use either potable or non-potable supplies of water, like irrigation or industrial uses. In such cases, management strategies that promote the optimal use of water can help stretch the highly-valuable potable sources and supplies of water further.

In 2005, approximately 60% of the supply during normal years in the SARW Region is projected to be locally derived, with groundwater providing the bulk of local supplies (Figure 21). Recycled water supplies around 5% of the total demand in 2005, however, in 2025 recycled water supplies increase to meet 13% of the demand (Figure 22). Overall, however, the import to local supply ratio is not projected to change much from 2005 to 2025 as a 40:60 ratio is approximately maintained.

⁶ Urban Water Management Plans (UWMPs) were collected for the seven agencies listed in Supporting Research, Section A. Although the San Bernardino Valley Municipal Water District (SBVMWD) also lies within the watershed, a 2005 UWMP was not available so we do not include them in our analysis due to a lack of data.

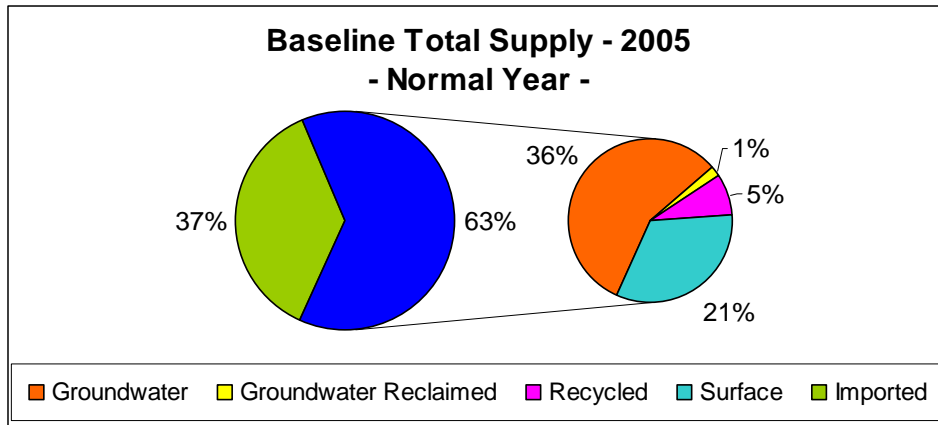


Figure 21: Projected baseline supply resource mix in the 2005

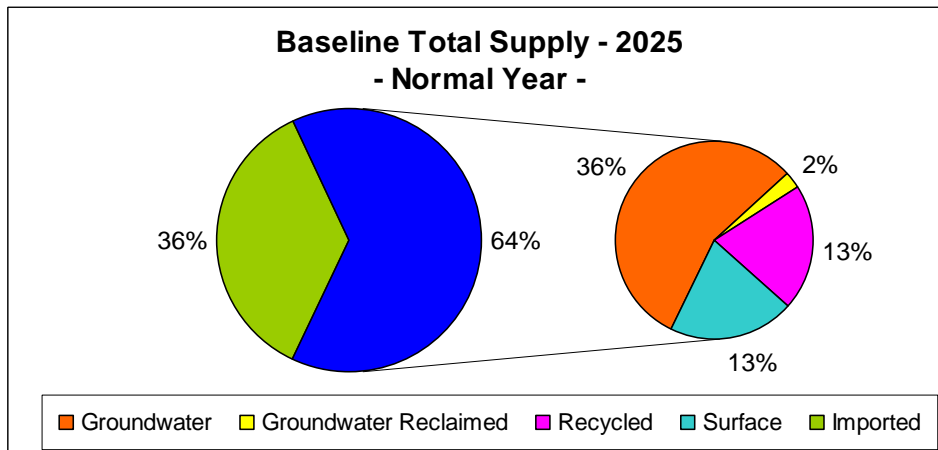


Figure 22: Projected baseline supply resource mix in 2025

Aggregating the individual district supply data, the total supplies for the SARW Region are projected to increase nearly 630,000 AF from 2005 to 2025, an increase of 37%. Figure 23 illustrates total water supplies by source for the SARW Region. It is important to note that while local resources are projected to increase, so too are imported supplies. Supplies of imported water, indicated in green, are projected to increase 35% over 2005 levels. This percentage increase over 2005 requires that nearly 836,000 AFY come from outside the Region.

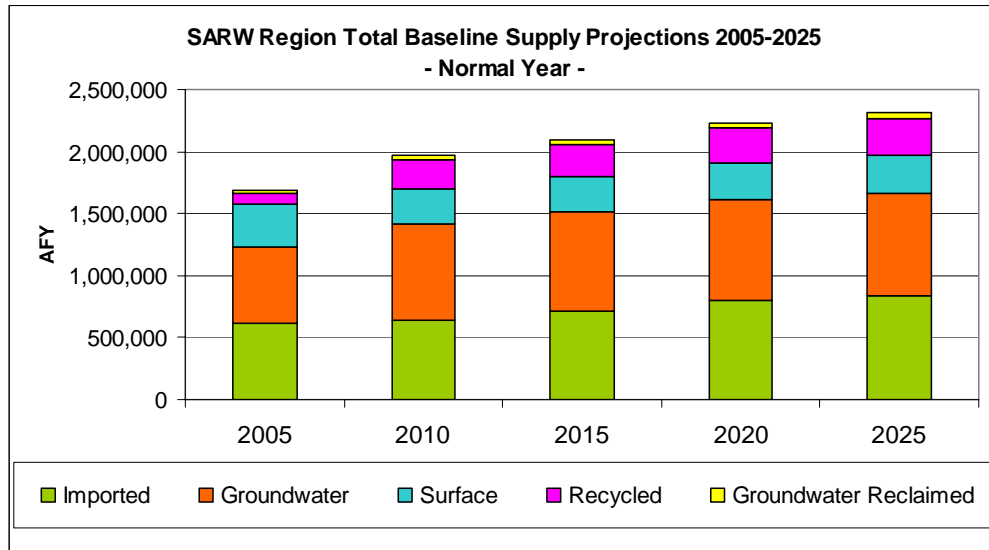


Figure 23: Projected total baseline supply projections to 2025.
Source: SARW Region Water District UWMPs

Alternative Supply Scenarios

As described in the Supporting Research, Section C, we consider how further developing the municipal reuse of treated wastewater and the conjunctive use of freshwater flows with groundwater recharge can augment local supplies and create locally reliable sources of water over the long-term future. For this report, three alternative supply scenarios were created that feature increased levels of local resource development above and beyond what the SARW Region’s water district UWMP project and plan for. The three supply strategies are:

- 1) 75% Maximum Reuse + Baseline Recharge Scenario
- 2) 75% Maximum Reuse + Max Recharge Scenario
- 3) Maximum Local Supplies Scenario⁷

These alternative supply scenarios have been created such that they progressively develop additional local groundwater and municipal reuse supplies. At the far end, the Maximum Local Supplies Scenario, each water district in the region is reusing 95% of their treated wastewater by 2025, which is in line with IEUA’s stated goals, and maximizing the sustainable safe yield of the groundwater basins that underlie each district through recharge. The scenarios in which reuse is at 75% of maximum calculates the additional water supplies if each water district reuses 75% of treated wastewater by 2025. Table 10 compares the development of additional local supplies for the three

⁷ The estimated maximum groundwater safe yield extraction with conjunctive use for the groundwater basins in the SARW region is based on AGWA’s estimates (AGWA 2000) and the estimates for $\frac{3}{4}$ maximum and maximum reuse of municipal wastewater are based on the future treated wastewater projections in each district’s UWMP. Refer to previous chapters for more detailed discussions on how these estimates were obtained.

alternative supply scenarios to the reference or baseline scenario based on the water district's UWMP's.

Figure 24 illustrates the supply projections that result from the three alternative supply scenarios. The baseline scenario is on the far left in grey with the Maximum Local Supplies Scenario on the far right, in blue. By 2025, the max local supplies scenario is projected to increase total supplies by about 260,000 AF over baseline projections, or 11%.

Supply Strategies (AF)				
Resources	Reference*	75% Max Reuse		
		+ Baseline Recharge	75% Max Reuse + Max Recharge	Max Local Supplies
Groundwater Supplies	223,000	223,000	372,000	372,000
Municipal Reuse	218,000	263,000	263,000	327,000
Total	441,000	486,000	635,000	699,000

* Additional local supplies for reference scenario estimated as difference between 2030 and 2005 projections

Table 10: Additional long-term average supply yield for the reference supply scenario and the three alternative supply scenarios

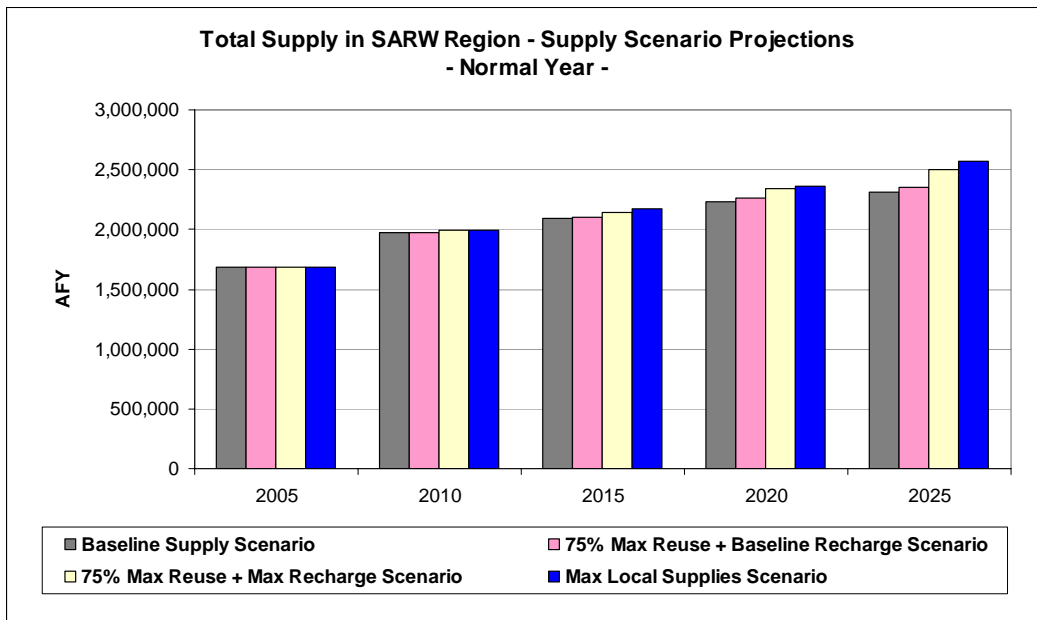


Figure 24: Total supply projections for the SARW Region based on different supply strategies

4.1.4 Interplay of Supply and Demand Scenarios

Water managers in the SARW Region are tasked with procuring, developing, storing, and delivering the requisite water resource to supply the growing demands of the region. Uncertainties abound with regards to developing or importing water supplies; demands over time are dynamic and changing. Thus, water managers must balance the delicate interplay between supplying the water demands of today while preparing a portfolio of supply options full of uncertainties to meet a changing future demand. We examine here plausible future supply and demand balances and the degree to which different scenarios result in the SARW Region becoming more locally-reliant in regards to future water supplies.

Baseline Supply to Demand Ratio and Resource Mix

Again we turn to the reference scenarios in order to establish a baseline from which we can compare other scenarios against. It is important to note that our baseline demand scenario is derived from demand and demographic data provided to us by MWD while the baseline supply scenario is generated by aggregating together data from the individual UWMP's for each water agency within the SARW Region. We were unable to obtain demographic data from individual water agencies so we have relied on MWD's demand assessment for the SARW Region. Thus, our demand and supply projections do not come from the same dataset so there may be error associated with this approach. However, this allows for meaningful analysis since we are interested in parsing out the long-term and overall demand and supply trends and exploring how developing alternative management strategies might affect the water resource mix for the water agencies in the SARW Region.

Water agencies tend to try and develop more supplies than there is demand in order to meet future demands since there is an inherent lag-time between developing water supplies and delivering them to meet the future demands. In addition, having a surplus of supplies at any point in time provides water agencies with a buffer to protect against uncertainties that may otherwise prevent supplying an agency's full demands. Thus, a supply to demand ratio greater than one is desired, however, there are often financial, political, and physical limitations to maintaining a supply to demand ratio well in excess of one.

For this reason, each agency will in reality have its own ratio, however, for this analysis we look at the SARW Region as a whole and report the supply to demand ratio for the entire region, as seen in Table 11. The baseline supply to demand ratio is projected to increase from 1.07 in 2006 to 1.19 in 2025. Such an increase can be explained by the fact that the local water agencies project greater local water resources development than what MWD considers in their demand assessment for the region. The resulting resource mix is illustrated in Figure 25. The key findings regarding the baseline resource mix is that projected total supplies will increase by 37% by 2025 and imported supplies are projected to increase by 35%.

Baseline Supply - Baseline Demand					
SARW Region	2006	2010	2015	2020	2025
Total Demand	1,575,460	1,682,690	1,770,080	1,846,050	1,937,640
Local Supplies	1,061,513	1,330,199	1,375,542	1,425,280	1,475,538
Imports	620,430	639,439	717,828	802,779	835,977
Total Supplies	1,681,943	1,969,638	2,093,370	2,228,059	2,311,515
Supply:Demand Ratio	1.07	1.17	1.18	1.21	1.19

Table 11: Baseline supply to baseline demand ratio. Notice by 2025, projected supplies will be 19% greater than what is projected to be demanded

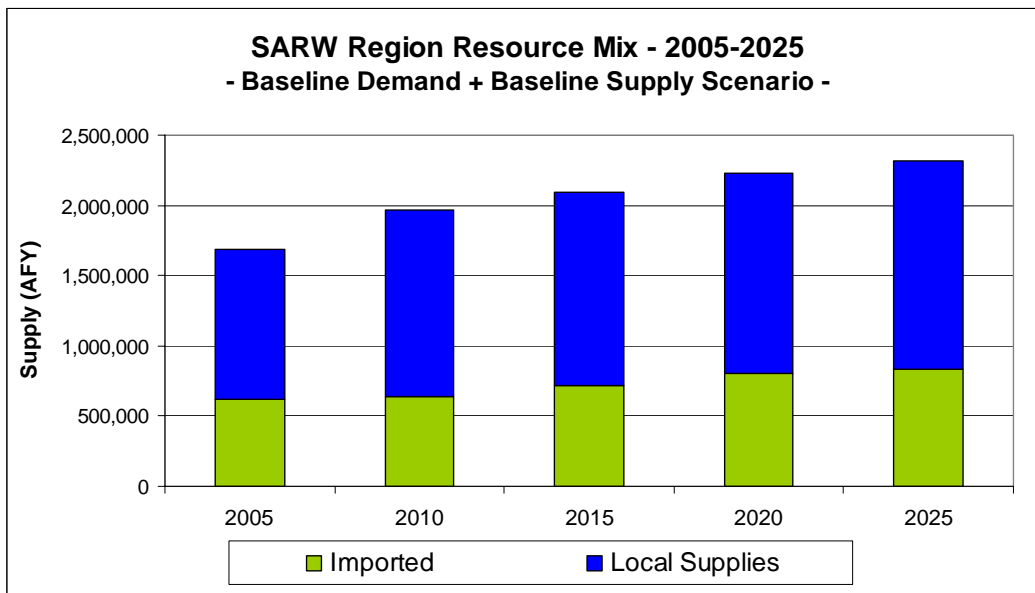


Figure 25: Baseline resource mix using MWD RUWMP Demand Projections and member agency UWMP supply projections.

Alternative Supply to Demand Ratios and Resource Mixes

In this analysis we have presented demand scenarios that have the potential to decrease demand in the SARW Region and supply scenarios which augment local supplies through municipal reuse of treated wastewater and recharging groundwater basins underlying the region. Different permutations of the demand and supply scenarios can be developed which can result in supply to demand ratios ranging from 1.19 in to 1.82 in 2025 (Table 12). The different demand scenarios can be seen in the columns with the various supply scenarios in the rows of Table 12. As additional local supplies are developed, the supply to demand ratio increases, which can be seen with the increase in ratios going down a column. Likewise, as water use efficiency intensity increases, the ratio increases since the demand decreases relative to supplies, thus the ratios increase from left to right in any given row.

Supply to Demand Ratios in 2025 Between Different Scenarios				
Scenarios	Baseline Demand	Pacific Institute	SARW Region - ET Controller	SARW Region - CALscapes
Baseline Supply	1.19	1.44	1.51	1.63
75% Reuse + Baseline Recharge	1.22	1.47	1.53	1.67
75% Reuse + Max Recharge	1.29	1.56	1.63	1.77
Maximum Local Supplies	1.33	1.60	1.68	1.82

Table 12: Supply to demand ratios in 2025

Because it is not fiscally or physically pragmatic to have 82% more supplies than there is demand for any given district or region, we have developed a methodology in which the water saved via efficiency strategies and additional local water supplies developed reduce and replace the equivalent quantities of imported water. Figure 26 provides an illustrative schematic in which imported sources of water can be reduced by demand reductions and replaced by local water sources.

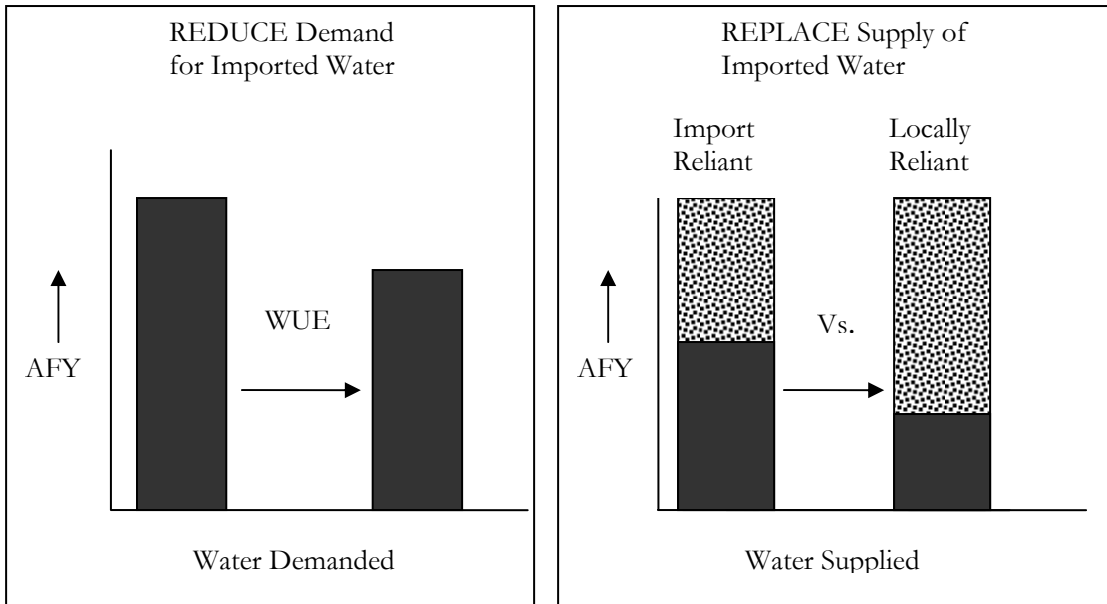


Figure 26: Schematic depicting how imported sources of water can be reduced through water use efficiency strategies and replaced by developing alternative local supplies of water.

Following this methodology, Table 13 breaks down the potential decrease in imported supplies which may result through various combinations of demand and supply scenarios. Potential reductions range from 45,000 – 785,000 AF as the potential reductions increase as one moves down the rows and to the right. Taken independently, management strategies that focus on reducing demand suggest greater potential reductions in imported supplies than do developing alternative supply scenarios. However, operating

in tandem, significant reductions are possible as seen when the SARW Region CALscape Demand Scenario is combined with the Maximum Local Supplies Scenario. This combination yields a reduction of nearly 785,000 AF in 2025, a reduction of 94% from the baseline projected imported supply in 2025!

Potential Decrease of Imported Supplies by Scenario (AF)				
Scenarios	Baseline Demand	Pacific Institute	SARW Region - ET Controller	SARW Region - CALscapes
Baseline Supply	0	330,000	403,000	525,000
75% Reuse + Baseline Recharge	45,000	375,000	448,000	570,000
75% Reuse + Max Recharge	195,000	525,000	598,000	720,000
Maximum Local Supplies	260,000	590,000	663,000	785,000

Table 13: Potential Decreases in Imported Water Supplies as a Result of Alternative Management Strategies

Taking these potential water reductions into account and subtracting them from the total supplies for each scenario combination yields the supply to demand ratios found in Table 14. These ratios offer a more realistic projection of the balance water agencies would desire between developing water resources to supply future demands. Because the methodology we use substitutes or replaces imported supplies with locally-developed water resources the supply to demand ratios for any supply scenario is determined by the demand scenario. The demand scenarios crafted specifically for the SARW Region (in green in Table 14) feature aggressive demand management strategies, thus the supply to demand ratio increases. Because the ratios in 2025 for the alternative scenarios are elevated over the baseline 1.19 supply to demand ratio the region benefits, the projected ratios offer enhanced robustness to vicissitudes in climate, environmental changes, political shifts, and demographic changes.

Supply to Demand Ratios in 2025 After Decreasing Imported Supplies				
Scenarios	Baseline Demand	Pacific Institute	SARW Region - ET Controller	SARW Region - CALscapes
Any Supply Scenario	1.19	1.23	1.24	1.26

Table 14: Supply to demand ratios in 2025 after accounting for reduced imported supplies

4.1.5 Plausible Future Resource Mixes in the SARW Region

Using a combination of alternative demand and supply management strategies, we have presented multiple plausible future projections of water supply and demand for the SARW Region. Combining different plausible future scenarios together, we have demonstrated that the region can continue to become more reliant on local supplies of water. To what extent and by what methods the different water agencies within the SARW Region become less reliant on imported water supplies will be determined by decision-makers in the region through policy options. Our intent here is to present

decision-makers with two plausible future projections of water resource mix that differ by degree in intensity to compare against the baseline resource mix. The two resource mixes will be discussed result from the following scenario combinations:

- 1) CALscape Demand Management Scenario + Maximum Local Supplies Scenario
- 2) Pacific Institute Efficiency Scenario + 75% Reuse/Baseline Recharge Supply Scenario

CALscape Demand Management Scenario + Maximum Local Supplies Scenario

As seen in Figure 27, this scenario combination has the potential to decrease the need to import approximately 785,000 AF of water into the SARW Region. Implementing the management strategies contained within each of the two scenarios would result in a total supply projection over time that begins to level off and decrease, despite population increases as seen previously in Figure 15. Total supplies reach a maximum around 2015 and then begin to decrease. By 2025, total supplies increase by about 104,000 AF, or 6% from 2005. More significant is the downwards trend in imported supplies that results from combining these two scenarios. This is in direct contrast to the projected baseline scenario in which imports increase by 35% in 2025 from 2005. Here, imported supplies are projected to decrease by to such an extent that by 2025 imports comprises only 3% of the resource mix with local supplies supplying the remaining 97% (Figure 28). Recall that the baseline resource mix in 2025 calls for imports to supply approximately 36% of the demand.

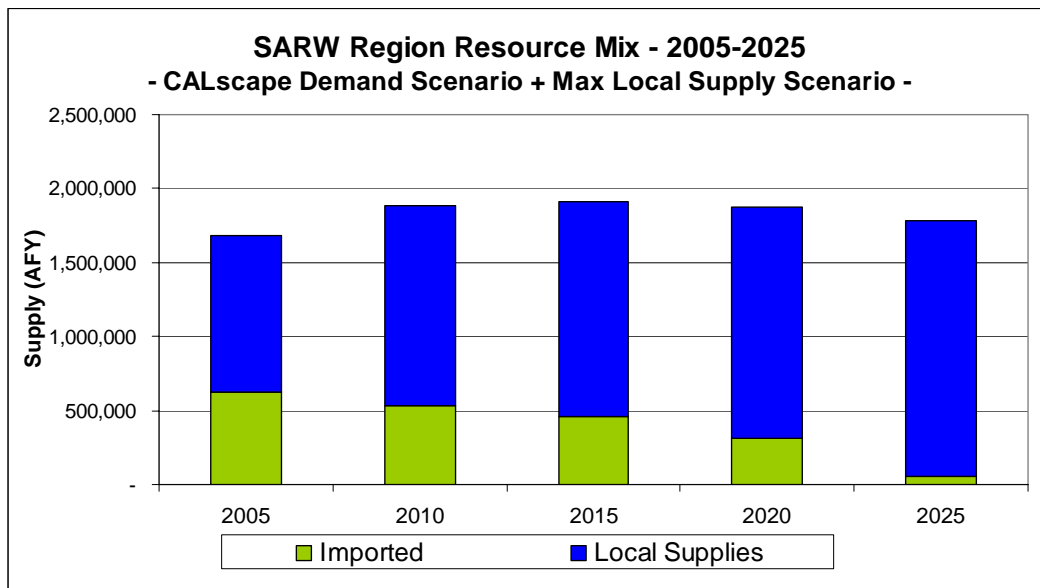


Figure 27: Resulting Supply Mix from Implementing Aggressive Alternative Management Strategies for both Supply and Demand

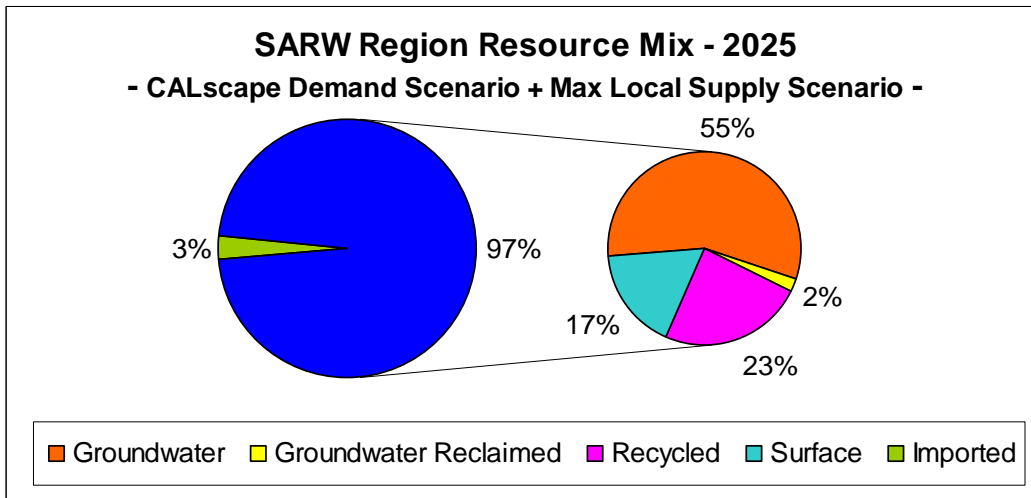


Figure 28: 2025 Resource Mix for the CALscape Demand Scenario + Max Local Supply Scenario

Pacific Institute Demand Management Scenario + 75% Reuse/Baseline Recharge Supply Scenario

This combination of the Pacific Institute’s Demand Scenario and the SARW Region 75% Reuse/Baseline Recharge Supply Scenario is presented to offer a glimpse of the plausible future supply and resource mix projections that can occur if water agencies pursue less aggressive alternative demand and supply management strategies than are found in the CALscape Demand Scenario + Max Local Supplies Scenario. This scenario combination has the potential to reduce imported water supplies by approximately 375,000 AF (Figure 29) in 2025. Implementing the various demand and supply management strategies that the two scenarios call for would result in the potential supply projection illustrated in Figure 30. Two specific trends emerge: 1) the total supply increases over time, peaking in 2020 and begins to decrease slightly by 2025, and 2) imported water supplies decrease over time but at a slower rate than is seen in the CALscape Demand Scenario + Max Local Supplies Scenario. Total supplies increase by approximately 300,000 AF by 2025, an increase of 18% over 2005. Import supplies decrease by about 159,000 AF over the twenty year period, a reduction of 26%. As a result of this reduction over time, imported supplies of water comprise about 23% of the total resource mix in the SARW region in 2025, as seen in Figure 30.

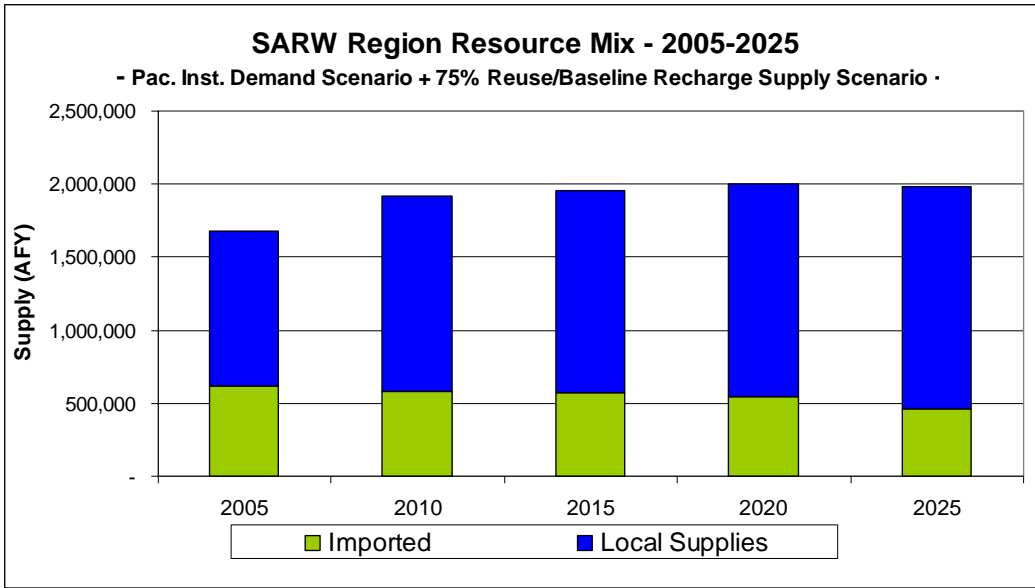


Figure 29: Supply trends resulting from Pacific Institute Scenario + 75% Reuse/Baseline Recharge Scenario

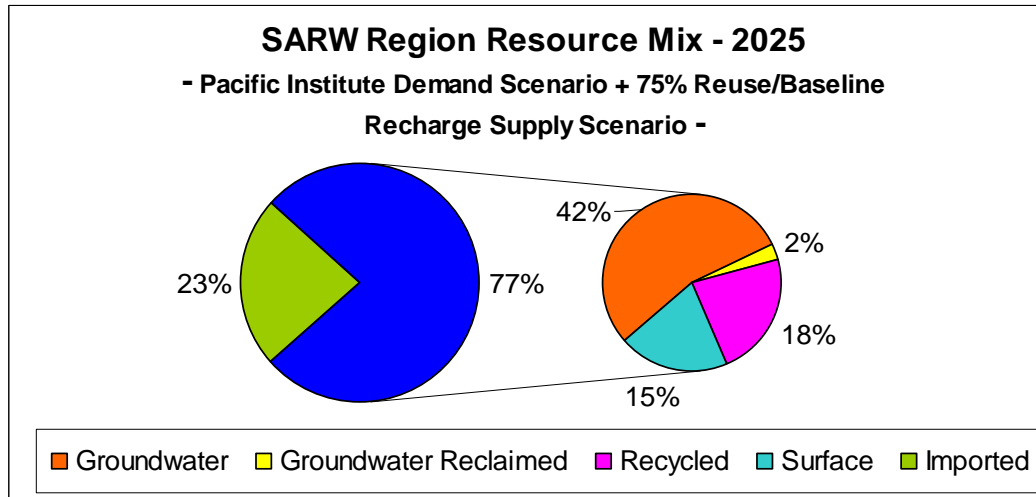


Figure 30: Resource Mix in 2025 for Pac Inst Scenario + 75% Reuse/Baseline Recharge Scenario

5 Analysis

5.1 Environmental & Financial Benefits of Increasing Local Water Reliance

The previous chapter demonstrated that there are many different possible demand and supply scenario combinations and as a result, imported water supplies may be reduced by 45,000 – 785,000 AF. The subsequent resource mixes differ as various supply sources change relative to total supply depending on the degree to which new local water resources are developed and demand is reduced. The goal is to explore how imported water supplies, as a percentage of total supply, can be reduced and to assess the potential environmental and fiscal impacts of such a reduction.

While we can assess the numerous permutations of demand and supply scenarios, we focus on the contrast between the Baseline scenario (no reductions to imported supplies) and the CALscape Demand + Max Local Supplies scenario (the scenario resulting in the greatest potential reductions, 785,000 AF). Table 15 documents the imported and groundwater resources as a percentage of total supply resulting from the Baseline Scenario and the CALscape scenario. In the Baseline scenario, both imported and groundwater resources are around 36% of the total supply over the 20-year period between 2005 and 2025. However, when aggressively increasing the WUE intensity and developing local resources, imported resources decline drastically from 37% to 3% of total supply in 2025 while groundwater resources increase from 36% to 55% of total supply.

Imported & Groundwater Resources as a Percentage of Total Supply					
Baseline Scenario	2005	2010	2015	2020	2025
Imports as a % of Total Supply	37%	32%	34%	36%	36%
Groundwater as a % of Total Supply	36%	40%	38%	37%	36%
CALscape Demand + Max Local Supplies Scenario					
Imports as a % of Total Supply	37%	28%	23%	16%	3%
Groundwater as a % of Total Supply	36%	43%	44%	48%	55%

Table 15: Baseline scenario and the CALscape Demand + Max Local Supplies scenario contrasted with respect to imported and groundwater resources as a percentage of total supply over time

These potential reductions in imported supplies have tremendous policy implications for the water agencies within the Region. A water agency’s operating budget and water rate structure is intimately tied to the both the type and amount of water resource being purchased/procured. Water agencies incur different costs depending on whether they procure imported sources from MWD or develop their own local resource, such as groundwater.

These costs are:

- \$453 per Acre-Foot for Imported Resources⁸
- \$320 per Acre-Foot for Groundwater Resources⁹

Table 16 highlights the avoided imported water costs for each year that may be obtainable in the SARW region if the CALscape Demand + Max Local Supplies scenario were implemented. In 2025, approximately \$80 million dollars per year can be saved since imported resources comprise only 3% of the total supply in 2025 in the CALscape scenario. It must be noted that we have discounted future costs at 7%¹⁰ in order to account for the time cost of money. Figure 31 illustrates the annual avoided costs in 5-year time-steps.

Avoided Imported Water Costs (\$ in Millions)					
Baseline Scenario	2006	2010	2015	2020	2025
Imported Costs	\$281	\$207	\$165	\$132	\$98
Groundwater Costs	\$195	\$178	\$129	\$94	\$69
Total	\$476	\$385	\$294	\$226	\$167
CALscape Demand + Max Local Supplies Scenario					
Imported Costs	\$281	\$172	\$99	\$51	\$6
Groundwater Costs	\$195	\$183	\$135	\$103	\$81
Total	\$476	\$355	\$234	\$154	\$87
Avoided Costs	\$0	\$30	\$60	\$72	\$80

Table 16: Calculated avoided imported water costs

⁸ This cost per AF was obtained from MWD’s water rates and charges webpage: http://www.mwdh2o.com/mwdh2o/pages/finance/finance_03.html, effective 1/1/2006. This cost was calculated by adding together the Tier 1 Supply Rate, System Access Rate, Water Stewardship Rate, System Power Rate and the Treatment Surcharge.

⁹ This cost per AF was obtained from the Orange County Water Agencies Water Rates, Water System Operations and Financial Information 2004 document, available at MWDOC’s website: <http://www.mwdoc.com/documents/Water%20Rate%20Survey%202004.pdf>. This cost was developed for Orange County water agencies that overlie the Orange County Water District groundwater basin area. However, we use this cost value and apply it to the whole SARW region for sake of comparison.

¹⁰ The U.S. Office of Management and Budget directs all federal agencies to use a 7% real discount rate in their analyses.

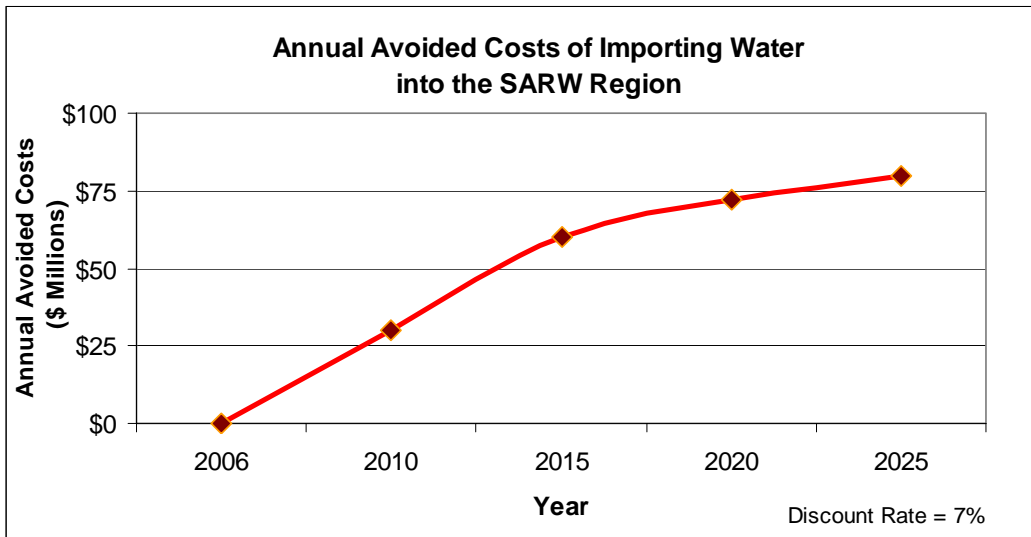


Figure 31: Annual avoided costs of importing water into the SARW Region

These avoided costs accumulate over the years, such that by 2025 just over one billion dollars can be avoided in imported water costs. Figure 32 shows how the avoided costs accrue over time.

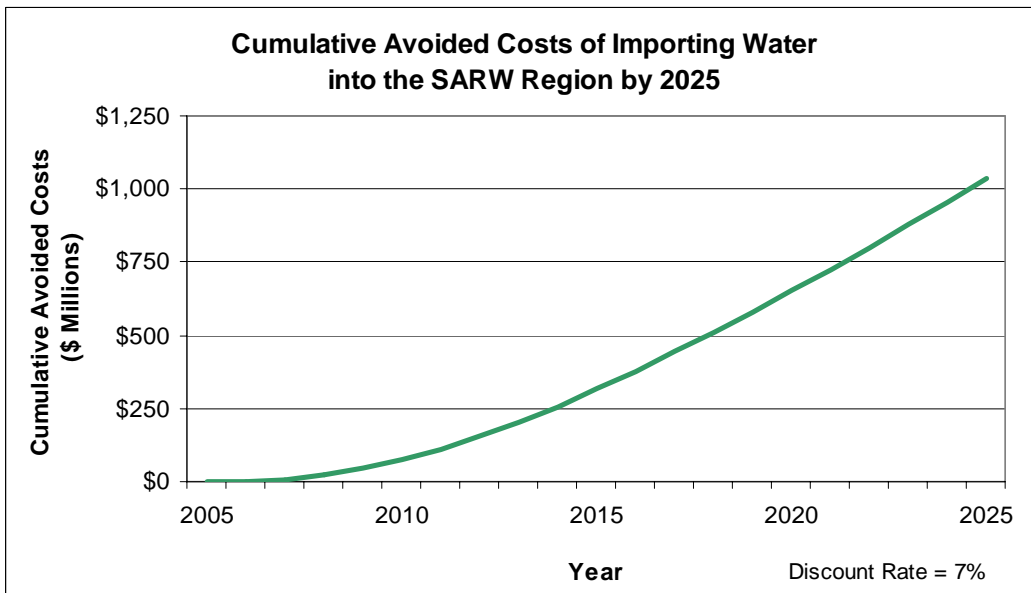


Figure 32: Over one billion dollars can potentially be avoided in imported water costs by 2025 if water agencies in the SARW region invest in demand management and local resources development strategies

These future scenarios we have explored are possible if agencies aggressively invest in demand management and local resources development strategies. The money saved by not having to purchase additional units of more expensive imported supplies can be

redirected towards planning for and implementing water reuse, recharge and use efficiency policies, programs, and technologies. Of additional benefit is that expensive, limited, and uncertain water supplies can be swapped out for affordable, untapped, and locally-reliable water resources. We have calculated that the simple payback time for CALscape and ET-Controller conversions to homeowners ranges from 2.9-9.7 and 2.3-18.9 years¹¹, respectively, depending on whether or not rebates are offered by water agencies and the type of water rate structure in use. Funds for providing rebates can be obtained through the avoided costs of procuring imported supplies.

Currently, there is considerable attention and money being appropriated to water resources and water projects at the regional, state and federal level. California Gov. Arnold Schwarzenegger is supporting a plan to spend \$222 billion on flood control projects, levee maintenance and repair, water conservation, water storage and ocean desalination. Ocean desalination, in particular, is in the spotlight with millions of dollars of regional and state grants funding research and development for desalination technologies. There are plans to develop and build ocean desalination plants within and adjacent to the SARW Region as the Poseidon Resources Corporation has targeted Huntington Beach, CA and Carlsbad, CA as potential sites.

The funding and research being given to ocean desalination is indicative of policy decisions to focus on the supply side of resources rather than aggressively target demand management strategies. Fiscally, ocean desalination is not competitive as the cost per unit for this supply source is approximately \$1,000 per Acre-Foot of water.¹² It should also be noted that Poseidon Resources Corp. does not have buyers for its supplies. We recommend that public funding go to water management strategies that are fiscally responsible, address the demand of water in the SARW Region, and have environmental benefits associated with their implementation.

In addition to the aforementioned avoided costs, reducing the amount of imported water by increasing water use efficiency and developing local supplies also provides several economic and environmental benefits. One such benefit is the provision of additional insurance against the rising variability associated with imported supply. Furthermore, improvements can be seen in terms of increased water quality as well as local ecosystem function. By importing less water and avoiding other more environmentally intrusive alternatives such as ocean desalination, the region can also reduce its impacts to other ecosystems impacted by such activities, such as the Colorado River, Bay Delta, and coastal regions. Economic benefits which could be gained from reducing the region's environmental footprint include reductions in the following: energy expenditures, greenhouse gas and pollutant emissions, and water pollution.

¹¹ See Supporting Research sections B2.1 & B2.2 to see how we calculated the simple return on investment and payback time for the various WUE technologies we've evaluated.

¹² Orange County Register, March 1, 2006.

http://www.ocregister.com/ocregister/homepage/abox/article_1022325.php

Increased protection against variability

It is acknowledged that imported water will become more variable and less reliable as time goes on. Figure 33 depicts the historical amounts of water imported by MWD from the CRA and SWP. It can be seen that there is marked variability from year to year.

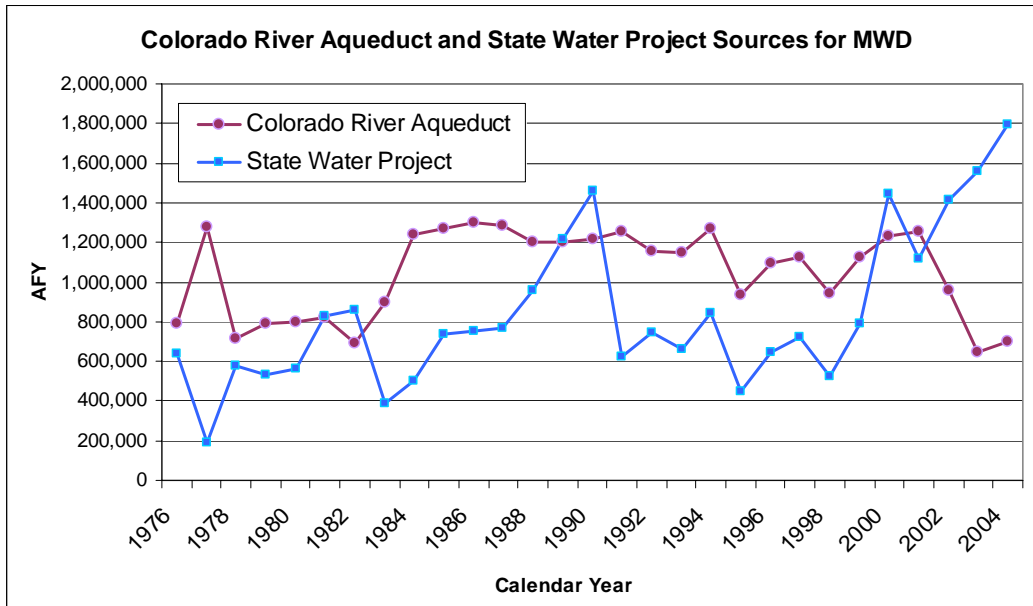


Figure 33: Colorado River Aqueduct and State Water Project sources for MWD
Source: MWD, RUWMP 2005

Of particular concern are the issues surrounding the water supply from the SWP. In February 2006, the Governor of California, Arnold Schwarzenegger, declared a state of emergency for California's levee system; 1,100 miles of levees surround the Sacramento-San Joaquin Delta, which is the source of water for the SWP. There is a 2 in 3 chance that a major earthquake or flood could cause levee failure in the next 50 years. If the levees fail due to a major storm or a strong earthquake, this means that 300 billion gallons of salt water could be pulled in (Mount, 2005), resulting in water pollution and disruption of the State Water Project. This is a frightening yet highly probable scenario (Kobely, 2006) In MWD's RUWMP, water from the SWP is recognized as becoming increasingly unreliable. In order to safeguard against a potential shortage of water from the Delta, MWD has taken steps to increase the SWP water's reliability as well as additional storage of water, for example, the filling of water in Diamond Valley Lake. MWD also recognizes the potential for natural disasters to disrupt the SWP if the 1,100 miles of levees in the Delta fails due to an earthquake or storm.

If the provider of imported water recognizes the future increase in variability and unreliability of water from the SWP, then local agencies must become even more proactive in reducing demand and developing local resources as they are the direct providers of water to communities, and thus responsible for the viability of the local economy. Many large industrial businesses dependent upon great amounts of water are

beginning to realize the risk involved with reliance on imported water; therefore, many are taking steps to secure a more reliable recycled water supply. As the region becomes more locally reliant, it will be in a better position to deal with the risk and uncertainties of the future of imported water supplies.

Increased water quality

Water quality was traditionally a concern for those trying to increase water reuse and recharge because as water is recycled the level of total dissolved solids (TDS) increases, affecting the amount of water which can be discharged and should be recharged into the groundwater basin. As technology improves with the emergence of better treatment techniques such as reverse osmosis, micro-filtration, etc., water reuse and recharge can now actually improve the water quality of the groundwater basin instead of damaging it with high levels of TDS. Though this is still new, and perhaps costly, OCWD's GWR System has undertaken this task. With plans to recycle and purify 70 MGD of water per day using advanced reverse osmosis, micro-filtration, and UV with hydrogen peroxide for disinfection, OCWD will inject the near-distilled water for groundwater recharge. The virus-, bacteria-, and salt-free water produced from the GWR System will mix with the higher mineral content groundwater in the basin, subsequently improving water quality.

Increased functioning of systems

Water tables in the groundwater basins in the SARW Region will rise if agencies more aggressively implement water recharge. Higher groundwater levels subsequently increase the surface water levels in local streams and wetland systems. More water in local streams and wetlands provides for more adequate ecosystem services and enhances the natural system with healthier riparian habitats. Increasing local water resources also increases the region's protection against seawater intrusion. In times of drought, barriers against seawater intrusion are one of the first things to be abandoned in terms of what is done with the remaining water supply. However, this poses a problem for the ecosystem and more importantly, a problem for groundwater. By reducing water demand and increasing local water supply availability, there will be more water with which to address the seawater intrusion issues.

Reduced impacts to other ecosystems

A reduction in imported water means more water that can be left in the Colorado River and the Bay Delta. The decrease in water levels in these areas has been detrimental to the ecosystems. In 2004, the U.S. Fish and Wildlife Service produced a study reviewing the status of the Delta Smelt. The Delta Smelt is an important ecological indicator for the Sacramento-San Joaquin Delta (Center for Biological Diversity, 2006). This study showed that record-high water imports from the Delta are related to the Delta smelt's population decline and that there is a fifty-percent likelihood that the Delta Smelt will go extinct within the next 20 years. Likewise, since the 1922 Colorado River Compact between the lower and upper basins, the water in the Colorado River has been overly and extensively apportioned. The Colorado, a powerful river that once flowed through these lower and upper basin states and was known as the "lifeblood of the West", is now

characterized as an intensively engineered river with dams and reservoirs. As a result, the once ecologically intact watershed no longer exists (RFA Staff, 2004). By importing less water, we can increase water levels in the Bay Delta and the Colorado River, thereby improving and restoring the habitat quality of these ecosystems.

Increased environmental quality through air pollutant emission and ocean discharge reductions

Reducing water imports can also help improve air quality and coastal water quality. According to the Los Angeles County Sanitation District's (LACSD) water recycling program, in the fiscal year 2001-2002, by replacing imported water with 95,000 AF of water, they reduced their nitrogen oxide emissions by 163.6 tons, carbon monoxide emissions by 28.5 tons, sulfur oxides emissions by 17.1 tons, 5.7 tons of particulates, and 1.4 tons of reactive organic gases.

Ocean discharges by municipalities are a source of water pollution for coastal communities, so by increasing water reuse and recycling, agencies would be able to further reduce their impacts on coastal water quality by discharging less water into the ocean.

Increased economic benefits through energy and chemical use reductions

It takes a tremendous amount of energy to pump and transport water from the Bay Delta through the SWP to various water agencies in Southern California. According to the OCWD, it requires double the energy to transport water from Northern California to Orange County as it takes to purify local wastewater. Saving approximately 140 million kilowatt hours (kWh) of electricity each year is an additional benefit for OCWD construction of its GWR System, which purifies large quantities of local resources to support a growing population.

Many agencies are beginning to recognize the environmental and economic benefits of increasing the local resources profile, but few have truly quantified these benefits. One notable agency that has is the LACSD recycling program. During the Fiscal Year 2001-2002, by reusing approximately 95,000 AF of water, approximately 285 mWh of energy was saved, which is equivalent to a little more than 154,000 barrels of oil, \$4 million spent in petroleum, and dollar savings of \$31 million. Chemical use was also decreased, which saved \$110,798 in chemicals. The savings for the LACSD were tremendous because water was imported from Northern California over a long distance and the use of local water resources took away the need to pump SWP water over the Tehachapi Mountains. These savings may not be the same for each water agency; therefore, we highly recommend agencies to assess and value individual benefits, in order to do as much as possible.

Controversies with other alternatives, such as ocean desalination

Ocean desalination has been promoted as a great way to increase water supply. Many ocean desalination projects are being proposed in Southern California and some are in the early stages of implementation. Proponents of ocean desalination argue that it will enhance fish habitat due to "reduced diversions from rivers, streams, and groundwater,"

energy savings and air pollutant emissions reductions from importing less water, and reduced groundwater withdrawals. Not surprisingly, these are the benefits that can also be achieved by increasing water use efficiency, reuse, and recharge. However, when compared to ocean desalination, water use efficiency, reuse, and recharge are much less environmental intrusive and typically more economically feasible. While ocean desalination has received a lot of attention due to its “reliability,” it has also received much criticism. Some criticisms are: intensive energy usage, high costs, highly concentrated brine discharge into the ocean, seawater intake which is intrusive to coastal environment, increase mortality of marine organisms, and destructive to the ocean environment.

We believe that the benefits of increasing water use efficiency, reuse and recharge exceed the benefits of ocean desalination. If the goal of ocean desalination is to increase the reliability of water resources for the growing population, then it should only be used after water use efficiency, reuse and recharge have been maximized. The superior economic and environmental approach should logically be used and exhausted prior to the implementation of one that is less economically feasible and environmentally sound.

6 Recommendations

In order to increase reliance on local supplies in the Santa Ana River Watershed Region, we recommend that the Region's water purveyors maximize water use efficiency, recharge, and reuse. Though these are broad recommendations there are several smaller scale means to maximization within the three topics.

6.1 Water Use Efficiency

Due to the nature of water use efficiency one of the best ways to ensure efficiency is to employ technology forcing mechanisms. One of the most effective ways to do this is to adopt codes and policies throughout the region. As such, recommendations include:

- Adopt AB 1608¹³
- Adopt AB 1881¹⁴
- Adopt AB 2496¹⁵
- Adopt AB 2515¹⁶
- Require the use of ET controllers in all new residential as well as CII developments
- Require large landscapes, public spaces, and common areas in new developments to implement CALscapes
- Require waterless urinals as standard installation for all CII applications

The importance of these specific recommendations is two-fold. First, these measures have proven water savings and second, and perhaps more importantly, these measures can be a way to educate the public as to the options available and to raise awareness. For example, CALscapes in public or common areas can help to demonstrate to the general public that there are attractive and cost-effective ways to reduce your landscape water demand.

6.2 Reuse

Taking full advantage of cost-effective reuse opportunities will necessitate efficient city planning as well as identification of, and capitalization on, the available opportunities to expand recycled water use. As such, our recommendations are to:

- Instigate plans to incorporate recycled water infrastructure prior to, or along with, new development, in order to avoid the more expensive cost of retrofits
- Ensure new wastewater treatment facilities are sited near water distribution sources so as to further reduce the costs of recycled water reuse.

¹³ http://www.cuwcc.org/landscape_task_force/sb_1608_bill_amended_sen_06-05-02.pdf

¹⁴ http://www.cuwcc.org/landscape_task_force/ab_1881_bill_amended_asm_06-05-04.pdf

¹⁵ http://www.cuwcc.org/uploads/hotnews/ab_2496_amended_asm_06-04-06.pdf

¹⁶ http://www.cuwcc.org/uploads/hotnews/ab_2515_amended_asm_06-04-17.pdf

- Implement codes and policies which promote water reuse (e.g. dual plumbing standards)
- Increase interagency collaboration so that districts that produce excess recycled water can then supplement the needs of smaller districts with limited access to a reclaimed water supply

These recommendations are essential in that they can determine the cost-effectiveness of the entire system. Requiring that the backbone of recycled water infrastructure is installed at the same time that sewerage, water supply and other utilities are installed will ensure that the costs are kept down by avoiding retrofitting of existing systems. Mandating reclaimed water use where available for permitted uses reserves higher quality water in the aquifer. Increasing cooperation and collaboration between districts can help the watershed region maximize its reuse potential.

6.3 Recharge

Maximizing recharge in an urban area will require creativity and effective planning due to the fact that space will no longer be available for large scale infiltration or percolation. As such, we recommend that developments include small-scale natural recharge opportunities that include:

- Use of pervious concretes in parking lots
- Implementation of bioswales, curb cuts, and infiltration islands where appropriate
- Incorporation of roof coverings to direct runoff into desired locations

These measures will help to increase stormwater recharge as well as having the added benefit of decreasing non-point source pollution loading from fertilizers, petrol products, pesticides and pathogens.

Supporting Research

A. Water District Backgrounds

The Santa Ana River Watershed Region is comprised of 9 major water districts. Beginning at the headwaters of the Santa Ana River and working towards the terminus, the Districts are: Big Bear Municipal Water District, San Bernardino Valley Municipal Water District, Eastern Municipal Water District, Western Municipal Water District, Inland Empire Utility Agency, Municipal Water District of Orange County, City of Fullerton, City of Santa Ana, and Anaheim Public Utility District.

A.1 Big Bear Municipal Water District

While part of the Santa Ana Watershed, the Big Bear Lake Department of Water and Power has not yet completed a 2005 Urban Water Management Plan and thus there is a lack of current and reliable data for this region. As a result, Big Bear has not been included in this regional analysis.

A.2 San Bernardino Valley Municipal Water District

Also part of the Santa Ana Watershed, the San Bernardino Valley Municipal Water District SBVMWD has not yet completed a 2005 Urban Water Management Plan and thus there is a lack of current and reliable data for this region. As a result, SBVMWD has not been included in this regional analysis.

A.3 Eastern Municipal Water District

Location and Service Area

Eastern Municipal Water District (EMWD) is located in western Riverside County and covers a service area of approximately 555 square miles. EMWD provides water to the municipalities listed in Table A-1. Figure A-1 shows an overview of the district's per capita water use, average rainfall, groundwater management zones and land use.

Eastern Municipal Water District's Service Area		
City of Hemet	Murrieta Hot Springs	Sun City
City of Moreno Valley	Homeland	Nuevo
City of Murrieta	City of Temecula	Valle Vista
City of Perris	Quail Valley	Winchester
City of San Jacinto	Romoland	Lakeview
Source: Eastern Municipal Water District UWMP 2005		

Table A- 1: Areas served by EMWD

In addition, EMWD is a wholesaler to various sub agencies which include:

- City of Hemet Water Department
- City of Perris Water Department
- City of San Jacinto Water Department
- Lake Hemet Municipal Water District

- McCanna Ranch Water Company
- Nuevo Water Company
- Rancho California Water District

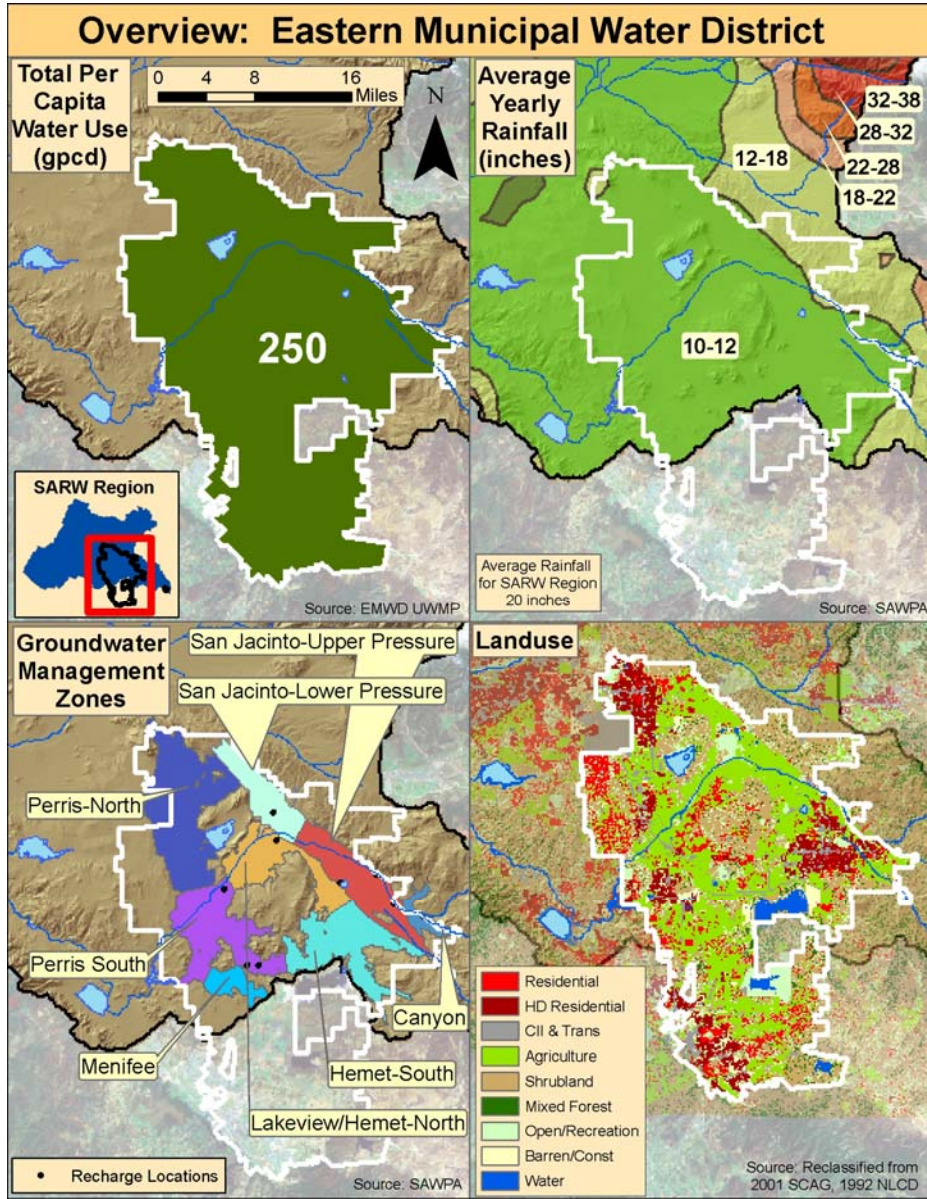


Figure A- 1: Overview of Eastern Municipal Water District

Population and Land Use

From 1990 to 2005, the population of the EMWD service area has nearly doubled to 493,960 people (EMWD, 2005). Table A-2 shows the current and projected population.

EMWD Service Area - Projected Population						
	2005	2010	2015	2020	2025	2030
Total	493,960	583,050	674,550	759,155	830,020	889,230
Source: EMWD UWMP, 2005						

Table A- 2: EMWD- Current and projected population

Open space and agriculture are being replaced by residential, commercial, and industrial developments. In addition, average home size is decreasing while income is rising. Low-density (0.05 and 3 structures per acre) residential accounts make up over 50% of the residential land use within the service area, but only use 20% of the water

Water Demand

As urbanization in the area continues, the demand for urban uses continues to grow as evidenced by the fact that the number of customer meters has risen to more than 100,000, most of which are for single family homes. The district has been experiencing a shift in demand from agricultural to urban uses as population grows. For the last five years, population growth has driven demand and will continue to do so into the future. Figure A-2 shows the district’s direct and indirect demands and Figure A-3 shows demand by sector.

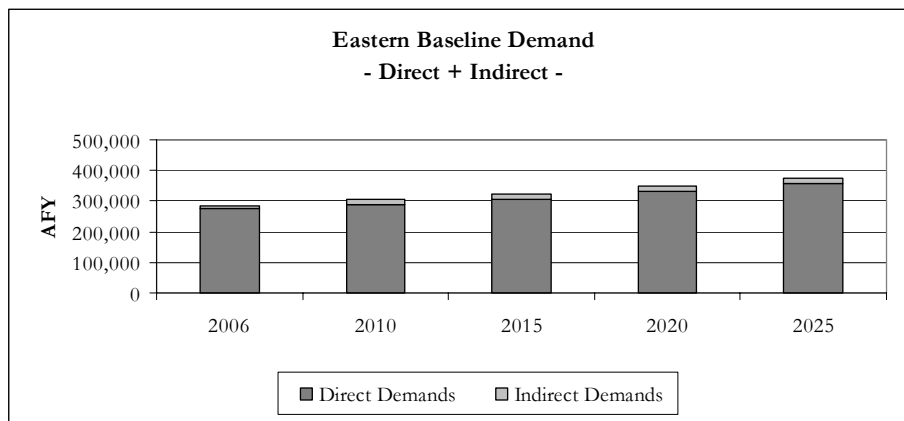


Figure A- 2: EMWD- Projected direct and indirect demands
Source: MWD, 2005

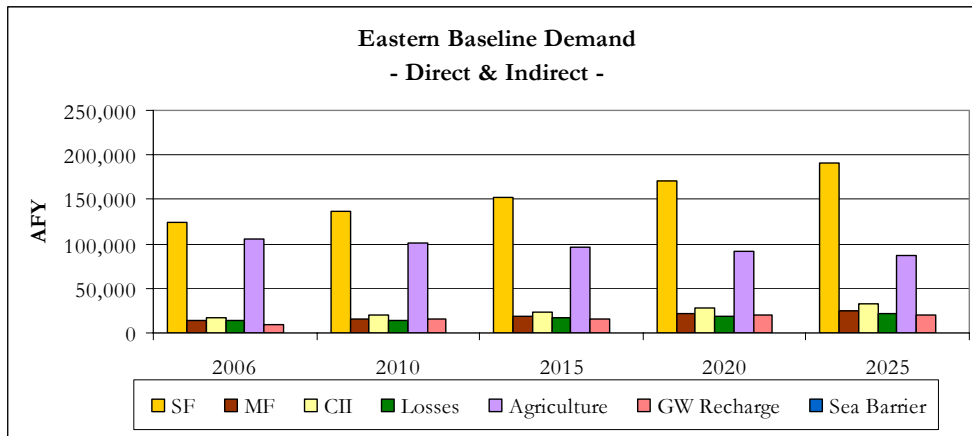


Figure A- 3: EMWD Demand by sector
Source: MWD, 2005

Water Supply

EMWD’s three sources of water are local groundwater, recycled water, and imported supply from MWD. Projected supply for the area can be seen in Figure A-4.

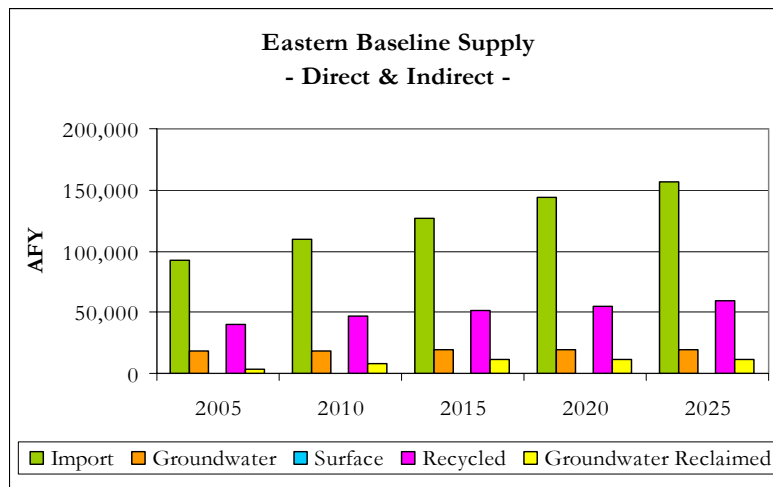


Figure A- 4: EMWD supply sources
Source: EMWD, 2005

Consistent with the watershed as a whole, 60% of Eastern’s supply is made up of imported water while the remaining 40% is locally procured. In order to increase

reliance on local sources, EMWD has developed several programs to expand groundwater reliability. Roughly 25% of the total potable supply is provided by groundwater wells from the northern section of the district as currently there are no groundwater resources in the southern part of the district. As a result all of the groundwater sources are located in the San Jacinto watershed, which roughly follows the boundary for the Santa Ana River Watershed. In addition the region has no local surface water supply. Figure A-5 shows the total supply (potable and non-potable) sources by percentage.

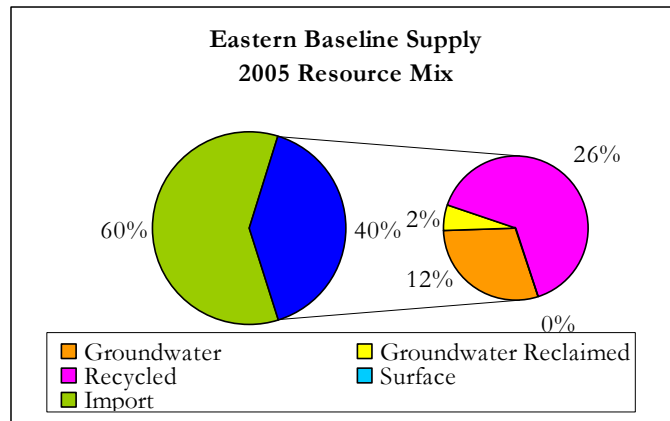


Figure A- 5: EMWD Supply resource mix
Source: EMWD, 2005

A.4 Western Municipal Water District

Location & Service Area

In 1954, Western Municipal Water District (WMWD) was created to bring supplemental water to the developing western branch of Riverside County. Western adjudicated and is a member of the Metropolitan Water District of Southern California (MWD) and the Santa Ana Watershed Project Authority (SAWPA). The agency currently provides more than 19,000 retail and nine wholesale customers (Table A-3) with groundwater and imported water from the Colorado River and the State Water Project. In addition, supplemental water is received from the City of Riverside. Figure A-6 depicts WMWD's per capita water use, average annual rainfall, groundwater management zones, and land use.

WMWD Stakeholders		
Wholesale Customers	Unincorporated Wholesale Customers	Retail & Contract Services Customers*
City of Corona	El Sabrante	Lake Hills
City of Norco	Eagle Valley	March Air Reserve Base
City of Riverside	Temescal Creek	Home Gardens
Elsinore Valley Water Agency	Woodcrest	City of Norco
Rancho California Water Agency	Lake Mathews	Lee Lake Water District
Box Spring Mutual Water District	March Air Reserve Base	
Source: WMWD UWMP 2005		

Table A- 3: Stakeholders in Western Municipal Water District
Source: WMWD, 2005

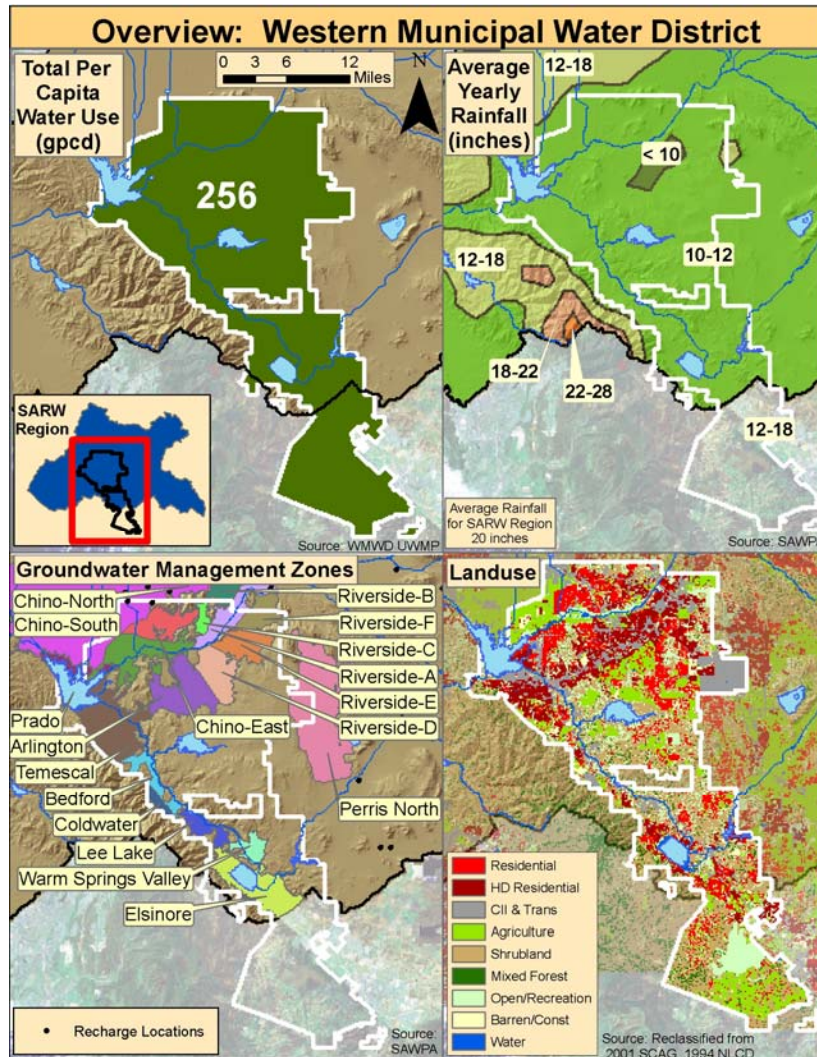


Figure A- 6: Overview of Western Municipal Water District

Population & Land Use

WMWD’s district covers 510 square miles in Western Riverside County and has a population of more than one-half million people. The District sells over 90,000 acre-feet (AF) of water a year. The retail portion of WMWD’s general district, called Improvement Districts, covers 73 square miles and has a population of 61,000. Riverside County is one of the most rapidly growing areas in California and between 1994 and 1999 the county’s population growth rate was 7%. In 2000, the Census showed that Riverside County had a population of over 1.5 million and 585,000 dwelling units (WMWD, 2005). The Southern California Association of Governments (SCAG) estimates that by 2025 the population of the county will almost double (Table A- 4), and contain 918,000 dwelling units (WMWD, 2005). The California Department of Finance projects that the population in Riverside County will grow to 3.5 million by 2030 (WMWD, 2005). SCAG estimates that the population of western Riverside County will

grow at an annual rate of 3.3% and the number of households will show an average annual growth rate of 3.9% (WMWD, 2005).

WMWD Service Area - Projected Population					
	2005	2010	2015	2020	2025
Total	61,000	72,700	85,500	100,600	118,400

Source: WMWD UWMP, 2005

Table A- 4: WMWD Current and projected population

Water Demand

WMWD tracks its retail water use by user codes and reports from the residential, industrial, commercial, institutional, and agricultural accounts. All retail sectors are expected to increase at the same rate as the estimated population growth (4% for 2006 and 2007, and a subsequent growth of 3.3% to 2030), except the agricultural accounts, which are expected to decrease due to increased urbanization (Western, 2005). Figure A-7 depicts WMWD’s direct and indirect demand and Figure A-8 shows demand by sector.

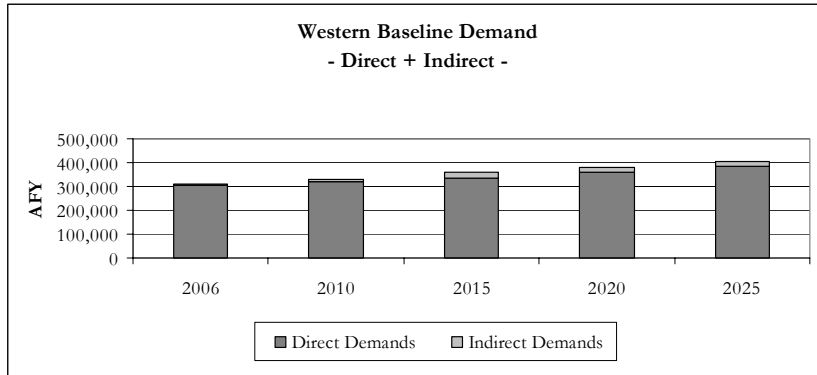


Figure A- 7: WMWD direct and indirect demand

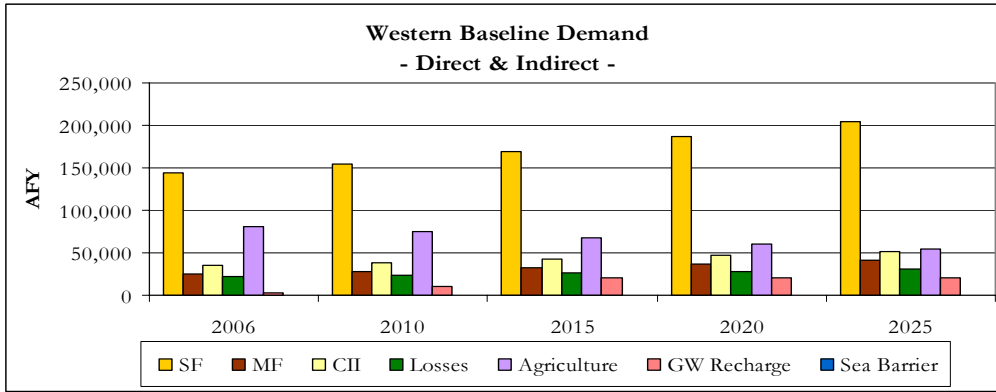


Figure A- 8: WMWD demand by sector
Source: MWD, 2005

WMWD uses numerous approaches to maximize their resources and minimize the need for imported water. A few of the notable projects are the Seven Oaks Dam Conservation Project, which utilizes storm water runoff; the Riverside-Corona Feeder, a conjunctive use project which provides increased water storage and a conveyance pipeline; and “Save Water – Save a Buck,” a conservation incentive program for commercial, industrial and institutional water customers.

Water Supply

Sources of WMWD’s water supply are groundwater and imported water from the Colorado River Aqueduct (CRA) and the State Water Project (SWP) (Figure A-9). The SWP makes up around three quarters of the imported supply. In addition, WMWD imports some groundwater from the Riverside/San Bernardino area. WMWD’s water sales include approximately sixty percent treated water with the rest of the sales being untreated or raw water for agricultural use.

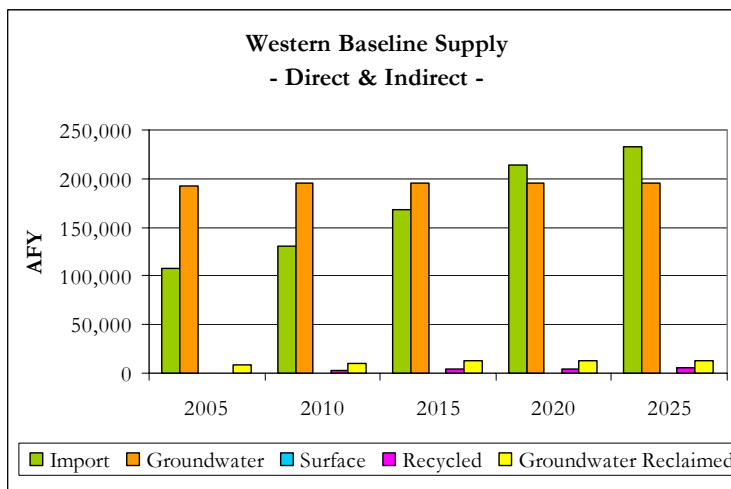


Figure A- 9: WMWD supply sources
Source: WMWD, 2005

One-third of these sales are for domestic use and the remaining water is for wholesale purposes. It is important to note that agricultural use in the District has decreased over the last couple of years due to increased urbanization. For potable water, WMWD has a purchase agreement with MWD for an initial base demand of 65,298 AF with an initial Tier 1 annual maximum of 58,768.7 AF (Western, 2005). For non-potable water, WMWD uses water from the CRA and groundwater from the San Bernardino/Riverside area. In 2004, The March Wastewater Reclamation Facility provided 425.5 AF of reclaimed wastewater (WMWD, 2005). Figure A-10 shows WMWD’s baseline supply resource mix.

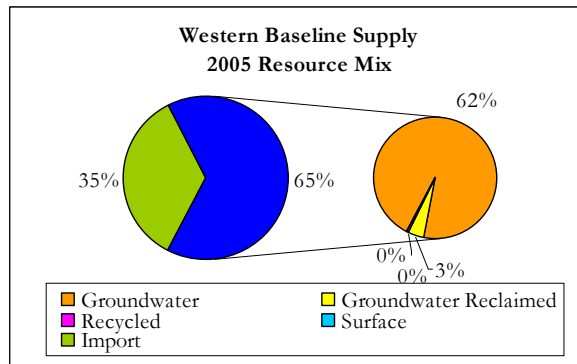


Figure A- 10: WMWD supply resource mix
Source: WMWD, 2005

A.5 Inland Empire Utilities Agency

Location and Service Area

The Inland Empires Utilities Agency’s (IEUA) service area is located in the southwestern portion of San Bernardino County, just north of the middle reaches of the Santa Ana River. The 242 square mile service area was formed in 1950 as a member agency of the MWD to import water resources. IEUA is the 10th largest customer of the twenty-seven member agencies within MWD, importing just over 83,000 AFY of water in 2004 (MWD, 2005). An overview of IEUA’s water use, precipitation, groundwater zones, and land use is summarized in Figure A-11 and is discussed in more detail below.

IEUA is a water wholesaler to the following cities and water districts (Table A-5):

Cities	Water Districts
Chino	Monte Vista Water District
Chino Hills	Fontana Water Company
Ontario	San Antonio Water Company
Upland	Cucamonga Valley Water District

Source: IEUA, 2005

Table A- 5: IEUA wholesale water customers

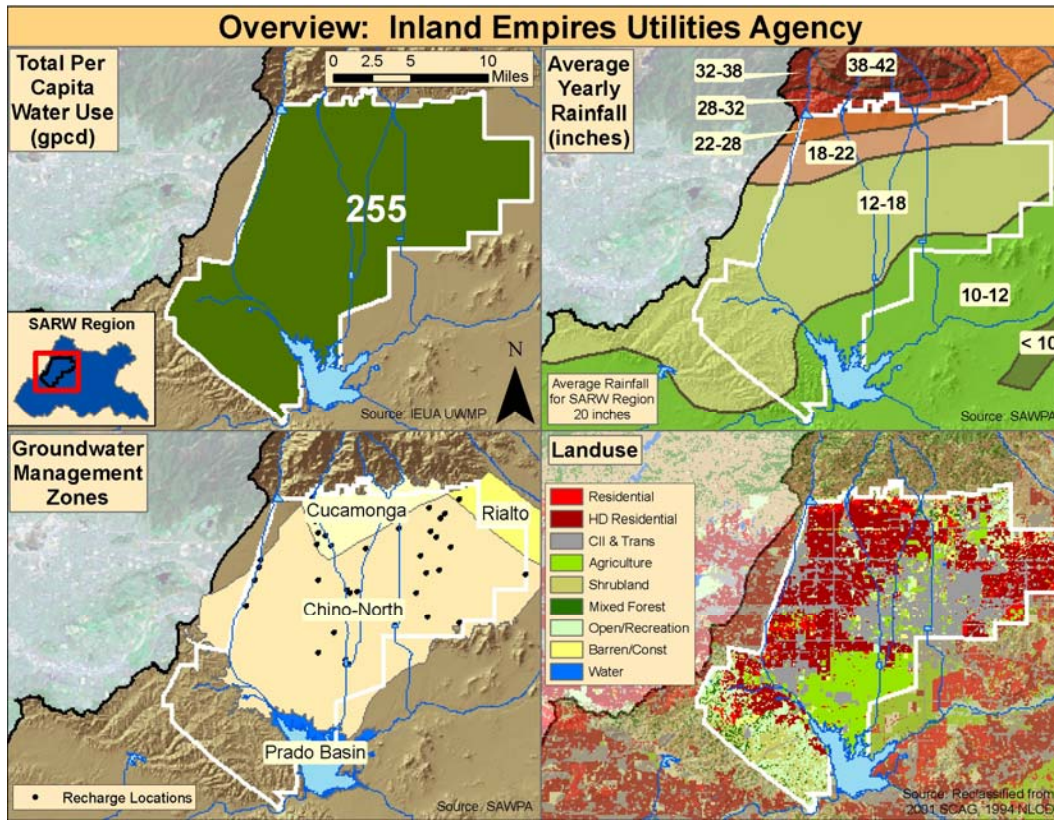


Figure A-11: Overview of Inland Empire Utilities Agency.

Population and Land Use

IEUA’s service area has experienced tremendous population growth from 1995 to present, with an annual growth rate of 2.8% (Table A-6). Projecting out to 2025, IEUA’s service area will include over 1,108,000 people. This 20-year projection results in a smaller annual growth rate of 1.8% as it nears build out.

IEUA Service Area – Historic & Projected Population							
	1995	2000	2005	2010	2015	2020	2025
Total	635,000	708,200	814,168	894,804	982,572	1,050,504	1,108,349

Source: IEUA RUWMP, 2005

Table A-6: IEUA- Historic and projected population

As the IEUA service area grows in population there has been a simultaneous change in land-uses. There has been an immense land-use conversion from non-urban and agricultural land-uses to urban. This trend is projected to continue as population increases in the region. Overall, from 1957 to 2001 total non-urban acreage has decreased by 51% to 64,246 acres, while total urban acreage has increased by 652%, to 79,954 acres (IEUA RUWMP, 2005).

Water Demand

Without factoring in water savings attributable to water conservation programs, total water demand within the IEUA service area in 2005 was approximately 244,200 AF and is projected to increase to 341,400 AF in 2025 as can be seen in Figure A-12. The total water demand from 2005 to 2025 is broken out by sector in Figure A-13. The projected agricultural demand plummets from 12% to 2% in 2025 and correlates with the historical land-use conversion trend away from agricultural uses to urban uses.

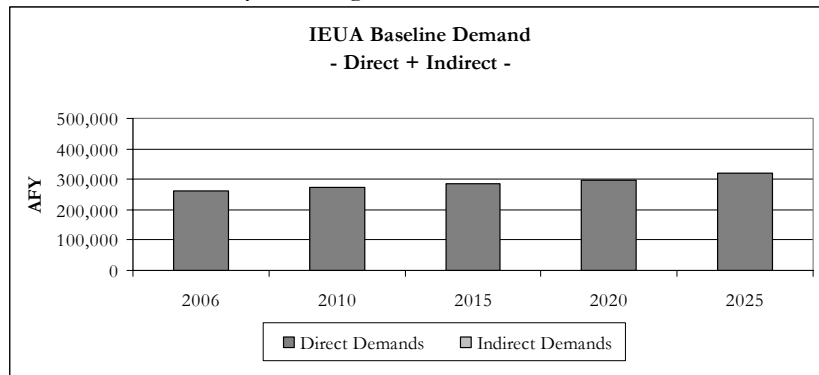


Figure A- 12: IEUA baseline demand.
Source: IEUA, 2005

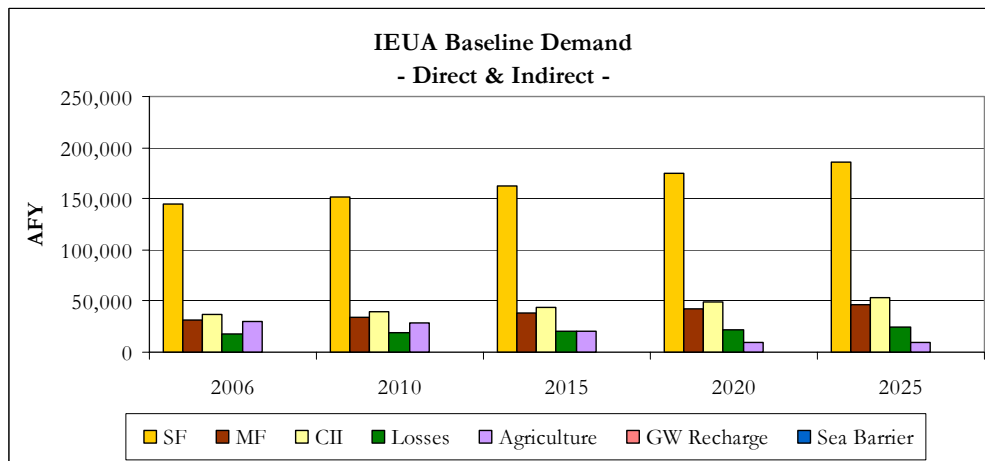


Figure A- 13: IEUA Demand by sector
Source: MWD, 2005

In order to augment local supplies, reduce imports, and save money, IEUA plans to significantly pursue water savings via conservation programs. IEUA and Regional Conservation Partners are developing new water conservation programs to support existing programs to significantly reduce residential and commercial demand over the next five year period. By 2010, IEUA projects to conserve 26,260 AF of water, a 205% increase in water savings to 2005’s conservation savings of 8,600 AF. IEUA plans on accomplishing these savings through indoor appliance rebate programs and aggressive outdoor (landscape and irrigation) water efficiency programs.

Water Supply

Currently, local water constitutes 73% of IEUA’s urban water supply, while imports from MWD account for the remaining 27%. Aggregated, local water supplies (groundwater, recycled water, and surface water) in 2005 supplied 159,880 AFY of urban water, while imported water supplied 60,200 AFY. Figure A-14 illustrates the projected urban water supply by source from 2005-2025. To supply the water needed in 2025 to support a growing populace and economy, IEUA is aggressively pursuing increasing its water reuse and groundwater management programs.

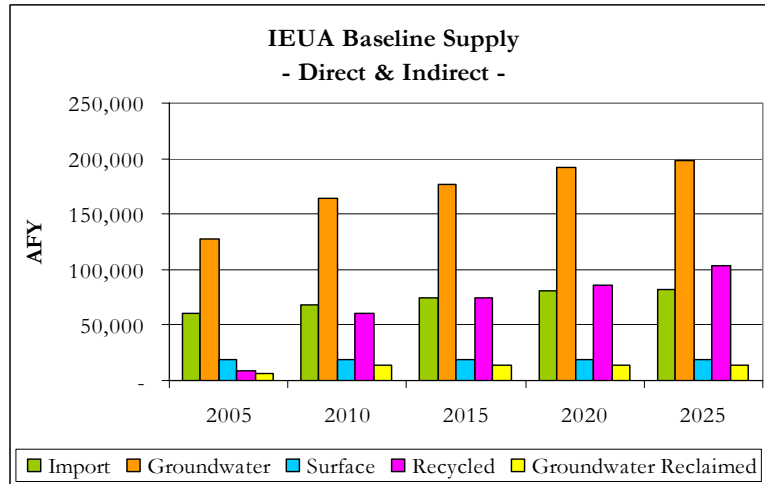


Figure A- 14: IEUA Supply by source
Source: IEUA, 2005

Recycled water supplied roughly 3% of total urban water supplies in 2005, and by 2010 recycled water will represent 13% of the total urban water supply. By 2025, IEUA plans call for 69,000 AFY of water to be supplied via recycling efforts, which equates to 18% of the total urban supply. This increase in recycling by year 2025 represents an amazing increase of 816% over 2005’s recycled water supply! Figure A-15 illustrates the current resource mix for IEUA.

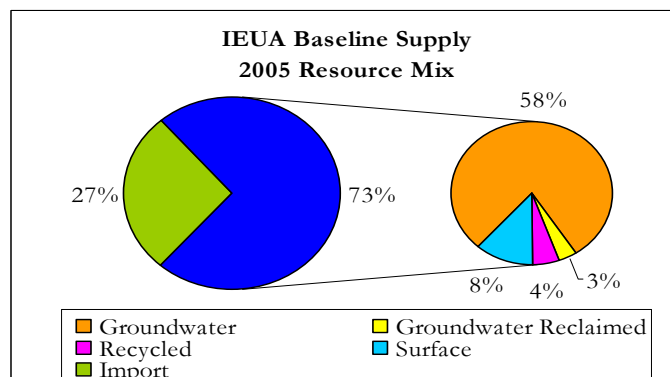


Figure A- 15: IEUA Supply resource mix
Source: IEUA, 2005

IEUA’s plans to dramatically increase recycled water supplies, while simultaneously pursuing multiple water conservation programs and technologies, will result in a projected per capita water use of 219 gallons per capita daily (gpcd), which is 4 units lower than current per capita usage despite the tremendous forecasted population growth and urbanization. Foregoing the water savings attributable to water conservation and developing additional recycled water supplies, the projected per capita rate for 2025 is 304 gpcd.

A.6 Municipal Water District of Orange County

Location and Service Area

The Municipal Water District of Orange County (MWDOC) is located in Orange County and its service area envelops the downstream reaches of the Santa Ana River. Formed by Orange County voters in 1951, MWDOC serves more than 2.3 million residents within the approximately 600 square mile service area. MWDOC provides wholesale imported water from Metropolitan Water District of Southern California (MWD) to 30 cities and water agencies within Orange County (Table A-7). MWDOC is the third largest customer of MWD’s twenty-seven member agencies, importing over 297,900 AF of water in 2004 (MWD, 2005). Figure A-16 provides an overview of MWDOC’s per capita water use, average precipitation, groundwater management zones, and land use.

MWDOC Stakeholders and Member Agencies	
Cities	Water Districts
Brea	East Orange County Water District
Buena Park	Emerald Bay Services District
Fountain Valley	El Toro Water District
Garden Grove	Irvine Ranch Water District
Huntington Beach	Laguna Beach County Water District
La Habra	Mesa Consolidated Water District
La Palma	Moulton Niguel Water District
Newport Beach	Orange County Water District
Orange	Orange Park Acres Mutual Water Company
San Clemente	Santa Margarita Water District
San Clemente	Santiago County Water District
San Juan Capistrano	Serrano Water District
Seal Beach	South Coast Water District
Tustin	Southern California Water Company
Westminster	Trabuco Canyon Water District
	Yorba Linda Water District

Source: MWDOC UWMP, 2005

Table A- 7: MWDOC stake holders and member agencies

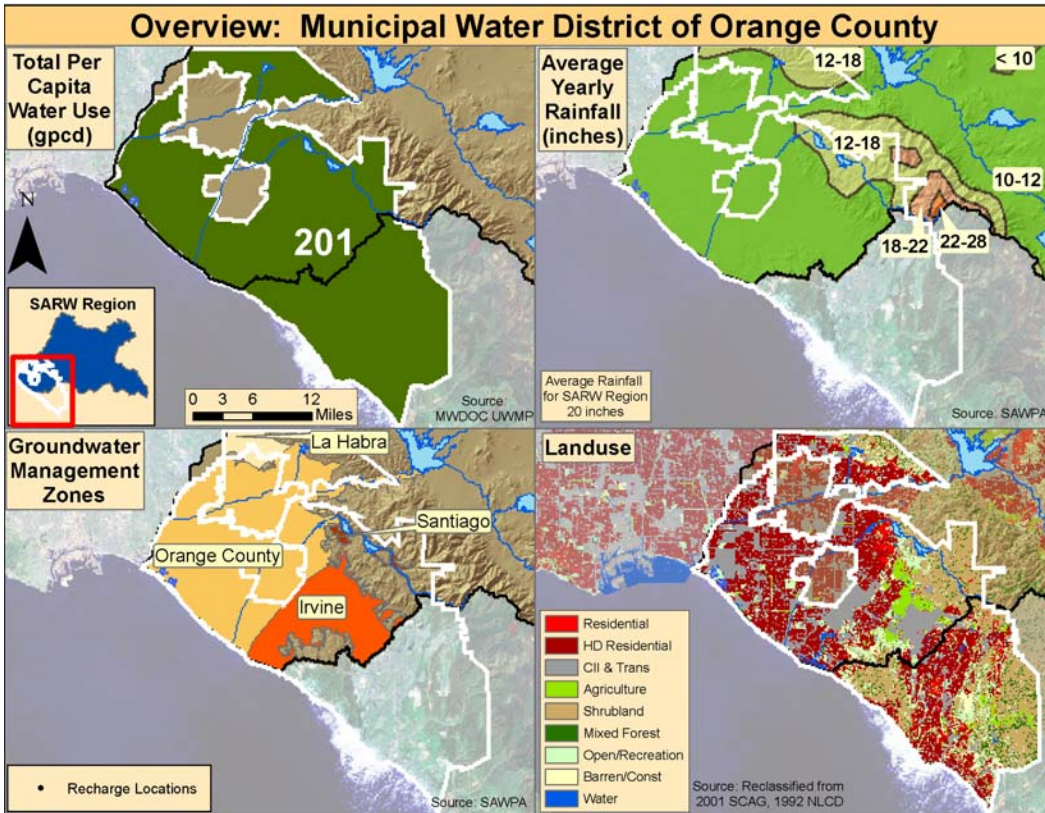


Figure A- 16: Overview of Municipal Water District of Orange County

Population and Land Use

The MWDOC service area has historically seen a rapid rise in population as the annual growth rate between 1970 and 2005 was 2.3%. However, the projected future annual growth rate is expected to decrease to 0.66%, as many municipalities approach build-out. By 2030, MWDOC projects that will have approximately 2.64 million people residing in its service area. Table A-8 provides the historic and projected population.

MWDOC Service Area - Historic and Projected Population*							
	2000	2005	2010	2015	2020	2025	2030
Total	2,040,000	2,240,000	2,410,000	2,480,000	2,540,000	2,590,000	2,640,000
* Based on DOF and SCAG projections							
Source: MWDOC UWMP, 2005							

Table A- 8: MWDOC- Historic and projected population

Water Demand

MWDOC does not account for water savings attributable to water conservation when deriving its projected service area direct-use demand, however, it is certain that there are water savings that MWDOC has not factored in on account of the many current and planned conservation programs. MWDOC’s baseline demand can be seen in Figure A-

17. Urban demand (M&I) is projected to increase from 504,997 AFY in 2005 to 611,757 AFY in 2030, an increase of 21%. Over the same period, demand for agriculture will decrease by approximately 12,000 AFY, a 71% reduction. This reduced agricultural demand is principally due to land use conversion as many parts of Orange County are near build-out and remaining agricultural fields are targeted for development. It is important to note that MWDOC projects M&I per capita use to increase by only 6 gpcd, from 201 gpcd in 2005 to 207 gpcd in 2030. Per capita use in the late 1980's was near 230 gpcd and the implementation of long-term water use efficiency measures is credited with reducing per capita use to what it is currently. Demand by sector is shown in Figure A-18.

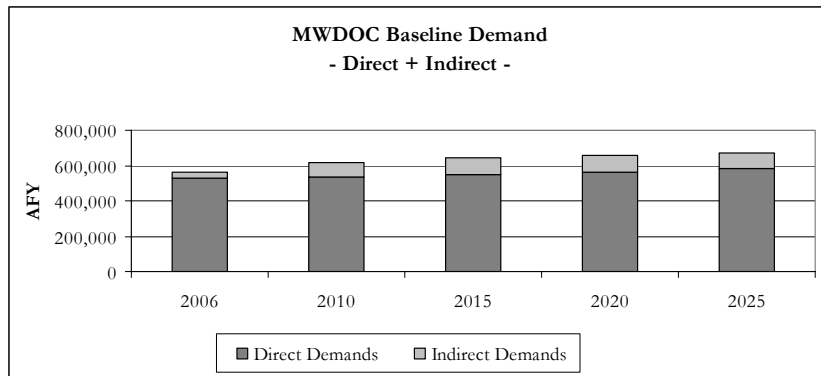


Figure A- 17: MWDOC direct and indirect demand
Source: MWD, 2005

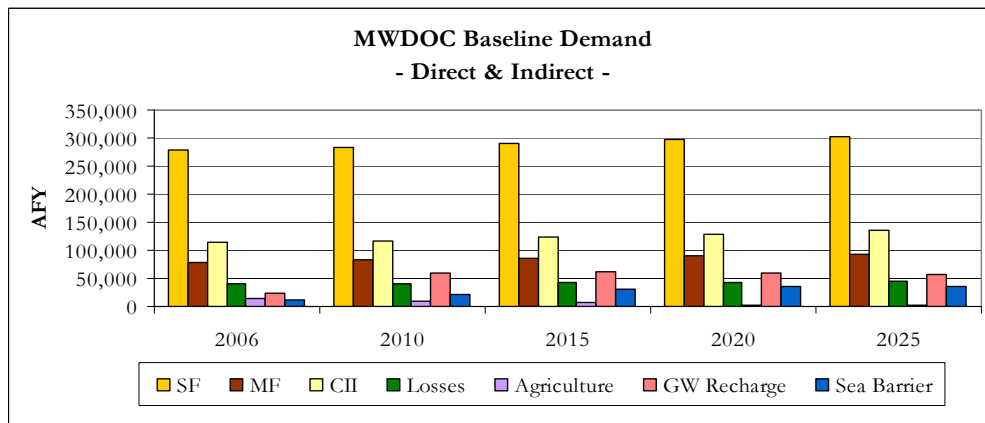


Figure A- 18: MWDOC Demand by sector
Source: MWDOC, 2005

Water Supply

Currently, local supplies comprise 53% of MWDOC's urban (direct) water supply while imported water supplies from MWD account for the remaining 47%. In 2005 local supplies (groundwater, recycled water, and surface water) provided MWDOC with approximately 276,500 AF of direct-use water and imported sources supplied approximately 245,200 AF. By 2030 MWDOC projects an increase from 53% to 60% in

reliance on local supply and a corresponding decrease in dependence on imported supply from 47% to 40%. MWDOC aims to boost local supplies by increasing direct use of recycled water by about 100% and groundwater resources by 27%, while only increasing imported supplies 0.7%. The current and projected supply within the MWDOC service area is illustrated in Figure A-19 while the current resource mix for direct consumption is shown in Figure A-20.

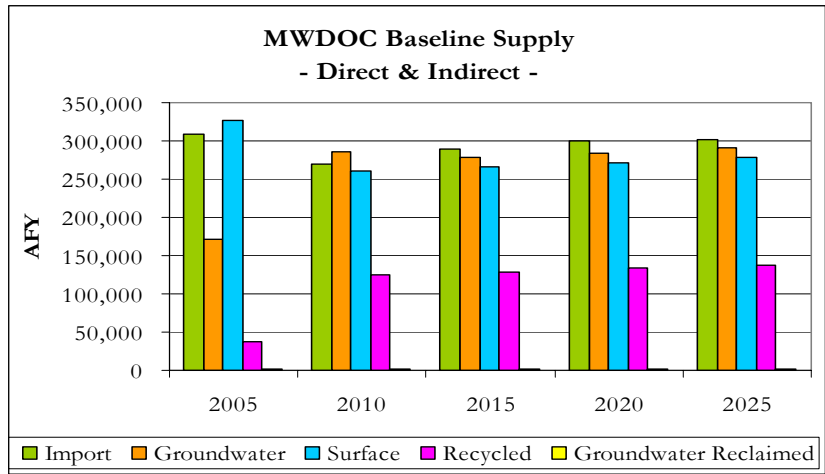


Figure A- 19: MWDOC supply by source
Source: MWDOC, 2005

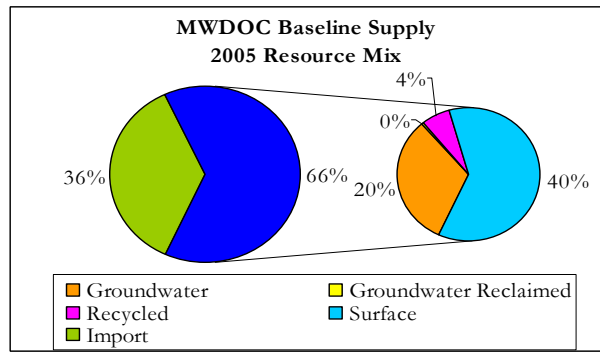


Figure A- 20: MWDOC supply resource mix
Source: MWDOC, 2005

The key component to the increase in local supply is the anticipated increase in recycled water with OCWD’s current construction of a recycling plant called the Groundwater Replenishment System (GWR System), which is expected to deliver 72,000 AFY of recycled water to meet indirect (groundwater replenishment and saltwater barriers) needs. By 2030 MWDOC projects to directly use 62,618 AFY of recycled water. For more detailed information on MWDOC’s recycling program, refer to Supporting Research, Section C.

A.7 Anaheim Public Utility Department

Location and Service Area

Located in the northern half of Orange County, the City of Anaheim is rated the tenth largest City in California. Formed in 1879, the Anaheim Public Utility Department (APUD) provides water service to the 48.2 square mile service area (APUD, 2005). In 1928 APUD was one of the 13 founding members of the Metropolitan Water District of Southern California. In addition, APUD is a groundwater producer from the Orange County Groundwater Basin, which is managed by OCWD (see Table A-9). The Department’s water supplies include treated and untreated imported water from Metropolitan and groundwater from the Orange County Groundwater Basin. An overview of Anaheim’s water use, precipitation, groundwater zones, and land use is summarized in Figure A-21 and discussed in more detail below.

APUD Stakeholders	
Metropolitan	City of Anaheim
Orange County Water District	Orange County Sanitation District
Municipal Water District of Orange Country	
Source: APUD, 2005	

Table A- 9: APUD Stakeholders

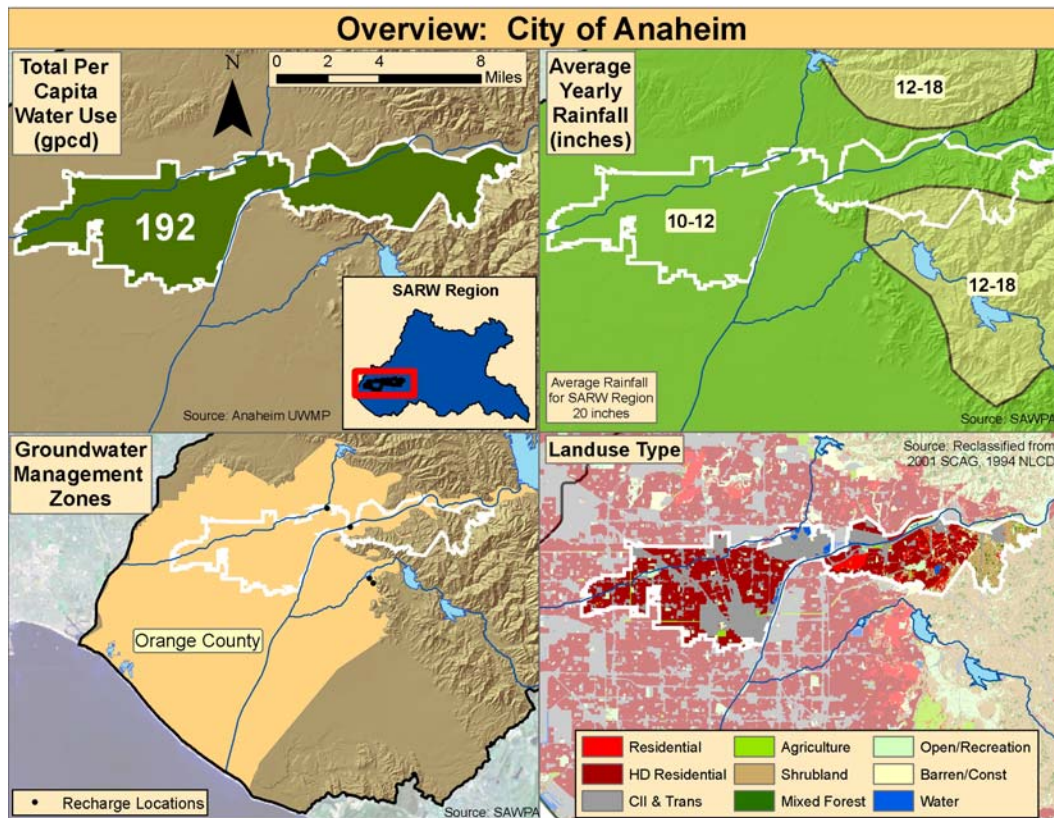


Figure A- 21: Overview of City of Anaheim

Population and Land Use

APUD has water sales averaging approximately 73,000 AF to a service area population of around 346,932 (APUD, 2005). Total water use is anticipated to increase around 13% to 87,330 AFY with population expanding to 401,000 people by 2030 (APUD, 2005). Most of the growth Anaheim is experiencing can be attributed to higher population densities from redevelopment projects as the city is near build out.

Water Demand

Figure A-22 shows Anaheim’s direct and indirect baseline demand, while Figure A-23 shows the direct and indirect demand by sector.

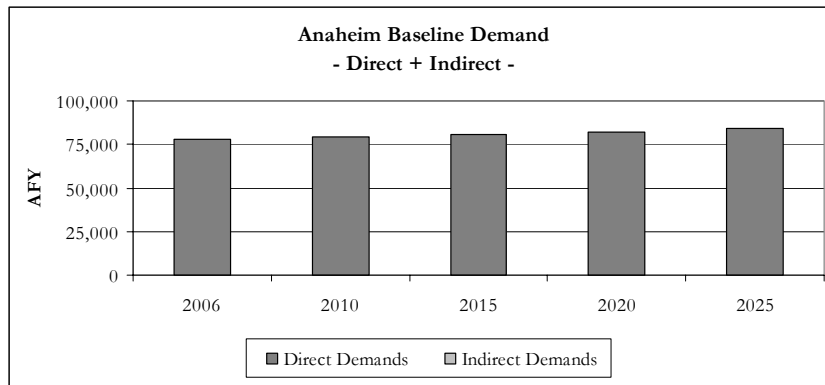


Figure A- 22: Anaheim direct and indirect demand
Source: MWD, 2005

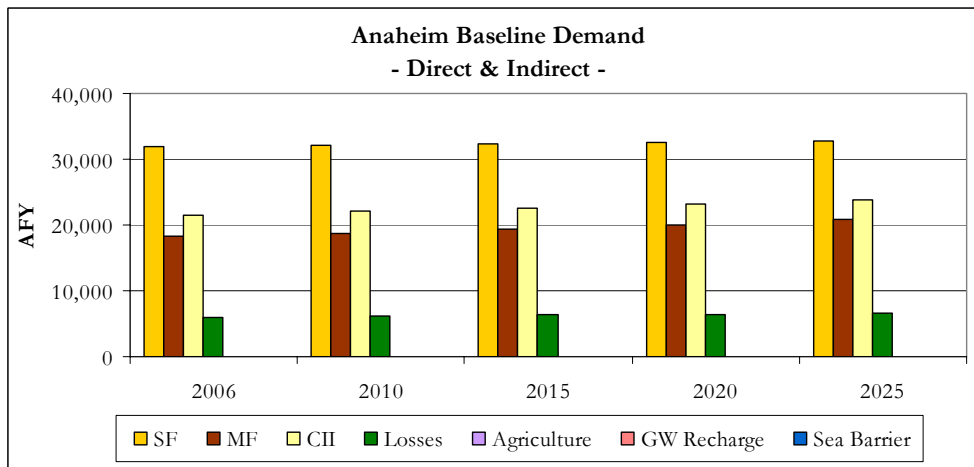


Figure A- 23: Anaheim demand by sector
Source: MWD, 2005

Water Supply

About 64% of the sales in APUD are supplied from groundwater pumping, based on the current Basin Pumping Percentage (BPP), and 36% is from imported water. Anaheim

overlays the Orange County Water Basin and recharges the aquifer by three methods. Natural recharge occurs both through incidental recharge and when groundwater producers use surface water in-lieu of groundwater.

Artificial recharge occurs at developed percolation ponds and through injection the Talbert and Alamitos Barriers. Anaheim does not own wastewater treatment facilities and does not expect to directly use reclaimed water. Figure A-24 shows the direct and indirect baseline supply for Anaheim. While, Figure A-25 shows the baseline supply resource mix.

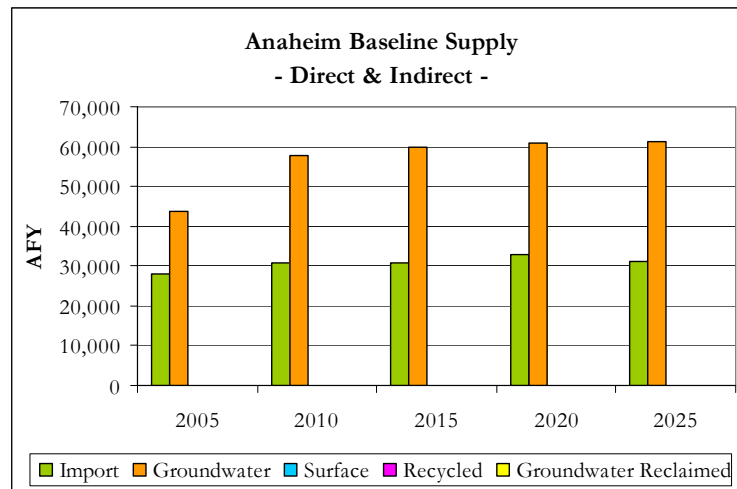


Figure A- 24 Anaheim supply by source
Source: Anaheim, 2005

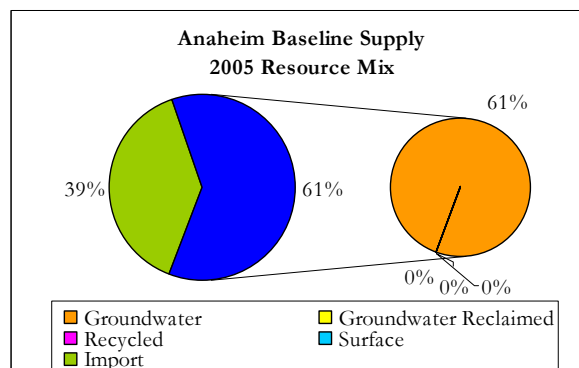


Figure A- 25: Anaheim supply resource mix
Source: Anaheim, 2005

APUD has implemented a variety of programs to ensure water reliability through diversity of supply.

These programs include:

- Water storage and transfer programs

- Enhanced conservation programs
- Development of additional local water supplies (i.e. recycled water, desalted water, groundwater remediation, conjunctive use, seawater barrier improvements)
- Establishment of a preferred resource mix in the IRP
- Executing the Colorado River GSA
- Continuing SWP modeling, implementing the Santa Ana Regional Water Quality Control Board Basin Plan
- Finalizing the OCWD Long-term Facilities Plan to optimize the beneficial uses of ground and surface waters (APUD, 2005)

A.8 Santa Ana

Location and Service area

The City of Santa Ana lies in the center of Orange County, and with an area of 27-square miles, it is the largest city within the county. The service area follows the city borders and water service is provided by the City’s Water Utility (Santa Ana, 2005). The municipal water system was formed in 1886 to supply the predominantly agricultural community. Eventual urbanization led to the need for outside sources of water so the city joined Metropolitan in 1931 as an original member (Santa Ana, 2005). Stakeholders for the City’s Water Utility can be found in Table A-10. Figure A-26 shows Santa Ana’s per capita water use, average annual precipitation, groundwater management zones, and land use.

Santa Ana Water Utility Stakeholders	
City of Santa Ana	Metropolitan Water District
OCWD	OCSD
MWDOC	
Source: Santa Ana UWMP, 2005	

Table A- 10: Santa Ana stakeholders

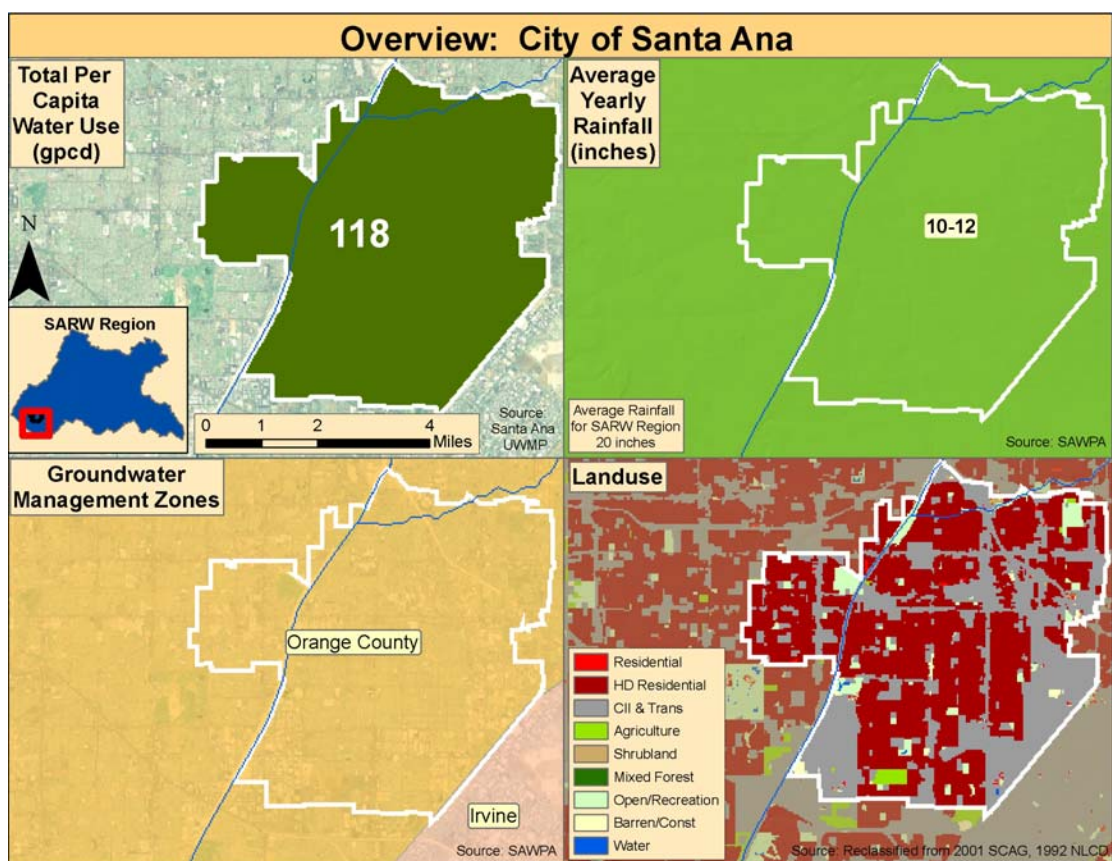


Figure A- 26: Overview of City of Santa Ana

Population and Land Use

According to the Center for Demographic Research at California State University of Fullerton, the population within the City is expected to increase by about 5.6% during the next 25 years, growing from an estimated 350,625 in 2005 to 370,130 in 2030.

Water Demand

As shown in Figure A-27, water demand within the City of Santa Ana is only direct, with no current or projected indirect uses. Demand is projected to remain relatively constant through 2030, increasing by less than 3%. Figure A-28 shows a breakdown of demand by sector, as well as losses from the system. The demand mix stays about the same through 2025, with the two most dominant demand drivers being single family housing and commercial, industrial, and institutional.

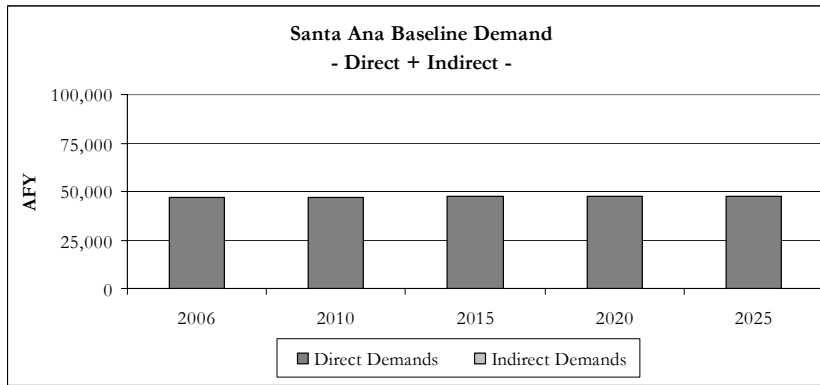


Figure A- 27: Santa Ana direct and indirect demands
Source: MWD, 2005

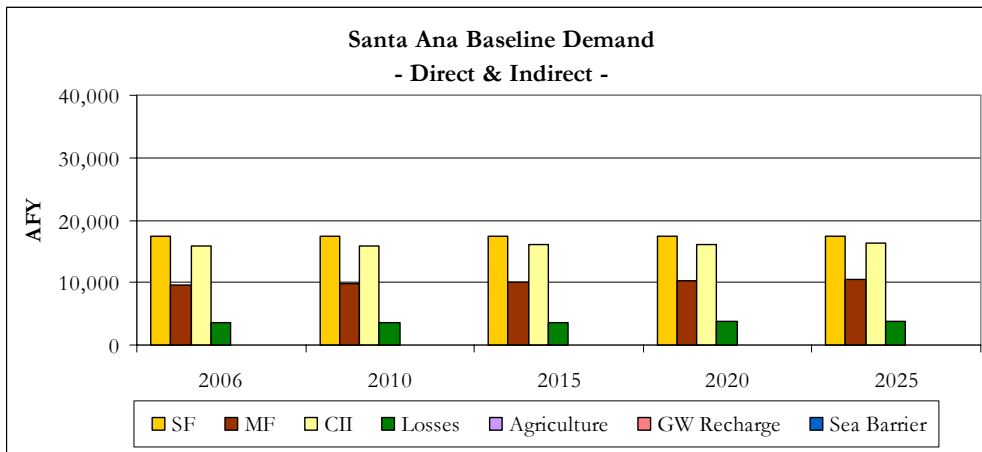


Figure A- 28: Santa Ana demand by sector
Source: MWD, 2005

Water Supply

The City works with two agencies, MWDOC and OCWD, to provide water to the service area. Currently, approximately 36% of the water supply is imported from MWD, while the remaining 64% is from groundwater wells in the Santa Ana River basin (Santa Ana, 2005). OCWD sets the allowable Basin Pumping Percentage (BPP) on an annual basis. The city also uses an extremely small amount of recycled water, 150 AFY, for irrigation purposes. Figure A-29 shows the current and projected water supplies through 2025 and Figure A-30 shows the baseline supply resource mix for the region.

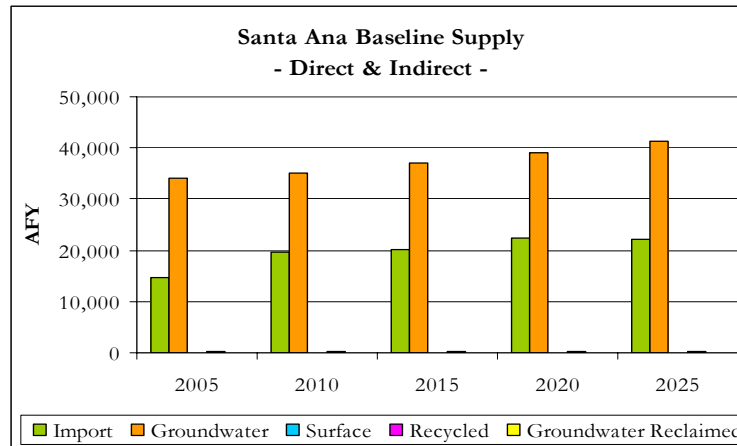


Figure A- 29: Santa Ana supply sources
Source: Santa Ana, 2005

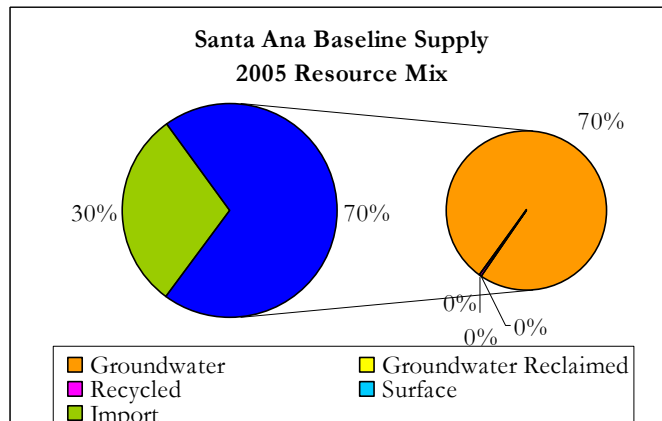


Figure A- 30: Santa Ana supply resource mix
Source: Santa Ana, 2005

A.9 Fullerton

Location and Service Area

The municipal water system for the City of Fullerton was formed in 1906 to supply the agricultural community; however, like the surrounding landscapes, the City quickly changed to an urban community. The City is a member of Metropolitan and OCWD and is fully dependent on these two agencies for their water supply. They have imported approximately 26% of the water supply from Metropolitan over the past ten fiscal years, and expect to import around 28% for the next 25 years (Fullerton, 2005). Fullerton is not a member agency of MWDOC; however, the City contracts and joins with them in conducting water education, conservation programs, and other activities (Fullerton, 2005). Table A-11 lists Fullerton stakeholders and Figure A-31 shows per capita water use, average annual rainfall, groundwater management zones, and land use.

Fullerton Stakeholders	
Metropolitan Water District	City of Anaheim
City of Placentia	City of Buena Park
City of Brea	Energy and Resource Management Committee
Orange County Water District	Southern California Water District
City of La Habra	Municipal Water District of Orange County
Source: Fullerton UWMP, 2005	

Table A- 11: Fullerton stakeholders

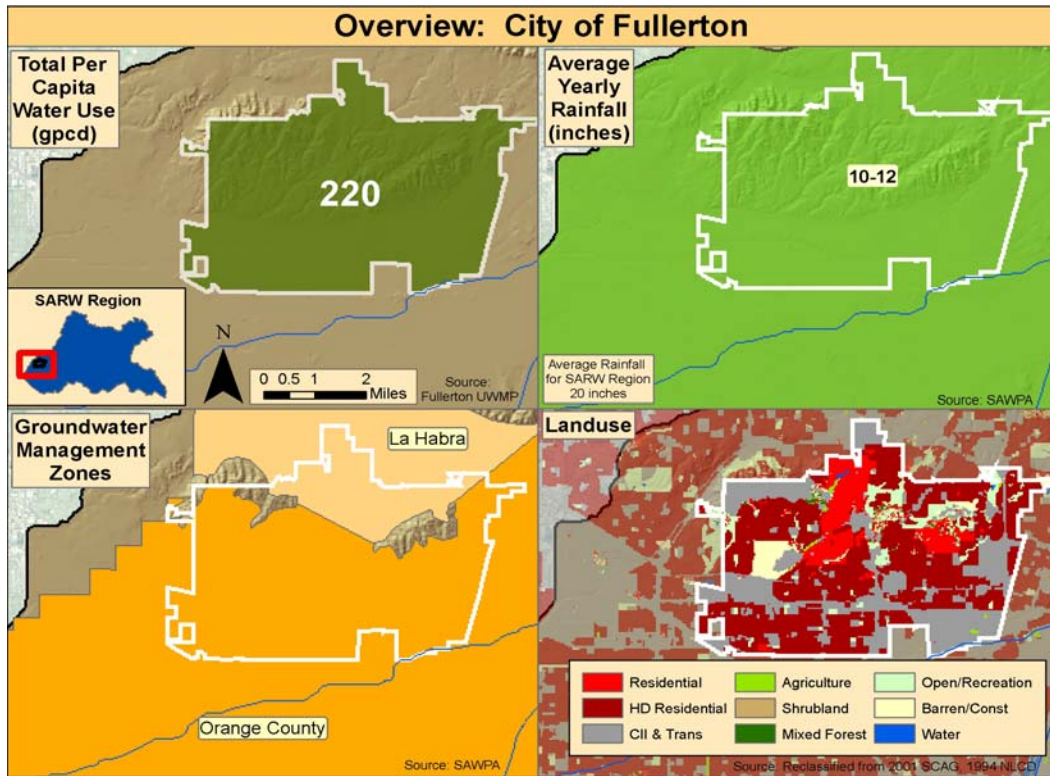


Figure A- 31: Overview of City of Fullerton

Population and Land Use

Fullerton's Water Utility provides water service to approximately 135,000 persons within its 22.3 square mile service area (Fullerton, 2005). Population projections show an increase of about 6.2% by 2030 for a total population of 144,700 (Fullerton, 2005). Although the City is almost at build-out multi-family housing is increasing due to multi-family and mixed housing replacing single-family homes in older areas of the City. Housing occupancy size is expected to increase from 2.92 to 3.03 persons per household from 2005 to 2030 (Fullerton, 2005).

Water Demand

Water demand has slightly decreased from 33,530 AF in 2000 to 33,268 AF in 2005. The water demands for the 2004/05 fiscal year were almost the same as demands for the 1980/81 fiscal year, even though population increased 24% during this period (Fullerton,

2005). The current per capita water use is 220 gallons per capita per day (GPCD). Single-family homes in Fullerton account for approximately 60% of total occupied housing stock in addition to 74% of total residential water demands (Fullerton, 2005). Of total water sales, commercial use represents 18.2%, industrial represents 13.1%, agricultural use represents .1%, and municipal represents 2% (Fullerton, 2005). The number of water accounts in the City has increased; however, overall usage has decreased due to conservation. Figure A-32 shows Fullerton’s direct and indirect baseline demand while Figure A-33 shows the demands by sector.

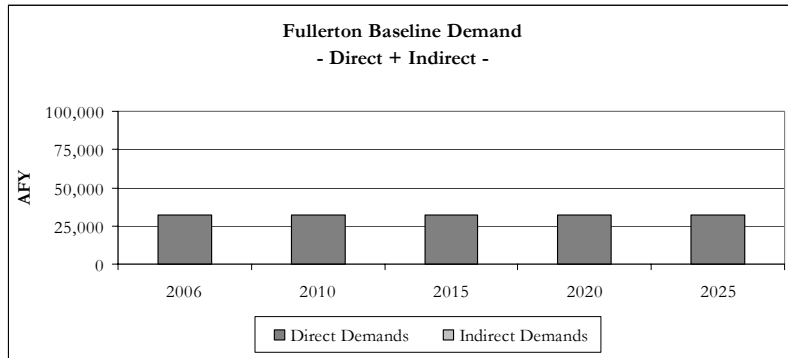


Figure A- 32: Fullerton direct and indirect demand
Source: MWD, 2005

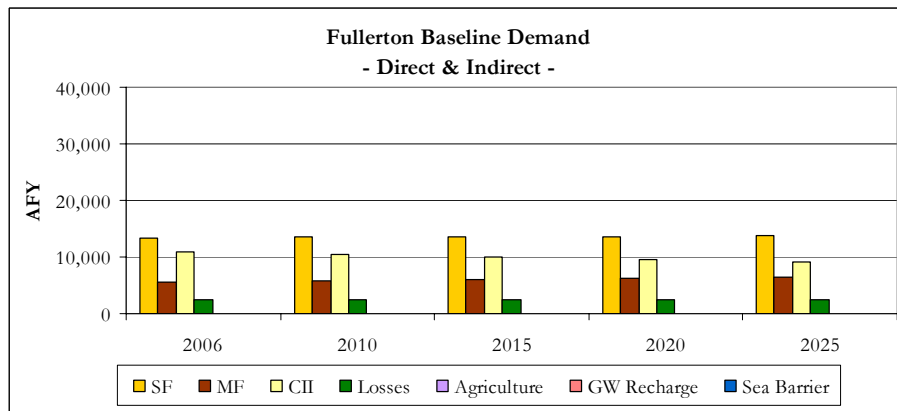


Figure A- 33: Fullerton demand by sector
Source: MWD, 2005

Water Supply

In 2005 imported water made up 29% of the total water supply, while the remaining 71% is comprised of local supplies. By 2025, these percentages are projected to change to 26% imported and 74% local. Figure A-34 shows the direct and indirect baseline supply for Anaheim, while Figure A-35 shows the baseline supply resource mix.

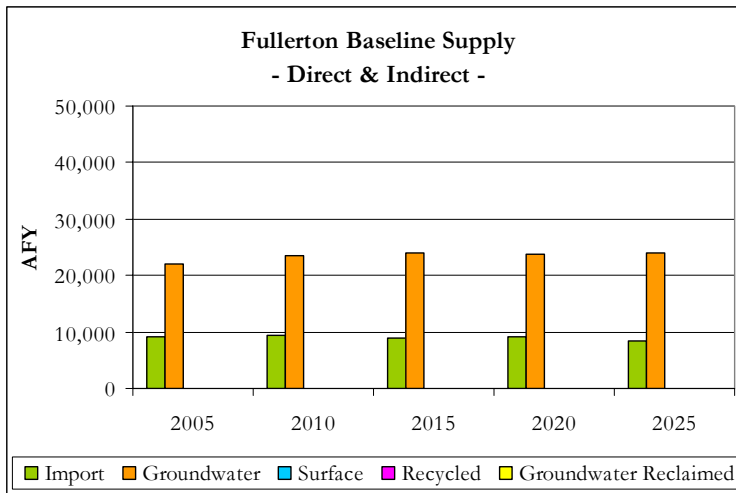


Figure A- 34: Fullerton supply by source
Source: Fullerton, 2005

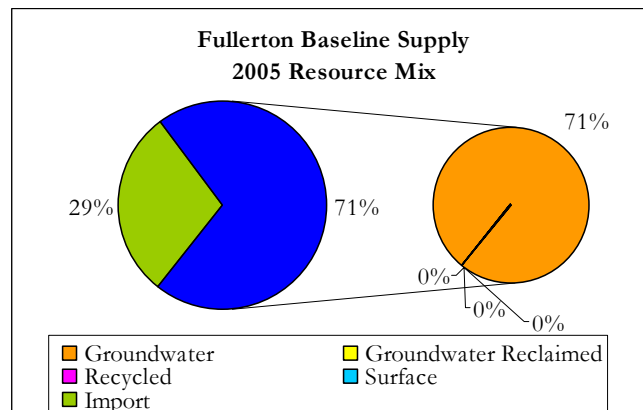


Figure A- 35: Fullerton supply resource mix
Source: Fullerton, 2005

B. Water Use Efficiency & Potential Water Savings Analysis

Specifically, we assessed the implementation of alternative demand management strategies to reduce demand within the SARW Region which the Pacific Institute’s analysis in *Waste Not, Want Not* and its subsequent demand-scenario projection in *California Water 2030* did not account for. Four efficiency measures have been identified that are applicable to different sectors, as seen in Table B-1.

Sector		
Interior	Residential	CII
	Dual-Flush Toilets	Waterless Urinals
Exterior	ET-Based Irrigation	
	Controllers	
	California Appropriate Landscapes	

Table B- 1: Efficiency Measures by Sector Identified for the SARW Region Water Use Efficiency Scenarios

B.1 Residential Interior Water Use & Efficiency Potential

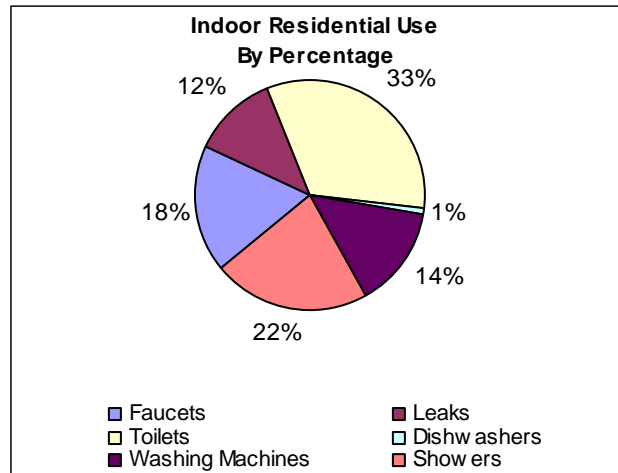


Figure B- 1: Indoor Residential Use by Percentage

Residential use can be considered as one of the largest urban demand sectors and as such has the highest potential for savings. Figure B-1 illustrates indoor residential use by various end uses. The *Waste Not, Want Not* analysis estimates that there is a potential for reducing indoor water demand by 39% simply as a result of existing, cost-effective technology.

The impetus behind residential water use efficiency is that the same end use tasks can be preformed but only with less water. The push to change would not affect the quality of the end use to the user but would simply employ technologies that meet and exceed existing codes and policies. As can be seen from the figure, toilets have had the single largest savings due to the establishing of codes that reduce the amount of water allowed

for flushing. In 1992, water efficiency standards in California reduced the amount allowable for toilet flushing to 1.6 gpf. Eventually the U.S. Congress followed suit and adopted the standards. But due to the persistence of a significant number of inefficient toilets, this sector may still hold the greatest potential for savings as toilets can consume 33% of indoor residential water as more efficient technology exists (Gleick et al, 2003).

Though low flush toilets have generated significant water savings, there are other available technologies that can further reduce water use. Dual flush toilets have been used reliably in Australia and most of Europe for many years, and with the introduction of dual-flush toilets to the United States in 1998 have introduced further savings for North America. For this study, we consider dual-flush toilets solely in residential settings until the general public has been educated regarding the proper use of these fixtures. Until that time it is best that they are not applied in public settings as water savings may be lost due to misuse and misunderstanding.

Dual-Flush Toilets

Dual flush toilets, unlike traditional toilets, have two flush options; a full flush (1.6 gpf) for solid waste and a half flush (0.8 gpf) for liquid waste. The actual flush rates for dual flush toilets range from 0.65 to 1.1 gpf for the short or half flush and 1.3 to 1.87 for the long flush or full flush (CHMC, 2002). There are five known and relied upon studies that have documented the savings for dual-flush toilets including both single and multi-family settings:

- Canada Mortgage and Housing Corporation and Veritec Consulting, Inc., 2002. Dual-flush Toilet Project, by Veritec Consulting, April 2002.
- Aqua craft, Inc., 2000. Seattle Home Water Conservation Study: Evaluation of High Efficiency Plumbing Retrofits in Single Family Homes, Seattle Public Utilities and the U.S. Environmental Protection Agency, December., 2000.
- Aquacraft, Inc., EBMUD, and the U.S. Environmental Protection Agency, 2003. Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single Family Homes in the East Bay Municipal Utility District, Service Area, July 2003.
- Jordan Valley Water Conservancy District, 2003. Residential Ultra-Low Flush Toilet Replacement Program
- Pacific Northwest National Laboratory, 2001. *Oregon's Save Water and Energy Education Program (SWEEP)*. Prepared for the U.S. Department of Energy, May 2001.

According to the Canada Mortgage and Housing Corporation, ratios of short to long flushes are as follows:

- Residential (SF) – 1.6 to 1.0
- Residential (MF) – 4.0 to 1.0

The Jordan Valley study found that half flush was used 59.6% of the time and full flush was used 40.4% of the time in single family homes (Mohadjer, 2003). As a result of this flush ratio, dual flush toilets reduced personal use to 6.9 gpcd (compared with 21.54 gpcd for current 1.6 gpf toilets) and added an additional 24% savings above the 1.6 gpf

toilets (Mayer et al, 2000). The following Table B-2 shows estimated savings when changing from various “inefficient” toilets in residential settings.

Projected Water Savings for Dual Flush Toilets	
	Residential
	Gallons/HH/year (1825 flushes/year)
Change from 1.6 gpf	949
Change from 3.5 gpf	6,388
Change from 4.5 gpf	8,213
Change from 5.5 gpf	10,038
Notes:	
Toilets from 1994-present are rated at 1.6 gpf or less	
Toilets from 1980-1994 are rated between 3.5 and 4.5 gpf	
Toilets from 1950-1980 are rated between 5.0 and 5.5 gpf	
Source: Vickers, 2001	

Table B- 2: Projected water savings for dual-flush toilets

In terms of market availability and cost, as of July 2005 there were nine dual-flush toilet manufacturers that collectively sell 41 different products (Koeller, 2005). Up until the last few years, Australia’s Caroma line was one of the only dual flush toilets available in the United States. The Caroma Caravelle dominated the dual flush market for many years and had a significant market advantage due to the lack of competition from other manufacturers.

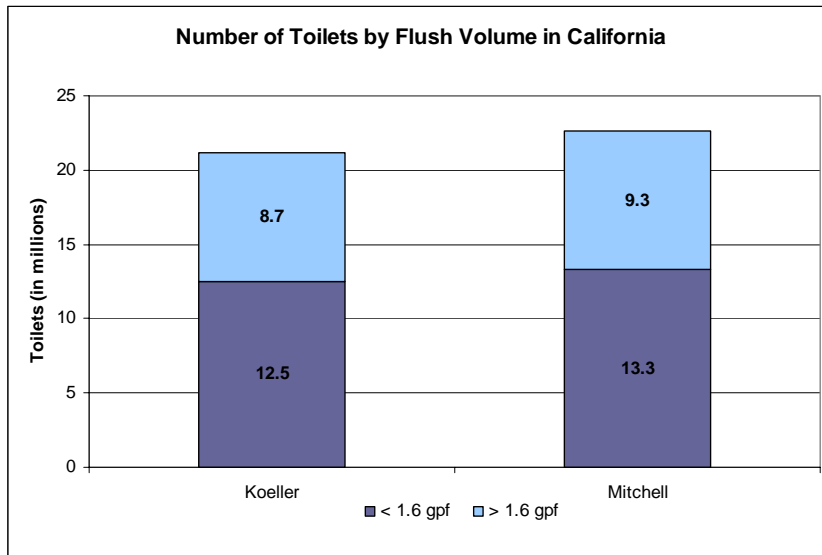


Figure B- 2: Number of toilets by flush volume in California

Saturation rates for dual flush toilets have been difficult to procure for the United States let alone specific regions such as the Santa Ana River Watershed Region. The figure below shows the estimated number of toilets, by type that have been estimated by two studies: Koeller and Company’s unpublished report on the impact of dual-flush toilets in

California and David Mitchell’s “Toilet Forecast”. Unfortunately there is no further distinction beyond the 1.6 gpf category that would distinguish between ultra low flush toilets, dual flush toilets or otherwise. Though this data constitutes projections for California, the ratios of efficient and inefficient toilets can be applied to the Santa Ana Watershed Region.

Potential Savings in the SARW Region

Savings from dual flush toilets for the SARW Region begins with the baseline results from the *Waste Not, Want Not* analysis. This study assumed that all inefficient toilets would be replaced to 1.6 gpf it does not account for the use of dual flush toilets. Based on the demographics taken from MWD’s demand data for the SARW Region, the current use assuming all toilets in the region were 1.6 gpf toilets is 48,694 AFY which is equivalent to 5% of total residential demand. Calculations were then made to determine what the demand would be if all toilets were then converted to dual flush toilets. In order to do this, several assumptions were made:

- 5.1 flushes per person per day¹⁷
- ½ flush is used 69% of the time¹⁸
- full flush is used 32% of the time¹⁹

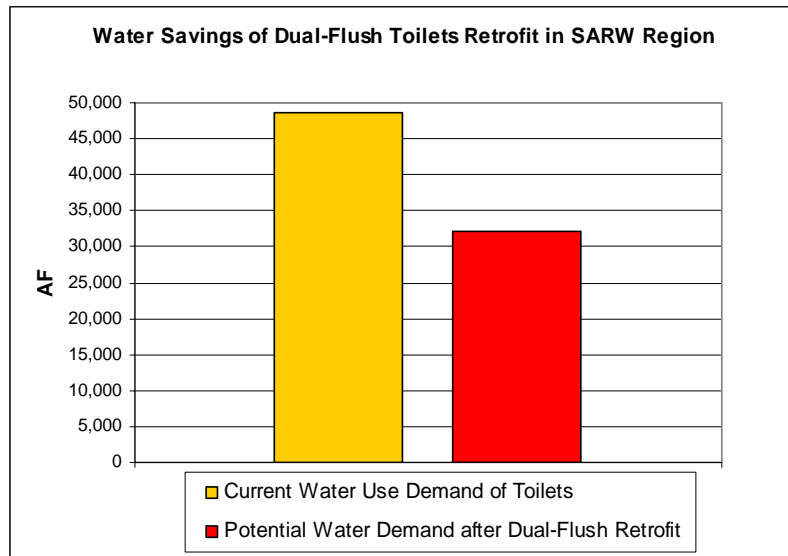


Figure B- 3: Water Savings Potential of Dual-Flush Toilet Retrofits in SARW Region

Based on these assumptions, potential demand was calculated to be 32,016 AFY. This is equivalent to a 16,677 AF decrease in consumption or a reduction in demand by 34.25%

¹⁷ Vickers, 2001.

^{18,4} Veritec, 2002. These values were determined by taking the average flush percentages between SF and MF use from the various studies, because we have aggregated SF and MF demand.

over assumed current 1.6 gallon toilet use. Potentially saving 16,677 AF represents an approximate 2.7% reduction in residential indoor demand for the entire region. Figure B-3 illustrates the decrease in demand due to retrofitting to dual flush toilets.

Cost-Effectiveness of Dual Flush Toilets

Retrofitting of a dual-flush toilet is no more cost intensive than a 1.6 gpf or higher use toilet. The rough-in area of the base and tank are comparable to those of less efficient toilet thus eliminating the need for any serious alterations to the existing area. In terms of maintenance, dual flush toilets do not require any more than a toilet with larger flush volumes. In addition, since there are now several other manufacturers on the market for dual flush toilets, competitive prices exist for dual-flush toilets. The average cost for dual-flush toilets is \$240.

B.2 Residential Exterior Water Use & Efficiency Potential

Outdoor water conservation can be considered the next frontier in water conservation as the savings potential for indoor water conservation is better understood and more easily estimated. Outdoor water savings potential is harder to quantify primarily for two reasons: 1) Most residences lack a dedicated outdoor water meter so an exact volume of water cannot be attributable to outdoor uses and 2) Outdoor use is a function of widely variable factors, such as human behavior, aesthetic values, and climate. As a result of the variability of factors that influence how much water is consumed outdoors it is assumed that there is an inherent waste or inefficiency in outdoor water applications that can be reduced through outdoor water use efficient technologies and policies.

The water savings potential of outdoor conservation is significant when considering that approximately one-third of the 8 million acre-feet of water per year consumed in California’s urban sector is applied to landscapes, as indicated in Table B-3 (DWR, 2005). Within the residential sector, studies indicate that between 50-60% of residential water is used outdoors in Southern California (Mayer, DeOreo, Nelson, Opitz, 1999). The percentage of residential water allocated to the landscape fluctuates spatially and temporally since it is influenced by a variety of factors such as the climate, season, type of vegetation, landscaped area etc.

California Urban Landscape Use				
Year	Type of Year	Total Urban Water Use (MAF)	Urban Landscape Water Use (MAF)	% of Urban Water Use
1998	Wet	7.79	2.58	33%
2000	Average	8.86	2.96	33%
2001	Dry	8.61	2.92	34%

Table B- 3: California Urban Landscape Water Use
Source: DWR, 2005

Existing Outdoor Water Conservation Policies and Laws

AB 325 – Model Landscape Ordinance

One of the first policies enacted was California Assembly Bill 325, the Water Conservation in Landscaping Act of 1990. This legal statute tasked the DWR to develop a Model Water Efficient Landscape Ordinance which would apply to all new and retrofitted landscapes over 2,500 square feet, and developer-installed single-family and multi-family landscaping. While this ordinance has been accepted by many communities, a report sponsored by the California Urban Water Agencies (CUWA) found that the lack of enforcement and monitoring was the ordinance's major weakness (Bamezai, 2001). The report called for more education, conservation rates that send a price signal to the consumer, and better enforcement efforts between land use agencies and water suppliers to make the Model Ordinance more effective (LTF, 2005).

MOU & BMP List

The California Urban Water Conservation Council (CUWCC) created a Best Management Practice list which many water districts, agencies, and municipalities agreed to adhere to in a Memorandum of Understanding. Signatories to the Council's MOU represent urban water agencies that provide 80 percent of all urban water supplied in California. Of the fourteen BMPs that comprise the MOU, four directly relate to landscape water conservation and are as follows:

- BMP 1 – Residential Survey Programs
- BMP 5 – Large Landscape Conservation
- BMP 11 – Conservation Pricing of Water
- BMP 13 – Water Waste Prohibition

AB 2717 – Landscape Task Force (2005)

Most recently, California Assembly Bill 2717 was passed to establish a Landscape Task Force with the responsibility of identifying actions to improve upon the efficiency of water use in California's urban landscapes. As highlighted by the AB 2717 Landscape Task Force in their new report, *Water Smart Landscapes for California*, water efficient landscapes benefit water suppliers, water users, and the environment through:

- Reduced:
 - Average daily water demand
 - Seasonal peak water demand
 - Water extractions
 - Runoff, overspray and soil erosion
 - Green waste production
- Avoided:
 - Costs of energy
 - Costs of water treatment
 - Costs of wastewater treatment

The Task Force recommendations include changes to California law, revisions to the Model Ordinance, and amendments to the California Urban Water Council's MOU and BMPs. In making the forty-three recommendations, the LTF report capitalizes on the

improvements in landscape technology and management in California over the past 15 years and relies upon the future improvements in landscape water use efficiency anticipated over the next 25 years. The LTF report organizes the forty-three recommendations around four overall themes, which are:

- Coordination, Processes, & Institutions
 - Addresses policies, laws, and education/awareness programs to affect WUE.
- Irrigation
 - Encourages adoption, analysis, and standardization of new technology that increases WUE and the training of landscape professionals.
- Landscape Design, Plants, Turf Grass, & Soils
 - Updates to the Model Ordinance (AB 325), conduct research on the water savings attributable to xeriscape landscapes and artificial turf.
- Economics
 - Identifies water rate structures, rebates, and incentives to encourage WUE.

The LTF estimates that approximately 600,000 to 1,000,000 acre-feet of water can be saved through the implementation of the forty-three recommendations, with an estimated average cost of \$250 to \$500 per acre-foot.

Outdoor Demand Management Programs and Technology

The following outdoor demand management technologies and programs will be evaluated for potential water savings and cost-effectiveness:

- California Appropriate Landscape Conversions
- ET-Based Irrigation Controller Retrofits

California Appropriate Landscape Conversions

Typical urban landscapes can be modified based on the composition of vegetation and the amount of area dedicated to different types of plants, which can have an appreciable effect on reducing urban landscape water use. Utilizing plant palettes in urban landscapes that are tolerant of and appropriate to Southern California's dry climate can stretch the "use" of water for landscape irrigation. For the purposes of this analysis, the water savings potential of converting conventional residential single-family landscapes to *California appropriate landscapes* has been targeted for two main reasons:

- 1.) Single-Family residential demand comprises approximately 60% of the total retail, municipal, and industrial demand within the SARW region so water savings here will be pronounced.
- 2.) Studies and research regarding the potential water savings via such conversions have focused on the single-family residential sector.

This analysis will use the term *California Appropriate Landscape (CAL or CALscapes)* to reflect urban and residential landscapes which utilize plant species tolerant of Southern California's dry climate and aesthetic ideals. Conventional residential landscapes have significant areas devoted to turf which typically have greater water requirements than other types of vegetation. California appropriate landscapes replaces cool-season grass varieties (e.g. Kentucky bluegrass, ryegrass, tall fescue) with warm-season turf grass varieties (e.g. hybrid Bermuda grasses, zoysia grass, St. Augustine Grass) in addition to flowers, shrubs, and trees which require less water than conventional turf. It should be noted that CAL conversions do not exclusively use native plants since many ornamental plants are equal in terms of low water-usage and are desired for their aesthetic values within Southern California. In summary, CAL conversions are based on the following seven principles:

Sound Landscape Planning and Design

- Limitation of Turf to Appropriate Areas
- Use of Water-Efficient Plants
- Efficient Irrigation
- Soil Amendments
- Use of Mulches
- Appropriate Landscape Maintenance

While many characterize this type of landscape conversion as xeriscape, this report will refrain from using this term so that a program specific to California and sensitive to its aesthetic ideals can be defined and evaluated.

While the Pacific Institute did provide a figure for potential water savings attributable to xeriscape conversions in *WNWN (30-80%)*, it did not include the savings into the overall outdoor landscape savings potential quantification in *California Water 2030*. The rationale was that although there was significant potential water savings, they did not want to impose or dictate a change in aesthetic or use of residential landscapes in their assessment. One SARW Region Water Use Efficiency Scenario evaluates the potential water savings within the SARW region as a result of CAL conversions for every single-family residence. Rationale for imposing such a region-wide conversion is provided by an analysis of what the Southern Nevada Water Agency (SNWA) has accomplished with its "cash for grass" conversion program.

The Southern Nevada Water Authority's multi-year Xeriscape Conversion Study (XCS) (2005) is the first quantitative study to project savings estimates of what a xeriscape conversion program could yield under real world conditions. The multi-year study consisted of three study groups: 1) A xeriscape study (XS) group; 2) A turf study group; and 3) A non-contacted comparison group for a control. The XS group was provided with a \$0.45 per square foot incentive to subsidize the cost of converting turf to a xeriscape plant palette. Despite the fact that the subsidy was capped at \$900 for 2,000 sq feet, the average area converted was 2,162 sq feet. As a condition for receiving the subsidy, the XS study group participants were outfitted with a separate meter to monitor irrigation consumption exclusively.

The XCS found significant water savings associated with converting traditional residential turf landscapes with appropriate landscaping. In addition, the study also concluded that there is a benefit in terms of reduced landscape labor and maintenance. Side-benefits of reduced energy demand, air pollution, and residential runoff were not assessed but are certainly associated with landscape conversions. In summary, Sovocool & Morgan report the following key findings multiple years post xeriscape conversion:

- Single-Family homes in the XS group saved an average of 96,000 gallons annually post average-size xeriscape conversion project, a savings of 30% from baseline.
- There was no erosion factor for savings over the course of this study. On average, household consumption dropped immediately and quickly stabilized.
- Converted landscapes required 55.8 gallons per square foot less than conventional turf landscapes (17.2 gallons per sq foot to 73.0 gallons per sq foot, respectively), a 76.4% reduction in water demand.
- Summer peak demands of outdoor landscapes were significantly reduced post xeriscape conversions. On average, the difference in water applied to the landscape is 9.62 gallons per square foot for the month of July.
- The average cost of conversion ran \$1.55 per sq ft of (\$1.37 for self-installation, \$1.93 for contracted work). These costs do not account for inflation.
- Xeriscape landscapes experienced a 2.2 hour per month reduction in landscape maintenance and an additional \$206 per annum savings in landscape maintenance, a 33% savings in total landscape labor and maintenance costs.
- Las Vegas Valley Water District customers who retrofitted their landscapes to xeriscape enjoyed an annual financial savings was \$239.92, which equates to a savings of nearly \$0.15 per square foot.

B.2.1 CALscape Conversions in SARW Region – Potential Water Savings

Applying the SNWA landscape retrofit findings to the SARW Region, one must first account for the different climates. The water requirement of similar vegetation will change as a result of climatic factors such as precipitation, ambient air temperature, solar radiation, wind speed, etc. Table B-4 shows that the average *ET* of the SARW Region is 51.8 inches while the *ET* for the SNWA service area average 90 inches. Thus, the SARW region's *ET* is 58% of SNWA's, which means that on average, similar vegetation in the SARW region would require 58% less water than the same vegetation would in the Las Vegas area.

ET stands for evapotranspiration and accounts for the amount of water both evaporated from a landscape and transpired (or “breathed out”) by vegetation on account of metabolic processes. ET_0 is the term used to describe the evapotranspiration rate measured from a known source, which is typically a cool-season turf grass. ET_0 , or reference ET, takes on a high value of 1 and other types of vegetation are assigned coefficients to compare the relative amount of water they need in relation to reference ET_0 .

To evaluate the volume of water that could be potentially saved as a result of converting all the single-family residential landscapes in the SARW Region, several assumptions were made, which include:

- Landscaped area per single-family house = 2,000 sq ft
- Gallons saved per sq ft of turf converted = 55.8 gallons/sq ft
- Reduction factor to account for different climate = 0.58
- Total single-family water demand applied outdoors = 0.375²⁰

SARWA Region Average Precipitation and ET Water Requirements						
	MWDOC	IEUA	EMWD	SARW Region Average	SNWA	SARW Region as % of SNWA
Average Precipitation (inches)	14	15	11	13	4	333%
Annual ET Water Requirement (inches)	49.63	51.25	54.56	51.8	90	58%

Table B- 4: Average ET and Precipitation Comparison between SARW Region and SNWA
Source: 2005 UWMP’s, Sovocool & Morgan, 2005

Demographic data for each water district supplied by MWD provided the number of single-family houses and the water demand, in acre-feet, needed in order to estimate the potential water savings. Table B-5 and Figure B-4 indicate that there is a total water savings potential of 217,765 AF through the conversion of water-intensive turf in residential landscapes to CAL landscapes (CALscapes). This savings represents 29% of the total single-family water demand or 77% of the outdoor demand for single-family residential houses.

²⁰ This number is based on the California Department of Water Resources Year 2000 South Coast SF Indoor vs. SF outdoor water use and can be found on the DWR website.

CALscapes- Potential Water Savings in the SARW Region	
Single Family Total Water Demand (AF)	754,121
Single Family Outdoor Water Demand (AF)	282,796
Water Saved through Xeriscaping (AF)	217,765
% Saved of Total SF Household Demand	29%
% Saved of Exterior SF Household Demand	77%

Table B- 5: Evaluation of Water Savings Potential of CALscapes of Single-Family Residential Houses in the SARW Region.

Source: Demographic data supplied by MWD, 2005.

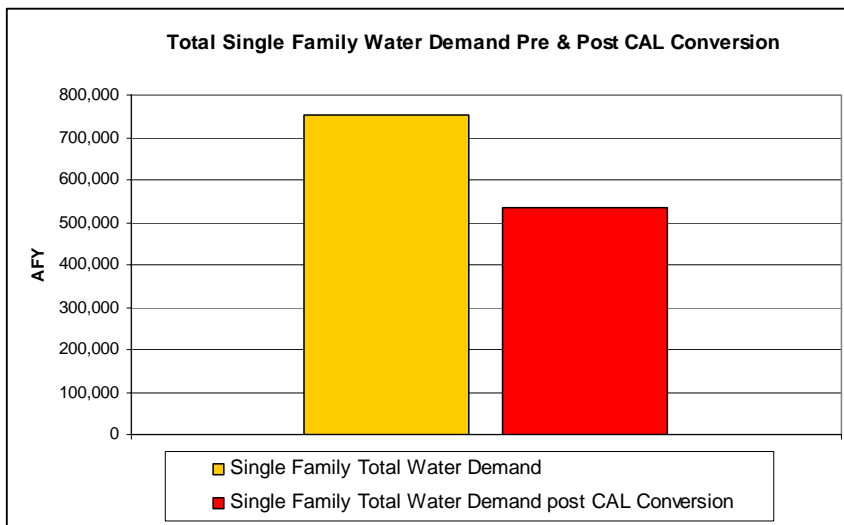


Figure B- 4: Total SF Water Demand Post CALscapes in SARW Region

Avoided Costs to Water Agencies

If the total cost of CAL retrofit implementation is cheaper than developing the same amount of water supplies that can be conserved through CALscapes, the program can be considered cost effective for agencies. Water agencies within the SARW Region typically pay \$453/AF²¹ to MWD for imported water supplies. Table B-6 demonstrates that as a result of saving nearly 220,000 AF, the water agencies within the SARW Region can potentially avoid costs²² of almost \$100 million dollars a year. Also significant but not factored into this assessment are the avoided costs of procuring water supplies and delivering those supplies during peak summer months. CALscapes effectively decrease the peak summer demand for water in single-family residences.

²¹ This cost per AF was obtained from MWD's water rates and charges webpage: http://www.mwdh2o.com/mwdh2o/pages/finance/finance_03.html, effective 1/1/2006. This cost was calculated by adding together the Tier 1 Supply Rate, System Access Rate, Water Stewardship Rate, System Power Rate and the Treatment Surcharge.

²² It should be noted that a simple avoided cost estimate is provided here. This estimate does not include the costs incurred by water agencies to implement the CAL conversion program.

Cost of MWD Imported Supplies
\$453 per AF
AF Saved through CALscapes
219,308 AF
Avoided Costs of Purchased Water
\$99,346,524

Table B- 6: Potential Avoided Costs of Purchased Imported Water from MWD within the SARWR Region post CALscapes

The benefits and cost-effectiveness of California appropriate landscapes become magnified when considering that approximately 280,000 new single-family homes are projected to be built within the region by 2025. It is assumed that the costs of installing CALscapes in new residential developments are the same as traditional turf landscapes therefore there are no costs incurred for retrofits, providing new homeowners with an annual savings of approximately \$350 in avoided water bill charges, subject to the specific water-rate structure. This savings can be promoted by developers who install California appropriate landscapes, especially in the warmer Inland Empire, whose single-family residential units are expected to increase by roughly 50% by 2025.

B.2.2 ET-Based Irrigation Controller in SARW Region - Potential Water Savings

Whereas CALscape conversions reduce the overall water demands of a landscape by substituting plants with high water-use requirements for those with low requirements, conservation technologies like *ET-based irrigation controllers* make supplying particular landscape demands more efficient. For this reason, the water savings potential for ET-based controllers is not as great as CALscapes. Better irrigation technology is critically important however, when considering that they do not require behavioral shifts or changes in aesthetic preferences on the part of landowners in the way CAL do. ET-based controllers work within any type of aesthetically desired or designed landscape and for this reason are viewed as being potentially viable instruments for water conservation.

ET-based irrigation controllers have been referred to as ET controllers and “Smart” controllers. The difference in names highlights how this emerging technology is not yet standardized or widely utilized. The “smart” moniker is added because many hoped that this technology, once setup, could run autonomously without the need for adjustments by landowners or landscape professionals. While many of these controllers demonstrate positive results independent of manual adjustments, optimal water use efficiency is obtained with manual fine-tuning by educated landowners and/or professionally trained/certified landscape professionals.

The Landscape Task Force (LTF) places a lot of attention on technologies and programs related to the efficiency of irrigation. The LTF distills its list of forty-three recommendations down to twelve principal recommendations. Of those twelve, six focus exclusively on technologies or policies related to irrigation. Taken from Taskforce’s report to the Governor and Legislature, the six recommendations are:

- #4 – Require dedicated landscape meters
- #8 – **Require Smart (or ET) Controllers**
- #9 – Adopt and enforce statewide prohibitions on overspray & runoff
- #10 – Provide training and certification opportunities to landscape and irrigation professionals
- #11 – Support upgrading the CIMIS (California Irrigation Management Information System) Program
- #12 – Adopt performance standards for irrigation equipment

This analysis will focus on the eighth recommendation, requiring controllers, and attempts to evaluate the potential water savings of retrofitting single-family residences within the SARW Region with “smart” or ET controllers. Similar to the CALscape analysis, the single-family sector is targeted again because that is where the bulk of the water demand in the SARW Region resides. Additionally, many of the studies and research consulted provide the best estimates for single-family water savings potential. There are several detailed studies that have shed considerable insight into the potential savings of particular types of “smart” controllers, however, there is need for additional documentation and research in order standardize the slew of existing technologies and clarify to the consumer and landscape professional what is meant by a “smart” controller and how to optimally operate and maintain one.

Literature Review

Conventional irrigation systems and policies often lead to over-watering and urban runoff, thus “smart” controllers and irrigation are those that reduce over-watering within the landscape by optimizing the application of water to plants. Different technologies determine “optimal” applications of water in a variety of ways; however, the Irrigation Association defines a “smart” controller as climate-based or sensor-based controllers that automatically adjust for local weather and site conditions (Landscape Taskforce, 2005). While there are numerous emerging “smart” controller technologies, they can be lumped into three categories (Koeller et al., 2004):

- *Controllers independent of broadcast signal* – in which the application of water is based on the historical ET of a region that is built into the controller.
- *Controllers dependent on broadcast signals* – the application of water is based on real-time ET conditions in addition to the site conditions and receives a signal from a centralized location.
- *Controllers with remote programming ability* – application of water is based on signals sent from a centralized location to the control and the control can also send signals back to the centralized computer.

Despite the lack of standardization, there are several encouraging studies which demonstrate sizeable water savings as a result of retrofitting conventional irrigation systems to “smart” controller-based irrigation systems. In total, there were 10 studies consulted for this analysis and are summarized in Table B-7 on the next page. This list

was modified from a chart presented by Tom Ash in a white paper available online (Ash, 2005).

Summary of Surveyed Literature & Studies						
Water Agency / Study Name	Year	Controller Type	Sector	Objective	Key Findings	Notes
IRWD/MWDOC- Irvine ET Controller Study	2001	Broadcast	SF Residential	Test Performance of ET Controllers	16%-25% outdoor water savings; < 7% total use; < 37 gpd; 97% customer satisfaction	Plant appearance improved; water bills reduced
AquaConserve - Denver Water	2002	Historical ET	SF Residential	Test Water Savings	21 % total water use savings;21% outdoor savings	Manufacturer Report
AquaConserve - City of Sonoma	2002	Historical ET	SF Residential	Test Water Savings	23% total water use savings;7% outdoor savings	Manufacturer Report
AquaConserve - Valley of the Moon Water District	2002	Historical ET	SF Residential	Test Water Savings	28% total water use savings;25% outdoor savings	Manufacturer Report
SB County ET Controller Distribution & Installation Program - SB County Water Agency	2003	Broadcast	SF Residential	Test Performance of ET Controllers	Average reduction in total water use by 26%	Targeted High water using households
LADWP - Weather Based Irrigation Controller Pilot Study	2003	Mix	MF Residential + Large Landscapae	Product Comparison	27% outdoor water savings for MF residential	Multi-use meters + dedicated irrigation meters saved 82 AFY
Seattle Public Utilities - Water Efficient irrigation Study	2003	Multiple Types	SF Residential	Test Water Savings	Water savings of 27.7 ccf per SF household	Hard to substantiate what % this was of pre-retrofit water use
IRWD/MWDOC - R3	2004	Broadcast	SF Residential + Large Landscape	Test Water Savings + Runoff Reduction	Total household water use < by 41gpd (10%); dedicated landscapes < by 545 (21%); 70% participants satisfied	Found runoff <70% in dedicated landscapes; peak demand < 51 gpd in SF residences
MWD -Weather Based Controller Bench Test Report	2004	Mix of Broadcast and Historical ET	Study Sites	Product Comparison	Broadcast ET Controllers faired quite well; Overwatering by Historical ET controller	Broadcast conroller (WeatherTrak) maintained soil moisture and did not contribute to plant stress
UC Riverside - Evaluation of Weather-Sensing Landscape Irrigation Controllers	2004	Mix of Broadcast and Historical ET	Study Sites	Water to UC Standard / Product Comparison	Different controllers performed better given different scenarios	Controller installation was not standardized

Table B- 7: Summary of multiple studies/reports regarding the water savings potential of ET Controllers

ET-Based Irrigation Controllers – Potential Water Savings within the SARW Region

The 2004 *Potential Best Management Practice Report*, prepared for the California Urban Water Conservation Council by Koeller & Company, offers the best estimate on the water saving potential of ET Controllers for the entire State of California, which this analysis will replicate for the SARW Region. The Koeller report utilizes many of the studies

referenced above, specifically those studies done within the IRWD. The Koeller et al. report estimates that approximately 114,000 acre-feet of water per year can be saved if 25% of all single-family houses retrofit their conventional auto-irrigation controllers to ET-based controllers. The 25% reduction factor takes into account the number of houses with automatic sprinklers and those high-use households which make the technology cost-effective. The Koeller et al. findings have been replicated in a later section and the same calculations for the SARW Region are provided there.

The exact same assumptions and calculations were performed to estimate the water savings potential within the SARW Region.²³ The SARW Region has the potential to save approximately 18,000 Acre-Feet of water per year if 25% of single-family homes were retrofitted with ET Controllers. This savings represents 2.4% of the single-family total water demand and 4.8% of the single-family outdoor demand.

The potential 18,000 AFY water savings presents a conservative estimate of the water savings potential. It must be noted that studies²⁴ within the region indicate that public and commercial landscapes outfitted with ET Controllers produce significant water savings (refer to summary of findings, Table B-7, above) however, only single-family residential ET retrofits are evaluated here.

Table B-8 provides a range of plausible water savings if the number of houses retrofitted with ET Controllers increases from the reported 25%. The SARW Region ET-Controller Scenario projections will assume that 50% of the single-family residences retrofit to ET Controllers. This value accommodates the rapid new growth in homes which can prescriptively build such technology into new developments and is in line with the water savings found in the major IRWD ET-Controller studies. The first IRWD ET Controller study reported a 37 gallon per day (gpd) decrease in total residential use while the IRWD & MWDOC R3 study concluded that ET Controllers reduced total household water consumption by 41 gpd, approximately 10% of total household use.

If 50% of single-family residences within the SARW region retrofit to ET controllers, approximately 36,000 acre-feet of water (59 gpd per retrofitted single-family residence) of water may be conserved, which equals 5% of the total single-family demand and 13% of the single-family outdoor demand. This potential annual savings of water translates to a 2.36 ccf/month reduction in the amount of water used by one retrofitted single-family house in the SARW Region. It should be noted that recent California legislation

²³ MWD demographic and demand data from their 2005 Regional Urban Water Management Plan was used to determine the number of single-family residences and the single-family demand for each water agency in the region. The region-wide water savings estimates were aggregated up from the district-level water savings.

²⁴ A good example is the Irvine Ranch Water District & Municipal Water District of Orange County's "Residential Runoff Reduction Study", 2004, in which they found that large landscape water use decreased 545 gallons per day after ET-Controller retrofit. <http://www.mwdoc.com/research.htm>

proposes that all irrigation controllers sold in the state must be certified smart controllers by 2009.

Range of Potential Water Savings Post ET Controller Retrofit in SF Homes within the SARW Region				
	25% of SF Houses Retrofitted	50% of SF Houses Retrofitted	75% of SF Houses Retrofitted	100% of SF Houses Retrofitted
Water Saved by ET Controllers (AFY)	17,956	35,911	53,867	71,822
% Saved of Total SF Household Use	2%	5%	7%	10%
% Saved of Outdoor SF Household Use	6%	13%	19%	25%

Table B- 8: Range of Potential Water Savings Potential Attributable to ET Controller Retrofits within the SARW Region

Cost Effectiveness of ET Controller Retrofits in the SARW Region

While there is evidence suggesting that ET controllers are effective in saving water and potentially reducing runoff, not all of the studies provide detailed analysis of whether the ET controller was a cost effective conservation measure. Because the studies are limited in scope (short time duration & sampled population) estimating the costs and extrapolating those out to the SARW region is difficult. Despite this difficulty, there are several studies that do attempt to account for the costs of the ET controller retrofit over a 10-year product life cycle.

In a BMP Costs & Savings Study prepared for the CUWCC, A&N Technical Services (2005) summarized ET controller retrofit costs for both participants and for the supplier/water agency as:

Participant Costs → Cost to purchase, install, operate, and maintain the system. Some systems have monthly signal fees (broadcast controllers).

Supplier/Agency Costs → Cost to purchase, install, operate, and maintain if supplier shares costs, and costs attributable to administration, contractors, and marketing or outreach.

The following two studies provide the best estimates for single-family residential ET retrofit costs:

Residential Weather-Based Irrigation Scheduling: Evidence from the Irvine ET Controller Study (Hunt et al., 2001)

The IRWD study found that the full lifecycle cost of a broadcast ET controller, including all the costs, was quite high and would be cost effective to only the largest residential customers (Hunt, et al., 2001). It should be noted, however, that there are benefits that are hard to put a value on, such as ease of use and convenience for customers, and if valued sufficiently, ET controllers become more cost effective. The study broke the costs down as such:

- \$100/controller
- \$75/installation
- \$4/month signal fee
- Useful life ~10-15 years

This study demonstrated that if only the top-third of high water using single-family homes are retrofitted with WeatherTRAK broadcast controllers (a 57 gpd savings per SF residence), the lifecycle water savings benefit to the customer would roughly equal \$338 (customer savings are valued at \$720 per AF) compared to a total lifecycle cost of \$528 (of which \$353 represent signal fees) over a ten year product life cycle. The analysis also shows that the water savings benefit to IRWD is approximately \$204, thus by offering a rebate IRWD can bring customer benefits in line with customer costs (Koeller & Company, 2004). It is important to note that 66% of the participants who received the ET controller indicated that they were willing to pay up to \$125 for the controller and a \$4/month signal fee.

Santa Barbara County ET Controller Distribution & Installation Program (SB County Water Agency + Partners, 2003)

The costs that were listed in this study include controller costs (\$200), installation fees (\$100-\$150 per controller), soil probes (\$12/probe), and consultant fees for marketing assistance, training workshops, and customer service. It is important to note that this study grossly underestimated the time and costs for both site visits and installation. The agency, using the IRWD study as a template, initially estimated site visit and installation times in keeping with smaller landscapes with newer irrigation systems like those found in Irvine. However, this study targeted much larger landscapes and spent an average of 4 hours to install a system which was budgeted for 2 hours.

Avoided Costs to Water Agencies

If the total cost of ET control retrofits is cheaper than developing the same amount of water supplies that can be conserved through CAL conversion, the program can be considered cost effective for agencies. Water agencies within the SARW Region typically pay \$453/AF²⁵ to MWD for imported water supplies. Table B-9 demonstrates that as a result of saving nearly 36,000 AF, the water agencies within the SARW Region can potentially avoid costs²⁶ of over \$16 million dollars in imported water supplies a year. Also significant but not included here are the avoided costs of procuring water supplies and delivering those supplies during peak summer months. ET controllers effectively decrease the peak summer demand for water in single-family residences. Also not factored into this calculation are the avoided costs associated with non-point pollution which has been shown to significantly decline with the implementation of ET controllers (IRWD & MWDOC, 2004).

Cost of MWD Imported Supplies
\$453 per AF
AF Saved through ET Controller Retrofits
35,911 AF
Avoided Costs of Purchased Water
\$16,267,683

Table B- 9: Avoided Imported Water Costs to Water Agencies in the SARW Region

B.3 Commercial, Industrial, and Institutional Water Use & Efficiency Potential

Pacific Institute's Waste Not, Want Not was the first statewide study to address water use in the CII sector. For the course of this analysis we consider the aggregated savings potential for the CII sector as a whole, recognizing that some studies group Commercial and Institutional uses together as they are most similar. One of the difficulties in estimating water savings for CII is that the uses vary so greatly because the uses include everything from process water, which would include things like cooling towers, to end uses, which includes restroom uses. End uses present less difficulty in estimations as the uses can be considered the same across all sectors.

²⁵ This cost per AF was obtained from MWD's water rates and charges webpage: http://www.mwdh2o.com/mwdh2o/pages/finance/finance_03.html, effective 1/1/2006. This cost was calculated by adding together the Tier 1 Supply Rate, System Access Rate, Water Stewardship Rate, System Power Rate and the Treatment Surcharge.

²⁶ It should be noted that a simple avoided cost estimate is provided here. This estimate does not include the costs incurred by water agencies to implement the CAL conversion program.

Waterless Urinals

According to *Waste Not, Want Not*, 15% of CII water is used in restrooms thus providing a great savings potential by measures such as waterless urinals. As of 1991, all urinals manufactured and installed in the United States are required to use 1.0 gpf or less. Even still there are many older urinals still in operation in the US that use 4.0 gpf or more. Though waterless urinals have been gaining acceptance since the 1990s, Klaus Reichardt from Waterless Co. and Randall Goble, Falcon Waterfree, have estimated that out of 8-9 million urinals installed in the US, only ½ of 1% of this total are waterless (*pers. conversation*). These estimates indicate that there is a significant savings potential still available with this sector. Unfortunately there is a severe lack of data regarding the installation base of urinals in the CII sector, thus making it difficult to make accurate savings estimations.

In office buildings, use is estimated at 2.0 times per day assuming a 260 day work year (Konen, 1986). Replacing 3.0 gpf urinals in office buildings can potentially save an estimated 1,560 gpcy (Vickers, 2001). Table B-10 shows estimated savings based on different replacement regimes.

Summary of Projected Water Savings from Waterless Urinals	
	Office
	Gallons/male/year
Change from 1.0 gpf	520
Change from 2.0 gpf	1,040
Change from 4.5 gpf	2,340
Notes: Work year is 265 days/year Urinals from 1994 – present are 1.0 gpf Urinals from 1980-1994 are rated between 1.5 and 4.5 gpf Assuming 2 uses/day/male (Konen, 1986)	

Table B- 10: Summary of projected water savings from waterless urinals

Potential Savings from Waterless Urinals in the SARW Region

In order to calculate savings, estimates were first made regarding the expected current use of urinals. Demographic data was used from the MWD's data and the following assumptions were made in calculating current use:

- Population consists of 49% males²⁷
- Average flush rating 2 gallons per flush²⁸
- Average urinal use is 2 times per day²⁹

²⁷ U.S. Census Data 2000

²⁸ As reported in the literature there is a considerable lack of data regarding installation rates as well as existing flush volumes of urinals throughout California. The range in urinal flush volumes can range anywhere from 5.0 gpf to 0 gpf and as such an assumption was made to use a mid-range averages as adopted from Vickers, 2001.

²⁹ Vickers. 2001, Konen, 1986.

Based on these assumptions, the current use was calculated at 11,696 AFY. Because waterless urinals require no water, this figure is equivalent to the amount saved. This is also 4.6 % of CII demand.

Cost Effectiveness of Waterless Urinals

Waterless urinals require only a drain line and since they do not use water, do not require the necessary hardware upon first install, thus decreasing the initial cost of installation. Operation costs include the changing of the trap which provides a liquid seal to ensure that potential odors are not released from the drain. The following Table B-11 depicts a costs summary.

Associated Costs for Waterless Urinals	
Costs	
Hardware	\$350-600
Labor	\$45-125
Operation	\$20/1500 uses
Source: (Vickers, 2001).	

Table B-11: Associated costs for waterless urinals

Barriers to Implementation

Though waterless urinals have been in use in the United States as well as California for many years, there are several unfounded concerns that the public as well as uninformed water managers may have. Some of the concerns associated with the use of waterless urinals is problems with smell and thus issues of sanitation as well as increased maintenance and costs.

To begin with waterless urinals are designed in such a way that the vitreous china resists urine residue from adhering to the bowl. In addition, traditional urinals that use water to flush expose restroom users to water vapor that potentially carries air-borne bacteria or viruses. Furthermore waterless urinals are touch free which reduces the likelihood of bacteria transfer like that from manual flush urinals.

Maintenance of waterless urinals has been considered less costly and labor intensive as compared to water-using urinals. The only thing to maintain is the liquid trap through which wastes pass through and which seals the air from the drain from entering the restroom. This liquid barrier cost approximately \$0.50 per ounce and 3 ounces lasts approximately 1500 uses. In addition, due to the design of the trap it is less likely that the trap can be clogged due to vandalism.

C. Water Reuse – Supply Management Strategies

C.1 Water District Reuse Profiles

This section provides a more detailed look at the individual water districts' reuse profiles. All of the data is drawn from the water district's respective UWMP's unless otherwise cited.

C.1.1 Eastern Municipal Water District

District Characteristics

Demand for recycled water in the region is high, and currently EMWD sells up to 26,000 AFY of recycled water to 91 customers. Demand for recycled water fluctuates from summer highs to winter lows, which means that in winter there is often greater supply than demand. Any water that cannot be stored in surface impoundments is then discharged. There are five regional wastewater collection and treatment facilities within the service area, and the management of these is The District's responsibility. There are interconnections between the collection systems that "allow for operational flexibility, improved reliability, and expanded deliveries of recycled water." (EMWD, 2005)

In 2005 EMWD recycled 80% of their treated wastewater, and although the overall volume of water re-used is projected to increase by 2025, the percentage of the total quantity of treated wastewater to be re-used will decrease to just below 69%. Current and projected recycled water use can be seen in Figure C-1.

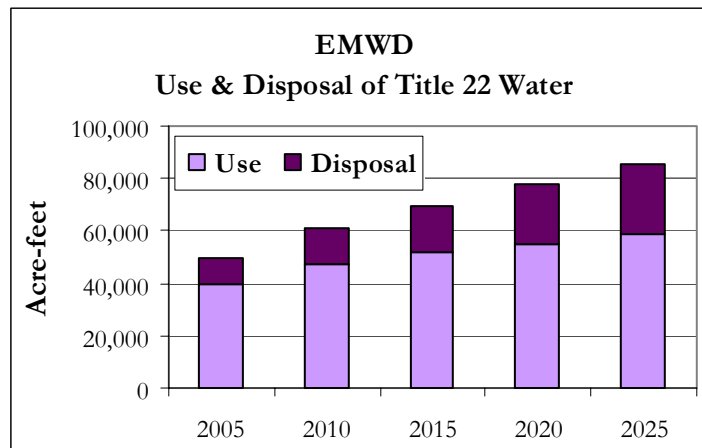


Figure C- 1: EMWD- Use and disposal of Title 22 Water
Source: EMWD, 2005

Recycled Water Use

As can be seen in Figure C- 2, more than half of the reclaimed water in EMWD is used for agricultural and irrigation purposes, but as farmland is displaced by urban and residential development sales to municipal customers continues to grow. Pipelines are being completed which will allow recycled water to be used at parks, schools, a cemetery, and more than a dozen golf courses and streetscapes. 90-100% of the recycled water produced is sold during the summer months, and the rest of the year, excess recycled water is stored in surface impoundments which allow for groundwater recharge. In the case where storage capacity is insufficient, water is disposed of through a regional outfall pipeline to Temescal Creek.

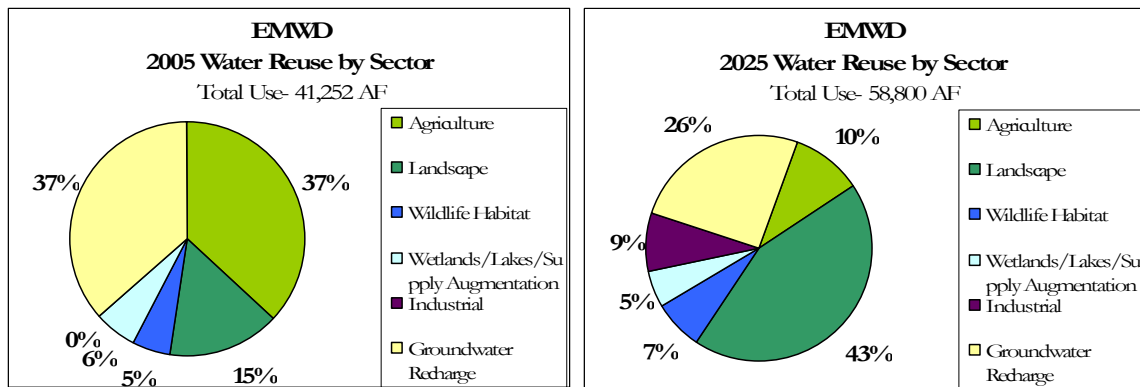


Figure C- 2: EMWD Water reuse by sector, 2005 and 2025
Source: EMWD, 2005

Barriers to Implementation

- Lack of infrastructure in certain areas
- Cost concerns

Methods to Overcome Barriers

- *Mandatory Recycled Water Use Ordinance*- A mandatory recycled water ordinance requiring customers to use recycled water, if available, for permitted uses provides a basis for denying potable water to customers if they are able to use recycled.
- *Rate Incentives*- Recycled water is priced lower than potable water: at 1/3 the cost for municipal use and 1/4 the cost for agricultural. Are they recovering costs?
- *Water Supply Assessments*- New major developments are required to use recycled water if it's available for permitted uses based on EMWD's SB 610 and 221 Water Supply Assessments Condition.
- *Public Education*- Educates the public and promotes the benefits of recycled water use.

Current and Planned Projects

Over the next 20 years, the treatment capacity of each of the four regional water reclamation facilities will be increased to accommodate the demands of the growing population. The timeline for treatment plant upgrades can be seen in Table C- 1.

Treatment Plant Upgrades		
Treatment Plant	Plan	Completion Date
<i>San Jacinto Valley RWRP</i>	Expansion from secondary to tertiary treatment	2008
	Expansion from 11 MGD capacity to 14 MGD	2011
	Expansion from 14 MGD capacity to 18 MGD	2024
<i>Moreno Valley RWRP</i>	Expansion from 13 MGD to 21 MGD	2009
<i>Temecula Valley RWRP</i>	Expansion from 12 to 18 MGD	2006
	Expansion from 18 MGD to 22 MGD	2018
<i>Perris Valley RWRP Expansion</i>	Expansion from 11 MGD to 22 MGD	2007
	Expansion from 22 MGD to 30 MGD	2019

Table C- 1: EMWD ongoing and planned treatment plant upgrades
Source: EMWD, 2005

EMWD is also doing the following to expand recycled water use:

- “Planning additional pipelines that will expand municipal use of recycled water.
- Planning several innovative projects to provide recycled water to long term agricultural customers (citrus orchards) in lieu of GW.
- Working with Cal DFG to expand the use of recycled water at the San Jacinto Wildlife Area.”

C.1.2 Western Municipal Water District

District Characteristics

Most of the wastewater in the WMWD is treated by the District’s March Wastewater Reclamation Facility (WWRP); however, a small portion of the service area’s wastewater is collected by The Western Riverside County Regional Wastewater Treatment Plant, the City of Riverside’s Riverside Regional Water Quality Control Plant, or by septic systems. Figure C- 3 shows WMWD’s use and disposal of Title 22 treated wastewater through 2025, but the wastewater volumes represent only those to the March WWRP. Of the wastewater treated by the Riverside Regional Water Quality Control Plant, only a small amount is reclaimed for irrigation while the rest is discharged into the Santa Ana River. Most of the discharge is required to satisfy the downstream water rights obligations of Orange County Water District vs. City of Chino et.al., Case #117628. The treated wastewater from the Western Riverside County Wastewater Treatment Plant is currently discharged to the Santa Ana River, but there are plans to diver some of the flow for landscape uses in the City of Norco.

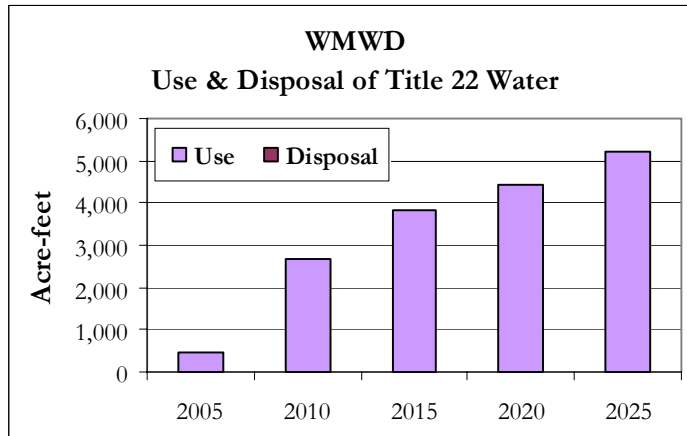


Figure C- 3: WMWD- Reuse and disposal of Title 22 Water
Source: WMWD, 2005

Recycled Water Use

Figure C- 4 shows the current and projected percentage breakdown of reclaimed water use by sector. In 2005, the total amount of recycled water used from the March WWRF was 450 AF, and currently, all of this goes to the Riverside National Cemetery and the Archie J. Gold Golf Course. When the March WWRF is upgraded to tertiary treatment, the treated effluent will be fed into the non-potable irrigation system for delivery to other expected landscape irrigation users such as area schools, parks, and a new golf course.

There is some large industry within the region, including a Pepsi Bottling Plant and Ralph’s Grocery Dairy Unit, and the industrial base continues to grow. One large industrial/commercial park, the Meridian Business Center, is under construction, with plans to build others in the works, so this could be a potential area where water reclamation could be implemented.

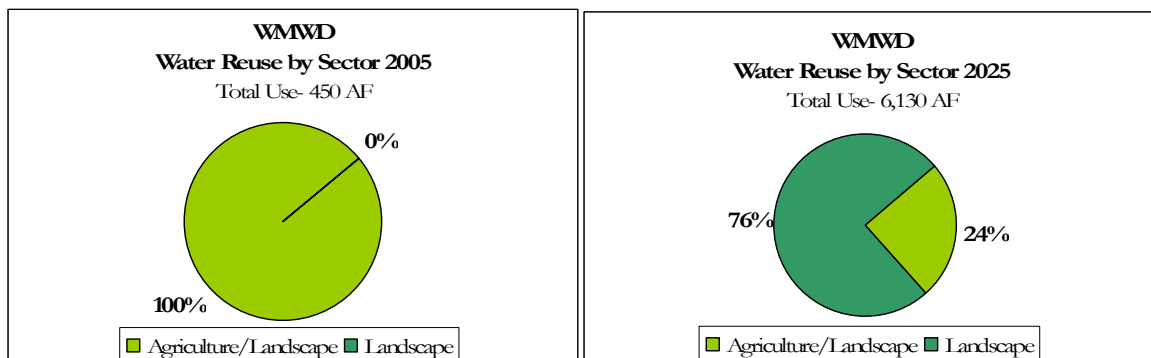


Figure C- 4: WMWD Water reuse by sector, 2005 and 2025
Source: WMWD, 2005

Barriers to implementation

- Currently wastewater cannot be fed into the non-potable irrigation distribution system, so the piping system from March WWRF must be integrated into this system in order for wastewater from the expanded capacity system to be utilized in the non-potable system.
- Availability of other sources of non-potable water diminishes the immediate pressure to invest in additional recycled water infrastructure.
- Decreased agricultural usage resulted in less than the projected 2005 recycled water consumption.

Methods to Overcome Barriers

- “It is expected that recycled water will be available to customers at rates below that of potable water
- It is also expected that recycled water use will be mandated by ordinance at sites where recycled water is available and can be properly used
- Additionally, industrial/commercial developers near non-potable distribution pipelines are required to plan for the future use of recycled water. This includes installation of proper piping and facilities to minimize economic impacts when recycled water becomes available at the use site. This is being implemented through the plan checking process, with plans not approved until required recycled water facilities are designed.
- Western also launched a public outreach campaign in 2005 to inform the general public about the benefits of use of recycled water.”

Current and Planned projects

Upgrade to the March WWRF- An ongoing upgrade will increase the treatment capacity from 0.3 MGD to 1 MGD and the treatment level to tertiary. Predict expansion to eventually need to be 5 MGD by 2030.

Riverside/Corona Feeder Project

This conjunctive use project allows for the capture and storage of water sources during wet years to supplement potable demand. Water sources include: local runoff and regulated releases from the SWP and Seven Oaks Reservoir. This water will be used for recharge and then extracted for local needs during dry years. Water storage will occur in the San Bernardino Basin Area, which has a safe yield of 5,000,000 AF. This water could then be transported for use in other areas through the Riverside Corona Feeder. The project’s facilities include 20 wells and 28 miles of pipeline, and it will be able to 40,000 AFY of groundwater.

Benefits of this project include:

- Reduction in the cost of water during drought years
- Increased reliability of supply during drought years
- Improved water quality in the San Bernardino area

- Better groundwater management

Additional proposed projects:

The San Bernardino Municipal Water District and Western have applied for the right to divert up to 200,000 AFY of local water. This would allow for capture of storm flows that would otherwise be lost.

C.1.3 Inland Empire Utilities Agency

District Characteristics

IEUA has been providing recycled water since 1972. Currently an aggressive recycling program is being implemented throughout IEUA’s service area, so that by 2020, IEUA projects recycled water use to increase over 1000% above 2005 levels which can be seen in Figure C-5.

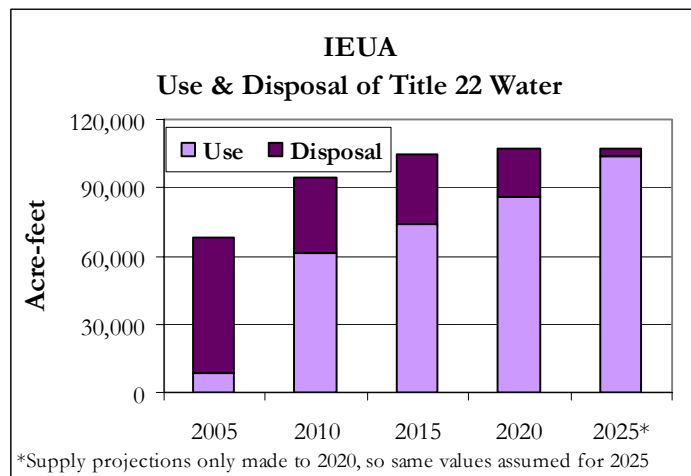


Figure C- 5: IEUA- Use and disposal of Title 22 Water
Source: IEUA, 2005

As mentioned previously, the population of IEUA’s service area is projected to increase from 814,618 to 1,108,349 over the next 20 years, and land use is being converted from agricultural to urban. IEUA has the opportunity to implement additional recycled water treatment and distribution infrastructure alongside the expanding population, which is cheaper and more convenient than retrofitting existing systems to use reclaimed water.

In trying to maximize reuse within its service area, IEUA has short and long-term goals laid out. The short-term goal is to connect industrial and landscape customers to the distribution system and develop facilities to transport reclaimed water to recharge areas, while the long-term focus is the construction of a looped distribution system that connects all four of the regional treatment facilities and maximizes the area throughout which recycled water can be delivered. It is extremely important for the local water

providers to develop recycled water facilities as well, in order to expand the distribution of supply.

Recycled Water Uses

Current and projected water use by sector is depicted in Figure C- 6. In addition to direct uses for agriculture, municipal, and industrial purposes, a substantial amount will be used to recharge the groundwater basins. This will provide a larger supply of banked water which can act as buffer during dry years. Currently most of the recycled water users are in the southern portion of the service area, but the water system is undergoing construction to expand service to the northern region. Tertiary water is sold wholesale to the City of Chino, City of Chino Hills, and the City of Ontario.

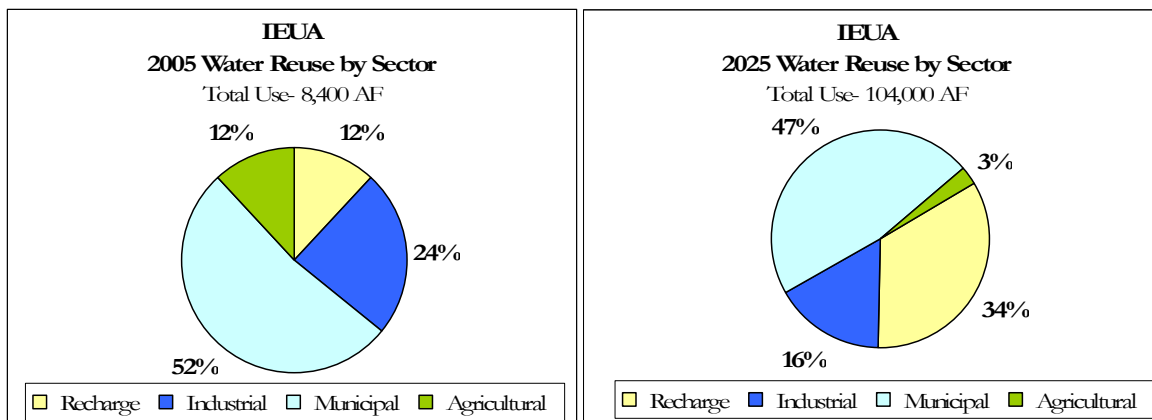


Figure C- 6: IEUA Water reuse by sector, 2005 and 2025
Source: IEUA, 2005

Barriers to Implementation

- *Salinity*- Half of the salt loading is from local water sources, while the other half comes from imports. IEUA only uses imported water from the SWP since this water has average TDS concentrations of 250 mg/L which is much lower than that of Colorado River water, which is approximately 650 mg/L. Salinity levels can vary depending on hydrologic conditions in the region.
- *Funding*- Construction of recycled water infrastructure becomes more cost-effective as more funding is made available. Investigation by IEUA staff showed that the capital costs for the Regional Water Distribution System can be funded by the Regional Program. This means that an increase in the Regional Capital Capacity Reimbursement Amount (connection fee) is not necessary, so agencies can implement the programs without affecting water and sewer rates. The UWMP states that, “in fact, recycled water sales could potentially lower water and sewer rates by 20% to 30% with full implementation of the Regional Recycled Water System. Recycled water sales revenue, combined with the MWD Local Projects Program (LPP/LRP) rebate, could generate sufficient revenue to offset projected water and sewer rate increases for the regional program.”

Overcoming Barriers

- *Funding-* IEUA encourages water reuse within its service area by establishing supplemental funding through federal, state, and regional programs. IEUA also works in close cooperation with local agencies in order to coordinate and maximize water reuse in the area. Together they are working on a recycled water marketing program and a database that identifies current and potential customers.
- *Dual plumbing-* Where recycled water is available, new developments are dual plumbed in order to allow for utilization of reclaimed water approved uses.
- *Mandatory Use-* Adopted in 2002, Ordinance No. 75 states that a 50% surcharge may be added to the potable water rates of potential recycled water customers who don't use recycled water when available.
- *Discounted water rates-* Retail water utilities give discounted recycled water rates from 30-50% of the potable water cost. As a financial incentive to encourage recycled water use, the wholesale price of recycled water is now 20% of the cost of imported (\$60/AF), whereas previously it was priced at 80% of the cost of imported. This rate is discounted even further, down to \$45/AF, for NRW industries. The Non-reclaimable Water (NRW) Line is a pipeline that transports industrial wastewater that can't be treated with the usual technologies from the service area to the Los Angeles County Sanitation District in Whittier. These industries use a large amount of water for non-potable applications and IEUA has identified them as significant potential users of recycled water.
- *Technical Assistance-* Provided by IEUA to assist customers in preparation of reports and to coordinate DHS approval of recycled water at the site.
- *Financial Assistance-* The 2000 Regional Recycled Water policy offers financing to facilities for capital improvements needed to separate water systems.

Current and Planned Projects

Provision of recycled water is dependent upon, among other things, both technical and economic factors. There must be end-users to utilize the supply as well as infrastructure in place to treat and distribute the water. Data gathered in IEUA's 2002 Regional Recycled Water Program Feasibility Study and the 2005 Regional Water Implementation Plan (RWIP) provided information used to plan the locations of recycled water distribution pipelines that will provide recycled water to the most customers.

Details of the RWIP are as follows:

- System will supply 1,900 customers with approximately 104, 000 AF of water.
- Plan implementation is scheduled over the next 10 years
- Cost of approximately \$110 million
- Provisions for additional expansion beyond this time horizon

- Funding will come from a combination of sources, including state and federal grants, low-interest state loans, MWD LRP rebates and Regional Sewage Program funds.

Plans for the Regional Water facilities include: a looped pipeline system connecting all four treatment plants, as well as 50 separate pipelines, pump station and reservoir projects that have been grouped into implementation phases based on criteria such as the amount of water that could be served and the proximity to the recycling plants or distribution systems. IEUA is also working closely with local agencies to coordinate planning efforts and assist with implementation of recycled water systems and distribution. Figure C- 7 shows the existing and planned distribution lines.

Recycled Water Distribution Lines and Regional Plants

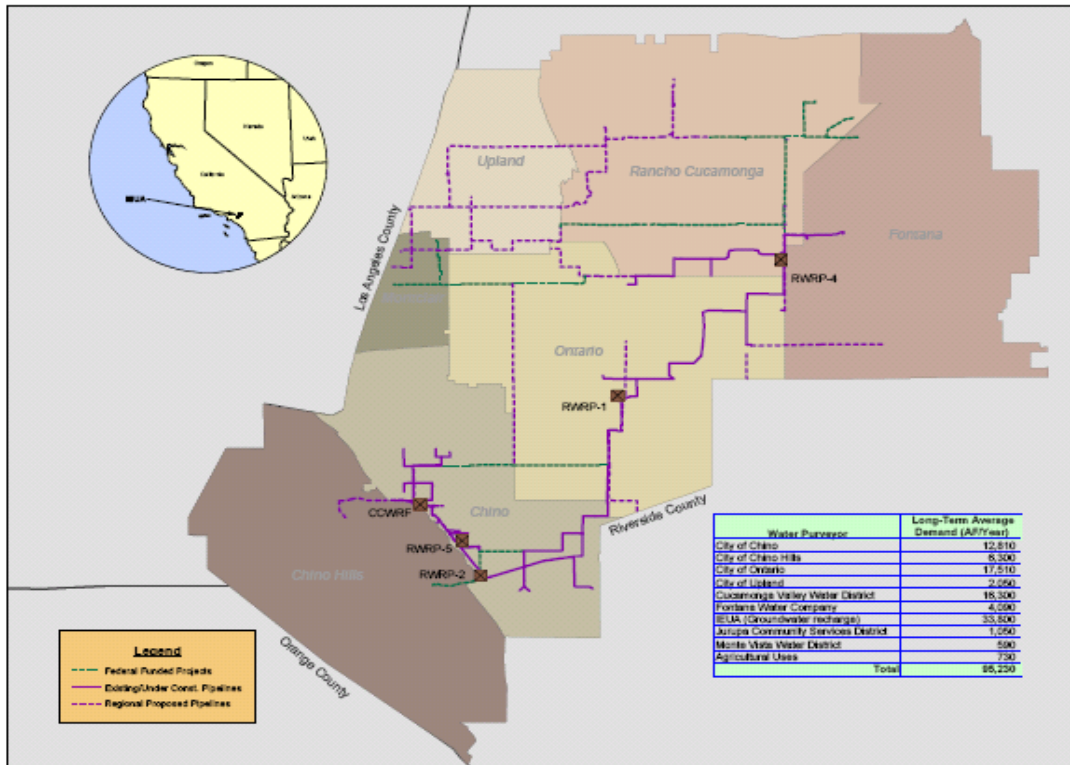


Figure C- 7: Recycled water distribution lines and regional plants
Source: IEUA UWMP, 2005

C.1.4 MWDOC

District Characteristics

The use of recycled water is widely accepted within MWDOC's service area. While in the past the main use of reclaimed water in the district was for irrigation purposes, the GWR system will vastly increase the amount of recycled water used for recharge and seawater barriers and make groundwater recharge the largest user of reclaimed water in Orange County.

Of the approximately 235,000 AF of wastewater projected to be treated to recycled standards in 2030, close to 135,000 AF is allocated for current and planned recycling projects. This leaves about 100,000 AF of treated water for new water projects in the region (Figure C-8).

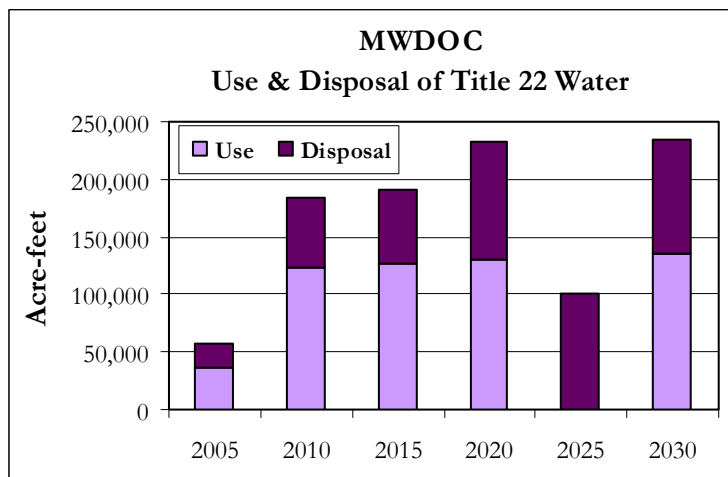


Figure C- 8: MWDOC- Use and disposal of Title 22 water
Source: MWDOC, 2005

Recycled Water Uses

Currently the majority of recycled water use in Orange County is for irrigation purposes (Figure C- 9), and according to the UWMP it is not likely that any direct reuse projects will be pursued in the near future. The WMP states that the projects providing the most benefit for the cost have either already been implemented or planned, and the water systems in place generally already serve the users for which costs are the lowest and as expansion of these systems increases, so do the costs to end users.. In general they find that the capital costs of new recycled water projects are higher than the short-term costs of buying imported water. They found that in many instances the production of more recycled water proves economically impractical given the costs of potable supplies compared to recycled water. Also noteworthy is the fact that the actual use of recycled water in 2005 was lower than that forecast by the 2000 UWMP, for reasons such as lack of funding and complex interagency agreements.

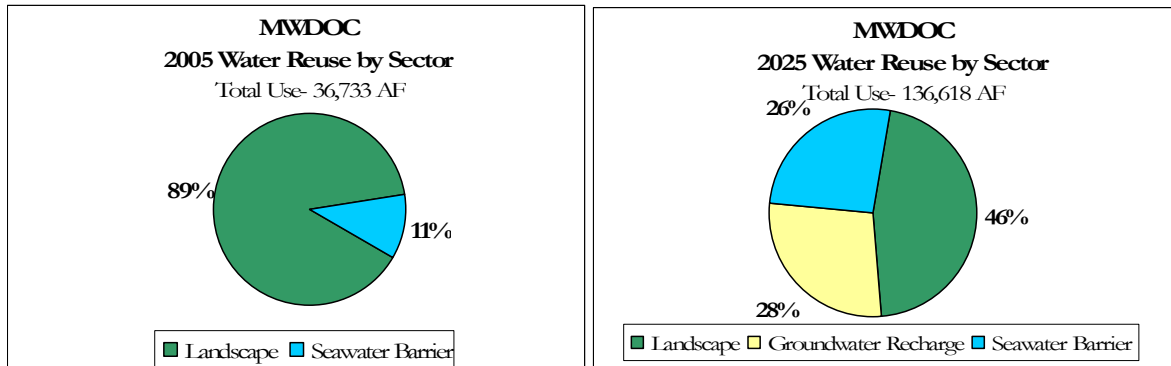


Figure C- 9: MWDOC Water reuse by sector, 20025 and 2025
Source: MWDOC, 2005

Barriers to Implementation

There are a number of factors that need to be taken into account when looking at expanding water recycling systems: type of water use, proximity to existing recycling infrastructure, the size of the end users, willingness to use recycled water, cost effectiveness of recycled water use. Constraints and barriers vary by agency as each has its own different constraints.

Within MWDOC’s service area, they following are listed as the most significant barriers limiting recycling expansion:

- *Funding*- Costs of construction, operation and maintenance
- *Infrastructure requirements*- Expansion of systems eventually gets to a point where the return on investment diminishes.
- *Public acceptance*- Generally high within MWDOC’s service area, but there is still some resistance to some types of use.
- *Water quality*- The levels of TDS in the water affect what type of areas can be irrigated with reclaimed water as plants have a certain threshold of tolerance for TDS levels.
- *Economics of treatment and distribution system extension* (including retrofits)- Even with high demand for reclaimed water it may not be economically efficient to supply water to all users.

Overcoming Barriers

With recycled water use projected to increase approximately 400% over the next 25 years, more than one-quarter of the service area’s wastewater will be recycled. To assist in meeting these projections, MWDOC plans to take numerous actions to facilitate the use and production of recycled water within its service area. However, MWDOC is a wholesaler and, as such, cannot impose development requirements or enact ordinances that require the use of recycled water” (MWDOC, 2005).

Most of the planning for recycled water is directed toward utilization of the water for groundwater recharge. In an effort to increase public acceptance of recycled water use, energy is also devoted to continued public education and involvement.

MWDOC itself does not produce recycled water, but rather represents retail agencies which produce and distribute reclaimed water. There are various methods used to encourage water reuse within the service area, one of which is MWDOC's passing on of benefits from Metropolitan to retail agencies. According to the UWMP, these benefits include: funding for local projects, partnership facilitation, regulatory issues, brine disposal, and public acceptance.

The UWMP cites these potential ways in which recycled water use could increase, but maintains that they are not likely to be implemented in the near future:

- Dual piping requirements in new developments
- Retrofits on existing landscaped areas
- Construction of piping and pumping stations to convey water to areas further from the treatment plants

Current and Planned projects

Southern California Comprehensive Water Reclamation and Reuse Study (SCCWRRS)

This six-year study, started in 1993 and conducted by the DWR examined the feasibility of a regional water reclamation plan. Goals of the study were to identify opportunities to increase the use of recycled water, as well as identifying existing constraints. While they found that a regional study was not applicable at present, the study identified the sub-region of Orange County and the Lower Santa Ana River as an area that merits continued evaluation, and as such is being examined for both short (2010)- and long-term (2040) water recycling applications

Green Acres Project (GAP)

The GAP is a water reclamation project that produces tertiary treated water, which is distributed wholesale to Mesa Consolidated Water District and the cities of Fountain Valley, Huntington Beach, Newport Beach, and Santa Ana. Uses of this water are mainly for irrigation, but it is also used for dual plumbing, industrial processes, and at OCSD for wastewater treatment processes. The plant has a capacity of 7.5 MGD, and when demand exceeds supply this water can be supplemented with up to 6 MGD of deep colored well water. GAP produces tertiary treated water for distribution from May to November, and during the winter months IRWD's Michelson WRP provides water to users as agreed upon with OCWD.

Groundwater Replenishment System (GWR)

Currently, Phase 1 of the GWR is scheduled for completion in 2007, and at that time will allow reuse of 72,000 AFY of wastewater effluent that is currently discharged to the ocean. The treatment process uses micro-filtration, reverse osmosis, UV, and hydrogen peroxide to treat secondary treated water from OCSD's Reclamation Plant No. 1, producing water that will exceed both federal and state drinking water standards. Further

phases have not yet been approved, but the development plans project production of up to 146,000 AFY of water.

Uses and benefits of this system include:

- Eliminates the need for another wastewater disposal ocean outfall
- Prevents seawater intrusion by injection of treated water into seawater barriers
- Boost the water quality of the OC Groundwater Basin by reducing mineral content
- Seawater barrier expansion may help sustain coastal area groundwater production.
- Potential augmentation of existing recycled water supplies.

This project reduces reliance on imported water for basin recharge, as well as increasing supply reliability by employing a drought-proof water source.

- OCSD and OCWD are equally sharing the capital construction costs, which are projected at \$487 million, and OCWD will be responsible for system maintenance and operation. There are also federal, state, and regional funding sources as well.

C.1.5 Cities of Santa Ana, Fullerton, & Anaheim

Wastewater generated in the service areas of Santa Ana, Anaheim, and Fullerton is transported to OCSD's treatment facilities in Huntington Beach and Fountain Valley. Although district characteristics and water reuse varies a bit between these districts, they share common barriers to implementation and employ similar methods to overcome these barriers, so we have combined these sections to be representative of all three districts.

District Characteristics & Recycled Water Use

Santa Ana

Water demand within the city of Santa Ana is projected to stay fairly constant over the next 20 years; due to both increased use of water efficiency measures and the projection that population is expected to grow only minimally. At this point the infrastructure for recycling is built out and there are no new plans to expand, so the use of recycled water is projected to remain constant, with an annual demand of 150 AF used for irrigation of greenbelts, parkways, golf courses, and other landscape uses. The recycled water used is purchased wholesale from OCWD through the GAP, and they do not expect any additional water to be provided for use by Santa Ana. Any new potential users of the reclaimed water will need to be able to connect to the existing distribution system.

Fullerton

Due to the lack of a source of reclaimed water, Fullerton does not plan for any direct use of reclaimed water in the next 25 years. Since wastewater generated in Fullerton is collected and treated by OCSD, they are indirectly a part of the reclamation projects of OCSD and OCWD (e.g. the Groundwater Replenishment System).

Anaheim

Although APUD recognizes that there are potential uses of reclaimed water within the service area, they are not currently directly using any reclaimed water due to a lack of infrastructure to support recycled water use. Wastewater generated in Anaheim is collected and treated by OCSD, so indirectly they are a part of the reclamation projects of OCSD and OCWD (e.g. the Groundwater Replenishment System). A 1991 reclaimed water feasibility study concluded that a recycled water treatment and distribution system in Anaheim was not economically feasible at the time; however the City plans to conduct another study prior to the 2010 UWMP update. Water demand within the city is projected to increase about 8% from 2005 to 2025. Landscape irrigation and industrial processes are potential end uses that are being considered. In an effort to promote the use of recycled water in the future, Anaheim has implemented programs that require separate irrigation systems.

Barriers to Implementation

- Lack of infrastructure
- Capital cost concerns
- Public acceptance

Ways in which they are trying to overcome these barriers

In an effort to increase public acceptance of recycled water use, energy is devoted to continued public education and involvement; however, most of the planning for recycled water is directed toward utilization of water for groundwater recharge. The cities do, however continue to evaluate opportunities for recycled water use within the service areas.

Current and Planned Projects

The majority of recycled water use in Orange County is for irrigation purposes, it is not likely that any direct reuse projects will be pursued by these cities in the near future. Currently, they have found that the capital costs of new recycled water projects are higher than the short-term costs of buying imported water. All three districts rely on groundwater for the majority of their water supply and thus support and encourage the use of recycled water in the region to recharge the groundwater basins and to prevent against seawater intrusion.

C.1.6 Irvine Ranch Water District

Although IRWD is not one of the seven water districts we looked at for the scenario generations, we have included a brief description of their recycling profile as an example of a district with a progressive approach to reuse.

District Characteristics

One MWDOC member agency that operates an aggressive recycled water program is the Irvine Ranch Water District (IRWD). IRWD is an independent public agency that was founded in 1961, and which serves the city of Irvine along with portions of Tustin, Newport Beach, Costa Mesa, Lake Forest, and Orange (Figure C-10).

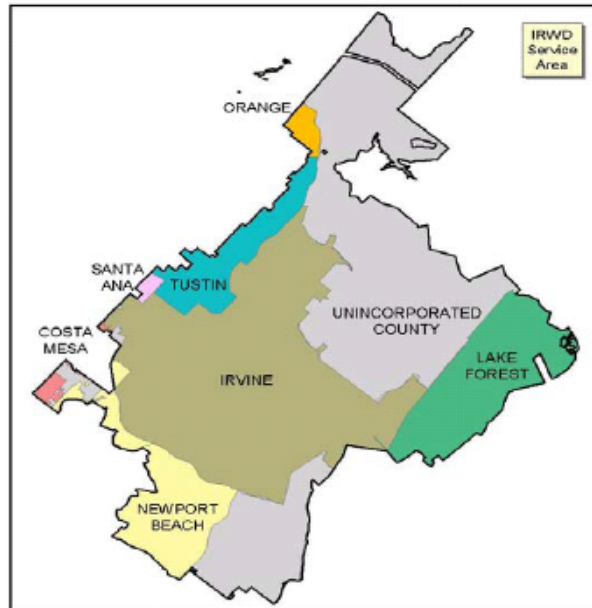


Figure C- 10: IRWD service area
Source: IRWD, 2005

According to Marilyn Smith from IRWD’s Public Affairs Department (Marilyn Smith, telephone interview, March 1, 2006) the typical barriers to recycled water use, infrastructure and public perception are not problems in IRWD. Since IRWD has been providing its customers with reclaimed water for 35 years water reuse is generally met with positive public perception. Additionally, the recycling infrastructure was in place before the population grew because the community planners recognized that water was a limiting factor and planned accordingly. The system reaches most of the service area, and generally recycled water lines are installed along with domestic water and sewer lines when new developments are built (Irvine Ranch, 2005). IRWD also has a public outreach program to educate the community about water reuse, which also enhances public acceptance (Irvine Ranch, 2005). Figure C-11 shows the current and projected amounts of recycled water use.

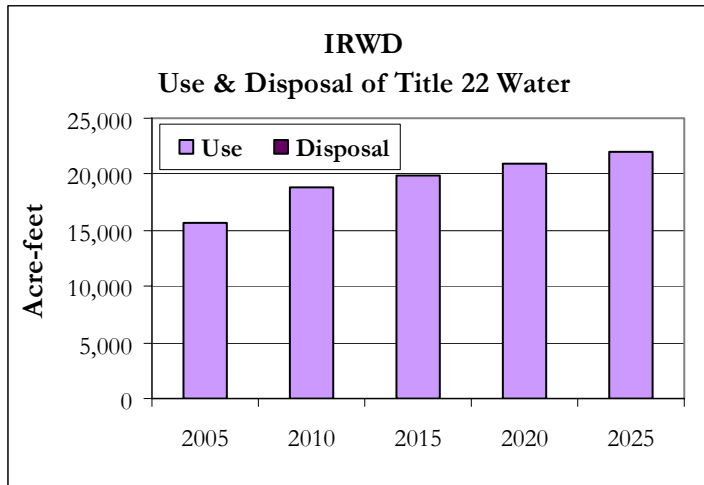


Figure C- 11: IRWD- Treated water use and disposal through 2025
Source: IRWD, 2005

Recycled Water Use

IRWD has over 3,500 recycled water customers and the recycled water system has a current storage capacity of 1,470 MGD and consists of: a separate pipeline system more than 300 miles long, 12 storage reservoirs, and 15 pump stations. Due to the high reliability of recycled water as a supply source, there is customer interest in using the water for landscape and industrial purposes. During the winter months IRWD provides recycled water to the GAP, per agreements with OCSD and OCWD, and during the rest of the year excess recycled water is wholesaled to the GAP project and Santa Margarita Water District.

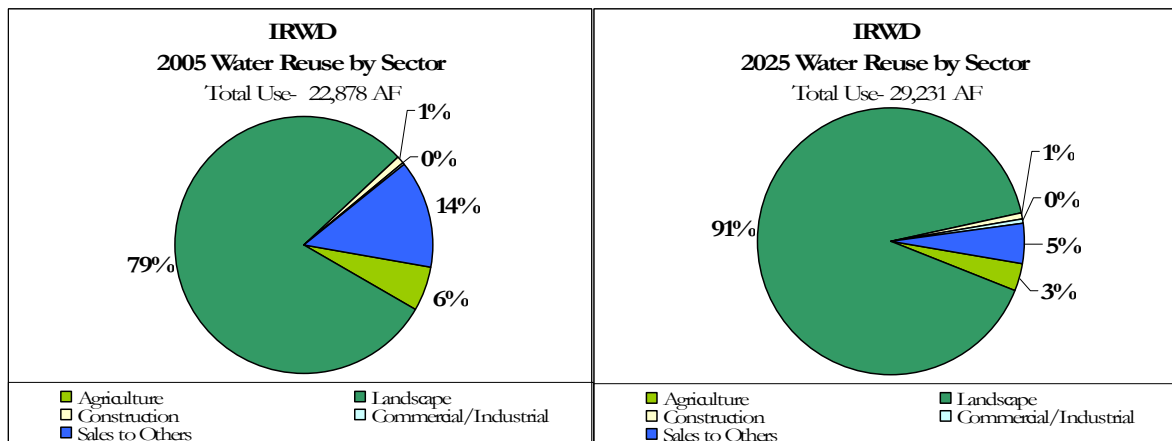


Figure C- 12: IRWD Water reuse by sector, 2005 and 2025
Source: IRWD, 2005

Barriers to Implementation

The main problems faced by IRWD with recycled water are related to:

- Water quality issues with salinity- Colorado River water is becoming more saline over time. Also, water softeners are a large source of salinity to wastewater. To target these problems so that they do not make water recycling more problematic, ordinances to ban the use of self-generating water softeners within IRWD boundaries were adopted. There is resistance but it is crucial in order to control increase salinity.
- Seasonal storage-not enough storage during the wet season.
- Increased maintenance-requires more maintenance than drinking water systems

Methods used to overcome barriers

- *Rate discounts*- Recycled water is priced 10% below the rate of local water.
- *Prohibit specific potable use*- IRWD's Rules and Regulations Section 1 states, "If recycled water service is determined by the District to be feasible in accordance with Section 4.12, the applicant, owner or customer will be required to utilize recycled water service (IRWD Rules and Regulations, 2003). IRWD makes efforts to provide customers with recycled water for approved uses in place of potable water, and tries to assist customers with retrofit conversions where possible.
- *Grants/low interest loans*- The most AF of use are projected to result from this method.
- *Dual plumbing standards*- All new buildings of a certain square footage and number of fixtures are required to have dual plumbing required to use recycled water for flushing toilets and urinals.

Current and Planned projects

The recycled water distribution system continues to undergo expansion, into new areas as well as retrofitting of current service areas. As a result, IRWD projects that recycled water demand will nearly double by 2025.

- *Planned expansion of the MWRP*- from a capacity of 18 MGD to 33 MGD by 2025, given that there is sufficient wastewater influent and that the expansion is feasible, economically, technologically, and environmentally.
- *LAWRP upgrade*- Current upgrades to the facility will allow recycled water to be delivered to IRWD's Zone B and Zone A in the Lake Forest area.
- *Conversion commercial buildings to recycled water use*- Next year 12 more buildings will be converted to recycled water.
- *Diversion of the Harvard Avenue Trunk Sewer (HATS) wastewater flows*- The 2003 Wastewater Treatment Master Plan outlines plans to re-direct the HATS flows from OCSD to MWRP. Maximum flows are projected to be 7.9 MGD, which would only be accommodated by the expansion of the MWRP.

- *Conversion of the San Joaquin Reservoir into a reclaimed water storage facility-* This reservoir, located between Newport Beach and Newport Coast, is currently empty and has a capacity 3,050 AF. Reclaimed water would be stored here during the winter months and then removed for use during other times of the year when demand is higher. Benefits of this plan include: provision of recycled water to a larger service area, energy savings, and protection of the Upper Newport Bay.
- *Study of Lake Forest area-* Possible interconnection of the 2 recycled water distribution systems and examination of retro-fit opportunities within the Lake Forest area.
- *2005 Local Resources Program (LRP) Agreement-* Agreement between MWD and IRWD (with MWDOC a signatory) for assistance on capital projects to deliver an additional 8,500 AFY of recycled water from MWRP and LAWRP.

C.2 Case Studies – Descriptions, Barriers, & Solutions

C.2.1 Within Watershed Case Studies:

OCWD

OCWD is a leader in water reuse both nationally and internationally. With Orange County serving 2.5 million people and receiving an average of only 13 to 15 inches of precipitation annually, innovative programs had to be implemented in order to sustain the growing population and booming economy. OCWD's two most notable water recycling projects are Water Factory 21 and the Groundwater Replenishment System.

Water Factory 21³⁰

Water Factory 21 began in the mid-1960's as a pilot water reclamation project. Water Factory 21 is located in Fountain Valley, California and produces a total of 22.6 million gallons per day (MGD) of reclaimed water. The different types of treated water are as follows:

- 5 MGD of reverse-osmosis treated water
- 9 MGD carbon-absorption-treated water
- 8.6 MGD deep well water is produced.

Of the 22.6 MGD, 15 MGD is reclaimed for various non-potable water uses, while 8.6 MGD is blended with recycled secondary effluent supplied by the Orange County Sanitation District (OCS D) and used for injection of recharge basins. The water produced meets both the drinking water standards and the injection requirements of the California Regional Water Quality Control Board (Santa Ana region).

For ultimate blending before injection of the water into recharge basins, the treatment process includes chemical clarification, re-carbonation, multimedia filtration, granular activated carbon, reverse osmosis, chlorination, and blending. Figure C-13 shows an illustration of the treatment process from secondary treatment to injection.

³⁰ <http://www.ocwd.com/html/wf21.htm>, <http://www.ocwd.com/assets/pdfs/OCWDWF21.pdf>

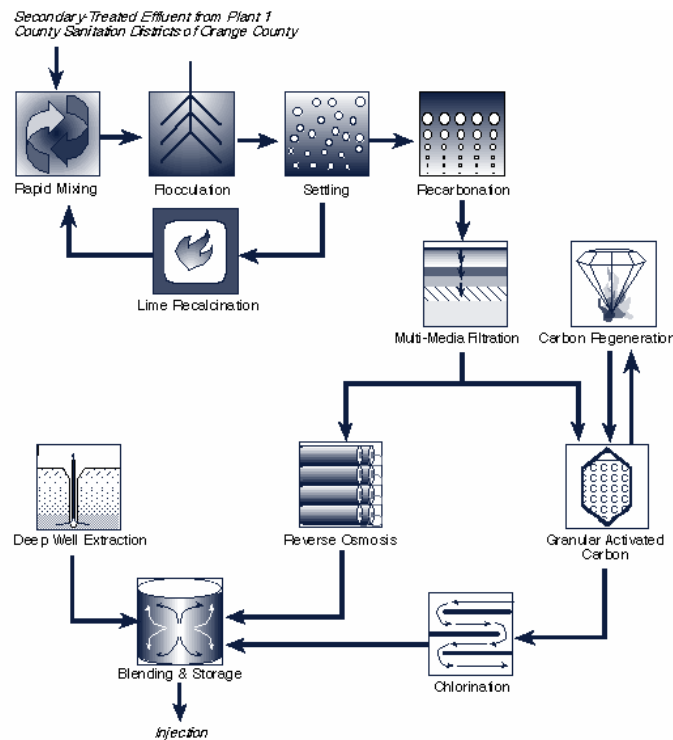


Figure C- 13: Illustration of treatment process from secondary treatment to injection
 Source: <http://www.ocwd.com/html/wf21.htm>

According to Shivaji Deshmukh, a project engineer at OCWD, the cost of producing recycled water in Water Factory 21 is comparable to the cost of imported supplies; however, the exact cost of recycling water at WF21 is undocumented (Personal Communication, 2006). The reason OCWD continues to support WF21 instead of comparably priced imported water is due to the added benefits of recycling water. These benefits are the reduction of 15,000 AF of wastewater that would have been discharged into the ocean each year and the prevention of seawater intrusions that would have been one of the last priorities in times of drought. By recycling water, increased amounts can be used toward the replenishment of aquifers in Orange County through recharge/injection, further ensuring the availability of local water supplies.

Groundwater Replenishment Project³¹

Aside from Water Factory 21, OCWD is now building one of the largest water purification projects of its kind in the world. The Groundwater Replenishment System (GWR) will be completed in 2007, and will produce enough water to meet the water demands of 144,000 families (approximately 1 acre foot of water is needed to supply the needs of two Orange County families per year). The Groundwater Replenishment System plans on producing 70,000 acre feet of water per year and can be further expanded in the future. Using advanced technologies, water will be purified through a

³¹ <http://www.gwrssystem.com/about/overview.html>

three step process which includes micro-filtration, reverse osmosis, and ultraviolet light with hydrogen peroxide disinfection. The quality of water produced will meet and exceed all state and federal drinking water standards.

Approximately half of the water produced from the Groundwater Replenishment Project will be injected along the coast to control Orange County's seawater barrier. The remaining portion of water will be sent to lakes in Anaheim, California to recharge the ground water basin. Water recharged to the basin will later be pumped out and utilized for non-potable uses as well as indirect potable reuse. Aside from the replenishment of the groundwater basin and prevention of seawater intrusion problems, another benefit of this project is the improvement of water quality over time. Water treated with the three-step process mentioned above will have lower minerals/TDS, and will "dilute" the groundwater in the basin, thereby increasing water quality.

Total capital cost of the GWR is \$486.9 million dollars, which is shared by OCWD and OCSD. One reason OCSD supports this project is because by reducing their discharge to the ocean, they avoid the need to build a second ocean outfall pipe-which is a lengthy and complicated process.³² Once the system begins operating, the cost of operations and maintenance will be paid for by OCWD. In order to fund the project, a number of grants, totaling \$92.5 million dollars have been secured through the CA State Water Bond (Prop 13), State Water Resources Control Board, and the EPA. The CA Energy Commission also helped fund the costs incurred during the design phase. In addition to the grant money, once the plant is in operation, MWD will provide \$3.8 million per year for the operation and maintenance costs of the GWR System for 23 years. This subsidy will greatly lower the cost for customers.

The current estimate to produce each AF of water is \$476, which is less expensive than both imported water and desalinated water. From an energy efficiency point of view, the GWR system will use 50% less energy than importing water from Northern California (OCWD, 2001).

From the description of OCWD's Water Factory 21 and Groundwater Replenishment System, some might think that these projects have come easily. In reality, there have been many challenges, particularly in obtaining public acceptance of indirect potable reuse. This topic will be further explored in the barriers to implementation section.

C.2.2 Outside The Watershed Case Studies:

From our evaluation of the current and projected state of water reuse by the seven water districts within our watershed, it can be seen that there are already many pioneers in the field. However, there is also progressive work being done in the water reuse field outside the watershed. In order to illustrate other ways in which water reuse could be furthered, four case studies were conducted to show additional innovative and successful strategies that were implemented outside our watershed. These case studies also help

³² http://www.gwrsystem.com/about/pdf/0503gwrs_cost_paper.pdf

illustrate the common barriers that are often seen when a water district or agency is trying to carry out water reuse projects, and what some agencies have done in order to overcome these barriers.

The four outside case studies conducted were:

- Marin Municipal Water District
(Personal Communication, Bob Castle, January 2006)
- Monterey Regional Water Pollution Control Agency (MRWPCA)
(Personal Communication, Bob Holden, January 2006)
- Los Angeles County Sanitation District
(Personal Communication, Earle Hartling, January 2006)
- West Basin Municipal Water District
(Personal Communication, Joe Walters, January 2006)

These case studies were chosen based upon suggestions from various water district managers and Mr. Wade Miller, the director of WaterReuse Association. These case studies are not necessarily the most successful in the Nation; however, they illustrate different and interesting factors that might need consideration in looking to expand water reuse in our watershed. Most importantly, these case studies demonstrate that if done correctly it is possible to expand water reuse.

Short agency background and reasons for success

Marin Municipal Water District (MMWD)

Marin Municipal Water District is located in Northern California and serves southern and central Marin County. MMWD's recycled water program began in the 1980s, and currently recycles approximately 2 MGD and distributes the water to more than 250 customers in Northern Rafael.

The water recycling program is notable due to its proactive approach in pursuing legislation to expand the uses of recycled water. MMWD was the first to use recycled water for car washes, air conditioning cooling towers, commercial laundries, and toilet flushing in non-residential buildings in California. In addition, MMWD is known for writing the guide on how to retrofit facilities to use recycled water. This guide, published in 1997, has become industry standard.

Monterey Regional Water Pollution Control Agency (MRWPCA)

MRWPCA's water recycling program was recommended to us by Mr. Bob Castle, recycling coordinator for Marin County Water Authority. This case study is successful in that it is a recycling program that has been able to recover its cost. It is also one of the largest recycling programs that produce water used for raw food crop irrigation.

MRWPCA serves approximately 250,000 customers in the areas of Pacific Grove, Monterey, Del Rey Oaks, Seaside, Sand City, the former Fort Ord, Marina, Castroville, Moss Landing, Salinas, and unincorporated parts of north Monterey County.

Deep aquifers are the major water source for Monterey County, and due to intense extraction there are problems with seawater intrusion, which has come as close as two miles from some of Salinas' wells.

The water recycling project was started in 1998 with the completion of the Salinas Valley Reclamation Plant, and since then, 23 billion gallons of water have been recycled from the facility. The plant capacity is 29.6 MGD, and currently, about 22 MGD of water goes through secondary treatment, with up to 22 MGD going through tertiary treatment during the growing season. The recycled water is used to irrigate 12,000 acres of local farm land in north Salinas Valley, and is also used for the slowing of sea water intrusion by 30 to 40%. From this recycled water, Monterey County supplies 70% of artichokes, 6.0% of cauliflower, 1.5% of celery, 1.8% of broccoli, 1.6% of lettuce, and 2.1% of the strawberries for the United States. Growers used approximately 21,532 AF of water in 2004. Projected ultimate use is 23,000 AF per year, out of which 14,000 AF is recycled water.

Los Angeles County Sanitation District (LACSD)

Los Angeles County Sanitation District's recycling program is considered a national leader in water reuse. LACSD is comprised of 25 distinct sanitation districts in Los Angeles County and has 11 wastewater treatment plants, 10 of which are able to produce recycled water. The plants have a treatment capacity of approximately 600 MGD, of which approximately 190 MGD are available for reuse. From 1970 to 2004, the number of reuse sites increased from 6 to 491. A total of 572,727 AF of wastewater effluent was produced, out of which approximately 34.5%, or 211,413 AF, was treated and reclaimed. Figure C-14 depicts the Century and Rio Hondo Reclaimed Water Distribution Systems.

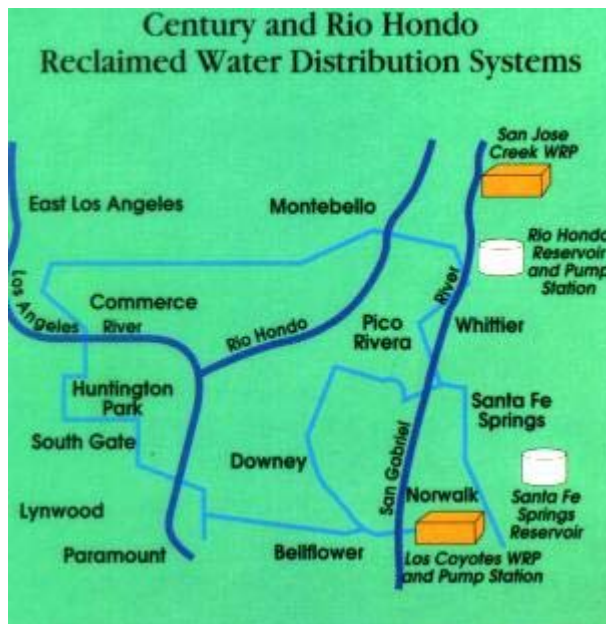


Figure C- 14: Century and Rio Hondo Reclaimed Water

West Basin Municipal Water District

West Basin Municipal Water District, located in the City of El Segundo, operates one of the largest water recycling programs in the nation. The recycling plant was named one of six National Centers for Water Treatment technologies in the nation during 2002 and is well-known for producing “designer water.” The 5 types of designer waters are: Tertiary Water, Nitrified Water, Softened Reverse Osmosis Water, Pure Reverse Osmosis Water, and Ultra-pure Reverse Osmosis Water, and all 5 meet the requirements of the California Department of Health Services Water Recycling Criteria. Secondary treated water is purchased from the City of Los Angeles’ Hyperion Treatment Plant and brought to the Recycling Facility for further customized treatment to produce each type of designer water.

A description of each water type as provided by West Basin Municipal Recycling Facility:

- **Tertiary Water:** Secondary treated wastewater that has been filtered and disinfected for a wide variety of industrial and irrigation uses.
- **Nitrified Water:** Tertiary water that has been nitrified to remove ammonia for industrial cooling towers.
- **Softened Reverse Osmosis Water:** Secondary treated wastewater pretreated by either lime clarification or micro-filtration, followed by reverse osmosis (RO) and disinfection for groundwater recharge, which is superior to state and federal drinking water standards.
- **Pure Reverse Osmosis Water:** Secondary treated wastewater that has undergone micro-filtration, RO and disinfection for low-pressure boiler feed water.
- **Ultra-Pure Reverse Osmosis Water:** Secondary treated water that has undergone micro-filtration, RO, disinfection and second-pass RO for high-pressure boiler feed water.

The goals of the West Basin Recycling Program are to reduce their reliance on imported water by 50%, provide alternative local water sources to meet demands even during drought periods, reduce their discharge to Santa Monica by 25%, and provide a seawater intrusion barrier to the groundwater supply. According to their 2005 urban water management plan, recycled water currently makes up 7% of their water supply and is projected to increase to 17% by 2030.

C.2.3 Issues, Barriers, & Solutions

There are existing technologies to recycle water to safe levels for use; however, there are many issues and barriers associated with water recycling and water reuse. Many agencies are already developing their water recycling programs in order to increase their local water supply as well as their water supply’s reliability. In this section, we will discuss

some common issues and barriers associated with water recycling and water reuse. In addition, we will draw from the information that we have gathered from both inside and outside of our watershed region in order to illustrate examples of how these barriers have been overcome.

Costs/Costs Recovery

Cost recovery for recycled water projects is a major concern for water agencies. Depending upon a variety of factors, water reclamation projects may or may not be able to recover costs. Project costs associated with water recycling are infrastructure, operation and maintenance, and, often, education and research. Some of the factors that determine whether or not water agencies are able to recover costs depend largely on the aforementioned project costs, the number and size of customers, the reclaimed water selling price, and whether or not there are end uses for the water.

MMWD

Currently, MMWD is not recovering all of the costs for the operation of their water recycling plant. Plant construction costs were \$16 million, and the costs of recycling water were calculated to be approximately \$1800-2000 per AF, yet MMWD only charges their customers \$592 per AF. In addition to operations and maintenance, there are oversight costs from inspections and connection tests for dual plumbing, which total approximately \$300 per year. In addition, pipeline is very expensive, ranging from \$125 - \$150 per foot. Mr. Bob Castle, the water quality manager at MMWD, says the reason why MMWD has not been able to recover costs is due to the county's small size. This means there is a limited amount of sewage, as well as a limited number of customers and recycled water uses. In addition, having a wet climate further reduces the opportunities for the county to reuse water. The cost for MMWD to build a new water recycling plant would be twice as much as building a water desalination plant. In order for MMWD to begin recovering costs, Mr. Castle predicts that they would need customers with "estate-sized" lots with turf.

LACSD

LACSD currently sells their water at 30% of the cost it takes to treat the water to reusable standards; therefore, they are not recovering the costs of producing recycled water. The reason water is sold at this reduced rate is to encourage and increase water reuse as much as possible. According to Earle Hartling, the water recycling coordinator at LACSD, the reason they continue to recycle water despite the fact that they are not recovering costs is because they do not compare the cost of recycling water to the cost of other sources of water, such as imported. Instead they compare the cost of recycling water now to the cost of water in the future, which they project will be much more expensive. LACSD believes that potable water is like a mutual fund, so in a way what they are doing is like water banking.

MWRPCA

MWRPCA is notable for recovering all the costs in their water recycling projects, which is why Mr. Bob Castle recommended this case study. The construction costs of the

SVRP and CSIP was \$75 million. The regional treatment plant and interceptor system cost a total of \$130 million. Secondary treatment is paid for by residential sewage users, while tertiary treatment and delivery is paid for by water use and property assessment fees. The water delivery charge is low, but property assessment fees are usually higher. Users of tertiary water pay for half of the cost of the recycling program, while the other half is paid for by those benefiting from the seawater intrusion barrier. The seawater barrier price varies depending on the distance you live from the barrier, increasing the closer you live. For the growers, water costs \$245.44 per acre annually, plus \$17.14 per AF. Well water costs approximately \$120 per AF for electricity. Residential users pay approximately \$9.70 for secondary treatment.

This program has been recovering all costs, and at times even generates extra revenue, which is used to repay the loans and bonds faster. Another reason why they are cost recovering is the fact that these users irrigate 365 days a year, and during the year when the tertiary plant is not on, there is still benefit to using the water as a barrier against seawater intrusion. Therefore, cost recovery in this case has a lot to do with the uses that are available.

West Basin

West Basin is another example of an agency which is recovering the costs of their water recycling program. West Basin is a unique case in that it has many large customers, such as refineries. With the large quantities of recycled water purchased by Chevron, Exxon Mobil, etc, most of the program costs are recovered. This allows West Basin to supply reclaimed water to smaller customers such as schools, parks, and small businesses without losing money.

From these examples, it can be seen that to run a recycled program and be able to recover costs, districts must increase the amount of available uses and/or find additional customers. On the other hand, even though the program might not recover costs, there are still benefits to recycling which include: reducing consumption of the potable water supply so that it can be 'banked' for future use, the increased reliability of recycled water, and local benefits to battle salt water intrusion.

Uses

Wastewater effluent is required to be treated to secondary standards, with only a few exceptions; therefore, a large quantity of water is available for reuse. Often times, water that is suitable for reuse is not used but is instead discharged into water bodies. This happens for various reasons, including: the seasonal variability of recycled water demand, lack of distribution infrastructure, and also negative public perception and legislation that limits uses. The barrier of limited uses is also a primary reason why many recycled water programs are unable to recover costs. In order to overcome this barrier, districts must be proactive in looking for innovative uses and in seeking policies that encourage or even mandate the use of recycled water for approved uses.

MMWD

MMWD is a great example of a water district that has taken action to increase water reuse in its service area. MMWD has worked on several different pieces of legislation; for example, in 1991 requiring dual plumbing in non-residential buildings so that recycled water can be used to flush toilets. This was an acknowledgement that using potable water to flush toilets is unnecessary and a waste of higher quality water. They also worked to set plumbing codes that facilitate dual plumbing design and usage. In 1995, they were given approval to use recycled water for air conditioning towers, and in 1997, they were authorized to use dual plumbing systems in many more places such as office buildings, schools, auditoriums, jails, etc. In the 1990s, with the help of MMWD, the first new dual-plumbed office building was constructed. MMWD also convinced the California Department of Health Services to allow recycled water to be used for toilet flushing in a building containing two restaurants.

West Basin

In order to increase the desirability of recycled water to satisfy more uses, West Basin designed five types of water to meet the different demands of municipal, commercial, and industrial entities. West Basin's recycled water is used for "landscape irrigation, cooling towers, refineries, and innovative uses such as street sweeping and toilet flushing." Their customers include: Chevron, Bp, Exxon/Mobil, Home Depot National Training Center, Toyota Motor Sales, USA, and Goodyear. Aside from municipal, industrial, and commercial uses, recycled water produced from this program is also used for injection into South Bay's groundwater basin as a seawater barrier.

MWRPCA

For MWRPCA, the Salinas Valley Reclamation plant is turned on in March and off in early November. During this period, 100% of the secondary standard water is treated to tertiary standards and used for irrigation. During the rainy season when there is a surplus of water, the extra water is discharged two miles away into Monterey Bay.

LACSD

LACSD has taken a number of steps to expand its water recycling project. One of the most significant steps was to expand the network so that more customers can have access to recycled water. In conjunction with Central Basin Municipal Water District and 29 other public utilities and private agencies, LACSD has implemented the Century and Rio Hondo Water Reclamation Programs. Through these programs, a network consisting of two major reclamation plants and large distribution pipelines was established, so there are now 65 miles of pipelines that can deliver up to 22,000 AFY of recycled water. The Century and Rio Hondo Water Reclamation programs will supply tertiary-treated effluent to a number of municipal and private purveyors who could not have recycled water themselves. By linking the system, LACSD was able to construct a new pump station, and convert a potable reservoir that increases storage of reclaimed water and serves as an emergency backup to the potable water supply, without incurring capital expenditures. In addition, LACSD is looking to produce a basin-wide system to supply recycled water to customers. All of the districts involved in this project realize that it would not have been possible had they not worked together.

OCWD

As recycled water is used, our source of potable water is conserved. In addition to this, many districts now view recycled water as a clean up tool for their groundwater basins as well as a water source with which to increase indirect potable reuse. A leading example of this is OCWD’s Groundwater Replenishment System, which takes very high quality recycled water and injects it into the Santa Ana Groundwater Basin. After injection, this water can then be pumped out for potable uses. Due to the fact that the water is highly purified, the basin is also being cleaned up. Another example is LACSD’s proposed Palmdale Reclamation project, which is currently going through its final EIR. One of the Palmdale project’s goals is to clean up the area’s groundwater. It was found that the concentration of nitrate in the groundwater exceeds regulated standards, so LACSD needed a plan to reduce the nitrate concentration. They plan to do this by injecting recycled water that has been specially treated to remove additional sources of nitrate.

MMWD

Seasonality of water reuse is a big problem for many water districts. As can be seen from Figure C-15, produced by MMWD, recycled water use significantly decreases during the winter, and poses a problem for districts because shutting down the system during these months is undesirable. In order to battle this problem, many districts have found ways to use this water during the winter months. For water districts in coastal regions, such as MMWD, a major way to do this is using the water for increased protection against salt water intrusion.

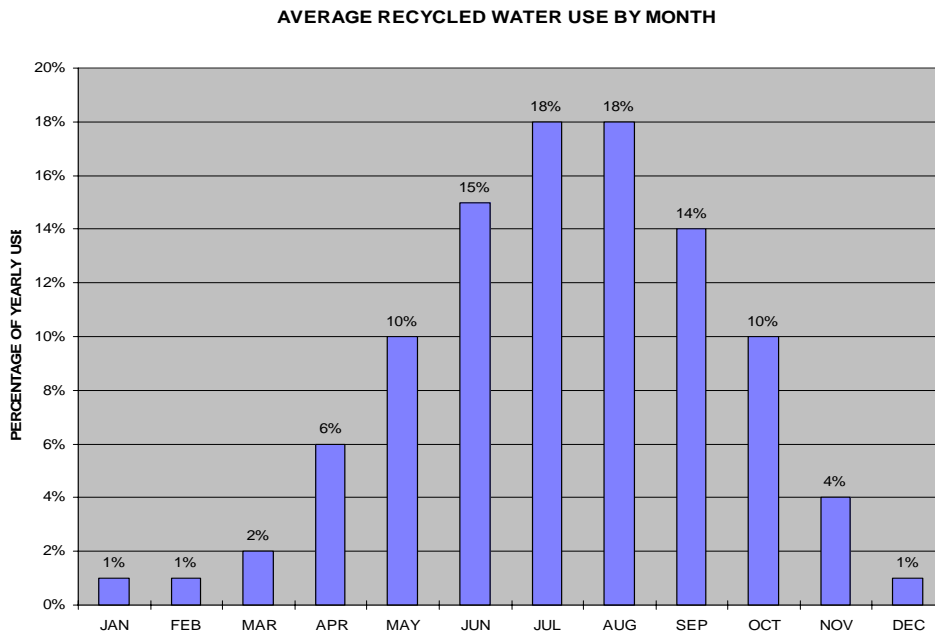


Figure C- 15: Marin Municipal Water District- Average recycled water use by month

Public Perception

Looking at all the issues and barriers associated with water reuse, many of them are tied to public perception and political attitude in one form or another. One reason for limited use is ultimately due to some customers' negative perception of recycled water. Similarly, municipalities are unable to implement or expand their recycling projects if the projects are not supported by the local politicians. Even with proof that recycled water is safe to use, some still believe that water from the Colorado River is cleaner, and refuse to use recycled water.

To battle the public perception barrier, water districts must deal with a number of issues including: semantics, the fact that projects are often longer than the political life of officials, public misperception that recycled water is not as clean as imported water, concerns with citizens' individual rights, and health officials who are concerned about water quality. These issues are very important to the future of water reuse because without public support and political will, projects would not be conceived and could not be implemented. At 2005's California Water Policy Conference, battling the public misperception, or "Bucking the Yuck Factor", was one of the main topics. How can we "buck the yuck factor"?

OCWD

As mentioned previously, OCWD is one of the leaders in water reuse, and their groundwater replenishment system will facilitate indirect potable reuse. Ron Wildermuth from OCWD indicated that there is a need to inform the public, especially those who are politically active because the non-participating public will likely follow the advice of those who are leading. OCWD gives approximately 150 talks per year, and in the past 10 years they have conducted numerous face to face talks. OCWD is active in public relations, conducting outreach, and facilitating public tours so that people understand the recycling process. Similar to IRWD, public and political support is garnered by gaining trust from the past 35 years of recycled water use. Importance lies in transparency in the process, as well as making sure the water is safe, and like OCWD, IRWD has had a long history in informing the public about recycled water.

MRWPCA

MRWPCA now runs one of the most successful water recycling projects in California; however, they put a great deal of effort into convincing users that the water was safe to use for raw food irrigation. When the project idea was first initiated in 1970's, there was resistance from the county health officer. With this objection, the Monterey Wastewater Reclamation Study for Agriculture (MWRSA) project was initiated. This 11 year study, which was funded by the federal and state government to look at the safety of recycled water irrigation of raw food crops, included 5 years of extensive field study in Casterville to look at crops grown with recycled water versus well water. The county health officer who had voiced the objection was made the director of the MWRSA project. Upon completion, the study results showed that the irrigation of raw food crops with recycled water was safe.

Soon after the completion of the study, funding for the project came through, in the form of loans and money. During the construction period, a committee was formed to provide input into the process. This group, called the Water Quality in Operations Committee was composed of the general manager of the Monterey County Resources Agency, County health director, and 6 growers. After project completion, the Water Quality in Operations Committee said they weren't sure if they wanted the recycling plant anymore. During the 10 years since the start of the project and the formation of MWRSA more health concerns, such as *e.coli*, *cryptosporidium*, and *giardia*, had arisen. In order to ease these concerns, they delayed the distribution of recycled water to the growers, and initiated another food safety study. This study indicated that food was safe to be eaten raw, and since then, other studies have been done, including a study conducted by UC-Berkeley, which once again showed that the food was safe to be eaten raw.

During the first year of operation another complication arose when many growers did not connect to the distribution system. A county ordinance was passed requiring all the growers to connect to the recycled water and to destroy the wells; however, the MRWPCA, desiring growers to fully accept and voluntarily use recycled water, asked the County not to enforce the ordinance. By the end of the first year, about half the growers connected to the system and by the end of the 2nd year, over 90% of the service area was connected. Presently, over 95% of the service area is connected. This was achieved through numerous meetings with the Water Quality in Operations Committee, proactive promotion of recycled water, and informational meetings with recycled water users.

Another concern of the growers was the requirement to put up large red signs all over their fields that warn of contact with recycled water. The MWRCPA convinced the county to replace the red warning signs with signs such as "no trespassing," or "irrigation water, not for drinking." In addition, a short video was also developed in collaboration with growers, the Department of Health Service, and the regional board, which is used by growers for the training of their employees and as a part of their own internal safety program.

This program is successful because MWRCPA continues to react to what its recycled customers (i.e. growers) want. When there are concerns, they are addressed as quickly and efficiently as possible. There have been many instances where growers wanted more tests than were required by the water quality and health boards, such as in the case of *e.coli*. Another example was when growers became concerned with the level of chlorine in the water. All of these issues were addressed by MWRCPA until the growers were satisfied.

Since 1998, the recycled water program has become more and more popular. There is actually more demand for recycled water than there is supply, as there is not enough wastewater influent to meet all of the needs. Growers within the project are now asking for more recycled water to irrigate their farms as well as for additional water for outside

the service area. Growers outside the project area are also asking to be included in the project and the county health officer that initially opposed the project is now one of its biggest proponents.

Other things that districts can do include building demonstration projects to show the public the true comparison between recycled water and potable water for different applications. One example of this was MMWD's collaboration with UC-Davis in which they built a demonstration garden comparing recycled water and potable water quality. Their demonstration garden experiment showed that plants irrigated with recycled water showed better performance than those irrigated with potable water when water was not over-applied

From these examples, it can be seen that it will take time and effort to inform customers and increase their trust in recycled water. The fact that these efforts have been able to drive water recycling within districts demonstrates that increasing water reuse in the SARW Region is a realistic goal. According to Joe Walters, part of the recycling team at West Basin, there is an interest in doing the right thing without paying more.

Infrastructure

As discussed, adding infrastructure to expand any type of wastewater treatment or reclamation is very costly. The costs can substantially increase if there are limited customers, limited uses, or large distances between the recycling plant and distribution facilities. Costs of recycling facilities and distribution vary from project to project due to the wide range of piping costs. If districts can plan ahead to place their wastewater treatment plants, reclamation plants, and distribution facilities close to one another, costs can be dramatically decreased. In cities that are facing outgrowth, it is expensive and difficult to retrofit facilities for water reuse; however, in cities where development is increasing, there are many opportunities to increase water reuse. A great illustration is IRWD, where they have been able to push for plumbing codes that require dual plumbing pipes as offices, houses, etc are built. By laying pipes during development, water reuse is increased while the costs of future retrofitting are avoided.

Another way to reduce the need for infrastructure is to coordinate with other districts and facilities as illustrated by LACSD's collaboration with other sanitary districts in the Century and Rio Hondo Reclamation program. Districts that are able to produce more recycled water can supplement the recycled water needs of smaller districts, thus maximizing the need and opportunities for cost recovery as a whole.

D. Water Recharge

D.1 Introduction – The Need for Groundwater

D.1.1 Decrease in Supply

Due to limited water supplies in California from dams, snow, and the Colorado River, groundwater must contribute one to two-thirds of California's annual water supplies (CADWR, 1998). Maintaining groundwater levels is necessary to increase water supply reliability and to ensure sustainable water levels in drought years. While in the past dams have allowed for storage and growth of the water supply, there is growing opposition to their use due to aesthetic and environmental concerns. Dams are often costly and previous projects have utilized many of the best locations for surface water storage. Upper reaches in the San Bernardino, eastern San Gabriel, and San Jacinto Mountains receive snow runoff. This reservoir of water which traditionally contributed 50-80% of streamflow in California has been decreasing (Howat & Tulaczyk, 2005) which could affect the timing of snowmelt runoff. Another problem facing California's water supply is the decreasing water levels received from the Colorado River.

Groundwater is defined by the California Water Plan as water that occurs beneath the land surface and fills pore spaces of the alluvium, soil, or rock formation in which it is situated (DWR, 2005).

Conjunctive use is the coordinated management of surface water and groundwater supplies to increase the yield of both

As a result, future plans for supply must rely heavily on groundwater. Figure 2, from the State Water Plan, displayed in Section 1, shows the possibility to increase water use from conjunctive management and groundwater recharge to between 0.5 million AFY and 2.0 million AFY by 2030. Northern

California receives significantly more surface water than Southern California because of regional drainage patterns. Much of Southern California relies heavily upon groundwater because of a lack of surface water. As discussed previously, 36% of the water supply from agencies in the SARW Region is provided by groundwater. By 2025, groundwater is estimated to comprise the same percentage, but will increase in yield to 223,000 AFY as a result of higher pumping rates.

D.2 Groundwater Management in California

California has a significant problem of groundwater overdraft as the amount of water withdrawn in the groundwater basin by pumping exceeds the amount of water that recharges the basin each year during average conditions (DWR, 2005). California does not monitor groundwater withdrawals on a statewide basis which has led to the development of six methods that address groundwater withdrawals on varying scales. The following list is a compilation of DWR's Water Facts and GW Management. The methods are in order of their development starting back in the late 1800s.

1. Overlying Property Rights

Property owners may extract their “share” of groundwater through a well unless the basin is adjudicated. If there is no adjudication, the “share” is not quantified.

2. Statutory Authority

The California Water Code provides 22 types of districts or agencies statutory rights to manage surface water for various purposes. Twenty of these types of local agencies are shown in Table D-1

Local Agencies with Authority to Deliver Water for Beneficial Use			
Community Services District	County Sanitation District	County Service Area	County Water District
County Water Works District	Flood Control and Water Conservation District	Irrigation District	Metropolitan Water District
Municipal Water District	Municipal Utility District	Municipal Water District	Public Utility District
Reclamation District	Recreation and Park District	Resort Improvement District	Resource Conservation District
Water Conservation District	Water District	Water Replenishment District	Water Storage District

Table D- 1: Local Agencies with authority for beneficial use water delivery

3. Adjudicated Groundwater Basins

Lawsuits initiate a court decision on how much groundwater can be extracted and who can extract it. A water master is assigned the job of carrying out the extraction plan. As can be see in Figure D-1, nineteen adjudicated basins exist in California, five of which shown in Table D-2 are in the SARW Region.

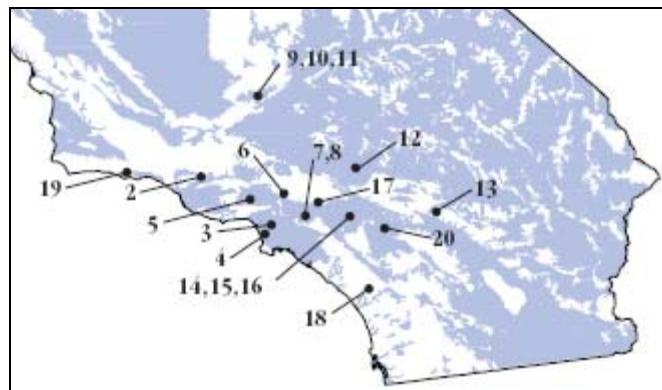


Figure D- 1: Adjudicated basins in Southern California

Adjudicated Basins in Santa Ana Watershed Region				
Court Name	Filed in Court	Final Decision	Watermaster	Location
Beaumont Basin	2003	2004	Directors of Public Work fro the Cities for Banning & Beaumont, General Managers of Beaumont-Cherry Valley Water District, South Mesa Mutual Water Company, Yucaipa Valley Water District	Riverside County
Chino Basin	1975	1978	Nine-member board	San Bernardino County
Cucamonga Basin	1958	1958	None appointed; operated as part of Chino Basin	San Bernardino County
Six Basins	1998	1999	Nine-member board	Los Angeles and San Bernardino Counties
Western San Bernardino	1963	1969	One Representative from each of WMWD, Riverside County & SBVMWD; San Bernardino Count	San Bernardino and Riverside Counties

Table D- 2: Adjudicated basins in the SARW Region

4. Special Act Districts

Special legislation allows 13 districts to limit or regulate groundwater management (Table D-3). Two basic categories exist for these districts: 1. Limitation of exportation and extraction; 2. Requirement of reports of extraction whereby fees can be levied.

In California there is a significant problem of groundwater overdraft as the amount of water withdrawn in the groundwater basin by pumping is exceeding the amount of water that recharges the basin in each year during average conditions (DWR, 2005). California does not monitor groundwater withdrawals on a statewide basis which has led to the development of six methods that address groundwater withdrawals on varying scales.

Special Act Districts with groundwater management authority in CA	
Desert Water Agency	Fox Canyon Groundwater Management Agency
Honey Lake Groundwater Management District	Long Valley Groundwater Management District
Mendocino City Community Services District	Ojai Groundwater Management Agency
Monterey Peninsula Water Management District	Orange County Water District
Pajaro Valley Water Management Agency	Santa Clara Valley Water District
Sierra Valley Groundwater Management District	Willow Creek Groundwater Management Agency
Mono County Tri-Valley Groundwater Management District	

Table D- 3: Special Act Districts with GW management authority in CA

5. Groundwater Management Plan (AB 3030 Plan)

This plan, enacted in 1992, is a systematic procedure for local agencies to develop groundwater management plans. The plan has been adopted by 160 agencies and allows the agency to raise revenue for extraction, recharge, conveyance, and quality.

6. City and County Ordinances

As state law does not regulate groundwater; cities and counties may regulate groundwater under their police powers following the decision of Baldwin v. Tehama County – 1984. Currently, the twenty-nine counties shown in Table D-4 have adopted ordinances.

Counties with Ordinances addressing groundwater management						
Alpine	Butte	Calaveras	Colusa	Fresno	Glenn	Imperial
Inyo	Kern	Lake	Lassen	Madera	Mendocino	Modoc
Mono	Monterey	Napa	Sacramento	San Benito	San Bernardino	San Diego
San Joaquin	Shasta	Sierra	Siskiyou	Tehama	Tuolumne	Ventura
Yolo						

Table D- 4: Counties with GW Management Ordinances

In addition to artificial recharge from either Watermaster plans or groundwater basin plans, groundwater is recharged naturally into the zone of saturation within an aquifer from snowmelt and runoff.

D.3 Groundwater Basins in the SARW Region

There are forty groundwater management zones in the SARW Region, as defined by SAWPA and shown in Figure D-3 (SAWPA, 2005). The Association of Groundwater Agencies (AGWA) combines these forty zones into four major groundwater basins: The San Jacinto Basin, the Bunker Hill Basin, the Upper Santa Ana River Basins, and the Orange County Coastal Plain. The report, “Groundwater and Surface Water in Southern California: A Guide to Conjunctive Use”, by AGWA (2000) provides a comprehensive evaluation of the basins in the SARW Region. The report was assembled from interviews with the groundwater basin managers but does not include the area south of the Temescal basin and other basins to the south and west nestled in the coastal mountains. For our purposes, this area was not studied in detail due to its size, which comprises only 3.7% of the total area of groundwater basins. We will examine the major basins shown in Figure D-2 as they represent the majority of groundwater storage in the SARW Region. The following section discusses the hydrogeology of each basin. Table D-5 shows the storage capacities, the optimal safe yield, and the potential storage for dry years in each of the four basins.

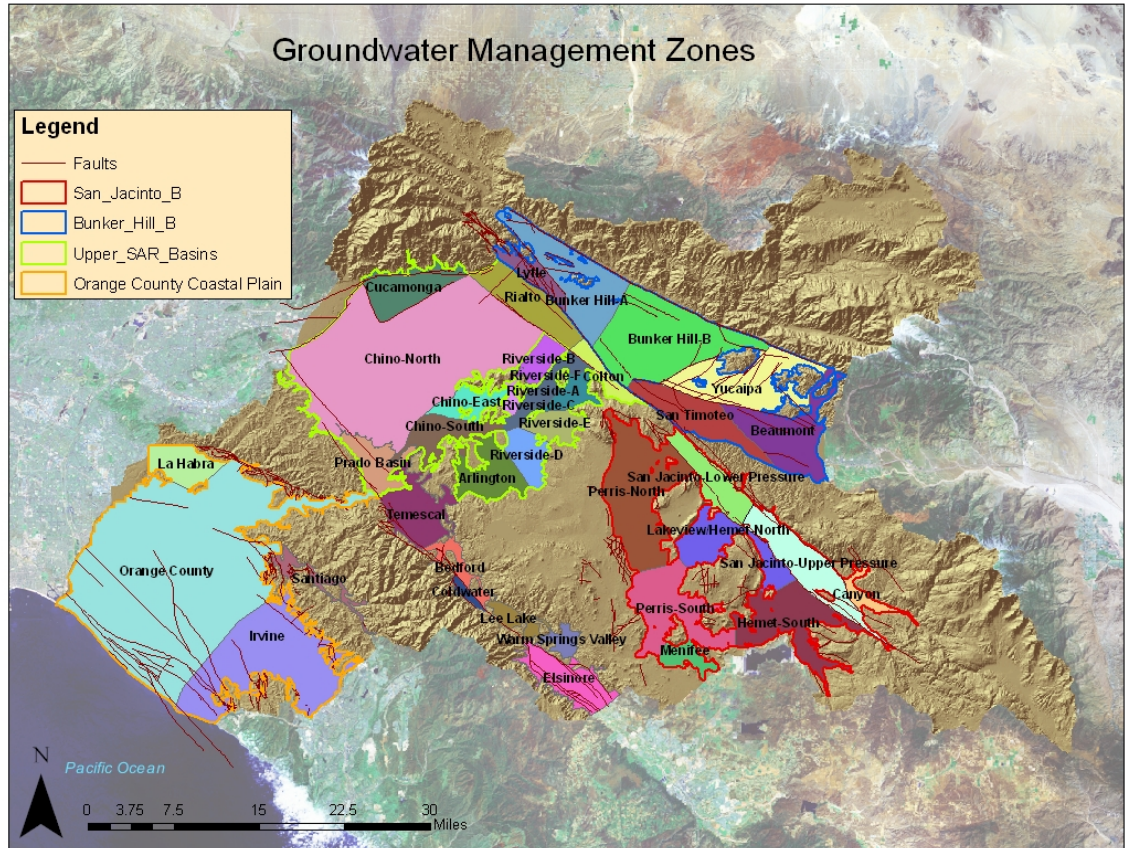


Figure D-2: Groundwater management zones
Source: SAWPA, 2005

Water District	Basin Group Name	Groundwater Management Zone		Storage Capacity (AF)	Potential Storage for Use in Dry Years (AF)	Current Annual Operational Safe Yield (AFY)	Current Annual Operational Safe Yield + Potential Increase from Conjunctive Use (AFY)
MWDOC managed by OCWD	Orange County Coastal Plain Basin	Orange County Groundwater Basin	La Habra Basin	1,000,000	300,000	350,000	480,000
		Irvine Basin	Santiago Basin				
Inland Empire Utility Company	Upper Santa Ana River Basins	Chino-North Basin	Chino-East Basin	5,053,600	1,000,000	167,000	214,000*
		Chino-South Basin	Cucamonga Basin				
		Prado Basin					
Western Municipal Water District	Upper Santa Ana River Basins	Temescal Basin	Riverside-B Basin	6-9,000,000	854,000	9,000	9,000
		Bedford Basin	Riverside-C Basin				
		Coldwater Basin	Riverside-D Basin				
		Lee Lake Basin	Riverside-E Basin				
		Warm Springs Valley Basin	Riverside-F Basin				
		Elsinore Basin	Arlington Basin				
		Riverside-A Basin					
		Rialto Basin					
San Bernardino Valley Municipal Water District	Bunker Hill Basin	Bunker Hill-A Basin	Yucaipa Basin	1,432,000	Basin is full	224,300	224,300**
		Bunker Hill-B Basin	San Timoteo Basin				
		Lytle Basin	Beaumont Basin				
		Lakeview/Hemet Basin					
Eastern Municipal Water District	San Jacinto Watershed Basins	Winchester Basin??	Menifee Basin	10,334,500	1,284,000	82,000	92,000
		Perris-North Basin	East Valley/East San Jacinto Groundwater Basin??				
		Perris-South Basin	San Jacinto-Canyon				
		San Jacinto-Lower Pressure Basin	San Jacinto-Intake and Upper Pressure Basin				
		San Jacinto-Lower Pressure Basin	Hemet-South Basin				

Table D- 5: Storage capacities, optimal safe yield, and potential storage for dry years in each of the four major groundwater basins
Sources: AGWA, 2000; CVWD, 2005; DWR, 2005

*The increase in Conjunctive Use for the whole Upper Santa Ana Basins is 47,000 AFY and is combined with the Safe Operational Yield for Chino Basin

**There is no increase in Conjunctive Use because the Basin is full

Upper Santa Ana River Basins

The Upper Santa Ana River watershed consists of the following:

- Chino Basin
- Cucamonga Basin
- Rialto Basin
- Colton Basin
- Riverside Basin

The Chino Basin covers 235 square miles (150,400 acres) and underlies portions of San Bernardino, Los Angeles and Riverside Counties. The Chino Basin is adjudicated and has been managed by the Chino Basin Watermaster since 1978. Sediments that comprise the unconfined aquifer in the basin are coarse alluvium derived from the San Bernardino and San Gabriel Mountains (AGWA, 2000). The depth of the Chino Basin ranges from less than 50 ft. in the southern part to 500 ft. in the northern section (Blomquist, 1992). Water exits this basin by surface and subsurface outflow at three points:

- The northwestern edge of the Pomona-C Claremont area
- The eastern boundary across the San Jacinto Fault in the Lytle Creek area
- The SAR Channel (the primary point of discharge)

The Cucamonga Basin consists of 22 square miles (14,000 acres) and is located at the base of the San Gabriel Mountains. The Cucamonga Basin is also adjudicated and has been managed by Cucamonga County Water District and San Antonio Water Company since 1958. The semi-confined aquifer consists of sediments that become finer-grained alluvium as you move southward. The Rialto and Colton Basins are located in western San Bernardino County. Both basins have been adjudicated since 1961. In addition, the two basins contain aquifers that are fine-grained and semi-confined. The Riverside Basin is located in northwest Riverside County and southwest San Bernardino County. The basin covers 92 square miles (58,600 acres).

The Bunker Hill Groundwater Basin is located in San Bernardino County and is partially overlain by the City of San Bernardino. The basin is adjudicated and is managed by the San Bernardino Valley Municipal Water District Watermaster. Recharge to the basin is from runoff, the SAR, Mill Creek, and Lytle Creek. Rivers and creeks in the basin account for more than 60% of the total recharge (DWR, 2004).

The basin is a sediment-filled structural trough between the San Andreas and San Jacinto faults in the upper SAR Watershed. These sediments consist of an unconsolidated alluvial fan with deposits derived from the surrounding San Bernardino Mountains. The deposits inter-finger with river-channel deposits and with freshwater marsh deposits associated with groundwater discharge near the San Jacinto Fault (AGWA, 2000). The younger alluvium is 70 to 110 ft. deep and consists of boulders, gravel, sand, silt, and clay while the older alluvium is made up of the same materials without the larger boulders.

This alluvium is fractured by numerous faults, in addition to being the principle aquifer. Lastly, it is worth mentioning that a bedrock complex of igneous and metamorphic rocks underlies the valley fill sediments (AGWA, 2000).

San Jacinto Watershed Basins

The San Jacinto Watershed Basins are located in western Riverside County and include the following basins:

- Lakeview Basin
- Perris North and South Basins
- Winchester Basin
- San Jacinto – Lower Pressure Basin
- San Jacinto Canyon Basin
- Menifee Basin
- East Valley or East San Jacinto Groundwater Basin Area
- San Jacinto – Intake and Upper Pressure Basin
- Hemet Basin

The Lakeview, Perris North, Perris South, Winchester, San Jacinto – Lower Pressure, and Menifee Subbasins have been managed under the West San Jacinto Groundwater Management Plan since 1995 (AGWA, 2000). The sub-basins are not adjudicated and are managed by EMWD. The San Jacinto Canyon, Intake and Upper Pressure, and Hemet Sub-basins are referred to as the East Valley or East San Jacinto Groundwater Basin Area by AGWA (AGWA, 2000). The basins are not adjudicated but EMWD, local agencies and cities, along with private groundwater producers are developing a groundwater management plan.

The groundwater aquifers for the San Jacinto Watershed Basins are made of alluvial deposits. In addition, the groundwater is unconfined except for the San Jacinto – Lower Pressure Subbasin. The San Jacinto – Upper and Lower Pressure Subbasins are defined by the graben from the Casa Loma and Claremont Faults (AGWA, 2000). These faults are part of the San Jacinto Fault Zone located in the northeast section of the basins.

Orange County Groundwater Basin

The Orange County Groundwater Basin covers 350 square miles (224,000 acres) and underlies the Orange County Coastal Plain, beneath the Tustin and Downy Plains. The basin is not adjudicated but has been managed by the OCWD since 1933. The OCWD was created to protect and manage the groundwater basin in north-central Orange County. OCWD has tripled the yield of the basin through expansion and improvements to recharge facilities, employment of well-head and other treatment technologies, water research, conservation, and reclamation projects (AGWA, 2000).

The basin is recharged primarily by the SAR and to a lesser extent from imported water from MWD. The SAR water source is primarily tertiary treated wastewater from upstream dischargers. The river also receives storm flows, natural run-off, and rising

groundwater. Additionally, OCWD estimates that an average of 155,000 AF of base flow and 60,000 AF of storm flows are recharged each year at the percolation ponds. OCWD owns 1500 acres that it uses for recharge programs and serves about 500 wells which pump 270,000 AFY (OCWD, 2005). OCWD imports between 35,000 and 60,000 AF of replenishment water from MWD for recharge use. OCWD also recharges through injecting water to prevent seawater intrusion. OCWD monitors the groundwater to make sure the basin is not overdrawn, along with carrying out an assessment program to pay for operating expenses and the cost of imported replenishment water (AGWA, 2003). OCWD's monitoring wells provide input to a three-layer groundwater model of the basin that is used for basin management.

The basin is dominated by a deep structural depression containing a thick accumulation of fresh water-bearing interbedded marine and continental sand, silt, and clay deposits. The strata in the basin is faulted and folded and may show rapid changes in grain size. The Newport-Inglewood fault zone parallels the coast and forms a barrier to groundwater flow. Erosional channels filled with permeable alluvium break this barrier in some locations; these are called gaps and can be susceptible to seawater intrusion. The sediments containing easily recoverable fresh water extend to around 2000 ft. in depth near the center of the basin. Well yields range from 500 to 4500 GPM, but mostly from 2000 to 3000 GPM (MWDOC, 2005). Upper, middle and lower aquifer systems are recognized in the basin. The upper aquifer is a shallow aquifer system with an average thickness of about 200 to 300 ft. and consists of sand, gravel and conglomerate with some silt and clay beds. Recharge to the upper aquifer system usually occurs mostly in the northeastern portions of the basin. Majority of the wells producing from the shallow system have industrial and agricultural uses and make up 5% of the total basin production (MWDOC, 2005). The middle aquifer has an average thickness of 1,000 ft. and is composed of sand, gravel, and a minor amount of clay. Primary recharge is derived from the SAR channel in northeastern Orange County. The middle aquifer provides 90 to 95% of the groundwater for the Basin (MWDOC, 2003). The lower aquifer system is composed of sand and conglomerate and is 350 to 500 ft. thick. This zone is too deep to economically construct production wells.

The aquifers comprising the basin form a complex series of interconnected sand and gravel deposits (OCWD, 2005). In the coastal and central portions of the basin, these deposits are more separated by extensive lower permeability clay and silt deposits. The inland area of the basin has clay and silt deposits that become thinner and more discontinuous, allowing groundwater to flow easily between shallow and deeper aquifers. The

The **forebay** refers to the area of intake or recharge, where most recharge occurs by direct percolation of SAR water. The forebay is characterized by highly permeable sands and gravel with few clay and silt deposits.

The **pressure area** is the area where surface water and near surface groundwater are prevented from percolating in large quantities into producible aquifers by silt and clay layers at shallow depths.

northwest portion of the basin includes a coarse-grained unconfined forebay area. As the basin nears the coast, the basin becomes confined with finer-grained sediments overlying the coarser grained aquifer. Thus, the basin is divided into two hydrologic components: the forebay and pressure areas. This forebay/pressure boundary delineates the area where surface water and shallow groundwater cannot move downward in significant quantities. This boundary is the transitional zone where low-permeability clay and silt deposits occur in near-surface sediments southwest of the boundary. The following section will discuss the different water sources and methods of recharge.

D.4 Artificial & Natural Recharge

D.4.1 Objectives

As noted earlier, groundwater is recharged in the SAR by natural and artificial recharge of recycled water, imported water, and stormwater supplies. Recharge facilities conduct surface water into the ground to replenish groundwater by using spreading basins, pits, ditches, furrows, streambed modifications or injection wells and can increase the safe yield of an aquifer. Other interrelated objectives for groundwater recharge include:

- Using aquifers to augment groundwater resources
- Reducing seawater intrusion or land subsidence
- Storing water for later use
- Improving the quality of the water supply through soil-aquifer treatment or geopurification
- Using aquifers as water conveyance systems.

Conditions needed for artificial recharge include:

- Permeable surface soils. However, where these soil types are not available, trenches or shafts in the unsaturated zone can be used, or water can be directly injected into aquifers through wells
- Absence of polluted areas. Water quality issues must be evaluated, especially with respect to formation of clogging layers on basin bottoms or other infiltration surfaces, and to geochemical reactions in the aquifer
- The aquifer should be sufficiently transmissive to avoid excessive buildup of groundwater mounds.

D.4.2 Costs

Recharge projects can lower the cost of water by decreasing the dependency on imported water. The 2001-2002 fiscal year costs in California for recharge projects show costs ranging from \$10 - \$600 per AF of increase in average annual delivery (DWR, 2005). The average cost is \$110 per AF of increased average annual delivery and statewide implementation costs are approximately \$1.5 billion for the conservative level of implementation and \$5 billion for the aggressive implementation (DWR, 2005). Cost is determined by: project complexity; regional differences in construction and land costs;

availability of infrastructure to capture, convey, recharge, and extract water; in addition to the intended use of water, water quality and treatment requirements. Costs for specific projects are noted in the following section titled: Current Recharge Projects in the SARW Region.

Conjunctive Management and Groundwater Storage

As discussed previously, conjunctive use is the planned and managed operation of a groundwater basin and a surface water storage system combined through a coordinated conveyance infrastructure. Water is stored in the groundwater basin for future planned use by recharging the basin during above average wet years and using surface storage to capture and temporarily store stormwater. The three primary components of conjunctive use include:

- Recharging groundwater when surface water is available to increase groundwater storage
- Switching to groundwater use in dry years when surface water is scarce
- Maintaining an ongoing monitoring program to evaluate and allow water managers to respond to changes in groundwater, surface water, or environmental conditions that could violate management objectives or impact other water users (DWR, 2005).

When surface water supplies are abundant during seasons or years of high precipitation the water is used to recharge groundwater basins. In times of drought when less surface water is available, the groundwater is used more extensively.

D.4.3 Sources and Methods

Spreading

Spreading is the most widely used technique for recharge using surface water. The goal of spreading is to capture stormwater in existing or new basins and to hold the water in storage until it is completely percolated into the basin and recharged into the groundwater. Spreading involves surface spreading of water in basins that are excavated in the existing terrain (USGS, 2005). For spreading to be effective, highly permeable soils are needed and often maintenance is required of surface layer over the permeable soils. When using direct discharge the amount of water entering the aquifer depends on three factors: the infiltration rate, the percolation rate, and the capacity for horizontal water movement (USGS, 2005). When the aquifer is homogenous, the infiltration rate is equal to the percolation rate. However, at the surface of the aquifer clogging occurs by deposition of suspended particles in water, algal growth, colloidal swelling, microbial activity, and soil dispersion (USGS, 2005). Spreading basins for recharge are most effective where there are no impending layers between the land surface and the aquifer and clear water is available for recharge. Clogging is the most common problem when recharging by surface spreading.

In-Lieu Recharge

In-lieu recharge is the practice of providing surplus surface water to historic groundwater users, thereby leaving storage for later use. Some basins within SARW Region use in-lieu replenishment, meaning available imported water is used in-lieu of groundwater; therefore groundwater can be stored for use when imported water is not available. When using in-lieu recharge, no actual water is recharged.

Stormwater Management

Recharge from rainfall is important because the water quality is higher than most recycled water and it is not energy intensive. The Santa Ana River Flow Impacts Report found that the driest rainfall year averaged 7.9 in. contributing 18,300 AFY of runoff; a typical year averaged 18.1 in. contributing 65,400 AFY; and the wettest period averaged 31.6 in., contributing 340,300 AFY of runoff (SAWPA 2004). In addition, retaining water from rainfall in groundwater storage helps reduce flooding. Capturing and using water from rainfall can save large volumes of water; for example IEUA plans to recharge 44,000 AF annually of combined storm water and recycled water (IEUA, 2005). As development in the watershed continues, the areas of impervious surfaces will increase, thereby decreasing natural recharge and increasing runoff. Replacing this water could be expensive if storm flow cannot be captured.

Increasing stormwater recharge can have multiple benefits. Currently, not all county infrastructures support tertiary treated water throughout their jurisdiction, although recycled water is permitted for all non-potable uses in California. Social acceptance to the use of recycled water for more than irrigation uses has been mixed. Injecting or infiltrating a larger volume of high quality stormwater will allow more recycled water of lower quality to be mixed and recharged as well. Reducing storm water flows at or near the point of rainfall will also decrease sediment loading and decrease the distance water travels on the surface accumulating pollutants.

Tree foliage can hold and absorb up to 35% of the rain falling annually on the diameter of the tree canopy (Wilkinson, 2003). Therefore, planting more trees is one approach to dealing with stormwater management. Turf management, another approach, uses aeration to increase the infiltration rates of lawns. Redirecting roof leaders, re-grading the landscape around a building, utilizing cisterns, and using constructed infiltration chambers are different techniques for infiltrating roof runoff. Surface infiltration basins can be used by residential and commercial landscapes to gather stormwater runoff and hold or infiltrate the runoff over varying time periods. Narrowing streets, in addition to modifying driveways and parking lots is another method of increasing pervious surfaces. Subsurface detention and infiltration chambers made of gravel or manufactured components can also be installed under lawns and parking lots to hold large volumes of site runoff during a storm and infiltrate that water to the subsoil hours or days later.

These approaches will help water quality while reducing high flows and providing recharge to augment low flows.



Figure D- 3: Examples of urban natural recharge

Natural Recharge

There are many methods to increasing natural recharge. Smart land use planning can significantly help natural recharge. Smart development requires a transition from poorly managed sprawl to planning that creates and maintains an efficient infrastructure and preserves natural systems. Smart development includes practices such as the use of bio-swales, detention/retention ponds, native and drought resistant vegetation, permeable pavement, curb cuts, open channel draining, reducing impervious surfaces, and increasing setbacks for septic systems, along with improving septic system technology. Figure D-3 depicts some

examples of urban natural recharge, such as curb cuts, bioswales, and permeable pavement. These practices can help improve stormwater recharge. Rapid urban sprawl in the SARW Region has increased the area of impervious surfaces thus reducing the natural percolation processes that recharge groundwater aquifers. This results in higher stormwater discharge that is often lost through surface runoff (Wildermuth Environmental et. al, 2001). The following section shows the current artificial recharge and major projects for the SARW Region.

SAWPA believes that levels of groundwater production will continue to increase with:

- the modification of operational rules for existing facilities
- construction of new recharge facilities
- salvaging of currently impaired groundwater by installing well head and regional treatment systems
- establishment of new sources of water for replenishment, i.e. recycled water

D.5 Current Recharge Projects in the Santa Ana Watershed

D.5.1 Current and Projected Sources

Currently, surface water comprises the majority of artificial recharge (SAWPA, 2002). This source of recharge is expected to continue as the main supply over the next 50 years as more and more facilities are constructed to capture and store storm and river flows. Imported water, currently, is the second largest water source for artificial recharge. However by 2050, projections indicate that imported water's contributions will drop to

last place (SAWPA, 2002). Recycled water represents the third largest water source for recharge, though by 2050 it is expected to surpass imported water, and become the second most significant water source (SAWPA, 2002). In IEUA, stormwater is considered the primary source of water for recharge into recharge basins. However in OCWD, recycled water is the primary source of water for the Groundwater Replenishment System. In the State Water Plan, SAWPA evaluated 20 potential groundwater recovery projects that would have a net yield of 95,000 AFY (DWR, 2005). Some of these projects are discussed below.

The agencies in the SARW Region that are directly responsible for managing groundwater include:

- Orange County Water District, which manages the Orange County Groundwater Basin,
- Chino Basin Water Master, whom manages the Chino Basin,
- San Bernardino Valley Municipal Water District, which is responsible for the Upper SAR Basins,
- Eastern Municipal Water District, oversees the San Jacinto Basin, and
- The Santa Ana Water Master, whom is responsible for the Riverside and Colton Basins.

D.5.2 Groundwater Management Agencies

Orange County Water District

The OCWD has developed a very innovative project called the GWR System. To summarize, the GWR System, takes highly treated sewage water from the Orange County Sanitation District (OCSD) and purifies the water to state and federal drinking standards using a 3-step process of advanced membrane purification technology through the use of microfiltration, reverse osmosis, and ultraviolet light with hydrogen peroxide advanced oxidation treatment to treat the water. The water will then be used to recharge the Orange County Coastal Plain, in addition to expanding an existing underground seawater intrusion barrier.

There are numerous benefits regarding OCWD's GWR System. OCWD states that their cost of water from the SWP is \$495 per AF versus \$476 per AF of water from the GWR System (OCWD, 2005). The need for imported water is thereby reduced which increases drought resistance. The high quality replenishment water reduces mineral build up in groundwater basin, not to mention that the supply of treated wastewater will essentially be limitless. Ocean outfall will be reduced as a result of the GWR System and additional water will be available to combat salt water intrusion. There will be no evaporation from groundwater aquifers. Finally, there is 10 MAF of groundwater storage at no cost, which will result in the option to expand operations. The total construction cost of the GWR System is \$410.3 million and the total program budget is \$486.9 million (OCWD, 2005). Upon completion of Phase I of the GWR 72,000 AFY of

water will be available for replenishment. The goal of the entire project is 140,000 AFY (OCWD, 2005). Components of the project include:

1. Advanced Water Purification Facility and pumping stations
2. A major pipeline to connect the purification facility to existing recharge basins
3. Expansion of existing seawater intrusion barrier

Currently in Orange County 270,000 AF of groundwater is pumped per year, and the Orange County Water District (OCWD) estimates that in the next 25 years pumping will increase to 450,000 AFY. OCWD supplements natural recharge with highly purified artificial recharge which improves water quality and reduces the energy needed to pump from deeper in the aquifer. In addition, this water can be used to stop salt water intrusion near the ocean. Table D-6 lists the sources of funding for the OCWD.

Sources of Funding for OCWD	
Funding Sources	Amount
EPA Grant	\$500,000
State Water Resources Control Board Grant	\$5,000,000
US Bureau of Reclamation Grant	\$20,000,000
Department of Water Resources (Prop. 13)	\$30,000,000
SAWPA	\$37,000,000
OCWD Contribution	\$198,560,000
OCSD Contribution	\$198,560,000
OCWD, 2005.	

Table D- 6: OCWD’s funding sources

OCWD’s Water Factory 21 is a reclamation project that produces water that is a blend of reverse osmosis-treated water, carbon adsorption-treated water and deep well water. The blend provides 22.6 MGD (46AFD) of water for replenishment and creates a fresh water barrier against seawater intrusion (OCWD, 2005). In addition, OCWD’s Green Acres irrigation and industrial water project frees up thousands of AF of potable water each year.

IRWD is in the process of constructing facilities, the Irvine Desalter Project (IDP), to treat some of the water produced. The IDP is a groundwater quality restoration project that is being constructed to clean groundwater around the former Marine Corps Air Station El Toro base. The IDP will pump and treat groundwater containing salts and nitrates to stop its migration from the Irvine Sub-basin into the Main Orange County groundwater basin and to prevent VOC-contaminated groundwater from spreading into the Main Orange County aquifer. The IDP will consist of three water purification plants with separate wells and pipelines systems. One plant will produce drinking water and the other will produce non-potable water. The drinking water plant will use reverse osmosis and disinfection, while the non-potable plants will purify VOC contamination using air stripping and carbon absorption. IDP will yield approximately 7,700 AFY of potable drinking water and 3,900 AF/YR of non-potable water (IRWD, 2005). IRWD produces tertiary-treated recycled water through the District’s MWRP and LAWRP, both of which are being upgraded to allow for increased production. MWRP’s upgrade will allow for an increase in production from 15 MGD to 18 MGD (IRWD, 2005). The LAWRP

treatment system will be upgraded and tertiary capacity to accommodate flows up to 7.3 MGD (IRWD, 2005). Pumping and piping facilities are included and will allow recycled water to be delivered to new zones in the service area. This should increase MWRP capacity to 33 MGD (IRWD, 2005).

San Bernardino Valley Municipal Water District

The San Bernardino Valley Water Conservation District (SBVWCD) and San Bernardino County Flood Control District (SBCFCD) are developing programs that will focus on expanding and enhancing groundwater recharge. This is due to the fact that the San Bernardino Basin can store 5.5 million AF with a safe yield of 232,000 AFY (DWR, 2005). Thus, there are numerous opportunities for recharge. The High Groundwater Pump-out Project, Phase I and II, by the San Bernardino Valley Municipal Water District was completed in 2005 and controls water levels in the area of Historic High Groundwater (AHHG) within the Bunker Hill Basin in San Bernardino and delivers water from the AHHG to local water users and to Orange County for percolation into the groundwater basin. The canal will be used by the Agricultural Water Conveyance System and the High Groundwater Pump-out Project.

The San Gorgonio Pass Water Agency completed the Little San Gorgonio Creek Recharge Project in 2003. The project provides banking and conjunctive use of State Water Project Water and local water for the Beaumont Storage Unit groundwater basin. The facility consists of six surface recharge basins for surface spreading. The recharge basins are estimated to percolate approximately 120 to 130 AF of water per month (SAWPA, 2005).

Santa Ana Water Master

Western Municipal Water District finished construction on the Agricultural Water Conveyance System which will deliver up to 6,000 AFY of non-potable water to the WMWD service area (SAWPA, 2005). In addition, the Riverside-Corona Feeder project will provide the infrastructure needed for WMWD to purchase water from the SWP when available and then store the water in the San Bernardino Basin. It is important to note that this surplus water could come from the SWP, local runoff and other local water sources with surplus during wet years (WMWD, 2005).

The City of Riverside constructed the Riverside Canal and Tunnel Reconstruction Project, allowing water transfers within the watershed with minimal water losses occurring during the transfer. The project involved the rehabilitation of around six miles of existing canal and tunnel system.

Chino Basin Water Master

Groundwater currently produces 62% of water supplies for IEUA (IEUA, 2005). Inland Empire, along with the CBW, is implementing the Regional Groundwater Recharge Program, the Chino Basin Desalter Program, and the Dry Year Yield (DYY) Program. Projects will significantly increase the overall yield of the Chino Basin in addition to improving the Basin's water quality.

Eastern Municipal Water District

Groundwater accounts for 20% of Eastern Municipal Water District (EMWD) water supply (EMWD, 2005). EMWD constructed the San Jacinto Water Harvesting Project to provide basin improvements consisting of inlet/outlet facilities, first-flush basin, diversion valve, and Line “E” Channel improvements. The facility has been percolating storm water since 2004. Currently, plans are underway for the Water District to recharge 8,000 AF using water from the SWP. In addition EMWD is preparing to implement the Hemet/San Jacinto Recharge and Recovery Program which involves 100 acres of ponds, eight recovery wells, and a 60-inch pipeline. The project will produce:

- 7,500 AFY for Tribal Settlement Water
- 10,000 AFY to offset groundwater overdraft
- 15,000 AFY towards long-term supply
- 45,000 AFY towards water storage for drought years (EMWD, 2005)

Last, EMWD is developing a program that involves replenishment and recovery for the Hemet/San Jacinto Basin. The project involves two phases. The first will recover 7,500 AF of water from the basin by 2010 (EMWD, 2005).

Table D-7 provides a summary of the sources of recharge for the five major Water Districts in the SARW Region.

Recharge Potential in the Santa Ana River Watershed in AF							
Agency	2000	2005	2010	2015	2020	2025	2050
Eastern Municipal WD							
w/ imported water for conj. use	3600	20700	18000	19100	27800	26000	28500
w/ reclaimed water	10122	11900	6200	6200	6900	6900	6900
Inland Empire Utility Agency							
w/replenishment a/o import	40000	45300	57600	54400	54900	60100	40000*
w/ surface storm water	18790	18790	23700	23700	23700	24500	29400
w/ recycled water	0	1000	22000	25000	28000	35000	52261
Orange County WD							
w/replenishment a/o import	111000	41750	17500	18250	0	0	0
w/ surface storm water	226000	216000	206000	224000	242000	261000	303000
w/ recycled water	7000	78400	100000	100000	145600	145600	145600
San Bernardino Municipal WD							
w/ imported water	0	0	0	0	0	0	0
w/ surface water	0	0	5250	10500	15750	21000	21000
w/ reclaimed water	0	0	3031	6062	9094	12125	27281
Western Municipal WD							
w/imported water	5000	15000	40000	40000	40000	40000	40000
w/ surface water	0	0	0	0	0	0	0
w/ reclaimed water	1000	1750	2500	3125	3750	5000	10000

* Number substituted from SAWPA, 2002.

Source: SAWPA, 2002 and IEUA, 2005

Table D- 7: Summary of recharge sources for the five major water districts in the SARW

D.6 Issues Related to Recharge

D.6.1 Barriers

There are numerous economic, political, and mechanical barriers to recharging groundwater. Some of these barriers are listed below:

- Lack of regional monitoring of groundwater levels, land subsidence, water quality, or the interaction of groundwater with surface water and the environment
- Reluctance of individuals who own groundwater monitoring or supply wells to provide information or allow access to collect information
- Operational constraints and physical capacities of existing storage and conveyance facilities are not large enough to capture surface water in wet years
- Lack of understanding of surface water and groundwater interactions
- Overlapping boundaries or responsibility do not necessarily have consistent management plans
- SWRCB regulates surface water rights from 1914 to present and groundwater quality, not rights, to groundwater use
- Individuals have few restrictions on groundwater use except in adjudicated basins
- Conjunctive activities need to be coordinated with groundwater clean-up to achieve multiple benefits to both water supply and groundwater quality
- Conjunctive use might affect habitat, water quality and wildlife caused by shifting or increasing patterns of groundwater and surface water use
- Reducing flood flows can impact ecosystems
- There is a lack of funding for infrastructure development and monitoring capabilities
- Clogging in Recharge basins reduces recharge rates (DWR, 2005; IEUA, 2005)

Impervious Surfaces

Impervious surfaces created by residential, commercial, industrial, and utility land use result in a loss of natural recharge. Wildermuth Environmental found that from 1977 to 1999 the SARW Region lost a volume of 41,000 AFY (IEUA, 2005). A leader in water resource management, IEUA has developed their headquarters with permeable pavement as part of their LEED certification, a practice which is becoming a viable option for increasing recharge. Table D-8 illustrates the cost for these pavements.

Impervious Surfaces are generally constructed surfaces such as rooftops, sidewalks, road, and parking lots that are covered by impenetrable materials such as asphalt, concrete, brick, and stone.
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Impervious surfaces overlying unconsolidated sediments are of special importance due to the natural recharge that can occur in this area. We conducted an analysis to determine the area of unconsolidated sediments overlain by impervious land uses. Figure D-5a shows impervious surfaces reclassified from 2001 SCAG land use classification, Figure D-5b shows unconsolidated sediment in the SARW Region, and

Figure D-4c shows the area that was formerly available for recharge but is now mostly impermeable.

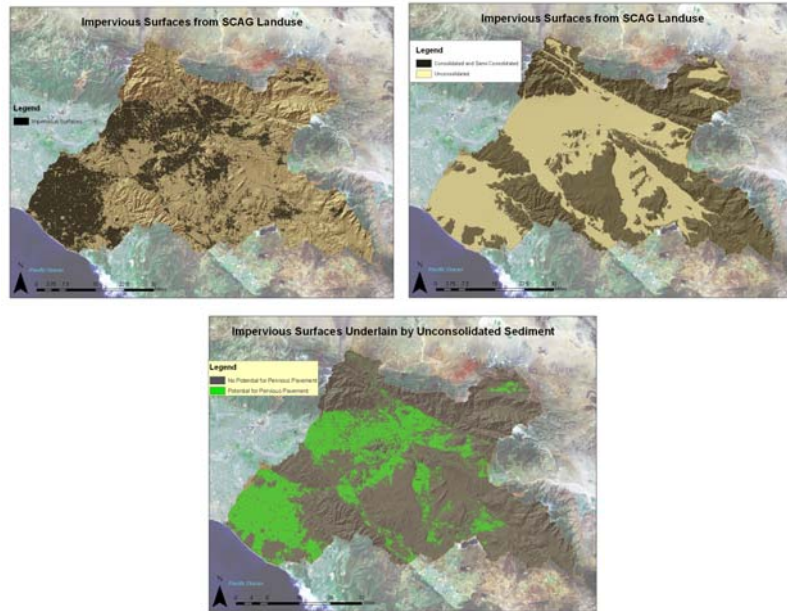


Figure D- 4 (a-c): a) Impervious land uses b) Unconsolidated sediments c) Impervious surfaces overlying unconsolidated sediments
Source: SCAG, 2001

The total area of impervious surface overlying unconsolidated sediment was 737 sq. miles in 2001 (SCAG, 2001). The same analysis on the National Landcover Data (not shown) (NLCD, 1992) resulted in 511 sq. mile of impervious surfaces overlying unconsolidated sediment an increase of 255 sq. miles. This difference is significant but may be attributable to land use reclassification. The amount of impervious surfaces will continue to grow especially in Riverside County. Riverside County is one of the most rapidly growing counties in terms of population percentage. An interest in maintaining some natural recharge has resulted in the development of permeable pavements which are becoming competitive in cost. New developments can easily use a form of permeable pavement, but retrofitting may be more difficult. Table D-8 shows the varying types of pavement used in construction of IEUA’s LEED Platinum Building and the cost for paving a lot with the area of Riverside City’s minimum lot size.

Total cost and recharge potential of surfaces		
Surface	Cost/ft ²	Total Cost for 10,000 ft ² lot
Asphalt with base	\$1.75	\$17,500
Gravelpave and/or concrete	\$2.50	\$25,000
Pavers (e.g. Ecostone) with concreted edges	\$6.75	\$67,500

Table D- 8: Surface costs
Source: IEUA, 2005

Table D-9 shows other products currently on the market and their associated costs as well.

Maximum and minimum costs of surfaces			
Product	Manufacturer	Minimum Cost (ft ²)	Maximum Cost (ft ²)
Asphalt	Various	\$0.50	\$1.00
Geoweb	Presto Products Inc	\$1.00	\$2.00
Grasspave, Gravelpave	Invisible Structures	\$1.00	\$2.00
Grassy	Paver RK Manufacturing	\$1.00	\$2.00
Geoblock	Presto Products Inc	\$2.00	\$3.00
Turfstone	Westcon Pavers	\$2.00	\$3.00
UNI-Eco- stone	Uni-Group USA	\$2.00	\$3.00
Checkerblock	Hastings Pavement Co.	\$3.00	\$4.00

Table D- 9: Minimum and maximum surface costs
Source: PATH, 2005

As impervious surfaces increase storm runoff, riparian buffers can also help to slow the velocity of urban runoff and allow water to infiltrate the soil and recharge the groundwater supply. Groundwater will reach the stream or river at a much slower rate and over a longer period of time than if it had entered the river as surface runoff. Thus, riparian buffers help control flooding and maintain stream flow during the driest periods of the year. An interesting program that uses riparian buffers is Orange County's study of vegetative treatment systems. The study includes 465 acres of constructed wetlands and riparian buffers that naturally filter storm water for recharge (NRCS, 2005).

Clogging and Percolation Basins

One of the largest problems with recharge is clogging of the permeable layer near the surface. Infiltration rates in percolation basins are dependent on a number of factors and are controlled by physical, biological and chemical processes including the temperature and the permeability of the surface and vadose zone. Warmer climates benefit from viscous water which can percolate at twice the rate of colder water, but biological activity is higher in warmer climates (Bouwer, 2002). Biologic activity is one of the three main factors that control clogging, a major obstacle in recharge. The main biological, physical, and chemical processes are which is shown in Table D-10.

Biological, Physical, and Chemical Processes	
Physical processes	accumulation of inorganic and organic suspended solids
	downward movement and accumulation of fine particles of soil
Biological processes	accumulation of algae and bacteria on infiltrating surfaces
	growth of microorganisms
Chemical processes	precipitation of calcium carbonate, gypsum, phosphate, and other chemicals
	gas producing bacteria that blocks pores creating vapor barriers

Table D- 10: Biological, Physical, and Chemical Processes
Source: Bouwer, 2002

D.6.2 Solutions

In the past, management of the actual clogging layer has been limited to drying the basin and then scraping or tilling the soil to remove or break up the clogging layer. This is a short term solution as the material is not actually removed. According to Bouwer's studies of artificial recharge, newly cleaned basins can percolate 10 ft. per day, but the rate decreases to nearly zero after six to eight months depending on soil types (Bouwer, 2002).

Santa Paula's United Water Conservation District (UWCD) is a leader in the development of recharge strategies outside the Santa Ana watershed. This organization achieved optimization of recharge by developing individual and bulk spreading capacity recession curves (Dickenson and Bachman, 1994). Using this formula, they combined the drying period with ground treatment in two of their recharge facilities. Figure D-5 shows the recharge rate cycle which decays as a function of time exponentially.

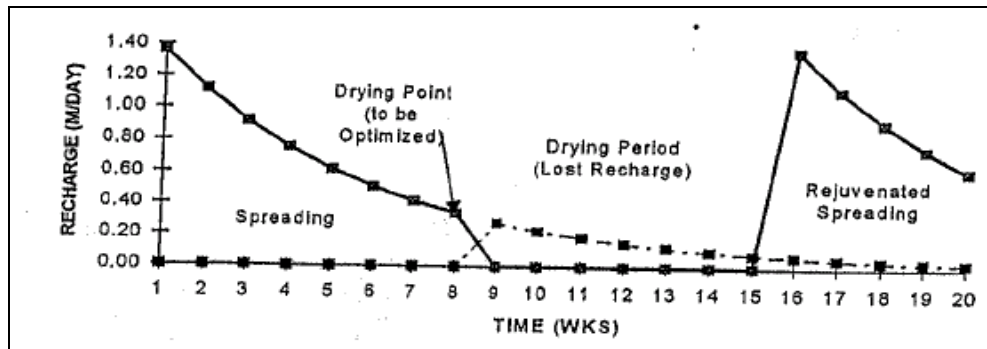


Figure D- 5: Recharge rate cycle
Source: Dickenson and Bachman 1994

It is obvious from Figure D-5 that although optimization of the drying cycle is occurring, there is a loss due to the drying period. It is possible to maintain a high rate if basins are rotated, for example, drying one while recharging with another. Recharge area is often limited due to development and the cost of purchasing more land. Innovative strategies are necessary to increase recharge rates.

Other solutions for this problem have been managed by desilting in settling basins and pre-treating to purify the water. In combination, these processes can remove suspended solids, nutrients, and organic carbon. However, the above techniques do not stop biological growth, which can seriously reduce percolation rates. One technique used by OCWD's GWR System to combat biological growth is adding hydrogen peroxide in small concentrations.

OCWD has studied recharge rates and clogging for 20 years by analyzing for HCL and chemical concentrations, protein, chlorophyll, and carbohydrate. In addition, they have monitored percolation rates in their recharge basins. Figure D-6 below shows the effects of clogging on recharge rates for OCWD basins shown in Figure D-7.

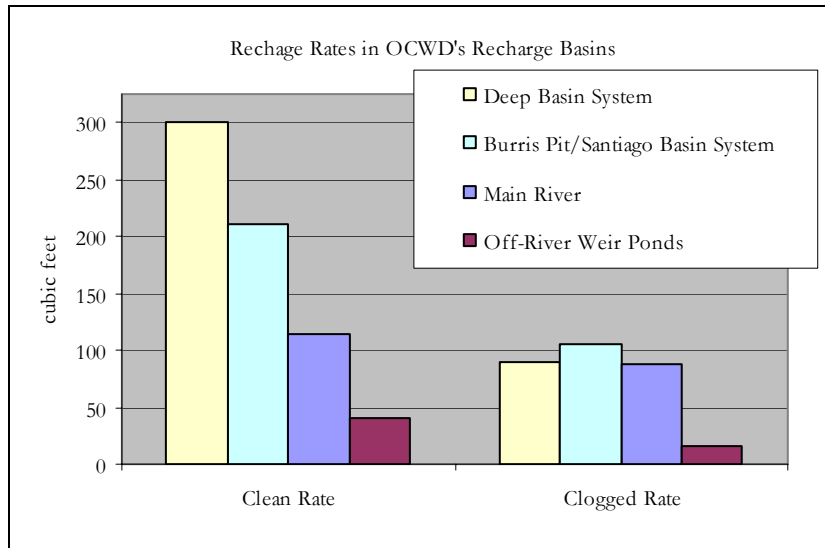


Figure D- 6: Recharge rates in OCWD's Recharge Basins
Source: OCWD, 2005

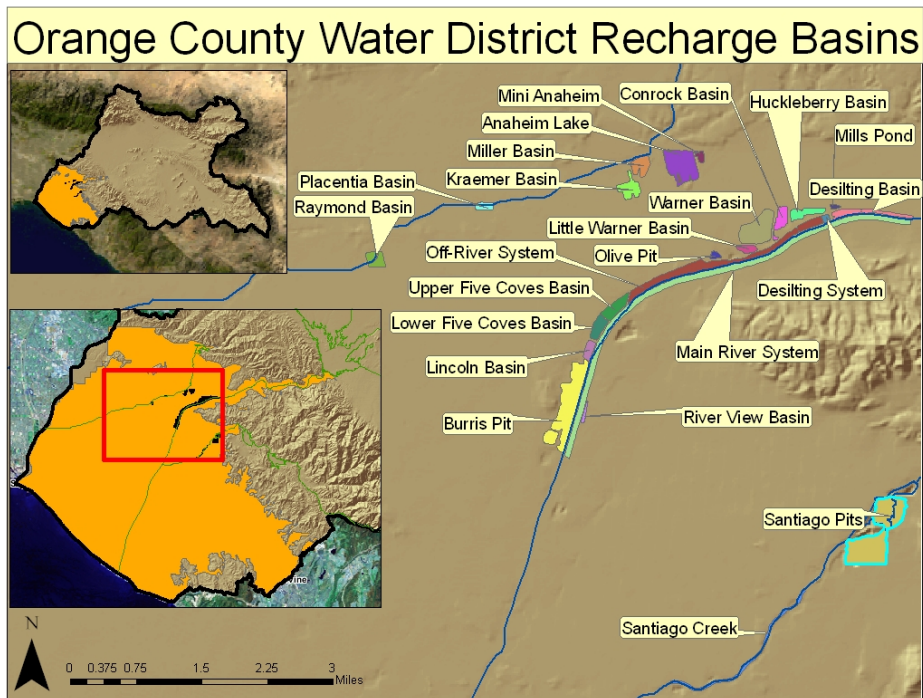


Figure D- 7: Orange County Water Recharge Basins
Source: SAWPA, 2005

Figure D-9 shows how infiltration rates are drastically reduced due to clogging. This in turn can affect total recharge seen in Figure D-8. One can see that clogging has the highest effect on deep basin systems. Much of this result is due to the compression of the clogging layer (Bouwer and Rice, 1989), but it is also related to the difference in the

distance from the water surface to the groundwater surface (Bouwer, 2002). For a 25 acre recharge area, this can mean a difference of 2,069 to 13,639 AFY depending on the initial infiltration rate.

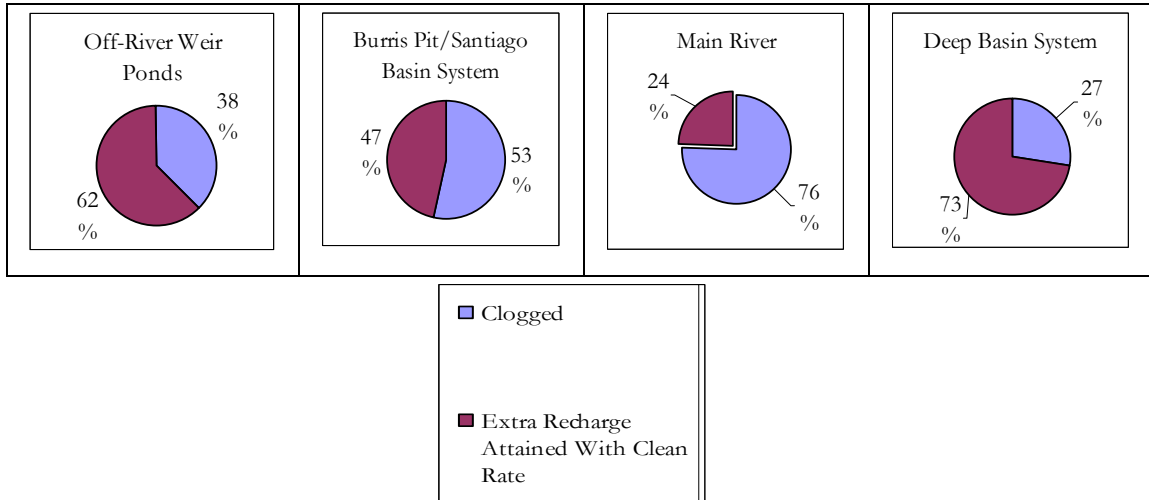


Figure D- 8: Water infiltration rates in OCWD’s recharge basins
Source: OCWD, 2005

Flocculation Systems

Settling and purification reduces the sediment load while residual hydrogen peroxide reduces biological growth. However, clogging still occurs because it is impossible to stop growth and hard to remove all the suspended particles from the water. Flocculation systems like those used at by UWCD can coagulate suspended particles in desilting ponds producing water with a lower turbidity and better quality for percolation. When high flow occurs, UWCD tests the water at their diversion facility for turbidity with an imhoff cone which measures the size and concentration of suspended particles in Nephelometric Turbidity Units (NTU). Water with above 3000 NTU is diverted for flocculation which involves adding a cationic polymer that attracts anions (usually clays) and is reduced to 500 NTU before being diverted to a settling pond and finally the spreading basin(UWCD, 2006). Orange County is considering such a system near the Imperial Hwy. and Lakeview Ave.

Basin Cleaning Vehicle (BHV)

The OCWD has studied the clogging layer composed of particulate matter which ranges from larger grains to sub-micron particles including diatom skeletons for 20 years using scanning electron microscopy (LWT, 2005). They determined that the makeup changed over time and has been more recently dominated by aluminum silicates while in the past it was dominated by calcium carbonate and sulfate as well as forms of carbohydrates. Orange County has led the industry in research and design of the Basin Cleaning Vehicle which combats the effects of clogging in percolation basins and increases recharge rates. The vehicle continuously cleans the subsurface of the recharge basin, removes the

clogging layer, and thus increases total recharge. This eliminates the need to dry out basins which, if dry for 3 months, reduces total percolation by 25% (OCWD, 2005). The BCV works by churning the clogging layer and then using a suction device to remove the silt and sand. The sand then returns to the bottom surface while silt is pumped to shore. The BHV can add 23,000 AF of water for recharge every year, meaning the vehicle increases annual recharge by 40%.

The first three generations of the remotely controlled vehicle were designed to operate in deeper basins cleaning the surfaces at a depth of 100 ft below the water surface. The newest design operates at 25ft to remove silt and clay, effectively cleaning the clogging layer. Liquid Waste Technology LLC was successful in designing the vehicle and OCWD purchased four dredges which operate in the shallow basins near the Santa Ana River.

Basin Pumping Percentage

OCWD uses the Basin Pumping Percentage (BPP) to manage the amount of production from the Orange County groundwater basin. OCWD recommends a BPP each water year, the BPP is calculated by dividing the optimum producer's groundwater production (basin yield) by their total potable water demands (Anaheim, 2005). The BPP is based on groundwater conditions, availability of imported water supplies, and basin management objectives. The BPP is a major factor in determining the cost of groundwater from the basin for that year. Producers may pump above the BPP to 100 % of their needs by paying the basin equity assessment (BEA). The BEA is an additional fee paid on any water pumped above the BPP, making the cost of that water approximately equal to the cost of imported water. Basically, the BEA rewards groundwater pumpers that extract less than their proportion of total demand of groundwater; while pumpers that extract more than their requested amount are penalized (OCWD, 2005).

D.6.3 Incentives

MWD currently provides a financial contribution of \$154 for each new AF of water developed from local water recycling that replaces a demand on MWD's system (MWD, 2005). In addition, local agencies may receive up to a maximum of \$250 per AF of firm yield for groundwater recovery projects that treat contaminated groundwater and produce clean water (MWD, 2005). Participation in the program is through a competitive request for proposal (RFP) process that seeks to identify local projects that best meet the region's need and provide the greatest return on investment. MWD is also responsible for distributing \$45 million in funds for the development of conjunctive management programs in Southern California (MWD, 2005).

D.7 Current Stormwater Recharge

<i>Agency</i>	<i>Name</i>	<i>Basin</i>	<i>County</i>	<i>Recharge Sources</i>	<i>Annual Recharge</i>	<i>AF Storm Recharge</i>
OCWD	Miller Basins	Santa Ana Forebay	Orange		0	0
OCWD	Santa Ana River Forebay Rech.	Santa Ana Forebay	Orange	Santa Ana River/Import	200000	0
OCWD	Santiago Basin Rech. Ops.	Santa Ana Forebay	Orange	Santa Ana River/Import	50000	0
OCWD	Creek Basins	Santa Ana Forebay	Orange		0	0
SBFCD	Montclair Basins	Chino I	San Bernardino	Imported	12000	2100
	Cucamonga Basins North & South	Cucamonga	San Bernardino	Seasonal	3500	0
	Eighth Street Basins	Chino I	San Bernardino	Seasonal	5100	1600
	Fifteenth Street Basin	Chino I	San Bernardino	Seasonal	2400	0
CBWCD	Ely Basins	Chino II	San Bernardino	Seasonal	2300	2800
	Red Hill Basin	Cucamonga	San Bernardino	Seasonal	500	0
CBWCD	Chris Basin	Chino II	San Bernardino	Seasonal	600	0
CBWCD	Lower Cucamonga Spr.	Chino II	San Bernardino	Seasonal	5400	0

Grounds						
	Turner Basins	Chino II	San Bernardino	Seasonal	3000	0
	Church Street Basin	Chino I	San Bernardino	Seasonal	1200	0
CBWCD	Riverside Basins	Chino II	San Bernardino	Seasonal	3600	0
CBWCD	Wineville Basin	Chino II	San Bernardino	Seasonal	4500	700
	Lower Day Creek Basin	Chino I	San Bernardino	Seasonal	4000	500
	Upper Day Creek Basins	Cucamonga	San Bernardino	Seasonal	1100	0
	Etiwanda Basin	Chino I	San Bernardino	Seasonal	3000	0
SBFCD	Etiwanda Conservation Basins	Chino I	San Bernardino	Imported	4000	1100
	East Ave. Spreading Grounds	Chino I	San Bernardino	Seasonal	0	0
SBFCD	Hickory Basin	Chino I	San Bernardino	Seasonal	1200	900
SBFCD	Victoria Basin	Chino I	San Bernardino	Seasonal	2200	1000
	East Etiwanda Creek Channel	Chino I	San Bernardino	Seasonal	4500	0
SBFCD	Banana	Chino I	San Bernardino	Seasonal	1300	800

Basins			Bernardino			
SBFCD	San Sevaive Spreading Area	Chino I	San Bernardino	Imported/Seasonal	8000	0
Lytle C. WCA	Lytle Creek Spreading Grounds	San Bern./Lytle Creek	San Bernardino	Local Runoff/SWP Water	22776	0
	Merrill Basin	Chino I	San Bernardino	Seasonal	800	0
LADWP	Linden Basin	San Bernardino GW	San Bernardino		0	0
	Linden Basin	Chino I	San Bernardino	Seasonal	1700	0
	Mill Basin	Colton-Rialto	San Bernardino		800	0
	Pepper Basin	Colton-Rialto	San Bernardino		400	0
	Randall Basin	Colton-Rialto	San Bernardino		1700	0
SBFCD	Devil Cyn/Swt. Spill. Gr. Spr.	San Bern./Bunker Hill	San Bernardino	Devil Creek	5823	0
LADWP	Muscoy (North)	San Bernardino GW	San Bernardino		0	0
LADWP	Muscoy (South)	San Bernardino GW	San Bernardino		0	0
CBWCD	Jurupa Basins	Chino II	San Bernardino	Seasonal	3600	0
LADWP	Mayfield	San Bernardino GW	San Bernardino		0	0

SBFCD	Waterman Cyn. Spr. Grounds	San Bern./Bunker Hill	San Bernardino	Local Runoff/SWP Project	5159	0
LADWP	Waterman (North)	San Bernardino Basin	GW San Bernardino		0	0
LADWP	Waterman (South)	San Bernardino Basin	GW San Bernardino		0	0
LADWP	Twin	San Bernardino Basin	GW San Bernardino		0	0
LADWP	Marshall	San Bernardino Basin	GW San Bernardino		0	0
LADWP	Patton	San Bernardino Basin	GW San Bernardino		0	0
SBFCD	City Creek Spreading Grounds	San Bern./Bunker Hill	San Bernardino	Local Runoff/SWP Project	3440	0
Eastern MWD	Skiland Ponds	Perris South II	Riverside	Moreno Valley WRF	3958	0
Eastern MWD	Winchester Ponds	Winchester	Riverside	Temecula Valley Reg. WRF	150	0
SBVWCD	Santa Ana River Spr. Grounds	San Bern./Bunker Hill	San Bernardino	Santa Ana River	23135	0
Eastern MWD	Salt Creek Water Harvesting	Winchester	Riverside	Salt Creek	3500	0
SBVWCD	Mill Creek Spreading Grounds	San Bern./Bunker Hill	San Bernardino	Mill Creek	5164	0

Eastern MWD	Fish & Game Wetlands	San Jacinto - Lower Pres.	Riverside	Hemet/San Jacinto WRF	0	0
Eastern MWD	EMWD Trumble Ponds - Romoland	Perris South II	Riverside	Perris Valley WRP	614	0
SBFCD	Wilson Creek Spr. Grounds	San Bern./Bunker Hill	San Bernardino	Local Runoff	256	0
Eastern MWD	San Jacinto Reservoir	San Jacinto - Upper Pres.	Riverside	Hemet/San Jacinto WRF	146	0
Eastern MWD	Alessandro Ponds	San Jacinto - Upper Pres.	Riverside	Multiple RWRF's	1020	0
Eastern MWD	SPW Recharge Ponds	San Jacinto Intake	Riverside	SPW	2000	0
Eastern MWD	Fruitvale 20 Ac. Basins - (L)	San Jacinto Canyon	Riverside	San Jacinto River	10	0
Eastern MWD	Fruitvale 40 Ac. Basins - (U)	San Jacinto Canyon	Riverside	San Jacinto River	75	0
CBWCD	Brooks		San Bernardino		0	1800
CBWCD	College Heights		San Bernardino		0	100
City of Upland	Upland		San Bernardino		0	1000
SBFCD	Declez		Riverside		0	300
IEUA	RP3		San		0	1700

Bernardino				
IEUA	Thomson Creek SG	Los Angeles	0	0
IEUA	San Antonio Dam	San Bernardino	0	0
IEUA	Pomona SG	Los Angeles	0	0
IEUA	Live Oak SG	Los Angeles	0	0
IEUA	Cucamonga SG1-2-3	San Bernardino	0	0
IEUA	Cucamonga 1	San Bernardino	0	0
IEUA	Cucamonga 2	San Bernardino	0	0
IEUA	Alta Loma 1- 2	San Bernardino	0	0
IEUA	Turner 1	San Bernardino	0	900
IEUA	Turner 2-3-4	San Bernardino	0	1800
IEUA	Turner 5-8-9	San Bernardino	0	0
IEUA	Grove Ave. Basin	San Bernardino	0	0
IEUA	Jurupa	San Bernardino	0	700
IEUA	San Sevaine 2	San Bernardino	0	0
IEUA	San Sevaine 1	San Bernardino	0	0
IEUA	Rich	San Bernardino	0	0
Sum			409626	19800

D. 8 Groundwater Recharge Stakeholder Concerns

Stakeholders support sole and/or cooperative efforts to develop additional economically feasible recharge facilities for imported water as well as native high quality runoff and reclaimed water. They want a program developed to increase recharge of native runoff and create a mechanism to pledge the value of the increase in safe yield from these new water sources to help pay for the construction of these facilities. There is a desire to maximize the use of existing recharge facilities. Water Districts want to develop reuse and recharge projects to maximize water use. Stakeholders want the ability to market basin losses through monitoring groundwater levels and the amount in storage, and also encourage storage and underproduction in the north to flush out the south end of the basin. Water Districts want to determine and allocate storage capacity based on technical data and basin management goals. They want to provide transfer mechanisms between pools to ensure beneficial use of water. Additionally, they would like to develop means to export water, and determine and assess storage losses. There is a need for economical programs to store additional MWD water and reduce pumping costs in the North. Stakeholders want to allow transferability of stored overlying non-agricultural water. Lastly, they would like programs to be developed to construct facilities and deliver water between agencies during periods of shortage and allow transferability of stored overlying non-agricultural water.

D.9 Santa Ana Watershed Water and Groundwater Management Plans

Table 1 Santa Ana Watershed Water and Groundwater Management Plans

Plan	Authorizing Agency	Relationship to SAWPA
Orange County Groundwater Management Plan	Orange County Water District, March 2004	SAWPA Member Agency
Chino Basin Optimum Basin Management Program	Chino Basin Water Master	Informal Cooperating
Western Judgment Rialto Basin Decree Orange County Judgment San Bernardino Valley Municipal Water District Master Plan, Final Draft Santa Ana River Water Right Applications for Supplemental Water Supply Environmental Impact Report Seven Oaks Accord U.S. EPA, the U.S. Department of the Army, the City of San Bernardino, and the California Department of Toxic Substances Control - Consent Decree	San Bernardino Valley Municipal Water District	SAWPA Member Agency
West San Jacinto Groundwater Management Plan	Eastern Municipal Water District, April 2004	SAWPA Member Agency
Santa Ana Integrated Watershed Plan Update	SAWPA, April 2005 (public release)	

Table D- 11: Santa Ana Watershed Water and Groundwater Management Plans

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