City of San Diego • Public Utilities Department

2012 Long-Range Water Resources Plan

City of San Diego
PUBLIC UTILITIES
Water & Wastewater

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AF	acre-feet
AFY	acre-feet per year
Agreement	Cooperative Agreement
ASA	Alvarado Service Area
ASR	aquifer storage and recovery
AWT	Advanced Water Treatment
BCSD	bias correction and spatial downscaling
BMPs	best management practices
CA	constructed analogues
Cal-Am	California American Water Company
CEPT	Chemically enhanced primary treatment
CDP	Criterium Decision Plus
CDPH	California Department of Public Health
CIMI	California Irrigation Management Information
City	City of San Diego
Compact	1922 Colorado River Compact
CRA	Colorado River Aqueduct
CUWCC	California Urban Water Conservation Council
CWA	Clean Water Act
Delta	Sacramento-San Joaquin River Delta
DMM	demand management measures
DWR	Department of Water Resources
FY	fiscal year
GCMs	general circulation models
GED	gallons per employee per day
GFDL	Geophysical Fluid Dynamics Laboratory
GMP	Groundwater Management Plan
GPHD	gallons per housing unit per day
IPCC	Intergovernmental Panel on Climate Changes
IPR	Indirect potable reuse
IRP	Integrated Resources Plan
LRP	Local Resource Program
LRWRP	Long-Range Water Resources Plan
Max Efficiency	Maximum Water Use Efficiency
mgd	million gallons per day
MOU	Memorandum of Understanding Regarding Urban Water Conservation in California
MSA	Miramar Service Area
MWD	Metropolitan Water District
NCAR	National Center for Atmospheric Research
NCWRP	North City Water Reclamation Plant
NPDES	National Pollutant Discharge Elimination System
NRW	non-revenue water
O&M	Operation and Maintenance
OPRA	Ocean Pollution Reduction Act
OSA	Otay Service Area
Plan	California's Colorado River Water Use Plan
PV	present value
QSA	Quantification Settlement Agreement
RWMP	Recycled Water Master Plan
RWS	Recycled Water Study
SANDAG	San Diego Association of Governments
SB7-7	Senate Bill 7 as part of the Seventh Extraordinary Session
SBWRP	South Bay Water Reclamation Plant
SDCWA	San Diego County Water Authority
SDPUD	San Diego Public Utilities Department
SDSIM	San Diego Simulation
SRES	Special Report Emissions Scenarios
SWP	State Water Project
TDS	total dissolved solids
TM	Technical Memorandum
TMDL	Total Maximum Daily Load
USBR	United States Bureau of Reclamation
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
WTP	water treatment plant
WWTP	wastewater treatment plant

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2012 LRWRP Executive Summary

ES.1 Introduction

The City of San Diego (City) has a reputation of being one of the country's most desirable places to live and conduct business because of its climate, economy, and high quality of life. It is the eighth largest city in the United States and the second largest in California. San Diego, located on the coast of the Pacific Ocean and adjacent to the Mexican state of Baja California, is an international city, economically and culturally. The City is known worldwide as a prime tourist destination; home to important industries such as telecommunication, biotechnology, software, and electronics; boasts one of the largest defense and military complexes in the world; and its commercial port and location along the United States-Mexico border results in significant international trade of commerce.

Although the City is located in a semi-arid coastal climate with an average of 10 inches of rainfall annually, it has successfully provided a reliable water supply to its residents for more than 100 years. The City covers approximately 340 square miles and stretches nearly 40 miles from north to south. It is a city defined by varied landscapes – oceans, mountains, mesas, canyons, and estuaries. This varied topography requires sophisticated and innovative water and wastewater systems.

The City of San Diego Public Utilities Department (SDPUD) manages one of the largest water storage, treatment, and delivery systems in the United States. The water system extends over 404 square miles with water deliveries on the order of 200 million gallons per day (mgd). The City also has a separate recycled water distribution system that currently extends over 80 miles, and serves an annual average of approximately 7 mgd of

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water demands within the City and 4 mgd to three wholesale customers. In addition to securing water supplies for more than 1.3 million residents, SDPUD also manages a regional wastewater system that serves 2.2 million residents in San Diego County.

The water resources feeding these systems are the City's lifeblood—water is truly essential for public health, economic vitality and quality of life of San Diego's residents. This is reflected in SDPUD's mission to:

> ***"… ensure the quality, reliability, and sustainability of water, wastewater, and recycled water services for the benefit of the ratepayers and citizens served."***

The challenge for the City is to excel in its mission in the long-term, given the uncertainty of future economic conditions, climate change, regulatory and legal requirements, and reliability and cost of current water supply sources.

ES.1.1 Service Area Background

The City sells water to a population of over 1.3 million, and also sells water to four wholesale customers: raw water is sold to the Santa Fe Irrigation District and San Dieguito Water District, and treated water is sold to the City of Del Mar and California American Water Company (Cal-Am); Cal-Am in turn serves the City of Coronado, City of Imperial Beach, and portions of south San Diego. The City also has an agreement to sell surplus water to Otay Water District, and exchange water to Ramona Municipal Water District.

Table ES-1 presents demographic data for the City's service area (retail and wholesale), which was obtained from the San Diego Association of Governments (SANDAG). The City's combined retail and wholesale serviced population is expected to increase from about 1.41 million in 2015 to over 1.69 million in 2035, which is about a 20 percent increase in twenty years.

Table ES-1: City of San Diego Water Service Area Demographics

	2010	2015	2020	2025	2030	2035	Percent Change 2015 to 2035
Population	1,341,067	1,408,453	1,486,684	1,556,055	1,627,585	1,691,383	20%
Occupied Housing Units	486,104	514,520	549,556	575,908	602,021	625,904	22%
Non-Agricultural Employment	792,931	829,875	870,360	899,356	923,988	948,591	14%
Median Household Income ($1999)	$53,859	$57,148	$59,072	$65,799	$71,602	$76,202	33%

Source: SANDAG 2050 Regional Growth Forecast, Series 12. This data was used in the City of San Diego's June 2010 *Update of Long-Term Water Demand Forecast* (refer to Section 2).

SDPUD forecasts water demands using an econometric approach that is based on several driver, including socioeconomics, weather, household density, employment, and conservation. Figure ES-1 shows the City's baseline water demand projection with existing water conservation programs, under normal weather and economic conditions. The projected growth in water demands from 2015 to 2035 is 17 percent, which is lower than the expected population growth during the same period due to water-use efficiency.

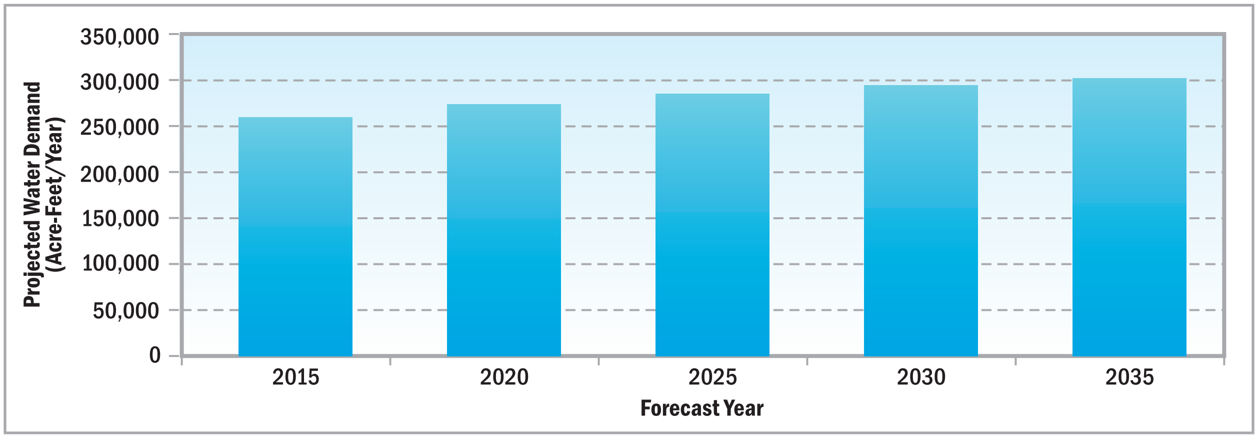

Figure ES-1: Projected Baseline Water Demands for the City's Service Area

The City purchases approximately 85-90 percent of its water from the San Diego County Water Authority (SDCWA), which is approximately 72.4 percent of the overall resource mix including conservation and reuse. The SDCWA is a wholesale water agency that provided approximately 417,000 acre-feet per year (AFY) of imported water to its 24 member agencies in San Diego County in fiscal year (FY) 2011. The City of San Diego is the largest SDCWA water user. Current water deliveries to the City account for approximately 38 percent of the SDCWA's total water sales.

The SDCWA, in turn, gets most of its imported water from the Metropolitan Water District of Southern California (MWD), which delivers water to 26 public water agencies and is the largest wholesale water agency in the nation. MWD was incorporated by the state Legislature in 1928 to build the Colorado River Aqueduct (CRA), a facility it owns and operates. MWD also imports water from Northern California, originating at the Sacramento-San Joaquin River Delta (Delta), through the State Water Project (SWP). MWD currently delivers approximately 1.8-2.1 million AFY of imported water to its customers, but demands vary significantly with weather and economic conditions.

Local resources make up approximately 28 percent of the City's existing overall water supply, including savings from conservation (see Figure ES-2). The SDPUD owns and operates an extensive raw water system that includes nine reservoirs which captures local surface water for treatment at its three drinking water treatment plants. The SDPUD has been investigating the feasibility of local groundwater, and is pumping a small amount of groundwater that is conveyed to the City's water treatment plant for potable use. To offset potable system demands, the SDPUD has two water reclamation plants and a large-scale distribution system that delivers recycled water for non-potable applications – primarily outdoor irrigation, and also industrial cooling towers.

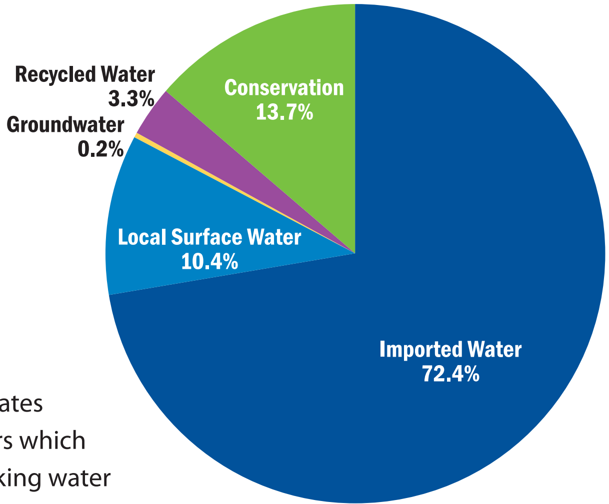

Figure ES-2: Existing Resource Mix Projected for 2015 Normal/Average Hydrologic Conditions
(Source: SDPUD 2010 UWMP)

Colorado River

Sacramento Delta

California Aqueduct

ES.1.2 Water Resources Issues

With such heavy reliance on imported water, the City must examine the various risk elements associated with that supply. A twelve year drought in the Colorado River Basin, more severe than any other measured in the 20th century, resulted in record lows in Colorado River water levels. Water supply from the SWP has also been significantly reduced due to recent court restrictions to protect fisheries in the Delta and a prolonged statewide drought. The Delta, where pumping for both the SWP and federal water projects originates, is of particular concern because of the long-term degradation of habitat, risk of levee failures due to natural disasters, and long-standing conflicts between agriculture, urban and environmental interests. These strains on MWD's water supply sources have resulted in imported water allocation limits to MWD's member agencies for the first time since 1991. While other SDCWA supplies help offset some of these shortages, San Diego is located at the "end" of imported water pipelines and is vulnerable to future restrictions – which are projected to be worse in the future with climate change.

Water quality for both the SWP and the Colorado River are also of significant concern to the City, since water quality tends to degrade over long distances of water conveyance. Salinity is of particular concern because source water high in salinity can cause damages to residential and industrial plumbing fixtures, destroy crops, and prevent the City from using its reclaimed water to its fullest potential.

In addition to reliability issues, the cost of imported water has increased significantly and is expected to continue to increase into the future. From 2007 to 2012, MWD's imported water costs increased over 12 percent annually and MWD projects its 2014 full service water rate to be 7 percent greater than its 2012 rate. Going forward, SDCWA untreated water rates are expected to double in the next twenty years[1]; however projections are uncertain and it is possible that increases could occur even faster. Overall, projected imported water costs are expected to continue to increase faster than inflation, particularly given the major multi-billion dollar improvements needed to solve the Delta conflicts. Finally, there are numerous institutional issues that cause uncertainty in imported water supplies, which mainly center around MWD's rate structure, wheeling, and drought allocation. The MWD and the SDCWA disagree on many of these issues.

In addition to imported water concerns, the City must consider the following key initiatives and issues regarding development of local water resources:

- **Limited Freshwater Resources:** Located in the semi-arid desert region of the southwestern United States where rainfall averages only 10 inches per year on the coast, San Diego's local water availability has always been an issue. The City effectively captures the majority of rainfall in the region in its reservoir network for water supply purposes, but has limited opportunities for additional surface water and groundwater supplies (there are some opportunities but the new yields are small compared with overall water needs).

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[1] Based on assumed future escalation rates provided to SDPUD by SDCWA staff in June 2011 for the *Water Demand Forecast Sensitivity Analysis* dated July 2011.

- **Emergency Storage:** According to City Council Policy 400-04, the City must meet requirements for emergency storage equal to six-tenths of annual demands (or enough water to meet demands for 7.2 months) in order to be prepared for catastrophic events, such as seismic events that interrupt supply from imported water pipelines. The City has been meeting this requirement. However, in the future, storage requirements will increase with increasing demands.
- **Water Quality:** The City has been investigating the possibility of developing local groundwater supplies. In some basins, this presents a challenge due to its salinity and nitrates, requiring blending with other sources (such as the raw water system) or groundwater treatment.

  Another water quality consideration for the City is Total Maximum Daily Load (TMDL) requirements. With over 93 miles of shoreline, there are water quality challenges due to urban stormwater runoff that picks up pollutants prior to discharging to streams, surface reservoirs, bays, lagoons and the ocean.

Point Loma WWTP

- **Wastewater Discharges:** The City has been treating wastewater at the Point Loma Wastewater Treatment Plant (Point Loma) since 1963. The federal Clean Water Act (CWA) was passed by Congress in 1972 requiring wastewater treatment plants to provide secondary treatment but allowing certain ocean dischargers to apply for waivers. The City was sued by the U.S. Environmental Protection Agency (EPA) and environmental groups in 1987 for violations of the CWA after submitting and then withdrawing a waiver application. Congress passed the Ocean Pollution Reduction Act (OPRA) in 1994 allowing the City to continue to apply for a Modified Permit which allows the discharge of chemically enhanced primary treated (CEPT) wastewater into the ocean. Through the OPRA legislation section 301 subsection "(h)" of the CWA was amended to allow facilities that discharge to certain marine waters to re-apply for a modified National Pollutant Discharge Elimination System (NPDES) permit, waiving secondary treatment requirements. The EPA has granted the City NPDES permit renewals in 2002 and again in 2010.

Conservation Garden

Watershed Signage

  During the 2010 Permit renewal application process, San Diego Coastkeeper and the San Diego Chapter of Surfrider Foundation entered into a Cooperative Agreement (Agreement) with the City to conduct a Recycled Water Study (RWS) with the objective of identifying ways to maximize reuse and minimize flows to Point Loma. The City Council approved the Agreement in January 2009. In accordance with the Agreement, both environmental organizations provided their support to EPA's decision to grant the modified permit in exchange for the City conducting the Recycled Water Study (RWS). In 2010, the EPA granted the City's its second 301 (h) modification to its Permit, allowing the City to continue to operate Point Loma as a CEPT facility. The current permit expires on July 31, 2015.

- **Conservation Mandates:** In 2009, Senate Bill 7 as part of the Seventh Extraordinary Session (SB7-7) was passed as part of a comprehensive legislative package to improve the state's water supply reliability and restoration of the Sacramento-San Joaquin Delta. SB7-7 includes the Water Conservation Act of 2009 (also known as California's "20x2020" plan), which requires that statewide per capita water use be reduced by 20 percent by the year 2020.

- **Climate Change:** Climate change is important to long-term planning since it could change hydrologic conditions and increase the need for new programs or investments that are resilient to climate variability in the future. While potential impacts of climate change are a global-scale concern, they are particularly important in the Pacific Coast region of the United States, which is one of the areas showing the most change with the greatest implications to water resources. For San Diego, climate change can impact water demands, local water supplies and availability of imported water.

ES.1.3 Purpose of 2012 Long-Range Water Resources Plan

Prudent planning is needed to address these critical water supply issues for San Diego. A safe, reliable, cost-effective water supply is one of the most fundamental services necessary to support the City's economic prosperity. Without a reliable water supply, public health is in jeopardy, businesses relocate to other cities, the tourism industry suffers, and overall quality of life is affected.

The SDPUD's vision is to be an industry leader in the delivery of water, wastewater and recycled water services. As such, the City is taking a proactive step in preparing this 2012 Long-Range Water Resources Plan (LRWRP). The 2012 LRWRP is a high-level strategy document intended to provide information to decision-makers regarding the tradeoffs of future water resource investments, with a long-range viewpoint through the year 2035 planning horizon. The 2012 LRWRP evaluates water supply and conservation options with consideration of multiple planning objectives. The plan was developed using an open, participatory planning process, with input from a dedicated Stakeholder Committee. The outcome of the 2012 LRWRP is a flexible and adaptive implementation strategy that accounts for future risk and uncertainty.

The City developed its first LRWRP in 2002, which provided direction for the City to pursue additional conservation, recycled water, and groundwater; with consideration of implementing potential water transfers, marine transport, and ocean desalination options if warranted. The City has been working hard to meet the resource targets outlined in the 2002 LRWRP. In the last ten years, however, several changed conditions made updating the LRWRP important. These included:

- MWD/SDCWA imported water reliability issues surrounding the Delta and Colorado River, especially in the areas of the Endangered Species Act
- Climate change and its potential impacts on water demands and supplies
- New approaches and public support for indirect potable reuse, using advanced purification of recycled water
- Viability of water transfers, marine transport and ocean desalination

As such, the 2012 LRWRP aims to re-assess planning objectives and stakeholder values, evaluate emerging issues, and use the most recent information available to determine a long-term water resources strategy for the City. The 2012 LRWRP uses the latest projections of water demands, imported water availability, and costs; and evaluates new supply opportunities that were not considered in the 2002 LRWRP. The 2012 LRWRP will chart a course for the City's water resources using the best information currently available, with a flexible and adaptive implementation strategy that accounts for the key uncertainties in current planning assumptions.

ES.2 2012 LRWRP Process

The 2012 LRWRP was developed using an open, participatory planning process. Stakeholder collaboration was essential to the success of this plan's development. Throughout the process, the following terminology was used:

Objectives	***Represent major goals of plan, defined in broad, understandable terms (e.g., ensure water reliability)***
Performance Measures	***Indicate how well an objective is being achieved (e.g., frequency and magnitude of water shortages; or total lifecycle cost)***
Options	***Represent individual water supply projects or demand-side management measures***
Portfolios	***Represent combinations of options designed to best meet the stated objectives, and will be evaluated in terms of metrics***

ES.2.1 Stakeholder Involvement

At the start of the 2012 LRWRP process, the City formed a Stakeholder Committee that represented a wide range of interests and backgrounds in order to help guide the development of the plan. Members of the Stakeholder Committee included individuals from the following groups: San Diego County Taxpayers Association, Independent Rates Oversight Committee, San Diego Regional Chamber of Commerce, Building Industry Association of San Diego, San Diego Coastkeeper, American Society of Landscape Architects, City Representative to the SDCWA Board, and San Diego Section of the American Planning Association. A total of five 2012 LRWRP Stakeholder Committee meetings were held over a period of approximately one year with the following goals:

1. Establish need for 2012 LRWRP and define goals and objectives;
2. Review water supply and conservation options, and develop initial portfolios;
3. Review evaluation of portfolios and provide comments on how to move forward;
4. Review adaptive management approach and obtain consensus on recommended strategy; and
5. Review draft 2012 LRWRP and provide final comments/suggestions.

After the third stakeholder meeting, one-on-one conversations were held with all stakeholders in which several questions were asked about the process thus far, and to ascertain whether the information provided to date was understandable, fair, objective and useful in the context of developing the 2012 LRWRP. The results of these one-on-one stakeholder conversations indicated that stakeholders felt the process was informative, objective, and very useful in the context of preparing the 2012 LRWRP. The stakeholders were also in general agreement with the overall evaluation process and findings to date.

ES.2.2 2012 LRWRP Objectives

Planning objectives indicate the goals of the 2012 LRWRP stated in broad, understandable terms. A brainstorming session was held early in the process with the Stakeholder Committee to identify and define the objectives. After some refinement, the 2012 LRWRP objectives were defined as:

- Provide Reliability and Robustness
- Manage Cost and Affordability
- Maximize Efficiency of Water Use
- Provide for Scalability of Implementation
- Maintain Current and Future Assets
- Provide for Local Control/ Independence
- Maximize Project Readiness
- Protect Quality of Life
- Protect Habitats and Wildlife
- Reduce Energy Footprint
- Protect Quality of Receiving Waters

Because not all stakeholders will view these objectives in the same way, with respect to relative importance, a weighting exercise was conducted. Each stakeholder was given a weighting form in which they allocated 100 points among the objectives in relation to their importance. The result of this weighting is shown in Figure ES-3, where the vertical line represents the range of weights assigned to each objective by all stakeholders, the diamond marker indicates the average (or mean) weight, and the square marker shows the median (half of respondents fall above, half fall below) for all stakeholders. Except for the reliability objective, the overall spread of the minimum and maximum weights are relatively close, indicating general consensus among the group on the importance of the objectives.

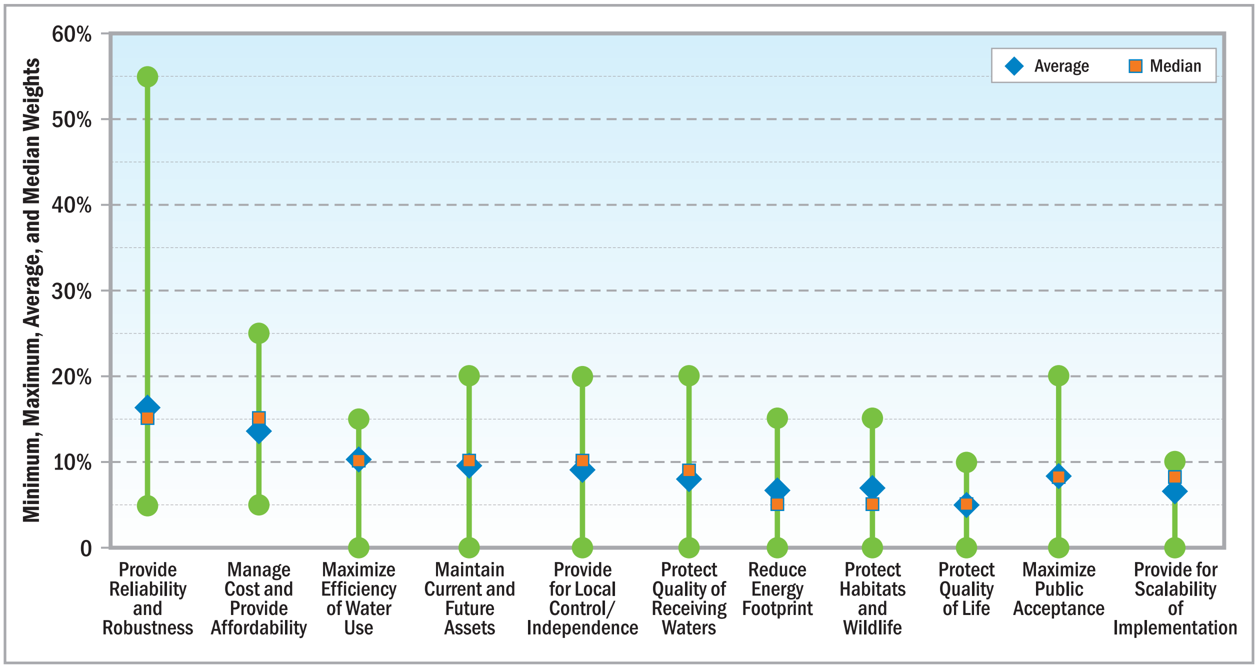

Figure ES-3: Comparison of Objective Weights for the 2012 LRWRP Stakeholder Committee

For each objective, several sub-objectives and performance measures were established that would indicate how well the objective was being achieved. The following provides an example of this for the reliability objective:

Primary Objective	Sub-objectives	Performance Measures
Provide a reliable water supply	Water shortages over planning horizon	Total water shortages in acre-feet (AF) over the planning horizon
	Resilience to climate change	Hydrologic Variability Score (1 to 5), 1 - high variability, 5 - low variability
	Ratio of emergency supply to six month demand	Average percentage of emergency supply to six month demand over the planning horizon (%)

In total, over 20 separate performance measures were established for the objectives and would be used to evaluate alternatives to develop the 2012 LRWRP strategy.

ES.2.3 2012 LRWRP Evaluation Process

Because of the complexity of the City's water, recycled water and wastewater systems, and due to the highly variable nature of local and imported water supplies, a sophisticated evaluation process was required to develop the 2012 LRWRP. This evaluation process relied on engineering expertise, past technical studies conducted by the City on various water supply alternatives, sound water demand forecasting, and the use of simulation models and decision tools.

During the development of the 2002 LRWRP, the City made a significant investment to develop a comprehensive system simulation model called San Diego Simulation (SDSIM). This model simulates water demands, local supplies and imported water availability under various hydrologic conditions and scenarios. The model routes local and imported water through the City's complex delivery system matching water demands along the way. The model tracks lifecycle costs (capital and O&M), water quality, storage operations, and other metrics such as greenhouse gas emissions. For the 2012 LRWRP, the model was enhanced to estimate the impacts of climate change on system reliability.

Because SDSIM produces output in various raw measurements (e.g., cost in dollars, flows in acre-feet per year, greenhouse gas emissions in metric tons), a decision software tool called Criterium Decision Plus (or CDP) is needed to standardize the outputs, align them to the planning objectives, and to apply stakeholder weights for the objectives. The process used by CDP to rank alternatives is called multi-attribute rating, a standard approach used for multi-criteria decision-making.

Figure ES-4 presents the overall evaluation process used to develop the 2012 LRWRP. It starts with the definition of planning objectives and performance measures, and the identification of water supply and conservation options (the building blocks for how the plan will be accomplished). Because no single water supply option can meet all of the goals of the 2012 LRWRP, options were combined in different ways to form portfolios. Much like a stock portfolio, a resource portfolio represents a diversified approach to meeting

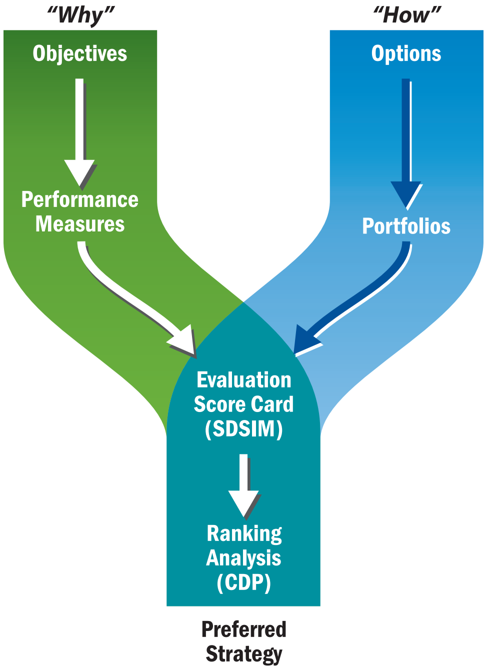

Figure ES-4: LRWRP Evaluation Process

the objectives of the plan. Stakeholders helped define how the portfolios would be assembled from the list of options. These portfolios were then input into SDSIM. Each portfolio was run against multiple hydrologic scenarios (wet, normal, dry, critically dry) and the output was synthesized and input into CDP. CDP standardized all of the raw performance metrics from SDSIM so they could be added together, aligned to objectives, and weighted. CDP produced an overall weighted score so portfolios could be ranked. Several initial portfolios were tested first, then based on their performance, several hybrid combinations were developed.

ES.3 Water Supply Options and Portfolios

ES.3.1 Water Supply Options

Using information from a variety of sources, including the 2002 LRWRP, 2010 UWMP, Water Conservation Update, technical groundwater studies and recycled water plans prepared over the last several years by SDPUD, and other reports and technical information, over 20 water supply and conservation options were identified for the 2012 LRWRP. Because of the high-level, strategic nature of this plan, these options are considered conceptual in nature—although some have more technical robustness than others. Before any specific project recommendations are made concerning these options, further detailed study would be required including engineering design, environmental/permitting, refined cost estimation, facility layouts, and rate justification.

Table ES-2 presents the range of water supply and conservation options and their planning-level supply yields and costs in today's dollars. The unit cost, expressed as dollars per acre-foot of supply produced, incorporates the cost of supply development (capital, O&M and energy), water distribution, and wastewater conveyance, treatment and discharge. This reflects the full cost and puts all options on the same level.

Table ES-2: Range of Options Considered

Supply Category	Number of Options	Range of Supply Yields (AFY)	Range of Unit Cost ($/AF)
Conservation Increase local conservation programs within San Diego	2	6,750 – 14,150	$200 –$500
Groundwater Increase groundwater supply within San Diego	6	500 – 10,000	$1,400 - $4,100
Recycled Water for Non-Potable Reuse[1] Increase reuse of treated wastewater for non-potable applications such as landscape irrigation	2	2,700 – 5,500	$2,100-$10,900
Recycled Water for Indirect Potable Reuse[1] Reuse of purified treated wastewater for indirect potable reuse	3	16,800 – 93,000	$2,100 - $4,700
Rainwater Harvesting Capture of urban runoff for water supply	2	100 - 416	$6,400 - $19,800
Graywater Non-sewage, on-site household wastewater that can be reused for non-potable uses	1	2,575	$13,500
Ocean Desalination Pay higher purchase cost to SDCWA in exchange for more reliable ocean desalination water	1	10,000	$3,100
Imported Water Increased imported water purchases from SDCWA	1	As Needed and Available	$1,700
Other Concepts Considered Other groundwater, recycled, imported, etc.	6	NA	NA
Total:	24	100 – 56,000	$200 - $19,800

AF = acre-feet   AFY = acre-feet per year   NA = Not Available

[1] Unit costs represent those used at the time of 2012 LRWRP analyses and are not based on most recent information available. Refer to Table 4-8b for the latest information available for these options

In addition to costs, another important consideration for the City in the development of the 2012 LRWRP was greenhouse gas emissions. Reporting of greenhouse gases by major sources is required by the California Global Warming Solutions Act (AB 32, 2006). The City's reliance on imported water that originates hundreds of miles away, and requires energy-intensive pumping, contributes significantly to greenhouse gas emissions. Figure ES-5 presents the greenhouse gas emissions per acre-foot of water supply for each of the options. Note that some options do not generate product water that is used indoors and enters the wastewater system; therefore, they do not produce greenhouse gas emissions associated with wastewater treatment.

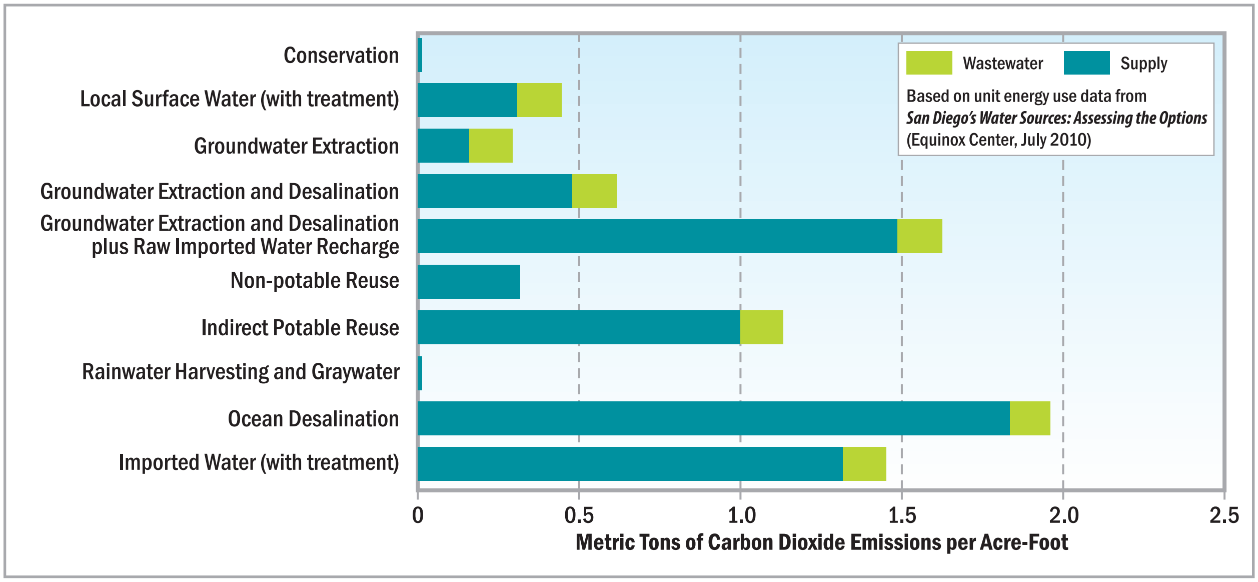

Figure ES-5: Greenhouse Gas Emission Produced by Various Water Supply Options
(Note: Emissions for imported water based on energy use of 3300 Kwh/acre-foot, reflecting pumping from Bay-Delta)

ES.3.2 Resource Portfolios

As stated previously, since no single supply option can meet all the objectives of the 2012 LRWRP, portfolios representing various combinations of options were developed. Stakeholders helped define how the initial portfolios were developed and which options were to be included. Based on the initial evaluation of these portfolios, the City/consultant team developed several hybrid portfolios. The portfolios are summarized below[2]:

- **Baseline (Status Quo):** Only existing water supply and conservation is included in this portfolio. Overtime, the reliance on imported water from the SDCWA will increase to meet growing water demands.
- **Maximize Reliability:** Options included in this portfolio are those that have little to no hydrologic variability (and therefore not subject to droughts or climate change), and are owned/operated by the SDPUD or the SDCWA. Options that rely solely on consumer behavior or customer maintenance are not included as they are not as reliable into the future.
- **Minimize Cost:** Options included in this portfolio are those that have a unit cost ($/AF) less than projected cost of imported water from the SDCWA.

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[2] Refer to Table 5-3 for a detailed matrix of which individual options are included in each portfolio

- **Minimize Local Environmental Impacts:** Options included in this portfolio are those that produce lower amounts of greenhouse gases (compared to imported water), those that have minimal or easily mitigated habitat impacts, and those that improve receiving water quality (rivers, streams, bays and natural groundwater).
- **Maximize Local Control:** Options included in this portfolio are those in which SDPUD and the City have control over in terms of cost, development and operations into the future.
- **Maximize Water Use Efficiency:** Options included in this portfolio are those that increase the efficiency of how water is used in the service area, including all levels of conservation, reuse, and rainwater harvesting.
- **Hybrid 1:** This portfolio builds off the Minimize Cost Portfolio by adding the Phase 1 Indirect Potable Reuse project.
- **Hybrid 2:** This portfolio builds off the Maximize Water Use Efficiency portfolio by adding groundwater projects, but removing non-potable reuse with satellite treatment plants, graywater, and centralized stormwater capture.

ES.4 Evaluation and Ranking of Portfolios

ES.4.1 Portfolio Ranking and Sensitivity

Over 20 performance measures were used to comprehensively evaluate each of the portfolios. These performance measures, detailed in Section 5, were aligned to planning objectives. Raw performance scores for reliability, cost, water quality, greenhouse gas emissions, and others metrics were standardized to a unitless scale so they could be added together. Then portfolios could be ranked based on their performance in meeting the objectives and the relative importance (or objective weight). Figure ES-6 presents the ranking of the portfolios based on the average stakeholder objective weights. The longer the color bar segment, the better the performance is in achieving each objective.

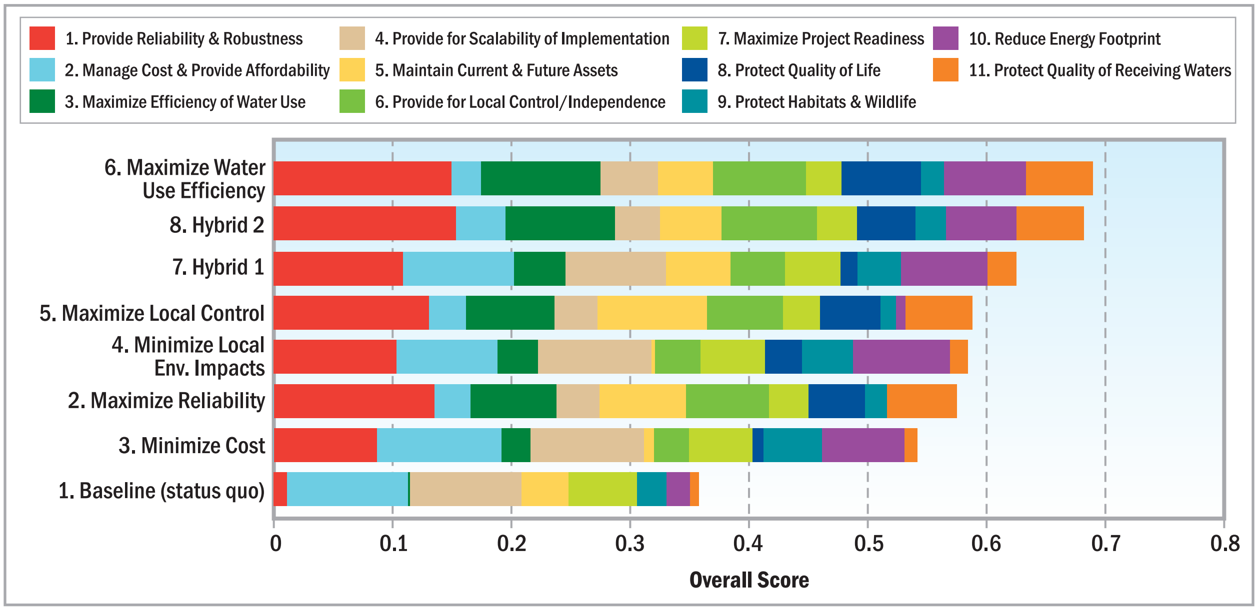


Figure ES-6: Portfolio Rankings with Average Stakeholder Committee Weights

The power of this approach is that stakeholders and decision-makers can clearly see trade-offs between the portfolios. For example, not all the portfolios that had the best performance in terms of reliability & robustness (dark red bar) ranked highest. Portfolio number 2 "Maximize Reliability" had one of the best performance for reliability, but ranked 6th overall. This is because it was one of the most expensive portfolios (as indicated by its poor performance for managing cost) and also because it was very energy intensive and produced significant greenhouse gas emissions. Another interesting finding is the difference between portfolios Hybrid 1 and Hybrid 2, which ranked number 3 and 2, respectively. While Hybrid 2 had a better reliability performance, Hybrid 1 had a much better cost performance.

Sensitivity analyses were performed in order to assess whether the rankings are robust under different objective weighting scenarios. In addition, since long-term planning requires forecasting variables that are uncertain, sensitivity analyses were performed to assess the rankings under future uncertain conditions. The following sensitivity analyses were performed:

1. **Revised Weights (from Figure ES-3):** Reliability and Cost objective weights were revised from 17 percent and 14 percent, respectively, to 23 percent weight each, and all other objectives were given a 6 percent weight

2. **Delta Fix:** No imported water shortages would be projected, although this assumes higher imported costs
3. **Higher Energy Costs**: Assume 30 percent higher energy costs, which affect cost of operations
4. **Lower Treatment Technology Costs:** Assume 30 percent lower operation cost for advanced treatment technologies used for indirect potable reuse and brackish groundwater treatment
5. **Revised Weights and Delta Fix:** Combines the first two sensitivity conditions

The findings for each weighting sensitivity scenario are summarized in Figure ES-7. The columns of the table represent the portfolios, the rows represent the sensitivity scenarios, and the number shows the rank order of the portfolio (1 being the best). The weighting scenarios are compared to the baseline rankings. The sensitivity results show that the top three portfolios are consistently Maximize Water Use Efficiency, Hybrid 2, and Hybrid 1 under all the sensitivity scenarios.

	6. Max Water Use Efficiency	8. Hybrid 2	7. Hybrid 1	5. Max Local Control	4. Min Local Env Impacts	2. Max Reliability	3. Min Cost	1. Baseline (status quo)
Baseline Ranking	1	2	3	4	5	6	7	8
Objective Weights	2	1	3	5	7	4	6	8
Delta Fix	1	2	3	5	4	6	7	8
Energy Cost	1	2	3	4	5	6	7	8
Treatment Tech	1	2	3	4	5	6	7	8
Objective Weights + Delta Fix	3	1	2	6	4	7	5	8

Figure ES-7: Portfolio Rankings under Sensitivity Conditions

ES.4.2 Climate Change Adaptation

In developing any long-term water supply plan, water utilities in California should consider the potential impacts of climate change. Climate change is important to long-term planning since it could change hydrologic conditions and increase the need for new programs or investments that are resilient to climate variability in the future. While the potential impacts of climate change are a global-scale concern, they are particularly important in the Pacific Coast region of the United States, which is one of the areas showing the most change with the greatest implications to water resources.

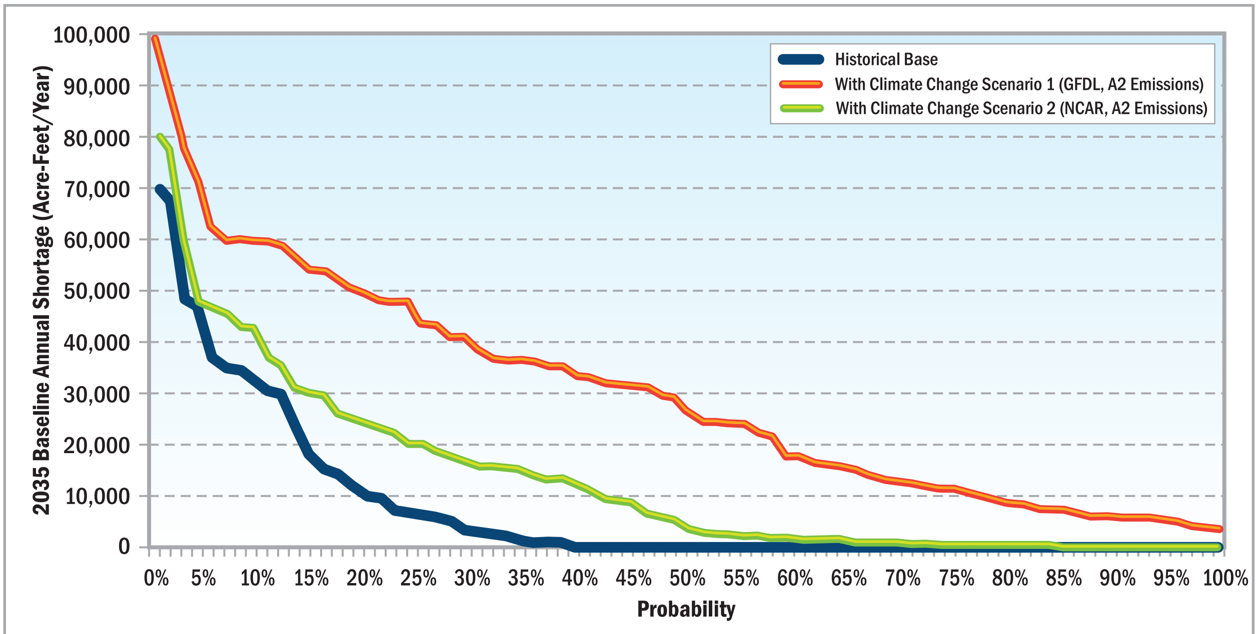
For San Diego, climate change can impact water demands, local water supplies and availability of imported water. To analyze climate change impacts, two climate change scenarios were used that are based on general circulation models downscaled to San Diego region by the Scripps Institution of Oceanography. These two climate scenarios represent a realistic lower and upper range of potential impacts. Figure ES-8 summarizes the impacts of these two climate change scenarios on local weather, local surface water, and imported water availability.

The impacts that changes in local weather will have on the City's water demand ranges from a 0.5 to 4 percent increase by 2035. This coupled with changes in local surface water and imported water availability results in changes in water supply reliability for the City, as shown in Figure ES-9. What is shown in Figure ES-9 is the likelihood and magnitude of water shortages in the year 2035 under the Baseline (status quo) portfolio, assuming no Delta fix. Under no climate change, overall water shortages for the City are estimated to occur roughly 1 in 3 years (33 percent) and the maximum shortage would be approximately 70,000 AFY (which is approximately 23 percent of projected 2035 baseline demands). The GFLD[3] climate scenario, characterized as being very warm and dry, would result in some type of shortage happening every year with a maximum shortage of approximately 100,000 AFY. The NCAR[4] climate scenario, characterized as being warm and wet, would result in shortages happening every 2 of 3 years (66 percent) with a maximum shortage of approximately 80,000 AFY.

Impact by 2035	**Climate Scenario 1 (GFLD)**	**Climate Scenario 2 (NCAR)**
Local Temperature (change from historical average)	+5% ↑	+3% ↑
Local Rainfall (change from historical average)	+1% ↔	+13% ↑
Local Water Demands (increase from historical normal)	+3.8% ↑	+0.5% ↔
Local Surface Water (change from historical average)	-7% ↓	+20% ↑
Imported Water (change from historical *normal* year)	-14% ↓	-8% ↓
Imported Water (change from historical *wet* year)	-6% ↓	-3% ↓

🟥 Bad Outcome 🟨 Neutral Outcome 🟩 Good Outcome

Figure ES-8:
Potential 2035 Climate Change Impacts for San Diego Water Supplies



Note: Projected shortages for all probabilities are shown; therefore once the probability of zero shortage is reached, the line extends along the x-axis.

Figure ES-9: 2035 Climate Change Impacts on Baseline Portfolio

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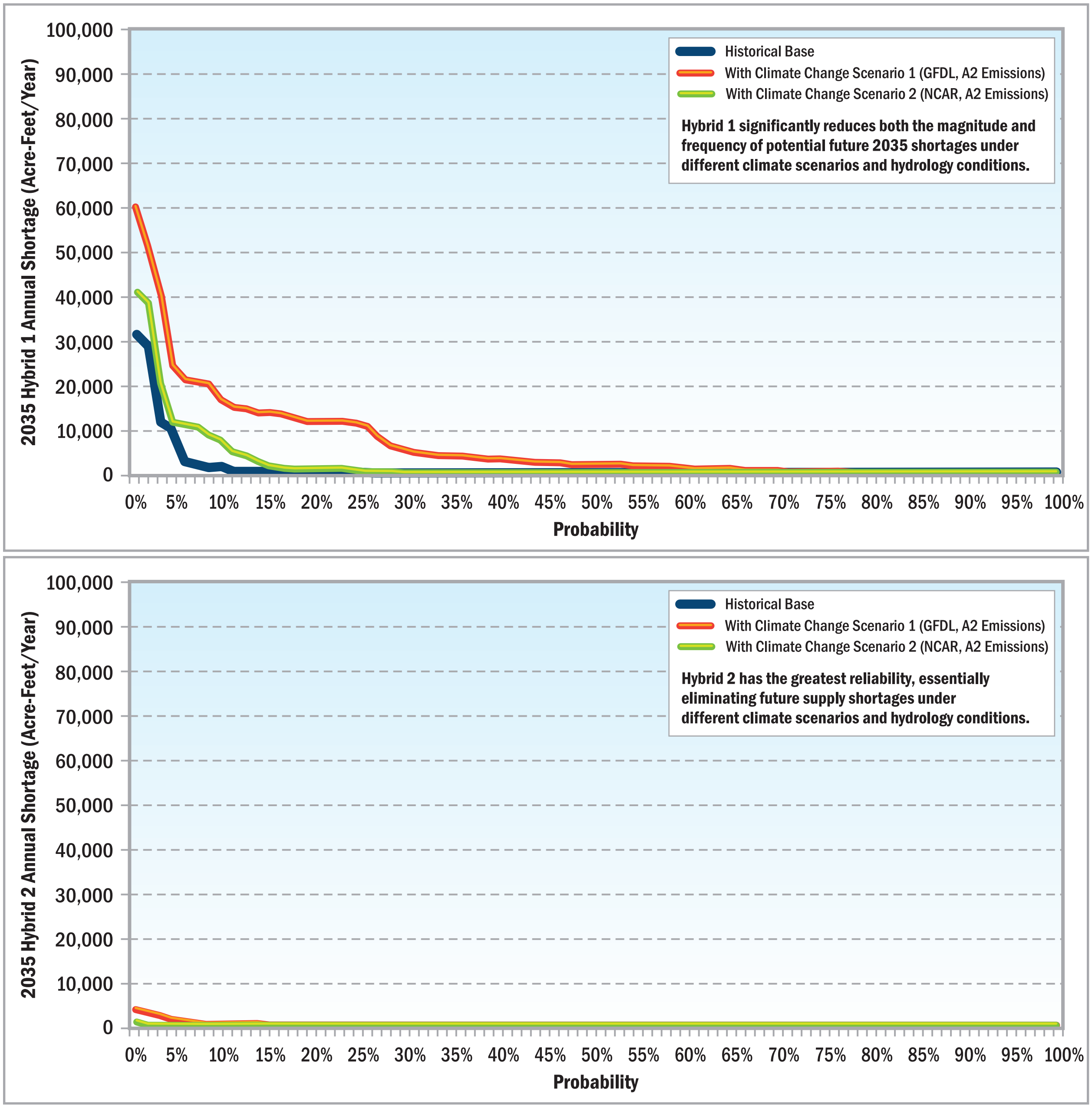
[3] Geophysical Fluid Dynamics Laboratory CM2.1

[4] National Center for Atmospheric Research Parallel Coupled Model

These climate scenarios were also tested against the Hybrid 1 and Hybrid 2 portfolios to evaluate how well they provided adaptation to climate change (see Figure ES-10).

Because Hybrid 2 included more phases of indirect potable reuse (which is very resilient to climate change), it provides almost 100 percent adaptation to climate change impacts. Hybrid 1 provides solid adaptation benefits, just not as great as Hybrid 2, greatly reducing the frequency and magnitude of water shortages shown on Figure ES-9.



Hybrid 1 significantly reduces both the magnitude and frequency of potential future 2035 shortages under different climate scenarios and hydrology conditions.

Hybrid 2 has the greatest reliability, essentially eliminating future supply shortages under different climate scenarios and hydrology conditions.

Figure ES-10: Hybrid 1 and 2 Climate Change Adaptation Capabilities for Supply Reliability

ES.4.3 Ranking Conclusions and Stakeholder Recommendations

Based on the conclusions from the portfolio evaluation and climate change analysis, the Stakeholder Committee recommended that the City develop a long-term strategy around the three top-ranking portfolios using an adaptive management framework.

ES.5 Adaptive Management and 2012 LRWRP Strategy

As discussed previously, eight portfolios were evaluated against more than 20 performance metrics. The portfolios were ranked in terms of their cumulative performance. The portfolios were tested against five sensitivities and re-ranked. Based on these rankings, and their climate change adaptation benefits, three portfolios consistently ranked highest—Hybrid 1, Hybrid 2 and Maximum Water Use Efficiency (Max Efficiency). Table ES-3 summarizes the resource options that are included in these three top-scoring portfolios.

Table ES-3: Resource Options Common to Top-Scoring Portfolios

Resource Options	Hybrid 1	Hybrid 2	Max Efficiency
Active Conservation with Water Pricing Effects[1] –20,900 AFY	■	■	■
Groundwater (either San Pasqual, Santee-El Monte, or Mission Valley) – up to 4,000 AFY	■	■	■
Groundwater in San Diego Formation – additional 10,000 AFY		■	
Indirect Potable Reuse (Phase 1) – 16,800 AFY	■	■	■
Indirect Potable Reuse (Phases 2 and 3) – up to additional 76,200 AFY		■	■
Non-Potable Reuse from Satellite Plants – 5,500 AFY[2]			■
Rainwater Harvesting – 420 AFY	■	■	■
Rainwater Harvesting – Additional 100 AFY			■

🟨 Options common to top-scoring portfolios

[1] Based on City of *San Diego Water Demand Forecast Sensitivity Analysis* dated July 2011, which evaluates the responsiveness of water demands to changes in the marginal price of water.

[2] Assumes yield from new satellite plants is additive to indirect potable reuse projects (they are not mutually exclusive).

Because there are more resource options in common among the three top-ranking portfolios, the City developed a strategy that uses adaptive management for the implementation of options.

ES.5.1 Adaptive Management

For purposes of the 2012 LRWRP, adaptive management is defined as a process in which options are implemented in a phased and incremental manner based on the outcome of identified future conditions or "risk triggers". Adaptive management balances the cost of option implementation with the risks of no action. Figure ES-11 presents an overview of adaptive management, which has four major steps:

Step 1 Analyze trade-offs in terms of benefits and costs for the top-scoring portfolios.

Step 2 Determine no regret options that perform the best under most scenarios or sensitivities. This is based on the portfolio rankings in Section 6, as well as the trade-off analysis in Step 1 of adaptive management.

Step 3 Establish near-term actions required to implement the no regret options.

Step 4 Develop risk triggers (points of uncertainty, along with projected possible outcomes) to determine future alternative paths of implementation for the remaining long-term options.

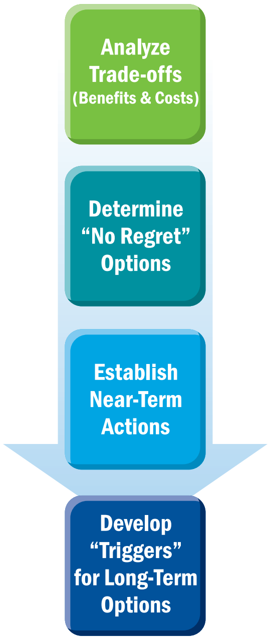


Figure ES-11: Adaptive Management Overview

Although the three top-scoring portfolios have more in common than not in common, the total lifecycle costs in present value terms is very different. As such, it is important to analyze the trade-offs in terms of benefits and costs. Three main benefits were aggregated from key objectives and performance measures; these three benefits were then analyzed in comparison with costs:

1. Supply Reliability Benefit – representing drought supply protection, emergency storage, and resiliency to climate change
2. Environmental Benefit – representing local habitat impacts and greenhouse gas emissions
3. Water Quality Benefit – representing receiving water quality (from wastewater and stormwater discharges), groundwater basin quality, and salinity in drinking water.

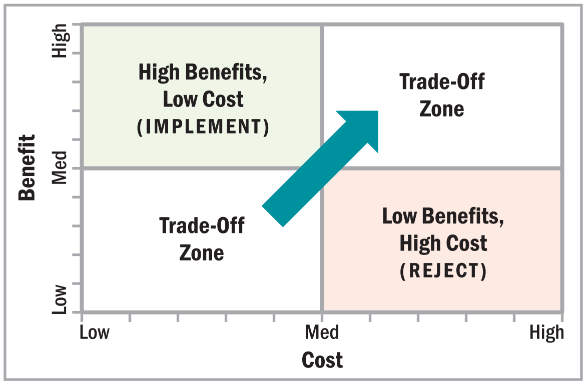


Figure ES-12: Benefit-Cost Trade-Off Analysis

For ease of comparison, all three benefits were normalized to a score ranging from 0.0 (no benefit) to 1.0 (maximum achievable benefit). For each of the benefit categories, the three top-scoring portfolios and the status quo (do nothing alternative) were plotted on a chart with benefit on the vertical axis and total lifecycle cost on the horizontal axis. This produces a four quadrant analysis that indicates the overall benefit-cost trade-off. Figure ES-12 presents an example of this quadrant analysis.

Portfolios that fall into the upper left quadrant (high benefit, low cost) are the best alternatives and should be implemented with priority. Alternatively, portfolios that fall in the lower right quadrant (low benefit, high cost) should be rejected outright. But it is not so apparent whether to implement portfolios that fall in the lower left (low benefit, low cost) or upper right (high benefit, high cost) quadrants because this is where trade-offs are made. For example, is it worth increasing supply reliability by 30 percent for a 40 percent increase in cost?

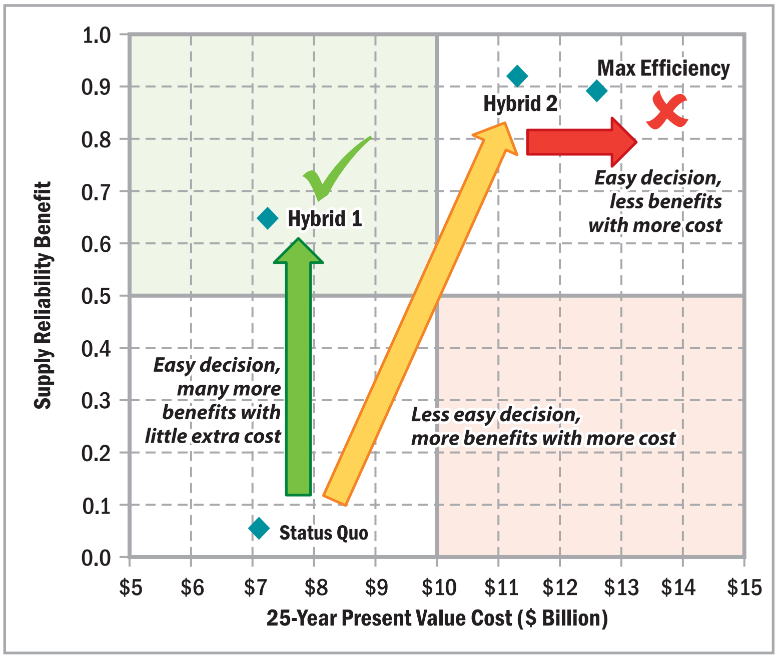


Figure ES-13: Reliability Trade-Off Analysis

Figure ES-13 presents the results of the trade-off analysis for supply reliability benefit. What is shown in this figure is that moving from the Status Quo to Hybrid 1 greatly improves supply reliability for very little additional life-cycle cost. In fact, Hybrid 1 has a 10-fold increase in reliability benefits for only a 3 percent increase in cost compared to the Status Quo. From a supply reliability perspective only, implementing Hybrid 1 over the Status Quo is an easy decision. But moving from the Status Quo to Hybrid 2 is not as easy of a decision. Supply reliability is increased 14-fold, but cost increases by almost 60 percent. Furthermore, the decision to not implement the Max Efficiency Portfolio is an easy decision because it produces no more supply benefit than Hybrid 2 but costs more.

Based on the other trade-off analyses, no regret options were recommended by the Stakeholder Committee for initial implementation. These no regret options include:

- Additional water conservation
- Additional groundwater investments
- Phase 1 indirect potable reuse
- Rainwater harvesting

Beyond the near-term, Stakeholders recommended that other options should be implemented based on outcomes of future triggers. The Stakeholder Committee identified the following triggers for consideration in the 2012 LRWRP strategy:

Table ES-4: Risk Triggers and Implications

Major Risk Trigger	Uncertainty	Implication or Impact
1. Acceptance	Permitting	Key to implementation of indirect potable reuse
	Customer Acceptance	Key to implementation of indirect potable reuse
	City Council Approval	Needed for large capital expenditures including funding
2. Cost	MWD/SDCWA Water Rates	If imported water rates are higher than expected, additional phases of IPR become more favorable
	Grant Funding	Grants could lower capital costs of more expensive groundwater and indirect potable reuse projects, making them more favorable
	Technology Improvements	Advancements in membrane technology could reduce costs of indirect potable reuse and brackish groundwater desalination
3. Imported Supply	Delta Fix	A Delta fix would improve imported water reliability, making investments beyond Hybrid 1 less favorable
4. Climate Change	Impact to Demands and Supplies	Would increase water demands and reduce water supplies making Hybrid 2 investments more needed
5. Direct Potable Reuse	Regulatory Approval	If DPR is approved by California regulatory agencies, and publicly accepted as well, the City may wish to consider DPR instead of Phase 2 and 3 of IPR

The original Stakeholder Committee recommendations for the 2012 LRWRP included having a phased approach for indirect potable reuse, with the first phase being developed by 2020. Then, if conditions were favorable and warranted, additional phases of indirect potable reuse would be implemented after year 2020. This phased approach for indirect potable reuse was recommended by stakeholders based on their assessment of risk, benefits and costs at the time of this plan's development.

The 2012 LRWRP was prepared over two and half years (2010-2012), drawing upon the best technical assumptions and information available at that time. The analysis conducted and input provided over the course of five stakeholder meetings during the preparation of the 2012 LRWRP are reflected in Sections 1 through 7 of this report.

Since the completion of the 2012 LRWRP technical analysis, several detailed studies and investigations on water reuse options were finalized and adopted by City Council. These source documents, which include the Recycled Water Study and the Water Purification Demonstration Project Report, provide additional information on the length of time necessary to plan, design, and construct potable reuse facilities. These finalized studies and confirmed direction by City Council emphasized a strong water reuse strategy for the City. On April 23, 2013, the City Council directed the San Diego Public Utilities Department (SDPUD) to determine a preferred implementation plan and schedule that considers potable reuse options for maximizing local water supply and reduced wastewater flows to the Point Loma Wastewater Treatment Plant.

Therefore, SDPUD staff modified the stakeholder recommendations, presented in Section 7, for consideration by the City Council's Natural Resources and Culture (NR&C) committee at their July 31st 2013 meeting. The staff recommendation was to consider an alternative implementation strategy that would grant planning level approval to pursuing all three phases of indirect potable reuse, along with the same near-term water resource options that were recommended by the stakeholders. Those stakeholders present at the NR&C committee supported the SDPUD staff recommendations. In addition, a motion was made by a City Council member to change the phrase "indirect potable reuse" to "potable reuse" in order to give the City more flexibility in its water supply options. The NR&C committee unanimously voted to approve the SDPUD staff recommendation and to change the phrase "indirect potable reuse" to "potable reuse" in the staff recommendation.

With NR&C committee motion approved, SDPUD staff has since made changes to the 2012 LRWRP to ensure the NR&C committee actions was consistent with the work done by the stakeholder committee in preparing the 2012 LRWRP. Sections 1 through 6, as well as all technical appendices, were left unchanged—as these sections form the basis of any and all recommendations. Section 7 was slightly modified to remove some of the more detailed phasing of projects, in order to provide more flexibility for implementation of projects by the City. Section 8 was modified to include the NR&C committee approval and final recommendations for the 2012 LRWRP. Finally, appropriate sections of the executive summary were also modified to reflect the changes made to Sections 7 and 8.

On July 31, 2013, the City's Natural Resources & Cultural (NR&C) Committee approved the 2012 LRWRP for full City Council approval with the following implementation strategies:

2013-2020

- Additional Active Conservation – 20,900 AFY (18.7 mgd)
- Rainwater Harvesting – 420 AFY (0.38 mgd)
- Groundwater Supply – up to 4,000 AFY (3.6 mgd)

2013-2035

- Potable Reuse (for all 3 phases) – 93,000 AFY (83 mgd)

On July 15, 2013, the Independent Rates Oversight Committee (IROC) unanimously supported the adoption of the 2012 LRWRP. The project team made a presentation on the 2012 LRWRP to the Natural Resources & Culture Committee (NR&C) on July 31, 2013. At the NR&C meeting, a number of speakers spoke in favor of the 2012 LRWRP, including representatives from San Diego Coast Keeper, Surfrider Foundation and the business community. The speakers told committee members that they supported the 2012 LRWRP and encouraged them to approve the Plan, which they did unanimously. On December 10, 2013, the City Council voted unanimously to adopt the 2012 LRWRP. The City Council resolutions for the 2012 LRWRP Council adoption and the 2012 LRWRP California Environmental Quality Act (CEQA) Exemption are in Appendix I.

Looking forward, the SDPUD will monitor water demand and supplies, climate change, success or failure of a Delta fix in Northern California, regulations, and other factors that could impact reliability for the city. Figure ES-14 outlines an overall adaptive management strategy that will monitor the success of the 2012 LRWRP implementation and make modifications if necessary.

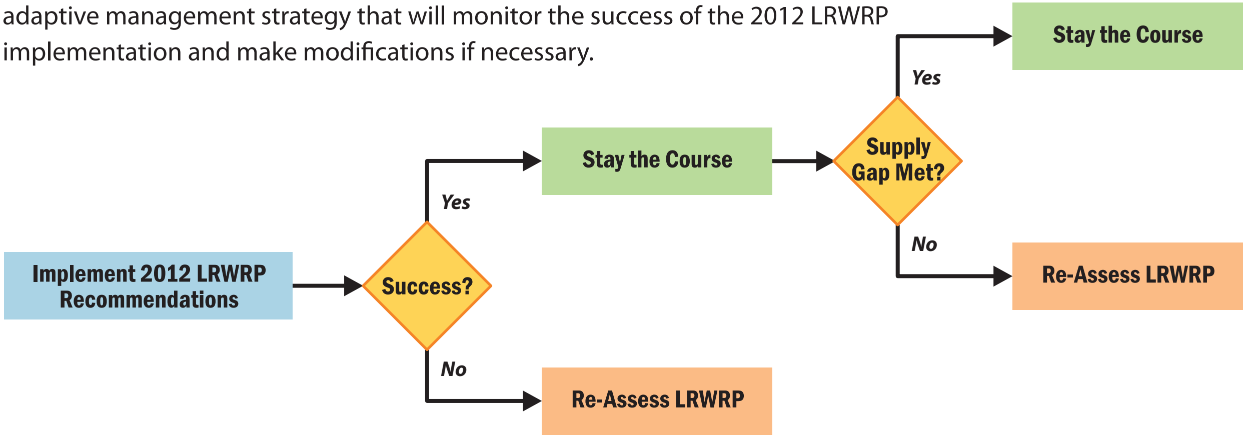


Figure ES-14: Adaptive Management Process for LRWRP

The implementation of the 2012 LRWRP strategies will have numerous benefits for the City of San Diego and its residents. These include:

- Greater water supply reliability and reduced dependency on imported water
- Greater resiliency against climate change and disasters
- Improved water quality, including: (1) that which is delivered to water customers, (2) groundwater quality, and (3) the quality of water discharged to the natural environment from stormwater and wastewater
- Greater local control over how water investments are made, helping to manage costs and maximize city assets

Figure ES-15 presents the water supply mix for the year 2035, assuming drought conditions with climate change. The figure shows that under the current, status quo approach reliance on imported water would be 83 percent, with potential water shortages that approach 80,000 AFY (or 25 percent of water demand). With the LRWRP strategy, reliance on imported water is reduced to 50 percent, and even under droughts and climate change there would be no anticipated water shortages.

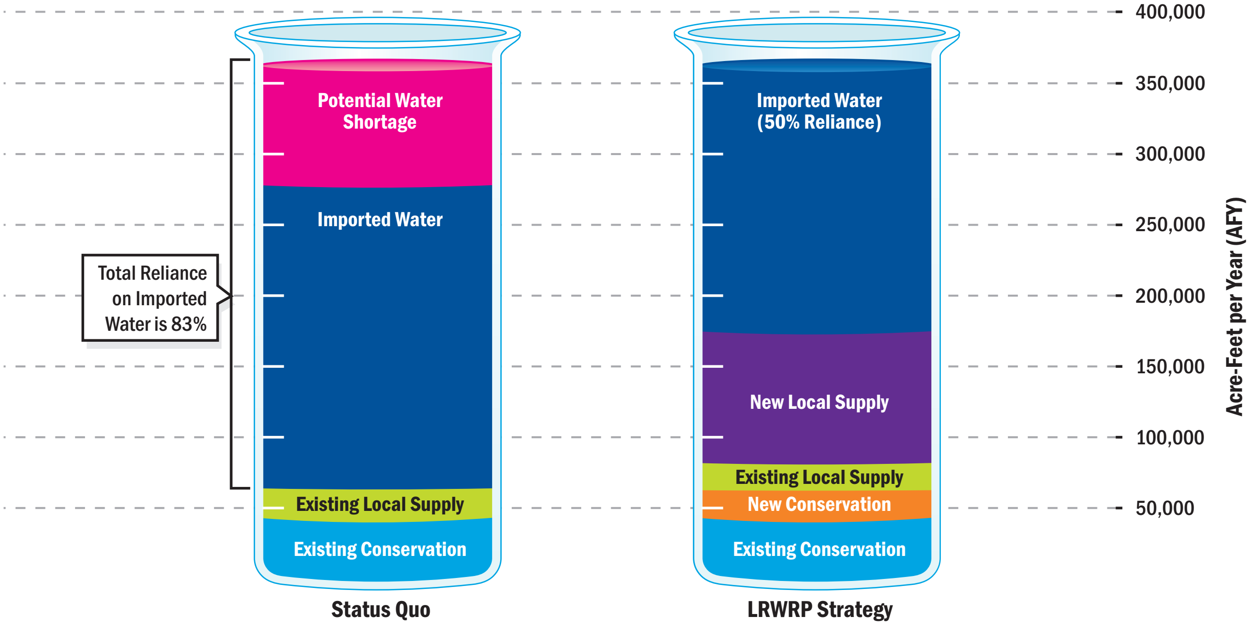


Figure ES-15: Comparison of Water Supply Mix in Year 2035 Under Drought and Climate Change

ES.6 Summary of Recommendations

The following recommendations are made for the 2012 LRWRP and its implementation:

1. Move forward with implementation of recommended strategies that include:
   - Additional Active Conservation – 20,900 AFY (18.7 mgd)
   - Rainwater Harvesting – 420 AFY (0.38 mgd)
   - Groundwater Supply – up to 4,000 AFY (3.6 mgd)
   - Potable Reuse (for all 3 phases) – 93,000 AFY (83 mgd)
2. Assess progress made on implementation of options, and re-assess risk triggers concurrent with the City's UWMP schedule (2020, 2025, 2030, 2035)
3. Update the 2012 LRWRP in 2020 (and every 10 years thereafter), in order to identify new trends, reliability of imported water, and additional resource options.

SECTION 1

Introduction

The City of San Diego (City) has the distinction of being one of the country's most desirable places to live and conduct business because of its climate, economy, and high quality of life. It is the eighth largest city in the United States and the second largest in California. San Diego, located on the coast of the Pacific Ocean and adjacent to the Mexican state of Baja California, is an international city, economically and culturally. The City is known worldwide as a prime tourist destination, and hosts important industries such as telecommunication, biotechnology, software, and electronics[1]. San Diego boasts one of the largest defense and military complexes in the world[2], and its commercial port and location along the United States-Mexico border also make international trade an important part of the City's economy[1].

Although the City is located in a semi-arid coastal climate, it has successfully provided a reliable water supply to its residents for the last 100 years. The City covers approximately 340 square miles and stretches nearly 40 miles from north to south. It is a city defined by varied landscapes – oceans, mountains, mesas, canyons, and estuaries. This varied topography requires sophisticated and innovative water and wastewater systems.

The City of San Diego Public Utilities Department (SDPUD) manages one of the largest water storage, treatment, and delivery systems in the United States. The water system extends over 404 square miles with water deliveries on the order of 200 million gallons per day (mgd). The City also has a separate recycled water distribution system that currently extends over 80 miles and serves an annual average of approximately 7 mgd of water demands within the City and 4 mgd to three wholesale customers.

INSIDE

- *Background*
- *Overview of Water Issues*
- *Purpose of the 2012 Long-Range Water Resources Plan*

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[1] City of San Diego Fiscal Year 2012 Adopted Budget.

[2] San Diego Chamber of Commerce Website. May 4, 2012.
http://www.sdchamber.org/public-policy/regional-issues.html

In addition to securing water supplies for more than 1.3 million residents, SDPUD also manages a regional wastewater system that serves 2.2 million residents in San Diego County.

For the City, the water resources feeding these systems are its lifeblood - water is essential for quality of life. The SDPUD has a mission to:

> ***"… ensure the quality, reliability, and sustainability of water, wastewater, and recycled water services for the benefit of the ratepayers and citizens served."***

The challenge for the City is to excel in its mission in the long-term, given uncertainty of future economic conditions, climate change, regulatory and legal requirements, and reliability and cost of current water supply sources. This section provides a background of the City's service area and water issues, and describes the purpose of developing a 2012 Long-Range Water Resources Plan (LRWRP).

1.1 Background

The City sells water to a population of over 1.3 million, and also sells water to four wholesale customers: raw water is sold to the Santa Fe Irrigation District and San Dieguito Water District, and treated water is sold to the City of Del Mar and California American Water Company (Cal-Am); Cal-Am in turn serves the City of Coronado, City of Imperial Beach, and portions of south San Diego. The City also has an agreement to sell surplus water to Otay Water District, and exchange water to Ramona Municipal Water District.

Table 1-1: City of San Diego Water Service Area Demographics

Service Area	2010	2015	2020	2025	2030	2035	Percent Change 2015 to 2035
Population	1,341,067	1,408,453	1,486,684	1,556,055	1,627,585	1,691,383	20%
Occupied Housing Units	486,104	514,520	549,556	575,908	602,021	625,904	22%
Non-Agricultural Employment	792,931	829,875	870,360	899,356	923,988	948,591	14%
Median household Income ($1999)	$53,859	$57,148	$59,072	$65,799	$71,602	$76,202	33%

Source: SANDAG 2050 Regional Growth Forecast, Series 12. This data was used in the City of San Diego's June 2010 *Update of Long-Term Water Demand Forecast* (refer to Section 2).

Table 1-1 presents demographic data for the City's service area (retail and wholesale), which was obtained from the San Diego Association of Governments (SANDAG). The data are from SANDAG's latest projections, *The 2050 Regional Growth Forecast Update Series* 12, released in February, 2010. The SANDAG data supply the necessary socioeconomic and demographic variables used by water demand forecast models. The City's combined retail and wholesale serviced population is expected to increase from about 1.41 million in 2015 to over 1.69 million in 2035, which is about a 20 percent increase in twenty years.

The City purchases approximately 85-90 percent of its water from the San Diego County Water Authority (SDCWA), which is approximately 73.6 percent of the overall resource mix including conservation and reuse (Brown and Caldwell et al., 2011a). The SDCWA is a wholesale water agency that provided approximately 417,000 acre-feet per year (AFY) of imported water to its 24 member agencies in San Diego County in fiscal year (FY) 2011 (SDCWA, 2011b). A 36-member Board of Directors governs the SDCWA. The City of San Diego is the largest water user within the SDCWA and is represented by 10 Board members. Current water deliveries to the City account for approximately 38 percent of SDCWA's total water sales (SDCWA, 2011b).

The SDCWA, in turn, gets most of its imported water from the Metropolitan Water District of Southern California (MWD), which delivers water to 26 public water agencies and is the largest wholesale water agency in the nation. The Board of Directors at MWD is composed of 37 members. The SDCWA, with four board members, is the largest purchaser of water among MWD's member agencies. The SDCWA purchases approximately 21 percent of MWD's water. However, the SDCWA has preferential rights to about 17.5 percent of MWD supplies, and has about 16 percent of MWD's voting entitlement.

Figure 1-1: Major Water Conveyance Facilities in California

MWD was incorporated by the state Legislature in 1928 to build the Colorado River Aqueduct (CRA), a facility it owns and operates (refer to Figure 1-1). MWD also imports water from Northern California, originating at the Sacramento-San Joaquin River Delta (Delta), through the State Water Project (SWP). MWD currently delivers approximately 1.8-2.1 million AFY of imported water to its customers, but demands vary significantly with weather and economic conditions. MWD's 2010 Integrated Resources Plan Update has targeted a core resources strategy that builds on existing programs in the Colorado River and Northern California, as well as additional conservation and local supply development. Both SDCWA and MWD are actively engaged in regional planning to ensure water supply reliability to its respective customers.

1.2 Overview of Water Issues

1.2.1 Imported Water Issues

All American Canal

Colorado River

California Aqueduct

With such heavy reliance on imported water, the City must examine the various risk elements associated with that supply. A twelve year drought in the Colorado Basin (USBR, 2012), more severe than any other measured in the 20th century, resulted in record lows in Colorado River water levels. Water supply from the SWP has also been significantly reduced due to recent court restrictions to protect fisheries in the Delta and a prolonged statewide drought. These strains on MWD's supply sources have resulted in water allocation limits to its member agencies for the first time since 1991. While other SDCWA supplies help offset some of these shortages, San Diego is located at the "end" of imported water pipelines and is vulnerable to future restrictions – which are projected to be worse in the future with climate change.

Water quality for both the SWP and the Colorado River are also of significant concern to the City, since water quality tends to degrade over long distances of water conveyance. Salinity is of particular concern because source water high in salinity can cause damage to residential and industrial plumbing fixtures, destroy crops, and prevent the City from using its reclaimed water to its fullest potential.

In addition to reliability issues, the cost of imported water has increased significantly and is expected to continue to increase into the future. From 2007 to 2012, MWD's imported water costs have increased over 12 percent annually and MWD projects its 2014 full service water rate to be 7 percent greater than its 2012 rate[3]. Going forward, the SDCWA projects its untreated water rates to double in the next twenty years[4]. Overall, projected imported water costs are expected to continue to increase faster than inflation, particularly given the major multi-billion dollar improvements needed to solve the Delta conflicts.

Finally, there are numerous institutional issues that cause uncertainty in imported water costs and reliability. The institutional issues mainly center around MWD's rate structure, wheeling, and drought allocation. The MWD and the SDCWA disagree on many of these issues.

1.2.2 Local Water Issues

In addition to imported water concerns, the City must consider the following key initiatives and concerns regarding development of local resources:

- **Limited Freshwater Resources:** Located in the semi-arid desert region of the southwestern United States where rainfall averages only 10 inches per year on the coast, San Diego's local water availability has always been an issue. The City effectively captures rainfall runoff in the region for supply purposes, and has limited opportunities for additional surface water and groundwater supplies (there are some opportunities, but the new yields are small compared with overall water needs).

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[3] Source: http://mwdh2o.com/mwdh2o/pages/finance/finance_03.html

[4] Based on water rate data provided by SDCWA to SDPUD.

- **Emergency Storage:** According to Council Policy 400-04, the City must meet requirements for emergency storage equal to six-tenths of annual demands (or enough water to meet demands for 7.2 months) in order to be prepared for catastrophic events, such as seismic events that interrupt supply from imported water pipelines. The City is meeting this requirement. However, in the future, storage requirements will increase with increasing water demands.
- **Water Quality:** The City has been investigating the possibility of developing local groundwater supplies. In some basins, this presents a challenge due to its salinity and nitrates, requiring either blending with other sources of water (such as the raw water system) or groundwater treatment.

  Another water quality consideration for the City is Total Maximum Daily Load (TMDL) requirements. With over 93 miles of shoreline, there are water quality challenges due to urban stormwater runoff that picks up pollutants prior to discharging to streams, surface reservoirs, bays, lagoons and the ocean. Rainwater harvesting options that capture this runoff may not be cost-effective from a supply perspective, but if a stormwater project is identified for water quality improvements and also provides supply, there would be dual benefits.
- **Wastewater Discharges:** The City has been treating wastewater at the Point Loma Wastewater Treatment Plant (Point Loma) since 1963. The federal Clean Water Act (CWA) was passed by Congress in 1972 requiring wastewater treatment plants to provide secondary treatment but allowing certain ocean dischargers to apply for waivers. The City was sued by the U.S. Environmental Protection Agency (EPA) and environmental groups in 1987 for violations of the CWA after submitting and then withdrawing a waiver application. Congress passed the Ocean Pollution Reduction Act (OPRA) in 1994 allowing the City to continue to apply for a Modified Permit which allows the discharge of chemically enhanced primary treated (CEPT) wastewater into the ocean. Through the OPRA legislation section 301 subsection "(h)" of the CWA was amended to allow facilities that discharge to certain marine waters to re-apply for a modified National Pollutant Discharge Elimination System (NPDES) permit, waiving secondary treatment requirements. The EPA has granted the City NPDES permit renewals in 2002 and again in 2010.

  During the 2010 Permit renewal application process, San Diego Coastkeeper and the San Diego Chapter of Surfrider Foundation entered into a Cooperative Agreement (Agreement) with the City to conduct a Recycled Water Study (RWS) with the objective of identifying ways to maximize reuse and minimize flows to Point Loma. The City Council approved the Agreement in January 2009. In accordance with the Agreement, both environmental organizations provided their support to EPA's decision to grant the modified permit in exchange for the City conducting the Recycled Water Study (RWS). In 2010, the EPA granted the City's its second 301 (h) modification to its Permit, allowing the City to continue to operate Point Loma as a CEPT facility. The current permit expires on July 31, 2015.

Lake Hodges Dam

Point Loma WWTP

Landscape Conservation

- **Conservation Mandates:** In 2009, Senate Bill 7 as part of the Seventh Extraordinary Session (SB7-7) was passed as part of a comprehensive legislative package to improve the state's water supply reliability and restoration of the Delta. SB7-7 includes the Water Conservation Act of 2009 (also known as California's "20x2020" plan), which requires that statewide per capita water use be reduced by 20 percent by the year 2020.

1.3 Purpose of the 2012 Long-Range Water Resources Plan

Prudent planning is needed to address these critical water supply issues. A safe, reliable, cost-effective water supply is one of the most fundamental services to support the City's economic prosperity. Without a reliable water supply, businesses relocate to other cities, the tourism industry suffers, and overall quality of life is affected.

The SDPUD's vision is to be an industry leader in the delivery of water, wastewater and recycled water services. As such, the City is taking a proactive step in developing its 2012 LRWRP. The 2012 LRWRP is a high-level strategy document intended to provide information to decision-makers regarding the tradeoffs of future water resource investments, with a long-range viewpoint through the 2035 planning horizon. The 2012 LRWRP evaluates water supply and demand-side options with consideration of multiple planning objectives, and was developed using an open, participatory planning process, with input from a dedicated Stakeholder Committee.

The outcome of the 2012 LRWRP is a flexible and adaptive implementation strategy that accounts for future risk and uncertainty. The plan will set broad resource targets in different categories of supply development (e.g., conservation, recycled water, groundwater) for the next 20 to 25 years. The 2012 LRWRP will not, however, make recommendations on specific projects. Project implementation recommendations require more in-depth study and engineering. Figure 1-2 shows the relationship between the 2012 LRWRP and other SDPUD planning activities for water.

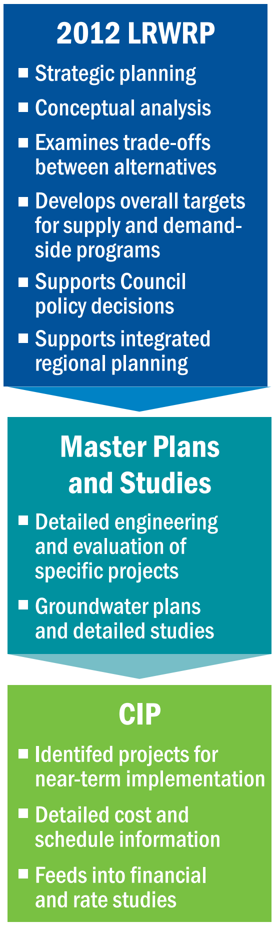


Figure 1-2: Relationship of 2012 LRWRP to Other Water Planning Efforts

1.3.1 Progress since 2002 LRWRP

The City developed its first LRWRP in 2002, which provided direction for the City to pursue additional conservation, recycled water, groundwater; with consideration of implementing potential water transfers, marine transport, and ocean desalination options if warranted. The City has been working hard to meet the resource targets outlined in the 2002 LRWRP, and the following is an update on progress:

- **Conservation:** The City is successfully meeting it conservation goals, and actually exceeded its goal of 32,000 AFY savings by 2010. This savings has been achieved by creating a water conservation ethic, adopting programs, policies and ordinances designed to promote water conservation practices, and implementing comprehensive public information and education initiatives. The Water Conservation Section continues to integrate existing programs while developing new programs to increase conservation and meet established goals.

- **Recycled Water:** The City has almost doubled the amount of recycled water for non-potable reuse since 2002, with existing reuse within the City's water service area of 7,933 AFY (average of 2009 and 2010 reuse). Total existing water reuse is 12,210 AFY including wholesale customers. The City recently completed its 2010 Recycled Water Master Plan Update, and the Recycled Water Study that evaluates ways to maximize recycling throughout the City using either non-potable reuse, indirect potable reuse, or a combination of both. In order to assess the feasibility of indirect potable reuse, the City has initiated the Water Purification Demonstration Project, which includes a one-mgd demonstration-scale advanced water purification facility located at the North City Water Reclamation Plant (NCWRP). Refer to Sections 3 and 4 for further discussion of non-potable and indirect potable reuse.

- **Groundwater:** The City has completed feasibility studies and a management plan, and has installed a number of groundwater monitoring and pilot production wells. The groundwater studies have been focused on the San Pasqual, San Diego Formation, Mission Valley, Santee – El Monte, and Tijuana basins. In addition, groundwater wells have been installed in the Santee – El Monte, Mission Valley and San Diego Formation basins. Groundwater has proven to be a challenging resource locally due to water quality, basin characteristics, and inter-jurisdictional issues; but the City continues to actively study potential opportunities for groundwater supplies.

- **Water Transfers:** The SDPUD evaluated purchasing water transfers from Northern California in the early 2000's, prior to the signing of the Quantification Settlement Agreement (QSA) in 2003 (refer to Section 3). In 2002, and even today, it is highly unusual for retail water agencies within MWD's service territory to independently purchase and transfer water in large part because of the high cost of transporting the water. In addition to the higher costs, water transfers from Northern California have the lowest priority for conveyance and there is a risk that water purchased by the City could not be transported when needed. This is especially true due to court-ordered pumping restrictions within the last five years to protect fish in the Delta. After the signing of the QSA in 2003, the SDPUD discontinued actively evaluating water transfers as an option for the City.

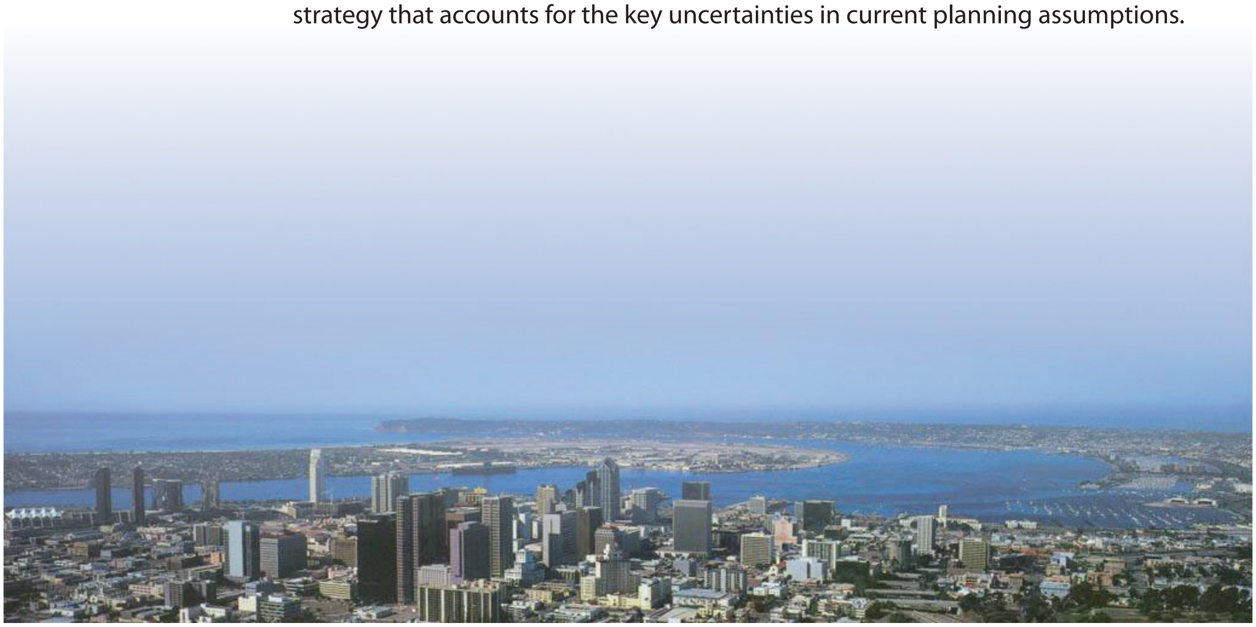
- **Seawater Desalination:** The SDCWA and the City of Carlsbad have been actively considering a potential partnership with Poseidon Resources to build a 50 mgd seawater desalination project co-located with the Cabrillo power plant in Carlsbad since the early 2000s. On November 29, 2012, the Board of Directors of the San Diego County Water Authority (Water Authority) approved a water purchase agreement with Poseidon Resources, to purchase up to 56,000 acre-feet per year (AFY) of treated drinking water that will be produced by filtering seawater to meet federal drinking water standards. The desalination facility will be the largest of its kind in North America and is expected to be online by 2016. This option is evaluated in this 2012 LRWRP. In addition, SDCWA is studying the possibility of building a 150 mgd seawater desalination facility in the southern coastal are of Camp Pendleton.

- **Marine Transport:** The City actively evaluated marine transport in the 2000's. Although the City of San Diego is a coastal community and marine transport would seem ideally suited, the SDCWA's system is generally built to accommodate water flowing from North to South (via the SDCWA's aqueducts) and the City's system from East to West (downhill for gravity flow). The SDPUD's three drinking water treatment plants are located sufficiently inland as to need major investments in new pipelines and pump stations to get the raw transported water from the harbor to the treatment plants. After reviewing the cost of needed infrastructure investments (off-shore platform, piping, pump stations, etc), unknown water quality, and the reliability of marine technology (baggies, tug boats, tankers etc), the SDPUD determined that this supply option was not viable at the time.

1.3.2 Goals for 2012 LRWRP

At the time the 2002 LRWRP was written, few could have predicted the societal changes that would unfold – namely increased globalization and the worst national economic downturn in 70 years. Since the 2002 LRWRP was completed, there have not only been societal changes but also changes in the water industry. These changes include evolving regulatory requirements; and increased awareness of emerging issues such as climate change, energy use, and contaminants not previously detected. Today, increasing water shortages and costs of imported water sources are being realized and the value of local resources is more apparent than ever.

This 2012 LRWRP aims to re-assess planning objectives and stakeholder values, evaluate emerging issues, and use the most recent information available to determine a preferred future water resources mix for the City. The 2012 LRWRP uses the latest water demand projections, imported water availability, and costs; and evaluates new supply opportunities that were not considered in the 2002 LRWRP. With these updates, the 2012 LRWRP will chart a course for the City's water resources using the best information currently available, with a flexible and adaptive implementation strategy that accounts for the key uncertainties in current planning assumptions.



SECTION 2 Water Demands and Conservation

2.1 Current Water Use

Understanding the City's water use patterns is essential to developing a long-term water supply strategy. Water demand is a function of many factors:

- **Demographics:** characteristics of the population living and working in the area, such as number of residential homes, family size, lot size, and types and quantity of employment
- **Socioeconomics:** economic and social characteristics of the population, such as average income, unemployment rates, quality of life, and price of water
- **Conservation:** efforts to reduce demand for water and improve the efficiency in use and reduce waste of water
- **Weather:** fluctuations in temperature, rainfall, and customer response to drought

Average water demands under normal conditions have remained relatively stable throughout the last decade, even in the face of increasing demands from a growing population, as shown in Figure 2-1. The average daily use in 1990 was 182 gallons per capita per day. By 2010, per capita use had declined to 127 gallons per day based on information in the City's 2010 Urban Water Management Plan. While weather, drought, increased cost of imported water and economic conditions do play a role in the year-to-year demand fluctuations, the overall decline in per capita use can be attributed to the active conservation program established by the City's Water Conservation Section in 1985, as well as delivery of recycled water through the Recycled Water Program since 1997. Today,

INSIDE

- *Current Water Use*
- *Future Water Demands*
- *Compliance with 2009 Water Conservation Act*

the City's Recycled Water Program helps to offset potable demands with retail reuse of an average annual demand of 7.4 mgd or approximately 8,300 AFY. The water conservation activities achieve 31 mgd in savings, or more than 34,000 AFY.

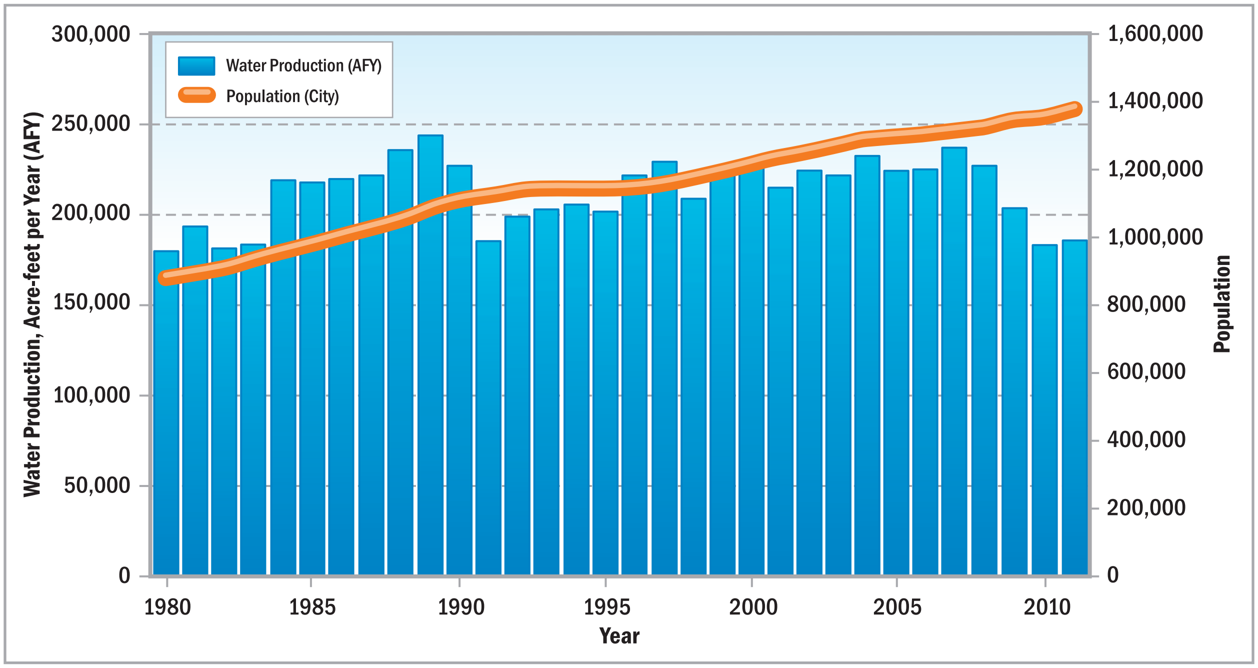


Figure 2-1: Historical Population and Total Water Production (by calendar year)

In addition to ongoing conservation programs and initiatives, the City has responded to critical drought situations in the past by enforcing mandatory water conservation. In 2009, Mayor Sanders and the City Council approved a Level 2 Drought Alert Condition which required limitations on landscape irrigation, car washing, ornamental fountains, excessive off-site drainage from overwatering, and leaks. These drought restrictions were in place for a two year period from 2009-2011, and successfully reduced demands by 13 percent during that period, when controlling for weather and economy. When added to long-term, active and passive conservation that has been in place since the early 1990's, current water demands are over 25 percent lower than they would have been without drought restrictions and conservation. The City demonstrated exceptional commitment and capability in communicating water issues to the public by developing the *No Time to Waste, No Water To Waste* public involvement and educational campaign.

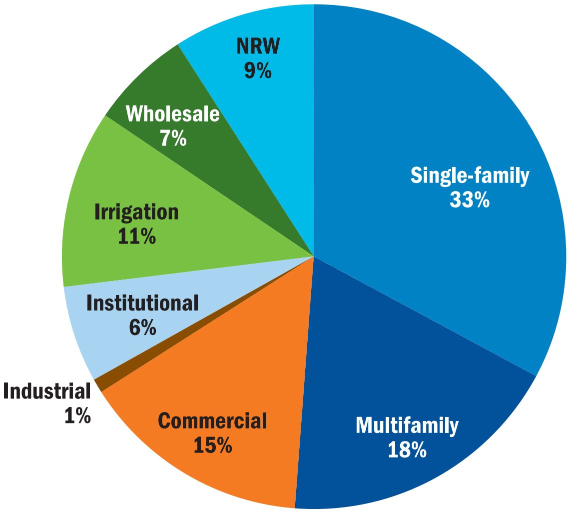


Figure 2-2: Current Breakdown of Water Use

It is often useful to analyze demands by grouping similar water users into categories, also referred to as demand sectors. As shown in Figure 2-2[1], residential homes account for half of all water use during an average year in the City. The remaining water is

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[1] Source: City of San Diego June 2010 Update to the Long-term Water Demand Forecast, Table 6.5.

used by non-residential establishments, irrigation-only accounts, non-billed and unaccounted for water (collectively non-revenue water (NRW)), or sold to the City's wholesale customers.

2.2 Future Water Demands

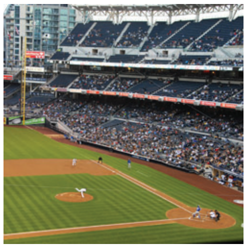
Long-range water demand forecasting is a fundamental component of integrated water resources planning for the City. Projecting future water demand requires understanding of current uses and a forecast of the driving factors that impact demand. The City maintains an updated water demand forecast, most recently the June 2010 *Update of Long-term Water Demand Forecast*. The forecasts are based on the demographic and economic projections available from the San Diego Association of Governments (SANDAG) and an *Econometric Model* that provides mathematical measures of how water users respond to changes in weather and economic conditions.

The Econometric Models used by the City were developed by the SDCWA and adapted for the City's service area. There are three independent models for each of the three major water demand sectors: single-family, multi-family, and non-residential. Non-revenue water and wholesale use is also included in the forecast.

For each sector, the water use forecasting technique adopted for the models estimates future water use through a *driver times average* rate approach. The *driver* represents the number of water users or growth in a given sector. Changes in the number of users are projected over time, and thus drive changes in the water use forecast. For the residential sectors, the drivers are the number of occupied single-family and multi-family housing units. For the non-residential sector, the driver is employment.

Average rate of use is measured on a per-unit basis for each sector and is a function of explanatory variables such as weather, income, household density, industrial productivity, and the price of water. The average rate of use is in gallons per housing unit per day (GPHD) for the residential sectors, and gallons per employee per day (GED) for the non-residential sector. The *Econometric Models* provides equations to estimate the average rate of use for each sector that take into account the explanatory variables. Each explanatory variable has an *elasticity* that indicates the percent change in the rate of water use given a change in the explanatory variable.

Monthly demands are estimated through 2035 in five year increments. The sector models have a seasonal component that demonstrates the variation in water use that occurs over the calendar year due to normal weather fluctuations. Each sector model includes a weather component that captures the effects of changes in temperature and precipitation. Socioeconomic effects, such as responses to increases in the cost of water and changes in economic prosperity, are also captured. SANDAG Series 12 (2050 regional growth forecast) provides future estimates of housing stock, housing density, household income, and employment.



A baseline forecast scenario is first developed that assumes no additional conservation efforts beyond those currently in place, average weather patterns, SANDAG demographic projections, and known water rate increases planned by the City. Baseline demands are then adjusted to account for planned active conservation activities, referred to as the With Additional Active Conservation scenario.

A third forecast scenario, With Additional Active Conservation and Price Effects, was developed through further efforts in a *Water Demand Forecast Sensitivity Analysis (Technical Memorandum)* dated July 2011 and updated in February 2012. This scenario assumes all variables are equal to the Additional Active Conservation scenario with a few exceptions. First, this scenario assumes projections of real (above inflation) price increases based on projections of SDCWA untreated water rates. Economic theory and statistically estimated econometric models for SDCWA and MWD show that when real increases in price occur, water demand decreases. Water customers decrease their demand for water by implementing water conservation practices. Some of these practices represent behavioral changes while others involve installation of water-saving devices. Because the City has an active conservation program that includes rebates for water-saving devices, there is an expected overlap between the price effect and active conservation. MWD and other water utilities have made planning assumptions that indicate a 50 percent overlap between price effect and active conservation is reasonable. Therefore, the City has assumed that only 50 percent of the statistically measured price effect will be additive to the active conservation forecasted by the City.

Results of these forecasts are provided in Table 2-1. System-wide demands in 2035 are estimated at 302,700 AFY under Baseline conditions. The planned conservation programs effectively reduce this demand by 6,700 AFY to 296,000 AFY. Demands under the scenario With New Conservation and Price Effects are further reduced to 281,800 AFY, for a total reduction of almost 21,000 AFY from the Baseline.

Table 2-1: City of San Diego Service Area Water Demand Forecast (including Wholesale Deliveries)

Scenario	Calendar Year Demands (AFY)				
	2015	2020	2025	2030	2035
Baseline Demand	259,600	273,500	285,400	294,700	302,700
With Additional Active Conservation	254,400	267,700	278,800	286,800	296,000
With Additional Active Conservation and Price Effects	246,800	258,000	267,800	274,600	281,800

Source: Tables 6.1 and 6.5 of June 2010 *Update of Long-term Water Demand Forecast*, and Table 8 of February 2012 *Water Demand Forecast Sensitivity Analysis*

It should be noted that the demand forecasts generated by the City in the June 2010 Update of Long-term Water Demand Forecast are used as the basis for many planning activities. In some instances, such as the 2010 Urban Water Management Plan, the forecasts are adapted for the particular effort (e.g., different disaggregation of the City's service area) and may not match the demands provided herein but will be comparable (within 2 percent difference for the baseline demand forecast).

2.3 Compliance with 2009 Water Conservation Act

Future conservation goals are mandated by the recently passed SB7-7, known as the Water Conservation Act of 2009. The new law seeks to achieve a 20 percent statewide reduction in urban per capita water use in California by 2020, commonly referred to as "20 x 2020". As demonstrated in Figure 2-3, the City is on-track to meet its 20 x 2020 goal of 142 gallons per capita per day under baseline demand conditions. The per capita water use in Figure 2-3 is estimated based on retail water demand projections in the June 2010 *Update of Long-term Water Demand Forecast*, subtracting planned non-potable reuse of 9,250 AFY, and then dividing by the City's service area population[2]. Additional savings achieved through planned conservation activities and rate increases are estimated to reduce per capita water use beyond the 20 x 2020 goal.

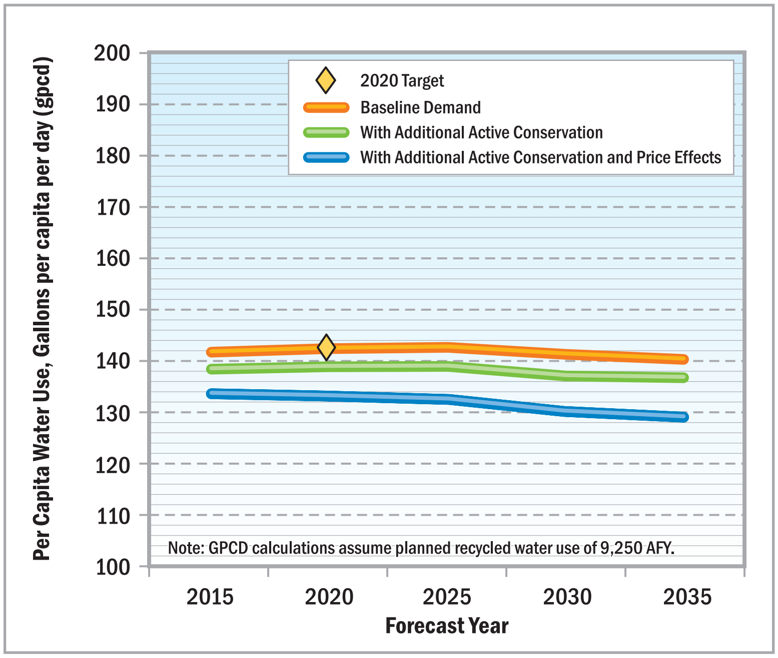
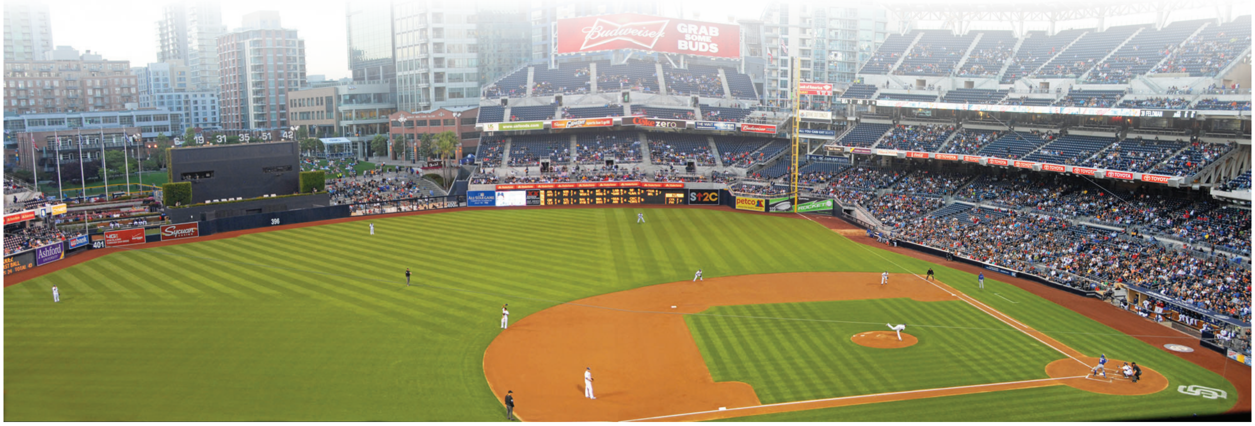


Figure 2-3: Projected Per Capita Water Use



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[2] Note: Population is not a driver of the econometric models used to estimate demand projections in the City's June 2010 *Update of Long-term Water Demand Forecast*. Therefore, demand projections are divided by City service area population reported in the City's 2010 Urban Water Management Plan, Table 3-1.

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SECTION 3 Existing Sources of Water Supply

SDPUD currently relies primarily on imported water from the Colorado River and Northern California to meet most of its water demands. Local water supplies include impounded runoff collected by the City's nine reservoirs (surface water), groundwater, and recycled water. Figure 3-1 presents the current overall resource mix. In this chart, existing conservation savings are considered a resource since it helps to offset use of water supplies that would otherwise be needed to meet higher demands.

3.1 Local Supply

Local resources make up approximately 26 percent of SDPUD's existing overall water supply, when including savings from conservation. SDPUD owns and operates an extensive water system that captures local surface water in its nine reservoirs for treatment at its three drinking water treatment plants. SDPUD has been investigating the feasibility of including local groundwater into its supply mix, and is pumping a small amount of groundwater that is conveyed to the City's water treatment plant for potable use. To offset potable system demands, SDPUD has two water reclamation plants and a large-scale distribution system that delivers recycled water for non-potable applications – primarily outdoor irrigation.

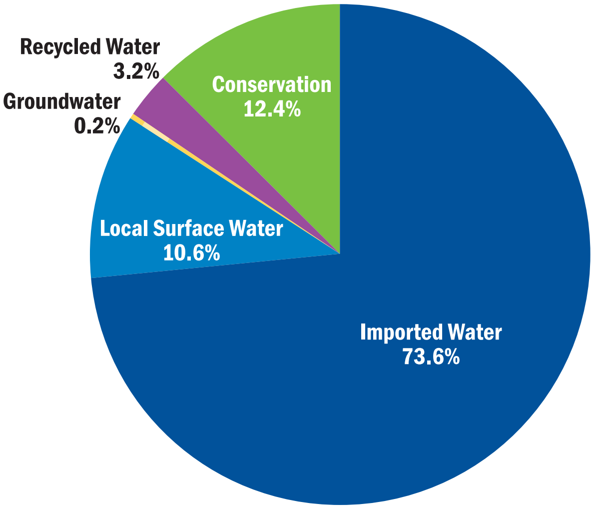
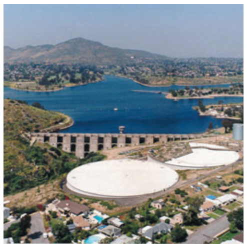


Figure 3-1: Existing Resource Mix Projected for 2015 Normal/Average Hydrologic Conditions
(Source: SDPUD 2010 UWMP)

3.1.1 Surface Water System

Sutherland Reservoir

Barrett Reservoir



Lake Murray

SDPUD's reservoirs capture local rainwater and runoff from watersheds covering more than 900 square miles. Figure 3-2 shows the watershed capture areas and the distribution of average rainfall in the area. The rainfall along the coast averages only about 10 inches per year, but rainfall is over twice this amount east of the City where the large reservoirs are located. On average, 90 percent of the annual rainfall occurs between the months of November and April. In their natural condition, local streams and rivers feeding the reservoirs are ephemeral or intermittent. Since soils need to be sufficiently saturated before runoff can occur, only 13 percent of local precipitation results in surface runoff to streams, and about half of the total runoff into the reservoirs is produced during very wet years. To conserve runoff during these wet years requires a large water storage capacity (SDPUD, 2011).

Local runoff is captured and stored in nine reservoirs with more than 408,000 acre-feet of capacity available for SDPUD's use.[1] This reservoir system operates in combination with the imported water system, and is a major asset to SDPUD in providing reliability in emergency conditions and for balancing seasonal and cyclical variations in water supply and demands. The raw water system is shown in Figure 3-3; reservoirs include Sutherland, Hodges, San Vicente, El Capitan, Miramar, Murray, Morena, Barrett, and Upper and Lower Otay. Raw surface water is treated at SDPUD's three drinking water treatment plants (WTP), with the following current rated capacities: Alvarado WTP (200 mgd), Miramar WTP (215 mgd), and Otay WTP (33 mgd). SDPUD has already made commitments to investments that will increase the total combined treatment capacity to 448 million gallons per day (mgd), which is the capacity assumed for this long-range planning document (CDM, 2011a).

Even with the vast reservoir storage capacity available, local surface supply can vary greatly due to weather and hydrology. During wet periods, SDPUD's production from the reservoirs has reached well over 50,000 AFY with a maximum of about 97,000 AF in 1984. During dry periods, however, local water supply is greatly reduced. Based on historical data from 1948-2011, local water supply (runoff plus water in storage) has ranged from 4,500 AFY in extreme dry weather conditions to approximately 97,000 AFY in the wettest conditions. During normal weather conditions, local surface supply is approximately 30,000 AFY.

The management of the reservoirs is guided by San Diego City Council Policy 400-04, which outlines the City's Emergency Storage Policy. The policy mandates that the City store sufficient water to meet six-tenths of the annual (7.2 months) water demands. Going forward, it is expected that the City will protect and maintain this important resource. Coordinated management is needed to maximize conservation of local runoff with the least amount of losses. Additionally, watersheds and water quality must be protected in order to increase reliability of the water supply system and maintain a usable water source that is low cost compared with imported water purchases.

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[1] Includes 89,312 AF of storage in San Vicente Reservoir. This reservoir will be expanded to 242,000 AF by 2013, although the additional storage capacity is for the SDCWA's regional Emergency and Carryover Storage Project.

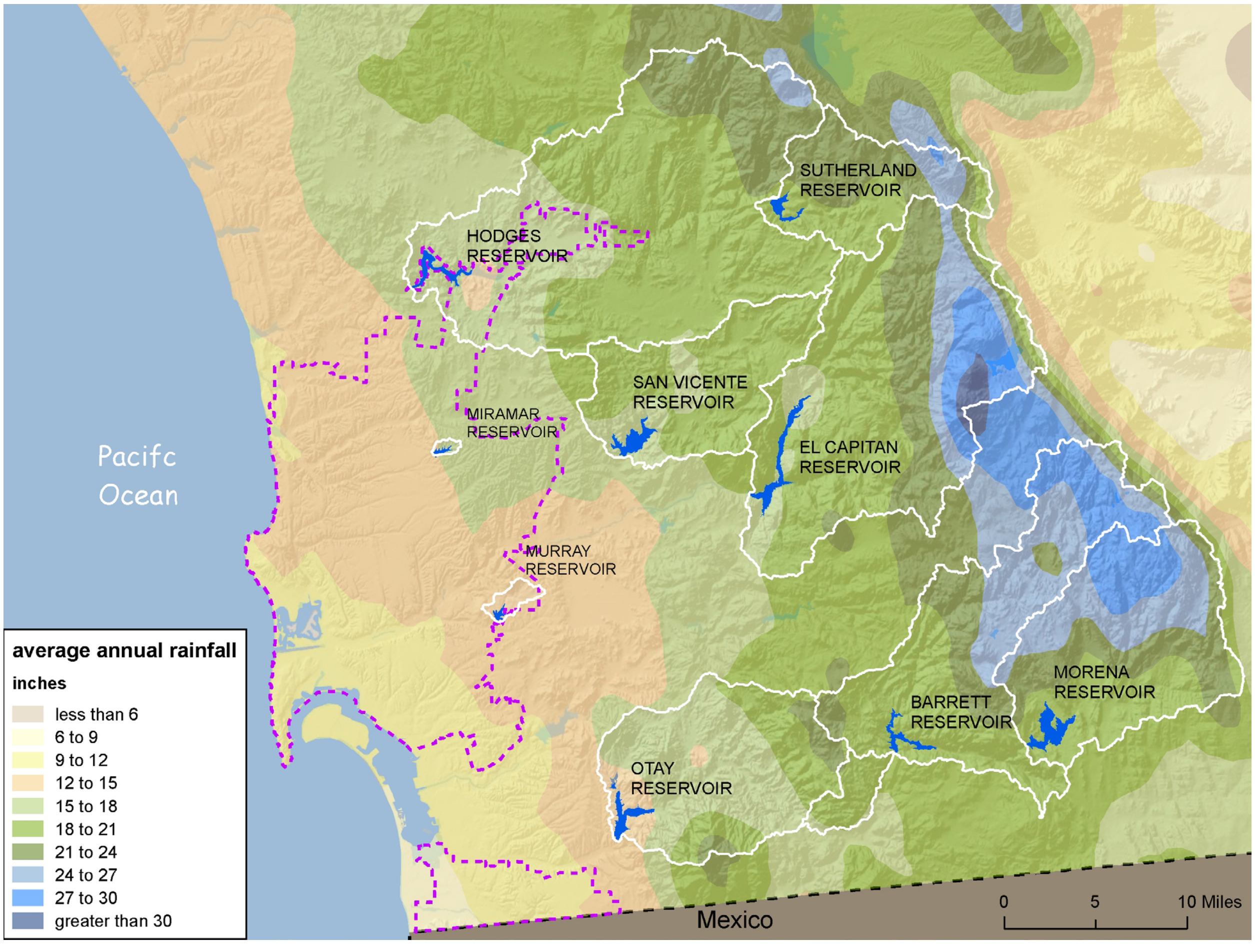


Figure 3-2: Reservoir Locations and Rainfall Catchment Areas

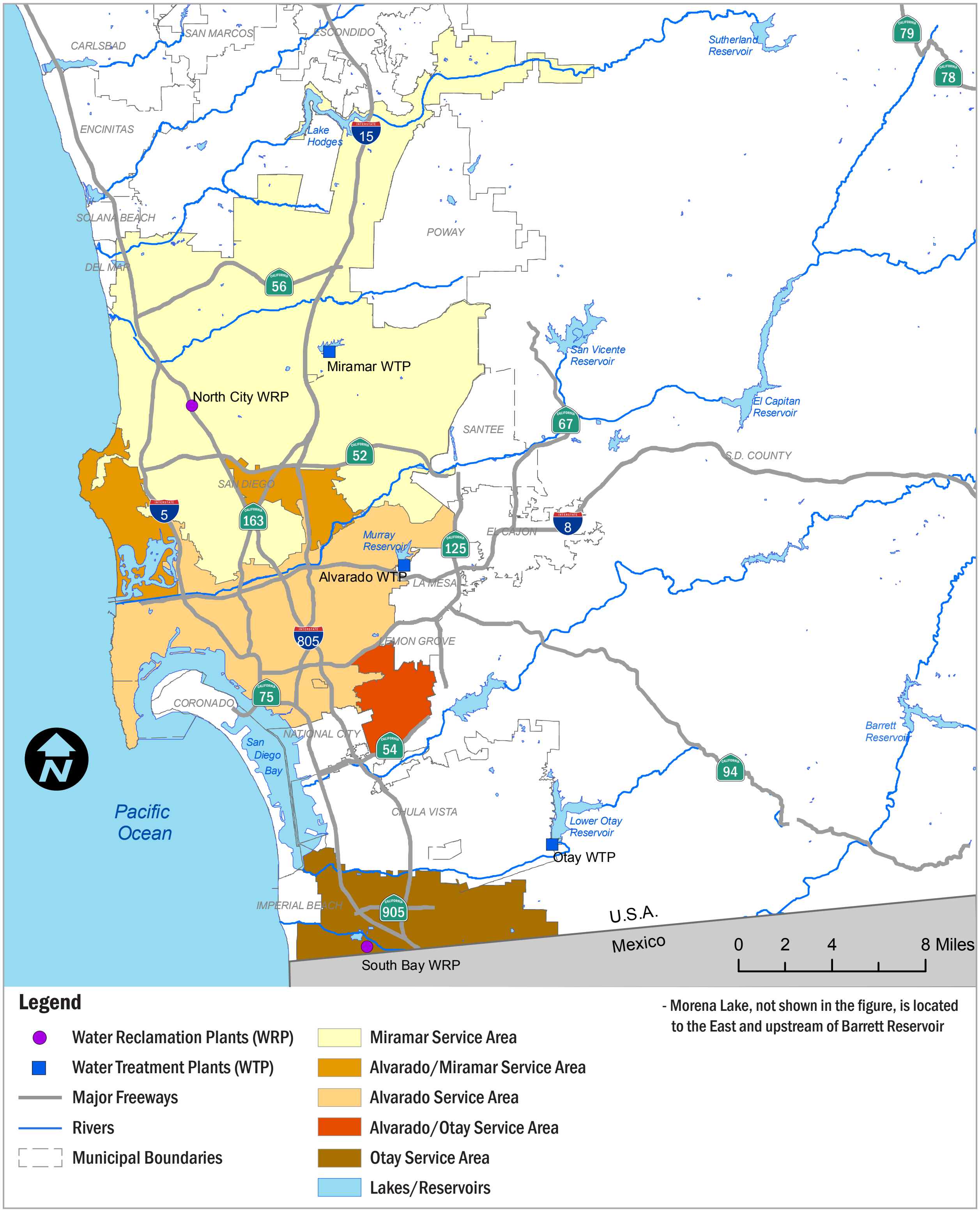
Water Delivery System

The City's reservoirs are connected through a series of pipelines and streams (refer to Figure 3-3). Sutherland is upstream of San Vicente, and the reservoirs are connected through a pipeline. Similarly, San Vicente is connected to the Alvarado WTP through the El Monte pipeline. The El Capitan pipeline connects El Capitan Reservoir to the El Monte Pipeline. Therefore, Sutherland, San Vicente, and El Capitan reservoirs all supply raw water to the Alvarado WTP. In addition, the Alvarado WTP is supplied by Lake Murray which is located adjacent to the plant.

In the Otay WTP system, Morena Reservoir feeds the Barrett Reservoir through the Cottonwood Creek, and Barrett is connected to Lower Otay Reservoir through the Dulzura Conduit. The Miramar WTP is supplied by Miramar Lake and, in the future, will also be served by Lake Hodges through the SDCWA raw water pipelines.

SDPUD divides its overall water service area into three areas: Miramar Service Area (MSA), generally including all the northern area of the City; the Alvarado Service Area (ASA), from approximately the Mission Bay and Mission Valley area and Interstate 8, south to the limits with National City; and the Otay Service Area (OSA) serving the area south of Chula Vista to the U.S.-Mexico border.

Each service area has a water treatment plant: the Miramar WTP, the Otay WTP, and the Alvarado WTP, which treat raw imported water and local runoff from the City's reservoirs. Note that there are some overlap areas that are served by two treatment plants. Raw imported water and treated imported water can be delivered to each of the service areas, through the SDCWA aqueducts.



- Morena Lake, not shown in the figure, is located to the East and upstream of Barrett Reservoir

Figure 3-3: SDPUD Water Reservoirs and Water Treatment Plants

3.1.2 Recycled Water

Recycled water is wastewater that has undergone additional treatment in order for it to be suitable for a range of beneficial uses. Tertiary-treated recycled water is also known as Title 22 water as defined by the California Title 22 Standards (Title 22, Division, 4, Chapter 3, 4 of the California Code of Regulations), regulated by the California Department of Public Health.

Recycled water that has undergone tertiary treatment can be safely used for many non-potable applications, including landscape irrigation (e.g., golf course, parks, roadway medians, and cemeteries), industrial cooling towers, toilet flushing, fountains, and wetlands restoration. Recycled water has been in use in the County of San Diego for over 50 years and within the City of San Diego for more than 30 years[2]. The majority of the recycled water is used for irrigation purposes, and there are some industrial meter connections that use recycled water for cooling tower purposes. Recycled water for non-potable use is delivered to customers in a separate distribution system of "purple pipes"; which are required to keep recycled water separate from drinking water pipelines. On average, over 11 mgd of recycled water was produced and beneficially reused in FY12[3].

SDPUD operates a non-potable recycled water distribution system comprised of two service areas – the Northern Service Area and the Southern Service Area (refer to Figure 3-4). The Northern Service Area is supplied with recycled water from the North City Water Reclamation Plant (NCWRP) with a peak treatment capacity of 30 mgd. On average, the NCWRP processed 16 mgd of wastewater during FY12. Water is treated to a tertiary level if destined for plant use or distributed to customers. As of July 2012, the Northern Service Area consists of 80 miles of pipeline within San Diego, distributing recycled water to 546 retail customers in the City and two wholesale customers: the City of Poway and the Olivenhain Municipal Water District.

The Southern Service Area is supplied non-potable recycled water by the South Bay Water Reclamation Plant (SBWRP) with a peak design capacity of 15 mgd. On average, the SBWRP processed 8 mgd of wastewater in FY12[3]. The conveyance system includes 3.12 miles of pipeline that distributes recycled water to SDPUD's retail customers and the Otay Water District, a wholesale customer.

SDPUD recently completed their 2010 Recycled Water Master Plan (RWMP) Update, a document that is updated every five years. In the 2010 RWMP, the baseline recycled water system is defined as existing (2010) facilities and demands, as well as any planned expansions of the distribution system through 2015. With a long-range focus, the already planned near-term expansions of pipelines and additional customers are considered part of the baseline system.

The 2010 RWMP estimates total average baseline non-potable reuse demands of 15.1 million gallons per day (mgd) by 2015[4]; of which 9.1 mgd is from the NCWRP (with 81 percent of the demands from retail customers or plant use, and the remainder from

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[2] Santee Lakes came on-line in 1961 and Mission Valley Aquaculture Plant commenced operation in 1981

[3] FY12 Wastewater Flows Report/Recycled Water Production Report, prepared by Jose Cervantes, WWTD.

[4] Source: 2010 RWMP Update, Summary of Baseline Recycled Water Demands by 2015 Annual Average, Table 2-6, p 2-11

wholesale customers). For SBWRP, the 6.0 mgd is comprised of about 13 percent from retail customers or plant use, with the remaining 87 percent from Otay Water District (a wholesale customer). Note that baseline demands are projections, and actual demands can vary.

It is important to recognize that outdoor irrigation demands fluctuate significantly; peak day demands experienced in summer months are typically twice as much as average demands, while demands in winter months are typically lower than average. Due to the high fluctuations in outdoor irrigation demand (which currently represent the majority of recycled water usage), less than half of all wastewater available is beneficially reused in winter months.

Refer to Section 4 regarding additional recycled water opportunities.

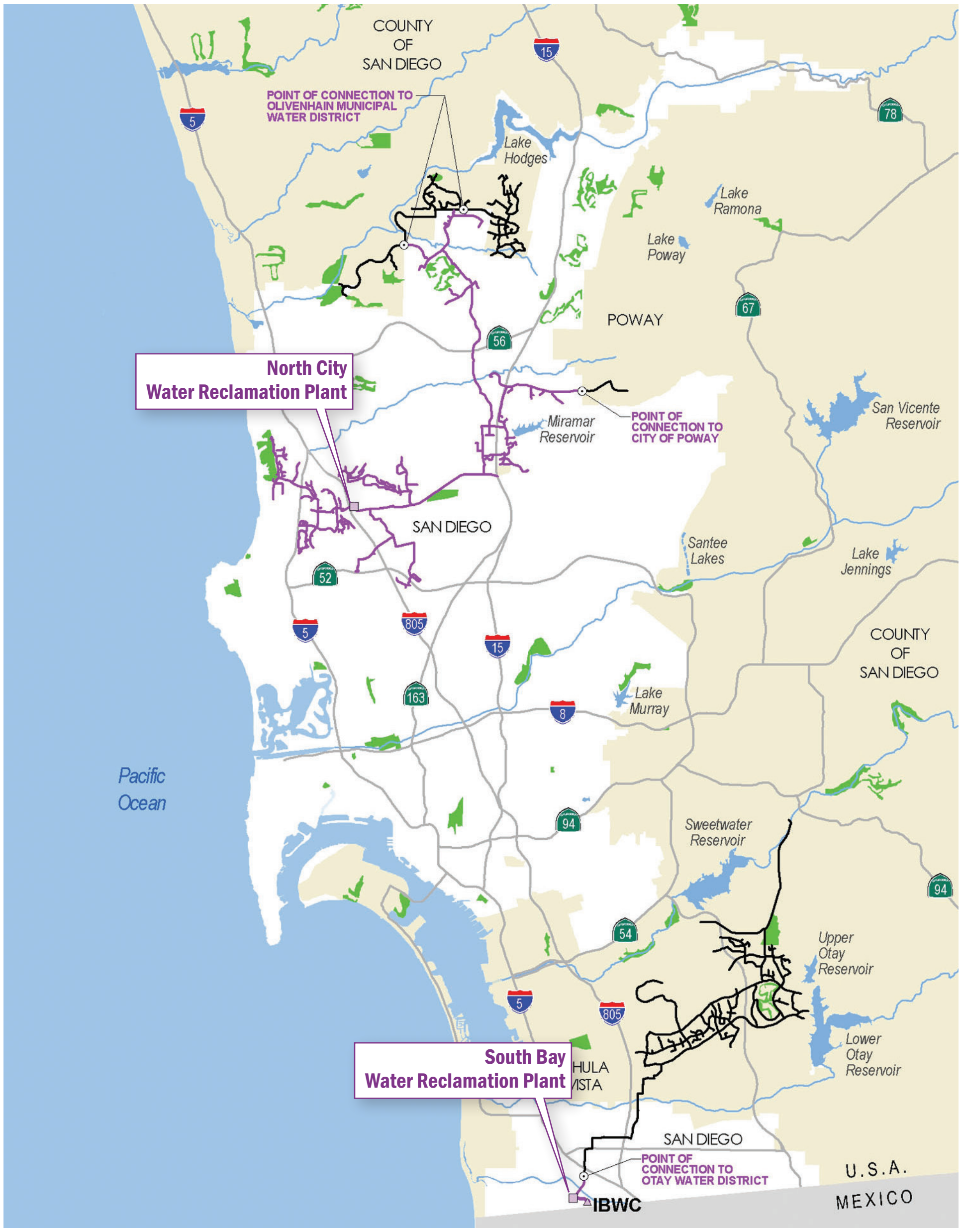


Figure 3-4: SDPUD Non-potable Recycled Water System

3.1.3 Groundwater

There are a number of separate and distinct groundwater sources in San Diego County. SDPUD is currently investigating and is in the process of developing groundwater basins within its jurisdiction, and current production from groundwater sources is approximately 500 AFY. Groundwater basins under investigation or being developed include (see Figure 3-5 for locations):

- San Pasqual,
- Mission Valley,
- Santee-El Monte, and
- San Diego Formation.

None of the groundwater basins are adjudicated or have been declared to be in overdraft. However, the California Supreme Court decreed in 1930 that the City has Pueblo Water Rights to all of the water (surface and underground) of the San Diego River including its tributaries, from its source to its mouth. The Mission Valley basin and the Santee-El Monte basin are part of the San Diego River system.

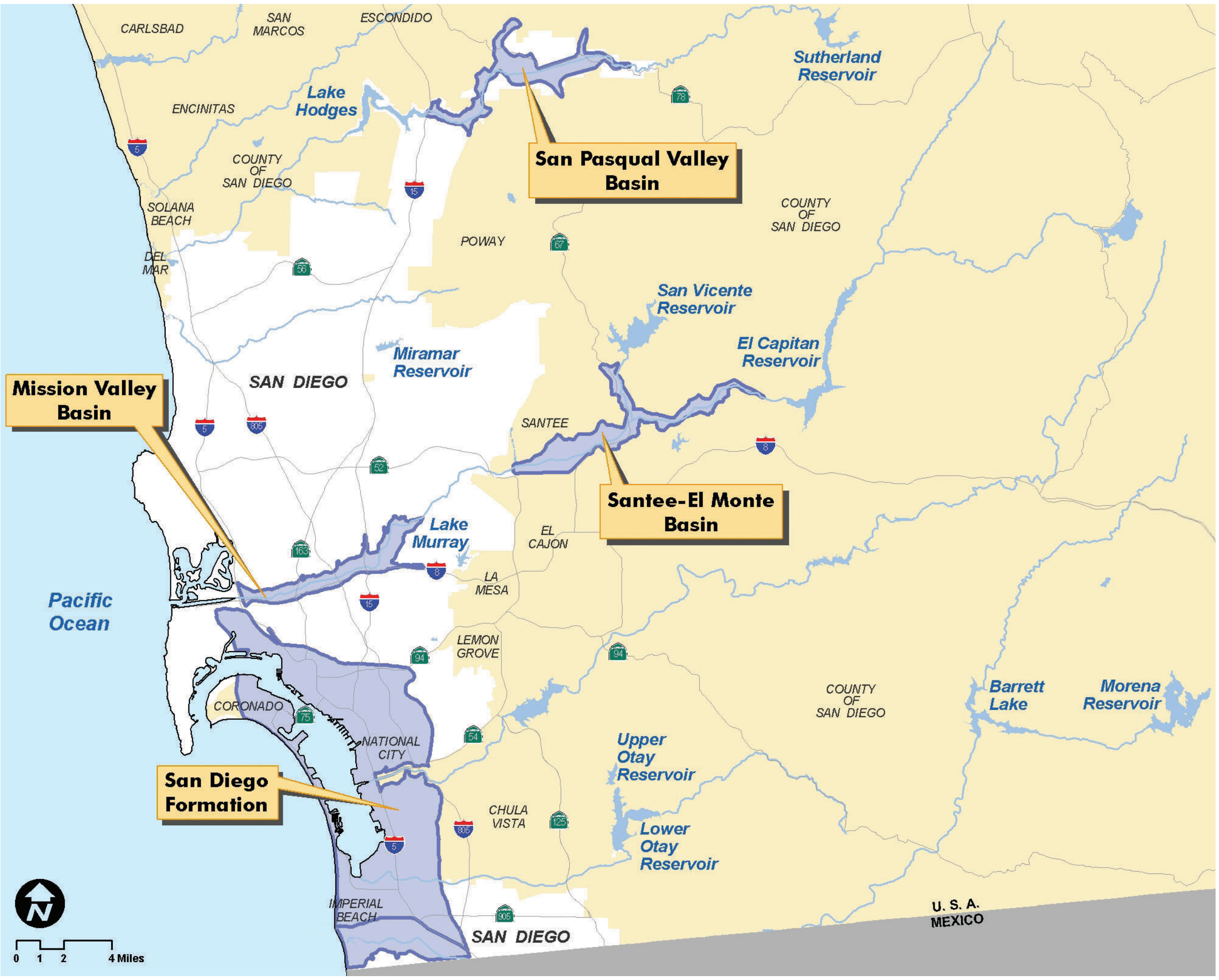


Figure 3-5: Groundwater Basins in San Diego

Per recent state water legislation (SBX7-6), monitoring of groundwater levels is required with specific reporting requirements under the California Statewide Groundwater Elevation Monitoring program.

San Pasqual Basin

Groundwater Monitoring Well

The San Pasqual basin is located in the northern part of the City, approximately 25 miles northeast of downtown San Diego, and is within the San Pasqual Valley which is a designated agricultural preserve. The San Pasqual Valley is sparsely populated and includes row crop, orchard, nursery and dairy operations. In November 2007, the City Council adopted the San Pasqual Groundwater Management Plan (GMP) that defines an adaptive management approach for the basin. The City has been actively managing and implementing the GMP basin recommendations in cooperation with the local community and agricultural groups.

Several studies have already been completed for this basin, and include:

1. Piloting a brackish groundwater desalination process to evaluate water treatment processes for the groundwater present in the basin.
2. Utilization of the basin for groundwater conjunctive use.
3. Performing a Salinity Study

Future work will involve installing several United States Geological Survey (USGS) multi-depth monitoring wells, collaboration with the California Department of Water Resources (DWR) on a groundwater monitoring plan, metering of agriculture production wells, development of metrics for land use, exploration of basin recharge alternatives and further implementation of the goals in the GMP. The continued work in this basin is with the intent of developing an integrated, comprehensive understanding of the geology and hydrology of the San Pasqual basin, and to use this understanding to manage the basin in a sustainable and environmentally sound manner.

Santee – El Monte Basin

The Santee-El Monte basin (identified as the San Diego River Valley Basin in DWR Bulletin 118) is located outside the City's municipal boundary but within San Diego County, in the eastern portion of the San Diego River watershed near the cities of Santee, El Cajon, and the community of Lakeside. The City has an existing municipal supply well along San Vicente Creek downstream of the San Vicente Reservoir. In March 2010, the City drilled a pilot production, municipal supply well about a quarter mile downstream of its El Capitan Reservoir. This pilot production well is anticipated to be connected to the City's raw water supply system in fiscal year 2013.

To prepare for eventual use of the groundwater from these sites, the City has installed a network of monitoring wells, obtaining groundwater levels and has been collecting biological data in the groundwater basin to establish baseline environmental conditions. This baseline data will help determine if groundwater pumping is impacting the natural system and how groundwater pumping can be adaptively managed to mitigate such impact.

Mission Valley Basin

The Mission Valley Basin is located in the central region of San Diego within the City's municipal boundary and is part of the San Diego River system. The City, working with USGS, installed a monitoring well in 2004. In addition, the City installed another monitoring well cluster in 2011 to gather hydrogeologic and water quality data.

This basin is being studied to determine the feasibility of pumping and desalinating the groundwater using reverse osmosis. The Mission Valley Basin is an historic groundwater basin that was an original water supply for the City of San Diego. An owner-operator of a petroleum tank farm negatively impacted the basin with a large unauthorized release of gasoline. The release was discovered in 1986. The San Diego Regional Water Quality Control Board issued a clean-up and abatement order to the party responsible for the release in 1992. Remediation activities, which have been ongoing for over 20 years, utilize up to 1.26 million gallons per day of groundwater. This quantity of groundwater would otherwise be available to the City as a resource, but for the contamination clean-up activities. In 2007, the City sued the 'responsible party' over the loss of the resource and damage to the Mission Valley Groundwater Basin. The City has conceptual plans to develop groundwater in the most favorable part of the basin, however, it is in the most favorable part of the basin that the contamination has occurred and remediation is ongoing. The most prudent course of action for the City is to let the discharger complete the remediation before any development occurs in this portion of the basin.

Groundwater Well Installation

San Diego Formation Basin

The coastal plain groundwater basin in southern San Diego County contains multiple geological formations but is commonly referred to as the San Diego Formation. It is one of the larger groundwater basins in San Diego County. The City of San Diego is engaged in investigations to gain a better understanding of the San Diego Formation. Since 2007, the City has worked with its hydrogeological consultants and the USGS to install several groundwater monitoring wells in the San Diego Formation. Future monitoring and pilot production wells will help characterize the water quality, quantity, and sustainability of the formation. The City is working with the USGS and others to develop an integrated, comprehensive understanding of this groundwater basin. The City's interest in developing the San Diego Formation is complicated by other parties' existing and planned use of the basin for municipal supply. Estimates of sustainable yield for the San Diego Formation vary greatly. The sources of natural recharge to the basin have not yet been clearly identified or quantified but is the subject of extensive research currently being led by the USGS and underwritten by local water purveyors, including the City of San Diego, who have an interest in expanding development of the San Diego Formation as a groundwater resource. The City and others are waiting on results of the USGS research to advance the understanding of this basin's features so it may be developed in a sustainable manner.

3.2 Imported Supply

Since 1947, the City has obtained imported water supplies from the San Diego County Water Authority (SDCWA) and, during the last 20 years, has purchased between 150,000-228,000 AFY of water. Most water purchased by the City is untreated (or raw), and then undergoes treatment at one of the City's three drinking water treatment plants prior to delivery to customers. However, the City does have connection capacity to receive treated water from the SDCWA, although this makes up only about 10 percent of the City's net imported water purchases (Brown and Caldwell et al., 2011a).

Historically, the SDCWA has purchased imported water from Metropolitan Water District (MWD). Imported water from MWD arrives from the Colorado River through the Colorado River Aqueduct (CRA) and from northern California through the State Water Project (SWP). There are many on-going issues related to these sources of imported water.

The main factors impacting the reliability of the SWP are:

- **Delivery of contract allocations:** The 2011 State Water Project Delivery Reliability Report indicates reductions in water deliveries on average compared with historical deliveries as a result of environmental constraints and hydrologic changes derived from climate change.

Sacramento Delta

- **Delta issues:** The Delta is a unique and valuable resource and an integral part of California's water system. It receives runoff from over 40 percent of the State's land area including flows from the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras rivers. The Delta provides habitat for many species of fish, birds, mammals, and plants; supports agricultural and recreational activities; and is the focal point for water distribution throughout the State. The SWP system that brings water from northern California to San Diego County relies on a viable Delta for its water supply.

  And yet given its importance to California, the Delta is in peril. Its earthen levees are vulnerable to natural disasters such as earthquakes, extreme storm events, and sea level rise. Its habitats and endangered species are vulnerable to urban activity and water exports. And it has significant water quality issues. Further, conflicts between environment, agriculture and urban water users have prevented a comprehensive solution to the Delta for many years. As a result of these conflicts, court rulings have limited major SWP pumping facilities from conveying water through the Delta because of protections afforded to certain Delta fish species under the Endangered Species Act. The reliability of future water supplies from the Delta is uncertain, since exports are vulnerable to environmental constraints, impacts of climate change, and potential catastrophic levee failure.

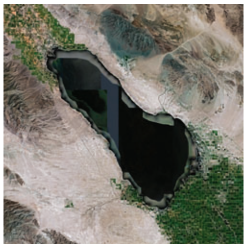
- **Water quality issues:** Water quality issues include total organic carbon, bromide, arsenic, nutrients, N-nitrosodimethlamine, and pharmaceuticals and personal care products.

Main factors impacting the reliability of the CRA are:

Colorado River

- **Supply apportionment:** The CRA is considered the most regulated river in the world, and is ruled by a series of laws, treaties and court treaties that together are referred to as the "Law of the River". Under the Law of the River, various states and Mexico have been allotted portions of the Colorado River water; the centerpiece of this is the 1922 Colorado River Compact (Compact), an interstate agreement between seven states that outlines a priority system for the use of the water. Historically, California received available supplies in excess of its apportionment; however, as other users (specifically, Arizona and Nevada) have began to use their full apportionments, excess water is no longer available. California's Colorado River Water Use Plan (Plan), prepared by the California Department of Water Resources (DWR), identified actions that California will take to operate within its 4.4 million acre-feet entitlement. Completion of the Quantification Settlement Agreement (QSA) in 2003, which established baseline water use for each California Party with rights to the Colorado River, is a critical component of the California Plan. The QSA has faced legal opposition which has potential to cause delays and increase costs of the programs authorized as part of the QSA. On February 11, 2010 the QSA and 11 other agreements were ruled as invalid by the Sacramento County Superior Court. MWD and others appealed the decision, and the California Court of Appeal for the Third District made a decision to uphold the QSA agreement in December 2011.

  Even if all users of the Colorado River stay within their entitlements, tree-ring studies show that pre-1900 flows in the Colorado were lower than the average flows of the river when the 1922 Compact apportionments were established[5]. This decreased supply is further exacerbated with recent decade-long drought conditions and future climate change that is expected to further diminish presently over-allocated water supplies.



Salton Sea

- **Salton Sea:** The Salton Sea was formed in 1905 when the Colorado River breached an irrigation diversion structure, re-routing the Colorado River flows into the Salton basin. The Salton Sea water levels were then sustained by agricultural runoff containing salts, pesticides and fertilizers. With no natural outlet, the sea is now about 30 percent saltier than the ocean. Despite its salinity, the Salton Sea has become an important refuge that is relied upon by many species, given that the majority of the historical wetlands in California have been lost to other land uses. Several bird and fish species found in the sea are threatened or endangered and therefore have protected status.

  The heart of the QSA is a long-term water transfer of water from agricultural users in the Imperial Valley to urban water users in Southern California. As agricultural flows to the sea are reduced as part of the QSA, the sea will no longer be suitable habitat for fish and birds, and exposed lake beds will cause dust containing salts and other chemicals, imposing adverse air quality impacts. During the negotiations of the QSA, a critical issue was the financial responsibility for

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[5] National Research Council. *Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability*. Washington, DC: The National Academies Press, 2007.

negative environmental impacts on the sea from the water transfer. To facilitate the signing of the QSA, the State of California agreed to assume most of the financial responsibility of a multi-billion dollar effort to restore stable habitat for fish and wildlife and mitigate against negative air and water quality impacts. However, funding for this effort remains uncertain.

- **Water quality issues:** Water quality issues associated with CRA supplies include high salinity levels, perchlorate, nutrients, uranium, chromium VI, N-nitrosodimethlamine, pharmaceuticals and personal care products. High salinity levels (TDS) present the most significant issue and the only foreseeable water quality constraint for the CRA supply.

3.2.1 MWD Planned Water Supplies

As noted previously, MWD's imported water supplies from the Colorado River and northern California are fully subscribed and face significant challenges. In order to address these issues, MWD updated its Integrated Resources Plan (IRP) in 2010. The IRP represents a regional strategy for assuring water reliability by resolving the conflicts in the Delta, as well as other improvements to imported water, and developing significant local water supplies through financial incentives and other means by MWD's 26 member agencies and local water providers. In this way, MWD helps to bridge the affordability gap between core imported water supplies and the development of new, more expensive supplies in the region. The 2010 MWD IRP has three main components: (1) meet water demands by building on its existing core resources to provide reliability under foreseen conditions; (2) implement a supply buffer of 10 percent of retail demand through multiple actions to adapt to short-term uncertainty; and (3) implement adaptive management through low-regret foundation actions, monitoring of key vulnerabilities (such as climate change) and bringing adaptive resource options online, if required. Each component contains multiple milestones to guide attainment of water resource targets, with the ultimate achievement of the local water resource targets being the responsibility of the member agencies and local water providers.

To demonstrate the reliability of the IRP Update and resource targets through 2035, MWD analyzed regional demands, supplies, and storage and transfer availability under anticipated dry weather conditions. If MWD and its member agencies successfully implement the local supply projects to produce the yields identified in MWD's IRP for core supplies, buffer supplies, and adaptive management; the MWD region is expected to exceed 100 percent reliability through 2035, inclusive of a 10 percent buffer.

It is important to note that achieving the levels of reliability included in MWD's IRP Update assumes the following:

- A comprehensive solution to the decades-old conflicts in the Sacramento-San Joaquin Delta is implemented within the next 10-15 years
- The QSA will be upheld and MWD will be able to keep the CRA nearly full most of the time, despite 1922 Compact over-apportionment and the looming affects of climate change

- The member agencies and local water providers will be successful in developing new supplies and conservation of 482,000 acre-feet per year by 2035 (compared to its projected demands of 4.5 million acre-feet per year in 2035)

Accordingly, any investments the City makes in local supply projects will fit within the vision established by MWD's IRP and contribute towards future regional water supply reliability in addition to future local water supply reliability.

San Vicente Dam Construction

3.2.2 SDCWA Planned Water Supplies

Severe water shortages caused by a drought in 1987-1992 triggered the SDCWA to pursue additional actions to diversify the region's supply sources. The SDCWA has pursued additional Colorado River water through the Imperial Irrigation District Water Conservation and Transfer Agreement (Transfer Agreement) and All-American Canal and Coachella Canal Lining Projects. In 2010, the SDCWA received 70,000 AFY from the Transfer Agreement and deliveries are expected to increase annually up to 200,000 AFY by 2021. The All-American Canal and Coachella Canal lining projects are complete and provide a supply of 80,200 AFY in normal hydrology conditions. (SDCWA, 2011a)

In addition, the SDCWA is pursuing additional sources of water including (SDCWA, 2011a):

- **SDCWA's Carlsbad Seawater Desalination:** The SDCWA and the City of Carlsbad have been actively considering a potential partnership with Poseidon Resources to build a 50 mgd seawater desalination project co-located with the Cabrillo power plant in Carlsbad since the early 2000s. On November 29, 2012, the Board of Directors of the San Diego County Water Authority (Water Authority) approved a water purchase agreement with Poseidon Resources, to purchase up to 56,000 (AFY) of treated drinking water that will be produced by filtering seawater to meet federal drinking water standards[6]. The desalination facility will be the largest of its kind in North America and is expected to be online by 2016. For conceptual evaluation in the 2012 LRWRP, it is assumed 51 percent of the SDCWA's yield would be reserved for the benefit of the region. In addition, there may be potential to enter an agreement with the SDCWA to purchase a portion of the desalinated water at a higher rate than standard SDCWA rates in turn for a more reliable local supply (this option is evaluated in the 2012 LRWRP as a potential supply for the City, refer to Section 4 of the report).
- **Out of Region Groundwater Program:** To increase dry year supplies, the SDCWA has invested in an out-of-region groundwater banking program in California's Central Valley. In 2008, the SDCWA acquired 70,000 acre-feet of groundwater storage in the Semitropic-Rosamond Water Bank Authority and Semitropic Water Bank located in Kern County. The SDCWA has a take capacity from the groundwater banking program of approximately 12,000 AFY in dry years.
- **San Vicente Dam Raise:** The San Vicente Dam Raise project (estimated completion 2013) will increase in-region carryover storage capacity by

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[6] SDCWA November 2012 Special Board of Director's Meeting approving a water purchase agreement with Poseidon Resources to bring a proposed desalination plant to Carlsbad.

approximately 100,000 AF and emergency storage by about 52,000 AF. Similar to the out-of-region storage program, in-region carryover storage helps ensure supply reliability during periods of potential imported water shortages. For planning purposes, it is assumed that 1/3 of the total storage capacity would be available on an annual basis for the region's use during periods of MWD imported water shortages.

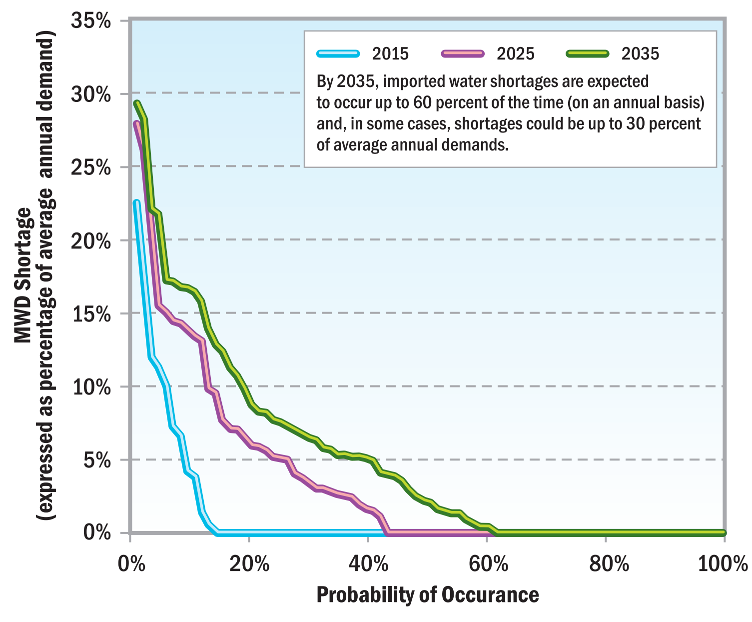
3.2.3 Assumed "Base" Imported Water Reliability Condition

While MWD and SDCWA are making efforts to improve future supply reliability, many planned efforts such as a Delta "fix" may not occur for several years and their actual implementation remains uncertain due to enormous complexity. In addition to this, climate change is another potential uncertainty that could significantly reduce imported water to the City. For the purposes of the 2012 LRWRP, the following "base" imported water reliability scenario was assumed:

1. A comprehensive solution in the Sacramento-San Joaquin Delta (or Delta "fix") is not reached within the planning horizon for this 2012 LRWRP;
2. The SDCWA implements half of their planned local supply projects to help offset future imported water shortages; and
3. Climate change does not result in significant reductions in imported water within the planning horizon for this 2012 LRWRP.

The assumptions were used to establish a "gap" between future water demands and existing water supplies which is used to calculate reliability benefits of future alternatives. To test the uncertainty in imported water, sensitivity analyses were performed assuming that a Delta "fix" does occur as planned by MWD, as well as two climate change scenarios.

Figure 3-6 shows projected MWD shortages in the "base" reliability scenario, which is based on output from MWD's IRPSIM model.[7] The shortages in Figure 3-6 account for the SDCWA's contracted imported supply through the Imperial Irrigation District Water Conservation and Transfer Agreement and All-American Canal and Coachella Canal Lining Projects.



Note: Projected shortages for all probabilities are shown; therefore once the probability of zero shortage is reached, the line extends along the x-axis.

Figure 3-6:
Projected Risk of MWD Imported Water Shortages Without a Delta "Fix"

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[7] Provided to the City by Grace Chan (MWD) on August 10, 2011. Data is based on IRPSIM model output developed for MWD's 2010 Integrated Resources Plan.

Some of the potential water shortages shown in Figure 3-6 can be offset by planned local water supplies by the SDCWA shown in Table 3-1. As previously stated, the 2012 LRWRP "base" imported water reliability scenario assumes only half of the yield from these planned SDCWA projects would be realized. The water supplies from these projects were allocated to the City proportional to the current amount of City water demands to total SDCWA demands.

The remaining overall imported water shortages after accounting for SDCWA local water supply are used for evaluating the City's supply reliability using a dynamic systems model (described in Section 5 and Appendix B).

Table 3-1: SDCWA Planned Local Water Supplies

Planned Project	Total Yield or Storage	Total Regional Dry Year Yield (AFY)
Seawater Desalination Projects	56,000 AFY(1)	28,560(2)
Out-of-Region Groundwater Program	Up to 12,000 AF in dry years(1)	12,000
San Vicente Dam Raise	Adds 100,000 AF of carryover(1) storage	33,000(3)
Planned Total Regional Supply in Dry Years:		**73,560**
Assumed Dry Year Yield for City Planning:		**36,780(4)**
SDCWA Imported Shortage Offset for City:		**14,700(5)**

(1)Source: SDCWA 2010 UWMP

(2)Assumes 51 percent will be available for regional benefit.

(3)Assumes 1/3 of capacity would be available in dry years.

(4)Assumes 50 percent of yield of planned projects is realized.

(5)Assumes City demands are approximately 40 percent of total SDCWA demands.

San Vicente Reservoir

3.3 Potential Shortfalls in the City's Water Supply

Future baseline demands (presented in Section 2) were compared with assumed existing base supplies described previously. Figure 3-7 presents the potential supply shortages the City would experience in the baseline scenario assuming no additional future water supplies or conservation are implemented by the City. The figure shows the potential shortages in 2035 under a range of historical hydrologic conditions, where the probability of shortage would be higher in more severe drought conditions and there is no shortage in wetter years when supply is abundant.

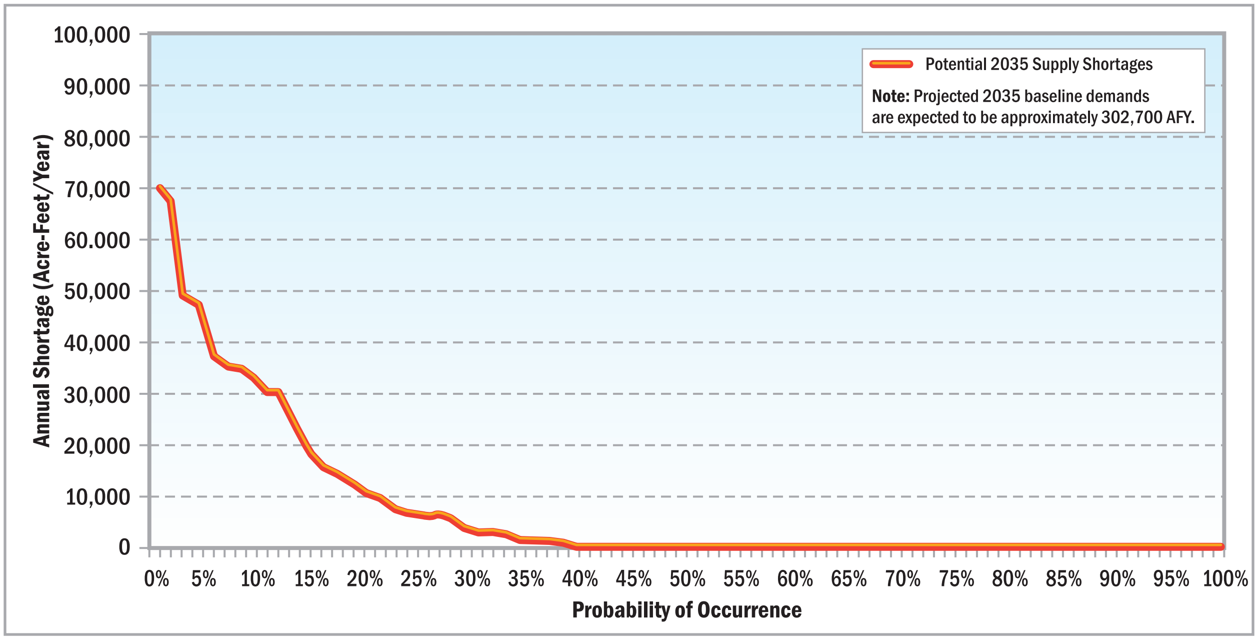

Figure 3-7: Projected Risk of City Water Shortages in 2035 for the "Baseline" Scenario

The demand and supply balance used to estimate shortages does not account for reduction in demand by imposing mandatory water rationing. This is because having to regularly impose mandatory water restrictions can be detrimental on the economy and quality of life. For example, if businesses perceive that water is not reliable they may not choose to locate in San Diego.

As shown, the potential supply shortages in 2035 could be as much as 70,000 AFY (or 23% of baseline water demands) with a 2 percent chance of occurrence, and smaller shortages (10,000 AFY or less) have a probability of occurrence ranging between 20-40 percent. Given the uncertainty surrounding future reliability of imported water supplies, it would be prudent for the City to plan for the contingency in the case that MWD and/or SDCWA are not able to implement planned projects within the 2035 planning horizon. The potential water shortages would have to be made up by either: (1) developing new sources of water supply, (2) additional water conservation and/or (3) imposing mandatory restrictions.

SECTION 4

Future Water Supply and Conservation Options

As described in Section 3, there are significant issues with imported water that, if not addressed, could lead to chronic water shortages, resulting in negative economic and quality of life consequences for the City. Assuming existing imported water supply conditions going forward into the future, the City could be short of water one out of every three years by 2035. If climate change materializes as projected, shortages could occur more frequently and with greater magnitude (see Section 6 for more detail on climate change).

This section presents the full range of water supply and conservation options that were considered in the 2012 LRWRP. In describing conceptual options, it is important to recognize that the 2012 LRWRP is a high-level strategy document and does not make recommendations on specific supply project details (i.e., facility layouts, configurations, exact timing, rate impacts, etc.) —as those project recommendations will come in subsequent, detailed studies and the capital improvements program. However, in order to evaluate alternatives needed to develop the long-term strategy, conceptual options were characterized based on planning-level analyses. The data used to characterize these options were based on previous and/or ongoing studies conducted by the City, as well as other sources, and resulted in estimates of potential water supply yields, high-level identification of potential facilities required for implementation, conceptual mode of operation, range of capital and operating costs, and issues related to water quality, environmental impact, and other implementation factors. It should be noted that some of the studies used to characterize these options have been updated, as they were conducted in parallel to the 2012 LRWRP. As a result, some of

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- *Water Conservation*
- *Groundwater*
- *Recycled Water*
- *Rainwater Harvesting*
- *Graywater*
- *Ocean Desalination*
- *Imported Water*

The numbers presented in this section for the conceptual options should not be mistaken for detailed estimates, nor should they be misconstrued as final configurations or commitments by SDPUD or the City for implementation. They were developed solely for the purpose of evaluating high-level alternatives in order to develop a long-term water resources strategy.

the cost information presented in updated studies and those cited in the 2012 LRWRP are now different; however, they are within a planning-level range and still acceptable for use in development of the overall water resources strategy for the City.

Over 20 representative water supply and conservation options were considered in the 2012 LRWRP. The full list of option concepts was developed based on input from the 2012 LRWRP Stakeholder Committee and City staff, and is presented in Appendix A. The options were then screened down based on technical review that examined implementation feasibility, cost and other factors. The options fall in the main categories shown in Table 4-1. The unit cost shown in Table 4-1 represents the total cost per unit volume of water produced in today's dollars.

Table 4-1: Range of Options Considered

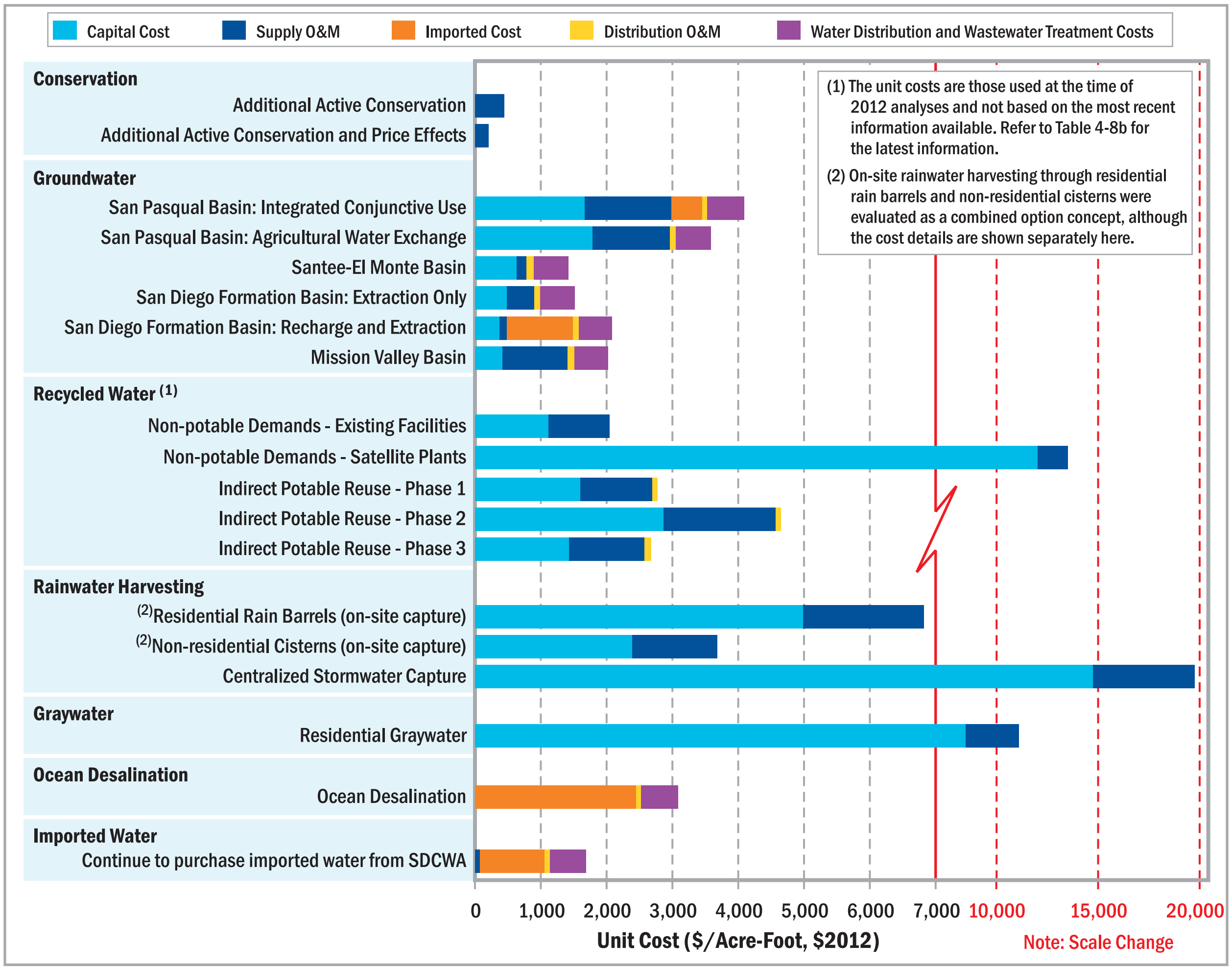
Supply Category	Number of Options	Range of Supply Yields (AFY)	Range of Unit Cost ($/AF)
Conservation Increase local conservation programs within San Diego	2	6,750 – 14,150	$200 –$500
Groundwater Increase groundwater supply within San Diego	6	500 – 10,000	$1,400 - $4,100
Recycled Water for Non-Potable Reuse[1] Increase reuse of treated wastewater for non-potable applications such as landscape irrigation	2	2,700 – 5,500	$2,100-$10,900
Recycled Water for Indirect Potable Reuse[1] Reuse of purified treated wastewater for indirect potable reuse	3	16,800 – 89,600	$2,100 - $4,700
Rainwater Harvesting Capture of urban runoff for water supply	2	100 - 416	$6,400 - $19,800
Graywater Non-sewage, on-site household wastewater that can be reused for non-potable uses	1	2,575	$13,500
Ocean Desalination Pay higher purchase cost to SDCWA in exchange for more reliable ocean desalination water	1	10,000	$3,100
Imported Water Increased imported water purchases from SDCWA	1	As Needed and Available	$1,700
Other Concepts Considered Other groundwater, recycled, imported, etc.	6	NA	NA
Total:	24	100 – 56,000	$200 - $19,800

AF = acre-feet AFY = acre-feet per year NA = Not Available

[1] Unit costs represent those used at the time of 2012 LRWRP analyses and are not based on most recent information available. Refer to Table 4-8b for the latest information available for these options

Traditionally, unit cost comparison of water supply options has only included the capital and operating costs to produce the water supply. However, in order to fully compare these options for the 2012 LRWRP, the costs of distributing the water supply and costs associated with wastewater collection, treatment and discharge were added to this analysis. This is important because not all water supply options require water distribution or wastewater costs. And in fact, some actually reduce wastewater costs for the City. For example, conservation, rainwater harvesting, and graywater can be used on-site and do not require distribution through the City's piping system. In addition, they do not generate water that is used indoors and enters the wastewater system. Recycled water has the greatest potential to offload the amount of wastewater treated at Point Loma WWTP and help avoid some costs associated with infrastructure improvements at Point Loma WWTP for secondary treatment upgrades. The level of avoided costs depends on the magnitude of wastewater that could be recycled, and is evaluated on a system-wide basis (based on the approach described in Section 5 and Appendix B).

The existing cost breakdown for each option is presented in Appendix A. In order to account for these differences in overall cost components, the unit cost includes the capital and operating costs associated with supply production, and also the cost of water distribution and wastewater treatment. Figure 4-1 presents a summary of the unit cost for the options showing the various cost components in today's dollars.



(1) The unit costs are those used at the time of 2012 analyses and not based on the most recent information available. Refer to Table 4-8b for the latest information.

(2) On-site rainwater harvesting through residential rain barrels and non-residential cisterns were evaluated as a combined option concept, although the cost details are shown separately here.

Figure 4-1: Unit Cost of Options

In addition to costs, another important consideration for the City in the development of the 2012 LRWRP was greenhouse gas emissions. Reporting of greenhouse gases by major sources is required by the California Global Warming Solutions Act (AB 32, 2006). Water production, conveyance, treatment and distribution is one of the state's largest users of energy. And the City's reliance on imported water that originates hundreds of miles away, and requires energy-intensive pumping, contributes significantly to greenhouse gas emissions which can exacerbate climate change. Figure 4-2 presents the greenhouse gas emissions per acre-foot of water supply for each of the options. These emissions were derived from energy requirements, assuming that the mix of energy sources was constant for each option. Note that some options do not generate product water that is used indoors and enters the wastewater system; therefore, they do not produce greenhouse gas emissions associated with wastewater treatment.

To estimate the greenhouse gas emissions for imported water, the energy use for pumping from the Bay-Delta was used (approximately 3300 Kwh/acre-foot). This reflects the fact that MWD baseloads its Colorado River supplies and uses SWP supplies as its marginal source. Therefore, any reduction in imported water would reduce the power consumption of pumping from the Bay-Delta.

The following describes the categories of options evaluated in the 2012 LRWRP; more details for all of the options can be found in Appendix A. Several important planning considerations for these options are evaluated with a comprehensive and systematic approach described in Section 5. This section is intended to introduce the option concepts and summarize general benefits and challenges.

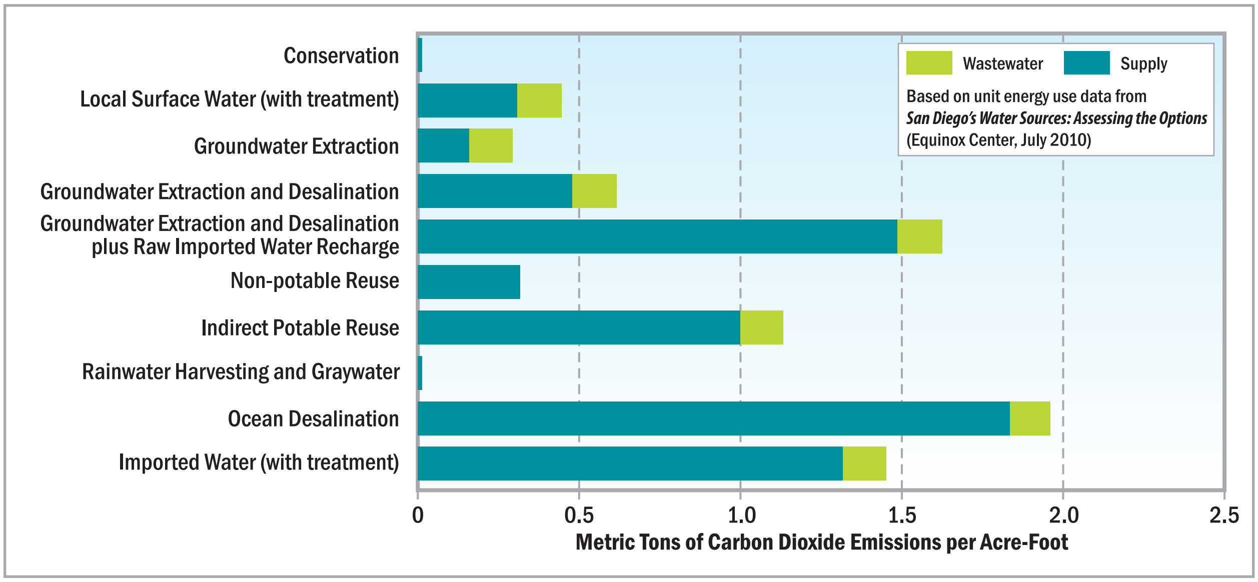


Figure 4-2: Greenhouse Gas Emissions Produced by Various Water Supply Options
(Note: Emissions for imported water based on energy use of 3300 Kwh/acre-foot, reflecting pumping from Bay-Delta)

4.1 Water Conservation

The SDPUD Water Conservation Program was established in 1985 to reduce San Diego's dependence on imported water, and has resulted in conservation savings of over 31 million gallons per day, or 34,833 acre-feet per year (AFY) in 2011. This savings has been achieved by creating a water conservation ethic, adopting programs, policies and ordinances designed to promote water conservation practices, and implementing comprehensive public information and education campaigns.


Drip irrigation system

In 1991, the City became an original signatory of the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU), which formalizes an agreement to implement best management practices (BMPs), also known as demand management measures (DMMs), making a cooperative effort to reduce the consumption of California's water resources. The MOU is administered by the California Urban Water Conservation Council (CUWCC).


Irrigation Timer

The Water Conservation Section continues to integrate existing programs while developing new programs to increase conservation and meet established goals. The following lists the City's ongoing programs and initiatives:


Landscape Conservation

- Residential Interior/Exterior Water Surveys
- Commercial Landscape Survey Program
- Water Conserving Municipal Code - Retrofit Upon Resale
- SoCal Water$mart Rebates for Single Family Dwellings
- Save a Buck Rebates for Commercial Industrial and Institutional and Multi-Family Properties
- Water Conservation Film and Poster Contest
- Outreach using Facebook, Twitter, and YouTube Media
- Water Conservation Garden on the Campus of Cuyamaca College
- California Friendly Landscape Contest
- Public Education, Information and Community Outreach
- California Irrigation Management Information (CIMIS) Stations
- Water Waste Investigations
- Water2Save Program
- Junior Lifeguards
- WaterSmart
- Storm Water Pollution Prevention
- Water Effluent Landscape and Irrigation Rebate Program
- Rain Barrel Rebate Program
- Online Landscape Water Calculator

The state adopted initiatives to increase conservation with the Water Conservation Act of 2009. The new law seeks to achieve a 20 percent statewide reduction in urban per capita water use in California by 2020, commonly referred to as "20 x 2020." The City is on target to achieve its 20 x 2020 goals through existing conservation activities. The following conservation options (also described in Section 2.2) represent future conservation goals that would meet or exceed the City's 20 x 2020 targets:

- **Existing/Baseline Conservation:** Assumes existing conservation programs (as of 2008) are continued, but no additional conservation efforts are implemented.
- **Additional Active Conservation:** Baseline conservation, plus additional active conservation measures. Examples of active conservation measures include

rebates for efficient outdoor landscape irrigation devices, rebates for efficient indoor devices such as clothes washers or urinals, providing water budget audits and water saving recommendations at no additional charge, and other conservation program initiatives sponsored by the City. The additional active conservation would reduce baseline demands by 6,750 AFY in 2035.

- **Additional Conservation and Price Effects:** Baseline conservation and active conservation, plus potential water savings from increasing the price of water. Economic studies indicate that real increases in the price of water will drive customers to be even more water efficient by changing their behavior and increased participation in City programs to reduce water. New conservation from water pricing would reduce baseline demands by 14,150 AFY in 2035[1].

It should be noted that the Equinox Center published a report discussing the potential for conservation (*The Potential of Water Efficiency and Conservation: Opportunities in Single Family Homes in San Diego*, October 2012).

Table 4-2 summarizes the yield and costs of the conservation options. For conservation, there are no costs associated with distribution of water through the City's piping network, nor are there costs associated with treatment of wastewater.

Table 4-2: Conservation: Summary of Conceptual Yield and Cost of Supply (in current dollars)

Option	New 2035 Yield (AFY)	Capital Cost ($)	Annual O&M Cost ($/year)	Add Cost of Distribution?	Add Wastewater System Costs?	Overall Unit Cost ($/AF)
Additional Active Conservation	6,750	$0	$3.1M	No	No	$465
Additional Conservation and Price Effects	14,150	$0	$3.3M	No	No	$233

AF = acre-feet AFY = acre-feet per year O&M: Operation and Maintenance M: Million

Table 4-3 provides an overview of general benefits and challenges associated with additional conservation, although a comprehensive and systematic evaluation of combinations of options against specific planning objectives is presented in later sections.

Table 4-3: Conservation: Summary of General Benefits and Challenges

Objective	Benefits	Challenges
Reliability	▪ Improves reliability by reducing water demands ▪ Reliable under changing climate and hydrologic conditions	▪ Little control by SDPUD since conservation is voluntary and relies on water customers to install and maintain
Cost	▪ Eligible for Grant Funding ▪ Conservation is currently relatively low cost compared with other options	▪ Upfront cost to customers/developers maybe high ▪ More expensive conservation measures may be needed if low cost programs are not achieving conservation goals
Environmental/Water Quality	▪ Zero to low energy use ▪ Indoor conservation reduces wastewater discharges	▪ No significant challenges
Implementation	▪ Helps with meeting State's 20 x 2020 requirement	▪ Requires large-scale voluntary customer participation and behavioral changes for successful implementation ▪ Conservation through water pricing will require public education effort

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[1] Based on City of San Diego *Water Demand Forecast Sensitivity Analysis* dated July 2011, which evaluates the responsiveness of water demands to changes in the marginal price of water.

4.2 Groundwater

While there is not a large groundwater basin underlying the entire City, there are several basins located along river systems and the San Diego Formation located beneath the coastal plain of the southern San Diego region that could bring localized supply opportunities. Local groundwater basins considered in the 2012 LRWRP include San Pasqual, Santee – El Monte, San Diego Formation, and Mission Valley (refer to Figure 3-5 for basin locations).

As described in detail in Section 3, SDPUD is currently studying the use of groundwater as a local supply resource; however, there are multiple challenges associated with development of these groundwater resources. The groundwater basins in San Diego are predominantly brackish in nature, and may require desalination before they could be used for potable or other beneficial (irrigation, industrial) use. In some cases, specifically the Mission Valley basin, challenges include contamination that inhibit or prevent development of groundwater resources until remediation efforts that clean up the groundwater resources are complete. Additionally, there are inter-jurisdictional issues regarding the City's use of these basins. For example, the City's interest in developing the San Diego Formation is complicated by multiple parties' existing and planned use of the basin for municipal supply.

Amidst all these challenges, SDPUD is exploring the feasibility of these local groundwater resources to determine their potential as a future water supply source. While several concepts are being studied, the following are evaluated as representative groundwater resource strategies, and have been grouped based on whether the supply source is:

1. use of sustainable yield groundwater production,
2. an exchange where existing groundwater uses are replaced with other sources, or
3. conjunctive use with imported and/or recycled water.

4.2.1 Sustainable Yield Production

Sustainable yield groundwater production is a function of natural recharge, natural discharge, capture, the health of groundwater-dependent ecosystems, hydrogeological characteristics of the aquifer system, and adaptive management policies. The City is interested in developing groundwater sources in a sustainable manner, and has a history of supporting the health of the groundwater basins. The SDPUD is currently investigating the sustainable yield of local groundwater basins through pilot wells and studies. If these investigations determine that yields are not sustainable, the City may investigate the potential for replenishment projects. The following options represent concepts for extraction of sustainable yield:

Groundwater Well Installation

- **Santee – El Monte Basin:** The conceptual yield for this option has ranged from 1,400-3,400 AFY (Brown and Caldwell et al, 2011a; CDM, 2011a). For the 2012 LRWRP, a representative conceptual option proposes to extract up to 3,400 AFY by installing two well fields at the Santee – El Monte Basin. The extracted groundwater would be conveyed to existing raw water pipelines, delivered to surface water treatment plants and treated to potable standards prior to customer use.

- **San Diego Formation Basin - Extraction Only:** The City is investigating the sustainable yield and treatment requirements of extracted San Diego Formation groundwater. Current concepts propose a sustainable yield ranging between 650-2,900 AFY (Brown and Caldwell et al, 2011a), with desalination treatment depending on amount of water extracted, blending opportunities, and type of water use. A representative option is considered that proposes to extract a total of 500 AFY from the basin through new wells. The extracted groundwater would undergo appropriate treatment and disinfection, and conveyance to the potable water distribution system and/or other beneficial use.
- **Mission Valley Basin:** This option proposes to extract approximately 2,000 AFY and construct a new desalination plant to reduce salinity prior to customer use. The Mission Valley Basin is currently undergoing large-scale remediation due to contamination from Mission Valley Terminal petroleum tank farm. It is expected that this project would not proceed until after the remediation is complete, and the City would treat the groundwater to acceptable quality and health standards prior to delivering to customers.

4.2.2 Agricultural Water Exchange

The San Pasqual Valley is comprised of agricultural producers that currently use groundwater for irrigation demands. There may be an opportunity for an agricultural water exchange in the San Pasqual Valley, where the City could deliver recycled water to agricultural users in the San Pasqual Valley to replace most of the existing agricultural groundwater production. In exchange, the groundwater could be extracted by the City for municipal use. Primary new facilities required include: (1) a tertiary wastewater treatment plant to produce recycled water supply for agricultural use; (2) an extensive distribution system to switch agricultural irrigation from groundwater to recycled water; and (3) new groundwater extraction wells, pipelines for conveyance of extracted water, and a groundwater treatment plant to remove salinity prior to delivery to municipal customers. The conceptual yield of this option has ranged from 3,100 - 4,660 AFY (CDM Smith, 2012; CDM, 2011b). For the 2012 LRWRP, a representative supply yield of 4,660 AFY was used.

Agricultural Crops in San Pasqual Valley

Note that this option cannot be implemented with the San Pasqual Integrated Conjunctive Use and Groundwater Desalination option (presented in Section 4.2.1); they are mutually exclusive options.

4.2.3 Conjunctive Use with Imported and/or Recycled Water

Conjunctive use storage is the process by which non-native water supply is artificially recharged into the basin to produce a supply yield. Whereas sustainable yield supply requires that natural runoff and rainfall replenish the groundwater, conjunctive use can offer increased supply where little or no natural replenishment is available.

Conjunctive use storage of the groundwater basins can essentially operate like an underground surface reservoir. The following conjunctive use options were considered:

San Pasqual Monitoring Well

- **San Pasqual Basin - Integrated Conjunctive Use and Groundwater Desalination:** This option involves recharging advanced treated recycled water and imported water into the basin to augment municipal water supplies. New facilities required include: (1) an advanced water treatment (AWT) plant to purify recycled water; (2) an imported water pipeline to the AWT plant for blending prior to groundwater recharge, in accordance with current California Department of Public Health (CDPH) regulatory requirements for recharge of recycled water; and (3) new groundwater treatment for extracted groundwater prior to delivery to customers due to the salinity of the basin. This option has potential to substantially improve water quality in the basin over the long-term, but would require brine disposal for both the recycled water AWT and groundwater treatment plant. The conceptual yield for this option ranges from about 3,000-6,000 AFY depending on recharge locations and rates (CDM, 2010a). For the 2012 LRWRP, a representative total supply yield of up to 5,600 AFY is used. Note that this option cannot be implemented with the agricultural water exchange option (presented in Section 4.2.2); they are mutually exclusive options.
- **San Diego Formation Basin - Aquifer Storage and Recovery:** The City is currently working with the USGS to gain a better understanding of the geology and hydrogeology characteristics of the San Diego Formation, and evaluate the potential for groundwater recharge and extraction. Due to a variety of complex issues, including land availability, injection wells will likely be required in order to artificially recharge water to the underlying San Diego Formation groundwater aquifer. This option considers a conceptual aquifer storage and recovery (ASR) system, where treated imported water would be injected to the groundwater aquifer to build storage in the basin. The stored water would then be recovered for use in dry years when there are imported water shortages. Historically, the water quality of San Diego Formation has varied widely (Boyle, 1999). While some areas of the San Diego Formation are brackish, it is assumed this concept could be implemented in areas of the basin that would not require treatment of extracted water other than disinfection prior to delivery to customers. New facilities for this option include new injection/extraction wells, and pipelines that connect the potable water distribution system with the injection/extraction wells. The conceptual yield for this option has ranged from about 8,000-22,000 AFY (Boyle, 1999); however, this information is over a decade old and may change with current investigations underway. For the 2012 LRWRP, it is assumed that up to 10,000 AFY could be recovered for use in dry years.

4.2.4 Summary of Groundwater Options

Table 4-4 summarizes the yield and costs of the groundwater options. Since groundwater produces potable water supplies, there are costs associated with distribution of water through the City's piping network, as well as costs associated with treatment of wastewater. These costs are factored into the overall unit cost.

Table 4-4: Groundwater: Summary of Conceptual Yield and Cost of Supply (in current dollars)

Option	Range of Conceptual Yield (AFY)	Representative Conceptual Yield in 2012 LRWRP (AFY)	Capital Cost ($)	Annual O&M Cost ($/year)	Add Cost of Distribution?	Add Wastewater System Costs?	Overall Unit Cost ($/AF)
San Pasqual Basin: Integrated Conjunctive Use and Groundwater Desalination¹	3,000-6,000	5,600	$145.1M	$10.0M (includes imported water purchases)	Yes	Yes	$4,100
or San Pasqual Basin: Agricultural Water Exchange¹	3,100-4,460	4,460	$124.5M	$5.2M	Yes	Yes	$3,485
Santee-El Monte Basin	1,400-3,400	3,400	$34.2M	$500K	Yes	Yes	$1,437
San Diego Formation: Extraction Only	500-2,900	500	$4.1M	$200K	Yes	Yes	$1,551
San Diego Formation: ASR	8,000-22,000	10,000	$29.9M	$1.0M (extraction years); $10.3M (recharge years, includes imported water purchases)	Yes	Yes	$2,142
Mission Valley	1,760	2,000	$13.9M	$2.0M	Yes	Yes	$2,060

AF = acre-feet AFY = acre-feet per year O&M: Operation and Maintenance M: Million

[1] The San Pasqual options cannot both be implemented; they are mutually exclusive options

[2] References for information provided in Appendix A (see Table A-2)

Table 4-5 provides an overview of general benefits and challenges associated with groundwater, although a comprehensive and systematic evaluation of combinations of options against specific planning objectives is presented in later sections.

Table 4-5: Groundwater: Summary of General Benefits and Challenges

Objective	Benefits	Challenges
Reliability	▪ Possibly greater reliability under changing climate and hydrologic conditions ▪ Local resource that would be available in emergency conditions	▪ For options that rely on imported water for conjunctive use or blend water, some reliability issues may exist
Cost	▪ Eligible for Grant Funding	▪ Brackish groundwater would require advanced treatment prior to use, which can be expensive
Environmental/Water Quality	▪ Options with advanced treatment would produce high quality water that has low salinity	▪ Advanced treatment for desalination would produce brine, which would need to be discharged ▪ Varying levels of energy use; options requiring advanced treatment can be energy intensive, as well as options that involve imported water for groundwater recharge
Implementation	▪ Would not require as great a public education effort compared with other options	▪ Varying levels of permitting, legal and institutional challenges exist, depending on basin

4.3 Recycled Water

Recycled water is wastewater that has undergone additional treatment in order for it to be suitable for a range of beneficial uses. SDPUD currently operates two recycled water treatment facilities that supply recycled water for non-potable reuse such as irrigation or industrial applications: the North City Water Reclamation Plant (NCWRP) and the South Bay Water Reclamation Plant (SBWRP).

SDPUD recently completed its Recycled Water Study (RWS) to evaluate reuse projects that maximize recycling and offload (or reduce) wastewater flows to the Point Loma WWTP. The RWS concepts include indirect potable reuse, non-potable reuse, or a combination of both. In conjunction, the SDPUD completed its 2010 Recycled Water Master Plan (RWMP) Update, which is required by a City Council Ordinance every five years. The 2010 RWMP Update presents concepts to expand the recycled water system for non-potable reuse, if projects identified in the RWS are not pursued (per Council Resolution R-303095). While several concepts are being studied, the following are evaluated in the 2012 LRWRP as representative recycled water strategies.

4.3.1 Non-potable Reuse

Tertiary-treated recycled water is also known as Title 22 water as defined by the California Title 22 Standards (Title 22, Division, 4, Chapter 3, 4 of the California Code of Regulations), regulated by the California Department of Public Health. Title 22 water can be safely used for many non-potable applications, including landscape irrigation (e.g., golf course, parks, roadway medians, and cemeteries) and industrial cooling towers.

Typical signage indicating non-potable recycled water in use

In order to quantify the maximum potential non-potable demands for recycled water, the 2010 RWMP Update included a market assessment that identified potential demands from irrigation and industrial uses within the City's service area. In addition, the 2010 RWMP Update developed supply and conveyance concepts that could deliver recycled water to areas with high concentrations of non-potable demands.

North City Water Reclamation Plant

If the projects identified in the RWS are not pursued, the following alternative recycled water concepts are evaluated in the 2012 LRWRP as representative non-potable reuse concepts:

- **New non-potable demands from existing reclamation plants:** Use existing capacity of the NCWRP to serve additional infill retail recycled water customers. This option would provide an additional 2,700 AFY of non-potable supply[2]. Note that the indirect potable reuse (described in Section 4.3.2) also uses the existing water reclamation plant capacity. Therefore, this option cannot be combined with indirect potable reuse.
- **New non-potable demands from new privately-developed satellite plants:** Construct three new satellite plants to produce additional local recycled water supply, andconstruct new distribution facilities for delivery to nearby retail customers. This option would provide an additional 5,475 AFY of non-potable supply[2,3].

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[2] Source: City of San Diego 2010 Recycled Water Master Plan, page 5-10.

[3] In the 2010 RWMP, this concept was not presented as a privately-funded option. However, this option conflicts with recommendations of the RWS and is therefore evaluated as a privately funded option for the 2012 LRWRP.

Table 4-6 provides an overview of general benefits and challenges associated with non-potable reuse, although a comprehensive and systematic evaluation of combinations of options against specific planning objectives is presented in later sections.

Table 4-6: Non-potable Reuse: Summary of General Benefits and Challenges

Objective	Benefits	Challenges
Reliability	▪ Reliable under changing climate and hydrologic conditions ▪ Local resource that would be available in emergency conditions	▪ Since non-potable recycled water can only be used for certain applications (e.g. irrigation and some industrial processes), reliability improvement could be limited to those uses
Cost	▪ Eligible for Grant Funding ▪ Offsets wastewater flows to Point Loma WWTP, and thereby reduces future costs for ocean discharge	▪ Capital cost to customers/developers for connection to the recycled water system ▪ Varying levels of cost-effectiveness, with greatly increased cost the further away from user is from reclamation plant
Environmental/Water Quality	▪ Offsets wastewater flows to Point Loma WWTP, and thereby reduces ocean discharges and improves water quality ▪ Relatively low energy use compared with other options	▪ Non-potable recycled water used for irrigation demands typically follow a seasonal curve and offsets to Point Loma WWTP would be lower in winter months
Implementation	▪ Helps with meeting State's 20 x 2020 requirement	▪ Requires large-scale voluntary customer participation and behavioral changes for successful implementation ▪ Reduces water available for indirect potable reuse

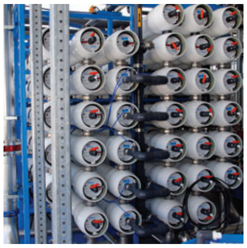
4.3.2 Indirect Potable Reuse

City of San Diego's Water Purification Demonstration Project

Indirect potable reuse (IPR) represents a relatively new approach for maximizing the use of recycled water. The term "indirect" refers to the distinction that the purified water is mixed with a natural water source (groundwater basin or surface reservoir) that can be used as a source of drinking water. Reservoir augmentation has been proposed for IPR for the City. IPR involves a three-step process after tertiary treatment of wastewater:

1. Purifying the tertiary-treated wastewater using advanced treatment processes, including membrane filtration, reverse osmosis, and advanced oxidation technologies (ultra-violet disinfection and hydrogen peroxide);
2. Adding the purified water to a surface water reservoir located upstream of a drinking water treatment plant for blending with natural water; and
3. Further treating the water from the reservoir at a downstream drinking water plant before being distributed to customers.

Many communities in the United States and throughout the world are currently practicing or are planning to implement IPR projects. The largest and most well-known project in the world has been implemented just north of San Diego in Orange County, California. The Orange County Groundwater Replenishment System can produce up to 70 million gallons per day (mgd) of highly purified recycled water that serves the water demands of nearly 600,000 residents. The project is currently being expanded to 100 mgd with an anticipated operational start up in 2014.



City of San Diego's Water Purification Demonstration Project

City of San Diego's Water Purification Demonstration Project

In order to assess the feasibility of indirect potable reuse with reservoir augmentation in the San Diego area, the City has completed the Water Purification Demonstration Project, which includes a one-mgd demonstration-scale advanced water purification facility located at the North City Water Reclamation Plant (NCWRP). Other components of the Demonstration Project include definition of regulatory requirements, studying San Vicente Reservoir to test the behavior of the reservoir and determine the viability of a full-scale project, performing an energy and economic analysis (which was executed through this 2012 LRWRP), and conducting a public outreach and education program. The final project report on the Demonstration Project was completed in April 2013.

Several full-scale IPR concepts are being evaluated by the SDPUD in the 2012 Recycled Water Study, and the following options are evaluated as representative strategies for indirect potable reuse based on the scale of the project. These phases could be implemented independently or combined together. However, if Phase 1 and 3 are both implemented, there may be potential cost savings if conveyance facilities to San Vicente Reservoir can be shared.

- **Phase 1 (North City):** This would be the first phase of indirect potable reuse supply development, and involves construction of an advanced water purification facility at the NCWRP with an average production of 15 mgd (16,800 AFY). The purified water would augment surface water in the San Vicente Reservoir. Under normal operations, water from the reservoir would be further treated at Alvarado Water Treatment Plant (WTP) prior to delivery to customers, although San Vicente Reservoir will be capable of supplying 5 other WTPs in the region during extreme drought or emergency conditions. Note that this option (Phase 1 IPR) cannot be combined with additional non-potable demands from existing water reclamation plants, a separate option evaluated in the 2012 LRWRP, since both options propose to use existing NCWRP capacity.
- **Phase 2 (South Bay):** This phase involves construction of a 15 mgd (16,800 AFY) advanced water purification facility at the SBWRP. Purified water would augment the Otay Reservoir, and water would be further treated at the Otay WTP.
- **Phase 3 (Harbor Drive):** This phase involves construction of an approximately 53 mgd (59,000 AFY) water purification facility at the north end of Harbor Drive. Purified water would be pumped to the San Vicente Reservoir and would be further treated at the Alvarado WTP.

If implemented, the three phases of an enhanced water reuse program listed above would substantially reduce the City's reliance upon imported water by creating a new, locally controlled and reliable water supply. An added benefit is that wastewater flows to Point Loma would be diverted, and the overall volume of ocean discharges reduced. Point Loma's discharge permit is up for renewal in 2015, and it is expected that long-term regional wastewater and reuse plans will be a key aspect of negotiations with the United States Environmental Protection Agency (USEPA). The 2012 LRWRP Stakeholders recognized the importance of this linkage between reuse and reduced discharge.

Table 4-7 provides an overview of general benefits and challenges associated with indirect potable reuse, although a comprehensive and systematic evaluation of combinations of options against specific planning objectives is presented in later sections.

Table 4-7: Indirect Potable Reuse: Summary of General Benefits and Challenges

Objective	Benefits	Challenges
Reliability	▪ Reliable under changing climate and hydrologic conditions ▪ Local resource that would be available in emergency conditions	▪ No significant challenges
Cost	▪ Eligible for Grant Funding ▪ Offsets wastewater flows to Point Loma WWTP, and thereby reduces future costs for ocean discharge	▪ Conveyance and treatment needs can be expensive
Environmental/Water Quality	▪ Offsets wastewater flows to Point Loma WWTP, and thereby reduces ocean discharges and improves water quality ▪ High quality product water with low salinity	▪ Advanced treatment processes would produce brine ▪ Conveyance and treatment needs can be energy intensive
Implementation	▪ Helps with meeting State's 20 x 2020 requirement	▪ Challenging permitting effort ▪ Requires extensive public education

4.3.3 Direct Potable Reuse

Direct potable reuse (DPR) may offer an important opportunity for San Diego to expand the use of recycled water and help meet California's legislative goal for water reuse. The statewide recycling goal, adopted in February 2009, is to increase the use of recycled water in the state by at least one million acre-feet a year by 2020, and by at least two million acre-feet a year by 2030.

DPR differs from IPR because the use of an environmental buffer, either a groundwater basin or reservoir, is eliminated and the advanced treated recycled water is conveyed directly to a drinking water plant. California Senate Bill 918, adopted in September 2010, provides funding and deadlines to establish a clear framework for both direct and indirect potable reuse. The bill requires the CDPH to investigate the feasibility of developing uniform water recycling criteria for indirect and direct potable reuse and to provide a final report on that investigation to the State Legislature by December 31, 2016. In addition, this bill requires CDPH to develop and adopt uniform water recycling criteria for indirect potable reuse through reservoir augmentation on or before December 31, 2016.

While interest in DPR has been expressed by water agencies, environmental groups and others, there are several challenges regarding when and if direct potable reuse projects can be implemented. Given that a regulatory and technical framework was not available at the time of the analysis of the 2012 LRWRP, a DPR option was not evaluated nor included in the document. However, when the 2012 LRWRP is re-assessed in five years time DPR, if found acceptable by the state, will be included as an option.

Table 4-8 summarizes the benefits and challenges of DPR.

Table 4-8: Direct Potable Reuse: Summary of General Benefits and Challenges

Objective	Benefits	Challenges
Reliability	▪ Reliable under changing climate and hydrologic conditions ▪ Local resource that would be available in emergency conditions	▪ No significant challenges
Cost	▪ Eligible for Grant Funding ▪ Offsets wastewater flows to Point Loma WWTP, and thereby reduces future costs for ocean discharge ▪ Potentially lower cost than indirect potable reuse (IPR) as it involves less conveyance facilities	▪ Treatment costs can be expensive
Environmental/Water Quality	▪ Offsets wastewater flows to Point Loma WWTP, and thereby reduces ocean discharges and improves water quality ▪ High quality product water with low salinity	▪ Advanced treatment processes would produce brine ▪ Treatment needs are energy intensive
Implementation	▪ Helps with meeting State's 20 x 2020 requirement	▪ California regulations for direct potable reuse are not yet established ▪ Public opinion on direct potable reuse is unknown and would likely require extensive public education

4.3.4 Summary of Recycled Water Options

During the development of the 2012 LRWRP, the costs of recycled water options were refined in other parallel studies being conducted by the City. Table 4-9a summarizes the yield and costs of the recycled water options used for the 2012 LRWRP analysis (which were the best available information at the time of modeling analyses), and Table 4-9b summarizes the latest information available as of March 2013. Note the capital costs in Tables 4-9a and 4-9b represent the total cost of the option, including the cost to customers. The differences in costs shown in Table 4-9b are acceptable for the 2012 LRWRP high-level planning analyses, and do not affect the outcome of the 2012 LRWRP, as demonstrated in Appendix G.

It should be noted that a major advantage of recycled water is that it could significantly reduce wastewater system costs, especially if large volumes of recycled water are implemented.

Table 4-9a: Recycled Water: Summary of Conceptual Yield and Cost of Supply (used in 2012 LRWRP analyses, shown in current dollars)

Option	2035 Yield (AFY)	Capital Cost ($)	Annual O&M Cost ($/year)	Add Cost of Distribution?	Add Wastewater System Costs?	Overall Unit Cost ($/AF)
Non-potable Reuse: Satellite Plants	5,475	$712.6M	$13.5M	Already included in O&M Cost	No	$10,936
Non-potable Reuse: Existing Facilities	2,700	$47.6M	$2.5M	Already included in O&M Cost	No	$2,079
Indirect Potable Reuse: Phase 1	16,800	$285.2M	$15.9M	Yes	No	$2,138
Indirect Potable Reuse: Phase 2	16,800	$748.4M	$28.5M	Yes	No	$4,680
Indirect Potable Reuse: Phase 3	59,000	$1,100.0M	$53.9M	Yes	No	$2,358

AF = Acre-foot AFY = Acre-feet per year O&M: Operation and Maintenance M: Million

Table 4-9b: Updated Recycled Water Option Costs

Option	2035 Yield (AFY)	Capital Cost ($)	Annual O&M Cost ($/year)	Add Cost of Distribution?	Add Wastewater System Costs?	Overall Unit Cost ($/AF)
Non-potable Reuse: Satellite Plants	5,475	$620.2M[1]	NA	Already included in O&M Cost	No	$9,838
Non-potable Reuse: Existing Facilities	2,700	$47.6M[1]	NA	Already included in O&M Cost	No	$2,079
Indirect Potable Reuse: Phase 1	16,800	$369.9M[2]	$12.6M[2]	Yes	No	$2,290
Indirect Potable Reuse: Phase 2	16,800	$467.4M[3]	$22.9M[3]	Yes	No	$3,261
Indirect Potable Reuse: Phase 3	59,000	$1,168.0M[3]	$60.5M[3]	Yes	No	$2,525

AF = acre-feet AFY = acre-feet per year O&M: Operation and Maintenance M: Million NA: Not available

[1] 2010 Recycled Water Master Plan Update, July 2012 which does not include capital cost to customer. For non-potable reuse with existing facilities, capital costs shown are assumed costs to customers for on-site retrofits, plan checking, meter fees, cross-connection testing, and soft costs. These costs are assumed to be approximately $72 million for non-potable reuse with new satellite plants and are included in the capital cost estimates.

[2] Water Purification Demonstration Project, final Report, March 2013.

[3] Recycled Water Study, July 2012.

4.4 Rainwater Harvesting

Rainwater in urban areas, also referred to as stormwater, is currently routed to a storm drain pipe network and discharged to streams and flood control channels that lead to the ocean. Typically, this stormwater carries with it pollutants and trash that have been picked up along parking lots, streets, and other impervious surfaces. Harvesting rainwater for water supply would improve receiving water quality by reducing the transport of pollutants to the bays and ocean.

Large Residential Rain Barrel

The City's Storm Water Division is responsible for stormwater management and compliance responsibilities. Responsibilities include implementing education programs, enforcing storm water ordinances established to reduce pollutant discharges to the storm drain system, and implementation of non-structural and structural storm water best management practices (BMPs) to reduce pollutants in storm water discharges in order to comply with the Municipal Storm Water Permit (National Pollutant Discharge Elimination System Permit No. R9-2007-0001) issued by the San Diego Regional Water Quality Control Board, and Total Maximum Daily Load (TMDL) regulations that protect receiving waters (local streams and ocean). In some cases, reducing the volume of stormwater runoff is a design objective of some stormwater compliance strategies. In those instances, BMPs that are designed to reduce stormwater runoff volumes may also present opportunities to harvest rainwater for water supply purposes, such as:

- **Cisterns and Rain Barrels (onsite capture):** Cisterns and rain barrels are installed to capture runoff from rooftops or parking lots for use in non-potable water demands, such as irrigation. Residential properties tend to install rain barrels at the end of downspouts, while businesses can have storage tanks installed above-ground or buried that capture volume from larger rooftops or parking lots. Assuming 20 percent of residential and non-residential units participate, this option would yield approximately 416 AFY in normal to wet years.

  During the development of the 2012 LRWRP, the City initiated a rainwater harvesting program as a tool to raise public awareness of water issues, promote customer responsibility, and reduce imported water use. The 2012 LRWRP evaluates rain barrels and cisterns as a supply option against other options available to SDPUD.

- **Centralized Rainwater Capture:** Centralized rainwater capture involves construction of a diversion at an existing storm drain network or channel to capture stormwater for use as a non-potable water supply. Given limited dry-weather flows and frequency of storm events, significant and costly storage would be needed to capture all the urban stormwater runoff when it occurs – particularly since rain events do not occur in summer months when irrigation demands are the highest. For this option, it is assumed a representative centralized stormwater project would yield approximately 100 AFY for irrigation use.

Note that there are many other stormwater options that offer water quality benefits, such as bioswales and permeable pavement. These options allow stormwater to infiltrate into soils, reducing runoff into receiving waters. However, because of the hydrogeology of urban San Diego (e.g., location and permeability of local groundwater) these options do not have significant water supply benefits as very little of the infiltrated water makes its way to local groundwater.

Table 4-10 summarizes the yield and costs of the urban runoff options. For urban runoff, there are no costs associated with distribution of water through the City's piping network, nor are there costs associated with treatment of wastewater. And although options such as rain barrels are relatively inexpensive per device, unit cost of beneficial water for supply purposes is relatively high compared with other options because of the nature of rain events and storage limitations of the barrels.

Table 4-10: Rainwater Harvesting: Summary of Conceptual Yield and Cost of Supply (in current dollars)

Option	New 2035 Yield (AFY)	Capital Cost ($)	Annual O&M Cost ($/year)	Add Cost of Distribution?	Add Wastewater System Costs?	Overall Unit Cost ($/AF)
Residential Rain Barrels (on-site capture)	356	$13.2M	$700K	No	No	$6,844
Non-residential Cisterns (on-site capture)	60	$1.5M	$76K	No	No	$3,695
Centralized Stormwater Capture	100	$9.1M	$200K	No	No	$19,758

AF = acre-feet AFY = acre-feet per year O&M: Operation and Maintenance K: Thousand M: Million

Table 4-11 provides an overview of general benefits and challenges associated with capturing urban runoff as a supply source, although a comprehensive and systematic evaluation of combinations of options against specific planning objectives is presented in later sections.

Table 4-11: Rainwater Harvesting: Summary of General Benefits and Challenges

Objective	Benefits	Challenges
Reliability	▪ Local resource available in normal to wet years, although not reliable during droughts or emergency conditions	▪ Flows are highly variable with changing climate and hydrologic conditions ▪ Effectiveness of on-site capture in offsetting imported water use is dependent on customer use and maintenance
Cost	▪ Eligible for Grant Funding ▪ Potential funding partnerships with other departments or agencies ▪ Relatively low cost per device	▪ Relatively expensive unit cost per supply ▪ Limited cost-effective options for centralized capture due to lack of dry weather flows and lack of opportunities for surface recharge to underlying groundwater basins
Environmental/Water Quality	▪ Zero to low energy use ▪ Reduces stormwater discharges and thereby improves surface water quality	▪ None
Implementation	▪ May help with meeting TMDL requirements	▪ On-site stormwater capture requires large-scale voluntary customer participation and behavioral changes for successful implementation

4.5 Graywater

Graywater is wastewater that originates from household fixtures such as showers, bathtubs, clothes washing machines, and bathroom sinks; it excludes wastewater from toilets, dishwashers, and kitchen sinks. Graywater is generated onsite and reused for other purposes such as landscape irrigation or disposal fields. It is important not to mistake graywater with recycled water, which is subject to monitored treatment and purification to make it suitable for a range of beneficial uses.

The California Plumbing Code was recently revised with less stringent requirements for graywater installations[4]; however, enforcement of these regulations is administered through the local enforcing agency (City of San Diego Development Services Department). It is important to note that because graywater has not been widely used previously, code standards are still evolving to reduce potential health risks.

The current regulations allow for the following types of graywater systems:

- **Clothes Washer System:** uses only a single domestic clothes washing machine in a one- or two-family dwelling
- **Simple system:** discharge of 250 gallons per day or less and serves a one- or two- family dwelling
- **Complex system:** discharges over 250 gallons per day

While all three are viable options, only one system is evaluated as a representative graywater option. For this analysis, a "Simple System" graywater collection system is evaluated, where wastewater from the laundry, bath, and shower are combined, filtered, and reused for drip landscape irrigation. This evaluation assumes graywater is filtered in order to reduce liability associated with public health risks, although proper use of any graywater system is highly dependent on customer behavior. See Figure 4-3 for a schematic of a Simple System.

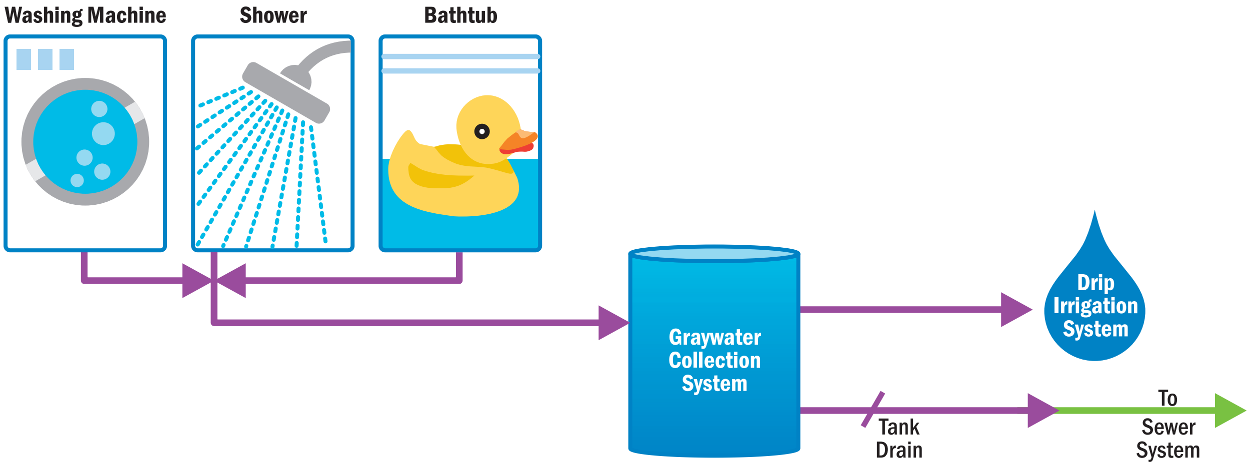


Figure 4-3: Simple System (Laundry + Bath + Shower)

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[4] Graywater systems are required to meet the acceptable design criteria outlined in California Plumbing Code, Chapter 16A "Nonpotable Water Reuse Systems."

This concept assumes that existing homes are retrofitted for graywater reuse. Assuming 50,000 homes participate, annual water supply would yield 2,575 AFY (46 gallons per household per day).

Table 4-12 summarizes the yield and costs of a graywater option. Installation of a Simple System is assumed to include costs for: ½ horsepower submersible pump, 55 gallon surge tank, 50 pound filter and sand, subsurface drip irrigation system, water meter, plumbing connections, and labor.

Table 4-12: Graywater: Summary of Conceptual Yield and Cost of Supply (in current dollars)

Option	New 2035 Yield (AFY)	Capital Cost ($)	Annual O&M Cost ($/year)	Add Cost of Distribution?	Add Wastewater System Costs?	Overall Unit Cost ($/AF)
Graywater	2,575	$270M	$3.8M	No	No	$13,499

AF = acre-feet AFY = acre-feet per year O&M: Operation and Maintenance M: Million

For graywater, there are no costs associated with distribution of water through the City's piping network, nor are there costs associated with treatment of wastewater. Despite these benefits, the cost per unit of water is relatively high compared with other options.

Table 4-13 provides an overview of general benefits and challenges associated with graywater, although a comprehensive and systematic evaluation of combinations of options against specific planning objectives is presented in later sections.

Table 4-13: Graywater: Summary of General Benefits and Challenges

Objective	Benefits	Challenges
Reliability	▪ Local resource that is available under changing climate and hydrologic conditions	▪ Effectiveness of on-site system in off-setting imported water use is solely dependent on customer use and maintenance
Cost	▪ Eligible for Grant Funding	▪ Capital cost to customers/developers ▪ Relatively expensive per unit supply
Environmental/Water Quality	▪ Low energy use	▪ Unknown long-term effects to soils
Implementation	▪ No significant benefits	▪ Potential health risks if not used properly by customers ▪ Little data for applications in California ▪ Evolving code standards ▪ Requires large-scale voluntary customer participation and behavioral changes for successful implementation ▪ Requires extensive public education ▪ Diverted water not available for reuse ▪ May not reduce consumption

4.6 Ocean Desalination


Pacific Ocean

Ocean desalination removes dissolved minerals (salts and others) from seawater through advanced treatment processes. The SDCWA is studying various ocean desalination supply opportunities in the San Diego region, including the Carlsbad Desalination Project, which is a fully-permitted ocean desalination plant and conveyance pipeline currently being developed by Poseidon Resources, a private investor-owned company. The project, when completed, will provide a regional water supply of 50 million gallons per day (mgd), or 56,000 acre-feet per year (AFY).

The SDCWA and Poseidon Resources are currently negotiating terms to see if a final agreement can be reached for the SDCWA to use the desalinated water; current negotiations involve the SDCWA purchasing a minimum of 48,000 AFY and potential to purchase excess available water if needed. If and when an agreement is made, the SDCWA will announce a 60-day review period wherein retail member agencies, such as the City of San Diego, could purchase desalinated water from the SDCWA at a higher rate than standard SDCWA rates in turn for a reliable local supply. The SDCWA would sell up to a maximum of 49 percent of the desalinated product water and the majority of the water will be maintained for regional reliability benefits of all member agencies. In order to evaluate a representative conceptual yield for this option, the 2012 LRWRP assumes that 10,000 AFY would be available to the City of San Diego.

The cost to the SDCWA and charges to its member agencies are currently being negotiated. The cost to the SDCWA is projected to range from $2,042-$2,290 per AF[5]. During the time of 2012 LRWRP analysis, it was assumed that the cost to member agencies would be the same full cost that the SDCWA will pay per AF[6], plus additional costs for transportation and administration. However, the terms of member agency costs are under negotiation and actual costs will be determined in the future.

Table 4-14 summarizes the yield and costs of the ocean desalination option. Since ocean desalination produces potable water supplies, there are costs associated with distribution of water through the City's piping network, as well as costs associated with conveyance, treatment, and discharge of wastewater (to reflect full cost). These costs are factored into the overall unit cost.

Table 4-15 provides an overview of general benefits and challenges associated with ocean desalination, although a comprehensive and systematic evaluation of combinations of options against specific planning objectives is presented in later sections.

Table 4-14: Ocean Desalination: Summary of Conceptual Yield and Cost of Supply (in current dollars)

Option	New 2035 Yield (AFY)	Capital Cost ($)	Annual O&M Cost ($/year)	Add Cost of Distribution?	Add Wastewater System Costs?	Overall Unit Cost ($/AF)
Ocean Desalination	10,000	$0	$24.8M	Yes	Yes	$3,104

AF = acre-feet AFY = acre-feet per year O&M: Operation and Maintenance M: Million

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[5] SDCWA Proposed Carlsbad Seawater Desalination Project Water Purchase Agreement Factsheet, September 2012.

[6] Assumed to be $2,065 per AF based on SDCWA October 27, 2011 Water Planning Committee Meeting Presentation on Carlsbad Seawater Desalination Project Status Report.

Table 4-15: Ocean Desalination: Summary of General Benefits and Challenges

Objective	Benefits	Challenges
Reliability	▪ Reliable under changing climate and hydrologic conditions ▪ Local resource that would be available in emergency conditions	▪ None
Cost	▪ SDCWA could deliver desalinated water through existing infrastructure to the City	▪ Relatively high per unit cost (primarily due to energy requirements), although cost-efficiency has improved in recent decades due to advances in treatment technologies
Environmental/Water Quality	▪ Product water with low salinity that can improve blended water quality purchased from the SDCWA	▪ Very energy intensive ▪ Advanced treatment processes produce brine, which needs to be discharged
Implementation	▪ No significant benefits	▪ Challenging permitting and regulatory issues ▪ Requires contract negotiations with SDCWA

4.7 Imported Water

As discussed in Sections 1 and 3, the City currently relies on imported water purchases from the SDCWA to meet the majority of its demands, and in turn, the SDCWA obtains the majority of its imported water from MWD. Table 4-16 provides an overview of general benefits and challenges associated with imported water, although a comprehensive and systematic evaluation of combinations of options against specific planning objectives to develop a long-term strategy is presented in later sections.

Table 4-16: Imported Water: Summary of General Benefits and Challenges

Objective	Benefits	Challenges
Reliability	▪ Large water yields when available	▪ Availability of water is highly uncertain in the future, as Delta fix is not a given and impacts from climate change could be significant
Cost	▪ Uses existing supply infrastructure	▪ Relatively high per unit cost to purchase water, and costs are expected to increase significantly in the future
Environmental/Water Quality	▪ No significant benefits	▪ Very energy intensive conveyance ▪ Delta habitat impacts ▪ Imported water from Colorado River has high salinity
Implementation	▪ Represents the status quo option, and is easiest to implement (purchase) for existing imported water	▪ Implementation of Delta fix will require resolution of many institutional and legal issues

Because of the issues associated with imported water, the City is interested in reducing its reliance on imported water supplies in order to gain greater local control of its water resources, and avoiding uncertainty about the cost and reliability of imported water in the future. While the City is interested in reducing imported water use, it is not feasible to eliminate total reliance on imported water. Imported water will always be an important part of the City's portfolio of water supply. As such it is important to the City that imported water be as reliable and cost-effective as possible.

Section 3 presented the "base" imported water reliability scenario, which takes a conservative approach in evaluating the City's reliability risk by assuming that a Delta "fix" will not be implemented within the 2035 LRWRP planning horizon. This base reliability scenario is used for evaluating the City's potential overall supply mix reliability presented in Section 6. In order to address uncertainty of the Delta "fix", and incorporate risks into the City's long-term resource strategy, a sensitivity analysis was performed under the condition that a Delta "fix" does occur within the planning horizon (assumed in 2025).

If a Delta "fix" occurs, the future reliability of imported water supply is expected to significantly increase, but not without cost. This section describes what a Delta "fix" means and the potential cost implications for purchasing imported water. In addition, an overview of general benefits and challenges associated with imported water is provided.

4.7.1 California Delta "Fix"

Two separate efforts have been launched by California, the federal government, environmental interests, agriculture and water agencies to explore comprehensive solutions that will restore habitats and stabilize water supply. The first effort, the Delta Stewardship Council, was established by California in 2009 to develop an overall Delta Plan to achieve the co-equal goals of Delta restoration and water supply. A draft Delta Plan and Environmental Impact Report is expected to be finalized by 2012.

The second effort was launched in 2006, called the Bay Delta Conservation Program, with a mission to evaluate technical solutions to restore the Delta's habitat, including conveyance alternatives. The current preferred plan by BDCP involves creation of 30,000 acres of aquatic habitat over the next 15 years, with a total of up to 113,000 acres of habitat restoration within 50 years (the Delta encompasses roughly 700,000 acres). In addition, the proposal involves a new "isolated" alternative for water conveyance infrastructure that includes:

1. Three new intake pipelines and pumping plants located at the north end of the Delta, together with a combined capacity to divert up to 9,000 cubic feet per second,
2. State-of-the-art fish screens to protect fish passage,
3. A forebay for temporarily storing water pumped from the river, and
4. Two twin tunnels approximately 35 miles long and 40 feet wide that will carry water by gravity to the existing pumping plants located at the south end of Delta.

The estimated costs of "fixing" the Delta have been estimated to be $3-4 billion for restoration[7] and approximately $14 billion for water conveyance facilities,[8] although final cost estimates have yet to be determined. The costs of restoration would be paid mostly by the State through bond measures, taxes and user fees; a potential funding source could be the water bond that is currently scheduled for the November 2014 statewide ballot. The cost of water conveyance facilities and associated mitigation would be paid through charges to the water users who benefit from its development and operation, such as MWD.

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[7] Bay Delta Conservation Plan, Chapter 8 Implementation Costs and Funding Sources, Draft February 2012.

[8] BDCP and California's Water Future, Joint Announcement Q&A, Working Draft July 24, 2012.

4.7.2 Projected SDCWA Rates

Over the planning horizon, projected water rates for imported water are expected to increase faster than inflation, primarily due to rising energy costs, future MWD and SDCWA capital improvements, and the enormous cost of implementing a comprehensive solution in the Delta. Figure 4-4 shows projected SDCWA fixed and total volumetric rates for untreated water, with and without a Delta "fix".

Projections of SDCWA water rates (without cost of a Delta "fix") were provided to the City by the SDCWA staff. The SDCWA volumetric imported water rate, which includes the untreated purchase rate plus transportation, is assumed to escalate at 6 percent annually through 2016, 4.5 percent annually from 2017 to 2020, and 3 percent annually from 2021 to 2035. Fixed annual costs for SDCWA imported water are assumed to escalate at 3 percent annually throughout the planning horizon. The fixed costs do not vary and cannot be reduced based on reducing the City's dependence on imported water.

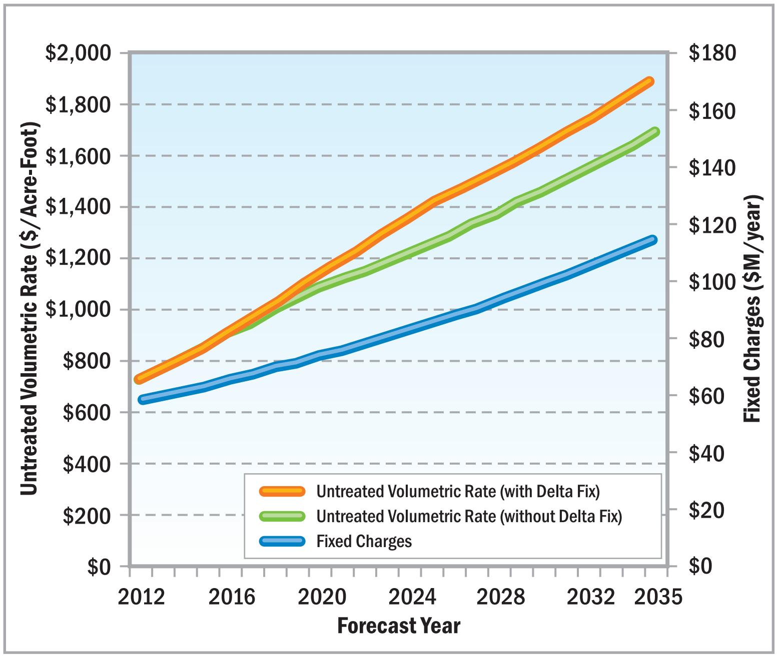

Figure 4-4: Projected SDCWA Water Rates

Estimating the potential cost implications of a Delta "fix" to the SDCWA water rates is highly speculative with much uncertainty. To incorporate the cost of a Delta "fix" into SDCWA water for 2012 LRWRP analysis, it was assumed that SDCWA volumetric rates increase at 6 percent through 2020, 4.5 percent through 2025, and 3 percent through 2035. These increases results in higher imported water costs around 2017 compared with a scenario without a Delta "fix".

In either case, continued reliance on imported water to meet future demands would substantially increase the costs for the City to provide water in the future.

For the City, the overall unit cost of imported water supply includes the cost to purchase raw water from the SDCWA (volumetric and fixed charges), treatment at the City's drinking water treatment plants, distribution to customers, and wastewater system costs. Table 4-17 summarizes the conceptual yield and current cost to the City for imported water supplies. However, the overall unit cost is expected to increase significantly in future primarily due to expected SDCWA rate increases.

Table 4-17: Imported Water: Summary of Yield and Cost of Supply (in current dollars)

Option	New 2035 Yield (AFY)	Capital Cost ($)	Annual O&M Cost ($/year)	Add Cost of Distribution?	Add Wastewater System Costs?	Overall Unit Cost ($/AF)
Imported Water	As needed and available	$0	Included in Unit Cost	Yes	Yes	$1,707

AF = acre-feet   AFY = acre-feet per year   O&M: Operation and Maintenance

SECTION 5

2012 LRWRP Process

INSIDE

- *Stakeholder Involvement*
- *Evaluation Process Overview*
- *Objectives and Performance Measures*
- *Definition of Portfolios*
- *Portfolio Evaluation Method*

The 2012 LRWRP was developed using an open, participatory planning process. Stakeholder collaboration was essential to the success of this plan's development. Throughout the process, the following terminology was used:

Objectives	*Represent major goals of plan, defined in broad, understandable terms (e.g., ensure water reliability)*
Performance Measures	*Indicate how well an objective is being achieved (e.g., frequency and magnitude of water shortages; or total lifecycle cost)*
Options	*Represent individual water supply projects or demand-side management measures*
Portfolios	*Represent combinations of options designed to best meet the stated objectives, and will be evaluated in terms of metrics*

5.1 Stakeholder Involvement

At the start of the 2012 LRWRP process, the City formed a Stakeholder Committee that represented a wide range of interests and backgrounds in order to help guide the development of the plan. Members of the Stakeholder Committee included individuals from the following groups: San Diego County Taxpayers Association, Independent Rates Oversight Committee, San Diego Regional Chamber of Commerce, Building Industry Association of San Diego, San Diego Coastkeeper, American Society of Landscape Architects, City Representative to the SDCWA Board, and San Diego Section of the American Planning Association.

A total of five Stakeholder Committee meetings were held over a period of approximately one year with the following goals:

1. Establish need for 2012 LRWRP and define goals and objectives;
2. Review water supply and conservation options, and develop initial portfolios;
3. Review evaluation of portfolios and provide comments on how to move forward;
4. Review adaptive management approach and obtain consensus on recommended strategy; and
5. Review draft 2012 LRWRP report and provide final comments/suggestions.

Prior to each stakeholder meeting, presentation materials were provided to all stakeholders. Each stakeholder meeting began with a clear agenda, meeting goals, and expectations. The meetings were facilitated to allow stakeholders and City staff to express their views in an open, non-confrontational manner. Meeting notes were taken that summarized the presentation, stakeholder comments and responses by City staff/consultant project team; and these meeting notes were provided to the stakeholders, often along with follow-up technical resources and information.

After the third stakeholder meeting, one-on-one conversations were had with all of the stakeholders in which several questions were asked about the process thus far, and to ascertain whether the information provided to date was understandable, fair, objective and useful in the context of developing the 2012 LRWRP. The results of these one-on-one stakeholder conversations are summarized in Appendix F.

The participation by and suggestions received from the stakeholders were key to the success of the 2012 LRWRP.

5.2 Evaluation Process Overview

The 2012 LRWRP proceeded initially along two parallel paths: the objectives path or "why" and options path or "how" (see Figure 5-1). The "why" path is devoted to defining the major goals of the 2012 LRWRP and sets the stage for why the plan is being undertaken. This path defines planning objectives and establishing how the objectives will be measured. Establishing planning objectives upfront is fundamentally important to a successful 2012 LRWRP as they describe what the City aims to achieve with its long-term management of water resources.

The "how" path identifies the various options and strategies that can be selected for achieving the objectives stated in the "why" path. Options can be water supply projects, programs, or contracts with other agencies. Since no single supply option is going to be able to meet all of the City's objectives, these options are combined into portfolios. Portfolios, because of their multiple sources, can increase diversity and can better meet multiple objectives.

At the joining of the two paths, an evaluation process occurs in which portfolios are analyzed using a combination of a water systems model and a multi-attribute rating tool to rank portfolios against stated objectives.

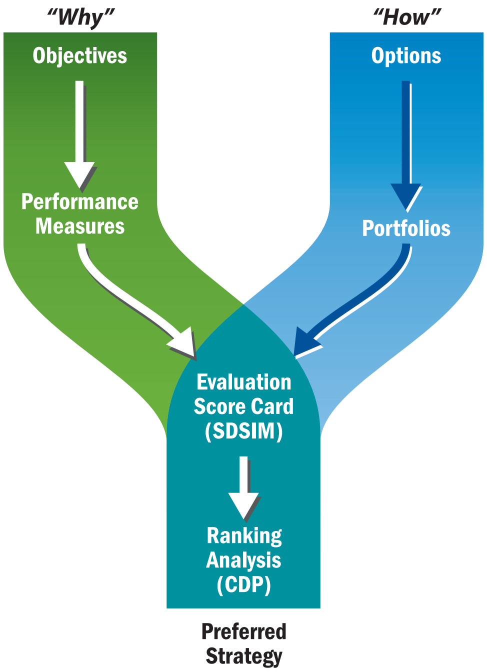

Figure 5-1: 2012 LRWRP Evaluation Process

Because of the dynamic and complex nature of the City's water supply system, evaluating the performance of portfolios without a model would be very difficult. During the development of the City's 2002 LRWRP, the SDPUD developed a water resources systems simulation model called San Diego Simulation Model (SDSIM). This model simulates water demands, water supply, conveyance of supply, and storage operations under multiple hydrologic conditions. SDSIM produces output of supply reliability (shortages and surpluses), lifecycle costs, ending period storage, and other metrics. Over the years, SDSIM has been enhanced to provide more robust information. For this update to the 2012 LRWRP, SDSIM was enhanced to model greenhouse gas emissions, estimate discharges to receiving waters from stormwater and wastewater, and incorporate climate change along with other updates. The output from SDSIM provides scores for each performance measure, known as the "raw" performance scorecard.

Because the "raw" output provided by SDSIM is in different units (e.g., water supply in acre-feet, or cost in dollars), a decision tool is needed to standardize the raw metrics and to apply the relative weights for each of the objectives. For this purpose, the multi-attribute rating software called Decision Criterium Plus (CDP) was used. CDP allows decision-makers to clearly see trade-offs between portfolios and how these portfolios rank against stated criteria. CDP also allows for quick sensitivity analysis to be conducted by altering the objective weights.

The 2012 LRWRP process is iterative where initial portfolios were evaluated first, using themes like minimize cost, or maximize reliability. Then, based on the performance and trade-offs of those initial portfolios, hybrid portfolios were created and analyzed in order to determine if overall performance could be improved. Ultimately, the portfolio evaluations provide information that is useful in development of a long-term water resources strategy.

Note that the development of any long-term strategy requires assumptions and projections to be made with some uncertainty. In order to assess uncertainty associated with key planning considerations such as future imported water reliability, energy costs, treatment technologies, and climate change, sensitivity analyses are also performed for consideration in the strategy development.

5.3 Objectives and Performance Measures

The 2012 LRWRP planning objectives serve as the major goals or reasons "why" the 2012 LRWRP is being undertaken. Objectives are usually categorized into primary and secondary (or sub-objectives). Primary objectives are more general, while secondary help define the primary objectives in more specific terms.

For each sub-objective, a performance measure is required. The performance measure is used to indicate how well an objective is being achieved.

An example of the hierarchy of objectives, sub-objectives, and performance measures is shown in Table 5-1.

Table 5-1: Example of Hierarchy Objectives and Performance Measures

Primary Objective	Sub-objectives	Performance Measures
Provide a reliable water supply	Water shortages over planning horizon	Total water shortages in acre-feet (AF) over the planning horizon
	Resilience to climate change	Hydrologic Variability Score (1 to 5), 1 - high variability, 5 - low variability
	Ratio of emergency supply to six month demand	Average percentage of emergency supply to six month demand over the planning horizon (%)

For effective decision-making, primary objectives should be developed with the following attributes:

- **Distinctive:** objectives should be developed to distinguish between one portfolio and another
- **Measurable:** objectives should be able to be measured, either quantitatively or qualitatively, in order to determine if they are being achieved
- **Non-Redundant:** objectives should not overlap with each other
- **Understandable:** objectives should be easily explainable
- **Concise:** objectives should be kept to manageable numbers

The objectives, sub-objectives and performance measures defined by the Stakeholder Committee for the 2012 LRWRP are shown in Table 5-2. The method for determining portfolio scores for each performance measure is described in Section 5.5.

In any decision-making process, the objectives are generally not equally important for every stakeholder. Some objectives may be more relevant for one stakeholder than others. Thus, weighting objectives is necessary to better reflect the values and preferences of stakeholders and decision-makers.

Table 5-2: Objectives, Sub-objectives, and Performance Measures

Primary Objective	Sub-objectives	Performance Measures
Provide Reliability & Robustness	▪ Cumulative water shortages over planning horizon (averaged under various hydrologic conditions)	▪ Total water shortages in acre-feet (AF)
	▪ Resilience to climate change	▪ Hydrologic Variability Score Score of 1 to 5, 1 - high variability, 5 - low variability
	▪ Ratio of emergency supply to six month demand	▪ Percentage (%)
Manage Cost and Provide Affordability	▪ Total present value costs to the SDPUD and customers/developers, both capital and O&M, over planning period	▪ Dollars ($)
	▪ Amount of SDPUD annual capital costs relative to total annual costs to SDPUD	▪ Percentage (%)
	▪ Potential for external funding	▪ External Funding Score Score of 1 to 5, 1 - low funding opportunities, 5 - high funding opportunities
Maximize Efficiency of Water Use	▪ Cumulative level of water conservation and reclamation over the planning horizon (averaged under various hydrologic conditions)	▪ Acre-feet per year (AFY)
Provide for Scalability of Implementation	▪ Flexibility for project phasing and expansions	▪ Scalability Score Score of 1 to 5, 1 - low scalability, 5 - high scalability
Maintain Current & Future Assets	▪ Cumulative amount of water supplied from existing drinking water treatment plants, recycled water plants, and groundwater sources (averaged under various hydrologic conditions)	▪ Acre-feet per year (AFY)
Provide for Local Control/Independence	▪ Total local resources(1)	▪ Acre-feet per year (AFY)
Maximize Project Readiness	▪ Public education effort for supply development and use	▪ Public Education Score Score of 1 to 5, 1 - significant public education effort, 5 - minimial public education effort
	▪ Implementation risk developing a water supply due to regulatory or permitting challenges	▪ Implementation Risk Score Score of 1 to 5, 1 - significant regulatory/permitting challenges, 5 - minimal regulatory/permitting challenges
Protect Quality of Life	▪ Potential for local job creation	▪ Job Creation Score
	▪ Potential for recreation/open space benefits	▪ Recreation/Open Space Score Score of 1 to 5, 1 - low recreation/open space benefits, 5 - high recreation/open space benefits
Protect Habitats & Wildlife	▪ Impact of supply development and use on ecosystems	▪ Habitat Impact Score Score of 1 to 5, 1 - high negative impact, 5 - high positive impact
Reduce Energy Footprint	▪ Cumulative greenhouse gas emissions from water sources (averaged under various hydrologic conditions)	▪ Metric Tons of carbon dioxide (CO_2)
Protect Quality of Receiving Waters	▪ Cumulative reduction in stormwater and wastewater discharges to rivers and ocean (averaged under various hydrologic conditions)	▪ Million gallons per day (mgd)
	▪ Concentration of total dissolved solids (salts) in water supply and groundwater basins	▪ Milligrams per liter (mg/l) of total dissolved solids (TDS)
	▪ Potential water quality impacts to local groundwater basins	▪ Groundwater Quality Score: Score of 1 to 5, 1 - high negative impact, 5 - high positive impact

(1) Local resources include any non-imported supply, such as conservation, groundwater, recycled water, stormwater, and ocean desalination.

Figure 5-2 presents the results from the weighting exercise for the 2012 LRWRP Stakeholder Committee, where the vertical line represents the range of weights assigned to each objective by all stakeholders, the diamond marker indicates the average (or mean) weight, and the square marker shows the median (half of respondents fall above, half fall below) for all stakeholders. Except for the reliability objective, the overall spread of the minimum and maximum weights are relatively close, illustrating that all objectives are important. The average objective weights indicate that overall, every objective has importance among the group. The median weights were found to be similar to the average weights.

The average weights for the Stakeholder Committee are used for ranking the portfolios using a multi-attribute rating method described in Section 5.5.

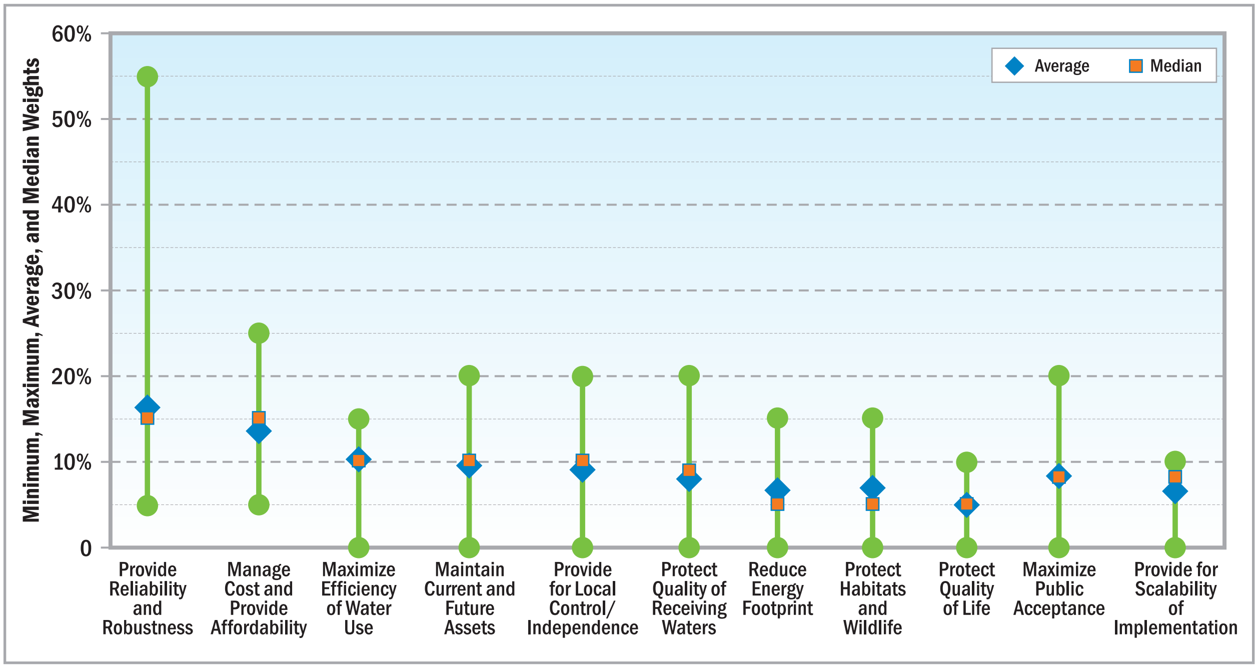

Figure 5-2: Comparison of Objective Weights for 2012 LRWRP Stakeholder Committee

5.4 Definition of Portfolios

As stated previously, no single option available to the City will meet all of the stated objectives for the 2012 LRWRP. Therefore, portfolios were developed from various combinations of options. But given the number of options available to the City, the different combinations to form portfolios could be very large to evaluate. Therefore, initial portfolios were developed around themes. Themes represented achieving key objectives without regard for the other objectives. For example, what would a portfolio look like if the only objective was to achieve supply reliability? Through the evaluation, we can then see how this portfolio would respond to cost, water quality, protection of the environment and other objectives. By developing these initial portfolios to "push" the bounds of each of the most important objectives, trade-offs can be easily seen which can then provide insights in developing "hybrid" portfolios that are more balanced and have a better likelihood of meeting multiple objectives well.

The initial portfolio themes were developed through discussions with the Stakeholder Committee. Descriptions of the portfolio themes is provided below, and a "quick-reference" matrix showing which individual options are included in each portfolio is shown in Table 5-3.

- **Baseline (Status Quo):** Only existing water supply and conservation is included in this portfolio. Overtime, the reliance on imported water from the SDCWA will increase to meet growing water demands.
- **Maximize Reliability:** Options included in this portfolio are those that have little to no hydrologic variability (and therefore not subject to droughts or climate change), and are owned/operated by the SDPUD or the SDCWA. Options that rely solely on consumer behavior or customer maintenance are not included in this portfolio as they are not as reliable into the future.
- **Minimize Cost:** Options included in this portfolio are those that have a unit cost ($/AF) less than projected cost of imported water from the SDCWA.
- **Minimize Local Environmental Impacts:** Options included in this portfolio are those that produce lower amounts of greenhouse gases (compared to imported water), those that have minimal or easily mitigated habitat impacts, and those that improve receiving water quality (rivers, streams, bays and natural groundwater).
- **Maximize Local Control:** Options included in this portfolio are those in which SDPUD and the City have control over in terms of cost, development and operations into the future.
- **Maximize Water Use Efficiency:** Options included in this portfolio are those that increase the efficiency of how water is used in the service area, including all levels of conservation, reuse, and rainwater harvesting.
- **Hybrid 1:** This portfolio builds off the Minimize Cost Portfolio by adding the Phase 1 Indirect Potable Reuse project.
- **Hybrid 2:** This portfolio builds off the Maximize Water Use Efficiency portfolio by adding groundwater projects, but removing non-potable reuse with satellite treatment plants, graywater, and centralized stormwater capture.

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Table 5-3: 2012 LRWRP Portfolios

Source of Supply or Demand Option	Ave. Supply Yield (1), (2) (AFY)	Unit Cost (2), (3) ($/AF)	PORTFOLIOS 1. Baseline (status quo)	2. Maximize Reliability	3. Minimize Cost	4. Min Local Env Impacts	5. Maximize Local Control	6. Maximize Water Efficiency	7. Hybrid 1	8. Hybrid 2
Conservation (4)										
▪ Existing/Baseline Conservation	42,650	NA (5)	■	■	■	■	■	■	■	■
▪ Additional Active Conservation	6,750	$465			■	■		■	■	■
▪ Additional Active Conservation and Water Pricing	14,150	$233			■	■		■	■	■
Local Surface Supply										
▪ Existing/Baseline Local Surface Runoff to City Reservoirs	29,000	$695	■	■	■	■	■	■	■	■
Groundwater										
▪ Existing/Baseline Groundwater Supply	500	$707	■	■	■	■	■	■	■	■
▪ San Pasqual Basin: Integrated Conjunctive Use and Groundwater Desalination ***or*** (6)	5,600	$4,100		■						
▪ San Pasqual Basin: Agricultural Water Exchange	4,660	$3,485				■	■	■		
▪ Santee-El Monte Basin	3,400	$1,437		■	■	■	■		■	■
▪ San Diego Formation Basin: Extraction Only	500	$1,551		■	■	■	■		■	■
▪ San Diego Formation Basin: Aquifer Storage and Recovery	10,000	$2,142		■						■
▪ Mission Valley Basin	2,000	$2,060		■						■
Ocean Desalination										
▪ Ocean Desalination	10,000	$3,104		■			■			
Recycled Water										
▪ Existing/Baseline Non-potable Reuse	9,253	$662	■	■	■	■	■	■	■	■
▪ New Non-potable Demands from New Privately-Developed Satellite Plants	5,475	$10,936				■		■		
▪ New Non-potable Demands from Existing Reclamation Plants ***or*** (6)	2,700	$2,079								
▪ Indirect Potable Reuse Phase 1	16,800	$2,138		■			■	■	■	■
▪ Indirect Potable Reuse Phase 2	16,800	$4,680		■			■	■		■
▪ Indirect Potable Reuse Phase 3	59,000	$2,358		■			■	■		■
Graywater										
▪ Residential Graywater	2,575	$13,499				■		■		
Rainwater Harvesting										
▪ On-site Capture (rain barrels and cisterns)	416	$6,393			■	■		■	■	■
▪ Centralized Stormwater Capture	100	$19,758				■	■	■		
Imported Water										
▪ Continue to Purchase Imported Water from SDCWA (7)	as needed and available	$1,707	■	■	■	■	■	■	■	■

Notes:

(1) Estimated supply yield (or savings) by year 2035

(2) All yields and costs are planning level estimates. Estimates will be refined as more detailed analyses are conducted in later phases of project implementation and design.

(3) Represents total cost of water including cost of supply source, distribution to customers, and wastewater system costs (collection, treatment, and disposal), in current dollars.

(4) Incremental savings. Values are additive.

(5) Most costs of conservation are incurred during installation of conservation devices or demand management measures. The program costs to maintain existing conservation savings are minimal in volumetric terms.

(6) these options are not additive; only one can be selected for each portfolio.

(7) Imported water purchases from the SDCWA are assumed as the last priority supply after all other resources included in each portfolio have been utilized. Therefore all portfolios will have purchases of imported water, but with varying amounts.

Acronyms:

AFY: Acre-Feet per Year AF: Acre-Feet ENV: Environmental Min: Minimize NA: Not applicable SDCWA: San Diego County Water Authority

Instructions for Interpreting this Table:

This table is a matrix showing the combination of options that will be included in each portfolio. The options are listed in the first column, and portfolios are listed across the top row. The options included in each portfolio are indicated with a "■". These portfolios will be evaluated against each of the LRWRP 2012 planning objectives with the City's water systems simulation model (SDSIM), and will then be ranked base on their performance in meeting the objectives.

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5.5 Portfolio Evaluation Method

After developing objectives and portfolios, the next step in the planning process is to evaluate and rank the portfolios. Performance measures assess the ability of a portfolio to achieve the planning objectives, and can be quantitative in nature (developed using models and analyses), or qualitative in nature and assessed based on a variety of factors using professional judgment (refer to Appendix C for guidance on qualitative scoring).

The SDPUD's SDSIM model was used to evaluate portfolios and provide raw scores for quantitative performance measures such as supply reliability, cost, water quality, and green house gas emissions. The systems model is summarized below in Section 5.5.1, with more details provided in Appendix B.

Scores for each of the qualitative and quantitative performance measures from Table 5-2 are summarized in what is called a "raw" performance scorecard (refer to Section 6 for the scorecard results). Because the raw performance of the objectives are measured in different units (e.g., supply reliability is measured in AFY, cost measured in dollars, and carbon dioxide emissions measured in metric tons per year), a decision tool is often needed to rank the portfolios. Therefore, a software tool known as Criterium Decision Plus (CDP), developed by Infoharvest, Inc., is used for the portfolio ranking method, which is described further in Section 5.5.2.

5.5.1 System Simulation Model Overview

Model Purpose

The City's water system consists of complex and dynamic sources of supply and interdependence among the sources. To simulate the use of existing sources of supply and facilitate decisions on future supply options, the SDPUD's SDSIM model was used as the main tool for evaluating system performance. SDSIM was developed for the 2002 LRWRP and has been updated several times to incorporate new parameters. This tool is appropriate for strategic level decision-making, with the ability to look at comprehensive systems in an integrated manner. Systems models combine natural, physical, and social systems to help decision-makers understand impacts and trade-offs. Systems simulation models are also dynamic, meaning they can evaluate parameters through time. Such dynamic evaluation is crucial for long-term water resources planning.

The systems model is programmed with the commercial software STELLA, developed by Isee Systems, Inc. The modeling platform has a very flexible and relatively simple programming environment. In addition, the STELLA software provides graphical interfaces that create an engaging virtual environment, increasing the ability of technical staff to share their understanding of system with decision-makers and stakeholders. The model is quite useful in generating large amounts of comparative data with a relatively short simulation time, which is helpful for running multiple configurations of water resource portfolios.

SDSIM was developed to: (1) represent the physical water delivery system for the City; (2) simulate the operations of existing and future water supplies under different hydrological conditions in order to meet current and projected demands; and (3) provide "raw" performance scores for each portfolio in achieving the stated planning objectives.

In order to do this, the following model components were updated or added for the 2012 LRWRP:

- Updated demand projections
- Updated imported water availability and costs
- Update existing system components to reflect recent and planned near-term improvements (use of Lake Hodges, emergency storage requirements, raw water conveyance capacity, treatment capacity, costs).
- Updated supply option information (costs, yields, etc.) and added new supply options not previously evaluated, including indirect potable reuse, graywater, and urban runoff
- Updated performance measures calculated by the model; this included addition of several new performance measures including greenhouse gas emissions, potential for job creation, reduction in stormwater and wastewater discharges, etc.)
- Added functionality to evaluate climate change impacts

Model Structure

The model performs a water balance based on the City's projected demands, existing water supplies, and potential future water supply options – under different weather (or hydrologic) conditions. Refer to Figure 5-3 for a conceptual model representation of water supply flows. The model simulates water supplies and demands from 2010 to 2035, on a monthly timestep to analyze important seasonality elements of supplies and demands.

The City's water delivery system is divided into three service areas: Miramar Service Area, Alvarado Service Area, and Otay Service Area (see Figure 3-3). For each service

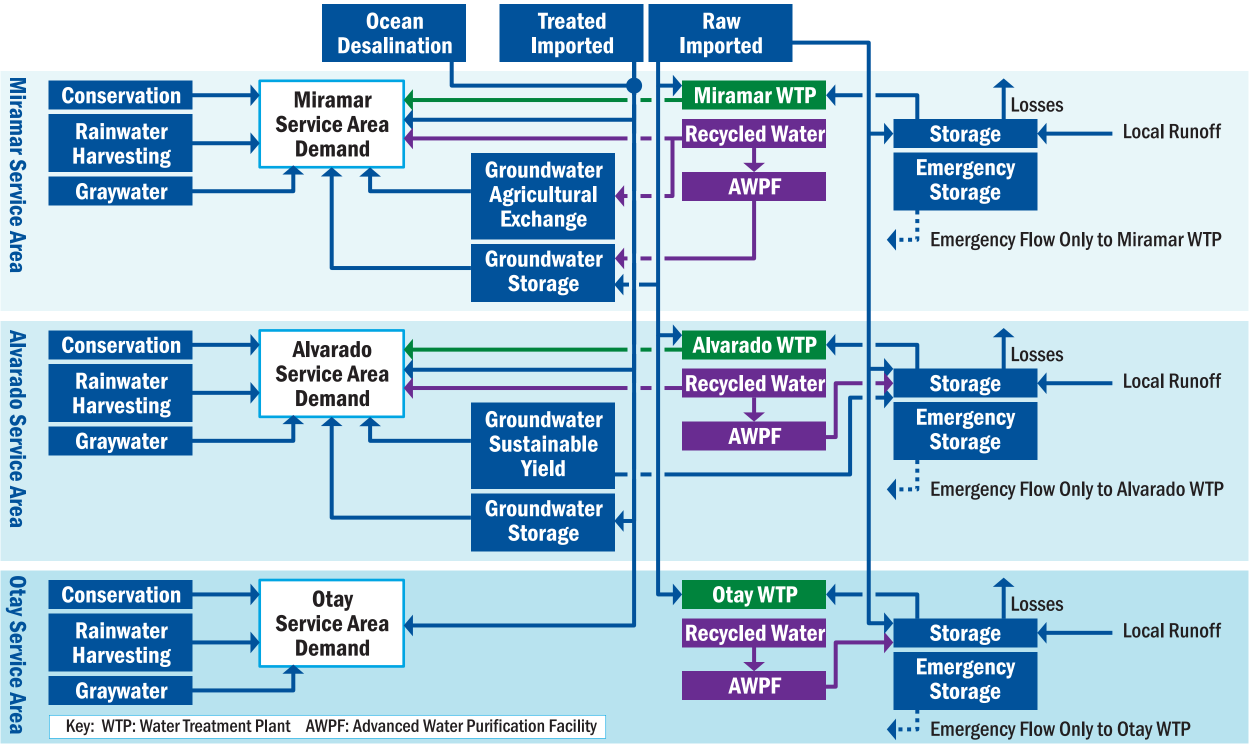

Figure 5-3: Conceptual Model Flow Chart

area, SDSIM represents the major water facilities such as reservoirs, pipelines, and treatment plants. All supply options are represented in the model including groundwater, recycled water, local surface water, graywater, urban runoff, ocean desalination, and imported water. Major elements that interact together (e.g. rainfall interacting with reservoir storage) are simulated as well.

Modeling hydrology requires addressing several difficulties. One of the most common problems in modeling a water supply and delivery system is the use of averages for the representation of inherently probabilistic variables, such as precipitation. Water demands and supplies fluctuate significantly with weather. With water demands, outdoor irrigation demands are typically higher in drier, hotter years; and generally lower in cooler, wetter years. Weather conditions that typically drive demands upward, conversely, tend to drive local supply generated from rainfall and runoff downward. In addition to fluctuating local water demands and supplies, imported water supplies also vary from year to year. However, hydrology in northern California and Colorado River basin (where the City's imported water supply originates) is not always correlated to hydrology in San Diego County (where local runoff originates). To account for these fluctuations, demand and supply factors were applied to long-term averages in order to estimate the variability in demand and supply under different hydrological conditions. For the purpose of modeling and evaluation, four 26-year hydrologic traces were developed: (1) critically dry; (2) dry; (3) normal; and (4) wet. These traces were selected based on analysis of historical data for a 77-year period of record.

It is important to note that the water system represented in the model is at the conceptual level only – meaning that the model will not simulate any hydraulic or hydrologic routing. The system model does not replace the need for a more detailed engineering model of a single system (e.g. detailed distribution system model). The system model should be used supplementary and iteratively with these types of models.

To evaluate the unique set of supply options that make up a "portfolio", the model includes a management panel—a graphic user interface incorporated into the model's design. The management panel allows the user to switch different options "on" or "off," depending on whether an option is implemented in a portfolio. Figure 5-4 is a screenshot of the main management panel for SDSIM.

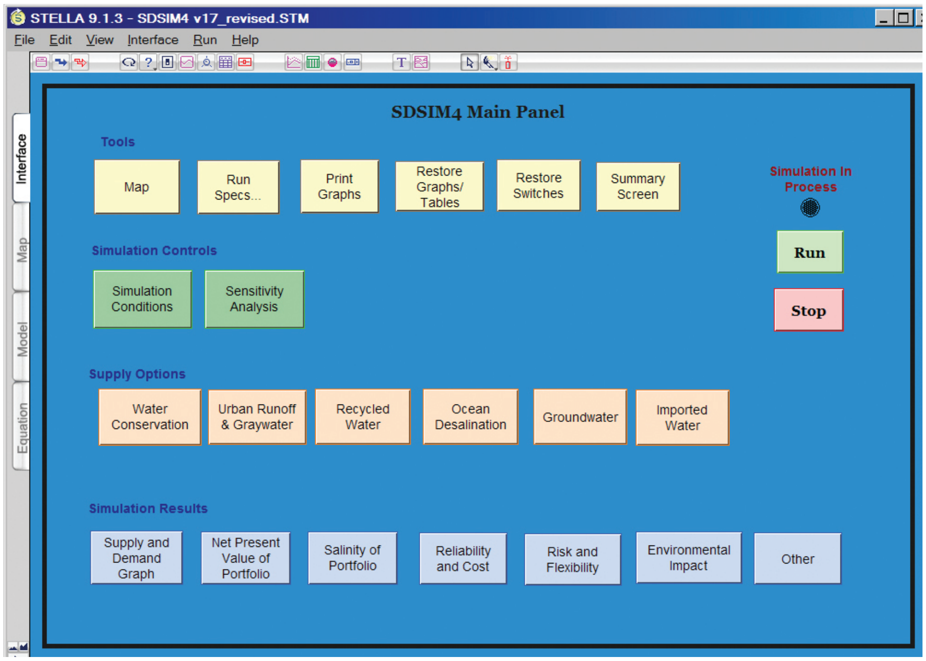

Figure 5-4: Screenshot of SDSIM Main Management Panel

5.5.2 Portfolio Ranking Method

All of the planning objectives, performance measures, and weights (described in Section 5.3), and the raw performance scorecards for each portfolio (developed using SDSIM), are put together into a decision model to rank the portfolios. This section describes the methodology used to develop the portfolio rankings.

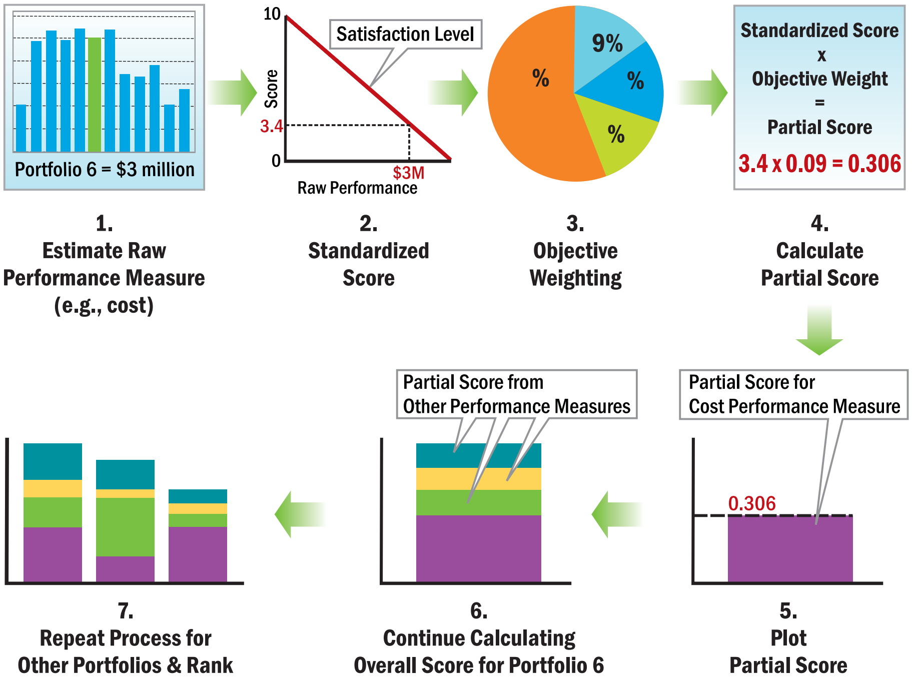

Figure 5-5: Multi-Attribute Rating Method

The software Criterium Decision Plus (CDP), developed by Infoharvest Inc., was used to rank the portfolios. This software tool converts raw performance measured in different units into standardized scores so that the performance measures can be summarized into an overall value. CDP is ideal for multiple criteria decisions with diverse stakeholders. The technique used by CDP to rank portfolios is called Multi-Attribute Rating are described as follows (see Figure 5-5):

- Step 1 compares the raw performance of a given objective for all the portfolios. In this example, Portfolio 6 has a raw cost (or performance) of $3 million.
- Step 2 standardizes the raw performance score for each objective into comparable numeric scores (the higher the score the better the performance). In this example, Portfolio 6 has a relatively high cost when compared to the other portfolios, so the standardized score for this objective (between 0 and 10) is 3.4, a fairly low performance.
- Steps 3 and 4 calculate the partial score for the portfolio, based on the standardized score and the weight for the objective being calculated. In this example, the cost objective was given a weight of 9 percent (out of a possible 100 percent). The partial score for this objective represents the standardized score (3.4) multiplied by the objective weight (0.09) which equals 0.306.
- Step 5 plots the partial score of 0.306 for Portfolio 6, and this procedure repeats for all of the other objectives for Portfolio 6 until a total score for the portfolio is calculated (see Step 6).
- Steps 1 through 6 are then repeated for all portfolios, and then portfolios are ranked (see Step 7).

SECTION 6

Portfolio Evaluations

Water supply portfolios were evaluated and ranked using the approach described in Section 5. First, each portfolio was evaluated using SDSIM, which provides raw performance scores in terms of supply reliability, affordability, environmental protection, and other objectives.

This information from the raw performance scorecard was then standardized using CDP, which is a multi-attribute rating tool, in order to determine a portfolio's overall score and rank them. Initial portfolios were evaluated first. Then, based on the performance of initial portfolios, hybrid portfolios were developed and evaluated (see Figure 6-1). In addition, sensitivity analyses were performed to address uncertainty associated with key planning considerations such as future imported water reliability, energy costs, treatment technologies, and climate change.

This section presents the results of portfolio evaluations, which provides useful information for development of a long-term water resources strategy.

INSIDE

- *Raw Performance Scorecard*
- *Portfolio Rankings and Sensitivity*
- *Climate Change Adaptation*
- *Summary of Findings*

6.1 Raw Performance Scorecard

Table 6-1 presents the raw performance of the portfolios, which is the assessment of a given portfolios ability to achieve the planning objectives, regardless of the importance or weight of the objectives. It is important to recognize that the performance metrics used to evaluate portfolios are not intended to be accurate predictions, but rather they are used to determine the relative benefits that the portfolios have when compared to each other.

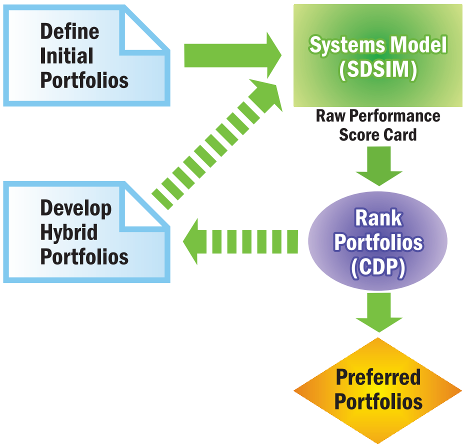

Figure 6-1: Portfolio Evaluation Process

Approximately 20 performance measures were evaluated to assess how well portfolios are achieving the planning objectives. Appendix D provides a more detailed accounting of all the performance measures used in the analysis to compare portfolios. A few key performance metrics are summarized below in order to illustrate the analytical process.

6.1.1 Water Shortages over Planning Horizon

Water supply reliability was analyzed using the SDSIM model, which accounts for variations in supplies and demands due to hydrology. Projected demands from 2010 to 2035 are simulated over time using 26-year hydrologic traces selected from 77 years of historical records. Four representative hydrologic traces are simulated: critical dry, dry, normal, and wet. It should be noted that not all the years included in the critically dry hydrology trace are dry, just that the cumulative sequence produces the greatest overall shortages.

As described in Section 3, the evaluation accounts for reliability risk to the City if a comprehensive Delta "fix" is not implemented within the 2035 planning horizon. In this scenario, there are projected to be continued imported water shortages to meet future water demands due to droughts and environmental flow restrictions. Figure 6-2 shows the status quo portfolio supply mix over time for the critically dry hydrologic condition. The supply mix over time for each portfolio is presented in Appendix D.

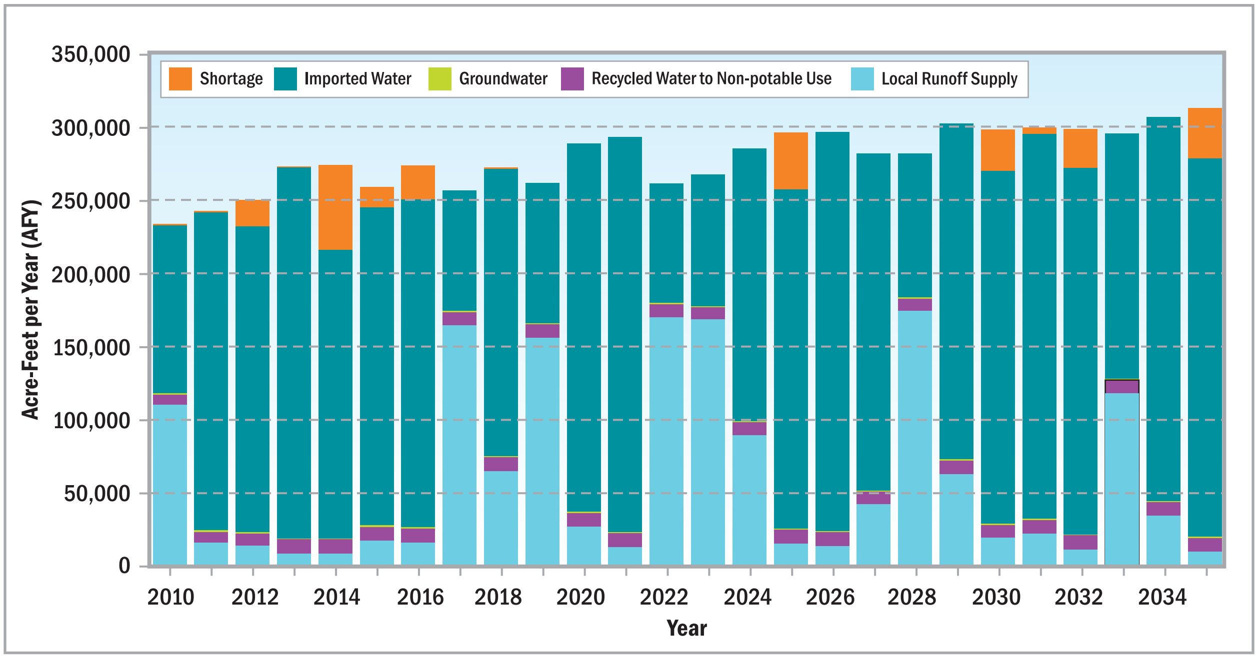

Figure 6-2: Projected Status Quo Supply Mix No Delta "Fix," with Critically Dry Hydrology

Figure 6-2 demonstrates the variability of supplies and demands from year to year based on weather conditions. Water demands fluctuate since outdoor irrigation demands are typically higher in drier, hotter years; and generally lower in cooler, wetter years. Weather conditions that typically drive demands upward, conversely, tend to drive local supply generated from rainfall and runoff downward. In addition to fluctuating local water demands and supplies, imported water supplies also vary

Table 6-1: 2012 LRWRP Portfolio Raw Performance Scores

			PORTFOLIOS							
Objectives	**Performance Measures**	**Units**	**1. Baseline (status quo)**	**2. Maximize Reliability**	**3. Minimize Cost**	**4. Min Local Env Impacts**	**5. Maximize Local Control**	**6. Maximize Water Efficiency**	**7. Hybrid 1**	**8. Hybrid 2**
Provide Reliability and Robustness	Cumulative water shortages over planning horizon	Total water shortages in acre-feet (AF)	153,585	27,155	55,417	35,986	29,811	19,311	34,544	15,581
	Resilience to Climate Change	Hydrologic Variability Score Score of 1 to 5: 1 - high variability, 5 - low variability	2.0	4.0	2.5	2.5	4.0	4.0	3.0	4.0
	Ratio of emergency supply to six tenths of annual demand	Percentage (%)	97%	116%	105%	107%	114%	121%	109%	122%
Manage Cost and Provide Affordability	Total present value costs to the City PUD and customers/developors, both capital and O&M, over planning period	Dollars ($)	7,096,152,512	11,934,798,781	6,923,257,424	8,363,225,553	11,804,673,480	12,596,806,711	7,287,851,141	11,317,058,270
	Amount of City PUD annual capital costs relative to total annual costs to City PUD	Percentage (%)	8%	16%	9%	10%	16%	16%	12%	16%
	Potential for external funding	External Funding Score Score of 1 to 5: 1 - low funding opportunities, 5 - high funding opportunities	1.0	3.5	1.5	2.0	3.5	4.0	2.0	4.0
Maximize Efficiency of Water Use	Cumulative level of water conservation and reclamation over the planning horizon (averaged under various hydrologic conditions)	Acre-feet (AF)	1,345,799	2,610,559	1,773,599	1,931,612	2,646,039	3,119,951	2,109,599	2,993,270
Provide for Scalability of Implementation	Flexibility for project phasing and expansions	Scalability Score Score of 1 to 5: 1 - low scalability, 5 - high scalability	5.0	2.5	5.0	5.0	2.5	3.0	4.5	2.5
Maintain Current & Future Assets	Cumulative amount of water supplied from existing drinking water treatment plants, recycled water plants, and groundwater sources (averaged under various hydrologic conditions)	Acre-feet (AF)	6,781,192	7,042,580	6,539,912	6,489,647	7,188,205	6,819,199	6,903,616	6,884,305
Provide for Local Control/Independence	Total local resources(1)	Acre-feet (AF)	102,326	150,420	122,621	129,773	147,647	1257,769	134,057	157,319
Maximize Project Readiness	Public education effort for supply development and use	Public Education Score Score of 1 to 5: 1 - significant public education effort, 5 - minimal public education effort	5.0	3.0	4.5	4.5	3.0	3.0	4.0	3.0
	Implementation risk developing a water supply due to regulatory (reg) or permitting challenges	Implementation Risk Score Score of 1 to 5: 1 - significant reg/permitting challenges, 5 - minimal reg/permitting challenges	4.0	3.0	4.0	4.0	2.5	2.5	3.5	3.0
Protect Quality of Life	Potential for local job creation	Job Creation Score	827	2,402	823	1,373	2,367	2,750	968	2,270
	Potential for recreation/open space benefits	Recreation/Open Space Score Score of 1 to 5: 1 - no recreation/open space benefits, 5 - high recreation/open space benefits	1.0	3.5	2.0	3.5	4.0	5.0	2.5	4.0
Protect Habitats & Wildlife	Impact of supply development and use on ecosystems	Habitat Impact Score Score of 1 to 5: 1 - high negative impact, 5 - high positive impact	3.0	2.5	5.0	4.5	2.0	2.5	4.0	3.0
Reduce Energy Footprint	Cumulative greenhouse gas emissions from water sources	Metric Tons of carbon dioxide (CO_2)	8,432,098	8,660,443	7,871,177	7,730,799	8,560,398	7,868,740	7,832,265	7,965,275
Protect Quality of Receiving Waters	Cumulative reduction in stormwater and wastewater discharges to rivers and ocean (averaged under various hydrologic conditions)	Million gallons (mg)	210	1,338	334	502	1,371	1,562	633	1,422
	Concentration of total dissolved solids (salts) in water supply	Milligrams per liter (mg/l) of total dissolved solids (TDS)	503	456	503	500	455	458	490	460
	Potential water quality impacts to local groundwater basins	Groundwater Quality Score Score of 1 to 5: 1 - high negative impact, 5 - high positive impact	3.0	5.0	3.0	2.5	4.0	3.0	3.5	4.0

Note:

(1) Local resources include any non-imported supply, such as conservation, groundwater, recycled water, stormwater, and ocean desalination.

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from year to year. However, hydrology in northern California and Colorado River basin (where the City's imported water supply originates) is not always correlated to hydrology in San Diego County (where local runoff originates).

In order to assess portfolio performance in reducing water shortages over the planning horizon, the cumulative water shortages over each of the hydrologic traces were averaged into a single performance score. Figure 6-3 presents performance scores for each portfolio. As shown, all portfolios significantly reduce water shortages compared to the status quo (or baseline portfolio). While most shortages are alleviated by new options, there is some near-term risk of shortages in earlier years before the new options are implemented.

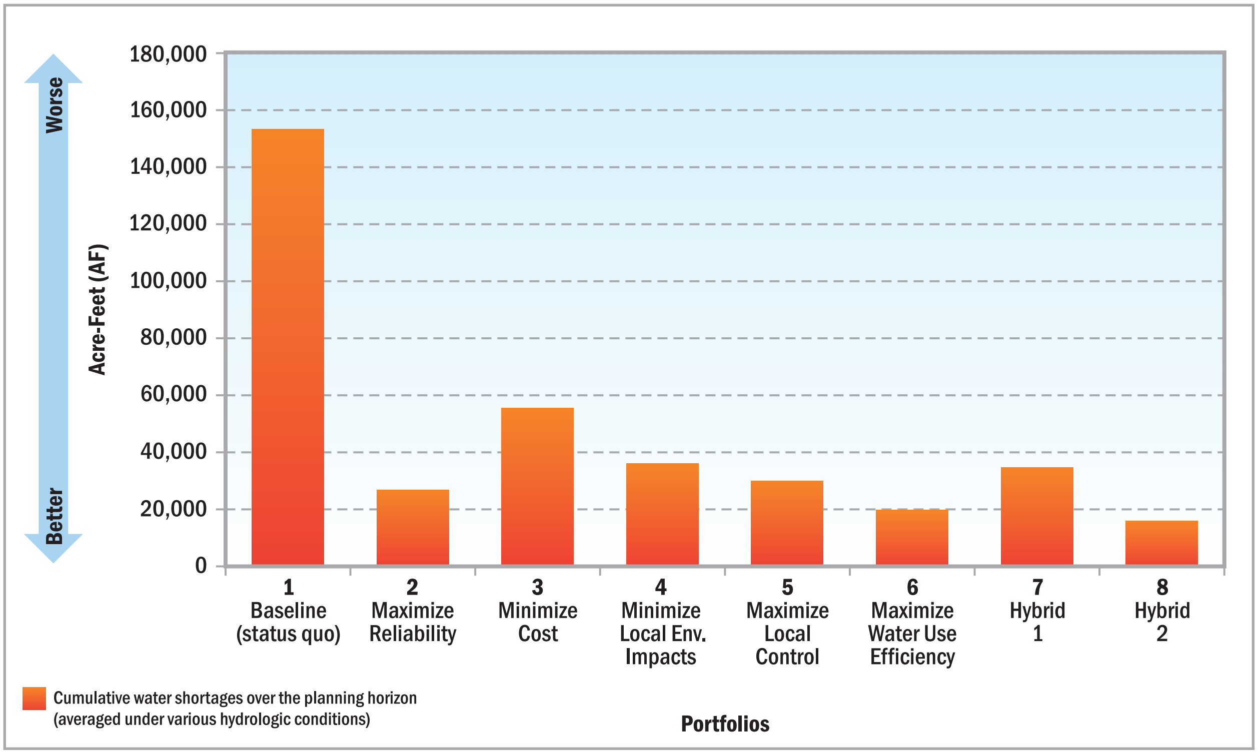

Figure 6-3: Portfolio Scores for Total Projected Water Shortages Over Planning Horizon

6.1.2 Water Use Efficiency

Since available freshwater resources are limited, the water use efficiency objective seeks to minimize "wasted" water. Performance is measured based on increasing efficient use of resources both on the demand-side through conservation, and also on the supply-side through use of wastewater as a resource for water recycling.

Figure 6-4 shows the cumulative amount of water conservation and recycling for each portfolio. The portfolios that include the maximum conservation savings and recycling through indirect potable reuse have higher scores in this performance measure. While recycling through non-potable reuse helps with water use efficiency, the magnitude of non-potable demands in the service area are limited compared with potential yield from indirect potable reuse opportunities.

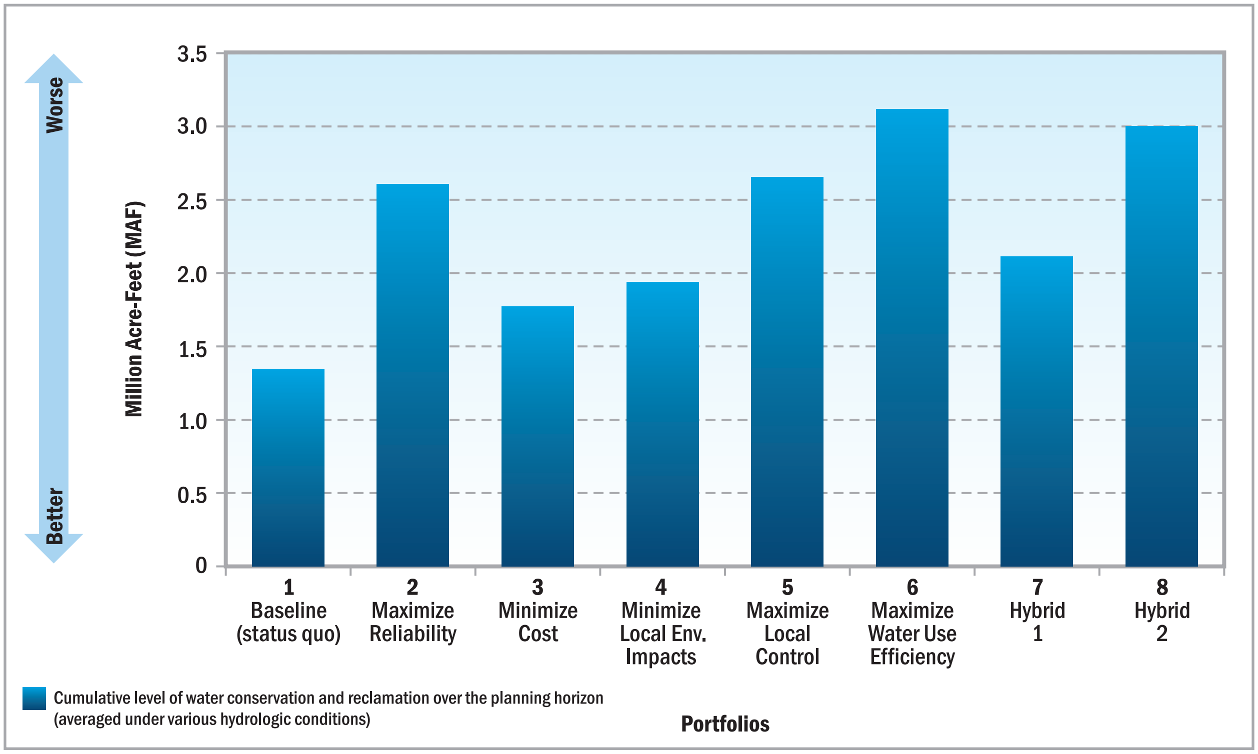

Figure 6-4: Portfolio Scores for Total Reclamation and Conservation Over Planning Horizon

6.1.3 Enhance Environment

A number of factors are considered in assessment of environmental impacts, including the impact of greenhouse gas emissions on air quality, long-term impacts to local habitat areas resulting from project construction and operations, and potential habitat degradation from water quality, among others.

Air Quality

Greenhouse gas emissions are important in order to assess air quality impacts. In addition, reductions in greenhouse gas emissions are a mitigation strategy to protect against potential climate change consequences. In this analysis, greenhouse gas emissions are calculated based on typical per unit energy requirements for each source of water supply, including energy requirements for distribution and wastewater treatment if applicable. The energy required was converted to carbon dioxide equivalents. While imported water sources have different sources of energy than local water resources, it is assumed that all water resources use the same energy resource for simplicity. Therefore, portfolio variations in carbon dioxide emission for this analysis are a reflection of the energy required to produce water; not the type of energy used for each water resource. Figure 6-5 presents the carbon dioxide emissions for each portfolio.

The baseline portfolio is showing relatively high carbon dioxide emissions, since imported water requires significant pumping. Water from Northern California requires a net lift of over 2,000 feet to cross the Telepachi Mountains, and water from the Colorado River requires a net lift of over 1,500 feet to move across the long, flat

Mojave Desert. While the 'Maximize Reliability' portfolio and the 'Maximize Local Control' portfolio reduce imported water use, they include options requiring advanced treatment processes with high energy requirements such as ocean desalination (the most energy intensive resource), indirect potable reuse, and groundwater desalination.

Figure 6-5 shows that some portfolios are performing better than others. Every portfolio showing significant reduction in carbon dioxide emissions includes the maximum level of conservation.

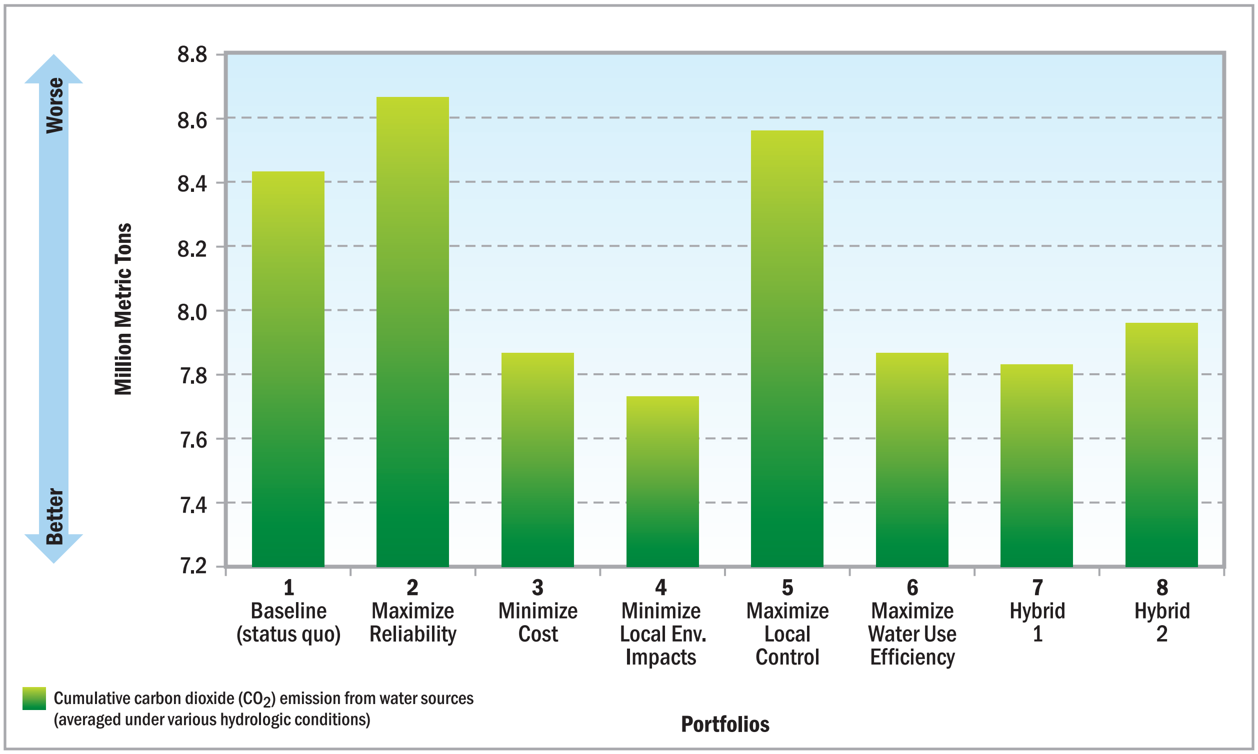

Figure 6-5: Portfolio Scores for Total Carbon Dioxide Emissions Over Planning Horizon

Water Quality

As discussed in Section 2, there are a number of constituents that affect imported water; however, salinity conditions are the most constraining particularly for Colorado River supplies. Salinity is also an issue with local supplies, since some surface water reservoirs have high salinity depending on their watershed characteristics and uses.

When potable water supplies (from local and imported water sources) are high in salinity, a portion of this water eventually becomes wastewater and affects salinity of recycled water for non-potable reuse. Given salinity management issues, the primary constituent considered in scoring of this performance measure was salinity concentrations of potable water supplies.

Figure 6-6 shows the average salinity concentrations of the overall potable water supply mix for each portfolio. The portfolios showing significant reductions in salinity include every phase of indirect potable reuse projects, which involves advanced treatment that removes salinity prior to potable use. The potential yield for indirect potable reuse is much higher compared with other supply opportunities that have advanced treatment or lower salinity; therefore, it has more affect on the overall supply concentrations than other options.

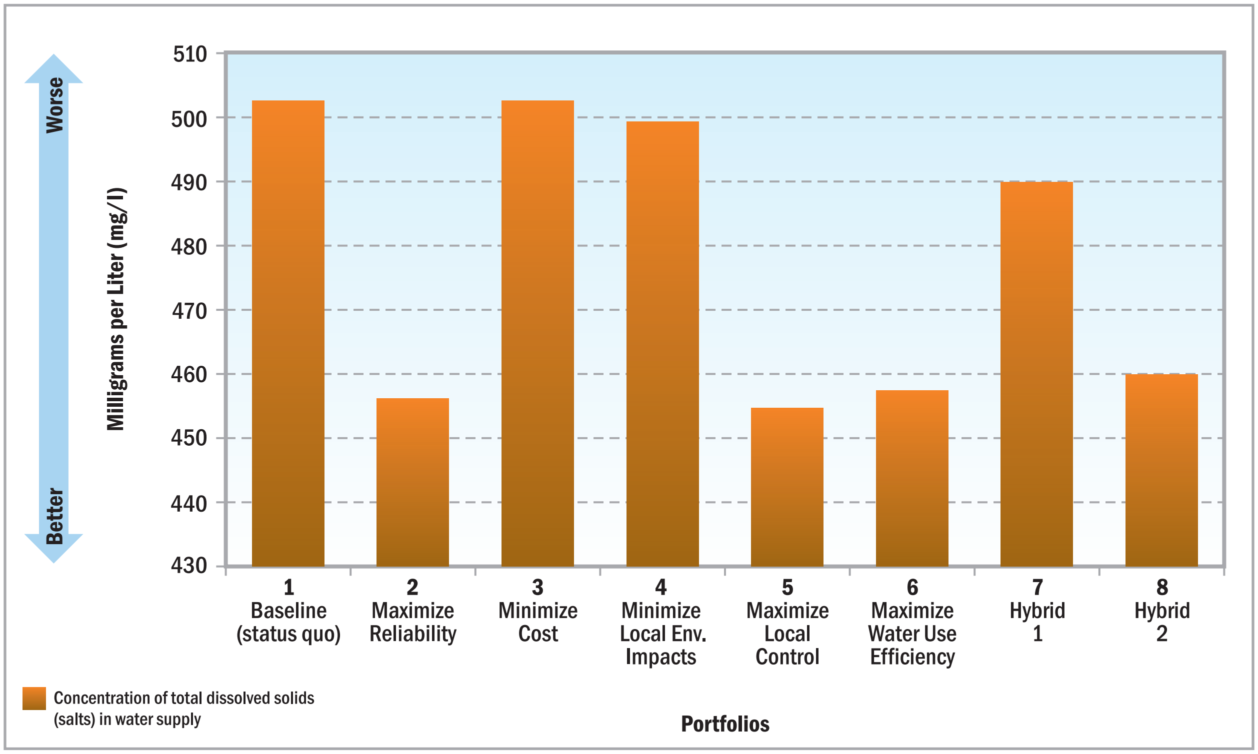

Figure 6-6:
Portfolio Scores for Average Total Dissolved Solids Concentration in Potable Water Supply Mix Over Planning Horizon

Habitat Protection

Any project that requires construction of pipelines or treatment plants has temporary habitat impacts. However, the 2012 LRWRP takes a long-term viewpoint and considers potential habitat impacts that would be sustained in the long-term. While habitat areas of imported water origin are at risk, the 2012 LRWRP evaluation includes other performance measures that are aimed at reducing imported water supply, such as Provide for Local Control and Independence, and would relieve stress on these ecosystems. For this reason, local habitat areas are considered for the impact of supply development and use on ecosystems. Figure 6-7 presents the portfolios scores.

As discussed, in terms of water quality, salinity management is an important issue for San Diego. Salinity can be removed from water supplies with advanced treatment technologies; however, this produces brine which must be disposed of properly. Brine is typically disposed of through an ocean outfall for dissipation with seawater. However, potential long-term consequences to habitat areas located close to the outfall location are uncertain without available long-term monitoring data. In order to take this into account, any portfolios with options requiring advanced treatment process and disposal of brine, such as ocean desalination, indirect potable reuse, and groundwater treatment; do not score well in this performance measure. Scores depend on relative impacts of options based on brine concentrations and yields.

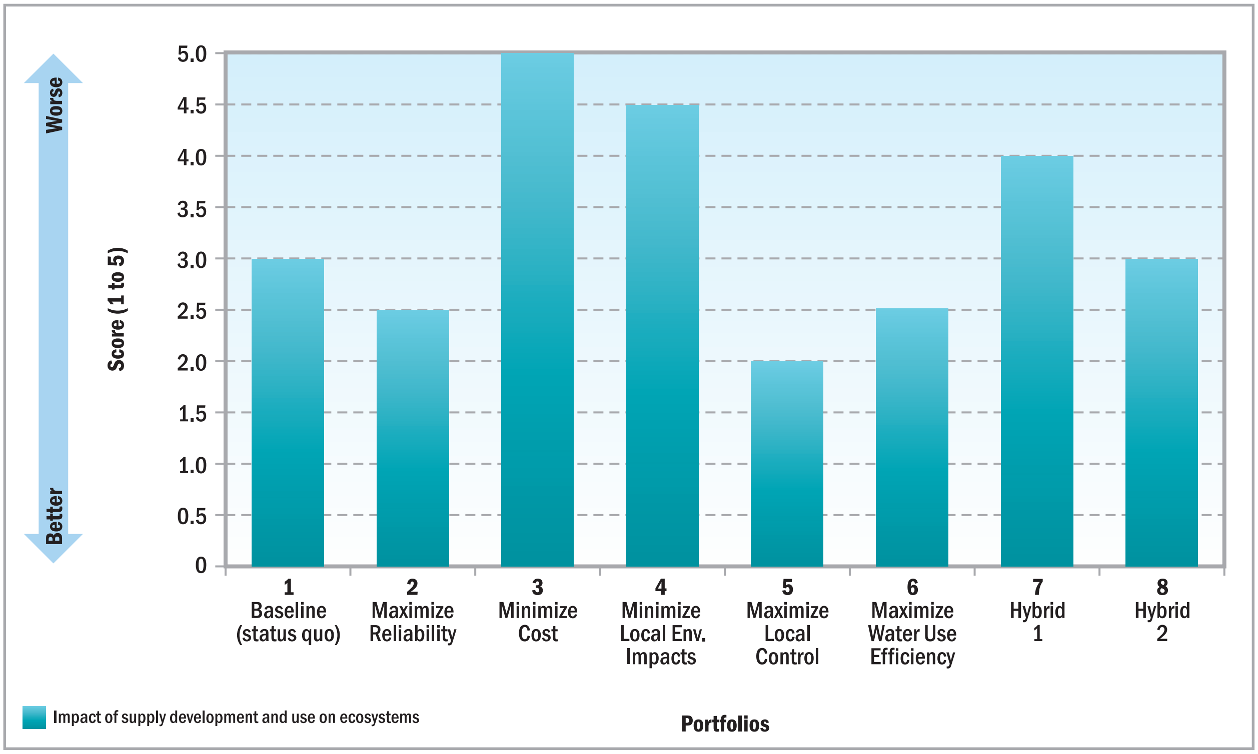

Figure 6-7: Portfolio Scores for Local Habitat Protection

6.1.4 Managing Costs and Affordability

For portfolio analyses, total "societal" costs are considered. This approach accounts not only for the cost to the City which could affect water rates, but also the cost to customers/developers. Some options that would result in added customer/developer costs include conservation, graywater, rainwater harvesting, and recycled water for non-potable reuse, since they require on-site retrofits or improvements during implementation.

Costs include operation of existing supplies and development of new options. For existing water supplies, only the variable operational cost of supply is included in the analysis. Typically, these represent "prospective" costs – or future costs that could be avoided if other actions are taken. Any "sunk" costs such as existing program costs, capital payments, or already planned capital improvements are not included in the analysis.

Costs for new options represent the incremental new capital, operational, or program costs. Traditionally, cost comparison of water supply options has only included the capital and operating costs to produce the water supply. However, in order to fully compare options, the costs of distributing the water supply and costs associated with wastewater collection, treatment and discharge were added to this analysis. This is important because not all water supply options require water distribution or wastewater costs. In fact, some options actually reduce wastewater costs for the City. For example, increased recycling can help offload wastewater treated at Point Loma WWTP and help avoid some costs associated with infrastructure improvements at Point Loma WWTP for secondary treatment upgrades. The level of avoided costs depends on the magnitude of wastewater that could be recycled.

Annual portfolio costs include:

- **Annual Capital Costs:** Includes amortized capital cost of new supply development and Point Loma WWTP upgrades, which vary depending on the magnitude of wastewater offloaded by the options in a portfolio.
- **Supply O&M:** This is the cost to produce the water resource, and including supply operation and maintenance (O&M) costs.
- **Distribution O&M:** The variable cost of distribution is included where applicable. Some supply options require distribution to customers, while others don't such as conservation, graywater, and rainwater harvesting.
- **Wastewater System O&M Costs:** The operational cost to collect and treat wastewater is included where applicable. Some options such as conservation, graywater, and recycled water reduce the amount of wastewater to Point Loma WWTP and may reduce potential operational costs of the wastewater system.
- **Imported Water Costs:** Includes fixed and variable (based on volumetric rate) costs to purchase imported water from the SDCWA.

In order to calculate annual costs over time, a 3 percent inflation rate is assumed for all O&M costs except imported water rates which are expected to increase faster than inflation (discussed previously in Section 4.7). Capital costs are inflated to the approximate 5-year timeframe projects could be implemented, and are assumed to be amortized at 5.5 percent over a 30 year period.

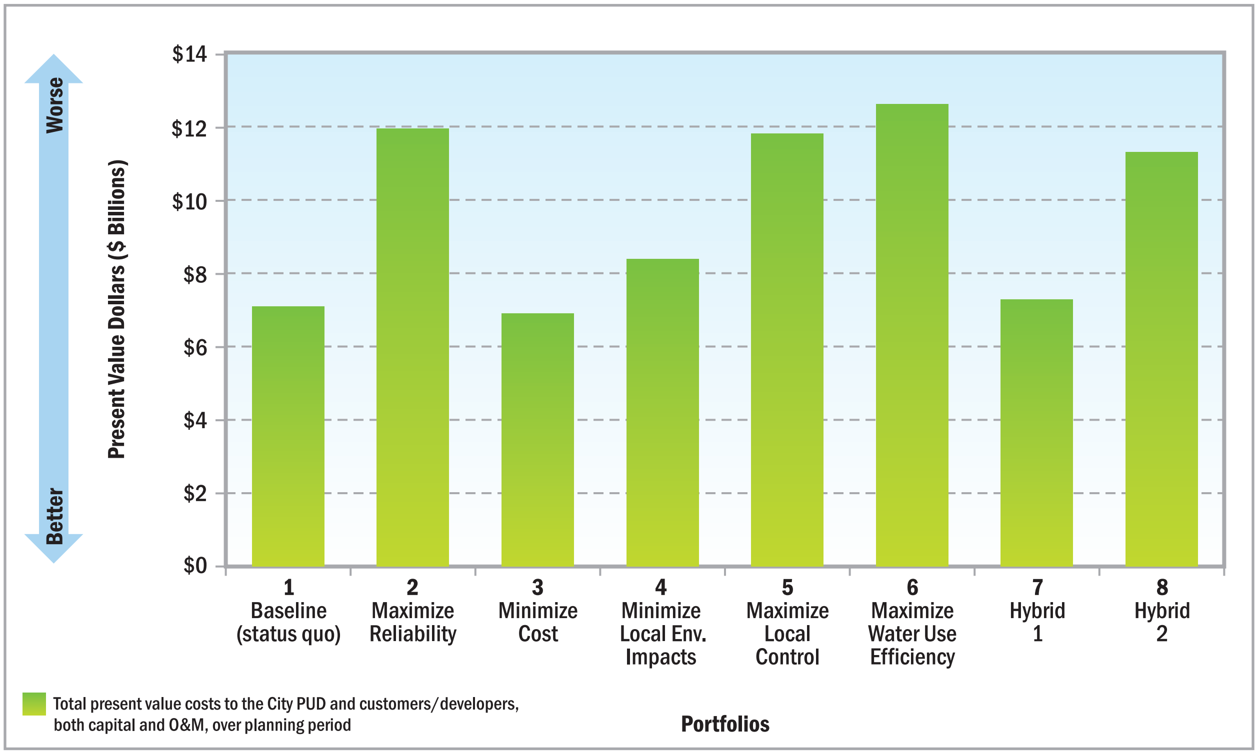

Figure 6-8: Portfolio Scores for Total Present Value Costs Over Planning Horizon

Total annual portfolio costs are analyzed over the entire planning horizon and discounted back to present value (PV) using the SDSIM model. Figure 6-8 shows cumulative PV costs over the planning horizon for each portfolio.

While there are some cost differences among the portfolio, it is important to recognize that not all these costs would be incurred by the City. The 2012 LRWRP takes a very conservative approach in estimating the potential cost risks, but there are a number of ways that these costs could be offset to avoid potential rate implications:

- Some costs would be incurred by participating customers/developer where on-site retrofits or improvements are needed
- No state or federal grant funding is assumed in the cost analyses, although the City has an excellent track record for securing grant funding for up to 40-50 percent of the cost of supply. Potential for grant funding is considered as a separate metric (refer to Appendix D for more information).
- No rebates or support from other regional agencies is included (historically, MWD and SDCWA have provided incentives for conservation and local supply development)

These factors are considered in the adaptive implementation strategy in Section 7.

6.2 Portfolio Rankings and Sensitivity

Using the raw performance scores in Table 6-1, the portfolios were ranked with the multi-attribute rating method using CDP described in Section 5.5.2. The portfolios were ranked based on the relative importance of each objective. Figure 6-9 shows the rankings of portfolios using the average weightings from the 2012 LRWRP Stakeholder Committee. This analysis not only shows which portfolio ranks highest, but also shows which objectives contributed to the scoring. The larger the color bar segment, the better the portfolio does in achieving that particular objective (as shown in the figure's legend).

Two factors determine the size of each color segment for a given portfolio: (1) the raw performance of the portfolio in meeting that objective; and (2) the weight of the objective assigned by the stakeholders. In general, if the color segment is larger, then the raw performance was better, and the objective was given a relatively high weight of importance. However, if the color segment is smaller, it could be either because of poor performance, or a low weight of importance, or both.

Based on the average objective weightings from the 2012 LRWRP Stakeholder Committee, the top three portfolios are:

- Maximize Water Use Efficiency
- Hybrid 2
- Hybrid 1

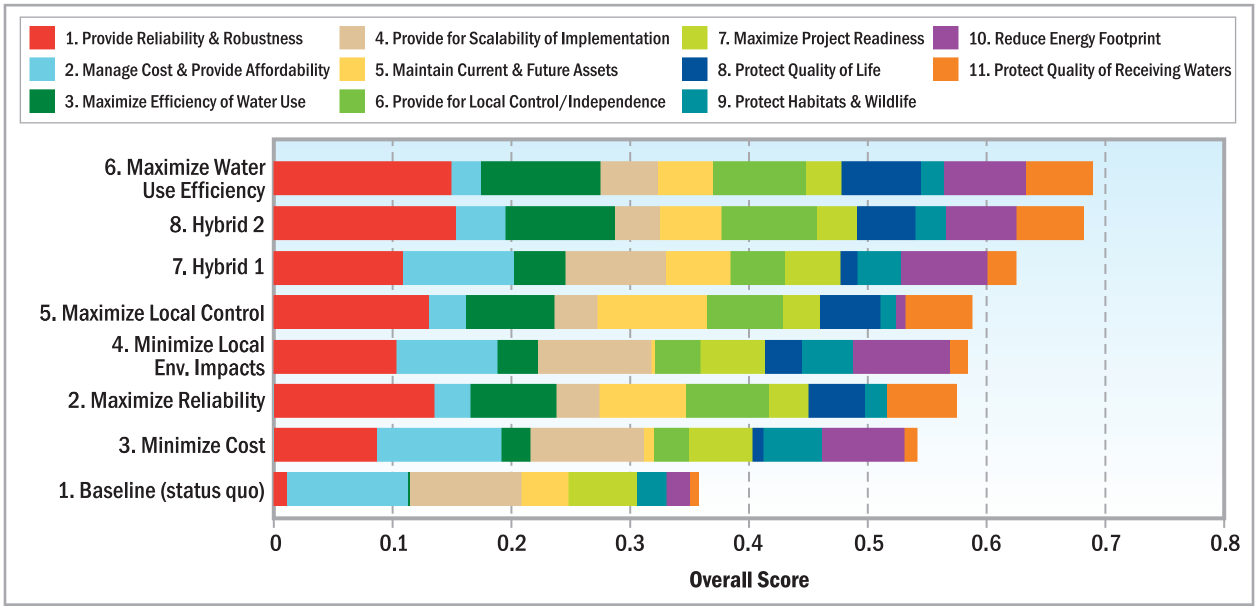

Figure 6-9: Portfolio Rankings with Average Stakeholder Committee Weights

Sensitivity analyses were performed in order to assess whether the rankings are robust under different objective weighting scenarios. In addition, since long-term planning requires forecasting variables that are uncertain, sensitivity analyses were performed to assess the rankings under future uncertain conditions. The following sensitivity analyses were performed:

1. **Revised Weights :** Reliability and Cost objectives with 23 percent weight each, and all other objectives at 6 percent weight
2. **Delta Fix:** No imported water shortages, although this assumes higher imported costs
3. **Higher Energy Costs:** Assume 30 percent higher energy costs, which affect cost of operations
4. **Lower Treatment Technology Costs:** Assume 30 percent lower operation cost for advanced treatment technologies used for indirect potable reuse and brackish groundwater treatment
5. **Revised Weights and Delta Fix:** Combines the first two sensitivity conditions

	6. Max Water Use Efficiency	**8. Hybrid 2**	**7. Hybrid 1**	**5. Max Local Control**	**4. Min Local Env Impacts**	**2. Max Reliability**	**3. Min Cost**	**1. Baseline (status quo)**
Baseline	1	2	3	4	5	6	7	8
Objective Weights	2	1	3	5	7	4	6	8
Delta Fix	1	2	3	5	4	6	7	8
Energy Cost	1	2	3	4	5	6	7	8
Treatment Tech	1	2	3	4	5	6	7	8
Objective Weights + Delta Fix	3	1	2	6	4	7	5	8

Figure 6-10: Portfolio Rankings under Sensitivity Conditions

The findings for each weighting sensitivity scenario are summarized in Figure 6-10. The columns of the table represent the portfolios, the rows represent the sensitivity scenarios, and the number shows the rank order of the portfolio (1 being the best). The weighting scenarios are compared to the baseline rankings. The sensitivity results show that the top three portfolios are consistently Maximize Water Use Efficiency, Hybrid 2, and Hybrid 1 under all the sensitivity scenarios.

6.3 Climate Change Adaptation

In developing any long-term water supply plan, water utilities in California should consider the potential impacts of climate change. Climate change is important to long-term planning since it could change hydrologic conditions and increase the need for new programs or investments that are resilient to climate variability in the future. While the potential impacts of climate change are a global-scale concern, they are particularly important in the Pacific Coast region of the United States, which is one of the areas showing the most change with the greatest implications to water resources. Consequently, California is leading the way with laws that require reductions in greenhouse gas emissions and requirements to incorporate climate change risks into water resources planning.

Climate change was factored into the portfolio evaluations and ranking presented in Sections 6.1 and 6.2, since two of the planning objectives had performance measures related to climate change (refer to Table 6-1): 1) reductions in greenhouse gas emissions, which help with climate change mitigation; and 2) resilience to climate change (in terms of reliability), which was qualitatively assessed.

The purpose of this climate change adaptation analysis is to use available information from DWR, MWD, and other resources to quantify potential future impacts to water supplies and demands under varying hydrologic conditions, in order to assess the potential risks of water supply shortages. The analysis evaluates how different resource portfolios provide adaptive capacity to reduce potential water shortages caused by climate change. While current data suggests that the most significant changes in climate (particularly temperature) do not occur until after 2050 (refer to Appendix E), this analysis is based on the 2012 LRWRP long-term planning horizon of 2035.

The consequences of climate change are expected to be wide-ranging, affecting multiple sectors including agriculture, forestry, public health, and others. However, the 2012 LRWRP is not intended to be a comprehensive assessment of the City's climate change risks, and does not evaluate other water management risks such as water quality, sea level rise, flooding, ecosystem and habitat vulnerability, or hydropower, etc. These factors are important to consider; however, it is recommended that they are considered in other studies and efforts.

6.3.1 Background

To understand potential climate change risks presented herein, it is important to put it into the context of the City's water supplies. The City relies on both local and imported water supplies, which originate in different regions and climate zones. Since each region will experience unique temperature and precipitation changes, the City must consider climate change risks to the local watershed, as well as the Sierra Nevada and Colorado River where a significant portion of MWD's and SDCWA's imported water originates. The impacts to the local watershed will be driven mainly by changes in precipitation; whereas the impacts to imported water that originates mainly from mountain snowpack will be driven mainly by changes in temperature. In addition to water supply impacts, climate change can also affect water demands since a large portion of water use is for outdoor irrigation which is sensitive to changes in both precipitation and temperature.

Scientists predict future climate scenarios for temperature and precipitation using highly complex computer general circulation models (GCMs). Although most of the scientific community agrees that climate change is occurring and, as a result, mean temperatures for the planet will increase the specific degree of this temperature increase cannot be accurately predicted at this time. Predictions of precipitation changes are even more speculative, with some scenarios showing precipitation increasing in the future and others showing the opposite. Therefore, it is always advisable to examine climate change impacts using a range of scenarios. Because the GCM models produce output at a very coarse-scale (e.g., Rocky Mountain or Pacific Northwest regions), it is necessary to "downscale" the climate change data to a more local geography. This is done by modeling techniques that examine local topography and weather conditions.

The City has already taken a proactive step in considering potential climate change impacts to water demand patterns in its June 2010 *Update of Long-term Water Demand Forecast* . For this effort, the City obtained projected climate data for the San Diego area from the Scripps Institution of Oceanography for 18 scenarios comprised of different combinations of 6 GCMs, two emissions conditions (higher and lower), and two downscaling techniques (constructed analogues (CA) and the bias correction and spatial downscaling (BCSD) methods). Based on their range of potential temperature and precipitation changes, two climate change scenarios were selected for evaluation:

- **Scenario 1:** Geophysical Fluid Dynamics Laboratory (GFDL) CM2.1
- **Scenario 2:** National Center for Atmospheric Research (NCAR) Parallel Coupled Model

For both scenarios, the status quo approach to reduce greenhouse gas emissions is assumed, which is known as the Intergovernmental Panel on Climate Change's (IPCC) Special Report Emissions Scenarios (SRES) A2 (medium-high) greenhouse gas emissions scenario. In addition, the data from both models is downscaled using the BCSD method.

The average projected change in temperature and precipitation, comparing future 2035 average conditions with 1970 average conditions, for each model is shown in Figure 6-11. In general, the GFDL model projects a stronger warming than the NCAR model[1]. On an average annual basis, the GFDL model is projecting temperatures almost 5 percent higher than historical and little change to precipitation. The NCAR model shows average temperatures almost 3 percent higher, but significant increases in precipitation in the San Diego area.

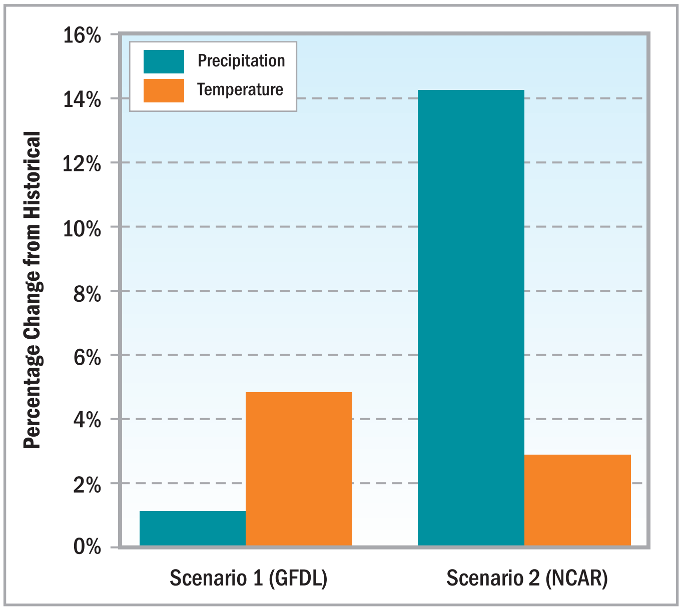

Figure 6-11:
2035 Average Local Climate Change A2 Emissions Scenarios

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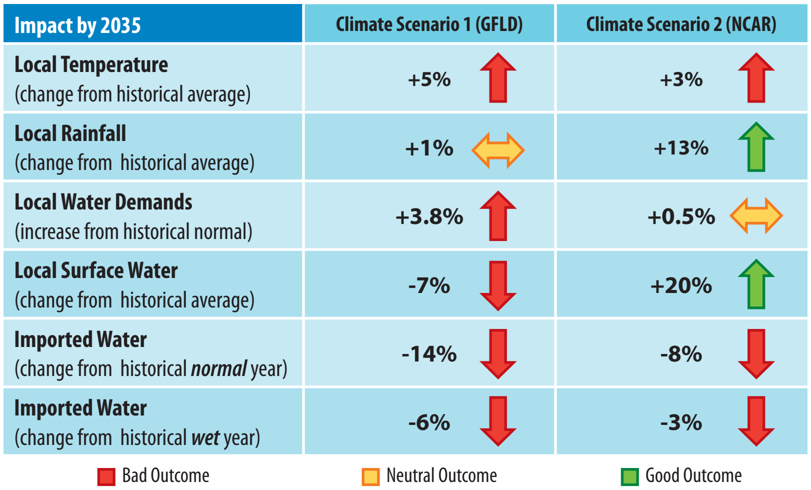
[1] Climate model results vary depending on the type of "forcing factors" modeled (i.e. type of aerosols, land cover, etc.), level of model resolution, and other factors.

6.3.2 Climate Change Impacts to Water Supplies and Demands

Various tools were used to estimate climate change effects to demands, local surface supply, and imported water supply for the City. The tools and methodology are described in detail in Appendix E. Figure 6-12 summarizes the impacts of the two climate change scenarios (GFDL and NCAR models) to the City's water supply reliability, including:

- Increased average annual water demands by about 4 percent for the GFDL scenario. This increase is mainly because higher temperatures result in increased irrigation needs (due to higher evapotranspiration rates) as well as increased domestic water use for cooling purposes. The NCAR model scenario does not show significant increase in local demands.
- Slight decrease in local surface water availability with the GFDL model scenario, but an increase in local surface water for the NCAR model scenario (primarily due to increased precipitation). Precipitation and temperature affect reservoir inflows and evaporation, respectively.
- Imported water availability is reduced in both cases, but to different degrees. In normal to wet years, this decrease has significant impacts on accumulation of water in storage in the imported water system, affecting the region's ability to sustain supply in drought periods. Note that, similar to the portfolio evaluations in Section 6.1, the imported water reliability scenario assumes that a comprehensive Delta "fix" is not reached within the planning horizon.



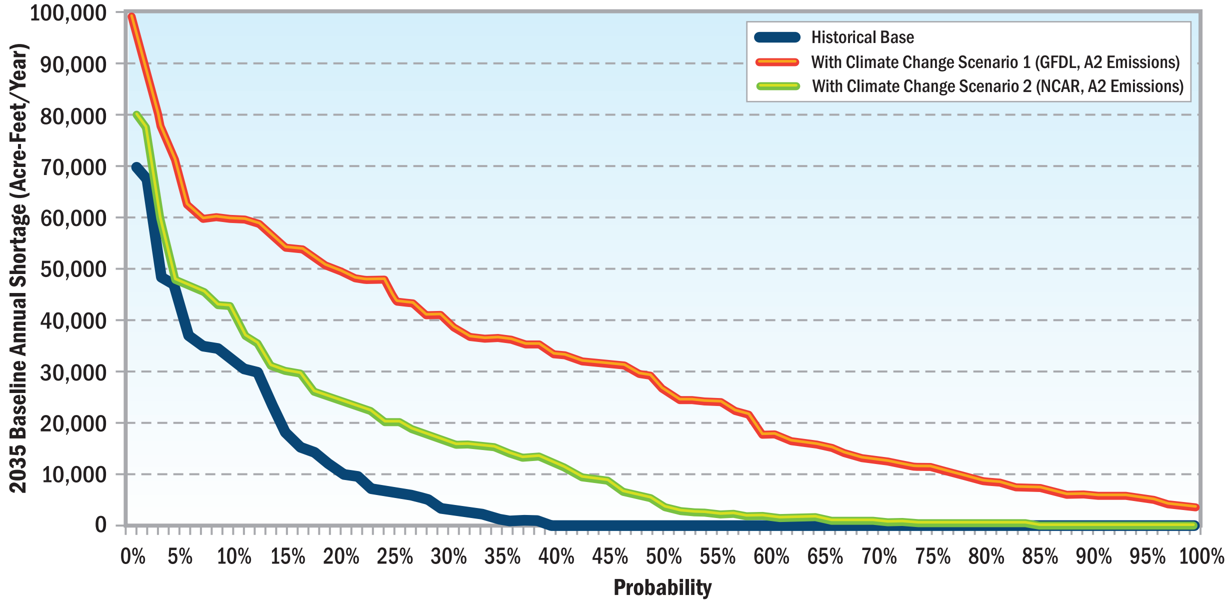
Impact by 2035	Climate Scenario 1 (GFLD)	Climate Scenario 2 (NCAR)
Local Temperature (change from historical average)	+5% ↑	+3% ↑
Local Rainfall (change from historical average)	+1% ↔	+13% ↑
Local Water Demands (increase from historical normal)	+3.8% ↑	+0.5% ↔
Local Surface Water (change from historical average)	-7% ↓	+20% ↑
Imported Water (change from historical ***normal*** year)	-14% ↓	-8% ↓
Imported Water (change from historical ***wet*** year)	-6% ↓	-3% ↓

🟥 Bad Outcome 🟧 Neutral Outcome 🟩 Good Outcome

Figure 6-12:
Potential 2035 Climate Change Impacts for San Diego Water Supplies

The overall effect of climate change to the City's water supply was evaluated by combining the changes to demands, local supplies, and imported water supplies into the City's SDSIM model. Projected 2035 shortages for the status quo (no additional projects or programs) is shown in Figure 6-13, where the magnitude of shortage is along the y-axis and the probability of occurrence is along the x-axis. For example, the projected 2035 shortages based on historical hydrology show that the probability of having an annual shortage of 30,000 AFY or higher is approximately 13 percent.

The results show that, with stronger warming projected by the GFDL model, climate change would not only increase the magnitude of shortages, but also the frequency of shortage – where the probability of having a shortage increases from 40 percent to 100 percent. Since the NCAR model is showing an increase in local surface supply availability, and less impacts on water demands and imported water, the overall supply impact is lower than the GFDL scenario.



Note: Projected shortages for all probabilities are shown; therefore once the probability of zero shortage is reached, the line extends along the x-axis.

Figure 6-13: 2035 Climate Change Impacts on Baseline Portfolio

6.3.3 Climate Change Adaptation

Climate change strategies fall under two main categories: adaptation and mitigation. For water resources planning, a climate change adaptation strategy involves taking steps to effectively manage the impacts of climate change by making water demands more efficient and using supply sources that are more resilient to climate change impacts. A mitigation strategy, in contrast, involves proactive measures that reduce greenhouse gas emissions thereby lessening one of the drivers of climate change. The distinction between climate change adaptation and mitigation is important because some strategies can provide both benefits, while others only address one. For example, ocean desalination is a supply option that performs very well in adapting to climate change, as its source the ocean will not be impacted; however due to the significant energy required, it produces significant greenhouse gas emissions if fossil fuel energy sources are used.

In order to measure the magnitude of the City's adaptation capabilities in reducing water shortages caused by climate change, two portfolios were analyzed: Hybrid 1 and Hybrid 2. These portfolios are among the top three portfolios based on the ranking analysis in Section 6.2. The other portfolio in the top 3 is Maximize Water Use Efficiency, which is expected to have similar climate change adaptation capabilities as Hybrid 2 but costs more.

Figure 6-14 shows the climate change adaptation capabilities of Hybrid 1 and Hybrid 2, respectively. Compared with the status quo scenario (in Figure 6-13), the results in Figure 6-14 show that Hybrid 1 significantly improves climate change adaptation capabilities, and Hybrid 2 would resolve almost all water shortages making the City's water supply very reliable even in the face of climate change.

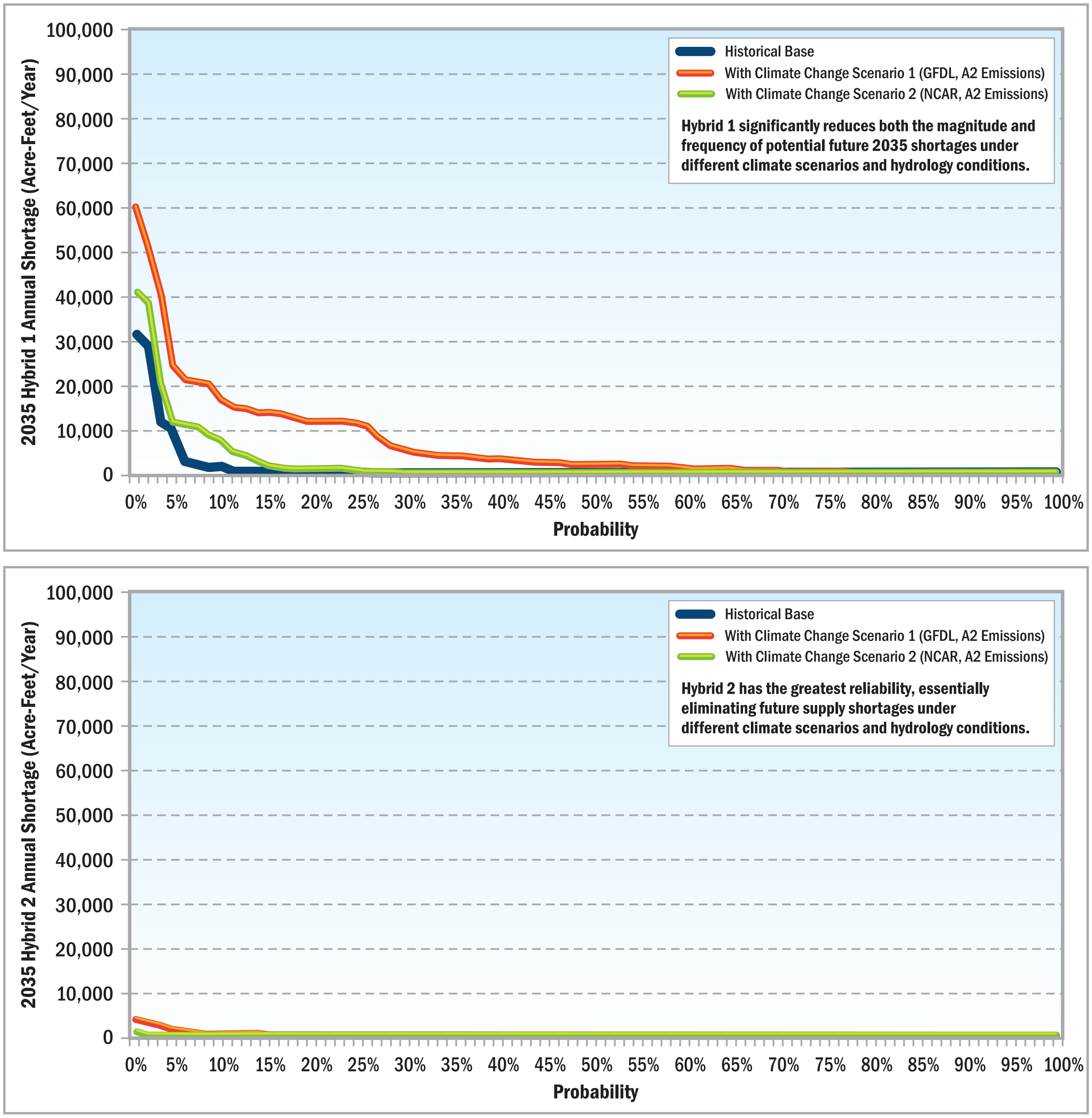


Figure 6-14: Hybrid 1 and 2 Climate Change Adaptation Capabilities for Supply Reliability

6.4 Summary of Findings

The portfolio ranking and sensitivity analysis indicates that the three top performing portfolios, Hybrid 1, Hybrid 2 and Max Efficiency best meet the goals and objectives of the 2012 LRWRP. In addition, Hybrid 1 and Hybrid 2 provide considerable climate change adaptation benefits. Based on these findings, it was the recommendation of the Stakeholder Committee that a long-term strategy for the City be developed based on these top-scoring portfolios using an adaptive management approach.

SECTION 7 Adaptive Management

Section 6 presented the evaluation of eight portfolios against over 20 performance metrics. The portfolios were ranked in terms of the cumulative performance. The portfolios were tested against five sensitivities and re-ranked. Based on these rankings, three portfolios consistently ranked highest—Hybrid 1, Hybrid 2 and Maximum Water Use Efficiency (Max Efficiency). Table 7-1 summarizes the resource options that are included in these three top-scoring portfolios.

As shown in Table 7-1, there are more options that are common to all three top-scoring portfolios than are not common. Because of this, a strategy that utilizes adaptive management in the implementation of options is wise.

INSIDE

- *Benefit and Cost Trade-Off Analysis*
- *Risk Triggers*
- *Stakeholder Recommended Actions*

Table 7-1: Resource Options Common to Top-Scoring Portfolios

Resource Options	Hybrid 1	Hybrid 2	Max Efficiency
Active Conservation with Water Pricing Effects[1] –20,900 AFY	■	■	■
Groundwater (either San Pasqual, Santee-El Monte, or Mission Valley) – up to 4,000 AFY	■	■	■
Groundwater in San Diego Formation – additional 10,000 AFY		■	
Indirect Potable Reuse (Phase 1) – 16,800 AFY	■	■	■
Indirect Potable Reuse (Phases 2 and 3) – up to additional 76,200 AFY		■	■
Non-Potable Reuse from Satellite Plants – 5,500 AFY[2]			■
Rainwater Harvesting – 420 AFY	■	■	■
Rainwater Harvesting – Additional 100 AFY			■

🟨 Options common to top-scoring portfolios

[1] Based on City of *San Diego Water Demand Forecast Sensitivity Analysis* dated July 2011, which evaluates the responsiveness of water demands to changes in the marginal price of water.

[2] Assumes yield from new satellite plants is additive to indirect potable reuse projects (they are not mutually exclusive).

Adaptive Management

For purposes of the 2012 LRWRP, adaptive management is defined as a process in which options are implemented in a phased and incremental manner based on the outcome of identified future conditions or "risk triggers". Adaptive management balances the cost of option implementation with the risks of no action. Figure 7-1 presents an overview of adaptive management, which has four major steps:

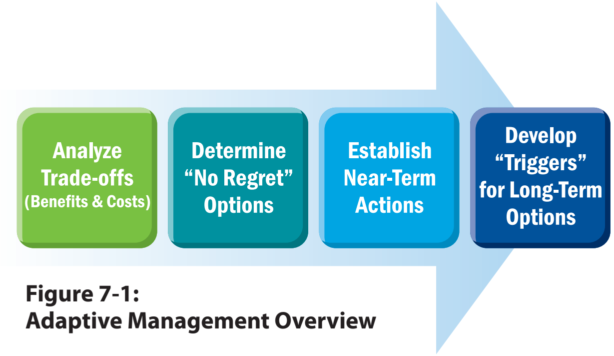


Figure 7-1: Adaptive Management Overview

Step 1 – Analyze trade-offs in terms of benefits and costs for the top-scoring portfolios.

Step 2 – Determine those no regret options that perform the best under most scenarios or sensitivities. This is informed by the portfolio rankings in Section 6, as well as the trade-off analysis in Step 1 of adaptive management.

Step 4 – Develop risk triggers (points of uncertainty, along with projected possible outcomes) that are used to determine future alternative paths of implementation for the remaining long-term options.

7.1 Benefit and Cost Trade-Off Analysis

Although the three top-scoring portfolios have more in common than not, the total lifecycle costs in present value terms is very different. As such, it is important to analyze the trade-offs in terms of benefits and costs. Three main benefits were aggregated from over 20 different performance measures, and these are:

1. Supply Reliability Benefit – representing drought supply protection, emergency storage, and resiliency to climate change
2. Environmental Benefit – representing local habitat impacts and greenhouse gas emissions
3. Water Quality Benefit – representing receiving water quality (from wastewater and stormwater discharges), groundwater basin quality, and salinity in drinking water.

For ease of comparison, all three benefits were normalized to a score ranging from 0.0 (no benefit) to 1.0 (maximum achievable benefit). For each of the benefit categories, the three top-scoring portfolios and the status quo (do nothing alternative) were plotted on a chart with benefit on the vertical axis and total lifecycle cost on the horizontal axis. This produces a four quadrant analysis that indicates the overall benefit-cost trade-off. Figure 7-2 presents an example of this quadrant analysis.

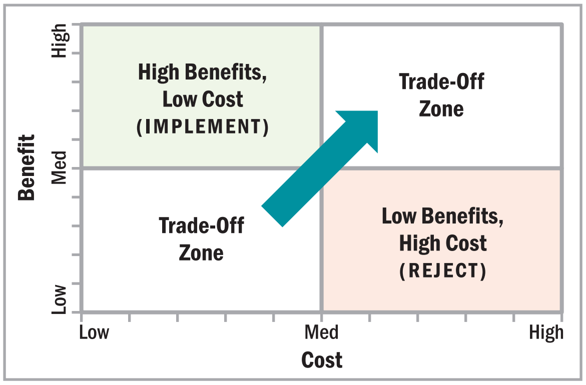


Figure 7-2: Benefit-Cost Trade-Off Analysis

Portfolios that fall into the upper left quadrant (high benefit, low cost) are the best alternatives and should be implemented with priority. Alternatively, portfolios that fall in the lower right quadrant (low benefit, high cost) should be rejected outright. What is not so apparent is whether to implement portfolios that fall in the lower left (low benefit, low cost) or upper right (high benefit, high cost) quadrants because this is where trade-offs are made. For example, is it worth increasing supply reliability by 30 percent for a 40 percent increase in cost?

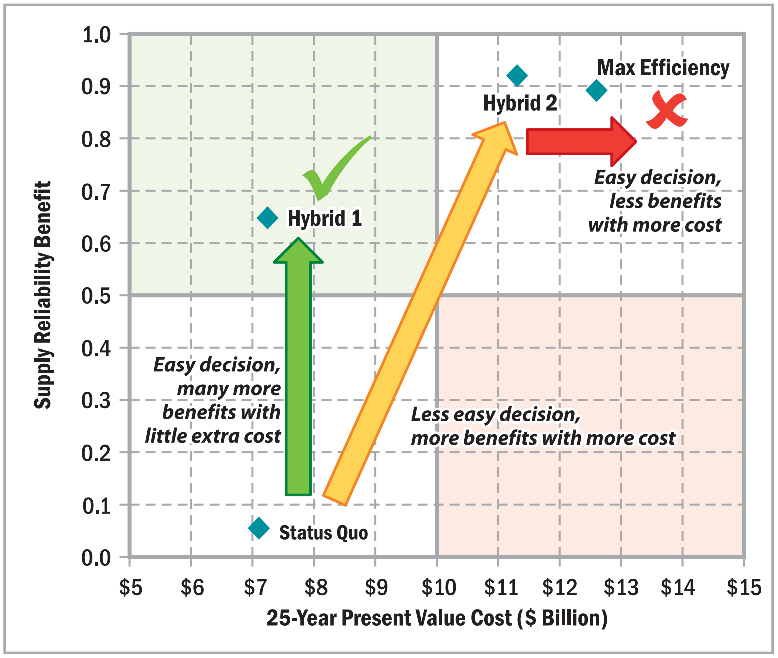


Figure 7-3: Supply Reliability Benefit

Figure 7-3 presents the results of the trade-off analysis for supply reliability benefit. What is shown in this figure is that moving from the Status Quo to Hybrid 1 greatly improves supply reliability for very little additional life-cycle cost. In fact, Hybrid 1 has a 10-fold increase in reliability benefits for only a 3 percent increase in cost compared to the Status Quo. From a supply reliability perspective only, implementing Hybrid 1 over the Status Quo is an easy decision.

But moving from the Status Quo to Hybrid 2 is not as easy of a decision. Supply reliability is increased 14-fold, but cost increases by almost 60 percent. Furthermore, the decision to not to implement the Max Efficiency Portfolio is an easy decision because it produces no more supply benefit than Hybrid 2 but costs more than Hybrid 2.

Figure 7-4 presents the trade-off analysis for environmental benefit. In this case, Hybrid 1 produces a 120 percent increase in benefits over the Status Quo for a 3 percent increase in cost—again an easy decision to implement. If environmental benefit was the only goal, Hybrid 2 and Max Efficiency would not be implemented as they produce less environmental benefit than Hybrid 1 for significantly more cost. The reason Hybrid 2 and Max Efficiency produce less environmental benefits than Hybrid 1 has to do with greater greenhouse gas emissions and brine impacts due to more indirect potable reuse.

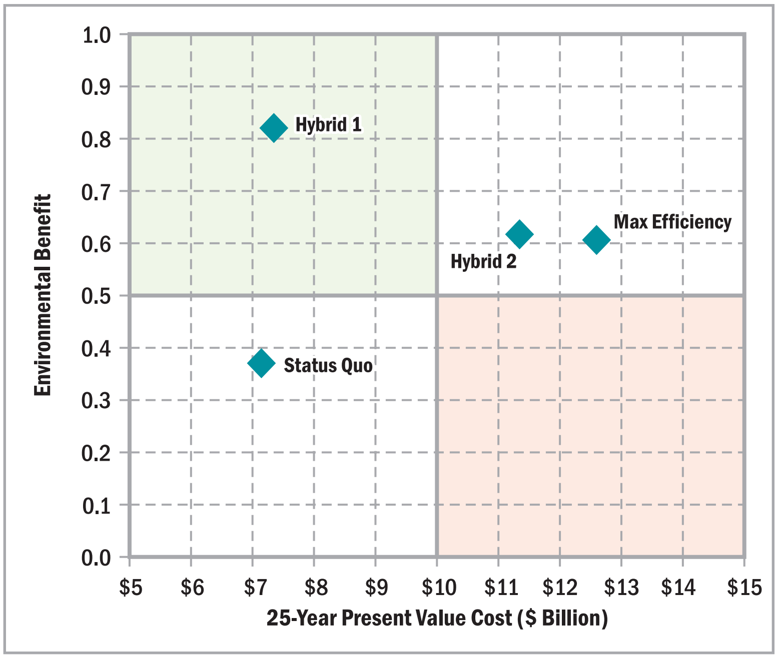


Figure 7-4: Environmental Benefit

Figure 7-5 presents the trade-off analysis for water quality. And while Hybrid 1 does improve water quality compared to the Status Quo, it does not produce enough benefits to move Hybrid 1 into the high benefit, low cost quadrant. Hybrid 2 represents a 5-fold increase in water quality benefits over the Status Quo for a 60 percent increase in cost. Max Efficiency produces no more water quality benefits than Hybrid 2 but costs 12 percent more. Because Hybrid 2 has more indirect potable reuse it results in substantially less wastewater being discharged into the ocean and reduces salinity of drinking water.

The overall trade-off analysis shows that Hybrid 1 generally produces the greatest benefits for the lowest cost compared to Hybrid 2 and Max Efficiency. Hybrid 2, though almost 60 percent greater in cost than Hybrid 1, produces greater supply reliability and water quality benefits that may be worth considering under future scenarios. The resource options that are included in Hybrid 1 can therefore be considered to be "no regrets" and should be prioritized in terms of implementation by the City.

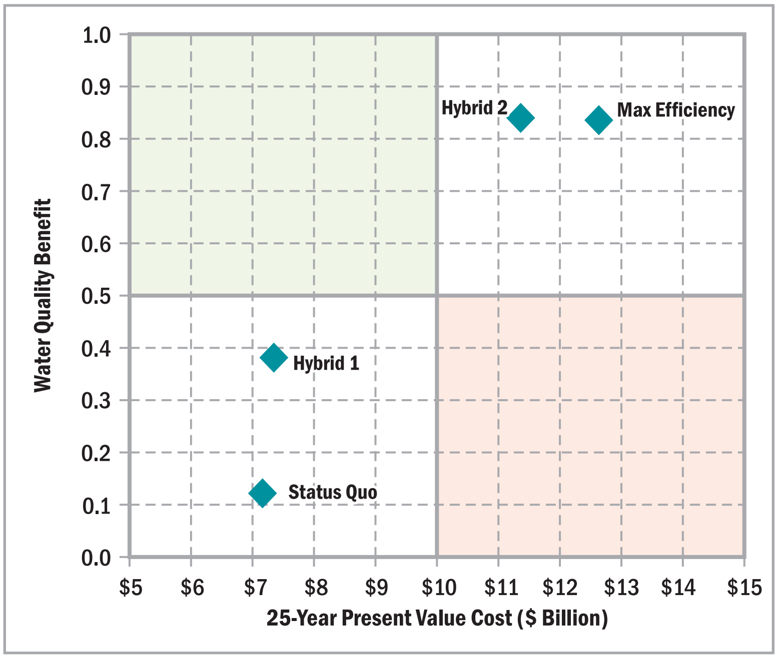


Figure 7-5: Water Quality Benefit (receiving water quality, groundwater quality, salinity of distributed water)

7.2 Risk Triggers

Any long-term plan is subject to some degree of uncertainty, but uncertainty is not a reason not to plan. In fact, uncertainty can be a useful tool for adaptive implementation. During the development of the 2012 LRWRP stakeholders were asked to identify sources of uncertainty, which included:

- Increased cost of imported water from MWD and SDCWA
- Recurring drought conditions
- Public acceptance of Indirect Potable Reuse
- Ability to obtain regulatory approval for a reservoir augmentation/ indirect potable reuse project
- City Council approval of major capital projects, including funding (rate increases)
- A long-term "fix" for resolving the conflicts in the Sacramento-San Joaquin Bay-Delta (Bay-Delta)
- Opportunities for grant funding, especially for indirect potable reuse
- Technology advances that reduce treatment equipment costs and improve energy efficiency (i.e. membranes) making some supply options more viable
- Impacts of climate change on water supply and demands
- Public acceptance of Direct Potable Reuse
- Permitting of Direct Potable Reuse

Some of these uncertainties will be known or resolved in the coming years while others, such as the "Delta "fix" and climate change impacts on water supply may not be known or evident for a decade or more. Table 7-2 presents the risks and implications for implementing the 2012 LRWRP strategy.

Table 7-2: Risk Triggers and Implications

Major Risk Trigger	Uncertainty	Implication or Impact
1. Acceptance	Permitting	Key to implementation of indirect potable reuse
	Customer Acceptance	Key to implementation of indirect potable reuse
	City Council Approval	Needed for large capital expenditures including funding
2. Cost	MWD/SDCWA Water Rates	If imported water rates are higher than expected, additional phases of IPR become more favorable
	Grant Funding	Grants could lower capital costs of more expensive groundwater and indirect potable reuse projects, making them more favorable
	Technology Improvements	Advancements in membrane technology could reduce costs of indirect potable reuse and brackish groundwater desalination
3. Imported Supply	Delta Fix	A Delta fix would improve imported water reliability, making investments beyond Hybrid 1 less favorable
4. Climate Change	Impact to Demands and Supplies	Would increase water demands and reduce water supplies making Hybrid 2 investments more needed
5. Direct Potable Reuse	Regulatory Approval	If DPR is approved by California regulatory agencies, and publicly accepted as well, the City may wish to consider DPR instead of Phase 2 and 3 of IPR

The risk triggers presented in Table 7-2 can be updated, changed, or new triggers added, depending on future circumstances. In addition, actions that are considered long-term strategies may be needed sooner rather than later, depending on how the future unfolds.

7.3 Stakeholder Recommended Actions

Based on the trade-off analysis in Section 7.1, the following no-regret options were recommended through the stakeholder process for implementation between now and 2020:

- Expanded water conservation
- Initial groundwater projects
- Rainwater harvesting, supporting the City's Public Works Department's program for rain barrels/cisterns
- Phase 1 of indirect potable reuse

Assuming that the no-regret actions are successfully implemented by 2020, additional actions would be taken if additional triggers warrant them. These additional actions included: (1) additional phases of indirect potable reuse; and (2) additional groundwater projects, including brackish desalination and conjunctive use storage.

The 2012 LRWRP was prepared over two and half years (2010-2012), drawing upon the best technical assumptions and information available at that time. The analysis conducted and input provided over the course of five stakeholder meetings during the preparation of the 2012 LRWRP are reflected in Sections 1 through 7 of this report.

Since the completion of the 2012 LRWRP technical analysis, several detailed studies and investigations on water reuse options were finalized and adopted by City Council. These source documents, which include the Recycled Water Study and the Water Purification Demonstration Project Report, provide additional information on the length of time necessary to plan, design, and construct potable reuse facilities. These finalized studies and confirmed direction by City Council emphasized a strong water reuse strategy for the City. On April 23, 2013, the City Council directed the San Diego Public Utilities Department (SDPUD) to determine a preferred implementation plan and schedule that considers potable reuse options for maximizing local water supply and reduced wastewater flows to the Point Loma Wastewater Treatment Plant.

Therefore, SDPUD staff modified the stakeholder recommendations, presented in Section 7, for consideration by the City Council's Natural Resources and Culture (NR&C) committee at their July 31st 2013 meeting. The staff recommendation was to consider an alternative implementation strategy that would grant planning level approval to pursuing all three phases of indirect potable reuse, along with the same near-term water resource options that were recommended by the stakeholders. Those stakeholders present at the NR&C committee supported the SDPUD staff recommendations. In addition, a motion was made by a City Council member to change the phrase "indirect potable reuse" to "potable reuse" in order to give the City more flexibility in its water supply options. The NR&C committee unanimously voted to approve the SDPUD staff recommendation and to change the phrase "indirect potable reuse" to "potable reuse" in the staff recommendation.

With NR&C committee motion approved, SDPUD staff has since made changes to the 2012 LRWRP to ensure the NR&C committee actions was consistent with the work done by the stakeholder committee in preparing the 2012 LRWRP. Sections 1 through 6, as well as all technical appendices, were left unchanged—as these sections form the basis of any and all recommendations. Section 7 was slightly modified to remove some of the more detailed phasing of projects, in order to provide more flexibility for implementation of projects by the City. Section 8 was modified to include the NR&C committee approval and final recommendations for the 2012 LRWRP. Finally, appropriate sections of the executive summary were also modified to reflect the changes made to Sections 7 and 8.

SECTION 8 Conclusions and Recommendations

INSIDE

- *Benefits of the 2012 LRWRP*
- *Implementation of the LRWRP Strategies*
- *2012 LRWRP Recommendations*

The 2012 LRWRP is a strategic document that outlines a long-term water resources strategy for the City of San Diego through the year 2035. The strategy represents over two and a half years of work summarizing master plans and water supply studies conducted by the SDPUD; conceptualizing various water supply and conservation options; and evaluating alternative portfolios (combinations of various water supply options) against a set of planning objectives. Key to the success of the 2012 LRWRP was the dedicated involvement of the Stakeholder Committee. This committee defined the planning objectives; provided insights and input on the conceptual options; reviewed evaluation results; provided suggestions for refinement; and provided input on the recommended strategy.

The stakeholder input to the adaptive management, and the recommended actions presented in Section 7.3 of this report was based on the best information at the time, as well as the stakeholders' perception of risks, costs, and benefits of taking action. However, the preparation of 2012 LRWRP was a lengthy process and many of the source documents and studies, which were concurrently being prepared at the time of this planning process, have since been completed and presented to City Council. These source documents, which included the Recycled Water Study and the Water Purification Demonstration Project Report, provided additional information which impact the risk triggers presented in Section 7.2, such as: (1) City Council and public support for potable reuse; (2) the length of time necessary to plan, design, and construct potable reuse facilities; and (3) the risks of water shortages due to climate change. Given this new information, and in conjunction with the City Council direction on April 23, 2013 to determine a preferred implementation plan and schedule that considers potable reuse options for maximizing local water supply and reduced flows to the Point Loma Wastewater Treatment Plant, the SDPUD modified the strategy presented in Section 7 accordingly.

On July 31, 2013, the SDPUD presented the Final Draft of the 2012 LRWRP to the City's Natural Resources & Cultural (NR&C) Committee recommending adoption of the 2012 LRWRP. The SDPUD also presented a recommendation that the NR&C Committee consider an alternative implementation strategy that would grant planning level approval to pursue all three phases of IPR, as well as the other near-term 2012 LRWRP resource options presented in Section 7.3. During the committee meeting, there was a motion by a NR&C Committee member to approve the staff recommendation and to change the phrase 'Indirect Potable Reuse' to 'Potable Reuse' in staff's recommendations. Thus, based on the NR&C Committee motion, the 2012 LRWRP and following strategies were recommended between now and 2035:


Additional Conservation


Rainwater Harvesting

2013-2020

- Additional Active Conservation – 20,900 AFY (18.7 mgd)
- Rainwater Harvesting – 420 AFY (0.38 mgd)
- Groundwater Supply – up to 4,000 AFY (3.6 mgd)


Groundwater

2013-2035

- Potable Reuse (for all 3 phases) – 93,000 AFY (83 mgd)

The 2012 LRWRP was presented at the on December 10, 2013 City Council meeting. The City Council voted unanimously to adopt the 2012 LRWRP. The City Council resolutions for the 2012 LRWRP Council adoption and the 2012 LRWRP CEQA Exemption are in Appendix I.


Indirect Potable Reuse

8.1 Benefits of the 2012 LRWRP

The implementation of the 2012 LRWRP strategies will have numerous benefits for the City of San Diego and its residents. These include:

- Greater water supply reliability and reduced dependency on imported water
- Greater resiliency against climate change and disasters
- Improved water quality, including: (1) that which is delivered to water customers, (2) groundwater quality, and (3) the quality of water discharged to the natural environment from stormwater and wastewater
- Greater local control over how water investments are made, helping to manage costs and maximize city assets

Figure 8-1 presents the water supply mix for the year 2035, assuming drought conditions with climate change. The figure shows that under the current, status quo approach reliance on imported water would be 83 percent, with potential water shortages that approach 80,000 AFY (or 25 percent of water demand). With the LRWRP strategy, reliance on imported water is reduced to 50 percent, and even under droughts and climate change there would be no anticipated water shortages.

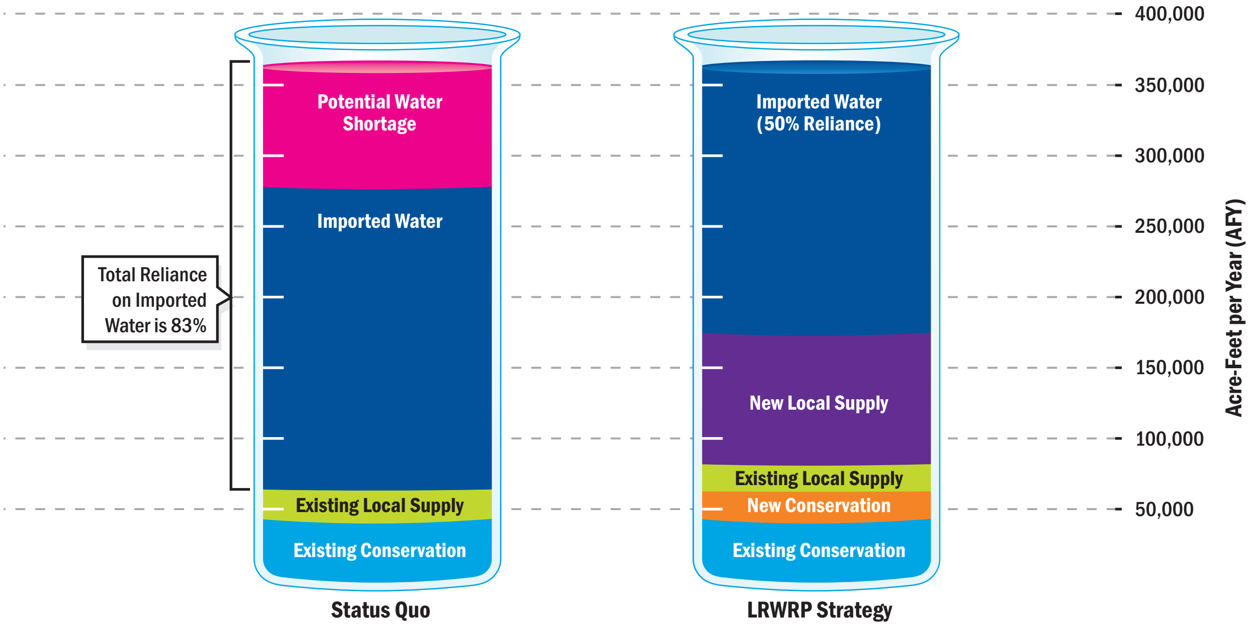


Figure 8-1: Comparison of Water Supply Mix in Year 2035 Under Drought and Climate Change

8.2 Implementation of LRWRP Strategies

The following represents the implementation timeline for the recommended 2012 LRWRP strategies. This timeline is based on the best possible information and is subject to change if conditions, regulations, and economics are different than what is expected.

Potable Reuse - 93,000 AFY / 83 mgd (anticipated timeline for all 3 phases)

- 2013-2016 Timeframe – Obtain required regulatory acceptance and public support.
- 2018-2026 Timeframe – Final engineering design and environmental process (CEQA).
- 2021-2035 Timeframe – Construction of project phases.

Initial Groundwater Project - up to 4,000 AFY/ 3.57 mgd

- 2013-2016 Timeframe – Prioritize groundwater projects and resolve institutional and legal issues regarding groundwater development. For the Mission Valley basin, it is expected that the City would not proceed with a groundwater development project until after ongoing remediation efforts are complete.
- 2016-2020 Timeframe – Final engineering design, CEQA, and construction of project in either Mission Valley, San Pasqual and/or Santee-El Monte basins.

Additional Active Conservation - 20,900 Acre-Feet a Year/ 18.7 mgd

- 2013-2020 Timeframe – Expand current conservation program and incentives, and study and implement conservation-oriented water rates.

Rainwater Harvesting with Cisterns and Rain Barrels - 420 AFY/ 0.38 mgd

- 2013-2020 Timeframe – Support the City's pilot programs for rain barrels and cisterns, which are developed by the San Diego Storm Water Division.

Looking forward past the year 2020, the SDPUD will monitor water demand and supplies, as well as climate change, success or failure of a Delta fix in Northern California, regulations, and other factors that could impact reliability for the city. Figure 8-2 outlines an overall adaptive management strategy that will monitor the success of the 2012 LRWRP implementation and make modifications if necessary.

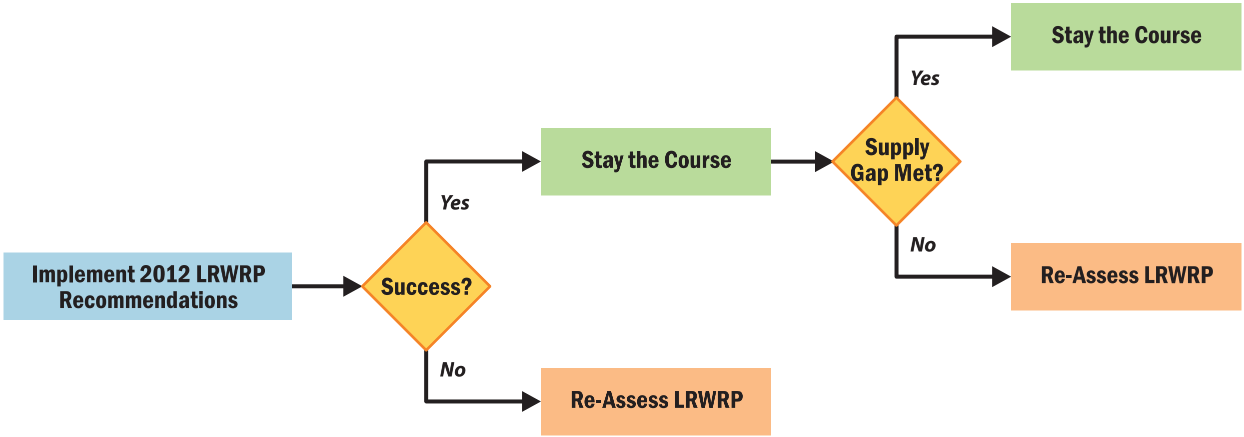


Figure 8-2: Adaptive Management Process for LRWRP

8.3 2012 LRWRP Recommendations

The following recommendations are made for the 2012 LRWRP and its implementation:

1. Move forward with implementation of the strategies that are summarized in Section 8.2;
2. Assess progress made on implementation of options, and re-assess risk triggers concurrent with the City's UWMP schedule (2020, 2025, 2030, 2035);
3. Update the 2012 LRWRP in 2020 (and every 10 years thereafter), in order to identify new trends, reliability of imported water, and additional resource options.

City of San Diego
PUBLIC UTILITIES
Water & Wastewater

2012 Long-Range Water Resources Plan
Appendices

Appendix A Options Summary Table and Fact Sheets

Appendix A

Options Summary Table and Fact Sheets

Roughly 20 future water supply and demand options were considered to capture the future possibilities for the City of San Diego's water picture. The list of options was developed based on input from the LRWRP Stakeholder Committee and City staff. The options generally fall under the following main categories:

- Conservation
- Groundwater
- Ocean Desalination
- Recycled Water
- Graywater
- Rainwater Harvesting
- Imported Water

The full list of options considered is shown in Table A-1. Some options were screened out from further evaluation due to implementation feasibility, cost and other factors; as indicated in the notes section of Table A-1. Other options were carried forward for planning-level analyses to characterize option concepts, yields, and costs. It should be noted that although option characterization is based on the best available technical information, more detailed analyses of any of these options will be required prior to implementation.

For options carried forward for portfolio evaluations, a summary of yield and cost is provided in Table A-2. The following is a brief description of columns in Table A-2:

- **Estimated Yield, Acre-feet per Year:** The estimated incremental average annual new supply (or demand savings) to the City
- **Capital Cost, $:** the total capital cost in current dollars, including cost to customers/developers or other partnering agencies
- **Annual Capital Payment, $/year:** the total annual capital payments of the option assuming a payment period of 30 years and 5.0% annual interest rate, in current dollars
- **Annual Supply Operation and Maintenance (O&M), $/year:** total operation and maintenance to produce supply, in current dollars
- **Annual Imported Cost, $/year:** total annual cost of SDCWA imported water purchases based on current water rates

- **Annual Distribution Cost, $/year:** total variable cost of distribution for options that require distribution through the City's pipe network for delivery to customers
- **Annual Wastewater System O&M, $/year:** total variable cost of wastewater collection, treatment, and discharge for options that produce potable water supplies for indoor applications and requires wastewater treatment after use
- **Wastewater Treatment Capital Cost, $/year:** capital cost to upgrade Point Loma Wastewater Treatment Plant (WWTP), expressed in volumetric terms of wastewater treated. This is used as a proxy to illustrate which options would require wastewater treatment and would not help to reduce wastewater system capital costs associated with upgrading Point Loma WWTP to secondary treatment.
- **Unit Cost, $/AF (current dollars):** total annual cost of the option (in current dollars) divided by the new supply yield. Cost includes supply and wastewater system costs, and represents total cost including cost to customers/developers or other partnering agencies**.**

Fact sheets (or summary sheets) were developed for several categories of options, many of which (but not all) were carried forward for portfolio analyses. Fact sheets were developed for the following options, and are included in this appendix:

A. Conservation

B. Groundwater – San Pasqual Basin

C. Groundwater – Other Basins

D. Water Transfers and Groundwater Banking

E. Marine Transport

F. Ocean Desalination

G. Recycled Water – Non-potable Reuse

H. Recycled Water – Indirect Potable Reuse

I. Graywater Reuse

J. Rainwater Harvesting – Onsite Capture

K. Rainwater Harvesting – Centralized Capture

Table A-1
City of San Diego Public Utilities Department
List of Potential Water Resource and Conservation Options

Source or Demand Option	Brief Description	Notes
Conservation		
Baseline Conservation	Continue existing conservation programs.	
Additional Active Conservation	Existing conservation programs and additional active conservation measures.	
Additional Active Conservation and Water Pricing	Additional active conservation measures and a water pricing structure that encourages conservation.	
Groundwater		
San Pasqual Basin: Conjunctive Use with Imported Water	Recharge the basin with imported water and extract for potable use during dry years or emergency conditions.	**No further evaluation.** The yield and cost for this option is not significantly different from the Integrated Conjunctive Use and Groundwater Desalination option. Given the uncertainty of replenishment water availability, the Integrated Conjunctive Use and Groundwater Desalination option will be carried forward as a representative groundwater recharge option. However, the City could decide to implement the Conjunctive Use with Imported Water in place of the Integrated Conjunctive Use and Groundwater Desalination depending on replenishment availability in the future.
San Pasqual Basin: Integrated Conjunctive Use and Groundwater Desalination (4)	Recharge the basin with advanced treated recycled water and imported water, and extract and treat water for potable use.	The USGS is currently studying the basin and will provide more information on basin characteristics to help determine whether indirect potable reuse would be feasible.
San Pasqual Basin: Agricultural Water Exchange (4)	Deliver recycled water to agricultural users to replace most of the existing agricultural groundwater production in the San Pasqual Valley. The City would extract and treat the unproduced groundwater for potable use.	
Santee -- El Monte Basin	Extract and deliver groundwater to existing raw water transmission pipelines, and provide treatment at the Alvarado water treatment plant for potable use.	
San Diego Formation Basin: Extraction Only	Extract groundwater for non-potable and potable uses.	
San Diego Formation Basin: Aquifer Storage and Recovery	Install injection/extraction wells and use the basin for imported water storage. Extract groundwater for potable use during dry years or emergency conditions.	
San Diego Formation Basin: Indirect Potable Reuse	Install injection/extraction wells and use the basin for storage of advanced treated recycled water	**No further evaluation.** The USGS is currently studying the basin and will provide more information on basin characteristics to help determine whether indirect potable reuse would be feasible (and could be considered in future planning efforts).
Mission Valley Basin	Extract groundwater for non-potable and potable uses. Will require treatment for potable use.	
Ocean Desalination		
Ocean Desalination	Evaluate ocean desalination supply from SDCWA. The City would pay a purchase cost for water once the plant is constructed. Assumes purchase cost would be higher than standard SDCWA rates but water would be more reliable.	The City has investigated construction of an ocean desalination plant in the past, and it was found to be infeasible due to site constraints and cost-effectiveness. This option assumes the ocean desalination plant will be constructed by other agencies (e.g. SDCWA), and the City would purchase the product water at a contracted rate.
Recycled Water		
Non-potable Demands - Satellite Plants	Construct new satellite treatment plants to produce recycled water, and expand recycled water distribution system to serve additional non-potable demands (beyond already planned non-potable reuse). This option could be implemented by the City or private developers.	
Non-potable Demands - Existing Facilities	Use existing water reclamation plant capacity, and expand recycled water distribution system to serve additional non-potable demands (beyond already planned non-potable reuse).	
Indirect Potable Reuse - Phase 1	North City Phase 1. This project involves construction of a 15 mgd advanced purification facility. Purified water would be transported to the San Vicente Reservoir for raw water augmentation, and receive further treatment prior to distribution to potable water customers.	
Indirect Potable Reuse - Phase 2	Initial IPR (Phase 1), plus an additional indirect potable reuse project for a total of about 30 mgd yield	This concept is also known as IPR South Bay.
Indirect Potable Reuse - Phase 3	Phase 1 and 2, plus an additional indirect potable reuse project for a total of about 80 mgd yield	This concept is also known as IPR San Diego Bay.

Table A-1
City of San Diego Public Utilities Department
List of Potential Water Resource and Conservation Options

Source or Demand Option	Brief Description	Notes
Groundwater Replenishment	See groundwater options.	
Direct Potable Reuse	This option concept involves advanced treatment of recycled water, which could either be connected directly to the distribution system or be blended with raw imported water in the SDCWA aqueduct and further treated prior to entering the potable distribution system.	**No further evaluation.** Although there have been significant advances in treatment technology and monitoring methodology that could make direct potable reuse a reasonable option to consider, there are currently no regulations or criteria in California for this type of a project. Direct potable reuse has yet to be applied in California, and has historically been deemed unacceptable by regulatory agencies. Due to current implementation issues, this option has been screened from further analysis in this study. However, it is recommended that Direct Potable Reuse be studied at a later date once treatment and blending requirements are established. The California Department of Public Health has a deadline of December 2016 to formulate guidelines for such requirements as a result of State legislation.
Graywater		
Residential Graywater	Program to assist with capturing, education and workshops to implement this resource.Graywater refers to the water from non-sewage household activities (such dishwashing, laundry, and bathing) that can be recycled for non-potable uses such as irrigation or toilet use.	
Rainwater Harvesting		
Rain Barrels (onsite rainwater capture)	Program to assist with installation of cisterns (or rainbarrels) to capture storm runoff from rooftops for on-site storage. The water can then be used for non-potable purposes such as irrigation. Systems should be designed to overflow into landscaping.	
Centralized Stormwater Capture	A diversion system would be constructed in the existing storm drain network to capture stormwater and divert it to location TBD. Facilities will likely be located at municipal parks or golf courses for non-potable uses (irrigation) or groundwater infiltration.	
Imported Water		
Continue to purchase imported water from SDCWA	Status Quo option (raw water purchases, with treated puchases as needed)	
North of Delta Transfers	Participate in a transfer agreement to receive water from Sacramento Valley area in drought years. Although this source water would not be purchased from Metropolitan Water District (MWD) or San Diego County Water Authority (SDCWA), it would be delivered via MWD/SDCWA facilities.	**No further evaluation.** This option has reliability issues due to delivery restrictions associated with capacity and environmental requirements in the Delta. In addition, this option would be at a very high cost due to MWD/SDCWA wheeling charges to transport the water to Southern California and other agencies (e.g. MWD) have already secured most of the cost-effective opportunities to date. Therefore, this option will not be further evaluated by the City at this time.
Groundwater Banking	Participate in a groundwater banking agreement to store water underground (i.e. in Central Valley) for future use during dry periods. Groundwater extractions would be delivered from the Central Valley to the City of San Diego via MWD/SDCWA faciliites.	**No further evaluation.** This option will not be further evaluated at this time for the same reasons as the North of Delta Tranfers option (see above). The SDCWA is already participating in groundwater banking opportunities which provide this type of supply to the San Diego region.
Marine Transport	Use of marine conveyance to import water from the North Pacific Coast to the City of San Diego for delivery to raw water system. Raw water is treated at one of three existing treatment plants prior to customer distribution.	**No further evaluation**. The City conducted analysis of this option in the 2000's and concluded the process of transferring marine water to the City's raw water system is extremely complex and too costly for normal operations. This option will not be further evaluated at this time. However, this option could be a consideration for extreme emergency conditions (e.g. complete Delta supply failure due to earthquake) or for other agencies with plans to construct a seawater desalination facility (where conveyance system could be shared if the marine transport water is already treated or does not require additional treatment beyond chlorination). A pilot study may be needed to determine the feasibility of this option.

Table A-2.
City of San Diego Public Utilities Department
Potential New Options Yield and Cos

			COST OF WATER SUPPLY[A]					WASTEWATER SYSTEM COSTS[A]		TOTAL UNIT COST[A]		
		Estimated Yield[B], Acre-feet per Year (AFY)	**Capital Cost[I], $**	**Annual Capital Payment[C], $/year**	**Annual Supply Operation and Maintenance (O&M), $/year**	**Annual Imported Cost[F], $/year**	**Annual Distribution Costs[K], $/year**	**Annual Wastewater System O&M[D], $/year**	**Wastewater Treatment Capital Cost[E], $/year**	**Unit Cost, $/AF (Current dollars)**	**Notes**	**Reference No.**
Conservation												
Additional Active Conservation		6,750	$0	$0	$3,138,800	$0	$0	$0	$0	$465	Includes customer retrofit costs. Assume new conservation is 40 percent indoor and 60 percent outdoor.	
Additional Active Conservation and Water Pricing		14,150	$0	$0	$3,290,000	$0	$0	$0	$0	$233	Includes customer retrofit costs. Assume new conservation is 40 percent indoor and 60 percent outdoor.	
Groundwater												
San Pasqual Basin: Integrated Conjunctive Use and Groundwater Desalination		5,600	$145,100,000	$9,439,000	$7,294,000	$2,732,400	$492,100	$845,600	$2,155,800	$4,100	Imported costs assume total cost of SDCWA untreated water for blending (2,700 AFY). This cost could be eliminated with changes to future regulations for indirect potable reuse.	2
San Pasqual Basin: Agricultural Water Exchange		4,660	$124,500,000	$8,099,000	$5,235,000	$0	$409,500	$703,700	$1,794,000	$3,485		2
Santee -- El Monte		3,400	$34,189,000	$2,224,100	$539,200	$0	$298,800	$513,400	$1,308,900	$1,437		3
San Diego Formation Basin: Extraction Only		500	$4,064,000	$264,400	$199,000	$0	$43,900	$75,500	$192,500	$1,551		3
San Diego Formation Basin: Aquifer Storage and Recovery	Extraction Years:	10,000	$29,903,000	$1,945,300	$1,003,000	$0	$878,800	$1,510,000	$3,849,600	$2,142	Unit Cost assumes yield is recovered every 3 years. Imported costs assumes SDCWA untreated melded supply, transporation, and fixed costs.	
	Recharge Years:	NA			$171,000	$10,120,000	$0	$0	$0			
Mission Valley Basin		2,000	$13,897,575	$904,100	$1,967,798	$0	$175,800	$302,000	$770,000	$2,060		5
Ocean Desalination												
Ocean Desalination		10,000	$0	$0	$0	$24,800,000	$878,800	$1,510,000	$3,849,600	$3,104	Imported costs assume cost to SDCWA, plus transportation and fixed costs.	
Recycled Water[J]												
Non-potable Demands - Satellite Plants		5,475	$712,621,600	$46,357,100	$13,519,800	$0	Included in Supply O&M Costs	$0	$0	$10,936	Includes customer retrofit costs.	
Non-potable Demands - Existing Facilities		2,700	$47,606,300	$3,096,900	$2,516,100	$0	Included in Supply O&M Costs	$0	$0	$2,079	Includes customer retrofit costs.	
Indirect Potable Reuse - Phase 1		16,800	$285,224,700	$18,554,300	$15,894,600	$0	$1,476,400	$0	$0	$2,138	Wastewater system costs accounted for in supply O&M. This option concept is also known as IPR North City.	6
Indirect Potable Reuse - Phase 2		16,800	$748,369,800	$48,682,600	$28,462,900	$0	$1,476,400	$0	$0	$4,680	Wastewater system costs accounted for in supply O&M. This option concept is also known as IPR South Bay.	4
Indirect Potable Reuse - Phase 3		56,000	$1,125,797,500	$73,234,800	$53,881,400	$0	$4,921,200	$0	$0	$2,358	Wastewater system costs accounted for in supply O&M. This option concept is also known as IPR Harbor Drive.	4
Graywater												
Residential Graywater		2,575	$270,000,000	$17,563,900	$3,811,600	$0	$0	$0	$0	$13,499	Includes customer retrofit costs. Assumes 20 percent of single family homes (50,000 homes) will participate.	
Rainwater Harvesting												
Residential Rain Barrels (on-site capture)[(H)]		356	$13,214,800	$859,700	$660,800	$0	$0	$0	$0	$6,844	Includes customer retrofit costs. Assumes 20 percent of single family homes (50,000 homes) will participate. See note G.	
Non-residential Cisterns (on-site capture)[(H)]		60	$1,518,000	$98,800	$75,900	$0	$0	$0	$0	$3,695	Includes customer retrofit costs. Assumes 20 percent of non-residential units (3,800 units) will participate. See note G.	
Centralized Stormwater Capture		100	$9,070,000	$590,100	$200,200	$0	$0	$0	$0	$19,758	Unit cost assumes full annual yield is only available 40 percent of the time due to hydrologic variability. See note G.	
Imported Water												
Continue to purchase imported water from SDCWA		As needed and available	$0	$0	$0	Included in Unit Cost	Included in Unit Cost	Included in Unit Cost	Included in Unit Cost	$1,707	Unit cost includes cost to purchase raw water, treatment, distribution, and wastewater system costs. The cost to purchase water is expected to increase significantly in the future.	

Notes:

[A] Based on conceptual planning level costs. All costs are presented in today's dollars. Portfolio evaluations will account for expected increases in costs over time.

[B] Estimated incremental new yield.

[C] Debt Financing Assumptions:

Annual Interest Rate:	5.0%
Capital Payment Period (years):	30

[D] Based on current average volumetric cost of wastewater collection, treatment, and solids handling. Assumes 40 percent of supply yield is used for indoor applications. Note that treatment O&M costs would increase with upgrades to Point Loma Wastewater Treatment Plant (WWTP).

[E] The construction cost to upgrade Point Loma WWTP is currently estimated to be $1.2 billion. During the time of 2012 LRWRP analyses, it was assumed that the cost would be $1.052 billion and expressed in volumetric terms of wastewater treated. This is used as a proxy to illustrate that these supplies produce wastewater flows and costs at Point Loma WWTP. This does not represent the actual cost to upgrade Point Loma, which varies depending on total system-wide wastewater flows that are generated.

[F] Includes SDCWA fixed costs expressed in volumetric terms. In portfolio analyses, fixed costs will not be calculated based on volumetric terms; only the melded supply and transportation costs vary depending on the volume of water purchased in a portfolio.

[G] Unit cost is based on the cumulative yield and costs over the planning horizon (in current dollars), assuming yield and O&M costs increase linearly over time as more devices are installed. Assumes capital replacement costs for rain barrels, cisterns, and graywater after 10, 20, and 15 year service life, respectively.

[H] Onsite rainwater harvesting through residential rain-barrels and non-residential cisterns were evaluated as a combined option concept, although the yields and costs of each are shown separately here.

[I] Capital costs for groundwater options inclue soft costs assumed in the SDPUD *Water Facilities Master Plan: Technical Memorandum 4* , February 2010 (where total soft costs are 79% of construction cost). Capital costs for recycled water options include soft costs assumed in the SDPUD *Recycled Water Study: Technical Memorandum 8,* Appendix A, August 26, 2011 (where total soft costs are 130% of construction cost). Soft costs are not applicable to capital cost of other options (conservation, graywater, ocean desalination, rainwater harvesting), except for the centralized stormwater capture option which assumes the Water Facilities Master Plan soft costs where appropriate.

[J] Costs shown are based on those used at the time of 2012 LRWRP analyses and do not represent the latest information available. Refer to Table 4-8b and Appendix G for the latest information.

[K] Distribution costs are based on average $/AF variable operating cost to distribute water to customers (refer to Table B-2).

Acronyms:

AFY: Acre-feet per year
O&M: Operation and Maintenance
NA: Not applicable.

References:

(1) CDM, 2010. City of San Diego *San Pasqual Groundwater Conjunctive Use Study* , May 2010.
(2) CDM, 2011. City of San Diego *Draft Preliminary Screening of New Recharge and Extraction Alternatives in San Pasqual Valley* , Draft June 2011.
(3) Updated from City of San Diego *Water Facilities Master Plan,* January, 2011. Appendix B.
(4) Recycled Water Study *Technical Memorandum No. 8 Financial Analysis of Recycled Water Project Alternatives* , dated August 26, 2011
(5) City of San Diego *Mission Valley Groundwater Desalter Project Concept Study* , March 2004. Costs have been inflated to current dollars based 3 percent annual inflation.
(6) City of San Diego *Draft Planning Level Cost Estimate for Long-Range Plan Technical Memorandum* prepared by RMC dated December 28, 2011

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Conservation

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

The City of San Diego's Water Conservation Program was established in 1985 to reduce San Diego's dependency on imported water, and water conservation today accounts for over 31 million gallons per day (mgd), or more than 34,000 acre-feet per year (AFY), of potable water savings. This savings has been achieved by creating a water conservation ethic, adopting programs, policies and ordinances designed to promote water conservation practices, and implementing comprehensive public information and education campaigns.

In 1991, the City was an original signatory of the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU), which formalizes an agreement to implement best management practices (BMPs), also known as demand management measures (DMMs), making a cooperative effort to reduce the consumption of California's water resources. The MOU is administered by the California Urban Water Conservation Council (CUWCC).

The Water Conservation Program continues to integrate existing programs while developing new programs to increase conservation and meet established goals. The following outlines ongoing programs and initiatives.

- Residential Interior/Exterior Water Surveys
- Commercial Landscape Survey Program
- Water Conserving Municipal Code - Retrofit Upon Resale
- SoCal Water$mart Rebates for Single Family Dwellings
- Save a Buck Rebates for Commercial Industrial and Institutional and Multi-Family Properties
- Water Conservation Film and Poster Contests
- Outreach Using Facebook, Twitter, and YouTube Media
- Water Conservation Garden on the Campus of Cuyamaca College
- California Friendly Landscape Contest
- Public Education, Information and Community Outreach
- California Irrigation Management Information (CIMIS) Stations
- Water Waste Investigations
- Water2Save Program
- Junior Lifeguards
- WaterSmart
- Storm Water Pollution Prevention
- Water Efficient Landscape and Irrigation Rebate Program
- Rain Barrel Rebate Program
- Online Water Landscape Calculator

Conservation

In addition to ongoing conservation programs and initiatives, the City has responded to critical drought situations in the past by enforcing mandatory water conservation and rationing. In 2009, Mayor Sanders and the City Council approved Level 2 Drought Alert Condition which required limitations on landscape irrigation, car washing, ornamental fountains, excessive off-site drainage from overwatering, and leaks. The City demonstrated exceptional commitment and capability in communicating water issues to the public by developing the *No Time to Waste, No Water To Waste* public involvement and educational campaign.

Future conservation goals are further promoted by the recently passed Senate Bill 7 as part of the Seventh Extraordinary Session (SBX7-7), also known as the Water Conservation Act of 2009. The new law seeks to achieve a 20 percent statewide reduction in urban per capital water use in California by 2020, commonly referred to as “20x2020”.

The following conservation options represent future conservation goals that would meet or exceed the City’s 20x2020 targets. These options are based on the City of San Diego’s 2010 Update of the Long-Term Water Demand Forecast, and 2011 Water Demand Forecast Rate Sensitivity Analysis.

- **Baseline Conservation:** Assumes existing conservation programs (as of 2008) are continued, but no additional conservation efforts are implemented.
- **Additional Active Conservation:** Baseline Conservation, plus additional active conservation measures
- **Additional Active Conservation and Water Pricing:** With Conservation option, plus potential savings from increasing the nominal price of water.

Yield

For each conservation option, the yields represent the total conservation savings that could be achieved, including savings from existing programs:

- **Baseline Conservation:** About 42,650 AFY by 2035
- **Additional Active Conservation:** About 49,400 AFY by 2035 (6,750 AFY additional over baseline)
- **Additional Active Conservation and Water Pricing:** About 63,550 AFY by 2035 (20,900 AFY over baseline)[1]

Advantages

- **Helps meet 20x2020 goals**. The Water Conservation Act of 2009 (SBX7-7) mandates a 20 percent reduction in urban per capita water use statewide by 2020.
- **Reliability/Local Resource**. Conservation can reduce demand for imported water.
- **Offset to Wastewater System.** Indoor plumbing rebates and graywater systems can reduce wastewater collected by the municipal wastewater system. While some parts of the service area could offload wastewater to Point Loma wastewater treatment plant, other areas may reduce wastewater used to produce recycled water.
- **Green Technology**. This option is considered a “green” technology with low energy requirements.
- **State funding**. Some costs may be offset by MWD’s conservation credits program and state grant funding.

Disadvantages

- **Cost.** Conservation programs can be expensive and difficult to implement depending on the level of conservation pursued. In addition, this option would involve a capital cost to homeowners and businesses for installation for the conservation devices, although the City could offer rebates to help offset some of these costs.
- **Customer Participation.** Requires large-scale voluntary customer participation and behavioral changes for successful implementation.

References

City of San Diego Public Utilities Department *2010 Urban Water Management Plan,* June 2011.
City of San Diego Public Utilities Department *Water Demand Forecast Rate Sensitivity Analysis (Technical Memorandum)*, July 2011.
City of San Diego Public Utilities Department *Update of Long-term Water Demand Forecast,* June 2010.

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[1] Based on City of San Diego *Water Demand Forecast Rate Sensitivity Analysis* dated July 2011, which evaluates the responsiveness of water demands to changes in the marginal price of water.

Groundwater – San Pasqual Basin

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

The San Pasqual Basin (Basin) lies within the City of San Diego (City), approximately 25 miles northeast of downtown San Diego. The Basin is upstream of Lake Hodges along the Santa Ysabel Creek. The estimated total groundwater storage volume of this Basin is approximately 58,000 acre-feet (AF). Refer to Figure 1 for the approximate location of the Basin.

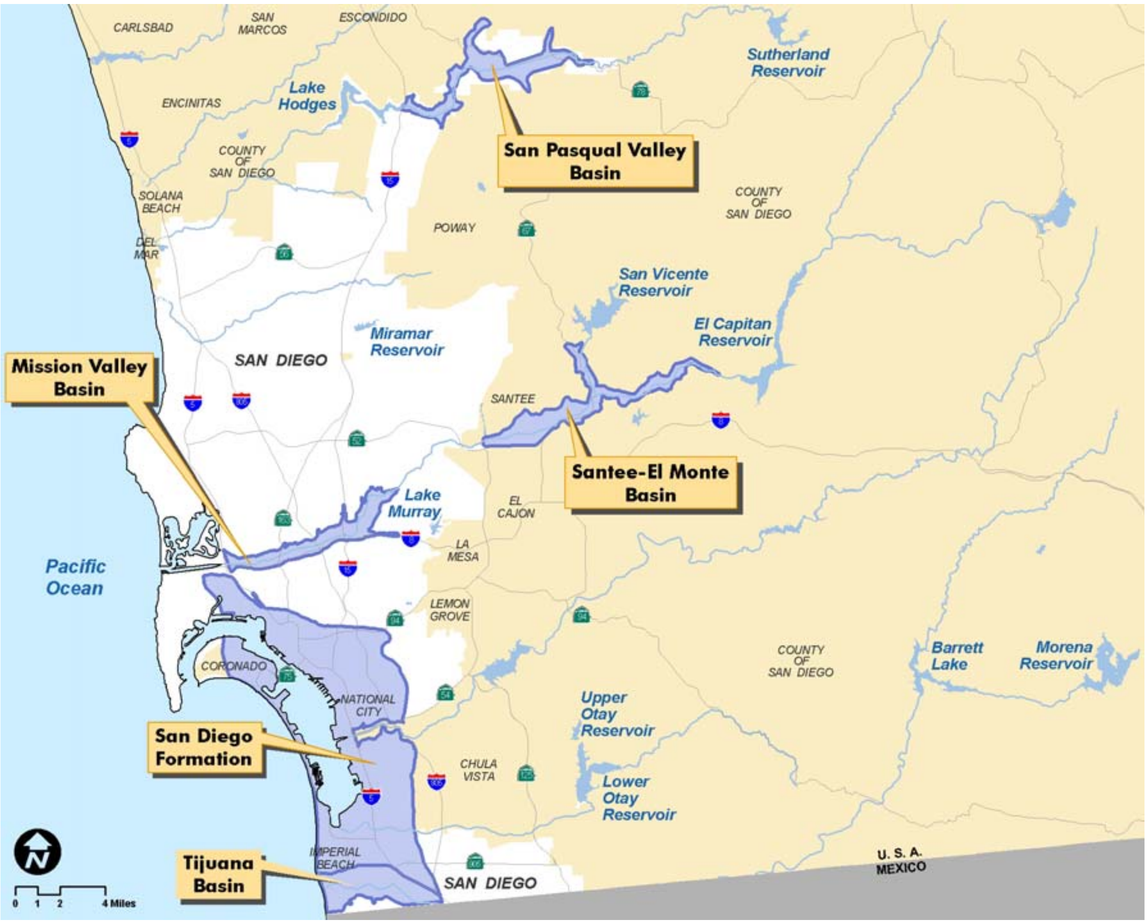

Figure 1. San Pasqual Basin Map

The City is evaluating use of groundwater in the Basin for municipal use. The Basin presents an opportunity for the City to create a new local water supply or storage to help meet future municipal water demands. Improved management and use of the Basin could reduce reliance on, and purchase of, imported water supplies from the San Diego County Water Authority (SDCWA). The San Pasqual Valley is an important agricultural and open space region within the City's boundaries and the City has committed to maintain the existing character of the valley.

Groundwater – San Pasqual Basin

Several San Pasqual concepts are being studied. The following are summarized as representative San Pasqual groundwater resource strategies:

1. **Conjunctive Use with Imported Water**: Recharge imported water into the Basin for use during dry years or emergency conditions. Raw imported water could be purchased at a reduced rate during wet years when excess water is available. Imported water from the SDCWA First Aqueduct would be delivered to the Basin through a new 30-inch bi-directional pipeline for recharge and storage. Recovered groundwater could be (1) treated and sent to the Rancho Bernardo distribution system or (2) returned to the SDCWA First Aqueduct for treatment at the Miramar WTP. This option would involve construction of a hydropower facility to recover excess energy due to the substantial excess hydraulic head from the Aqueduct to the Basin, creating a renewable energy source.

2. **Integrated Conjunctive Use with Groundwater Desalination**: Recharge advanced treated recycled water and imported water into the Basin[1]. Replenishment and groundwater recovery would occur every year. This option is considered an indirect potable reuse option using groundwater replenishment. This option involves construction of a new advanced water treatment (AWT) plant to purify recycled water, a 12-inch imported water pipeline to the AWT plant for blending prior to groundwater recharge, and a new groundwater treatment plant to remove salinity prior to delivery to the Rancho Bernardo service area. This option has potential to substantially improve water quality in the Basin over the long-term.

3. **Agricultural Water Exchange:** Deliver recycled water to agricultural users in the San Pasqual Valley to replace most of the existing agricultural groundwater production, and extract the groundwater for municipal uses in the Rancho Bernardo area. Primary facilities required include a tertiary wastewater treatment plant to produce recycled water that meets California Department of Public Health (CDPH) Title 22 requirements for unrestricted irrigation use, pipelines, extraction wells, and a groundwater treatment prior to delivery to the Rancho Bernardo service area. This alternative would require an extensive distribution system to switch agricultural irrigation from groundwater to recycled water.

Yield

The conceptual ranges of groundwater yields, and representative yields assumed at the time of 2012 LRWRP analysis are shown in Table 1.

Table 1. Summary of Conceptual San Pasqual Groundwater Yields, Acre-feet per Year (AFY)

Option	Range of Conceptual Yield, AFY	Representative Conceptual Yield assumed in 2012 LRWRP, AFY
Conjunctive Use with Imported Water	3,000(1)-6,000(1)	5,600(1)
Integrated Conjunctive Use with Groundwater Desalination	3,000(1)-6,000(1)	5,600 total; (2,900 AFY AWT recycled and 2,700 AFY imported)(1)
Agricultural Water Exchange	3,100(3)-4,660(2)	4,660(2)

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[1] Note that it is possible to recharge Title 22 recycled water into the basin rather than advanced treated recycled water; however, CDPH Draft Regulations for Groundwater Replenishment with Recycled Water require a ratio of 20 percent recycled water and 80 percent blend water (e.g. surface water) if advanced treatment is not used.

Groundwater – San Pasqual Basin

Advantages and Disadvantages

Option	Advantages	Disadvantages
Conjunctive Use with Imported Water	• **Reliability.** Better reliability during droughts and emergencies • **Grant Funding.** Eligible for state and federal grant funding	• **Replenishment Availability.** Availability of replenishment water is uncertain and depends on hydrologic conditions from year to year
Integrated Conjunctive Use with Groundwater Desalination	• **Reliability.** Better reliability during droughts and emergencies • **Grant Funding.** Eligible for state and federal grant funding • **Groundwater Quality.** Improved long-term groundwater salinity conditions, since replenishment water quality would have substantially lower total dissolved solids than existing groundwater.	• **Public perception.** This option is considered an indirect potable reuse (IPR) option. While historically, some public stakeholders have not been supportive of accepting IPR, great strides have been made in public education and outreach to demonstrate the safety and high water quality from purified recycled water. But for IPR to be successful, significant public outreach, education and information will be needed. • **Regulatory permitting**. Indirect potable reuse typically requires a more challenging regulatory process than other options, but these regulatory hurdles are not insurmountable. In addition, regulations for IPR are subject to a changing regulatory landscape in the future. • **Brine**. Advanced treatment processes would produce brine, which would need to be discharged.
Agricultural Water Exchange	• **Reliability.** Better reliability during droughts and emergencies • **Grant Funding.** Eligible for state and federal grant funding • **Maintains Agricultural Leases.** This option would maintain full agricultural production in the valley and does not require removal of agricultural lands for recharge basins that currently provide lease revenues to the City	• **Implementation Risk**. Significant coordination effort with landowners to switch to recycled water, and an extensive recycled water distribution system would be required with a complex network of pipelines, user connections, agreements, permitting, and recordkeeping and reporting.

References

[1] CDM, 2010. City of San Diego San Pasqual Groundwater Conjunctive Use Study, May 2010.

[2] CDM, 2011. City of San Diego Draft Preliminary Screening of New Recharge and Extraction Alternatives in San Pasqual Valley, Draft June 2011.

[3] CDM Smith, 2012. City of San Diego Draft Preliminary Screening of New Recharge and Extraction Alternatives in San Pasqual Valley, Draft July 2012.

Groundwater – San Pasqual Basin

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Groundwater – Other Basins

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

Groundwater resources are a promising local supply or storage option, providing more localized control and greater water reliability to the region by reducing dependence on imported water. While there is not a large groundwater basin underlying the entire City of San Diego (City), there are several basins located along river systems and the San Diego Formation located beneath the coastal plain of the southern San Diego region that could bring localized supply opportunities. One challenge associated with the groundwater basins is the water quality; as much of the groundwater in San Diego is brackish (salty) and may require desalination prior to use as a municipal supply.

Local groundwater basins that could be used for local supply or storage include the Santee – El Monte Basin, San Diego Formation, and Mission Valley Basin. **Figure 1** shows the general location of the groundwater basins. The options for these basins are a function of: natural recharge from precipitation, potential for yield, proximity to water production or conveyance facilities, overlying land use, potential or actual contamination, water rights and potential for seawater intrusion, subsidence, overdraft, or other environmental impacts.

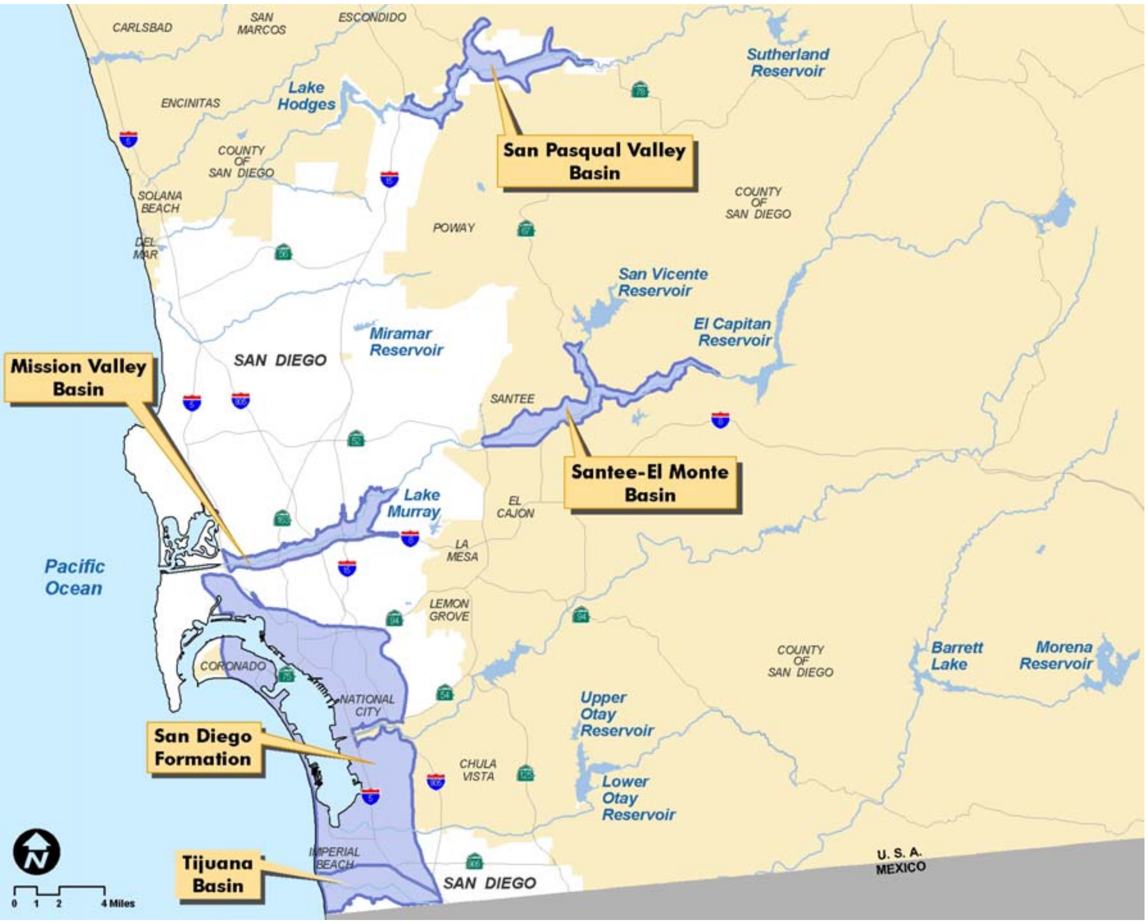

Figure1. Santee – El Monte, Mission Valley, and San Diego Formation

Groundwater – Other Basins

The City is interested in developing these sources in a sustainable manner, and has a history of supporting the health of the groundwater basins. The City is currently investigating the sustainable yield of the basins through pilot wells and studies. If these investigations determine that yields are not sustainable, the city may advance investigations of aquifer storage and recovery (ASR) projects.

- **Santee - El Monte:** The Santee – El Monte basin is located along the San Diego River outside the City of San Diego municipal boundary and mostly within the City of Santee and Lakeside. The conceptual option proposes to extract groundwater by installing two well fields at the Santee – El Monte Basin. The extracted groundwater would be conveyed to existing raw water pipelines, delivered to surface water treatment plants and treated to potable standards prior to customer use.

- **San Diego Formation – Extraction Only:** The San Diego Formation is located under the coastal plain of southwest San Diego County, south of Interstate 8 and north of State Route 905. The City is investigating the sustainable yield and treatment requirements of extracted San Diego Formation groundwater. A representative option is considered that proposes to extract groundwater from the basin through new wells. The extracted groundwater would undergo appropriate treatment and disinfection, and conveyance to the potable water distribution system and/or other beneficial use.

- **San Diego Formation – Aquifer Storage and Recovery:** The City is currently working with the USGS to gain a better understanding of the geology and hydrogeology characteristics of the San Diego Formation, and evaluate the potential for groundwater recharge and extraction. Due to a variety of complex issues, including land availability, injection wells will likely be required in order to artificially recharge water to the underlying San Diego Formation groundwater aquifer. This option considers a conceptual aquifer storage and recovery (ASR) system, where treated imported water would be injected to the groundwater aquifer to build storage in the basin. The stored water would then be recovered for use in dry years when there are imported water shortages. Historically, the water quality of San Diego Formation has varied widely. (Boyle, 1999) While some areas of the San Diego Formation are brackish, it is assumed this concept could be implemented in areas of the basin that would not require treatment of extracted water other than disinfection prior to delivery to customers. New facilities for this option include new injection/extraction wells, and pipelines that connect the potable water distribution system with the injection/extraction wells.

- **Mission Valley:** The Mission Valley basin is within the City of San Diego municipal boundary and service area. It is located along the San Diego River extending from coastal areas to just east of Interstate 15. This option proposes to extract groundwater and construct a new desalination plant to reduce salinity prior to customer use. The Mission Valley Basin is currently undergoing large-scale remediation due to contamination from Mission Valley Terminal petroleum tank farm. It is expected that this project would not proceed until after the remediation is complete, and the City would treat the groundwater to acceptable quality and health standards prior to delivering to customers.

Groundwater – Other Basins

Yield

The conceptual ranges of groundwater yields, and representative yields assumed at the time of 2012 LRWRP analysis are shown in Table 1.

Table 1. Summary of Conceptual Groundwater Yields, Acre-feet per Year (AFY)

Option	Range of Conceptual Yield, AFY	Representative Conceptual Yield assumed in 2012 LRWRP, AFY
Santee - El Monte	1,400(1)-3,400(2)	3,400(2)
San Diego Formation: Extraction Only	500(3)-2,900(1)	500(3)
San Diego Formation: ASR	8,000(4)-22,000(4)	10,000(3)
Mission Valley	1,760(1)	2000(3)(5)

Advantages

- **Local Water Supply/Reliability**. This option would reduce the City's dependence on imported water and develop a reliable, drought-resistant local water supply that would also be available in emergency conditions.
- **Grant Funding.** These options would be eligible for both state and federal grant funding.
- **Water Quality**. Groundwater options that require construction of desalination plants will produce very high quality water. However, blending may be an option for groundwater that is marginally high in total dissolved solids (TDS) and other beneficial uses may exist, such as irrigation, that do not require treatment to potable standards.

Disadvantages

- **Costs**. The need for desalination will make groundwater options more costly on a per unit supply basis compared with other options. However, grant funding can help offset the costs.
- **Brine**. Options that require treatment for desalination would produce brine, which would need to be discharged.

References

[1] Brown and Caldwell, 2011. City of San Diego Public Utilities Department Urban Water Management Plan.

[2] CDM, 2010. City of San Diego Water Facilities Master Plan, January 2010.

[3] Based on discussions with City staff during development of LRWRP analysis.

[4] Boyle, 1999. San Diego County Water Authority Aquifer Storage and Recovery Project: San Diego Formation Phase 1 Technical Report.

[5] City of San Diego, 2004. Mission Valley Groundwater Desalting Project Concept Study, March 2004.

Groundwater – Other Basins

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Water Transfers and Groundwater Banking

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

The San Diego Public Utilities Department (SDPUD) actively evaluated purchasing spot and long-term water transfers from Northern California in the early 2000's, prior to the signing of the Quantification Settlement Agreement (QSA) in 2003. In 2002, and even today, it is highly unusual for retail water agencies within the service area of Metropolitan Water District of Southern California (MWD) and the San Diego County Water Authority (SDCWA) to independently purchase and transfer water. This is in large part because of the high cost of transporting the water through the system with wheeling charges, and because other agencies including MWD and SDCWA have already secured most of the cost-effective opportunities to date. In addition to the higher costs, water transfers from Northern California have the lowest priority for conveyance and there is a risk water purchased by the city of San Diego (City) could not be transported when needed. This is especially true in the post-Wanger decision era that further limits the pumping season in order to protect fish in the Delta. After the signing of the QSA in 2003, the SDPUD discontinued actively evaluating water transfers as an option for the City.

Water Transfers

Water transfers are a potential water supply diversification strategy for the City. Water transfers can be short-term or long-term. Short-term water transfers are typically a one-time purchase of water, usually on an as-needed basis to offset the effects of drought. Long-term transfers are those that take place over a period of more than one year. Long-term transfers can be made through an options agreement, where buyers have the "option" to purchase a certain amount of water any time during the life of the agreement. An "option" payment would be made each and every year to secure the right to transfer the water. When the water is called, then the buyer would pay the water transfer cost for that amount of supply needed in that year. In past years, most water transfers have occurred between sellers north of the Sacramento-San Joaquin Delta (Delta) to buyers south of the Delta. Water transfers from the Central Valley or Colorado River Region have been limited because the lack of available water supplies. The City would have to find a seller, negotiate a price and transfer amount, and establish a wheeling agreement with MWD and SDCWA. Water transfers can occur through various mechanisms including stored water purchases, groundwater substitution, or crop idling agreements.

North to south water transfers require approval from the California Department of Water Resources (DWR) or U.S. Bureau of Reclamation (Reclamation), depending on the sellers' contract supplies (Central Valley Project (CVP) or State Water Project (SWP)) and the pumping facility used for transfer through the Delta. DWR and Reclamation closely coordinate transfers and have similar approval requirements. California Water Code Section 1810 and the Central Valley Project Implementation Act protect against injury to third parties as a result of water transfers. Three fundamental principles include use of a water conveyance facility is to be made with (1) no injury to other legal users of water; (2) no unreasonable effects on fish, wildlife or other in-stream beneficial uses of water; and (3) no unreasonable effects on the overall economy or the environment in the counties from which the water is transferred. DWR and Reclamation have defined the approval requirements of water transfers in "Draft Technical Information for Water Transfers in 2010", which the agencies update as needed before the transfer season.

In addition to the approval requirements, DWR and Reclamation must also implement water transfers within the operating parameters of the Biological Opinions on the Continued Long-term Operations of the CVP/SWP (Opinions) to protect sensitive fish species in the Delta. The Opinions' provisions applicable to conveyance of transfer water include:

- The maximum amount of water transfers covered in the Opinions is 600,000 acre feet per year (AFY); and
- Transfer water will be conveyed through the Banks Pumping Plant and Jones Pumping Plant during July through September only.

A major concern for water transfers is the ability to move the purchased water through the Delta. Export of the transfer water is dependent on availability of capacity at the SWP or CVP pumping facilities and subject to other operational requirements.

Water Transfers and Groundwater Banking

Available capacity is severely limited due to operational and regulatory restrictions. The current pumping window for transfers through Banks and Jones Pumping Plants is July through September. Pumping within this window can be further reduced based on specific hydrologic conditions and regulatory compliance or water quality issues. DWR and Reclamation determine the availability of pumping capacity during the transfer period.

Groundwater Banking

This option is similar to the water transfers option, but also involves a water banking agreement for groundwater storage outside of the San Diego area. Water banking involves storing water underground for future use, especially during dry periods. The Central Valley groundwater banking opportunities appear attractive due to reliability in drought conditions, but they are generally more expensive than other transfer opportunities. Several water agencies have established formal groundwater banks. Semitropic Water Storage District in Kern County operates a groundwater bank with a storage capacity in excess of one million acre-feet (AF). Multiple agencies already participate in the bank, including Metropolitan Water District (MWD) and Santa Clara Valley Water District. Semitropic Water Storage District is currently constructing the Stored Water Recovery Unit, which increases their banking operation and has storage and pump back capacity available for new banking partners.

The City can purchase “shares” in the bank, which would provide entitlement to storage and pump back. As currently planned, shares operate on a 3:1 storage to pump back ratio and a partner can only store 0.33 AF/share/per year. The City could purchase 5,000 shares and be eligible to store 15,000 AF of water in the bank and pump out 5,000 AF during dry years. It would take 9 years to store the entire 15,000 AF, the first 5,000 AF could be extracted after 3 years. The City would purchase high priority shares to be guaranteed extraction capacity during dry years.

Yield

Water Transfers

- 5,000 AFY max delivery
- 3,000 AFY long-term average
- Transfers are more likely to occur in dry years because pumping capacity would be available. In wet years, capacity may not be available because Banks and Jones Pumping Plants are pumping SWP and CVP water to meet contract demands.

Groundwater Banking

- 5,000 AFY max
- 2,000 AFY long-term average

Advantages

- **Increased Storage.** Groundwater banking programs would improve reliability through additional storage outside of the City’s local water system. Water transfers would likely be delivered in wet years but could enhance the City’s local raw water storage reserves.
- **No local environmental impacts.** There is no local construction associated with water transfers or groundwater banking; therefore, there would be no environmental impacts from construction activities. However, this option still requires conveyance of imported water from Northern California and would not reduce greenhouse gas emissions.

Disadvantages

- **Availability of Imported Water:** Water transfers and groundwater banking programs rely on imported water, which is subject to environmental restrictions, seismic interruption, droughts, and capacity limitations. There is a risk that water would not be available when needed.
- **Institutional Issues:** Wheeling arrangements for water transfers and groundwater banking must be agreed to by both MWD and SDCWA to use their systems to move the water to the City.
- **Costs.** This option is not as cost-effective compared with other options due to additional costs such as carriage losses and wheeling fees. Also, most opportunities for cost-effective water transfers and groundwater banking have been secured already by MWD and SDCWA.
- **Legal issues**. In addition to delivery issues, transfers and banking involve complex legal, operational, and financial transactions.
- **Distance**. Stored/banked water is hundreds of miles away, and must be conveyed through a significant length of pipelines and pump stations for delivery to San Diego.

Marine Transport

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

Marine transport is a relatively new concept for water supply in California. The marine transport of water supply proposes the use of marine conveyance to import water from the North Pacific Coast of North America to the City of San Diego (City). Proposals range from hauling fresh water from as far as Alaska, carried by either pulling large plastic bags (waterbags) behind ships or retrofitting old single hull oil vessels to carry water instead of oil. A similar oil vessel is shown **in Figure 1.**

Figure 1. Outdated oil vessels can be converted to carry water instead of oil

Transported water may need to be connected to the City's raw water system for treatment and delivery to customers. This requires major infrastructure including a loading buoy that is anchored offshore and serves as a mooring point for tankers to offload the water. The water is moved to the shore through a series of floating hoses, submarine hoses, buoy pipeline, and subsea pipelines. Since the City's raw water system and treatment plants are at inland locations, pump stations and pipelines are needed to convey the water from the shore to the City's raw water system, unless treated water could be delivered.

The City investigated the marine transport option in the 2000's; however, this option was not cost-effective at the time of analysis. The marine transport concept using waterbag technology has not been tested and feasibility costs could not be determined at the time of the 2012 LRWRP analysis.

Yield

- Assume up to 23,000 acre-feet per year (AFY)

Advantages

- **Emergency supply.** Bulk water carriers would not be subject to damage from seismic activity. Marine water would be a reliable external source of high quality emergency drinking water even in the event of an earthquake.
- **Water quality.** The quality of the source water would likely be lower salinity than current imported water supplies.

Marine Transport

Disadvantages

- **Economic and Legal Issues**. The World Water, SA (a global consortium of multi-national companies looking at the development of new water conveyance technologies for global markets) declared that the application of converted tanker was economically infeasible and politically unacceptable. Since the tankers are too big to enter San Diego's harbor, a mooring system would be constructed offshore and the water would be pumped through a force main to "tie-in" to the City's existing distribution system. The marine transport option is considered controversial due to uncertainty of political and public support. Multiple state and federal permits or contracts are required to obtain the water rights to buy the water from the North Pacific.
- **Infrastructure Needs**. Although the city of San Diego is a coastal community and marine transports would seem ideally suited, the City's water system is generally built to accommodate water flowing from North to South (via the San Diego County Water Authority's aqueducts) and from East to West (downhill for gravity flow). The City's three drinking water treatment plants are at inland locations, and major investments would be required for new pipelines and pump stations to move the water from the harbor to the treatment plants, unless the water needed minimal treatment or was already treated and just needed disinfection.

References

City of San Diego. 2002. *Long-Range Water Resources Plan*.
City of San Diego. 2007. *Spragg Waterbag Technology – Marine Transport Memorandum*.

Ocean Desalination

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

Ocean desalination removes dissolved minerals (salts and others) from seawater, and produces very high quality product water. Desalination offers improved water quality (low salinity), and can help protect against supply vulnerabilities due to droughts and earthquakes. The cost-efficiency of desalination has improved in the last couple of decades due to advances in treatment technologies, but is still very energy dependent and produces significant carbon emissions if non-renewable energy sources are used. Figure 1 shows treatment membranes used for ocean desalination. Seawater is pushed through these membranes at very high pressure in order to remove salts and minerals.

Figure 1. Treatment membranes for ocean desalination.

Desalination facilities are typically built along coastal communities and adjacent to power plants to take advantage of existing infrastructure for process efficiency and reduced environmental impacts. The San Diego County Water Authority (SDCWA), the agency from which the City of San Diego purchases imported water, is studying various ocean desalination supply opportunities in the San Diego region, including the Carlsbad Desalination Project, which is a fully-permitted ocean desalination plant and conveyance pipeline currently being developed by Poseidon, a private investor-owned company. The project, when completed, will provide a regional water supply of up to 50 million gallons per day (mgd), or 56,000 acre-feet per year (AFY).

The SDCWA and Poseidon Resources are currently negotiating terms to see if a final agreement can be reached for the SDCWA to use the desalinated water; current negotiations involve the SDCWA purchasing a minimum of 48,000 AFY and potential to purchase excess available water if needed[1]. If and when an agreement is made, the SDCWA will announce a

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[1] SDCWA July 12, 2012 Special Board of Director's Meeting Presentation on Incorporating Carlsbad Seawater Desalination Project into SDCWA Rates and Charges.

Ocean Desalination

60-day review period wherein retail member agencies, such as the City of San Diego, could purchase desalinated water from the Carlsbad Desalination Project at a higher rate than standard SDCWA rates in turn for a reliable local supply.

Other ocean desalination projects the SDCWA is planning include a new 50 to 150 mgd plant on Camp Pendleton, and a 25 to 50 mgd binational plant at Rosarito Beach, Mexico (product water would be shared between water users in the United States and Mexico, or product water would go only to water users in Mexico in exchange for Colorado River water). The Camp Pendleton Project and Rosarito Beach Binational Project are still in conceptual phases of planning.

Yield

- The SDCWA would sell up to a maximum of 49 percent of its desalinated product water from the Carlsbad Desalination Project, and the majority of the water will be maintained for regional reliability benefits of all member agencies. In order to evaluate a representative conceptual yield for this option at the time of 2012 LRWRP analysis, it was assumed that up to 10,000 AFY would be available to the City of San Diego.

Advantages

- **Local Water Source/Reliability**. Ocean desalination is a locally developed water source, reducing reliance on imported water and protecting against supply vulnerabilities due to droughts and earthquakes.
- **Water Quality**. Ocean desalination offers low salinity product water and can improve blended water quality purchased from the SDCWA.

Disadvantages

- **Energy Intensive**. Because the desalination treatment process is very energy intensive, there would be no significant reduction in the carbon footprint of water production.
- **Environmental Impacts/Permitting**. While ocean desalination is a locally developed water source that can reduce the environmental impacts associated with imported water in the Sacramento-San Joaquin Delta, it poses a number of environmental impacts and permitting challenges locally. Implementation requires environmental review of ocean aquatic habitat impact to determine the impacts of brine discharge and intake facilities. The Carlsbad Desalination Project has received all required permitting and clearances, but other ocean desalination opportunities the SDCWA is considering have yet to go through the permitting/regulatory process.
- **Costs**. Costs for construction, operation, and maintenance of desalination facilities have decreased since the technology was first implemented, but remain significantly higher than other water supply options. In addition, there will be added costs associated with SDCWA transportation and administration although water could be delivered through existing infrastructure to the City.

References

- CDM, 2011. City of Pasadena Water Integrated Resources Plan, January 2011.
- San Diego County Water Authority, 2011. 2010 Urban Water Management Plan. June 2011.
- San Diego County Water Authority Board letter dated June 15, 2011. “Approval of guiding principles for member agency purchases of potential Water Authority-owned local water supplies from the Carlsbad Desalination Project and corresponding revisions to the Local Supply Conveyance and Exchange Policy.”
- SDCWA July 12, 2012 Special Board of Director’s Meeting Presentation on Incorporating Carlsbad Seawater Desalination Project into SDCWA Rates and Charges.

Recycled Water – Non-Potable Reuse

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

Recycled water is wastewater that has undergone additional treatment in order for it to be suitable for a range of beneficial uses. Recycled water that has undergone tertiary treatment can be safely used for many non-potable applications, including landscape irrigation (e.g., golf course, parks, roadway medians, and cemeteries), industrial cooling towers, toilet flushing, and wetlands restoration. Tertiary-treated recycled water is also known as Title 22 water as defined by the California Title 22 Standards (Title 22, Division, 4, Chapter 3, 4 of the California Code of Regulations), regulated by the California Department of Public Health.

The City operates a non-potable recycled water system comprised of two service areas – the Northern Service Area and the Southern Service Area. The Northern Service Area is supplied with recycled water from the North City Water Reclamation Plant (NCWRP). As of June 2012, the Northern Service Area consists of 80 miles of pipeline within San Diego, distributing recycled water to retail customers in the City and two wholesale customers: the City of Poway and the Olivenhain Municipal Water District.

The Southern Service Area is supplied non-potable recycled water by the South Bay Water Reclamation Plant (SBWRP). The conveyance system includes 3.12 miles of pipeline that distributes recycled water to the City's retail customers and the Otay Water District, a wholesale customer. Figure 1 displays the Northern and Southern Service Areas, which includes 551 retail water meters as of June 2012. The majority of recycled water customers use the water for irrigation purposes.

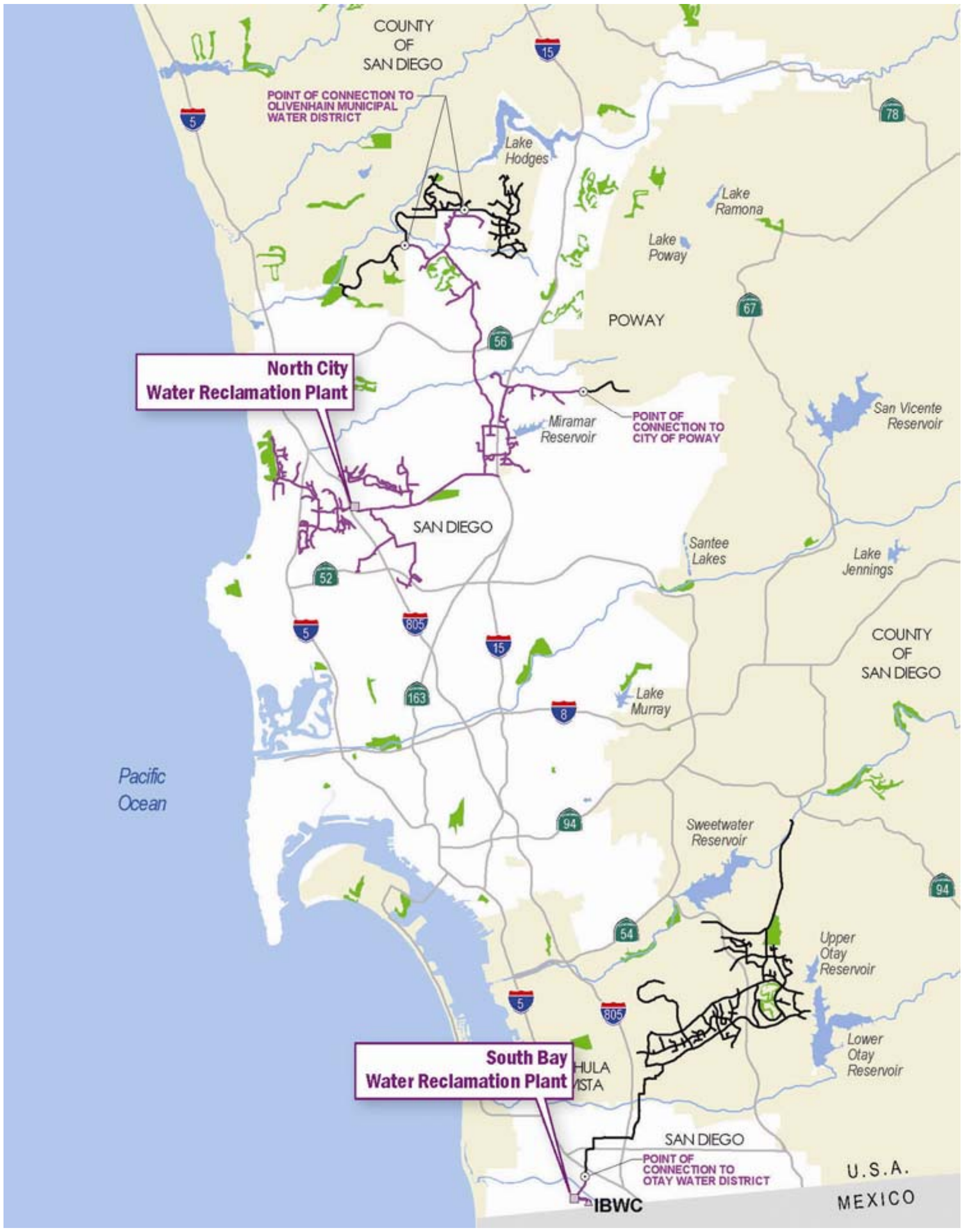

Figure 1. Non-potable Recycled Water System

Recycled Water – Non-Potable Reuse

The City has completed its 2010 Recycled Water Master Plan (RWMP) Update (master plan); the master plan is updated every five years to comply with the City's Water Reclamation Ordinance (64.0806 SDMC).

Typical signage indicating non-potable recycled water in use

For improved efficiencies, the 2010 RWMP Update was included as a component of the larger scale Recycled Water Study (Study); the master plan's market assessment serving as the foundation for non-potable demands in that Study. The market assessment summarized the potential non-residential, non-potable demands that exist within the City as well as from neighboring water agencies. The researchers used data collected from a variety of sources including: potable water irrigation meter records, industrial waste discharge data to identify potential cooling tower customers, phone surveys conducted with commercial and industrial customers who use large quantities of water for non-potable purposes, and surveys completed by water agencies to determine potential wholesale demands. The aggregate data was then incorporated into location demand and recycled water density map.

The main focus of the 2010 RWMP Update was to evaluate opportunities to maximize non-potable reuse if projects identified in the Study are not pursued. The Study will provide recommendations to maximize indirect potable reuse options with some additional non-potable reuse in order to reduce effluent flows to the Point Loma Wastewater Treatment Plant and maximize recycling.

The 2010 RWMP Update describes the existing recycled water system and near-term expansions (through 2015) and identifies conceptual long-term non-potable reuse expansion concepts. In the 2010 RWMP Update, the baseline recycled water system is defined as existing (2010) facilities and demands, as well as any planned expansions of the distribution system through 2015. With a long-range focus, the already planned near-term expansions of pipelines and additional customers are considered part of the baseline system.

By 2015, total baseline citywide retail and wholesale projected recycled water demands are estimated at 15.1 million gallons per day (MGD); of which, 9.1 mgd is from the NCWRP (with 81 percent of the demands from retail customers or plant use, and the remainder from wholesale customers). For SBWRP, the 6.0 mgd is comprised of about 13 percent from retail customers or plant use, with the remaining 87 percent from Otay Water District (a wholesale customer). Note that baseline demands are projections, and actual demands can vary. The majority of the increased demand by 2015 will be in the Northern Service Area and come from new customer connections in close proximity to the existing infrastructure as well as completion of Phase II pipeline projects. Phase II expansion, defined in the 2000 and 2005 Recycled Water Master Plan Updates, extends the distribution system along the Hwy 56 corridor from Rancho Peñasquitos to Carmel Valley.

North City Water Reclamation Plant

South Bay Water Reclamation Plant

Recycled Water – Non-Potable Reuse

If the projects identified in the Recycled Water Study are not pursued, the following alternative long-term non-potable reuse concepts are considered in the 2012 LRWRP as representative concepts from the 2010 RWMP Update. These options could be stand-alone or combined, as they do not serve the same non-potable demands:

1) **Supply from NCWRP.** Use existing capacity of the NCWRP to serve additional retail recycled water customers (primarily infill customers) through an expanded distribution system. Note that indirect potable reuse, a separate option evaluated in the Long-Range Water Resources Plan, also uses the existing water reclamation plant capacity. Therefore, this option cannot be combined with indirect potable reuse.
2) **Supply from Satellite Plants**. Construct new satellite plants at sanitary sewer interceptors to produce additional local recycled water supply for nearby retail customers. Three satellite plants are sited for this option: Balboa Park, Qualcomm Stadium, and Rancho Bernardo/I-15 Corridor. Satellite plants do not conflict with an indirect potable reuse option.

Yield

1) **Supply from NCWRP.**
   Average annual yield: 2,700 acre-feet per year (AFY);
2) **Supply from Satellite Plants**.
   Yields shown represent average annual yield for each of the three satellite plant locations.
   Balboa Park: Yield: 1,110 AFY
   Qualcomm Stadium: Yield: 1,745 AFY ***(could be a site location conflict with IPR Phase 3)***
   Rancho Bernardo: Yield: 2,620 AFY

Advantages

- **Local water source**. Recycling water creates a reliable, drought-proof local water supply, and reduces reliance on imported water that is subject to environmental restrictions, droughts, and seismic interruption.
- **Helps meet 20x2020 goals**. The Water Conservation Act of 2009 (SB7-7) mandates a 20 percent reduction in urban per capita water use statewide by 2020. Recycled water can be used to help meet this goal.
- **Reduces Ocean Discharges**. Recycled water use reduces wastewater flows to PLWTP and ocean outfall. If water recycling is not maximized to sufficiently offload PLWTP, the City will need to either upgrade PLWTP to secondary treatment to meet federal standards (very expensive), or renew the modification to the National Pollutant Discharge Permit (waiving the requirement for secondary treatment) which is challenging.
- **Grant funding**. Funding for recycled water projects is a state-wide objective; this option may be eligible for both state and federal grant funding.

Disadvantages

- **Costs**. Non-potable reuse has varying levels of cost-effectiveness, and can have high capital costs for distribution system infrastructure. In addition, there would be capital costs to customers/developers for installation of on-site recycled water system and connection to the City's recycled water system; costs vary on a case by case basis.
- **Seasonal demands**. Most recycled water customers use the water for outdoor irrigation demands, which have a seasonal demand curve with significant peaks in the summer (which are about twice the average day demands). Facilities need to be sized to meet peak summertime demands, which results in underutilization of the treatment plants' capacity during other times of the year. If developers build these plants, an agreement with the City is necessary to take sludge and treatment by-products as well as wastewater flows during cooler months when demands are low.
- **Customer Participation.** Requires large-scale voluntary customer participation for successful implementation.

References

City of San Diego Recycled Water Study Report, July 2012.
City of San Diego 2010 Recycled Water Master Plan Update, July 2012.

Recycled Water – Non-Potable Reuse

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Recycled Water – Indirect Potable Reuse

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

Indirect potable reuse (IPR) represents a relatively new approach for maximizing the use of recycled water, whereby recycled water is purified. The term “indirect” refers to the distinction that the purified water is mixed with a natural water (or raw water) source prior to treatment and delivery to customers. The purified recycled water meets rigid state and national water quality standards, and is often of higher quality than the natural water in which it is mixed. The two general categories related to IPR are groundwater recharge and reservoir augmentation. Groundwater recharge involves purifying the water using advanced treatment processes, similar to seawater desalination, and then recharging the groundwater using injection wells or surface spreading. Reservoir augmentation involves a three step process:

1. purifying the water using advanced treatment processes;
2. adding the water to a surface water reservoir located upstream of a drinking water treatment plant; and
3. further treating the water from the reservoir at a downstream drinking water plant before being distribution to customers.

Many communities in the United States and throughout the world are currently practicing or are planning to implement IPR projects. The largest and most well-known project in the world has been implemented just north of San Diego in Orange County, California. The Orange County Groundwater Replenishment System can produce up to 70 million gallons per day (mgd) of highly purified recycled water that serves the water demands of nearly 600,000 residents. The project is currently being expanded to 100 mgd with an anticipated operational start-up in 2014. This system requires less than half the energy needed to pump imported water from northern California to southern California and less than one third of the energy required for desalination of seawater.

In order to assess the feasibility of indirect potable reuse, the City has initiated the Water Purification Demonstration Project, which includes a one-mgd demonstration-scale advanced water purification facility located at the North City Water Reclamation Plant (NCWRP). The Water Purification Demonstration Project is the second phase of a process evaluating ways for the City to increase its use of recycled water. The first phase was the City’s 2005 Water Reuse Study that identified reservoir augmentation as the preferred option for developing recycled water sources. The Water Purification Demonstration Project will determine if reservoir augmentation is a feasible option for San Diego.

Figure 1. The City’s Water Purification Demonstration Project.

Recycled Water – Indirect Potable Reuse

Several full-scale IPR concepts are being evaluated by the City. The following options are representative strategies for indirect potable reuse based on the scale of the project:

- **Phase 1:** This would be the first phase of indirect potable reuse supply development, and involves construction of a 15 mgd advanced water purification facility at the NCWRP. The purified water would augment surface water in the San Vicente Reservoir. Water from the reservoir would be further treated at Alvarado Water Treatment Plant (WTP) prior to delivery to customers.
- **Phase 2:** This includes Phase 1, plus an indirect potable reuse project that involves construction of a 15 mgd advanced water purification facility at the South Bay Water Reclamation Plant (SBWRP). Purified water would augment the Otay Reservoir, and water would further be treated at the Otay WTP.
- **Phase 3:** Maximizes indirect potable reuse by including all projects in Phases 1 and 2, plus an indirect potable reuse project that involves construction of a 53 mgd water purification facility at the north end of San Diego Bay (Harbor Drive). Purified water would be pumped to the San Vicente Reservoir and would be further treated at the Alvarado WTP.

Yield

The indirect potable reuse options create the following new local supply yields:

- **Phase 1**: 15 mgd, or 16,800 acre-feet per year (AFY)
- **Phase 2**: 30 mgd, or 33,600 AFY (total including Phase 1)
- **Phase 3**: 83 mgd - which is approximately 93,000 AFY (total including Phases 1 and 2)

Advantages

- **Local water source**. Recycling water creates a reliable, climate independent and, drought-proof local water supply. It also reduces reliance on imported water that is subject to environmental restrictions, droughts, and seismic interruption.
- **Point Loma Water Treatment Plant (PLWTP) offsets (and reduced ocean discharges).** There are substantial savings to the City if costs can be avoided for PLWTP secondary treatment upgrades and wastewater facilities planned in the City's Wastewater Master Plan. Indirect potable reuse can significantly reduce flows to the PLWTP and ocean outfall, and create a new source of water supply. Indirect potable reuse projects can deliver water at a consistent rate year-round, and fully utilize existing water reclamation treatment capacity that is left over after seasonal non-potable recycled water demands are met.
- **Improved water quality in San Diego**. Salt management is a major water quality consideration for Southern California. The imported water supply, particularly Colorado River water, has high Total Dissolved Solids levels. Indirect potable reuse water would reduce salinity levels in the reservoirs, at homes, and in soils. Local indirect reuse projects could produce water with salinity levels 20 times lower than non-potable recycled water and 10 times lower than the drinking water currently delivered to residences.
- **Grant Funding**. Funding for recycled water projects is a state-wide objective; this option would be eligible for both state and federal grant funding.
- **Helps meet 20x2020 goals**. The Water Conservation Act of 2009 (SB7-7) mandates a 20 percent reduction in urban per capita water use statewide by 2020. Recycled water can be used to help meet this goal.

Disadvantages

- **Public perception**. While historically, some public stakeholders have not been supportive of accepting IPR, great strides have been made in public education and outreach to demonstrate the safety and high water quality from purified recycled water. But for IPR to be successful, continued public outreach, education and information will be needed.
- **Regulatory permitting**. Indirect potable reuse typically requires a more challenging regulatory process than other options, but these regulatory hurdles are not insurmountable. In addition, regulations for IPR are subject to a changing regulatory landscape in the future.
- **Brine**. Advanced treatment processes would produce brine, which would need to be discharged.

References: City of San Diego Recycled Water Study Report, July 2012.

Graywater Reuse (Decentralized On-site Systems)

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

Graywater is wastewater that originates from household fixtures such as showers, bathtubs, clothes washing machines, and bathroom sinks, but does not include fixtures that transport wastewater such as toilets, dishwashers, and kitchen sinks. It is important not to mistake graywater with recycled water, which is subject to multiple treatment steps to make it suitable for a range of beneficial uses.

This option would require retrofits to existing homes to enable on-site graywater recycling. On-site graywater can be collected and used for outdoor non-potable uses such as drip landscape irrigation. Graywater systems are required to meet the acceptable design criteria outlined in *California Graywater Regulations Chapter 16A "Nonpotable Water Reuse Systems;"* however, enforcement of these regulations is administered through the local enforcing agency (City of San Diego Development Services Department). The current regulations allow for the following types of graywater systems:

- **Clothes Washer System:** uses only a single domestic clothes washing machine in a one- or two-family dwelling
- **Simple system:** discharge of 250 gallons per day or less and serves a one- or two- family dwelling
- **Complex system:** discharges over 250 gallons per day

While all three are viable options, only one system is evaluated as a representative graywater option. For this analysis, a "Simple System" graywater collection system is evaluated, where wastewater from the laundry, bath, and shower are combined, filtered, and reused for drip landscape irrigation. See Figure 1 for a schematic of a Simple System.

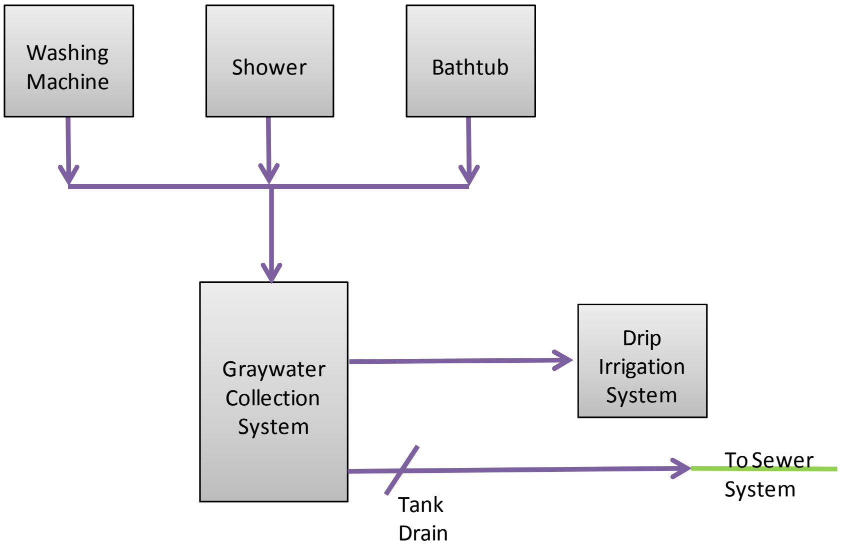

Figure 1: Simple System (Laundry + Bath + Shower)

A Simple System requires construction permits unless exempted by the enforcing agency (City of San Diego).

- **Irrigation field:** All graywater systems used for irrigation require a designated irrigation field. The irrigation field may include a drip irrigation system, a mulch basin, or any other approved method for dispersal of graywater.
- **Piping/plumbing:** For health reasons, graywater must have separate piping, valves, and other system components from potable water systems as regulated by the Uniform Plumbing Code (UPC). Provisions should also be provided for disposal of excess/unused graywater into the sewer system.
- **Drip irrigation / Subsurface system:** To mitigate contact to microbial in graywater, regulations require that graywater systems avoid breaching the land surface or becoming airborne. Thus, graywater is currently restricted to subsurface applications through drip irrigation emitters and non-clogging nozzles or in mulch basins.
- **Storage Tank (optional):** Storage tanks help to store graywater to be used at a later time. If storage is provided, regulations require that the graywater is not stored for more than 24 hours. Clear labeling as a non-potable water storage tank is required. Storage tank design should also ensure zero spills or overflows. If graywater is only used for irrigation, storage may be eliminated.

Graywater Reuse (Decentralized On-site Systems)

Key Assumptions

- Approximately 40% of single-family residential indoor water use becomes available as graywater supply (via clothes washing, shower, bathtub wastewater).
- On-site outdoor demands are sufficient to utilize graywater supply via drip irrigation.

Yield

Assuming 50,000 homes participate, annual water supply yield would be 2,575 AFY (46 gallons per household per day)

Advantages

- **Offset to Wastewater System.** Graywater systems can reduce wastewater collected by the municipal wastewater system. While some parts of the service area could offload wastewater to Point Loma wastewater treatment plant, other areas may reduce wastewater used to produce recycled water.
- **Green Technology**. Considered a "green" technology with low energy requirements.
- **Local Water Source**. This is a local water source and can reduce demand of imported water. This source is also relatively drought-resistant.
- **State funding**. May be eligible for state grant funding.

Disadvantages

- **Water Quality**. Graywater reused for outdoor water use is untreated wastewater with a lower concentration of bacteria than most other raw wastewater sources. Although no technology is potentially risk-free, the public health risk associated with graywater is a lot higher than municipally treated recycled water since water quality of graywater isn't monitored. Table 1 summarizes the typical bacteria concentration of different water treatment levels.

Table 1: Bacteria Concentration in Water

Type of Water	Coliforms/100 ml
Drinking water	<1
Disinfected Tertiary Recycled water	<2.2
Graywater	100 to 100 million
Raw Wastewater	Millions to billions

* Source: White paper on Graywater by Bahman Sheikh

- **Maintenance**. The success of graywater systems is highly dependent on customer behavior. Some residents may not wish to install a graywater system due to plumbing modifications. And customers would be fully responsible for maintenance of the system, which may or may not be done properly.
- **Liability**. Because graywater has not been widely used previously, code standards are still evolving to reduce potential health risks. There is little data available for applications in California and there is some risk for the City to support a system-wide graywater program.
- **Costs**. Installation of graywater systems have high cost per unit supply compared to some options. This option would involve capital costs to customers/developers.
- **Environmental Impacts**. According to regulations, the absence of groundwater in a test hole 3 feet (ft) below the deepest irrigation or disposal point is sufficient to satisfy the use of graywater systems, unless seasonal high groundwater levels have been documented. However, further investigation is necessary to determine potential adverse impacts to soils prior to installation of graywater systems. The chemicals in graywater applied to soils may alter biological, chemical, and physical properties of the soil. The effects of graywater chemicals in soils during irrigation, and their degradation products, are not clear.

References

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Rainwater Harvesting – On-site Capture

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

Rainwater in urban areas, also referred to as stormwater or urban runoff, is currently routed to a storm drain pipe network and discharged to streams and flood control channels that lead to the ocean. Typically, this stormwater carries with it pollutants and trash that have been picked up along parking lots, streets, and other impervious surfaces. Harvesting rainwater for water supply would improve receiving water quality by reducing the transport of pollutants to the bays and ocean.

The City's Storm WaterDivision is responsible for stormwater management and compliance responsibilities. Responsibilities include implementing education programs, enforcing storm water ordinances established to reduce pollutant discharges to the storm drain system, and implementation of non-structural and structural stormwater best management practices (BMPs) to reduce pollutants in stormwater discharges in order to comply with the Municipal Storm Water Permit (National Pollutant Discharge Elimination System Permit No. R9-2007-0001) issued by the San Diego Regional Water Quality Control Board, and Total Maximum Daily Load (TMDL) regulations that protect receiving waters (local streams and ocean). In some cases, reducing the volume of stormwater runoff is a design objective of some stormwater compliance strategies. In those instances, BMPs that are designed to reduce stormwater runoff volumes may also present opportunities to harvest rainwater for water supply purposes. Cisterns and rain barrels can be installed to capture runoff from rooftops or parking lots for use in non-potable water demands, such as irrigation. Residential properties tend to install rain barrels at the end of downspouts (refer to Figure 1ύ, while businesses can have storage tanks installed above-ground or buried that capture volume from larger rooftops or parking lots (refer to Figure 2). While these storage options provide for additional water supply, they also reduce stormwater going into receiving waters and thus have a water quality benefit as well.

Figure 1. Rain barrel on a residential property

Figure 2. Large cistern on a commercial property

Rainwater Harvesting – On-site Capture

Note that there are many other stormwater options that offer water quality benefits, such as bioswales and permeable pavement. These options allow stormwater to infiltrate into soils, reducing runoff into receiving waters. However, because of the hydrogeology of urban San Diego (e.g., location and permeability of local groundwater) these options do not have significant supply benefits as very little of the infiltrated water makes its way to local groundwater.

During the development of the 2012 LRWRP, the City initiated a rainwater harvesting program as a tool to raise public awareness of water issues, promote customer responsibility, and reduce imported water use. The 2012 LRWRP evaluates rain barrels and cisterns as a supply option against other options available to SDPUD.

Yield

- **Residential rain barrels**
  Storage: 200 gallons each; Supply yield: 356 AFY assuming 50,000 single-family homes participate
- **Commercial Cisterns**
  Storage: 2,500 gallons each; Supply yield: 60 AFY assuming 3,800 non-residential units participate

Advantages

- **Water Quality**. Reduces stormwater and pollutant discharges to streams and ocean, and helps achieve TMDL regulatory compliance.
- **Green Technology**. This option is considered a “green” technology with low energy requirements.
- **State funding**. This project would be eligible for state grant funding.
- **Local Water Source**. This is a local water source and can reduce demand of imported water.

Disadvantages

- **Reliability.** This option does little to improve reliability during extended droughts and drier summer months.
- **Cost.** This option would involve a capital cost to homeowners and businesses for installation for the stormwater capture device. While the cost per device for this option is low, the cost per unit of supply is relatively expensive compared with other supply options.
- **Maintenance**. Customers would be fully responsible for maintenance of the rain barrels and cisterns, which may or may not be done properly. Water must be used to allow for capture in the next rain event and retain supply benefits.
- **Customer Participation.** Requires large-scale voluntary customer participation and behavioral changes for successful implementation.

References

http://www.ecogardening.com
www.watertanks.com

Rainwater Harvesting – Centralized Capture

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), conceptual options were developed using best available information from previous and on-going studies by the city of San Diego (City) and other entities. Because the LRWRP and many of these other studies were prepared in parallel, and because some of these other studies have since been updated, some cost and yield information will be different in final reports. When this is the case, however, the cost and yield information used in the 2012 LRWRP analyses are still within acceptable planning-level ranges. The information presented here is used for high-level strategic planning and should not be mistaken for detailed estimates or misconstrued as final configurations or commitments by San Diego Public Utilities Department (SDPUD) or the City.

Brief Description

The existing local surface water reservoirs operated by the San Diego Public Utilities Department (SDPUD) captures local rainwater and runoff from watersheds covering more than 900 square miles in eastern areas of the city where average annual rainfall is over twice the amount along the coast. Local runoff is captured and stored in nine reservoirs with more than 408,000 acre-feet (AF) of capacity available for use by the City of San Diego (City)[1]. This reservoir system operates in combination with the imported water system, and is a major asset to the City in providing reliability in emergency conditions and for balancing seasonal and cyclical variations in water supply and demands.

While SDPUD is capturing rainwater for supply purposes in eastern areas of the city where average annual rainfall is higher, the rainfall in urbanized areas near the coast (also referred to as stormwater or urban runoff) is currently routed to a storm drain pipe network and discharged to streams and flood control channels that lead to the ocean. Typically, this stormwater carries with it pollutants and trash that have been picked up along parking lots, streets, and other impervious surfaces.

The City Storm Water Division is responsible for stormwater management and compliance responsibilities. Responsibilities include implementing education programs, enforcing storm water ordinances established to reduce pollutant discharges to the storm drain system, and implementation of non-structural and structural storm water best management practices (BMPs) to reduce pollutants in storm water discharges in order to comply with the Municipal Storm Water Permit (National Pollutant Discharge Elimination System Permit No. R9-2007-0001) issued by the San Diego Regional Water Quality Control Board, and Total Maximum Daily Load (TMDL) regulations that protect receiving waters (local streams and ocean). In some cases, reducing the volume of stormwater runoff is a design objective of some stormwater compliance strategies. In those instances, BMPs that are designed to reduce stormwater runoff volumes may also present opportunities to harvest rainwater for water supply purposes.

The centralized stormwater option involves construction of a diversion at an existing storm drain network or channel to capture stormwater for use as a water supply, either by using the water for groundwater recharge or for non-potable demands. An ideal location to set up a diversion structure is at a centralized location for runoff with a large tributary area and a location with space available for water storage. As a representative location for a centralized stormwater capture option, the City provided daily stormwater monitoring data for Chollas Creek[2] (Gage MAC 11) from November 1, 2009 to January 31, 2010, which is plotted in Figure 1.

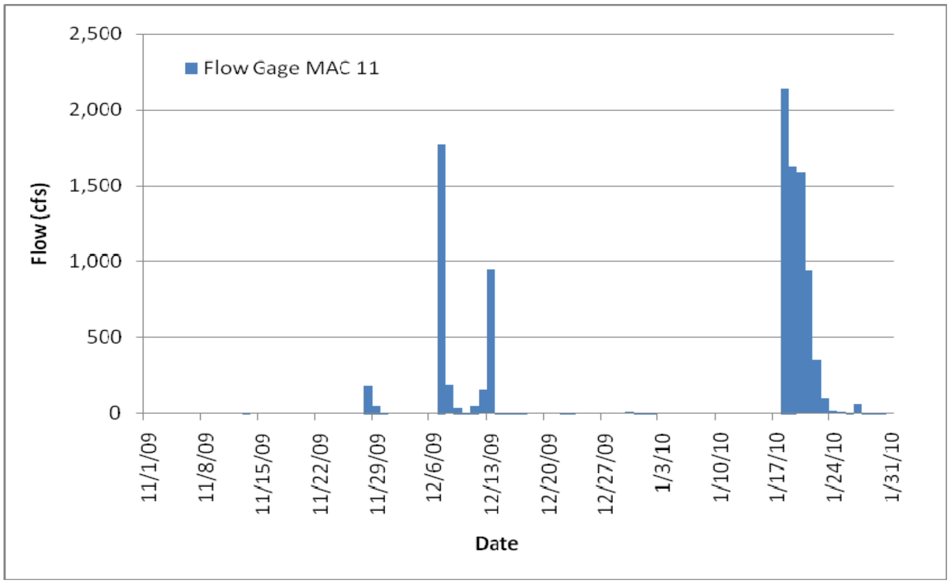

Figure 1. Recorded flows for MAC 11

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[1] Includes 89,312 AF of storage in San Vicente Reservoir. The reservoir expansion to 242,000 AF will be completed in 2013.

[2] Note that diverting water from Chollas Creek may not assist the City in achieving TMDL requirements for Chollas Creek, since attainment of pollutants is required prior to discharging into Chollas Creek or its tributaries. However, this type of representative concept could improve downstream water quality (in bays or ocean).

Rainwater Harvesting – Centralized Capture

The data in Figure 1 shows two key factors that affect the yield and cost of this option: 1) there are no dry-weather base flows in the creek, and 2) storm events have high flows but are infrequent. Dry-weather flows (typically originating as runoff from irrigated landscaping) make a centralized stormwater capture option more cost-effective since the flows are constant and year-round. Without dry-weather flows, a large volume of water must be captured during wet weather events. If these events are very infrequent, a significant amount of storage would be required to maximize the amount of flow captured. Using centralized stormwater for irrigation demands presents additional challenges, as rain events and stormwater flows typically occur in the winter months, while outdoor irrigation demands are typically higher in the summer months. When significant storage is required, this option becomes less cost-effective in urbanized areas.

Due to the seasonality of outdoor irrigation demand, it is sometimes more cost-effective to route the stormwater to spreading basins for recharge to an underlying groundwater basin. In this case, however, the area near the stormwater capture location at Chollas Creek overlies San Diego Formation groundwater basin. Due to a variety of complex issues, including land availability, new injection wells would be required to recharge the stormwater to the groundwater aquifer which could be cost-prohibitive.

Given these constraints with groundwater storage, this concept proposes to divert stormwater to a storage tank and use for outdoor irrigation. For this option concept, the runoff would be diverted from storm drains discharging into Chollas Creek and stored during wet weather events. Water could then be treated and conveyed to nearby demands for irrigation use.

With very limited flow data available to analyze this option, gross assumptions were made to estimate an annual yield. Based on precipitation data at the NCDC Lindbergh Field weather station, approximately 46 percent of annual rainfall occurred during the recorded timeframe for the 15-minute interval MAC 11 flow data. Therefore, it is assumed that supply captured during the period of recorded for MAC 11 data would produce 46 percent of the annual supply yield.

In order to capture stormwater and supply approximately 100 AFY to irrigation demands, two pump stations would be needed; the first would have 1.1 million gallons per day (mgd), 20 horsepower (HP) capacity to transfer water from Chollas Creek to a 20 AF storage unit, and a second would have a 0.2 mgd, 10 HP capacity to transfer water from the storage unit to treatment, and eventually to the irrigation demands. This option assumes a 0.2 mgd ultraviolet disinfection facility is needed to treat the water is before irrigation use.

Yield

- **Average supply yield**
  100 acre-feet per year (AFY) assumed
  The yield for this option depends on hydrologic conditions and is highly variable on a seasonal and annual basis. Based on facilities sized for this option, is assumed that approximately 100 AFY could be captured in a normal year, which may only occur 40-50 percent of the time. Note that more supply is available in the creek, but would require storage greater than 20 AF for capture and use, which may infeasible due to cost and site constraints.

  Limited flow data at MAC11 was available at the time of this analysis. Further analysis of facility requirements is recommended as more data becomes available.

Advantages

- **Local Water Source**. This is a local water source and can reduce demand of imported water.
- **Water quality**. Depending on channel conditions, may improve downstream water quality in bays or ocean through reducing pollutant loading
- **Grant funding**. This project would be eligible for state grant funding.

Disadvantages

- **Reliability.** This option is dependent on local hydrologic conditions and does little to improve reliability during extended droughts. Onsite capture and reuse is only maximized during months with sufficient rainfall (usually winter).
- **Cost.** Limited cost-effectiveness for supply purposes due to lack of dry weather flows and lack of opportunities for surface recharge to underlying groundwater basins.

Appendix B Simulation Model Overview

Appendix B

Simulation Model Overview

The City of San Diego Public Utilities Department (SDPUD) water system consists of complex and dynamic sources of supply and interdependence among the sources. To simulate the use of existing sources of supply and facilitate decisions on future supply options, the SDPUD's water resources systems model was used as the main tool for evaluating system performance. The systems model is programmed using STELLA, developed by Isee Systems, Inc.. This modeling platform was selected because of its flexible and relatively simple programming environment. In addition, the STELLA software was selected because it provides graphical interfaces that create an engaging virtual environment, increasing the ability of technical staff to share their understanding of the system with decision-makers and stakeholders. CDM Smith customized STELLA to create the San Diego Simulation (SDSIM) model.

This tool is appropriate for strategic level decision-making, with the ability to look at comprehensive systems in an integrated manner. Systems models combine natural, physical, and social systems to help decision-makers understand impacts and trade-offs. Systems simulation models are also dynamic, meaning they can evaluate parameters through time. Such dynamic evaluation is crucial for long-term water resources planning.

SDSIM was developed for the 2002 Long-Range Water Resources Plan (LRWRP) and has been updated several times to incorporate new parameters. Major updates to the SDSIM model (Version 4) for the 2012 LRWRP include:

- Updated demand projections
- Updated imported water availability and costs
- Updated existing system components to reflect recent and planned near-term improvements (use of Lake Hodges, emergency storage requirements, raw water conveyance capacity, treatment capacity, costs)
- Updated supply option information (costs, yields, etc.) and added new supply options not previously evaluated, including indirect potable reuse, graywater, and rainwater harvesting
- Updated performance measures calculated by the model; this included addition of several new performance measures including greenhouse gas emissions, potential for job creation, reduction in stormwater and wastewater discharges, etc.
- Added functionality to evaluate climate change impacts

This appendix describes the modeling objectives, model components of the physical water system, performance measures calculated by the model, and the simulation process.

B.1 SDSIM Model Purpose

The systems model was developed to (1) represent the physical water delivery system for the SDPUD; (2) simulate the operations of existing and future water supplies under different hydrological conditions in order to meet current and projected demands; and (3) provide “raw” performance scores for each portfolio in achieving the stated planning objectives.

The model development process included: (1) depicting the SDPUD’s water supply system, including reservoirs, major conveyance, and treatment capacity; (2) defining the water supply options to include in the model; (3) defining the outputs required; (4) identifying the general relationships between the water supply options and the components within each option; (5) developing a conceptual model; (6) collecting data and defining the response functions; (7) programming, and (8) performing a testing protocol.

The planning horizon for the systems model is the year 2035, and the simulation time step is specified as one month. Therefore, all units of water flows are in acre-feet per month. The model operates as a sequential time series with increasing demands over time from 2010 to 2035.

B.2 Physical System

The City of San Diego (City) divides its overall service area into three service areas: Miramar Service Area (MSA), including all the north area of the City; the Alvarado Service Area (ASA), from approximately the Mission Bay and Mission Valley area and Interstate 8, south to the limits with National City; and the Otay Service Area (OSA) serving the area south of Chula Vista to the U.S.-Mexico border.

Each service area is relatively independent from the others in terms of the treated water distribution systems, although some interconnectivity exists. Raw imported water and treated imported water can be delivered to each of the service areas, through the San Diego County Water Authority (SDCWA) aqueducts. Each service area has a water treatment plant: the Miramar Treatment Plant (MTP), the Otay Treatment Plant (OTP), and the Alvarado Treatment Plant (ATP), which treat raw imported water and local runoff from the City’s reservoirs.

Local reservoirs include Sutherland, San Vicente and El Capitan supplying raw water to the Alvarado Treatment Plant; Morena, Barrett and Lower Otay, supplying raw water to the Otay Treatment Plant; Miramar Lake and Lake Hodges supplying raw water to the Miramar Treatment Plant; and Lake Murray supplying water to the Alvarado Treatment Plant. Refer to Section 3 of the 2012 LRWRP for locations of reservoirs and treatment plants.

The City’s reservoirs are connected through a series of pipelines and streams. Sutherland is upstream of San Vicente, and the reservoirs are connected through a pipeline. Similarly, the El Monte pipeline connects San Vicente to the Alvarado Treatment Plant, and the El Capital pipeline connects the El Capitan Reservoir to the El Monte Pipeline, upstream of the Alvarado Treatment Plant. In the Otay system, Morena Reservoir feeds Barrett Reservoir through the Cottonwood Creek, and Barrett is connected to Lower Otay through the Dulzura Conduit.

To accomplish the geographic representation of the City’s sources and facilities in the SDSIM model, the system was divided into the City’s three service areas. The model did not go beyond the service area scale (i.e., the distribution system was not included in the SDSIM model). Demands and supply were analyzed at the service-area scale, and the imported water system, and SDCWA aqueduct, were represented as sources of raw and treated water to each one of the service areas, to mimic the actual system operation.

Reservoirs, pipelines, creeks and treatment plants were represented in the model using the elements of the systems dynamics software:

- Stocks: Used to represent elements that can accumulate over time
- Flows: Used to represent elements that feed or drain stocks, and elements that can be represented as rates
- Converters: Used to establish more detailed mathematical relationships between stocks and flows, introducing constants or exogenous variables (variables that are not affected by the model and serve as inputs)

In general, the SDSIM model used stocks to represent the City's reservoirs and groundwater basins, as they are essentially (or could be) used for storing water and releasing water to satisfy demand. Flows were used to represent pipelines, streams, wells and treatment plants (including desalination plants), because these elements are relevant to the system in terms of the volumes of water that they handle per unit of time (i.e., millions of gallons treated per day, cubic feet of water conveyed per second, etc.). Flows, however, were needed in the model to represent a great variety of water flows intrinsic to the system, not related to the City's facilities. Examples of such flows are the water losses in conveying water from one reservoir to another through a creek, and the evaporative losses at a reservoir.

Figure B-1 shows a screen capture of the SDSIM model, with the representation of the El Capitan Reservoir system. As Figure B-1 shows, stocks are storage elements with several inflows and outflows, that in some cases represent actual facilities (such as El Capitan Pipeline), natural flows (runoff or overflows to a stream), or water losses.

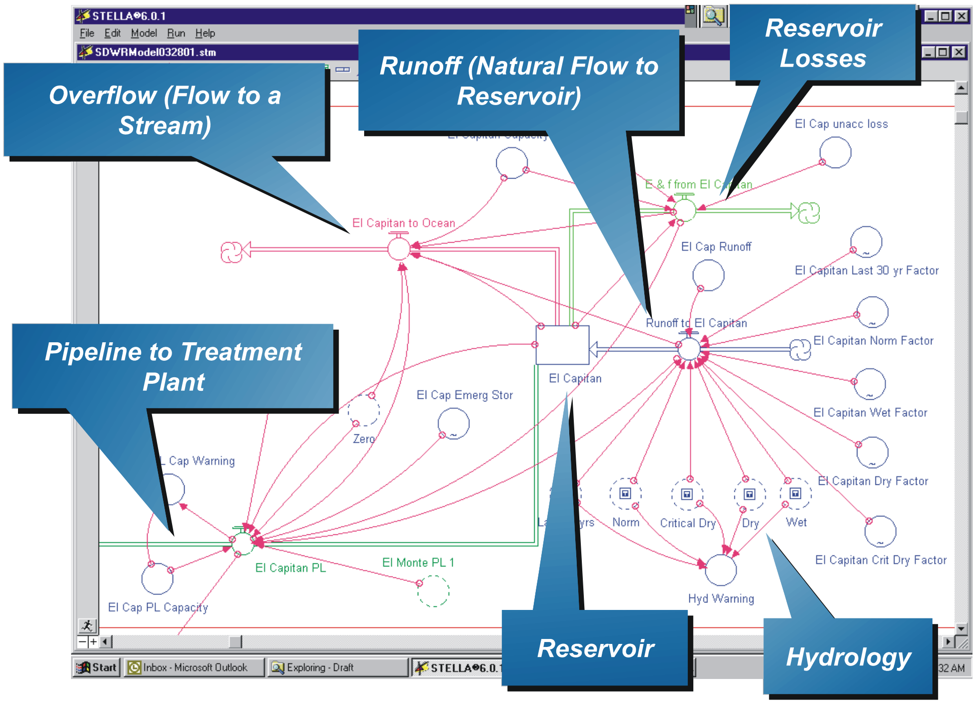

Figure B-1
Model Representation of a Reservoir

B.2.1 Surface Reservoir Operations

The SDSIM model assumes that the City will continue to maximize the supply yield from its surface reservoirs, as it is one of the lowest-cost supply options available. The water entering the reservoir by natural runoff was modeled as a function of the type of hydrology year (wet, normal, dry, or critically dry). Each year in a simulation has a given amount of runoff, depending on the hydrology.

Reservoir capacity was determined from City records, and the total capacity was divided into dead storage, emergency storage, and available storage for supply yield. Dead storage was also obtained from City's records for each reservoir. Emergency storage is required to meet the City's emergency storage policy. The emergency storage City Council Policy 400-4 establishes that enough water must remain in storage for emergency conditions, to be able to meet a demand equal to six tenths of a year. Available storage for supply represents the difference between total capacity (constant), dead storage (constant) and emergency storage (variable over time).

In addition to emergency storage and dead storage, the available storage was corrected for losses due to evaporation and infiltration. These losses were specific for each reservoir and based on the City's historical records. A function was estimated that allowed the model to calculate evaporative losses every year, as a function of the water level in the reservoir.

The model calculated reservoir storage for every year during the simulation, and used a mass balance to determine spillover based on inflows, outflows, and the capacity of the reservoir. The main outflow for the City's reservoirs was the actual draft as a function of demand in a given service area. Another constraint for the use of water from city reservoirs was the capacity of the pipeline conveying the surface water to the treatment plant. The model established the capacity of the conveyance as a constraint, and kept track of the times that the capacity of the pipe was the limiting factor for local runoff use.

Lake Miramar and Lake Hodges were assumed to be in-line with the Miramar Water Treatment Plant. Sutherland, San Vicente, Murray and El Capitan reservoirs were assumed to be in-line with the Alvarado Treatment Plant, Morena, Barrett, and Lower Otay reservoirs were assumed to be in-line with the Otay Treatment Plant.

B.2.2 Water Supply Options

The overall operational assumption for the model is that local supply options meet demands first, and remaining supply needs are met by imported water. Imported water is the default supply source after all other resources have been utilized. The following categories of options (existing and new) are included in the SDSIM model for the 2012 LRWRP:

- Conservation
- Local Reservoir Supply
- Groundwater
- Recycled Water for Non-potable Use
- Recycled Water for Indirect Potable Use
- Graywater

- Rainwater Harvesting
- Ocean Desalination
- Imported Water Purchases from SDCWA

These options are further described in Section 4 and Appendix A. Water supplies flows in the model followed the conceptual representation depicted in Figure B-2.

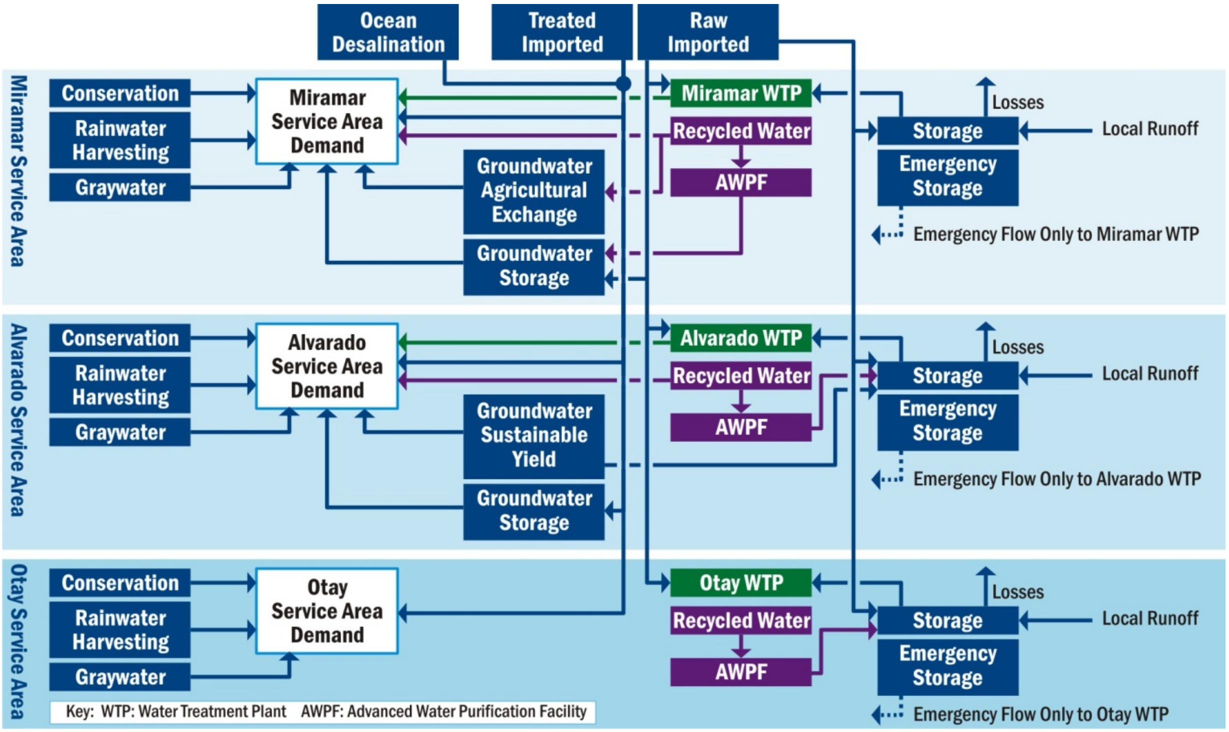

Figure B-2
Conceptual Model Flow Chart

B.2.3 Hydrology and Weather

Modeling hydrology requires addressing several difficulties. One of the most common problems in modeling a water supply and delivery system is the use of averages for the representation of inherently probabilistic variables, such as precipitation. Another hurdle to be overcome is that what typically drives water demands upward (warm, dry weather), also drives supply downward. Finally, hydrology in northern California and Colorado River basin (where the City's imported supplies originates) is not always correlated to hydrology in San Diego County (where local runoff originates). To avoid these problems, simulations of water demand and various supplies were modeled using available historical hydrology records from 1922 to 1998, indexed sequentially for all points of origin of the City's water supply. These records were used to generate demand and supply factors that were applied to long-term averages in order to estimate the variability in demand and supply under different hydrological conditions.

Weather factors for water demand were obtained from the Metropolitan Water District of Southern California (MWD), which developed them statistically for their long-term planning efforts. These demand factors were shared with and reviewed by the SDCWA in previous studies. These factors (shown in Figure B-3) were applied to "normal" weather water demand projections in the City of San Diego's *2010 Update to the Long-term Water Demand Forecast*. These same factors were also applied to water conservation, as dry weather not only affects demand, but also how much conservation occurs. Demands are typically higher in a dry, hot year (represented by a factor greater than 1.0 in Figure B-2) and lower in wet, cool year (represented by a factor less than 1.0 in Figure B-2).

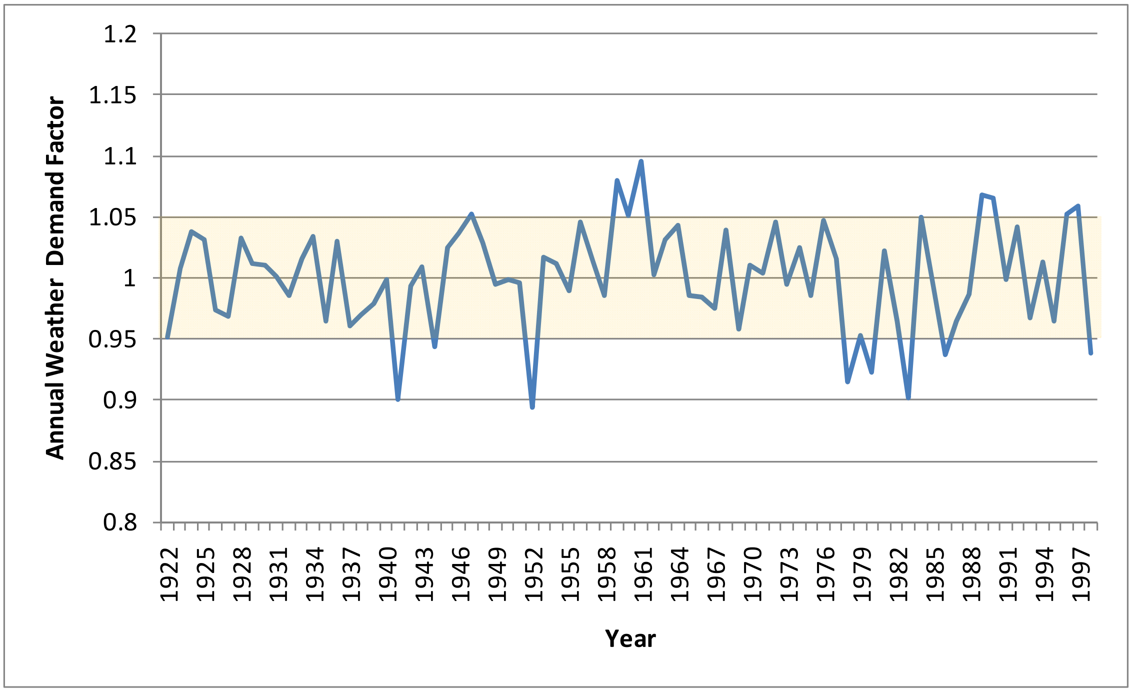

Figure B-3
Annual Weather Demand Factors

Imported water from the SDCWA and MWD is one of the most variable supplies. This variation is mainly due to hydrology in northern California. The imported water from the Colorado River is tempered by the massive storage of the system, which is over 10 times the storage on the State Water Project. Projected annual imported water shortages under varying hydrologic conditions from 1922-2004 (which extends beyond the SDSIM model hydrologic period of 1922-1998) were provided by MWD for the forecast period from 2010 to 2035[1]. These projected shortages were used to determine the amount of imported water supply available to the City, by applying the MWD percent shortage to the City's baseline imported water demand. Note that the SDCWA is pursuing additional sources of water that would help to offset these shortages (refer to Section 3 of the 2012 LRWRP report for assumed SDCWA supplies).

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[1] Provided to the City by Grace Chan (MWD) on August 10, 2012. Data is based on IRPSIM model output developed for MWD's 2010 Integrated Resources Plan.

In addition to demand and imported water, local runoff was also modeled using historical hydrology. Local runoff records to each reservoir were used as input to the model, based on the year sequence corresponding to each hydrology. A monthly runoff factor was applied to the average runoff for the period 1922 to 1998, resulting in the actual runoff observed in a given month. Thus, if a simulation included hydrology conditions for the years 1947, 1948, and 1949, all reservoirs were applied factors that resulted in a runoff equal to the recorded runoff for those specific years. Figure B-4 shows actual runoff records from Morena Reservoir from 1922 to 1998, as an example of the data used for every reservoir in the SDSIM model.

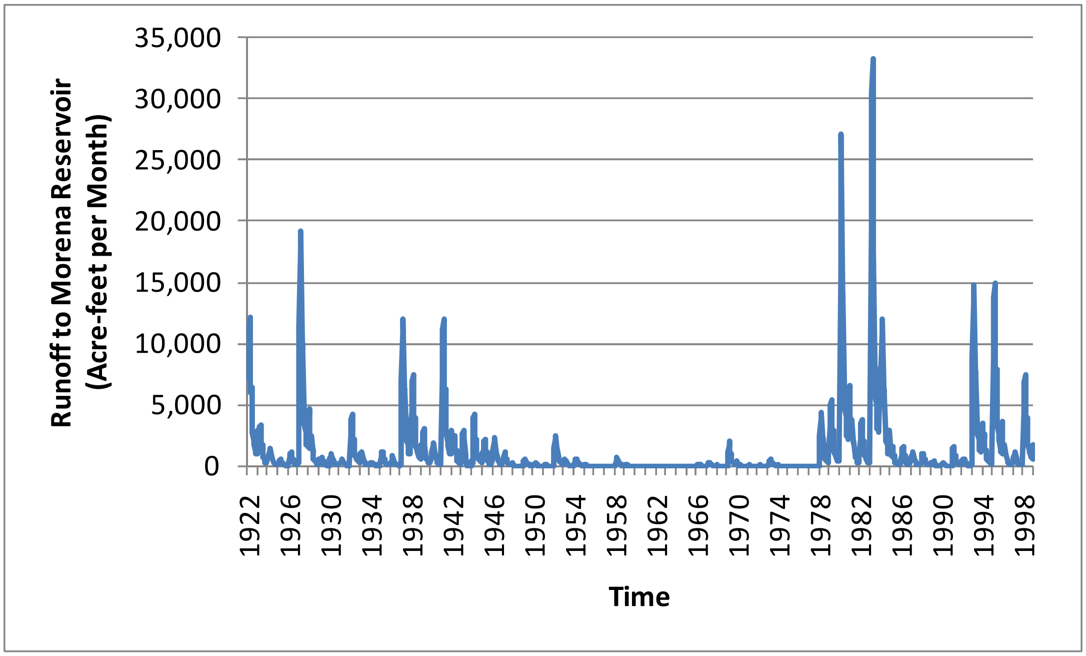

Figure B-4
Actual Runoff Records for Morena Reservoir

For the purposes of modeling and evaluation, four 30-year hydrologic traces were developed: (1) critically dry; (2) dry; (3) normal; and (4) wet. These four traces represented the most likely weather scenarios that the City could face. To determine the specific hydrologic years that went into each of these 26-year traces (from 2010 to 2035), cumulative hydrologic water supplies were generated. The cumulative supplies were generated by comparing local runoff and imported supplies for each hydrological year from 1922 to 1998. Those 26-year sequences with the lowest cumulative supply represented the critically dry hydrologies. It should be noted that not all the years included in the critically dry hydrology trace were dry, just that the cumulative sequence produced the lowest overall supply. Table B-1 presents the selection of the representative hydrologies used in the SDSIM model.

Table B-1
Selected Traces for Four Represented Hydrologic Scenarios

Hydrologic Scenario	Hydrologic Years Included in Trace	30-Year Cumulative Supply	Cumulative Probability
Critically Dry	1986-1998/ 1922-1934[1]	7,736,386 AF	3%
Dry	1966-1991	7,800,511 AF	21%
Normal	1957-1982	8,028,701 AF	51%
Wet	1937-1962	8,141,005 AF	84%

[1] Trace starts with 1986-1998, then wraps around and begins again using 1922-1934 data.

B.2.4 Water Demands

Projected average annual demands were included in the model for the planning horizon between 2010 and 2035. The demands are based on the City of San Diego 2010 Update to the Long-term Water Demand Forecast (2010 Demand Forecast) , which categorizes demands based on each of the three major service areas tracked in the systems model: Miramar, Alvarado, and Otay. The demand forecast also includes crossover areas served by more than one treatment plant: Miramar/Alvarado and Alvarado/Otay. Demands within the crossover area are assumed to be split 50/50 to estimate total demand for each of the three major service areas as input to the systems model. For example, the total Miramar service area demand is equal to Miramar demand plus half of the Miramar/Alvarado crossover demand.

Water demands fluctuate not only from year to year but also from month to month. To account annual and seasonal fluctuations in projected average demands, annual weather demand factors (from Figure B-3) and monthly seasonal factors (provided in the 2010 Demand Forecast) are applied in the systems model. The monthly simulated demand is equal to:

Average annual demand Tracked for each service area Divided by 12, to convert to average monthly demand	X	**Weather Factor** Varies from year to year (refer to Figure 3-2) Factor multiplied to every month within a given year	X	**Seasonal Factor** Varies from month to month

Demand management options such as additional conservation may be tested with the model. These options would decrease the average annual demand from the baseline projections.

B.3 Performance Measures

The systems model is a single model representing several systems (surface water, recycled water, groundwater, and imported water), and evaluates overall system performance of water supply portfolios (or combinations of options) against multiple planning objectives.

The 2012 LRWRP Stakeholder Committee defined the following eleven objectives, which formed the basis for evaluating performance of each portfolio:

- Provide Reliability and Robustness
- Manage Cost and Provide Affordability
- Maximize Efficiency of Water Use
- Provide for Scalability of Implementation
- Maintain Current & Future Assets
- Provide Local Control/Independence
- Maximize Project Readiness
- Protect Quality of Life
- Protect Habitats and Wildlife
- Reduce Energy Footprint
- Protect Quality of Receiving Waters

From these objectives, performance measures were developed. The performance measures are numerical values needed for the decision-making process; therefore, the model was programmed to provide output for these performance measures. Only quantitative performance measures were simulated in the model. Qualitative performance measures for each of the objectives are described in Appendix C.

Objective: Provide Reliability and Robustness

Supply reliability was measured in the model through two quantitative metrics:

<u>Cumulative Water Shortages Over Planning Horizon (Averaged Under Various Hydrologic Conditions)</u>
This performance measure calculates the cumulative water shortages over the planning horizon from 2010 through 2035 for a given portfolio, with water shortages classified as when the total demand for a given service area cannot be met by the available supply. The performance measure is based on the average cumulative water shortage of all four hydrologic conditions (critically dry, dry, normal, wet).

<u>Ratio of Emergency Supply to Six Tenths of Annual Demand</u>

Under City Council Policy 400-4, the City of San Diego is required to have available at all times a substantial emergency storage reserve equal to six-tenths of the annual demand for the entire city. The purpose of emergency storage reserve is to maintain water service in the event of a prolonged outage of the imported water system due to an earthquake, flood, or other catastrophe.

In order to evaluate this performance measure, the emergency storage requirements are calculated based on six-tenths of average annual demand, which increases over time. The emergency storage requirement is compared with the total supply available for the emergency condition. During an emergency condition, any local supplies would be available including conservation, reclamation (non-potable and indirect potable reuse), ocean desalination, groundwater, graywater and rainwater harvesting, and local reservoir supply.

The local reservoir supply available is limited by the pipeline capacities conveying water to the treatment plants for six-tenths of the year; therefore, the reservoir storage was compared to six-tenths of the year pipeline capacity in order to determine the reservoir supply available. Similarly, for groundwater storage options, supply is limited to production well capacities pumping water from the basin for six-tenths of the year; therefore the groundwater basin storage is compared to six-tenths of the year production well capacity in order to determine the groundwater basin supply available. For all other local supply options, the supply available is equal to the production over six-tenths of the year.

The performance measure is based on the ratio of supply available compared with demand for six tenths of the year. The average ratio over of the simulation period is calculated, and then the average is calculated for all four hydrologic conditions (critically dry, dry, normal, wet).

Objective: Manage Cost and Provide Affordability

Two quantitative performance measures are used to evaluate cost and affordability:

Total Present Value Costs to The City PUD and Customers/Developers

This performance measure accounts not only for the cost to the City which could affect water rates, but also the cost to customers/developers. Costs include operation of existing supplies and development of new options. The model calculates annual portfolio costs over the entire planning horizon (from 2010 to 2035) and discounts the total cost back to present value (PV). Annual portfolio costs over time include amortized capital payments, operation and maintenance costs, and costs to purchase imported water from SDCWA.

Model inputs include economic assumptions such as inflation rates, operation and maintenance (O&M) costs for existing supplies, capital and O&M costs for each option, projected SDCWA imported water rates, and water distribution and wastewater system costs.

Economic Assumptions

The following basic economic assumptions were used in the model:

- Inflation rate: 3% annually
- Capital Loan Interest rate: 5% annually
- Capital Loan Payment Period: 30 years
- Discount Rate: 5% annually
- Discount Period: 25 years (from 2010 to 2035)

The assumptions above apply to all new and existing options except for SDCWA imported water rates, which are expected to increase faster than inflation (as discussed subsequently).

Existing Local Supply Costs

The intent of the model is to compare relative costs of potential new options. Therefore, sunk costs such as existing capital payments were not included, nor were fixed costs to maintain the existing system. Variable operation and maintenance cost for local surface water supply, existing groundwater supply, and existing recycled water supply were included and inflated over time. However, since these existing supplies are included in all water resource portfolios, the variable O&M costs of existing supplies are the same among portfolios and the costs do not contribute to comparative cost differences during portfolio evaluations.

Table B-2 presents the assumed unit cost of existing supply in current dollars. For local surface treatment and groundwater pumping that produce potable water supplies, water distribution and wastewater system costs are also included.

Table B-2
Variable O&M Unit Cost of Existing Supply

Existing Supply	Water Supply Costs		Wastewater System Costs		Total Unit Cost[4], $/AF
	Supply O&M Cost (Current Dollars), $/AF	Distribution O&M Cost (Current Dollars), $/AF	Wastewater System Capital Costs[2], $/AF	Wastewater System O&M Cost[3], $/AF	
Local Surface Water Treatment	71 overall for current supply from all three treatment plants[1]	88	385	377	695
Groundwater Pumping	100	88	385	377	707
Recycled Water from North City WRP	662 (treatment and distribution)	Included in Supply O&M	0	0	662

[1] Ranges from $55/AF to $206/AF at individual treatment plants.

[2] The construction cost to upgrade Point Loma WWTP is currently estimated to be $1.2 billion. During the time of 2012 LRWRP analyses, it was assumed that the cost would be $1.052 billion and expressed in volumetric terms of wastewater treated. This is used as a proxy to illustrate that these supplies produce wastewater flows and costs at Point Loma WWTP. This does not represent the actual cost to upgrade Point Loma, which varies depending on total system-wide wastewater flows that are generated.

[3] Based on current average volumetric cost of wastewater collection, treatment, and solids handling. Assume 40 percent of supply yield is used for indoor applications. Note that treatment O&M costs would increase with upgrades to Point Loma Wastewater Treatment Plant (WWTP).

[4] Total unit cost is weighted average assuming 100 percent of supply and wastewater system capital unit costs, and 40 percent of wastewater system O&M unit costs (assuming 40 percent of supply yield is used for indoor applications and requires wastewater treatment).

Options Costs

Planning level estimates of total capital costs and O&M were developed for individual options. Costs for new options represent the incremental new capital, operational, or program costs. Traditionally, cost comparison of water supply options has only included the capital and operating costs to produce the water supply. However, in order to fully compare options, the major costs of distributing the water supply and costs associated with wastewater collection, treatment and discharge were added to this analysis. This is important because not all water supply options require water distribution or wastewater costs. In fact, some options actually reduce wastewater costs for the City. For example, increased recycling can help offload wastewater treated at Point Loma WWTP and help avoid some costs associated with infrastructure improvements at Point Loma WWTP for secondary treatment upgrades. The level of avoided costs depends on the magnitude of wastewater that could be recycled.

Table A-2 (in Appendix A) and Figure B-5 provide a summary of capital, supply and distribution O&M cost, imported water costs, and wastewater (WW) system costs in current dollars.

For on-site rainwater harvesting options (cisterns and rain barrels) and graywater options, it is assumed that the capital costs are phased in over time as implementation grows and more devices are installed. As such, the annual capital costs (a function of the number of devices installed in a given year) will increase with inflation. For all other options, it is assumed that capital costs would be paid through a bond or loan. The model calculates capital payments by inflating to the assumed implementation year, then amortizing the payment based on the interest rate and payment period.

Annual O&M and purchases costs ($/AF) are inflated over time, starting in the assumed implementation year. Note that the only option with a purchase cost is ocean desalination (purchased from the project proprietor). In addition, annual conservation costs are expected to vary over time depending on the best management practices that are being implemented in a given year.

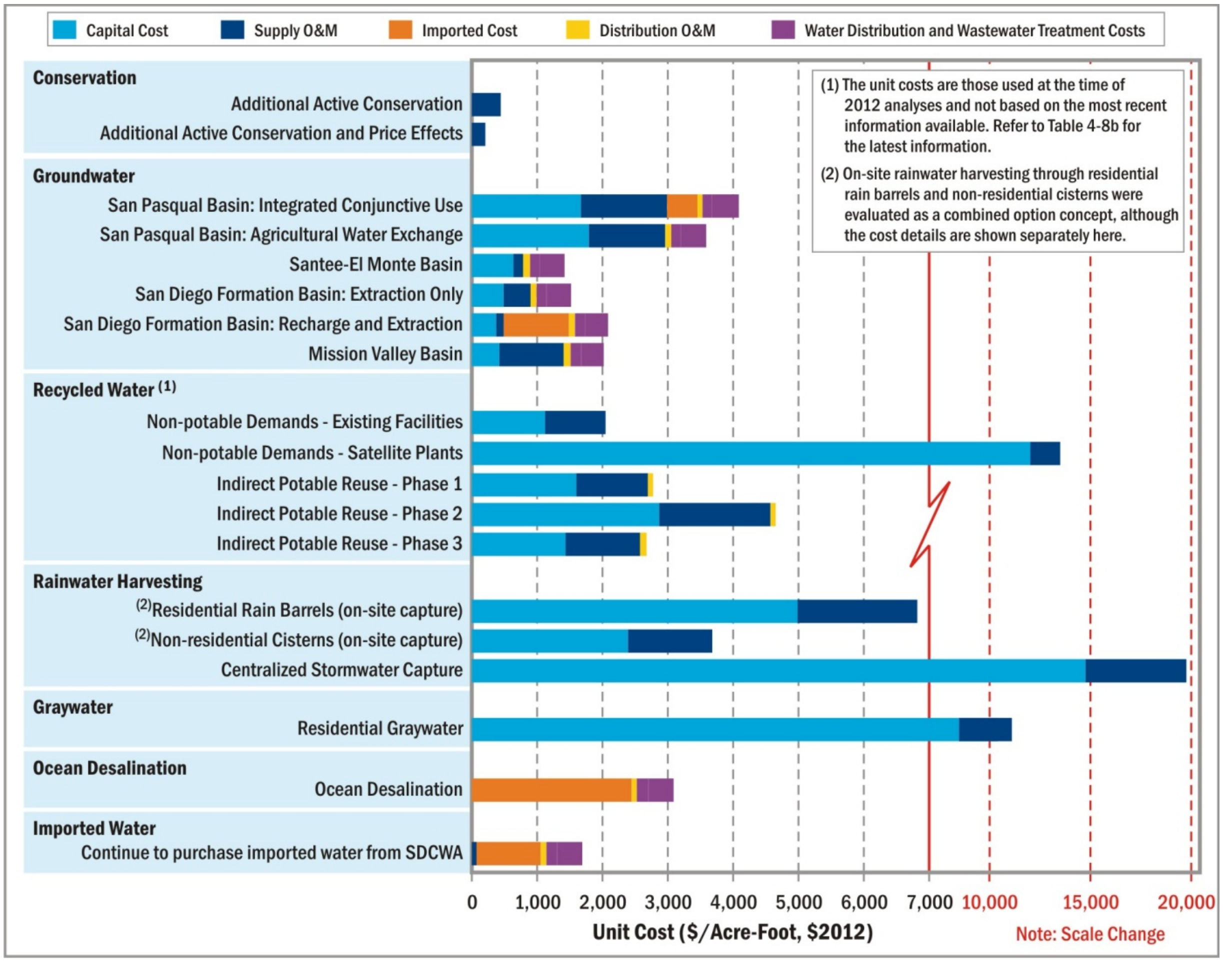

Figure B-5
Unit Cost Breakdown of New Options

SDCWA Imported Water Purchases

The City purchases imported water from the SDCWA. Projected water rates for imported supply are expected to increase faster than inflation, primarily due to rising energy costs, future MWD and SDCWA capital improvements, and the enormous cost of implementing a comprehensive solution in the Delta. Figure B-6 shows projected SDCWA fixed and total volumetric rates for untreated water. The volumetric rate (cost per unit volume of water used) includes the purchase cost plus the cost of transportation. The fixed costs do not vary and cannot be reduced based on the volume of water purchased per year.

The SDCWA volumetric imported water rate (untreated purchase rate plus transportation) is assumed to escalate at 6 percent annually through 2016, 4.5 percent annually from 2017 to 2020, and 3 percent annually from 2021 to 2035. Fixed annual costs for SDCWA imported water are assumed to escalate at 3 percent annually throughout the planning horizon.

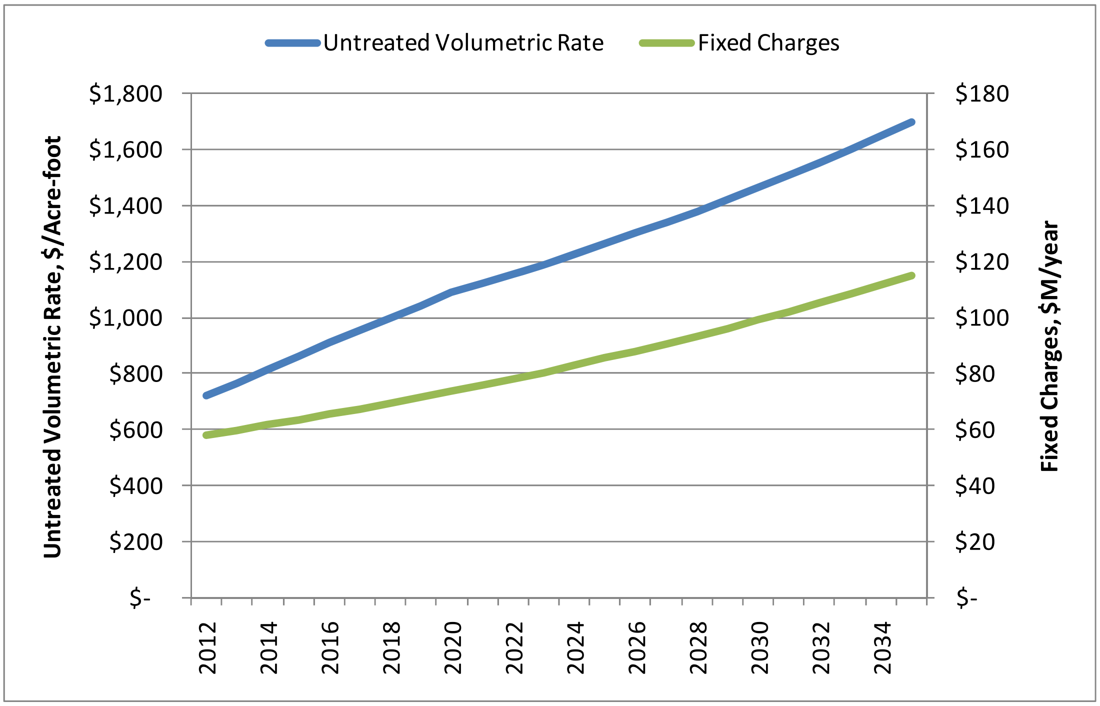

Figure B-6
Projected SDCWA Water Rates

Wastewater System Costs

In order to illustrate the total cost of each individual option (existing and new), the wastewater costs were expressed in volumetric terms in Tables B-2 and A-2 (in Appendix A). However, the SDSIM model evaluates wastewater system costs based on system-wide wastewater flows that are generated and treated at Point Loma Wastewater Treatment Plant (WWTP). Currently, system-wide dry weather wastewater flows are approximately 160 million gallons per day (mgd), and are expected to grow to about 195 mgd by 2035[2]. New options such as recycling, graywater, and indoor conservation can help

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[2] City of San Diego Recycled Water Study, Table 4-3, July 2012.

offload wastewater treated at Point Loma WWTP and help avoid some costs associated with infrastructure improvements at Point Loma WWTP for secondary treatment upgrades. The overall wastewater system costs depend on the amount of wastewater flows that can be offloaded from Point Loma WWTP and are presented in Table B-3; however, it is important to note that these estimates were used for modeling purposes in SDSIM only and do not reflect the most recent cost estimates resulting from other studies conducted in parallel with the 2012 LRWRP. The SDSIM model calculates wastewater system costs based on projected status quo wastewater flows and the total level of wastewater flows that are offloaded by new options included in each portfolio.

Table B-3
Estimated Point Loma Wastewater Treatment Plant Costs
(Source: City of San Diego Recycled Water Study TM 8, Figure B-2 and B-3, August 2011)

Wastewater Flow, MGD	Construction Cost (Millions)	Annual O&M Cost (Millions)
0	---	---
10	---	---
20	---	---
30	267.266	3.5155
40	283.138	4.6875
50	299.010	5.8595
60	343.566	9.347
70	358.432	10.905
80	373.298	12.463
90	388.164	14.021
100	403.030	15.579
110	684.289	14.877
120	706.358	16.117
130	728.427	17.357
140	750.496	18.597
150	772.565	19.837
160	794.634	21.077
170	816.703	22.317
180	838.772	23.557
190	1024.804	29.865
200	1052.080	31.393

NOTE: The 2012 LRWRP was conducted in parallel with the City's Recycled Water Study that was recently completed in July 2012. The values in this table do not reflect the final numbers resulting from the Recycled Water Study. The estimates in this table were used for SDSIM modeling purposes as a proxy for wastewater system costs during the time of 2012 LRWRP evaluations.

Calculation of Performance Measure

For each portfolio, the total costs are calculated on a monthly basis over the planning horizon (2010 to 2035). Portfolio cost calculations are divided into four general steps:

1) Calculate total supply O&M costs of existing sources, escalated over the planning horizon

2) Calculate the total supply cost of new options (capital and O&M), escalated over the planning horizon
3) Calculate imported water purchase costs, escalated over the planning horizon
4) Calculate the distribution O&M costs for existing and new options that require distribution, escalated over the planning horizon
5) Calculate the wastewater system costs (capital and O&M), escalated over the planning horizon
6) Sum the annual escalated costs (from Steps 1 through 5 above) and discount back to present value costs

The total PV cost over the planning horizon was calculated, and then averaged for the four hydrologic conditions (critically dry, dry, normal, and wet).

It is important to note that potential grant funding is not reflected in the cost analysis.

Amount of City PUD annual capital costs relative to total annual costs to City PUD

This performance measure considers only the costs to the City, and does not include costs to customers/developers for options that involve on-site costs. For this performance measure, both annual capital and total costs to the City are tracked for each portfolio in escalated dollars (costs are escalated similar the previous performance for total present value cost). For each year, the ratio of annual capital cost to total cost to the City is calculated on a annual basis. The ratio is averaged over the planning horizon, and then averaged for the four hydrologic conditions (critically dry, dry, normal, and wet).

It is important to note that potential grant funding is not reflected in the cost analysis.

Objective: Maximize Project Readiness

Evaluation of this objective is based on qualitative performance measures described in Appendix C.

Objective: Protect Quality of Life

One quantitative performance measure was used to evaluate the quality of life objective:

Potential for local job creation

In order to compare the potential for job creation among portfolios in SDSIM, a formula was developed based on information from the IMPLAN (Impact analysis for PLANning) system for the San Diego region. The IMPLAN system is a complete economic impact modeling and database system, with unique data across 440 sectors for each specific region (data is available for approximately 3,000 counties in the United States).

In order to estimate the potential for job creation from development of water supply options, 2009 data was used from IMPLAN system for the San Diego county region under Sector 33 (Water, sewage and other treatment and delivery systems) and Sector 36 (Construction of other new nonresidential structures). The 2009 data was available at the time of the LRWRP analyses, and updates are not expected to significantly change the comparative analysis among portfolios.

The following is the proxy formula used to calculate potential for job creation for each portfolio:

> *Potential for temporary construction jobs = (Total Capital Cost)/(Output per worker for IMPLAN Sector 36) = (Total Capital Cost)/$136,885*
>
> *Potential for long-term jobs = (Average annual operation and maintenance cost)/(Output per worker for IMPLAN sector 33) = (Average annual operation and maintenance cost)/$241,788*

For each month of the simulation, the overall potential for job creation is calculated as the combination of the potential for temporary construction jobs and potential for long-term jobs. Note that the temporary construction jobs are assumed to last for 3 years from the time of project implementation (when capital costs are assumed to be incurred). The overall average potential for job creation is calculated over the simulation period, and then the average is calculated for all four hydrologic conditions (critically dry, dry, normal, wet).

It is important to note that these formulas were used to develop a gross potential job creation index for high-level planning comparisons of water resource portfolios, and do not represent refined estimates of number of jobs created for specific projects.

Objective: Protect Habitats and Wildlife

Evaluation of this objective is based on qualitative performance measures described in Appendix C.

Objective: Maximize Efficiency of Water Use

One quantitative performance measure was used to evaluate quality of life:

<u>Cumulative Level of Water Conservation and Reclamation Over the Planning Horizon</u>

The objective of maximizing efficiency of water use means efficiency in how water is used and how waste is recovered or minimized. This performance measure calculates on a monthly basis the 1) total water conservation including existing conservation and additional conservation options, and 2) total reclamation through non-potable and indirect potable reuse. The cumulative water conservation and reclamation is summed over the planning horizon, and then the average is calculated for all four hydrologic conditions (critically dry, dry, normal, wet).

Objective: Provide for Scalability of Implementation

Evaluation of this objective is based on qualitative performance measures described in Appendix C.

Objective: Maintain Current & Future Assets

One quantitative performance measure was used for the objective to maintain current and future assets:

<u>Cumulative amount of water supplied from existing drinking water treatment plants, recycled water plants, and groundwater sources</u>

This objective aims to utilize the City's existing assets which include facilities and rights to water supply. On a monthly basis, the model calculates the total water supplied from 1) existing drinking water treatment plants, 2) existing recycled water plants, and 3) local groundwater sources originating from natural replenishment. For existing treatment plants, the utilization of the plants is accounted for regardless of the origin of the source water or the end use of the product water. For example, existing treatment plants currently treat local surface supply but could also treat advanced treated recycled water though indirect potable reuse with reservoir augmentation. In addition, existing recycled water plants could provide water for non-potable reuse, or treated effluent water could undergo additional advanced treatment for indirect potable reuse.

The cumulative amount of water supplied from existing drinking water treatment plants, recycled water plants, and groundwater sources is calculated over the planning horizon, and then averaged for all four hydrologic conditions (critically dry, dry, normal, wet).

Objective: Provide Local Control/Independence

One quantitative performance measure was used for the objective to provide local control/independence:

Total Local Resources

The majority of the City's current water supply is imported water purchased from the SDCWA, which in turn purchases imported water from MWD. The future reliability of imported water is uncertain with increased concern over shortages due to drought, environmental restrictions, climate change, and seismic catastrophes. In addition, the cost of imported water is expected to increase significantly and prices are not controlled by the City. This objective aims to reduce dependence on imported water by developing local resources. Local resources include any non-imported supply, such as conservation, groundwater, recycled water, stormwater, and ocean desalination.

For this performance measures, the total supply from local resources is calculated on a monthly basis. The total cumulative supply from local resources is calculated over the planning horizon, and then averaged for all four hydrologic conditions (critically dry, dry, normal, wet).

Objective: Reduce Energy Footprint

One quantitative performance measure was used for the objective to reduce the energy footprint of the City's water sources:

Cumulative carbon dioxide (CO_2) emissions from water sources

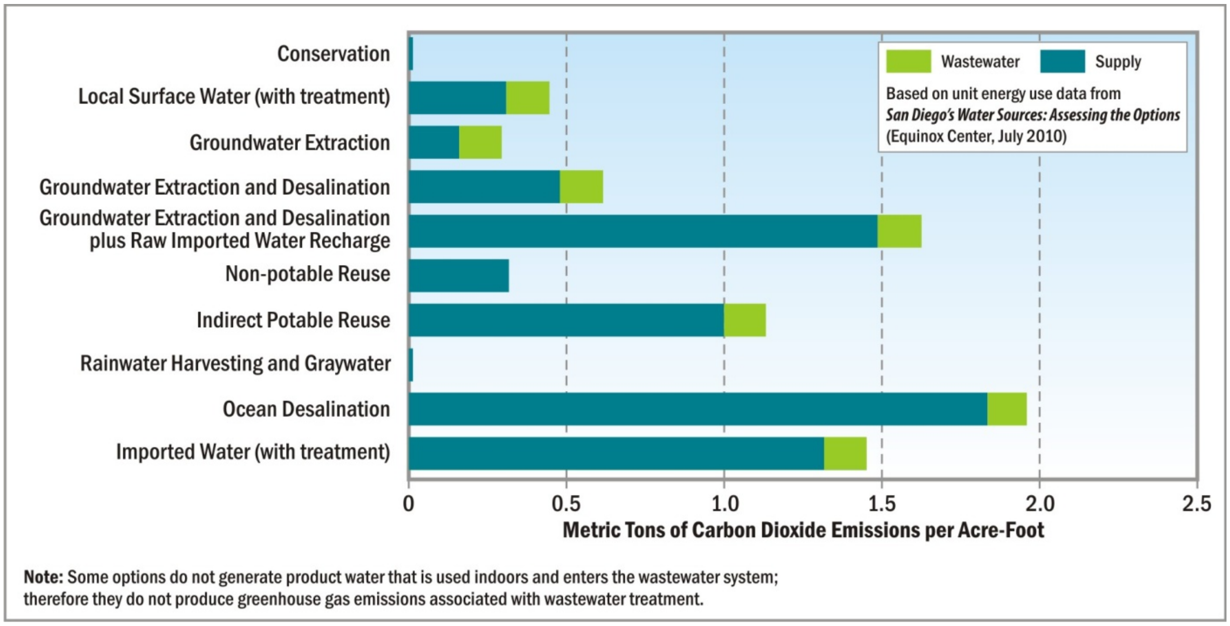
Greenhouse gas emissions are calculated based on typical per unit energy requirements for each source of water supply, including energy requirements for distribution and wastewater treatment if applicable. The energy required was converted to carbon dioxide equivalents. While imported water sources have different sources of energy than local water resources, it is assumed that all water resources use the same energy resource for simplicity. Therefore, portfolio variations in carbon dioxide emission for this analysis are a reflection of the energy required to produce water; not the type of energy used for each water resource.

Figure B-7 presents the approximate carbon dioxide emissions per acre-foot (AF) assumed for each type of water source. Greenhouse gas emissions from energy used to produce water supply (treatment and major conveyance) are accounted for, as well as energy required for wastewater treatment where applicable (options that produce potable water can be used indoors and generate wastewater that must be treated). In this analysis, it is assumed that 40 percent of potable water produced is used indoors. The emissions per AF in Figure B-6 are estimated based on information regarding unit emissions provided in a report prepared by the Equinox Center titled *San Diego's Water Sources: Assessing the Options* dated July 2010 and other similar analyses performed by CDM Smith.

Note that the analysis does not account for potential energy generation from water supplies that may offset greenhouse gas emissions. For example, the San Pasqual Integrated Conjunctive Use and

Groundwater Desalination Project could potentially generate hydropower which may offset some of the greenhouse gas emissions from this water source.

The total carbon dioxide emissions from water supplies are calculated in each month of the simulation based on 1) the CO2 emissions per AF of each source, and 2) the use in AF per month of each water source as a supply to meet demands. The cumulative carbon dioxide emissions over the planning horizon are calculated, and then averaged for all four hydrologic conditions (critically dry, dry, normal, wet).



Note: Some options do not generate product water that is used indoors and enters the wastewater system; therefore they do not produce greenhouse gas emissions associated with wastewater treatment.

Figure B-7
Carbon Dioxide Emissions per Unit Volume of Water Source
(Note: the emissions for imported water are based on pumping from the Bay-Delta, as this represents MWD's marginal water supply)

Objective: Protect Quality of Receiving Waters

Two quantitative performance measures were used for the objective to protect the quality of receiving waters:

Cumulative Reduction in Stormwater And Wastewater Discharges to Rivers and Ocean

Reducing discharges of stormwater and wastewater to rivers and the ocean can help improve water quality conditions. This performance measure accounts for 1) reduced stormwater discharges through implementation of urban stormwater capture options (both centralized capture as well as onsite capture with cisterns or rain barrels), and 2) reduced wastewater discharges through implementation of conservation and reclamation. It is assumed that 40 percent of new conservation savings are through reduced indoor consumption, thereby reducing wastewater generated. Other options that reduce wastewater discharges include graywater, non-potable reuse, and indirect potable reuse.

The reduction in stormwater and wastewater discharges is calculated on a monthly basis in the model. For this performance measure, the cumulative reduction in stormwater and wastewater discharges over the planning horizon is calculated, and then averaged for all four hydrologic conditions (critically dry, dry, normal, wet).

Concentration of Total Dissolved Solids (Salts) in Water Supply

Total dissolved solids (TDS) concentrations for each potable water supply option, excluding water conservation, were determined based on historic records and/or projected water quality of options currently not in place (i.e., indirect potable reuse, ocean desalination, etc.). A mass-balance of supplies was programmed into the model in order to track the total salinity for each portfolio. By multiplying the water supply's TDS concentration by the water supply yield, a TDS load is calculated and totaled for the entire San Diego supply. The total TDS load is then divided by the total San Diego supply yield to obtain an overall TDS concentration for each simulation. The following formula was used to calculate the TDS of the potable supply in the portfolio:

$$PortfolioTDS = \frac{(TDS)_{Option(1)} * (Flow)_{Option(1)} + \ldots + (TDS)_{Option(N)} * (Flow)_{Option(N)}}{\sum_{i=1}^{N} (Flow)_{Option(i)}}$$

The portfolio TDS values are calculated on a monthly basis in the model. For this performance measure, the average potable TDS values over the planning horizon is calculated, and then averaged for all four hydrologic conditions (critically dry, dry, normal, wet).

B.4 Quality Control

The SDSIM model was subject to quality control process. All data used in the model was obtained from information developed or compiled by CDM Smith technical staff, and was reviewed by senior CDM Smith staff. The modeling approach was discussed with the City in various work sessions.

The model was subject to a detailed review for flow and stock magnitudes and dynamics, mass conservation, dimensionality, and response under extreme input conditions. The model used explicit representation of units in every equation, forcing unit consistency. In addition, a 30-year historical hydrology record was used to validate the output for the use of local reservoir water, obtaining a mean error (mean over the 30-year simulation) on the order of ±3 percent of supply.

Frequent and effective communication with City staff was established to guarantee that any model reprogramming, and all of the assumptions for development of the most important response functions, were consistent with existing information about the system and congruent with modeling objectives. The conceptual nature of the model provided opportunity for validating most of the response functions using simple spreadsheets.

B.5 Simulation Process

The simulation setup process for the SDSIM model is facilitated by the use of a graphical interface based on switches that set the hydrology and turn options on and off. Figure B-8 shows the graphical management panel developed for the systems model.

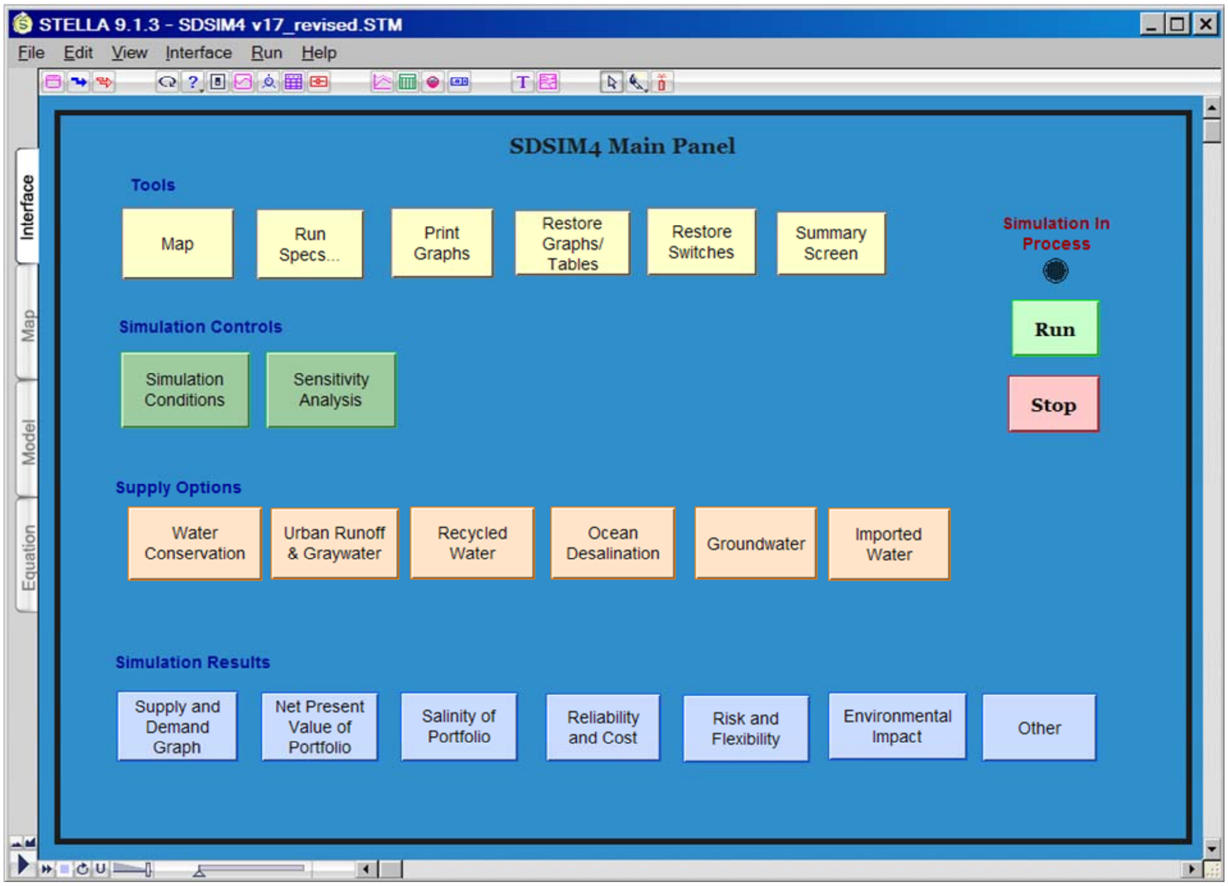


Figure B-8
SDSIM Model Management Panel

As Figure B-8 shows, the following options were included in the model in addition to local reservoir water, which was used in the model by default with no associated management decisions:

- Conservation: existing conservation (included in all simulations by default) and additional conservation efforts
- Rainwater Harvesting (or Urban Runoff): cisterns & rain barrels, as well as centralized stormwater
- Graywater
- Water reclamation: Includes the existing water reuse, new non-potable demand from satellite plants, new non-potable demand from existing reclamation plants, and/or varying phases of indirect potable reuse.
- Ocean desalination
- Groundwater: the existing groundwater supply, the Mission Valley Basin option, the San Pasqual options, the San Diego Formation Basin options, and the Santee – El Monte Basin option

Other supply options (Other Groundwater, Water Transfers, Marine Transport, and New Non-Storage Supply) are from the previous version of the model and were not updated as part of the 2012 LRWRP. It is not recommended to run these options as they may no longer be correctly represented in the model.

To run the model, the user switches on desired water supply options for the portfolio by clicking on the appropriate buttons (refer to Section 5 of the 2012 LRWRP report for definitions of portfolios). Each project alternative or "portfolio" was represented by a unique set of inputs to the model, which were entered into the model through the management panel.

The desired hydrology condition must be selected before running the simulation, because results can vary significantly depending on the hydrologic conditions. For the LRWRP portfolio analysis, all four hydrologic conditions were simulated (Critical Dry, Dry, Normal, and Wet).

In addition to the main inputs included in the management panel, the model was programmed to provide easy manipulation of certain variables for sensitivity analysis. Input variables were programmed for the following sensitivity analyses:

1. **Delta Fix:** No imported water shortages, although this assumes higher imported costs where SDCWA volumetric rates increase at 6 percent through 2020, 4.5 percent through 2025, and 3 percent through 2035 (compared with assumed base rates in Figure B-6).

2. **Higher Energy Costs:** Higher energy costs, which affect cost of operations. Energy cost factors are applied to all existing and new supplies.

3. **Lower Treatment Technology Costs:** Lower operation cost for advanced treatment technologies used for indirect potable reuse and brackish groundwater treatment.

4. **Climate Change:** Potential climate change impacts to water supplies based two global circulation model scenarios (refer to Appendix E for details).

The default simulation setup (under 'Run Specs') is a monthly timestep for26 years (312 months) to represent the 2012 LRWRP planning horizon through 2035. If the climate change sensitivity is selected, however, the simulation setup should be changed to run on a monthly basis for a total of 924 months. This is because the climate change sensitivity simulations represent the 2035 planning year over 77 years (or 924 months) of varying hydrologic conditions.

Results from the model are exported from a STELLA table (Export Table 2012) to an Excel portfolio output file. The Excel output file was then used for post-processing of data to develop scorecards for comparison of portfolio performance in each objective (refer to Appendix D for portfolio performance results from the SDSIM model).

Appendix C Qualitative Score Guidance

Appendix C

Qualitative Score Guidance

The performance measures used to evaluate portfolios, or combinations of options, against the objectives are shown in **Table C-1.** Some performance measures are quantitative in nature (developed using models and analyses), while others are qualitative and are assessed based on a variety of factors using professional judgment.

The following is a description of the factors used in assessing qualitative scores. All qualitative scores are based on a scale of 1 to 5, where 1 = poor performance and 5 = superior performance. Qualitative scores are assigned either to individual options (then rolled up to a portfolio using a weighted average of supply yield), or directly to portfolios. This is indicated in **Table C-1** with either 'Qualitative-O' for option level assessment, and 'Qualitative-P' for portfolio level assessment. **Table C-2** presents the qualitative scores for individual options when the former method is used. Note that existing supplies are included in every portfolio. Therefore, they do not influence the decision scores with the exception of imported water, which is the default supply after all other options have been used in the portfolio and has varying levels of use among the portfolios.

Hydrologic Variability Score: The availability of some sources of water vary depending on weather or climatic conditions, which influence hydrology. The following is some guidance for scoring options that are hydrology-dependent:

- Urban stormwater runoff that is directly used for non-potable uses, and rainwater capture for direct irrigation use (e.g., rain barrels and cisterns) have the greatest hydrologic variability.
- Imported water supply has great hydrologic variability, but MWD's storage mitigates this variability to some degree. Options that store available imported water in local groundwater basins improve reliability.
- Local groundwater options are less subject to hydrologic variability, since the availability of groundwater is a function of the long-term average recharge to the basin.
- Options such as conservation, recycled water and ocean desalination have essentially zero hydrologic variability.

Potential for External Funding: Any options that would have more funding resources (including State and Federal grants, partnerships with other City departments, or cost-sharing with other agencies and customers/developers) are given a higher score. Options that have higher scores in this performance measure include recycled water, urban runoff, and conservation options. Options that have low scores in this performance measure are imported water and ocean desalination (note that the ocean desalination option involves purchasing desalinated water from another agency, not the City building their own plant).

Flexibility for Project Phasing and Expansions: This performance measure considers the potential for downscaling or incremental phasing of options. Options that score well do not involve extensive infrastructure or piping, such as conservation, graywater, and rain barrels or cisterns. Imported water also scores well since it is an existing supply with infrastructure already in place.

Public Education Effort for Supply Development and Use: Options that have historically faced public opposition such as indirect potable reuse and ocean desalination will require a greater public outreach and education effort to build support for implementation of the option. This factor also considers the risk associated with the water utility's dependence on voluntary public or customer behavior in order for implementation to be successful. Graywater does not score well since public education is needed to prevent potential health risks from improper installation (cross-connection risks), use (type of detergents used, articles washed), and maintenance (changing of filters).

Implementation risk of developing a water supply due to regulatory or permitting challenges: All water projects fall under jurisdiction of local, state, and/or federal laws and permit processes can be time consuming, with some options facing more legal challenges than others. Ocean desalination has the most extensive regulatory and legal challenges, although this effort will be led by another agency. Indirect potable reuse and graywater projects face some challenges with strict regulations for health standards. Recycled water for non-potable use, stormwater capture will have moderate regulatory requirements and are generally accepted. Groundwater options have varying implementation risks depending on the location of the project (already developed areas would have fewer permitting challenges), level of coordination for legal agreements, and whether desalination treatment is needed. Conservation will likely have the least legal or regulatory challenges.

Potential for open space/recreation benefits: Projects that have greater potential to improve quality of life by supporting open space or recreational areas score better in this performance measure. Since some of the options that have potential to prove open space/recreational benefits have relatively small yields compared with the total overall water supply of the portfolio, this performance measure was scored at the portfolio level. The score was assessed based on the number of options included in a portfolio that provide potential open space/recreation benefits, compared with the status quo which has a neutral score.

Options that have potential for open space/recreational benefits include indirect potable reuse (potential to improve reservoir levels for aesthetic benefits), groundwater options in the San Pasqual area, centralized stormwater capture for irrigation of ballparks, etc., and conservation which helps to preserve water resources and encourage drought-tolerant landscaping.

Impact of supply development and use on ecosystems: This performance measure is focused on environmental impacts to local habitat areas. While habitat areas of imported water origin are at risk, other quantitative performance measures are aimed at reducing imported water supply and therefore benefit habitat areas of imported water origin. Options that include advanced treatment process that require disposal of brine, such as ocean desalination and indirect potable reuse, do not score well in this performance measure.

Potential water quality impacts to local groundwater basins: This performance measure is intended to represent very general trends associated with using various water sources. However, generalizations are very subjective since a water source may have better quality for one constituent but worse quality in another constituent when compared with another water source. The primary constituent considered in scoring of this performance measure was salinity concentrations.

Since some of the options that have potential impacts to groundwater quality have relatively small yields compared with the total overall water supply of the portfolio, this performance measure was scored at the portfolio level. The score was assessed based on the number of options included in a portfolio that provide potential groundwater quality benefits, compared with the status quo which has a neutral score.

Options that have the potential to improve salinity conditions in groundwater basins include advanced treatment processes such as San Pasqual Integrated Conjunctive Use, Indirect Potable Reuse, and Mission Valley groundwater. Imported water recharge and extraction in the San Diego Formation may have the potential to improve groundwater quality in the basin although this will require further investigation.

Any portfolio that includes graywater will have a lower score since there is still much uncertainty regarding the water quality from graywater systems. In addition, graywater quality is very dependent on behaviors of homeowners (type of detergents used, articles washed) and maintenance of the graywater filters. Therefore, graywater is assumed to have relatively poorer water quality than the City's existing water sources.

Other options are assumed to have a relatively neutral affect on groundwater quality compared with the status quo sources of supply. Note that non-potable recycled water options generally do not supply areas that overlie groundwater basins that are recharged through surface infiltration.

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City of San Diego Public Utilities Department
2012 Long Range Water Resources Plan
Table C-1. Objectives and Performance Measures

Objective	Brief Description	Performance Measures	Units	Scoring Method
Provide Reliability & Robustness	Reliability of water supply and distribution system under droughts, climate change, and catastrophes	Cumulative water shortages over planning horizon (averaged under various hydrologic conditions)	Total water shortages in acre-feet (AF)	Quantitative
		Resilience to Climate change	Hydrologic Variability Score Score of 1 to 5, 1 - high variability, 5 - low variability	Qualitative-O
		Ratio of emergency supply to six tenths of annual demand	Percentage (%)	Quantitative
Manage Cost and Provide Affordability	Managing total lifecycle costs (capital and O&M), as well as annual change in water rates	Total present value costs to the SDPUD and customers/developers, both capital and O&M, over planning period	Dollars ($)	Quantitative
		Amount of SDPUD annual capital costs relative to total annual costs to SDPUD	Percentage (%)	Quantitative
		Potential for external funding	External Funding Score Score of 1 to 5, 1 - low funding opportunities, 5 - high funding opportunities	Qualitative-O
Maximize Efficiency of Water Use	Efficiency in how water is used and how waste is recovered or minimized	Cumulative level of water conservation and reclamation over the planning horizon (averaged under various hydrologic conditions)	Acre-feet per year (AFY)	Quantitative
Provide for Scalability of Implementation	Can strategies be developed incrementally or phased, so that stranded investments are minimized	Flexibility for project phasing and expansions	Scalability Score Score of 1 to 5, 1 - low scalability, 5 - high scalability	Qualitative-O
Maintain Current & Future Assets	Assets include City's facilities and rights to water supply	Cumulative amount of water supplied from existing drinking water treatment plants, recycled water plants, and groundwater sources (averaged under various hydrologic conditions)	Acre-feet per year (AFY)	Quantitative
Provide for Local Control/Independence	Independence and reduced reliance from wholesale water purchases	Total local resources[1]	Acre-feet per year (AFY)	Quantitative
Maximize Project Readiness	Public concerns over potential health, reliability, and environmental impacts	Public education effort for supply development and use	Public Education Score Score of 1 to 5, 1 - significant public education effort, 5 - minimial public education effort	Qualitative-O
		Implementation risk developing a water supply due to regulatory or permitting challenges	Implementation Risk Score Score of 1 to 5, 1 - significant regulatory/permitting challenges, 5 - minimal regulatory/permitting challenges	Qualitative-O
Protect Quality of Life	Includes recreation, open space, and potential for job creation	Potential for local job creation	Job Creation Score	Quantitative
		Potential for recreation/open space benefits	Recreation/Open Space Score Score of 1 to 5, 1 - no recreation/open space benefits, 5 - high recreation/open space benefits	Qualitative-P
Protect Habitats & Wildlife	Habitats and wildlife locally, regionally and in the Sacramento/San Joaquin Delta	Impact of supply development and use on ecosystems	Habitat Impact Score Score of 1 to 5, 1 - high negative impact, 5 - high positive impact	Qualitative-O
Reduce Energy Footprint	Energy associated with development, use and operations of water supply	Cumulative greenhouse gas emissions from water sources (averaged under various hydrologic conditions)	Metric Tons of carbon dioxide (CO2)	Quantitative
Protect Quality of Receiving Waters	Receiving waters include ocean, bays, rivers and groundwater basins	Cumulative reduction in stormwater and wastewater discharges to rivers and ocean (averaged under various hydrologic conditions)	Million gallons per day (mgd)	Quantitative
		Concentration of total dissolved solids (salts) in potable water supply	Milligrams per liter (mg/l) of total dissolved solids (TDS)	Quantitative
		Potential water quality impacts to local groundwater basins	Groundwater Quality Score Score of 1 to 5, 1 - high negative impact, 5 - high positive impact	Qualitative-P

1 Local resources include any non-imported supply, such as conservation, groundwater, recycled water, stormwater, and ocean desalination.
Qualitative-O: Qualitative scores are assigned at the option level of analysis, and portfolio scores are calculated using a weighted average based on option yields
Qualitative-P: Qualitative scores are assigned at the portfolio level of analysis.
Quantitative: Scores were evaluated quantitatively using the City's SDSIM water resources systems model.

City of San Diego Public Utilities Department
Table C-2. Option Qualitative Scores

Source or Demand Option	QUALITATIVE SCORES (1 = worst, 5 = best)					
	Hydrologic Variability Score	External Funding Score	Scalability Score	Public Education Score	Implementation Risk Score	Local Habitat Impact Score
Conservation						
Existing/Baseline Conservation (1)	NA	NA	NA	NA	NA	NA
Additional Active Conservation	5	4.5	5	3	4	5
Additional Active Conservation and Pricing Effect	5	4.5	5	2	3	5
Local Surface Supply						
Existing/Basline Local Surface Runoff to City Reservoirs (1)	NA	NA	NA	NA	NA	NA
Groundwater						
Existing/Baseline Groundwater Supply (1)	NA	NA	NA	NA	NA	NA
San Pasqual Basin: Integrated Conjunctive Use and Groundwater Desalination or	4	4	2	4	3	3
San Pasqual Basin: Agricultural Water Exchange	5	4	2	3	1	4
Santee -- El Monte Basin	5	4	2	5	3	5
San Diego Formation Basin: Extraction Only	5	4	2	5	5	5
San Diego Formation Basin: Aquifer Storage and Recovery	4	4	2	5	4	5
Mission Valley Basin	5	4	2	5	3	5
Ocean Desalination						
Ocean Desalination	5	2	2	3	3	1
Recycled Water						
Existing/Baseline non-potable reuse (1)	NA	NA	NA	NA	NA	NA
New non-potable demands from new privately-developed satellite plants	4	5	4	4	5	4
New non-potable demands from existing reclamation plants	4	5	3	4	5	4
Indirect Potable Reuse - Phase 1	5	5	2	2	2	2
Indirect Potable Reuse - Phase 2	5	5	2	2	2	2
Indirect Potable Reuse - Phase 3	5	5	1	2	2	2
Graywater						
Residential Graywater	4	4	5	1	2	5
Rainwater Harvesting						
Rain Barrels (onsite capture)	1	5	5	3	2	5
Centralized Stormwater Capture	1	5	3	5	4	5
Imported Water						
Continue to purchase imported water from SDCWA (2)	2	1	5	5	4	3

Notes:

(1) The full yield of all existing local supplies will be included in every portfolio. Therefore, the qualitative scoring is the same and becomes a non-disriminator in the decision analysis. The only existing supply that will have varying levels of use among the portfolios is imported water.

(2) Imported water purchases from SDCWA are assumed as the last priority supply after all other resources included in each portfolio have been utilized. Therefore all portfolios will have purchases of imported water, but with varying amounts.

Acronyms:
AFY: Acre-feet per Year   AF: Acre-feet
NA: Not applicable
SDCWA: San Diego County Water Authority

Appendix D Portfolio Performance Scorecard

Appendix D

Portfolio Performance Scorecard

Section 6 of the LRWRP report presents the evaluation of portfolio results, including raw performance measured from the City's San Diego Simulation (SDSIM) model (refer to Appendix B), and the portfolio rankings using a multi-attribute rating software known as Criterium Decision Plus (CDP) developed by Infoharvest Inc. (refer to Section 5.5.2). This appendix includes more detailed information on the following material:

- **Appendix D.1:** Evaluation of raw portfolio performance scorecard (from SDSIM)
- **Appendix D.2:** Example of how the portfolio performance scorecard is used in the CDP portfolio ranking method
- **Appendix D.3:** Projected Annual Supply Mix Charts for each Portfolio (based on results from SDSIM model)

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D.1 Portfolio Performance Scorecard

The portfolio performance scorecard (or raw performance) represents the ability of a portfolio to achieve a given objective, regardless of the importance or relative weighting of the objective. The portfolio performance scorecard is provided as Table 6-1 of the 2012 LRWRP report. This appendix provides more discussion of the raw performance evaluations under each of the planning objectives. It is important to recognize that the performance metrics used to evaluate portfolios are not intended to be accurate predictions, but rather they are used to determine the relative benefits that the portfolios have when compared to each other.

Performance measures can be quantitative or qualitative in nature. Quantitative performance measures were evaluated using the City’s SDSIM model, and Appendix B provides a description of how the performance measure is calculated. Qualitative performance measures are assessed based on a variety of factors using professional judgment, and are described in Appendix C.

Note that the scales vary among the performance measures – in some cases, a higher score means better performance (such as resilience to climate change); in other cases, a higher score means worse performance (such as supply shortages or costs). The scales for each performance measure are adjusted accordingly in the decision model prior to portfolio ranking (see Section 5.5.2 of the main report).

D.1.1 Provide Reliability and Robustness

Three performance measures were evaluated for the objective to provide reliability and robustness: 1) cumulative water shortages over the planning horizon, 2) resilience to climate change, and 3) ratio of emergency supply to six tenths of annual demand.

Cumulative Water Shortages over the Planning Horizon

Refer to Appendix B for a description of how this performance measure is calculated using the City's SDSIM model, which accounts for variations in supplies and demands due to hydrology.

The reliability evaluation accounts for risk to the City if a comprehensive Delta "fix" is not implemented within the 2012 LRWRP planning horizon of 2035. In this scenario, there are projected imported water shortages to meet future water demands due to droughts and environmental flow restrictions.

Figure D-1 shows the cumulative water shortages over the planning horizon for each portfolio. The results show that all portfolios significantly improve reliability over the baseline (status quo) future in which no new projects or programs are implemented. The remaining shortages for the portfolios are related to near-term reliability risks until potential future projects come online.

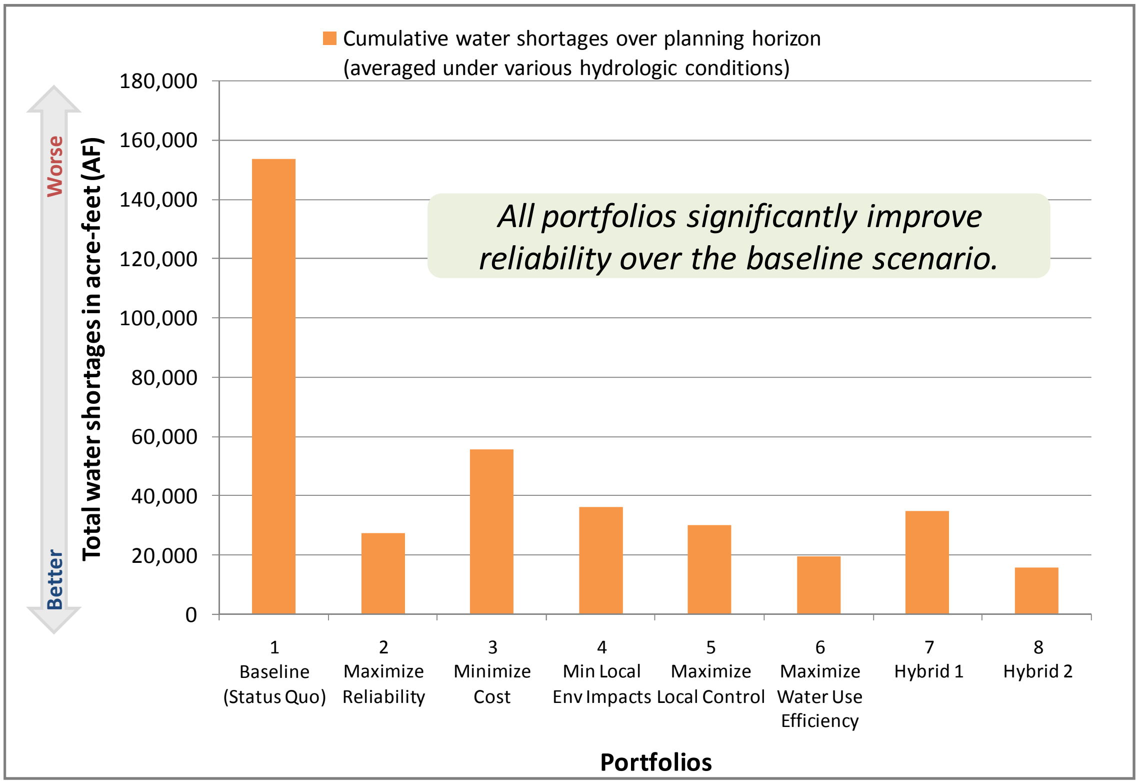


Figure D-1
Portfolio Reliability Performance: Total Projected Water Shortages over the Planning Horizon

Resilience to Climate Change

For this performance measure, each option in the portfolio is assigned a hydrologic variability score, and an overall score for the portfolio is calculated based on the weighted average of option yields. Refer to Appendix C for more details on how this performance measure is assessed.

In general, any supply options that are hydrology-dependent are vulnerable to climate change. For the City, approximately 95 percent of the current water supply is hydrology-dependent; the majority of which is imported water from the Sierra Nevada and Colorado River watersheds. The City also captures surface runoff from local watersheds for treatment and use.

Figure D-2 shows the potential resilience to climate change for each portfolio. Portfolios that have higher scores in this performance measure reduce imported water reliance by increasing use of local resources such as conservation, recycled water, groundwater, and ocean desalination, which are less vulnerable to climate change.

Portfolios 2, 5, 6, and 8 show the greatest resilience to climate change. All these portfolios maximize recycling with every phases of indirect potable reuse (which has a combined potential yield of approximately 90,000 acre-feet per year (AFY)). Since the potential yield for indirect potable reuse is much higher compared with other supply opportunities, it has more affect on the portfolio score. However, Portfolios 3, 4 and 7 do show better resilience to climate change from the status quo since they include additional conservation, and varying levels of reuse and groundwater options. The supply projects in these portfolios are generally smaller-scale projects.

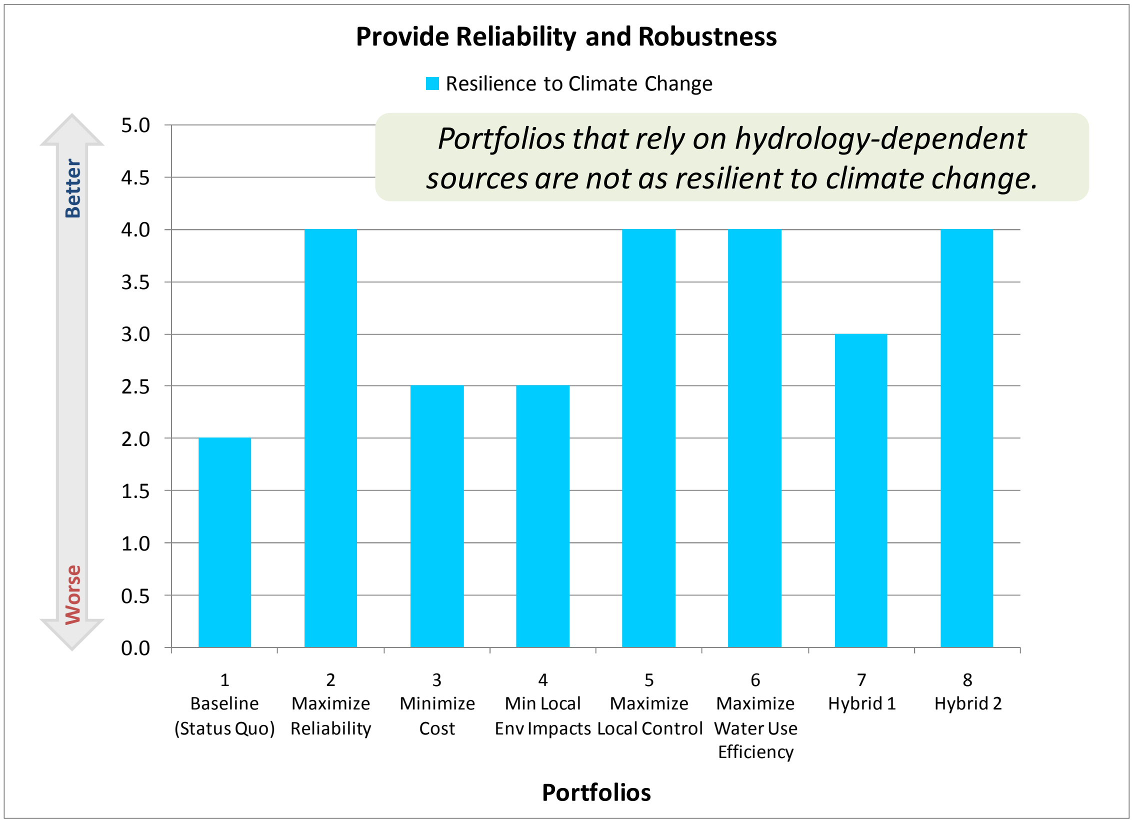


Figure D-2
Portfolio Reliability Performance: Resilience to Climate Change

Ratio of Emergency Supply to Six Tenths of Annual Demand

Under City Council Policy 400-4, the City of San Diego is required to have available at all times a substantial emergency storage reserve equal to six-tenths of the annual demand for the entire city. The purpose of emergency storage reserve is to maintain water service in the event of a prolonged outage of the imported water system due to an earthquake, flood, or other catastrophe.

Refer to Appendix B for a description of how this performance measure is calculated using the City's SDSIM model.

Figure D-3 shows the average ratio of emergency supply to six tenths of annual demand over the planning horizon for each portfolio. The results show that all portfolios improve the emergency supply capabilities. The portfolios that show the largest emergency supply (Portfolios 6 and 8) include the maximum levels of additional conservation combined with every phase of indirect potable reuse. Since neither of these options are hydrology-dependent, they both help to sustain water supply needs during emergency conditions. Portfolios 2 and 5 include every phase of indirect potable reuse combined with varying levels of groundwater, but they do not include the maximum conservation. Portfolios 3, 4 and 7 include maximum conservation combined with varying levels of groundwater, but do not include maximum levels of indirect potable reuse.

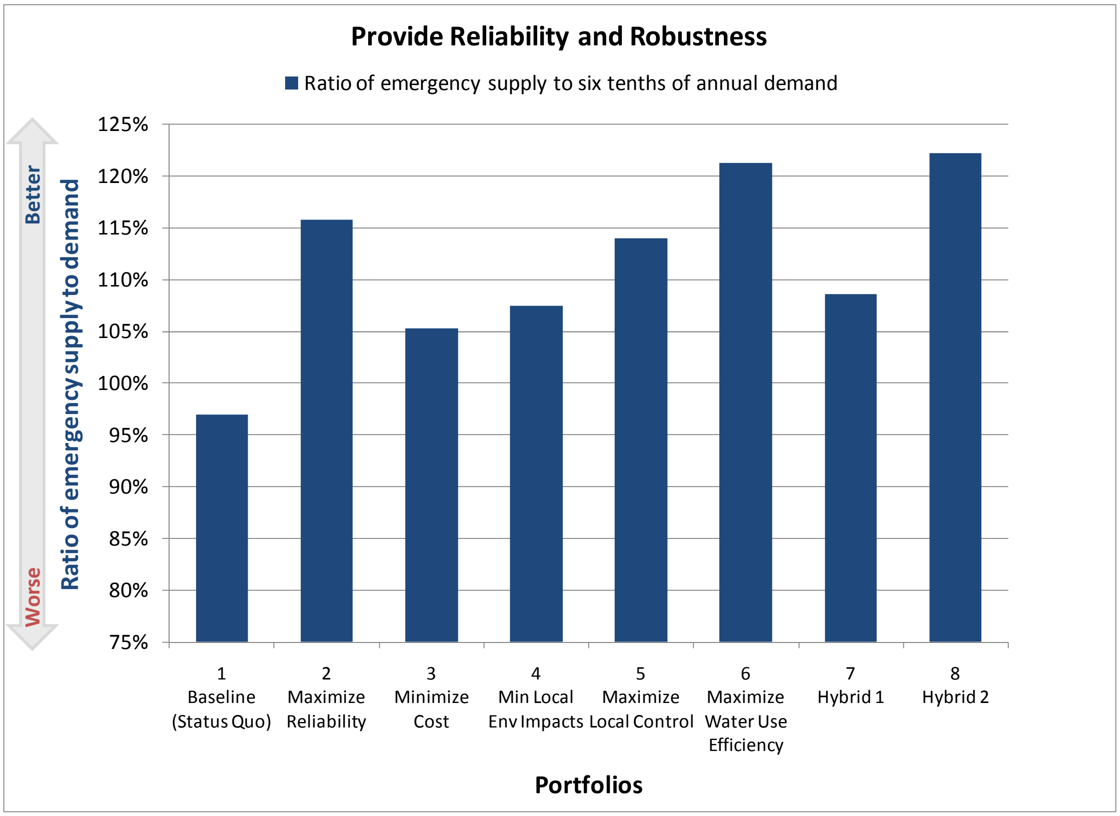


Figure D-3
Portfolio Reliability Performance:
Ratio of Emergency Supply to Six Tenths of Annual Demand

D.1.2 Manage Cost and Provide Affordability

Three performance measures were evaluated for the objective to manage cost and provide affordability: 1) total present value costs to the City PUD and customers/developers, both capital and O&M, over the planning period, 2) amount of City PUD annual capital costs relative to total annual costs to City PUD, and 3) potential for external funding.

Total Present Value Costs to the City PUD and Customers/Developers

Refer to Appendix B for a description of how this performance measure is calculated using the City's SDSIM model, which accounts for total costs over the planning horizon.

For this performance measure, total "societal" costs are considered. This approach accounts not only for the cost to the City which could affect water rates, but also the cost to participating customers/developers for onsite retrofits or improvements during implementation.

Costs include operation of existing supplies and development of new options. For existing water supplies, only the variable operational cost of supply is included in the analysis. Typically, these represent "prospective" costs – or future costs that could be avoided if other actions are taken. Any "sunk" costs such as existing program costs, capital payments, or already planned capital improvements are not included in the analysis.

Costs for new options represent the incremental new capital, operational, or program costs. Traditionally, cost comparison of water supply options has only included the capital and operating costs to produce the water supply. However, in order to fully compare options, the major costs of distributing the water supply and costs associated with wastewater collection, treatment and discharge were added to this analysis. This is important because not all water supply options require water distribution or wastewater costs. In fact, some options actually reduce wastewater costs for the City. For example, increased recycling can help offload wastewater treated at Point Loma WWTP and help avoid some costs associated with infrastructure improvements at Point Loma WWTP for secondary treatment upgrades. The level of avoided costs depends on the magnitude of wastewater that could be recycled.

Annual portfolio costs include:

- **Annual Capital Costs:** Includes amortized capital cost of new supply development and Point Loma WWTP upgrades, which vary depending on the magnitude of wastewater offloaded by the options in a portfolio.
- **Supply O&M:** This is the cost to produce the water resource, and including supply operation and maintenance (O&M) costs.
- **Distribution O&M:** The variable cost of distribution is included where applicable. Some supply options require distribution to customers, while others don't such as conservation, graywater, and rainwater harvesting.
- **Wastewater System O&M Costs:** The operational cost to collect and treat wastewater is included where applicable. Some options such as conservation, graywater, rainwater harvesting, and recycled water reduce the amount of wastewater to Point Loma WWTP and may reduce potential operational costs of the wastewater system.

- **Imported Water Costs:** Includes fixed and variable (based on volumetric rate) costs to purchase imported water from SDCWA.

In order to calculate annual costs over time, a 3 percent inflation rate is assumed for all O&M costs except imported water rates which are expected to increase faster than inflation (such as imported water, refer to Appendix B). Capital costs are inflated to the approximate 5-year timeframe projects could be implemented, and are assumed to be amortized at 5.5 percent over a 30 year period.

Total annual portfolio costs are analyzed over the entire planning horizon and discounted back to present value (PV) using the SDSIM model. Figure D-4 shows cumulative PV costs over the planning horizon for each portfolio. The results show that the portfolios with the lowest costs are Portfolios 1 (status quo), Portfolio 3 (Minimize Cost), Portfolio 4 (Minimize Environmental Impacts), and Hybrid 1. The status quo does not include any new projects or programs in the future, and the other portfolios with lower costs generally involve smaller-scale projects. Portfolios 2, 4, 6, and 8 show higher costs over the planning horizon, as these portfolios include every phase of indirect potable reuse.

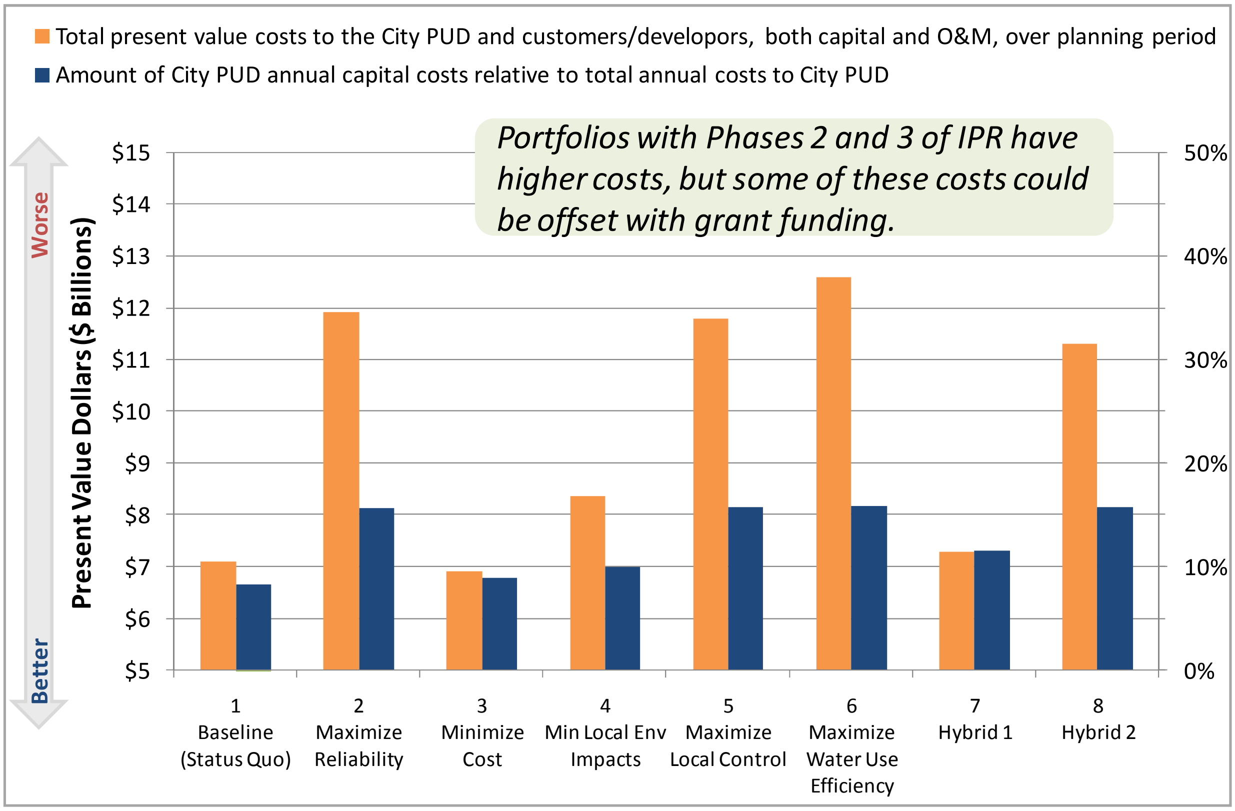


Figure D-4
Manage Cost and Provide Affordability Portfolio Performance:
Total Present Value Costs and
Ratio of SDPUD Capital Costs,
Over the Planning Horizon

While there are cost differences among the portfolios, it is important to recognize that not all the costs included in this analysis would be incurred by the City. The 2012 LRWRP takes a conservative approach in estimating the potential cost risks, but there are a number of ways that these costs could be offset to avoid potential rate implications:

- Some costs would be incurred by participating customers/developers where on-site retrofits or improvements are needed.
- No state or federal grant funding is assumed in the cost analyses. Potential for grant funding is considered as a separate metric (discussed subsequently).
- No rebates or support from other regional agencies is included (historically, MWD has provided incentives for conservation and local supply development).

These factors should be considered in an adaptive implementation strategy.

Amount of City PUD annual capital costs relative to City PUD total annual costs

Refer to Appendix B for a description of how this performance measure is calculated using the City's SDSIM model, which accounts for total costs over the planning horizon. This performance measure considers only the costs to the City, and does not include costs to customers/developers for options that involve on-site costs.

Annual capital payments represent fixed costs that the city must pay every year, regardless of how much water is sold to customers. The percentage of annual capital costs to total costs is an indication of how flexible a certain alternative is to changing conditions. Those portfolios that have a low percentage of capital costs can more easily adapt financially if changes in demand occur.

Figure D-4 presents the average ratio of annual capital costs to total annual costs to the City. The results show that the percentage of annual capital costs to total costs ranges between approximately 8-16 percent. Therefore, the portfolios do not show significant differences in terms of potential flexibility in annual costs (on a percentage basis).

Note that the cost analyses does not account for potential grant funding, which could reduce annual capital costs. Potential for grant funding is considered as a separate metric (discussed subsequently).

Potential for External Funding

For this performance measure, each option in the portfolio is assigned an external funding score, and an overall score for the portfolio is calculated based on the weighted average of option yields. Refer to Appendix C for more details on how this performance measure is assessed.

Figure D-5 shows the potential for external funding for each portfolio. Portfolios that score well in this performance measure include options that would have more funding resources including State and Federal grants, partnerships with other City departments, or cost-sharing with other agencies and customers/developers.

Portfolios 2, 5, 6, and 8 have the highest scores for potential external funding. These portfolios include every phase of indirect potable reuse (which has a combined potential yield of approximately 90,000 acre-feet per year (AFY)). Since the potential yield for indirect potable reuse is much higher compared with other supply opportunities, it has more affect on the portfolio score.

Portfolios 3, 4 and 7 do show some potential for external funding over the status quo, since they include additional conservation, and varying levels of reuse and groundwater options. The supply projects in these portfolios are generally smaller-scale projects.

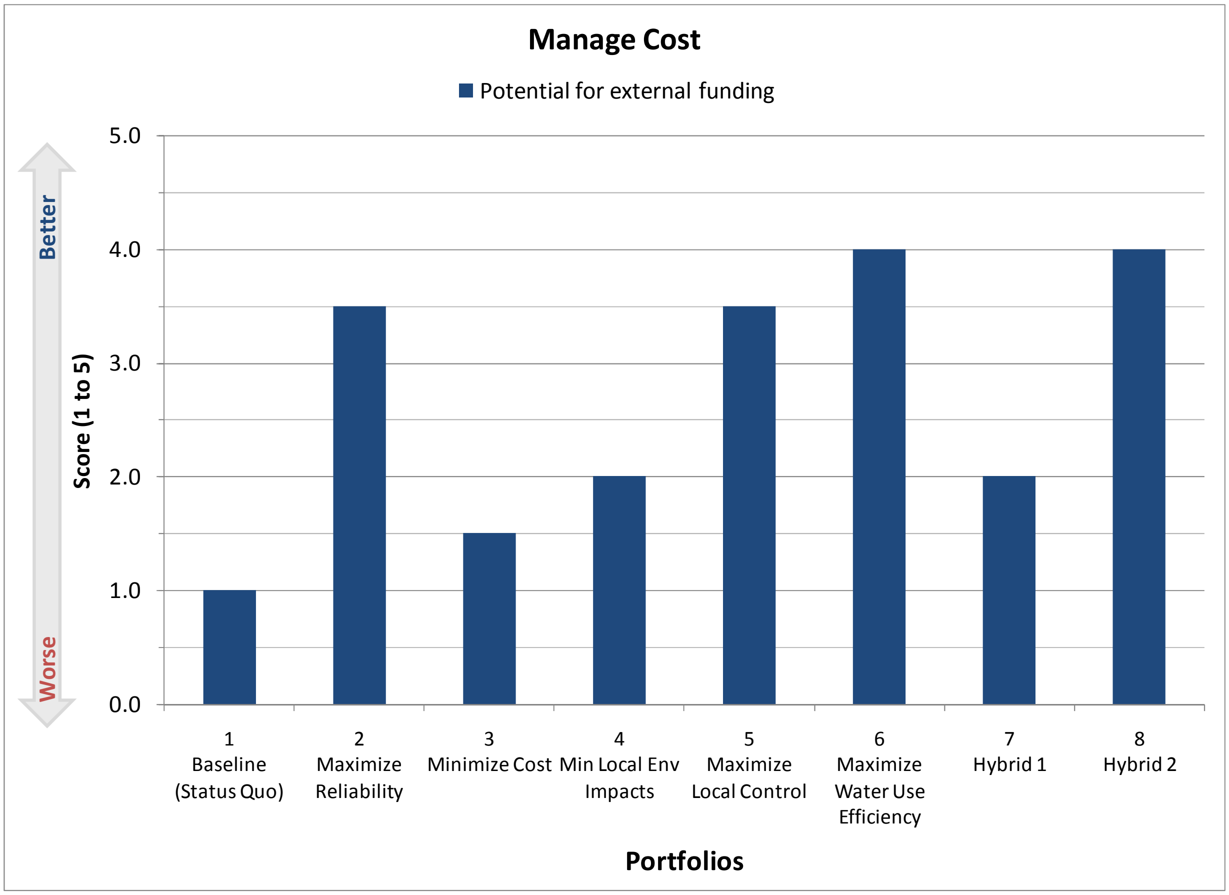


Figure D-5
Manage Cost and Provide Affordability Portfolio Performance: Potential for External Funding

D.1.3 Maximize Efficiency of Water Use

Refer to Appendix B for a description of how the performance measure for this objective is calculated using the City's SDSIM model.

The objective of maximizing efficiency of water use is related to efficiency in how water is used, and how waste is recovered or minimized. Performance is measured based on increasing efficient use of resources of the demand-side through conservation, and also increasing efficiency of the supply-side through use of wastewater as a resource for water recycling.

Figure D-6 shows the cumulative amount of water conservation and recycling for each portfolio. Portfolios 2, 5, 6, and 8 include the maximum recycling through all phases of indirect potable reuse, and have higher scores in this performance measure. Portfolios 6 and 8 combine maximum recycling with the maximum levels of additional conservation.

Portfolios 3, 4, and 7 have better scores than the status quo primarily because they include the maximum levels of additional conservation. While recycling through non-potable reuse helps with water use efficiency, the magnitude of potential additional non-potable demands in the service area are limited compared with the potential magnitude of yields from indirect potable reuse.

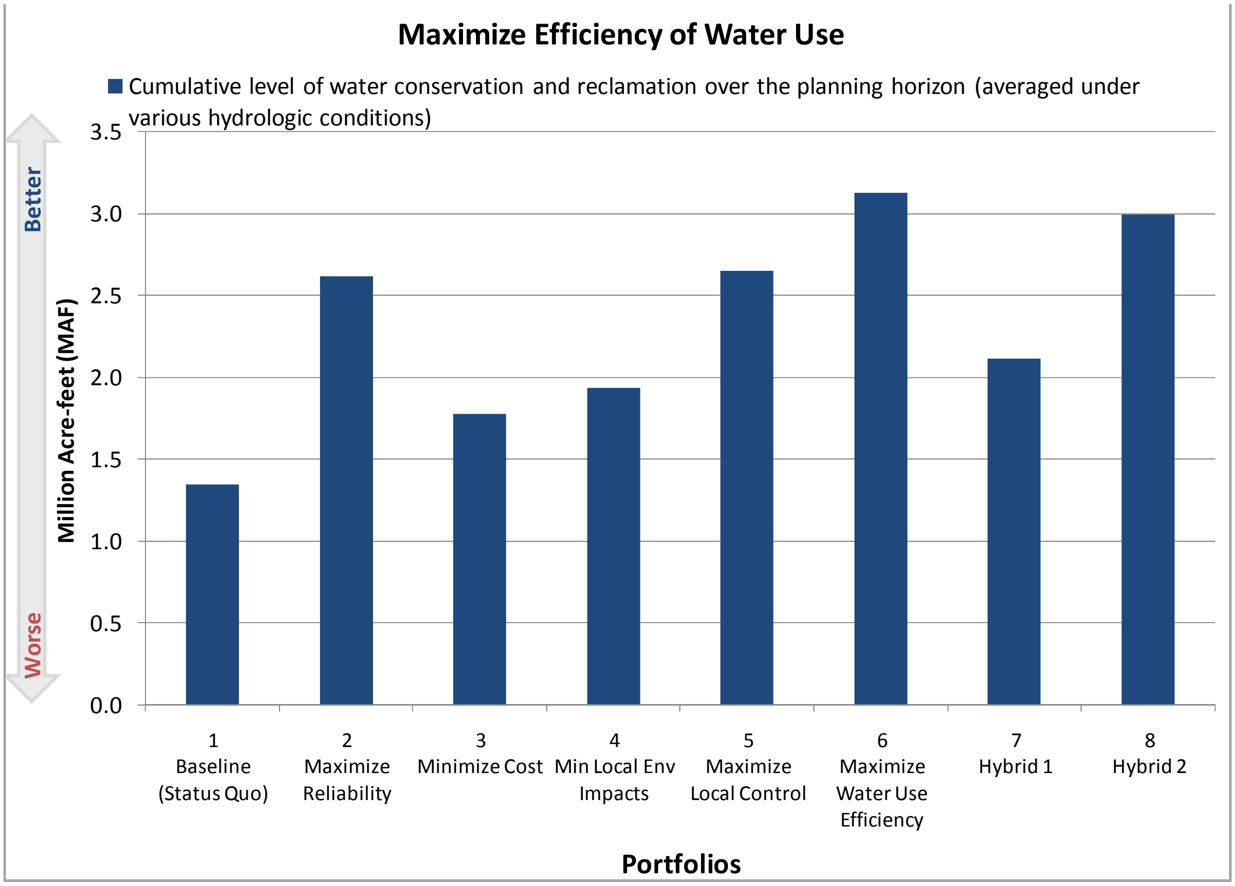


Figure D-6
Maximize Efficiency of Water Use Portfolio Performance:
Total Reclamation and Conservation over Planning Horizon

D.1.4 Provide for Scalability of Implementation

For this performance measure, each option in the portfolio is assigned a scalability score, and an overall score for the portfolio is calculated based on the weighted average of option yields. Refer to Appendix C for more details on how this performance measure is assessed.

Figure D-7 shows the potential for scalability or flexibility in project phasing and expansions. Portfolios that perform well in this performance measure include options that do not involve extensive infrastructure or piping.

The portfolios with the highest scores in this performance measure are Portfolios 1, 3, 4, and 7. Portfolio 1 (status quo) relies heavily on imported water, which scores well since it is an existing supply with infrastructure already in place. Portfolios 3, 4, and 7 include maximum levels of conservation, which provides significant flexibility in scalability and phasing. In addition, these portfolios include rainwater harvesting with rain barrels and cisterns. This option is easily scaled, although it does not produce a significant yield compared to other options.

Portfolios 2, 5, 6, and 8 have lower scores in scalability and in implementation. These portfolios include every phase of indirect potable reuse (which has a combined potential yield of approximately 90,000 acre-feet per year (AFY)).

The analysis assumes that indirect potable reuse will involve extensive piping to convey advanced treated recycled water to local surface reservoirs for supply augmentation. Note that Portfolio 7 includes the first phase of indirect potable reuse, but still maintained a relatively high overall portfolios score (since it would still have relatively high reliance on imported water compared with Portfolios 2,5, 6, and 8).

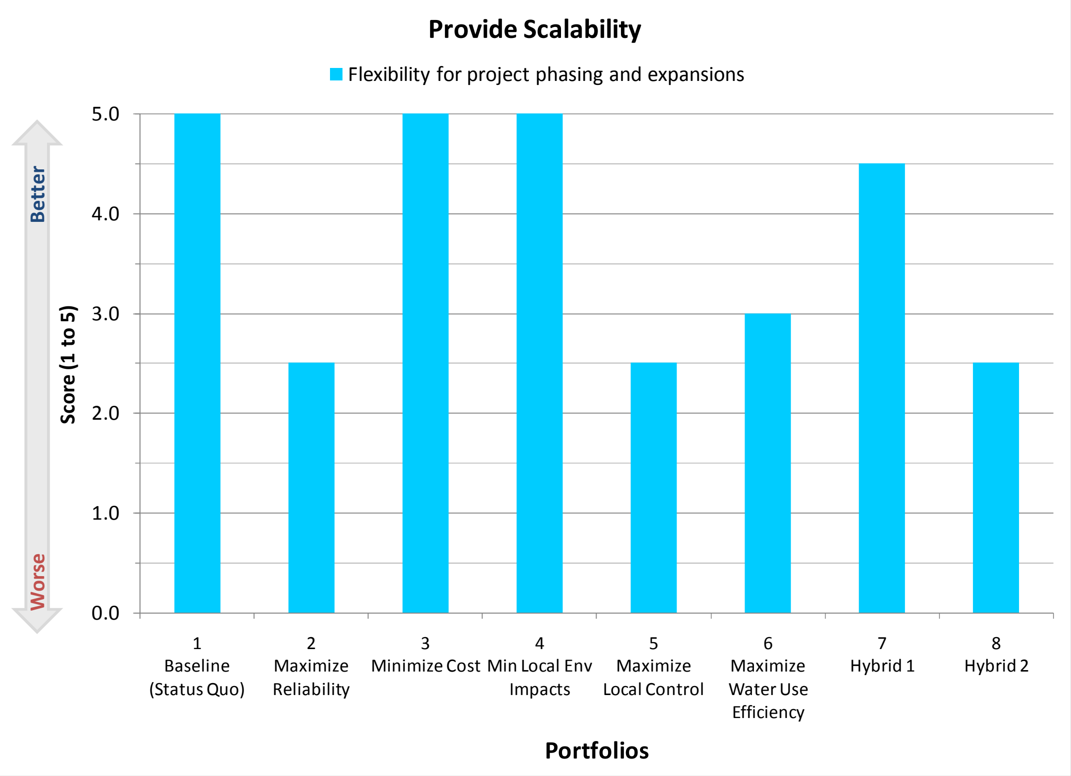


Figure D-7
Provide for Scalability of Implementation Portfolio Performance

D.1.5 Maintain Current and Future Assets

Refer to Appendix B for a description of how the performance measure for this objective is calculated using the City's SDSIM model.

The objective to maintain current and future assets aims to utilize the City's existing assets, which include facilities and rights to groundwater supply. Performance is measured based on utilization of existing drinking water treatment plants, existing recycled water plants, and local groundwater sources originating from natural replenishment.

Note that utilization of the existing drinking water and recycled water plants does not depend on the source water or the end use of the water. For example, indirect potable reuse would offset raw imported water purchases, but both options utilize local drinking water plants. In addition, supply from existing recycled water plants could be increased either through additional non-potable demands or the first phase of indirect potable reuse.

Figure D-8 shows the cumulative amount of water supplied from existing assets. Portfolio 5 has the highest score in this performance measure. This is primarily because it includes options that increase use of existing assets (several groundwater options, and first phase of indirect potable reuse) but does not include additional conservation which would reduce the need for imported water and decrease use of existing drinking water treatment plant assets.

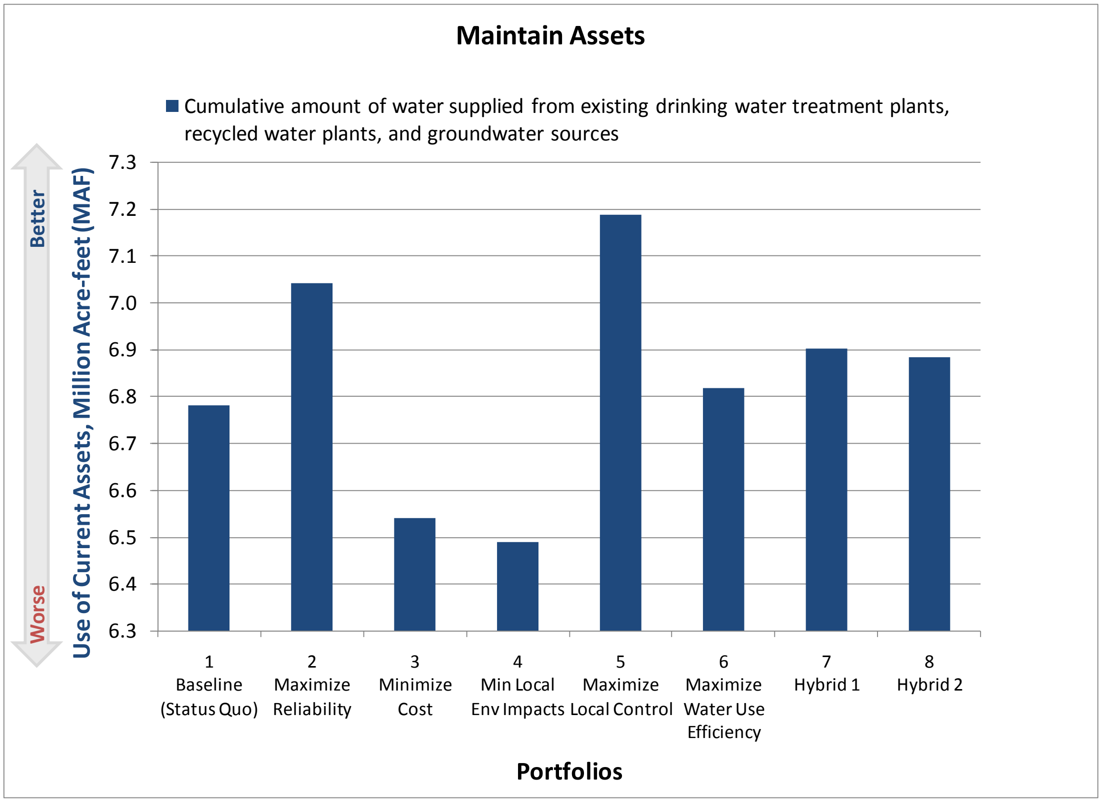


Figure D-8
Maintain Current and Future Assets

D.1.6 Provide for Local Control/Independence

Refer to Appendix B for a description of how the performance measure for this objective is calculated using the City's SDSIM model.

This objective aims to reduce dependence on imported water by developing local resources. The majority of the City's current water supply is imported water purchased from the SDCWA, which in turn purchases imported water from MWD. The future reliability of imported water is uncertain with increased concern over shortages due to drought, environmental restrictions, climate change, and seismic catastrophes. In addition, the cost of imported water is expected to increase significantly and prices are not controlled by the City.

Performance in this objective is measured based on local resources in a portfolio (existing and new). Local resources include any non-imported supply, such as conservation, local surface water, groundwater, recycled water, rainwater harvesting, and ocean desalination.

Figure D-9 shows the cumulative amount of local resources for each portfolio. All portfolios increase use of local resources over the status quo to some degree. The two portfolios that have the most local resources are Portfolio 6 and 8, which include a combination of all phases of indirect potable reuse and maximum additional conservation. Portfolios 2 and 5 have every phase of indirect potable reuse but do not include additional conservation; instead, they increase local supply through ocean desalination and several groundwater options. Portfolios 3, 4, and 7 include maximum additional conservation but have less groundwater and recycled water use than other portfolios.

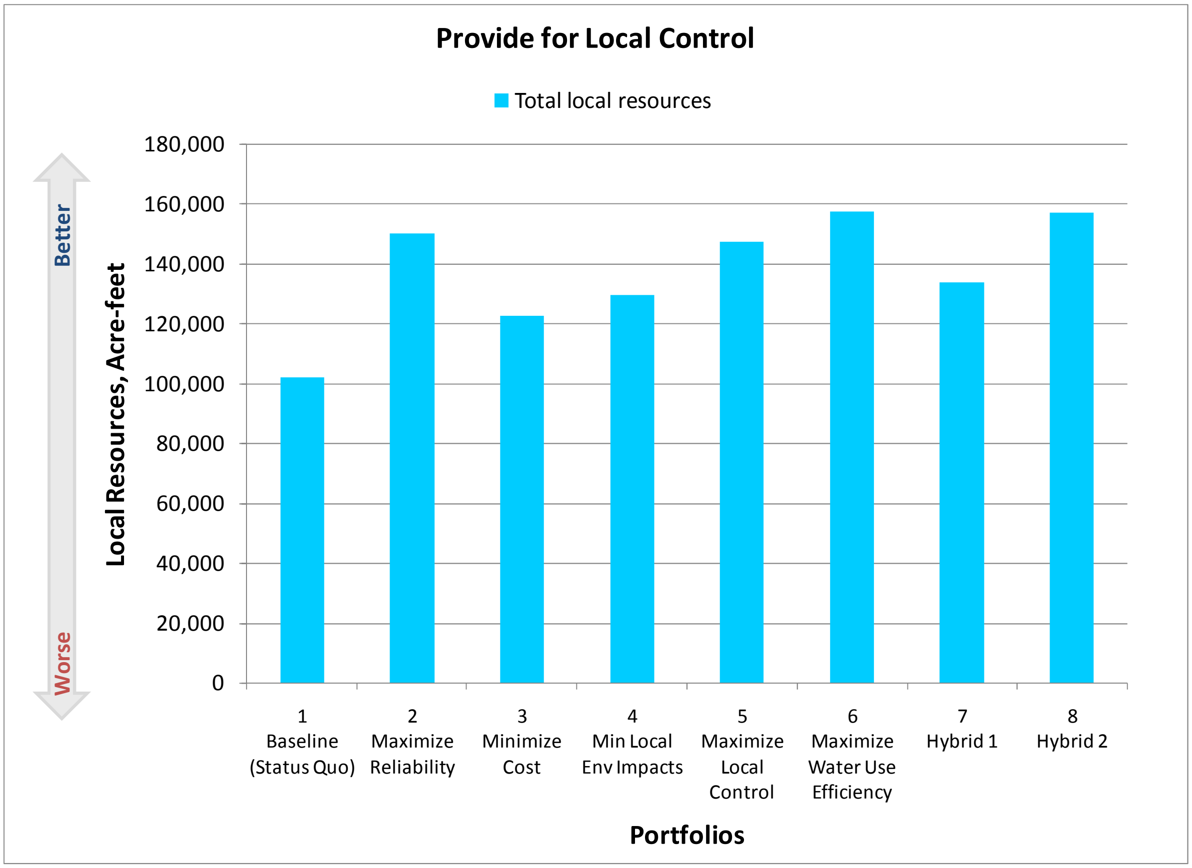


Figure D-9
Provide for Local Control/Independence Portfolio Performance

D.1.7 Maximize Project Readiness

Two performance measures were evaluated for the objective to maximize project readiness: 1) public education effort for supply development and use, and 2) implementation risk of developing water supplies due to regulatory or permitting challenges.

Public education effort for supply development and use

For this performance measure, each option in the portfolio is assigned a public education score, and an overall score for the portfolio is calculated based on the weighted average of option yields. Refer to Appendix C for more details on how this performance measure is assessed.

Performance is based on the level of public outreach and education effort for the option (e.g. options that use new or alternative technologies require more of a public education effort). In addition, performance is based on risk associated with the water utility's dependence on voluntary public or customer behavior in order for implementation to be successful.

Figure D-10 shows the public education effort scores for each portfolio. In this case, the status quo portfolio has the highest score since it does not involve any new projects or programs. Portfolios 3, 4, and 7 perform relatively well although the score is reduced from the baseline since these portfolios include additional active conservation and rainwater harvesting (with rain barrels and cisterns), both of which require voluntary customer participation. Portfolio 4 also includes additional recycled water for non-potable reuse, which requires voluntary participation. In addition, these portfolios (3, 4, and 7) as well as Portfolios 6 and 8 include conservation from pricing impacts, which requires public outreach and education.

Portfolios 2, 5, 6, and 8 include indirect potable reuse, which reduces the public education score further since this option will require significant public outreach given that it has historically faced opposition.

Implementation risk of developing water supplies due to regulatory or permitting challenges

For this performance measure, each option in the portfolio is assigned an implementation risk score, and an overall score for the portfolio is calculated based on the weighted average of option yields. Refer to Appendix C for more details on how this performance measure is assessed.

Performance is based on the permitting effort and level of potential legal challenges, which can be time consuming and delay project implementation. While all water projects fall under jurisdiction of local, state, and/or federal laws, some options face more legal challenges than others.

Figure D-10 shows the implementation risk scores for each portfolio. The portfolios with the highest scores include Portfolio 1, 3, and 4. Portfolio 1 (status quo) scores well since it does not include any new projects or programs, and relies on additional imported water to meet future demands. Portfolios 3 and 4 involve relatively small-scale projects that generally do not face difficult regulatory or permitting challenges such as groundwater, non-potable reuse, and rainwater harvesting.

The options in Portfolio 7 are similar to the options in Portfolio 3, except portfolio 7 includes the first phase of indirect potable reuse which has some challenges due to uncertainty associated with an evolving regulatory landscape. California Senate Bill 918 calls for new regulations for indirect potable reuse (which are expected by 2016 for surface water augmentation), and direct potable reuse framework guidelines (also expected by 2016) which are envisioned to provide new opportunities to the City. Portfolios 2, 5, 6 and 8 all include the maximum levels of indirect potable reuse (which has a combined potential yield of approximately 90,000 acre-feet per year (AFY)), which further reduces the score.

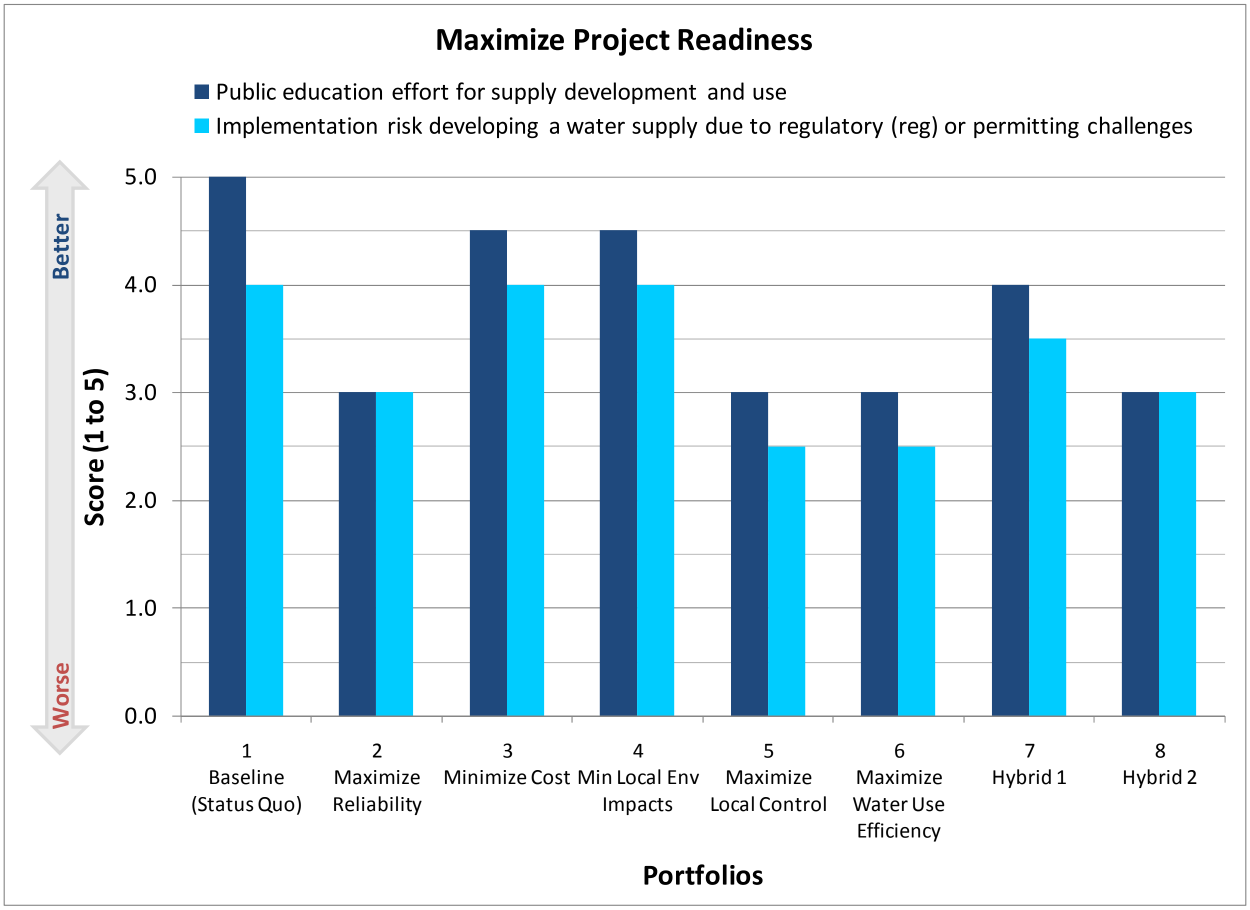


Figure D-10
Maximize Project Readiness Portfolio Performance

D.1.8 Protect Quality of Life

Two performance measures were evaluated for the objective to protect quality of life: 1) potential for job creation, and 2) potential for recreation/open space benefits.

Potential for Job Creation

Refer to Appendix B for a description of how this performance measure is calculated using the City's SDSIM model.

For this performance measure, portfolio costs are used as a proxy to assess the potential for job creation. Capital costs of a project typically result in short-term construction jobs during implementation, and can contribute to the local economy if equipment is purchased from local manufacturers. In addition, operation and maintenance of facilities can create long-term jobs. While higher costs indicate poor performance in the objective to Manage Costs and Provide Affordability, they are beneficial in the potential for job creation.

Figure D-11 presents scores for the potential for local job creation from each portfolio. Portfolios 2, 5, 6, and 7 have higher costs (refer to Section D.2), therefore have better performance in potential for job creation.

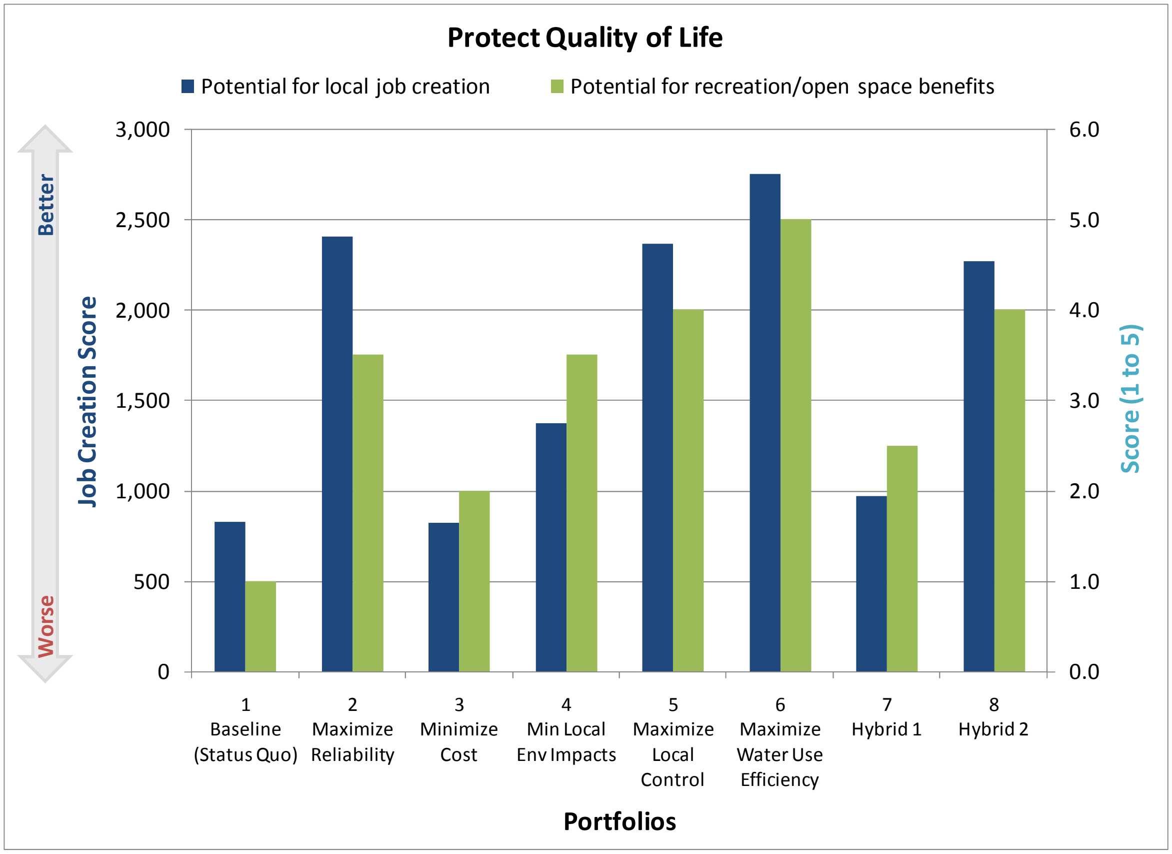


Figure D-11
Protect Quality of Life Portfolio Performance

Potential for Recreation/Open Space Benefits

For this performance measure, each portfolio is assigned a recreation/open space score based on qualitative assessment. Refer to Appendix C for more details on how this performance measure is assessed.

Performance is based on the number of projects in a portfolio that have greater potential to improve quality of life by supporting open space or recreational areas. Options that have potential for open space/recreational benefits include indirect potable reuse (potential to improve reservoir levels for aesthetic benefits), groundwater options in the San Pasqual area, rainwater harvesting for irrigation of ballparks, etc., and conservation which helps to preserve water resources and encourage drought-tolerant landscaping.

Figure D-11 presents the potential for recreation/open space scores for each portfolio. Portfolio 6 has the highest score since it includes several options that have greater potential for recreation/open space benefits, including maximum additional conservation, San Pasqual groundwater, satellite recycled water plants to serve irrigation demands, all phases of indirect potable reuse, and rainwater harvesting for irrigation demands.

Other portfolios that score well in this performance measure are Portfolios 2, 5, and 8. The status quo portfolio has the worst score, since it does not include any additional projects or programs, and therefore does not have potential for improving recreational benefits over current conditions.

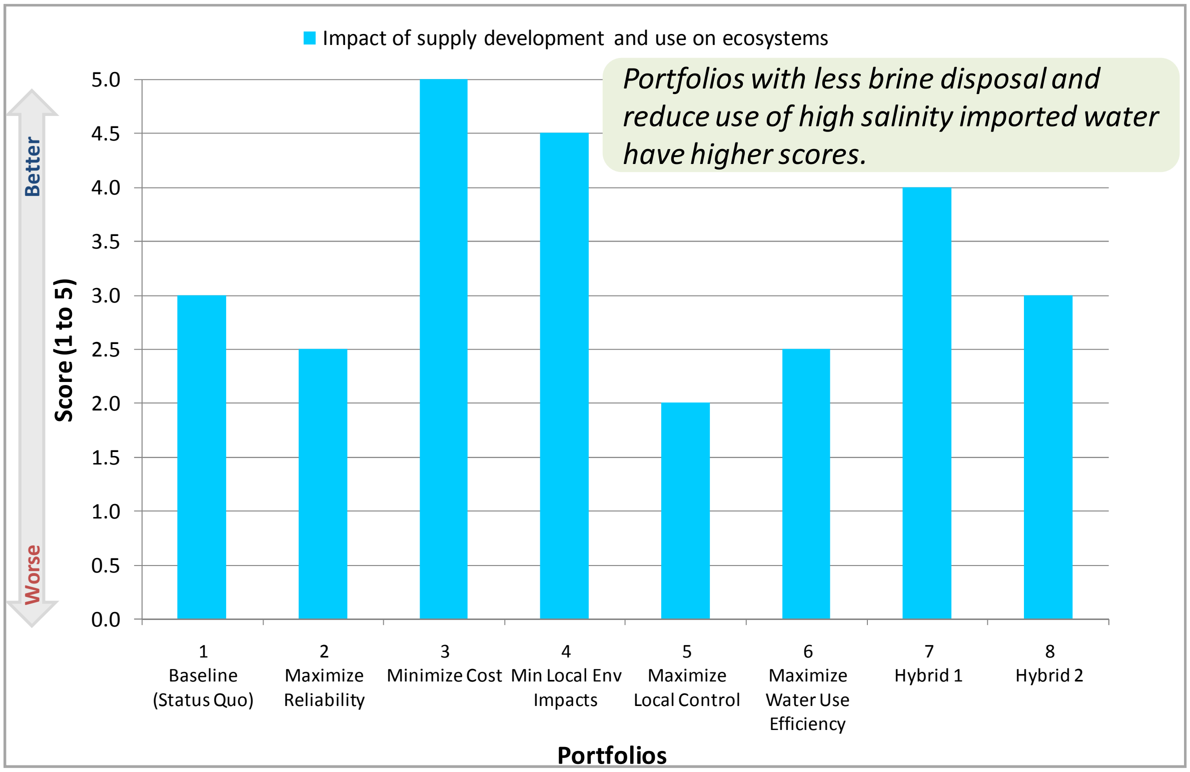
D.1.9 Protect Habitats and Wildlife

For this performance measure, each option in the portfolio is assigned a habitat impact score, and an overall score for the portfolio is calculated based on the weighted average of option yields. Refer to Appendix C for more details on how this performance measure is assessed.

Any project that requires construction of pipelines or treatment plants has temporary habitat impacts. However, this analysis takes a long-term viewpoint and considers potential habitat impacts that would be sustained in the long-term. While habitat areas of imported water origin are at risk, there are other performance measures aimed at reducing imported water supply, such as Provide for Local Control and Independence, which would relieve stress on these ecosystems. For this reason, local habitat areas are considered for the impact of supply development and use on ecosystems.

For this objective, performance is based on potential long-term consequences to habitat associated with salinity impacts. Salinity management is an important water quality issue for San Diego, and is a consideration in water quality performance measures (discussed in Section D.10). Salinity can be removed from water supplies with advanced treatment technologies. However, this produces brine which must be disposed of properly. Brine is typically disposed of through an ocean outfall for dissipation with seawater, although potential long-term consequences to habitat areas located close to the outfall location are uncertain without available long-term monitoring data. In order to take this into account, any portfolios with options requiring advanced treatment process and disposal of brine, such as ocean desalination, indirect potable reuse, and groundwater treatment do not score well in this performance measure. Scores depend on the relative impacts of the option based on their brine concentrations (e.g. brine from ocean desalination has a higher concentration than brine from groundwater sources) and relative yields.

Figure D-12 presents the portfolio scores for habitat impacts, where a higher score means a positive impact and a lower score means a negative impact. Portfolio 3 has the highest score since it does not include projects that involve brine disposal, and it also includes the maximum level of conservation which reduces use of high salinity imported water. Other portfolios that score relatively well are 4 and 7. Portfolio 8 would have relatively neutral long-term habitat impacts (compared with the status quo). Portfolios 2, 5 and 6 score worse than the status quo, with Portfolio 5 having the lowest score since it includes ocean desalination, all phases of indirect potable reuse, and some groundwater projects that produce brine. In addition, Portfolio 5 does not include additional conservation to reduce imported water use.



Portfolios with less brine disposal and reduce use of high salinity imported water have higher scores.

Figure D-12
Protect Local Habitats and Wildlife Portfolio Performance

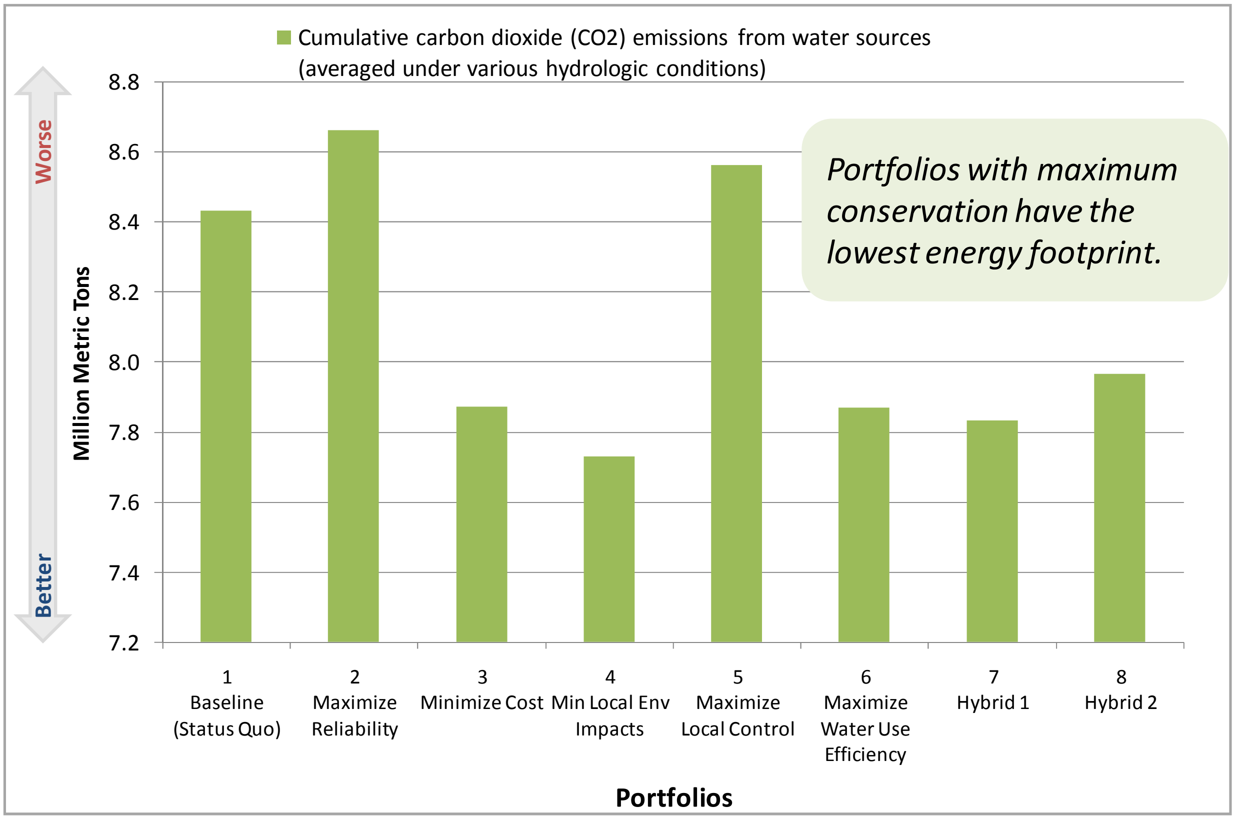
D.1.10 Reduce Energy Footprint

Refer to Appendix B for a description of how this performance measure is calculated using the City's SDSIM model.

For this analysis, greenhouse gas emissions are calculated based on typical per unit energy requirements for each source of water supply, including energy requirements for distribution and wastewater treatment if applicable. The energy required was converted to carbon dioxide equivalents. While imported water sources have different sources of energy than local water resources, it is assumed that all water resources use the same energy resource for simplicity. Therefore, portfolio variations in carbon dioxide emission for this analysis are a reflection of the energy required to produce water; not the type of energy used for each water resource. Figure D-13 presents the carbon dioxide emissions for each portfolio.

The baseline portfolio is showing relatively high carbon dioxide emissions, since imported water requires significant pumping for conveyance from Northern California and the Colorado River. While Portfolio 2 and Portfolio 5 reduce imported water use, they include options requiring advanced treatment processes with high energy requirements such as ocean desalination (the most energy intensive resource), indirect potable reuse, and groundwater desalination.

Figure D-13 presents the cumulative carbon dioxide emissions from water sources over the planning horizon. The results show that some portfolios are performing better than others; portfolios with significant reduction in carbon dioxide emissions all have the maximum level of conservation.



Portfolios with maximum conservation have the lowest energy footprint.

Figure D-13
Reduce Energy Footprint Portfolio Performance:
Total Carbon Dioxide Emissions over Planning Horizon

D.1.11 Protect Quality of Receiving Waters

Three performance measures were evaluated for the objective to protect quality of receiving waters: 1) cumulative reduction in stormwater and wastewater discharges to rivers and ocean, 2) concentration of total dissolved solids in water supply, and 3) potential water quality impacts to local groundwater basins.

Cumulative reduction in stormwater and wastewater discharges to rivers and ocean

Refer to Appendix B for a description of how this performance measure is calculated using the City's SDSIM model.

Reducing discharges of stormwater and wastewater to rivers and the ocean can help improve water quality conditions. Options evaluated in the 2012 LRWRP that help reduce stormwater discharges are rainwater harvesting with (1) on-site rain barrel or cisterns, and (2) centralized stormwater capture a diversion location. Options that reduce wastewater discharges include recycled water for non-potable or indirect potable reuse, graywater, and conservation (since conservation reduces indoor water consumption, a portion of which requires wastewater treatment). The reduction in discharges for a portfolio depends on the combination of options in the portfolio, and options with higher yields will have more potential to reduce discharges.

Figure D-14 presents the cumulative reduction in stormwater and wastewater discharges over the planning horizon for each portfolio. The portfolios with the greatest reduction in discharges are Portfolios 2, 5, 6, and 8, which include all phases of indirect potable reuse (with a combined yield of approximately 90,000 AFY). Portfolio 6 has the highest score since it also includes additional non-potable reuse, graywater, and rainwater harvesting options, although the combined reductions from these options are relatively small compared with those from indirect potable reuse.

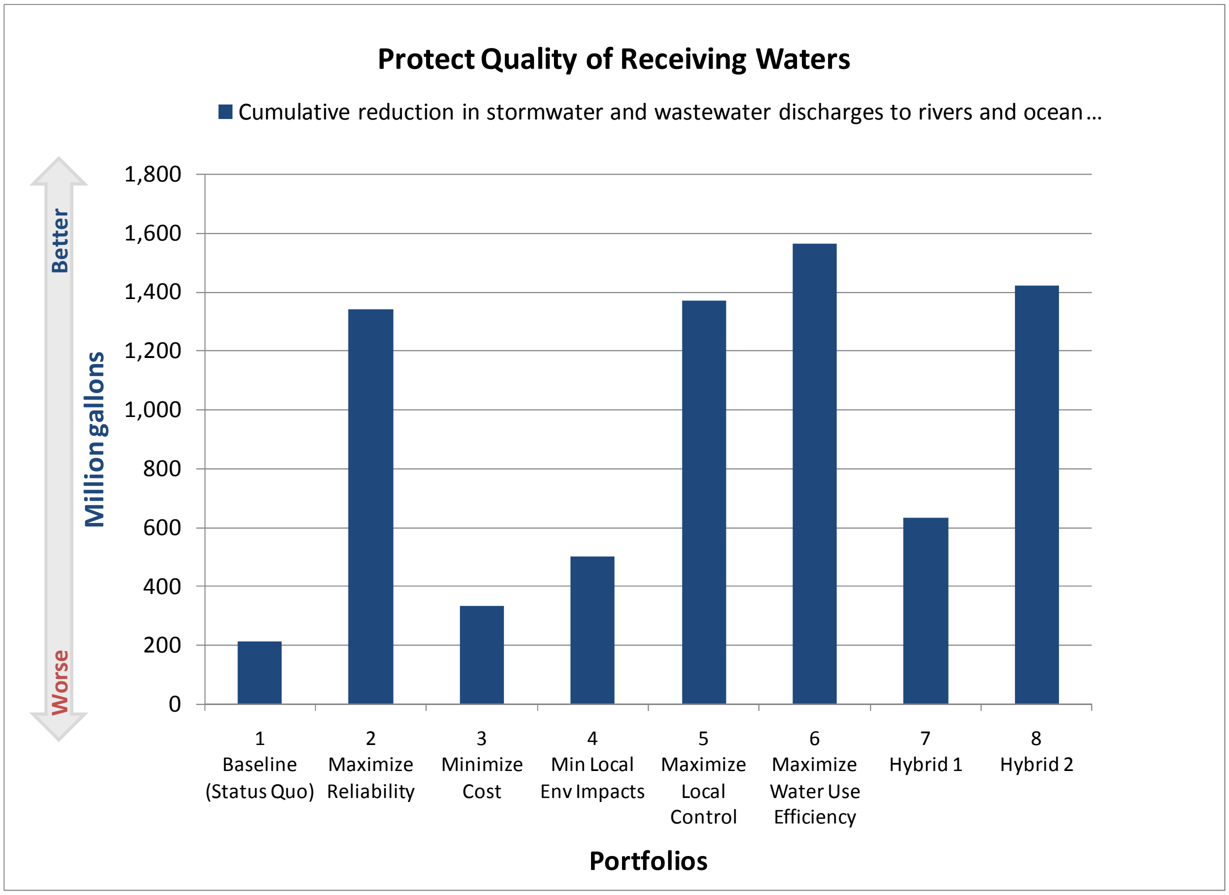


Figure D-14
Protect Quality of Receiving Waters Portfolio Performance:
Total Reduction in Stormwater and Wastewater Discharges over Planning Horizon

Concentration of total dissolved solids in water supply

Refer to Appendix B for a description of how this performance measure is calculated using the City's SDSIM model.

Salinity is an important issue for water management, since high salinity water can affect plant growth. Salinity is measured based on concentrations of total dissolved solids (TDS). Some of the City's current water sources for potable use have relatively high TDS concentrations, including imported water supplies from the Colorado River. Since a portion of potable water supply is used indoors, the salinity is carried through to the wastewater system and affects salinity of recycled water for non-potable reuse. Given salinity management issues, the primary constituent considered in scoring of this performance measure was salinity concentrations of potable water supplies.

Figure D-15 shows the average salinity concentrations of the overall potable water supply mix for each portfolio. The portfolios showing significant reductions in salinity (Portfolios 2, 5, 6, and 8) include every phase of indirect potable reuse projects, which involves advanced treatment that removes salinity prior to potable use. The potential yield for indirect potable reuse is much higher compared with other supply opportunities that have advanced treatment or lower salinity; therefore, it has more affect on the overall supply concentrations than other options.

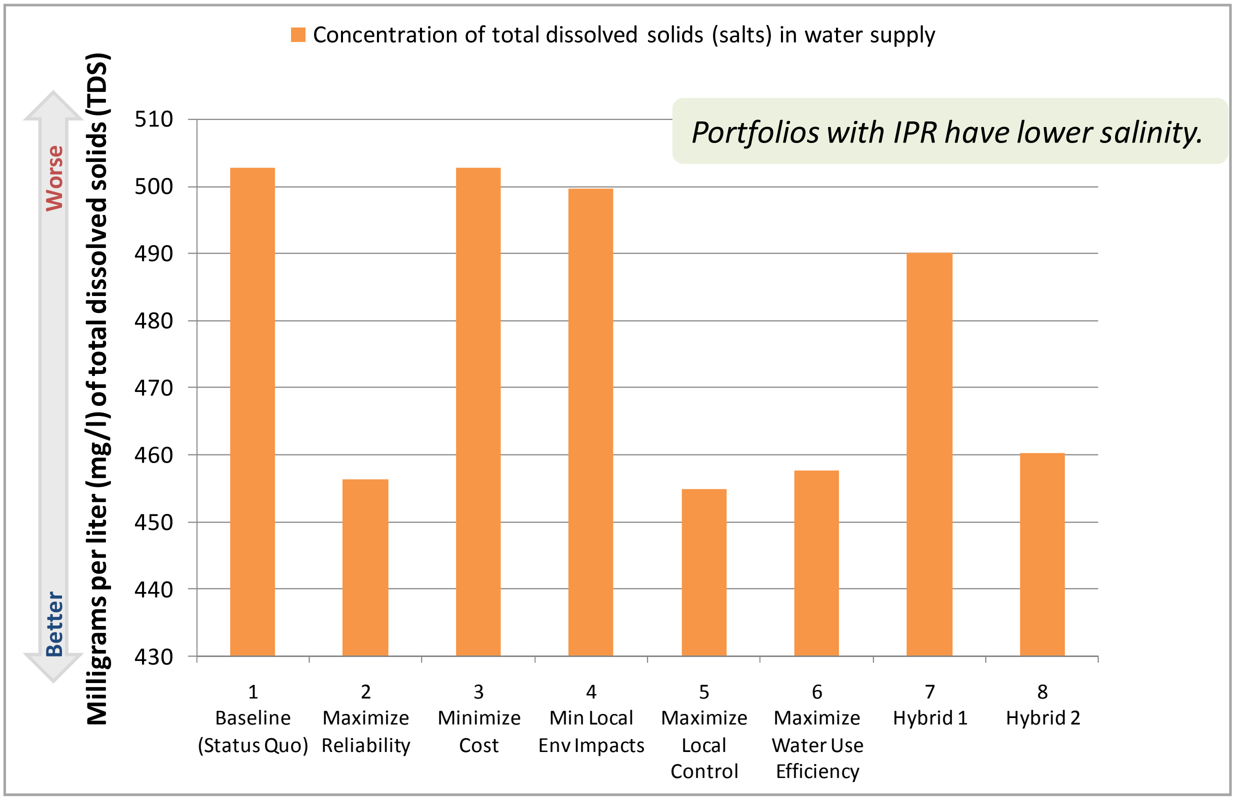


Figure D-15
Protect Quality of Receiving Waters Portfolio Performance:
Average Total Dissolved Solids Concentration in Potable Water Supply over Planning Horizon

Potential water quality impacts to local groundwater basins

For this performance measure, each portfolio is assigned a groundwater quality score based on qualitative assessment. Refer to Appendix C for more details on how this performance measure is assessed.

The City aims to maintain the health of local groundwater basins in terms of both water quantity and water quality. To assess potential groundwater quality impacts, this performance measure is intended to represent very general trends associated with using various water sources. However, generalizations are very subjective since a water source may have better quality for one constituent but worse quality in another constituent when compared with another water source. The primary constituent considered in scoring of this performance measure was salinity concentrations.

Groundwater quality can be influenced by the water quality of water sources that recharge the groundwater aquifer (e.g. through artificial recharge or surface infiltration from irrigation, where unconfined basins exist). Therefore, options with advanced treatment processes that improve water quality (e.g. indirect potable reuse and ocean desalination) could have positive impacts to groundwater quality compared with imported water. In addition, water extracted from the basin that undergoes advanced treatment removes salts from the system and can improve groundwater quality over time.

Options that have the potential to improve salinity conditions in groundwater basins include advanced treatment processes such as San Pasqual Integrated Conjunctive Use, Indirect Potable Reuse, and Mission Valley groundwater. Aquifer storage and recovery in the San Diego Formation may have the potential to improve groundwater quality in the basin although this will require further investigation.

Any portfolio that includes graywater will have a lower score since there is still much uncertainty regarding the water quality from graywater systems. In addition, graywater quality is very dependent on behaviors of homeowners (type of detergents used, soiled cloth) and maintenance of the graywater filters. Therefore, graywater is assumed to have relatively poorer water quality than the City's existing water sources.

Other options are assumed to have a relatively neutral affect on groundwater quality compared with the status quo sources of supply. Note that non-potable recycled water options generally do not supply areas that overlie groundwater basins that are recharged through surface infiltration.

Figure D-16 presents the portfolio scores for potential water quality impacts to local groundwater basins. Portfolio 2 is showing the highest score since it includes options with advanced treatment processes including San Pasqual Integrated Conjunctive Use, all phases of indirect potable reuse, ocean desalination, and Mission Valley groundwater. Portfolios 5 and 8 score well since they include all phases of indirect potable reuse and Mission Valley groundwater. Portfolio 5 also includes ocean desalination, while Portfolio 8 includes San Diego Formation Aquifer Storage and Recovery. Portfolio 7 has a slightly higher score (compared with the status quo) since it includes the first phase of indirect potable reuse. Although Portfolio 6 includes all phases of indirect potable reuse, it receives a neutral score due to the uncertainty regarding water quality from graywater systems. The remaining portfolios have relatively neutral scores in comparison to the status quo.

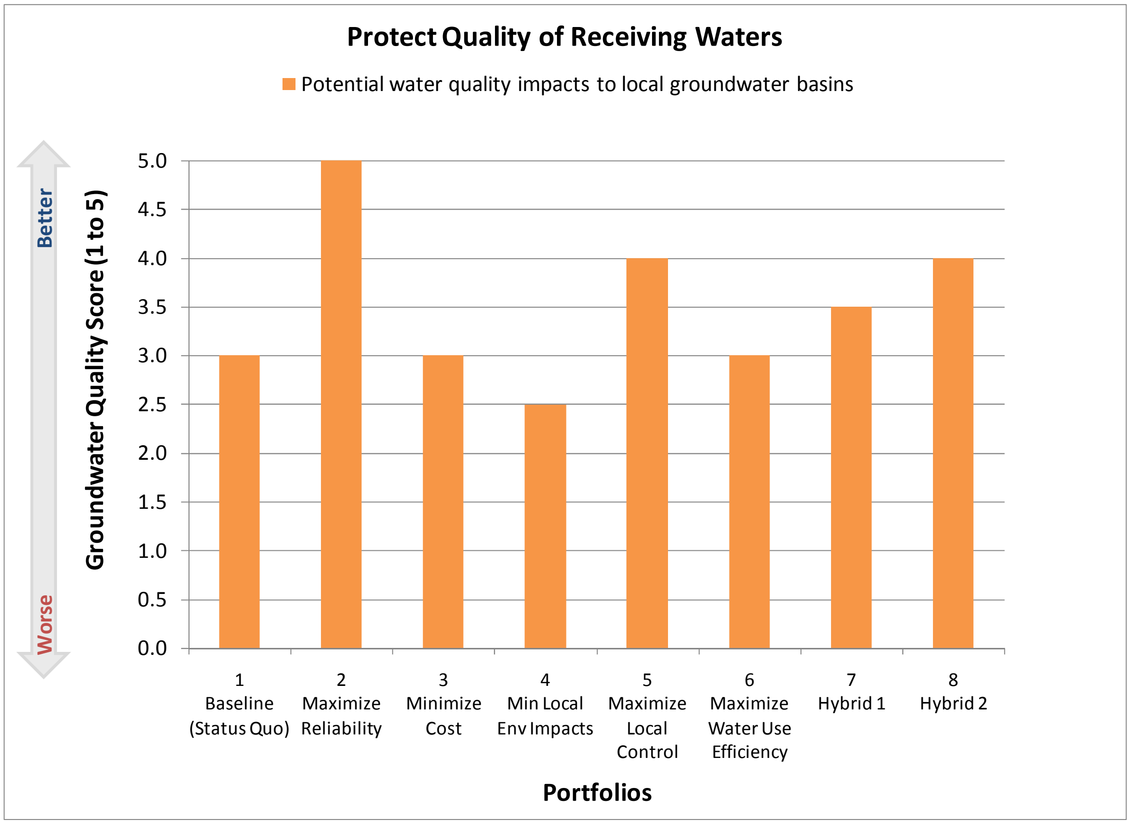


Figure D-16

Protect Quality of Receiving Waters Portfolio Performance: Potential water quality impacts to local groundwater basins

D.2 Portfolio Ranking Example

Section D.1 presents the “raw” portfolio performance based on output from the City’s SDSIM model. This information is summarized for each portfolio in what is called a portfolio performance scorecard (see Table 6-1). Because the “raw” output provided by SDSIM is in different units (e.g., water supply in acre-feet, or cost in dollars), a decision tool is needed to standardize the raw metrics and to apply the relative weights for each of the objectives in order to rank the portfolios. For this purpose, the multi-attribute rating software called Decision Criterium Plus (CDP) was used (refer to Section 5.5.2 for a description of CDP). The following provides an example of how the raw portfolio performance is used in CDP for the ‘Maximize Water Use Efficiency’ (Max Efficiency) portfolio.

There are two primary inputs to CDP: (1) raw performance of a portfolio against each perforamnce measure; and (2) the relative importance of the objectives and performance measures (see Figure D-17).

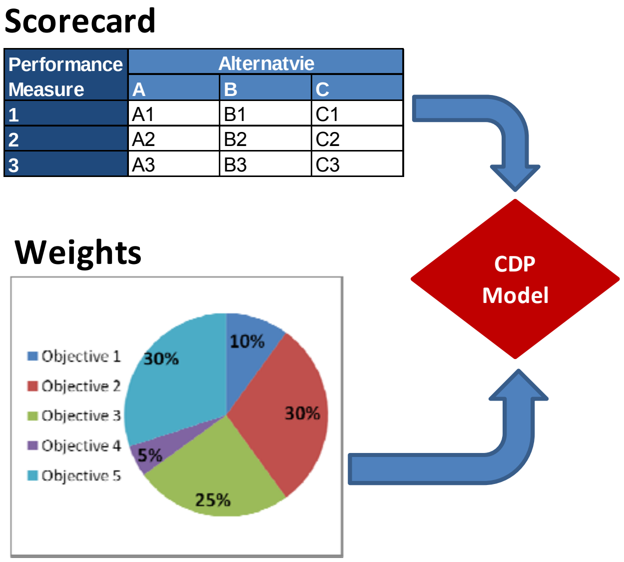


Figure D-17
Inputs to CDP

The raw performance scorecard for the Max Efficiency portfolio is shown in Table D-1. The CDP model standardizes these scores to a unitless scale that ranges from 0 to 1, as shown in the yellow column of Table D-1.

The weights of the objectives were assigned by the LRWRP Stakeholder Committee. Since objectives and performance measures have a hierarchal structure, the objective weights are multiplied by the performance measure weights to calculate and overall weight for each performance measure. This is demonstrated in Table D-2.

The CDP model multiplies the unitless performance scores (in yellow column of Table D-1) by the relative weights for each performance measure (in yellow column of Table D-2). The resulting values are shown in Table D-3. These weighted unitless performance scores are then aggregated to the objective level and an overall portfolio score is determined (see Table D-3 and Figure D-18). This process is repeated for each portfolio and then portfolios are ranked based on their overall scores (refer to Figure 6-9).

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Table D-1. Portfolio Performance Score Card for 'Maximize Water Use Efficiency' Portfolio

Objective	Performance Measure	Units	Raw Performance Scorecard (from SDSIM)	Standardized Unitless Score (from CDP)
Provide Reliability and Robustness	Cumulative water shortages over planning horizon (averaged under various hydrologic conditions)	Total water shortages in acre-feet (AF)	153,585	0.973
	Resilience to Climate Change	Hydrologic Variability Score Score of 1 to 5, 1 - high variability, 5 - low variability	2.0	0.75
	Ratio of emergency supply to six tenths of annual demand	Percentage (%)	97%	0.935
Manage Cost and Provide Affordability	Total present value costs to the City PUD and customers/developers, both capital and O&M, over planning period	Dollars ($)	7,096,152,512	0
	Amount of City PUD annual capital costs relative to total annual costs to City PUD	Percentage (%)	8%	0.11
	Potential for external funding	External Funding Score Score of 1 to 5, 1 - low funding opportunities, 5 - high funding opportunities	1.0	0.75
Maximize Efficiency of Water Use	Cumulative level of water conservation and reclamation over the planning horizon (averaged under various hydrologic conditions)	Acre-feet (AF)	1,345,799	1
Provide for Scalability of Implementation	Flexibility for project phasing and expansions	Scalability Score Score of 1 to 5, 1 - low scalability, 5 - high scalability	5.0	0.5
Maintain Current & Future Assets	Cumulative amount of water supplied from existing drinking water treatment plants, recycled water plants, and groundwater sources (averaged under various hydrologic conditions)	Acre-feet (AF)	6,781,192	0.478
Provide for Local Control/Independence	Total local resources[1]	Acre-feet (AF)	102,326	1
Maximize Project Readiness	Public education effort for supply development and use	Public Education Score Score of 1 to 5, 1 - significant public education effort, 5 - minimal public education effort	5.0	0.5
	Implementation risk developing a water supply due to regulatory (reg) or permitting challenges	Implementation Risk Score Score of 1 to 5, 1 - significant reg/permitting challenges, 5 - minimal reg/permitting challenges	4.0	0.375
Protect Quality of Life	Potential for local job creation	Job Creation Score	827	0.999
	Potential for recreation/open space benefits	Recreation/Open Space Score Score of 1 to 5, 1 - no recreation/open space benefits, 5 - high recreation/open space benefits	1.0	1

Table D-1. Portfolio Performance Score Card for 'Maximize Water Use Efficiency' Portfolio

Objective	Performance Measure	Units	Raw Performance Scorecard (from SDSIM)	Standardized Unitless Score (from CDP)
Protect Habitats & Wildlife	Impact of supply development and use on ecosystems	Habitat Impact Score Score of 1 to 5, 1 - high negative impact, 5 - high positive impact	3.0	0.375
Reduce Energy Footprint	Cumulative carbon dioxide (CO_2) emissions from water sources (averaged under various hydrologic conditions)	Metric Tons of CO_2	8,432,098	0.85
Protect Quality of Receiving Waters	Cumulative reduction in stormwater and wastewater discharges to rivers and ocean (averaged under various hydrologic conditions)	Million gallons (mg)	210	0.999
	Concentration of total dissolved solids (salts) in water supply	Milligrams per liter (mg/l) of total dissolved solids (TDS)	503	0.91
	Potential water quality impacts to local groundwater basins	Groundwater Quality Score Score of 1 to 5, 1 - high negative impact, 5 - high positive impact	3.0	0.5

[1] Local resources include any non-imported supply, such as conservation, groundwater, recycled water, stormwater, and ocean desalination.

Table D-2. Objective and Performance Measure Weights

Objective	Objective Weight	Performance Measures	Performance Measure Weight	Overall Performance Measure Weight (sum =100 percent)
Provide Reliability & Robustness	16.3%	Cumulative water shortages over planning horizon (averaged under various hydrologic conditions)	50.0%	8.14%
		Resilience to Climate change	20.0%	3.25%
		Ratio of emergency supply to six tenths of annual demand	30.0%	4.88%
Manage Cost and Provide Affordability	13.6%	Total present value costs to the SDPUD and customers/developers, both capital and O&M, over planning period	50.0%	6.82%
		Amount of SDPUD annual capital costs relative to total annual costs to SDPUD	30.0%	4.09%
		Potential for external funding	20.0%	2.73%
Maximize Efficiency of Water Use	10.2%	Cumulative level of water conservation and reclamation over the planning horizon (averaged under various hydrologic conditions)	100.0%	10.18%
Provide for Scalability of Implementation	9.6%	Flexibility for project phasing and expansions	100.0%	9.64%
Maintain Current & Future Assets	9.2%	Cumulative amount of water supplied from existing drinking water treatment plants, recycled water plants, and groundwater sources (averaged under various hydrologic conditions)	100.0%	9.18%
Provide for Local Control/Independence	8.1%	Total local resources[1]	100.0%	8.09%
Maximize Project Readiness	6.6%	Public education effort for supply development and use	50.0%	3.32%
		Implementation risk developing a water supply due to regulatory or permitting challenges	50.0%	3.32%
Protect Quality of Life	6.7%	Potential for local job creation	50.0%	3.36%
		Potential for recreation/open space benefits	50.0%	3.36%
Protect Habitats & Wildlife	4.8%	Impact of supply development and use on ecosystems	100.0%	4.82%
Reduce Energy Footprint	8.3%	Cumulative carbon dioxide (CO_2) emissions from water sources (averaged under various hydrologic conditions)	100.0%	8.27%
Protect Quality of Receiving Waters	6.5%	Cumulative reduction in stormwater and wastewater discharges to rivers and ocean (averaged under various hydrologic conditions)	50.0%	3.27%
		Concentration of total dissolved solids (salts) in potable water supply	25.0%	1.64%
		Potential water quality impacts to local groundwater basins	25.0%	1.64%

[1] Local resources include any non-imported supply, such as conservation, groundwater, recycled water, stormwater, and ocean desalination.

Table D-3. Weighted Standardized Scores for 'Maximize Water Use Efficiency' Portfolio

Objective	Performance Measure	Weighted Unitless Score (calculated by multiplying yellow column in Table D-1 by yellow column in Table D-2)	Weighted Unitless Score Aggregated by Objective
Provide Reliability and Robustness	Cumulative water shortages over planning horizon (averaged under various hydrologic conditions)	0.079	0.149
	Resilience to Climate Change	0.024	
	Ratio of emergency supply to six tenths of annual demand	0.046	
Manage Cost and Provide Affordability	Total present value costs to the City PUD and customers/developers, both capital and O&M, over planning period	0.000	0.025
	Amount of City PUD annual capital costs relative to total annual costs to City PUD	0.005	
	Potential for external funding	0.020	
Maximize Efficiency of Water Use	Cumulative level of water conservation and reclamation over the planning horizon (averaged under various hydrologic conditions)	0.102	0.102
Provide for Scalability of Implementation	Flexibility for project phasing and expansions	0.048	0.048
Maintain Current & Future Assets	Cumulative amount of water supplied from existing drinking water treatment plants, recycled water plants, and groundwater sources (averaged under various hydrologic conditions)	0.044	0.044
Provide for Local Control/Independence	Total local resources[1]	0.081	0.081
Maximize Project Readiness	Public education effort for supply development and use	0.017	0.029
	Implementation risk developing a water supply due to regulatory (reg) or permitting challenges	0.012	
Protect Quality of Life	Potential for local job creation	0.034	0.067
	Potential for recreation/open space benefits	0.034	
Protect Habitats & Wildlife	Impact of supply development and use on ecosystems	0.018	0.018
Reduce Energy Footprint	Cumulative carbon dioxide (CO2) emissions from water sources (averaged under various hydrologic conditions)	0.070	0.070
Protect Quality of Receiving Waters	Cumulative reduction in stormwater and wastewater discharges to rivers and ocean (averaged under various hydrologic conditions)	0.033	0.056
	Concentration of total dissolved solids (salts) in water supply	0.015	
	Potential water quality impacts to local groundwater basins	0.008	
OVERALL PORTFOLIO SCORE:		**0.689**	**0.689**
1 Local resources include any non-imported supply, such as conservation, groundwater, recycled water, stormwater, and ocean desalination.			

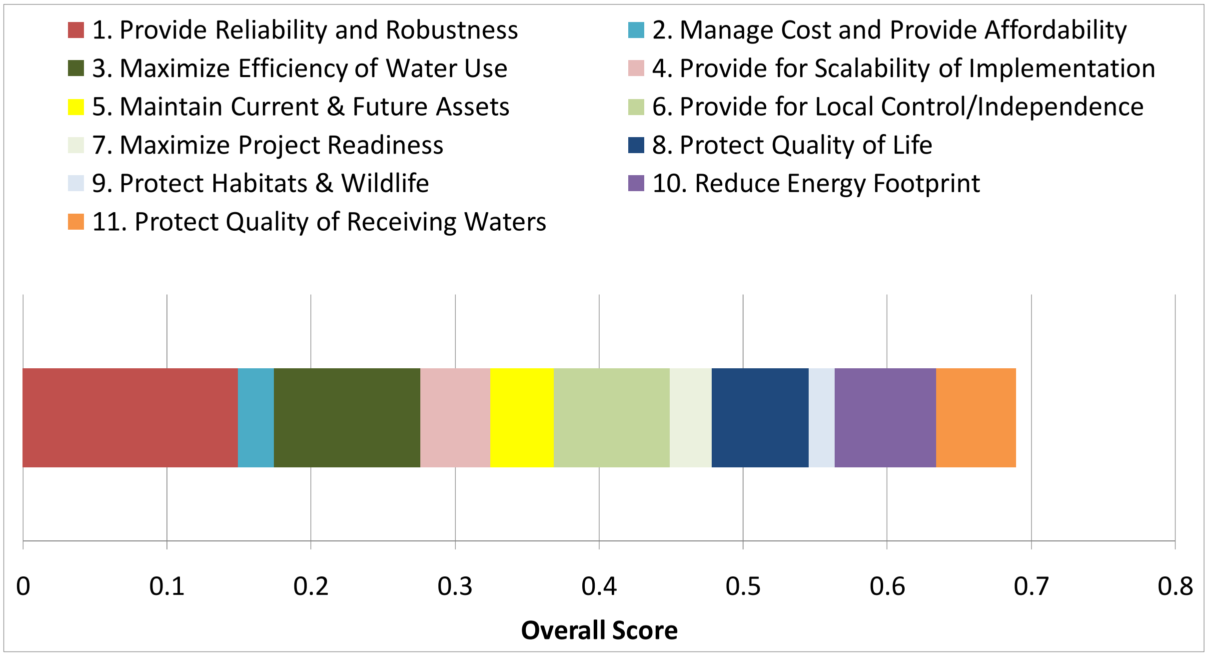


Figure D-18
Overall Max Efficiency Portfolio Score

D.3 Portfolio Supply Mix Charts

The projected annual supply mix charts resulting from SDSIM model simulations are provided in this appendix (refer to Appendix B for more information regarding the SDSIM model). As described in Appendix B, four hydrologic sequences were selected based on historical records to represent critically dry, dry, normal and wet conditions. The charts in this Appendix show the supply mix for the portfolios over time for the “normal” and “critically dry” hydrologic conditions.

It is important to note that the definition of “normal” and “critically dry” hydrologic conditions is based on the total cumulative shortages over the 25-year period. This metric was used to define the hydrologic condition because weather impacts on demands, local hydrology, and availability of imported water are not well correlated—meaning that there are some years in which local hydrology results in plentiful surface water supplies for the City, but imported water is limited due to the hydrologic conditions in Northern California, or vice versa. Because of this, in the “critically dry” hydrologic condition, there are years in which local surface water are quite high. But in these same years, imported water (which tends to drive shortages because of the City’s high dependency) is restricted. It should also be noted that these charts often show local surface water in excess of historical high deliveries of 97,000 AFY. This is due to two factors that occur into the future: (1) increased water treatment capacity, that allows more local surface water to be produced; and (2) new surface water supplies from Lake Hodges.

Potential shortage years are based on the hydrologic conditions in which MWD is projecting supply shortages in the base imported water reliability condition (defined in Section 3). Imported water shortages vary from year to year and are a function of both the specific hydrologic year (direct precipitation and temperature) and cumulative hydrologic conditions (affecting availability of water in storage). If there are not sufficient local supplies to fill the gaps, a shortage for the City is reported in the SDSIM model. Note that shortages are resolved for some portfolios in later years, but there is some near-term risk of shortage in earlier years before new options could be implemented.

The existing and potential new supplies included in each portfolio are summarized at the top of each page. Refer to Section 5.4 for more information on the definition of portfolios and the categories of options. If an option category is not included in the portfolio, it will not show in the bar charts. (Note that the chart legends are standardized to represent all potential options – not the specific options in each portfolio. This is because charts are dynamically linked to modeling output.) In some cases, such as Rainwater Harvesting and Graywater, the yields are significantly smaller than other supply options. Because the relative yields of these options are smaller, they are not clearly shown in the bar charts given the scales used to display total overall supply in acre-feet per year (e.g. this is evident in Portfolios 4 and 6 which include both Rainwater Harvesting and Graywater options).

For modeling purposes only, the timing of future supplies was assumed based on the approximate 5-year timeframe projects could be implemented, and should not be mistaken for the City’s plans for implementation of projects.

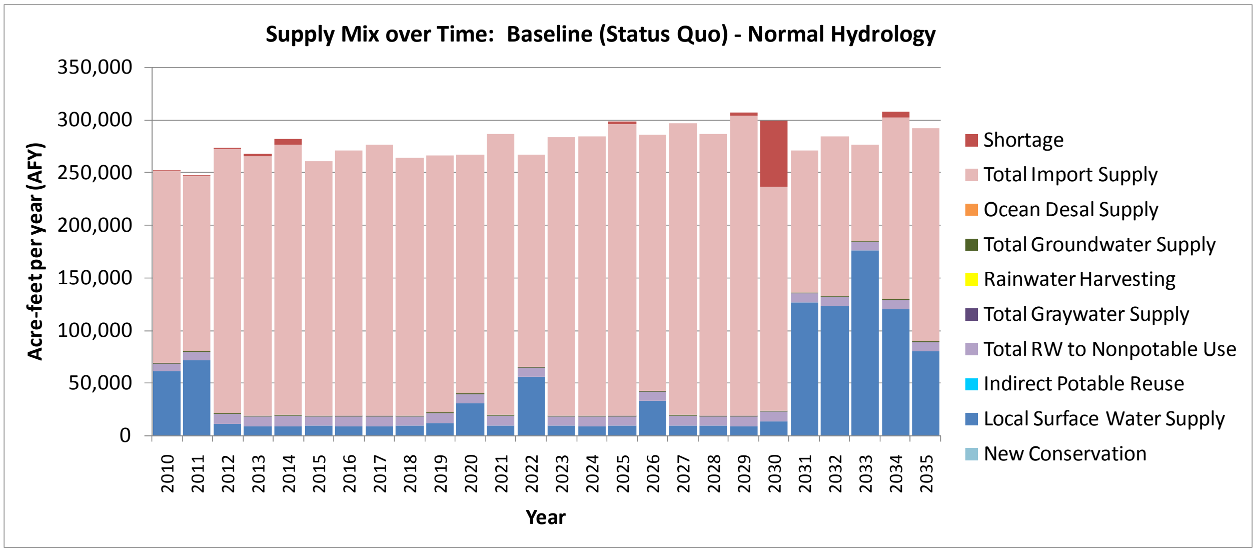
Portfolio 1: Baseline (Status Quo)

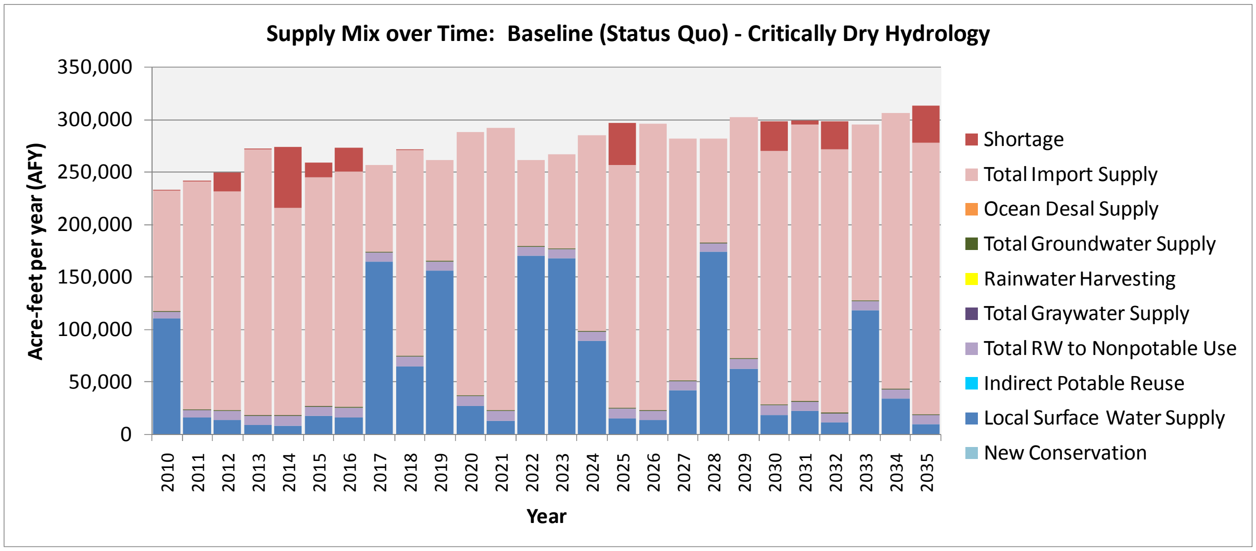
Baseline Options

- Baseline conservation
- Baseline local surface runoff to City reservoirs
- Baseline groundwater supply
- Baseline non-potable reuse
- Imported water purchases from SDCWA

New Options

- None. Purchase additional SDCWA imported water supplies as needed and available.





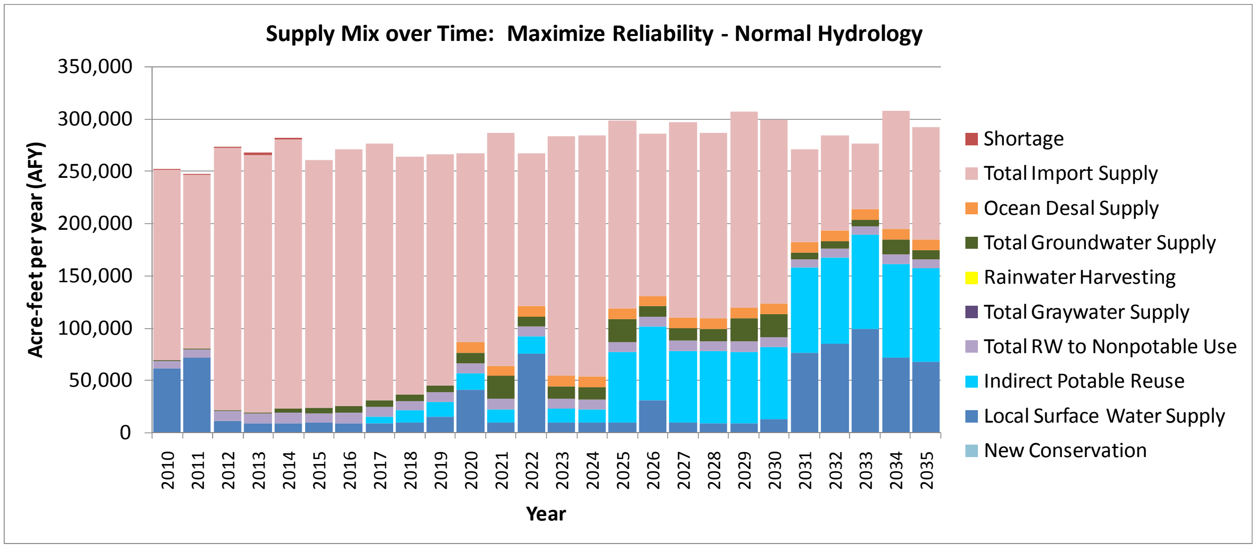
Portfolio 2: Maximize Reliability

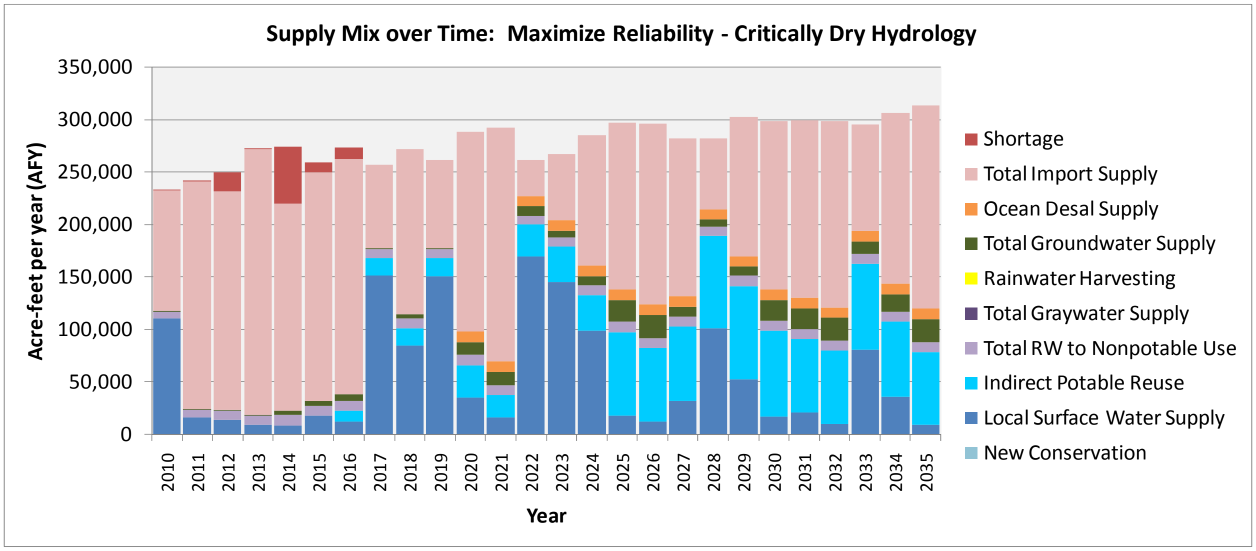
Baseline Options

- Baseline conservation
- Baseline local surface runoff to City reservoirs
- Baseline groundwater supply
- Baseline non-potable reuse
- Imported water purchases from SDCWA

New Options

- San Pasqual Basin: Integrated Conjunctive Use and Groundwater Desalination
- Santee – El Monte Basin Groundwater
- San Diego Formation Basin Groundwater: Extraction Only
- San Diego Formation Basin: Aquifer Storage and Recovery
- Mission Valley Basin Groundwater
- Ocean Desalination
- Indirect Potable Reuse - Phase 1,2,3





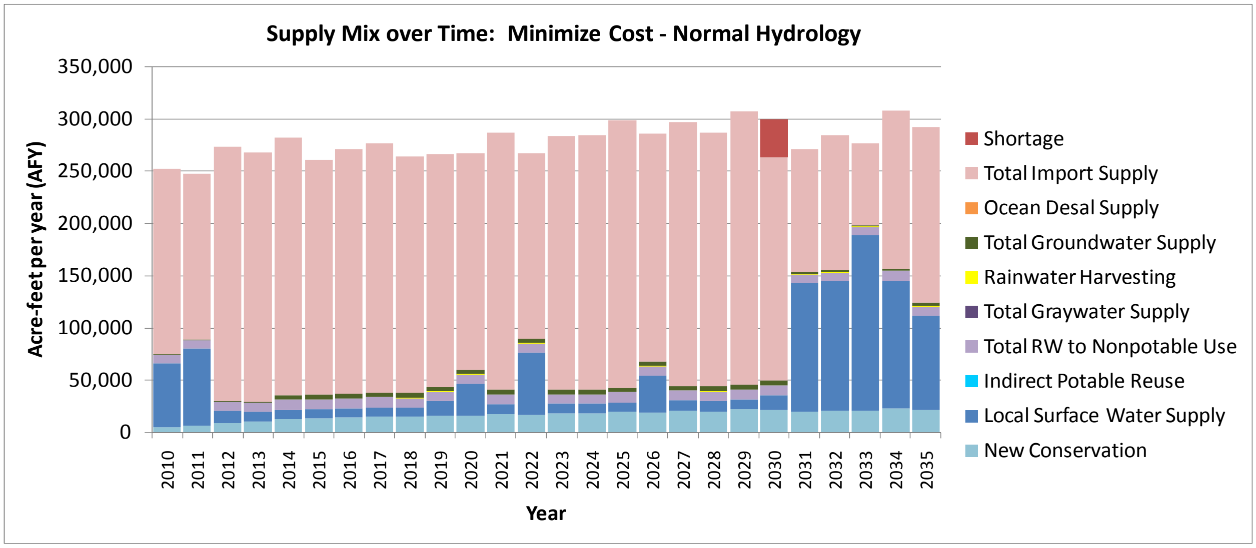
Portfolio 3: Minimize Cost

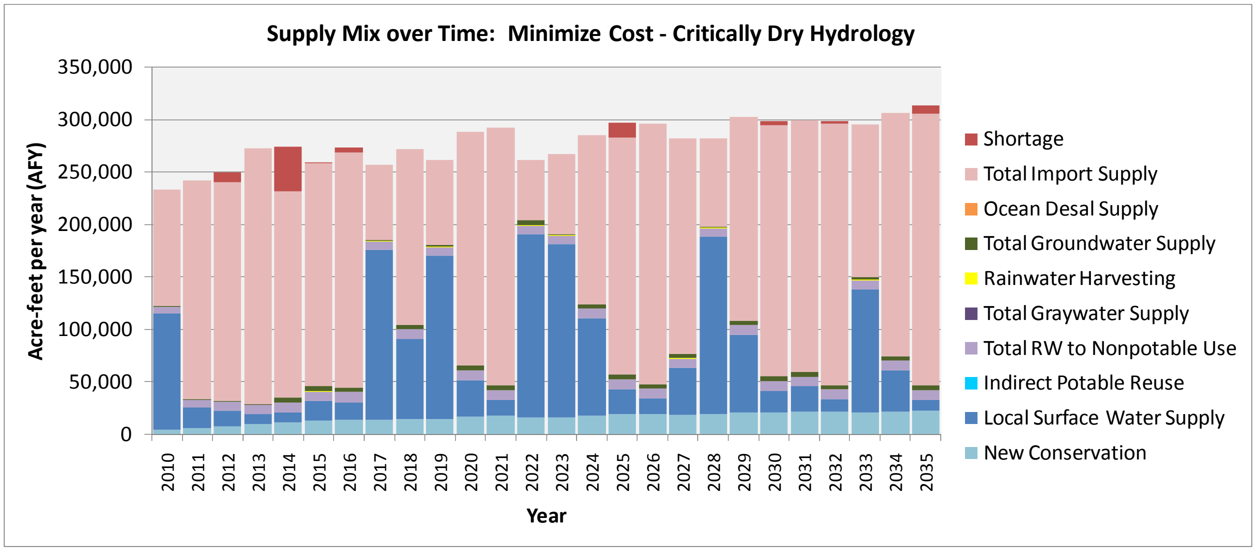
Baseline Options

- Baseline conservation
- Baseline local surface runoff to City reservoirs
- Baseline groundwater supply
- Baseline non-potable reuse
- Imported water purchases from SDCWA

New Options

- Additional active conservation
- Additional active conservation and price effects
- Santee – El Monte Basin
- San Diego Formation Basin: Extraction only
- Rain barrels (onsite capture)





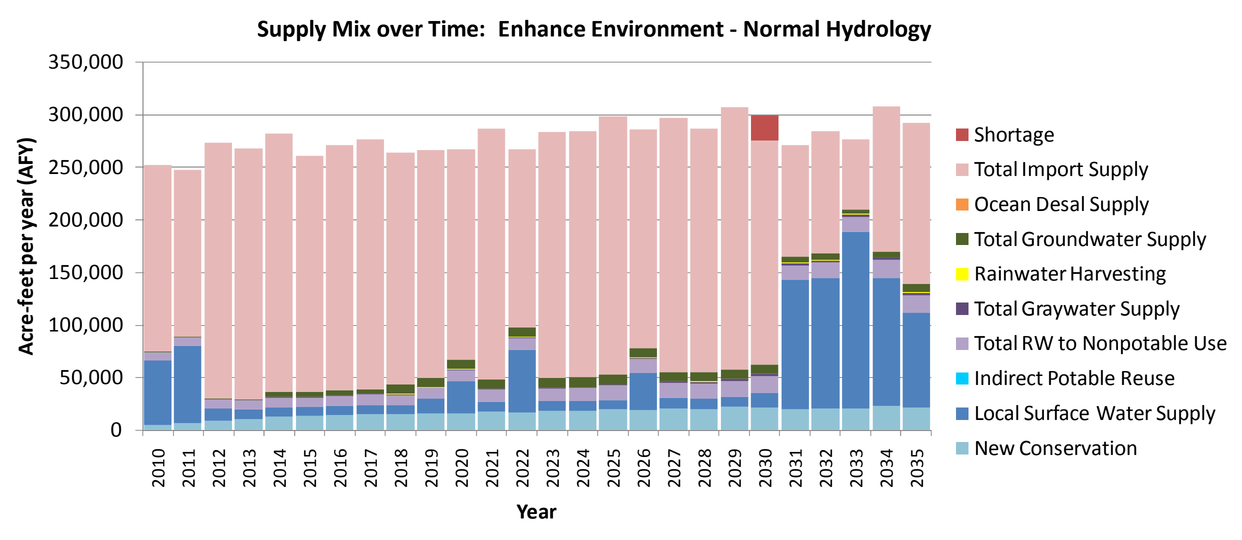
Portfolio 4: Minimize Local Enivornmental Impacts

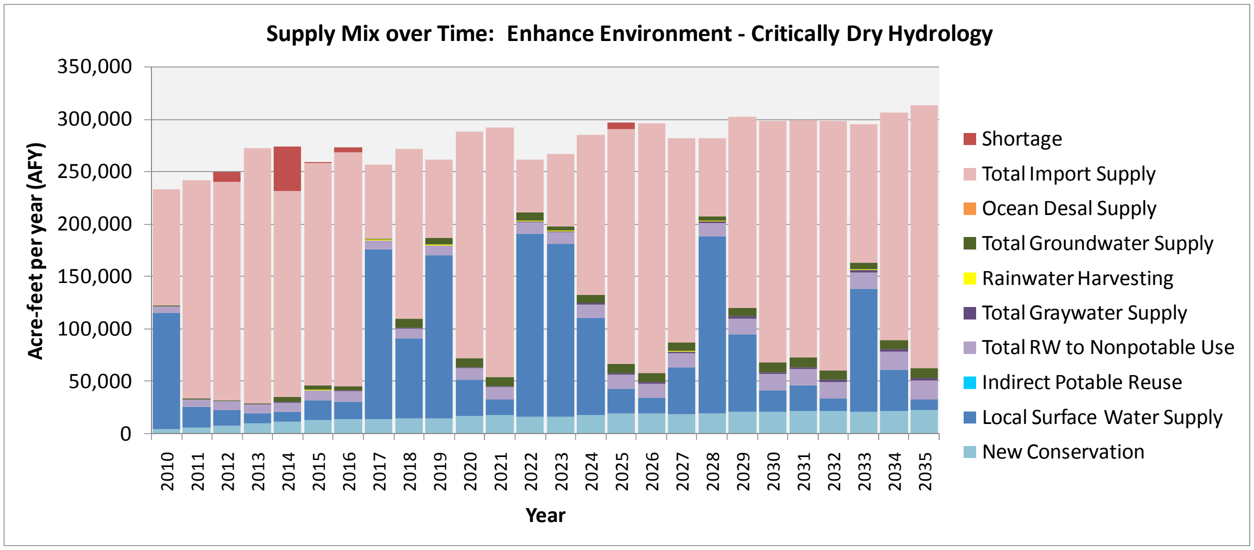
Baseline Options

- Baseline conservation
- Baseline local surface runoff to City reservoirs
- Baseline groundwater supply
- Baseline non-potable reuse
- Imported water purchases from SDCWA

New Options

- Additional active conservation
- Additional active conservation and price effects
- San Pasqual Basin – Agricultural water exchange
- Santee – El Monte Basin
- San Diego Formation Basin: Extraction only
- New non-potable demands from new privately-developed satellite plants
- New non-potable demands from existing reclamation plants
- Residential graywater
- Rain barrels (onsite capture)
- Centralized stormwater capture





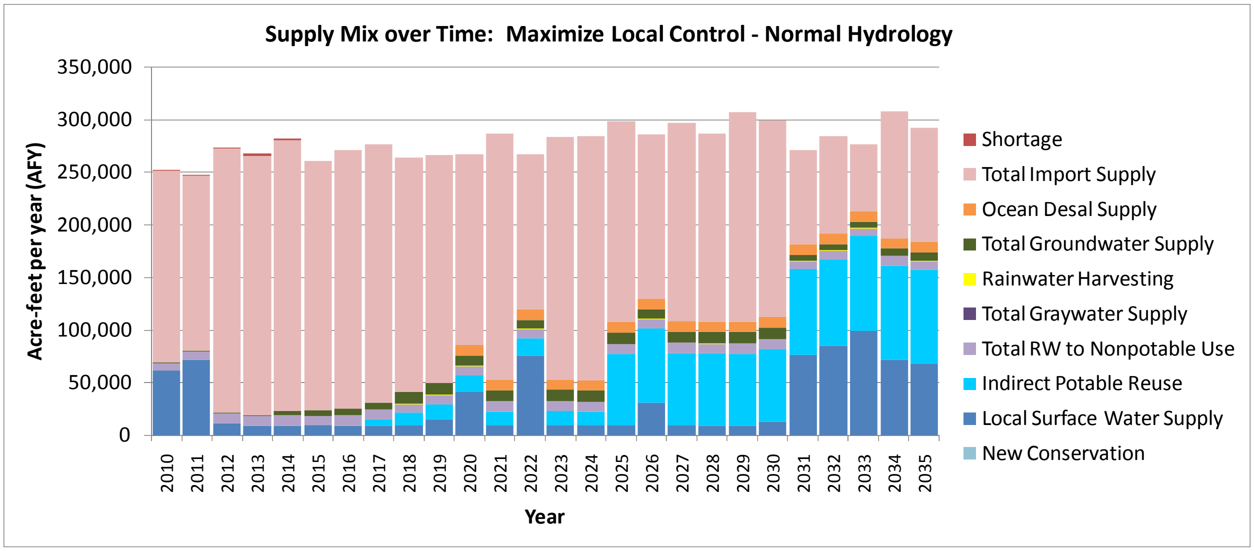
Portfolio 5: Maximize Local Control

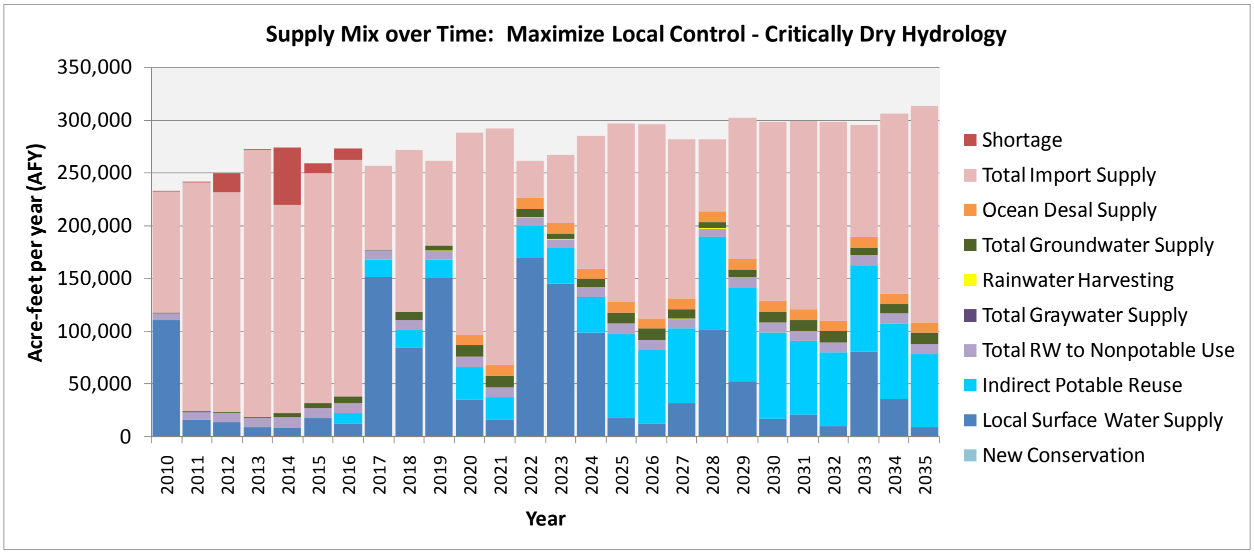
Baseline Options

- Baseline conservation
- Baseline local surface runoff to City reservoirs
- Baseline groundwater supply
- Baseline non-potable reuse
- Imported water purchases from SDCWA

New Options

- San Pasqual Basin – agricultural water exchange
- Santee – El Monte Basin
- San Diego Formation Basin: extraction only
- Mission Valley Basin
- Ocean desalination
- Indirect potable reuse – Phase 1,2,3
- Centralized stormwater capture





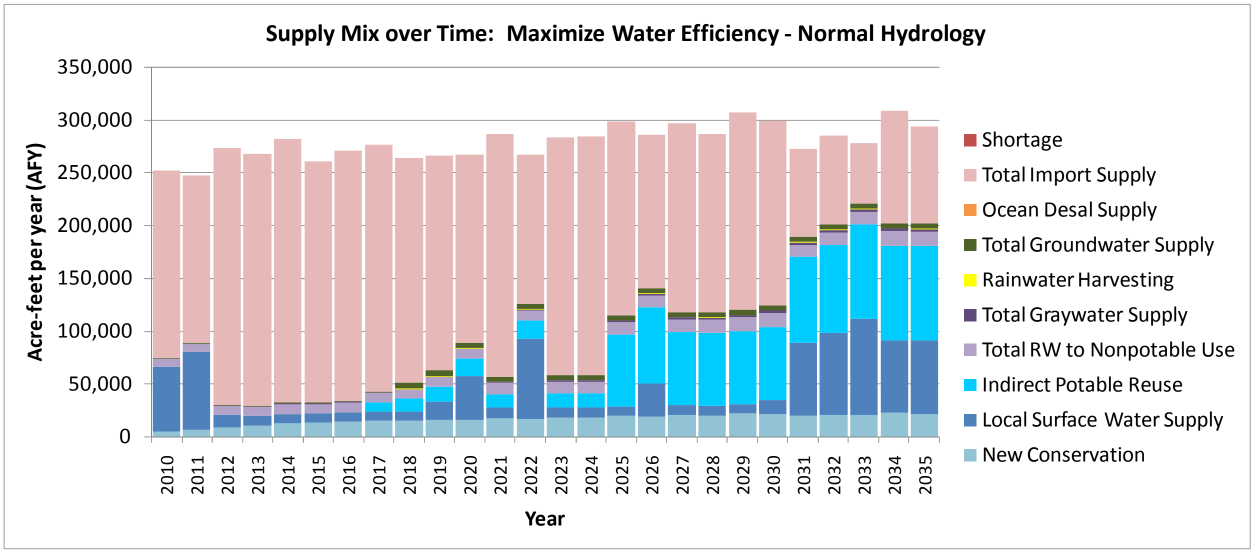
Portfolio 6: Maximize Water Efficiency

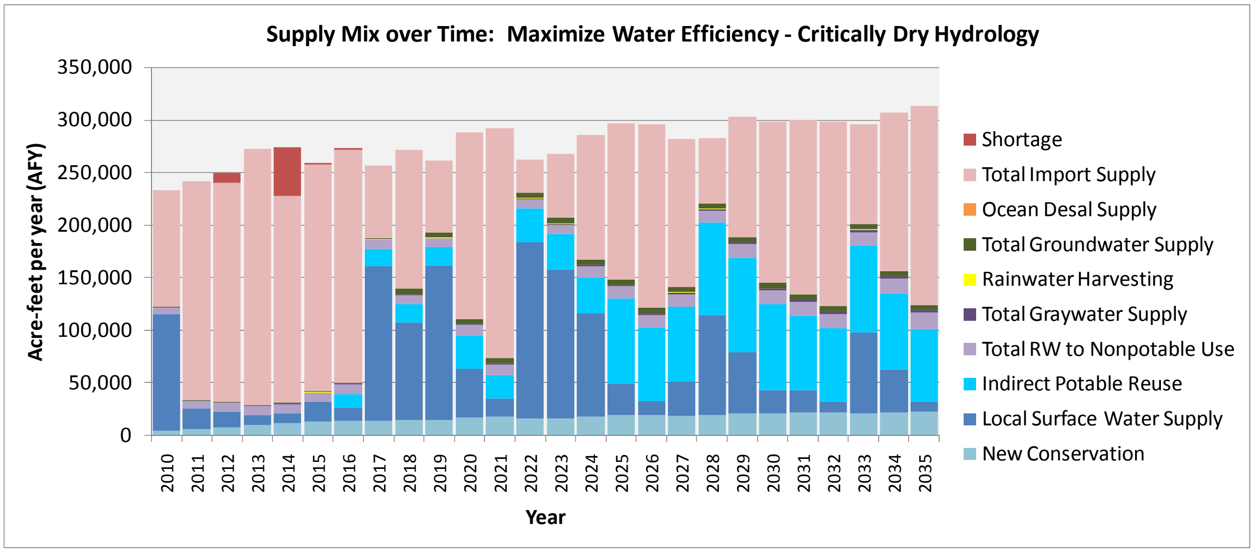
Baseline Options

- Baseline conservation
- Baseline local surface runoff to City reservoirs
- Baseline groundwater supply
- Baseline non-potable reuse
- Imported water purchases from SDCWA

New Options

- Additional active conservation
- Additional active conservation and price effects
- San Pasqual Basin – agricultural water exchange
- New non-potable demands from new privately developed satellite plants
- Indirect potable reuse – Phase 1,2,3
- Residential graywater
- Rain barrels (onsite capture)
- Centralized stormwater capture





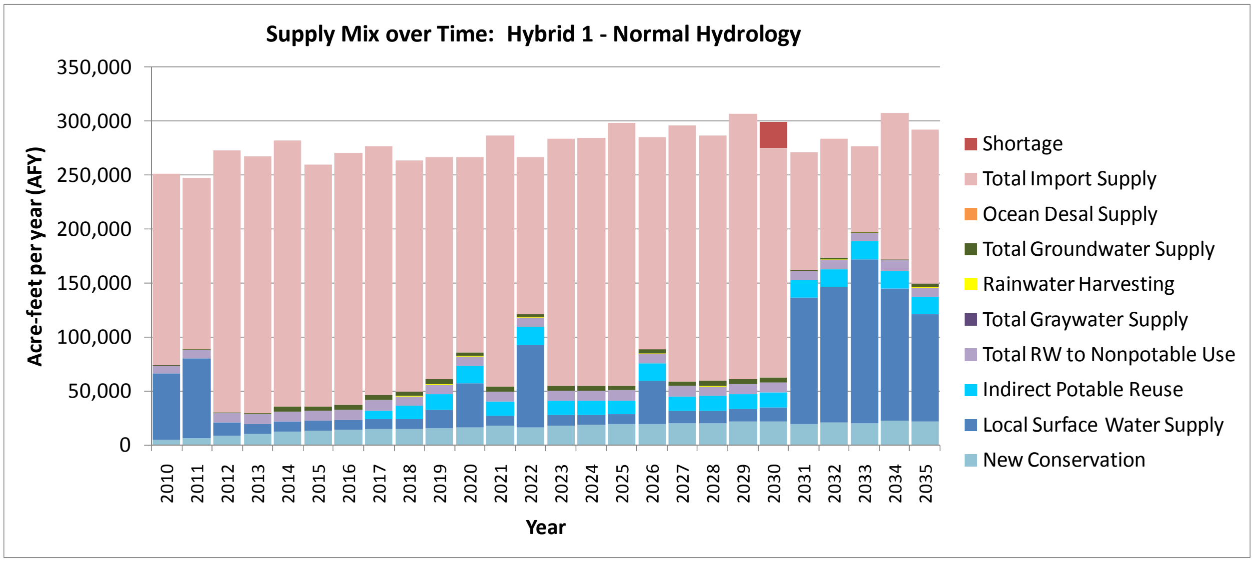
Portfolio 7: Hybrid 1

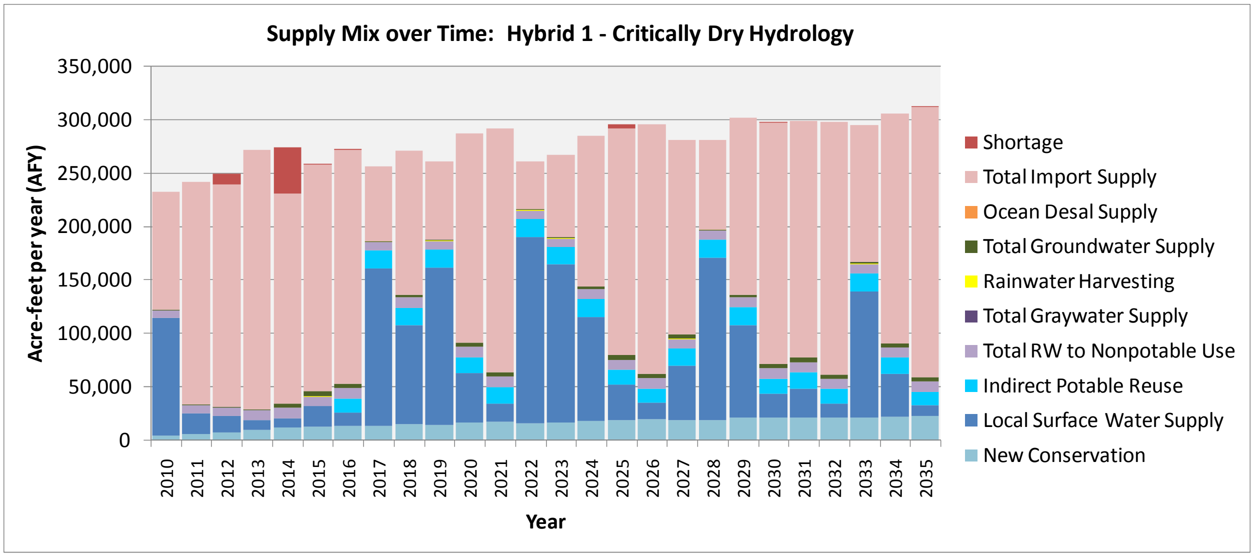
Baseline Options

- Baseline conservation
- Baseline local surface runoff to City reservoirs
- Baseline groundwater supply
- Baseline non-potable reuse
- Imported water purchases from SDCWA

New Options

- Additional active conservation
- Additional active conservation and price effects
- Santee – El Monte Basin
- San Diego Formation Basin: extraction only
- Indirect potable reuse – Phase 1
- Rain barrels (onsite capture)





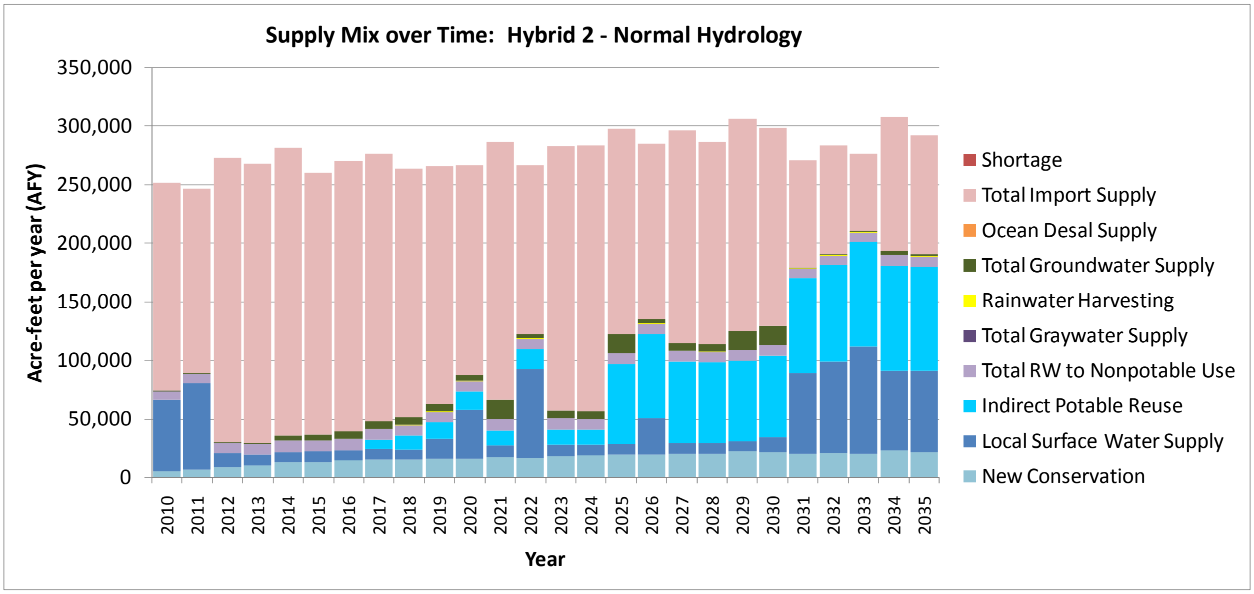
Portfolio 8: Hybrid 2

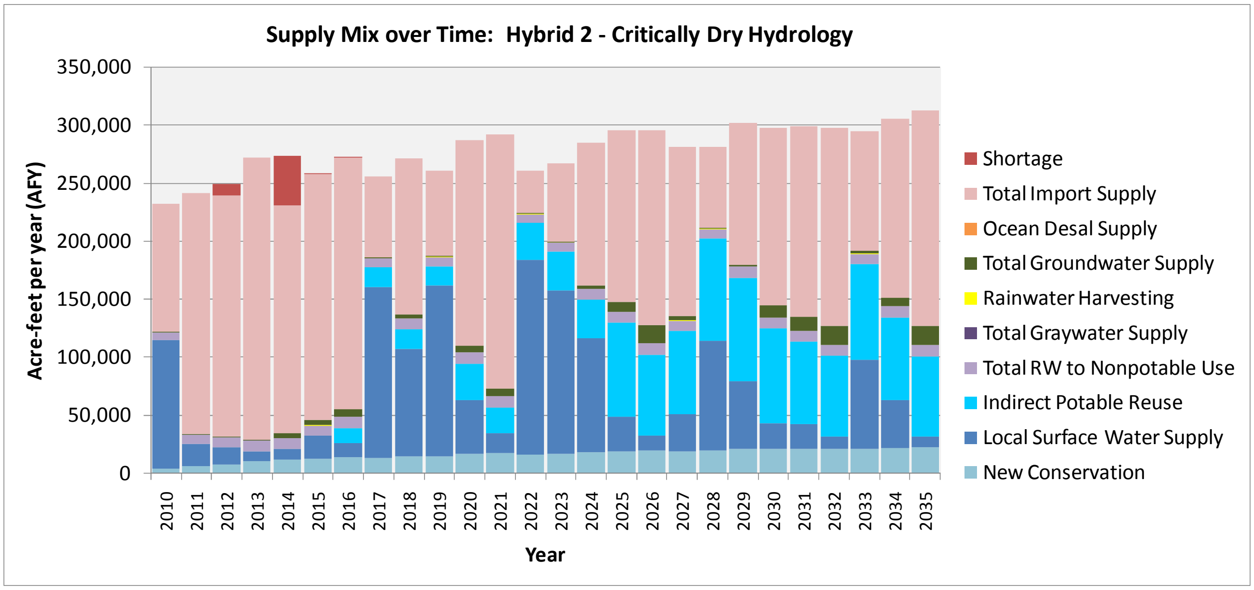
Baseline Options

- Baseline conservation
- Baseline local surface runoff to City reservoirs
- Baseline groundwater supply
- Baseline non-potable reuse
- Imported water purchases from SDCWA

New Options

- Additional active conservation
- Additional active conservation and price effects
- Santee – El Monte Basin
- San Diego Formation Basin: extraction only
- San Diego Formation Basin: Aquifer Storage and Recovery
- Mission Valley Basin Groundwater
- Indirect potable reuse – Phase 1, 2, 3
- Rain barrels (onsite capture)





Appendix E Assumptions for Climate Change Analysis

Appendix E

Assumptions for Climate Change Analysis

Any water supplies that are dependent on natural hydrology are vulnerable to climate change. For the City, about 95 percent of the current water supply is hydrology-dependent; the majority of which is imported from the Sierra Nevada and Colorado River watersheds and the rest originating in local watersheds. Changes to temperature and precipitation could affect the timing and quantity of these supplies. Since the City's water supplies originate in different regions and climate zones, each region will experience unique changes to climate and water supply. Therefore, the City must consider climate change risks to the local watersheds and those of imported water origin.

On top of potential impacts to water supplies, changes to local temperature and precipitation are also expected to alter water demand patterns. Increased temperatures tend to increase both outdoor irrigation and indoor cooling demands.

This appendix describes the assumptions and methodology to estimate adjusted demand, local surface supplies, and imported water availability, that could result from potential climate change. This information is used in the climate change adaptation analysis presented in Section 6.3.

E.1 Climate Scenarios

Scientists predict future climate scenarios for temperature and precipitation using highly complex computer general circulation models (GCMs). Although most of the scientific community agrees that climate change is occurring and, as a result, mean temperatures for the planet will increase, the specific degree of this temperature increase cannot be accurately predicted. Predictions of precipitation changes are even more speculative, with some scenarios showing precipitation increasing the future and others showing the opposite.

To place the global course-scale climate projections on a regional level that incorporates weather and topography in a particular area, the GCM data is refined in a process called "downscaling." The regional areas of interest in assessing climate change impacts to the City's water supplies include local areas (vicinity of San Diego) and areas of imported water origin (Northern California and Colorado River Basin).

For the June 2010 *Update of Long-term Water Demand Forecast*, the City obtained projected climate data for the San Diego area from the Scripps Institution of Oceanography for 18 scenarios comprised of different combinations of 6 GCMs, two emissions conditions (higher and lower), and two downscaling techniques (constructed analogues (CA) and the bias correction and spatial downscaling (BCSD) methods). It is important to consider several model scenarios given the uncertainty involved with each model. Based on their range of potential temperature and precipitation changes, two climate change scenarios were selected for evaluation:

- Geophysical Fluid Dynamics Laboratory CM2.1 (GFDLCM2)
- National Center for Atmospheric Research Parallel Coupled Model (NCARPCM)

For both scenarios, the status quo approach to reduce greenhouse gas emissions is assumed, which is known as the Intergovernmental Panel on Climate Change's (IPCC) Special Report Emissions Scenarios (SRES) A2 (medium-high) greenhouse gas emissions scenario. In addition, the data from both models is downscaled using the BCSD method.

Consistency must be maintained in climate models, emissions scenarios, and downscaling methods for evaluation of overall system reliability with climate change. Since the scenarios above were used for estimating climate change impacts to demands, the same scenarios were used for estimating climate change effects to local surface supplies and imported water availability.

It should be noted that large uncertainty exists in this type of climate change analysis. This uncertainty is incurred at multiple stages of the analysis, including but not limited to projections of greenhouse gas concentrations, simulation of future climate conditions using GCMs, hydrologic models, and affects of future changes in land use or land cover. We have not attempted to fully identify or quantify this uncertainty as part of this study. Future studies could more rigorously address uncertainty by, for example, including a broader range of climate model projections and/or multiple hydrologic models.

E.2 Overall Methodology

Various tools were used to estimate climate change effects to demands, local surface supply, and imported water supply. Tools and methodology for each are described in detail herein. Once climate change impacts demands, local surface supply, and imported water supply were estimated, they were input to the City's water resources systems model, known as SDSIM (refer to **Appendix B**), to evaluate the overall impact to the City's water supply reliability.

For the climate change analysis, the SDSIM model was programmed to simulate the 2035 planning year under varying hydrologic conditions for the period of 1922-1998 based on 1) historical data, and 2) adjustments to account for climate change. This approach was selected for consistency with the methodology in analyzing climate change impacts to imported water via the State Water Project (which is one of the imported water sources to the City) documented in the bi-annual California Department of Water Resources State Water Project Delivery Reliability Report.

Simulating a single planning year under varying hydrologic conditions allows for a more probabilistic representation of results. The 2035 planning year was analyzed given the planning horizon for the Long-Range Water Resources Plan; however, it should be noted that most significant climate change impacts are expected to occur after 2035, although there is uncertainty with the predictions since they are dependent on a number of complex factors such as population growth, economic growth and technology. It will be important for the City to monitor how climate change progresses into the future.

E.2.1 Climate Change Impacts to Local Demands and Surface Water Supplies

Changes to local demands and surface water supplies are driven by changes to local temperature and precipitation. To capture the trends in the climate change data, a moving average was calculated for each forecast year using all the data values that fall between five years before and after each forecast year. For example, the average value for the year 2015 is calculated from values 2010 to 2020 inclusive (11 years).

Projected Change in Local Temperature

Figure E-1 shows a comparison of average maximum daily temperature for the two climate change models, NCARPCM and GFDLCM2, and historical long-term average. As shown, GFDLCM2 predicts significantly higher than average maximum daily temperatures in 2035, with the greatest difference occurring in the summer months. NCARPCM predicts maximum daily temperatures that are very close to the historical average in 2035.

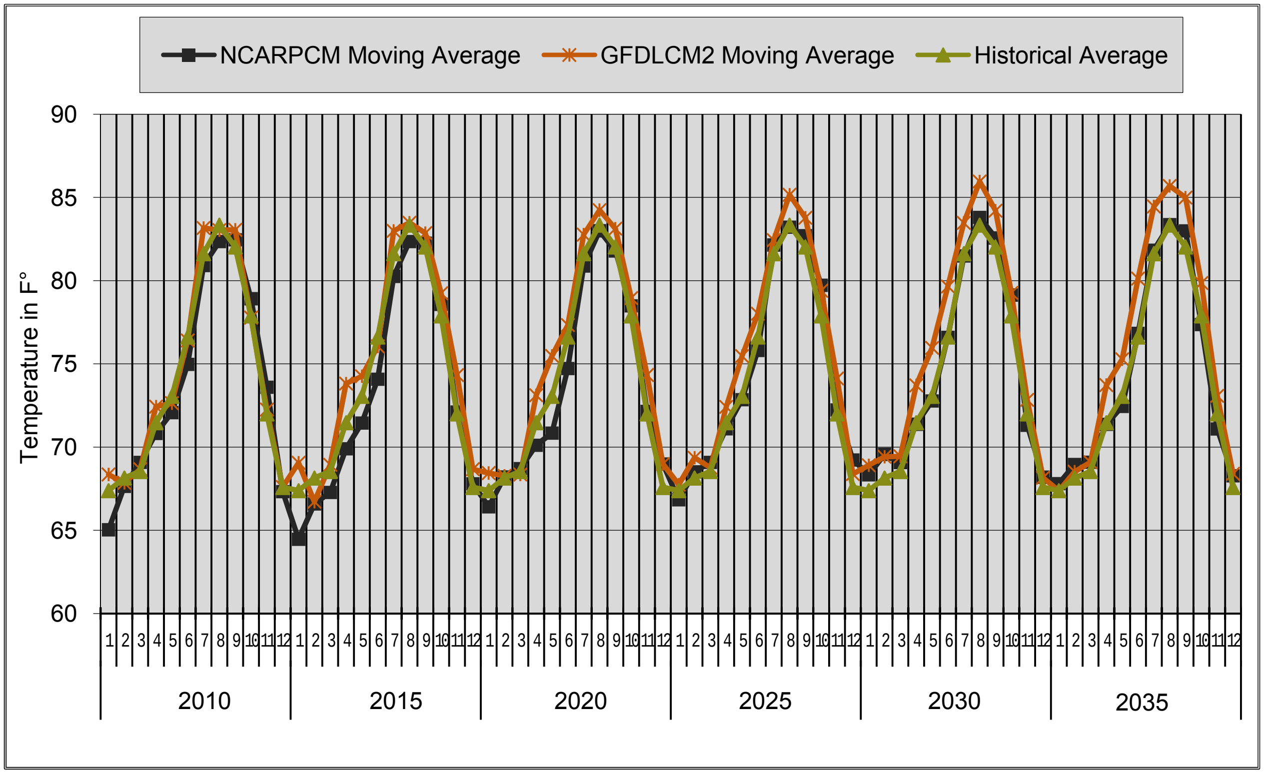


Figure E-1
Average Maximum Daily Temperature: Comparison of Historical Average and GCMs

Figure E-2 shows projected mean annual temperature for the San Diego area predicted by each model. Climate data shows that the most significant changes occur after 2050, which is beyond the 2035 planning horizon for the 2012 LRWRP.

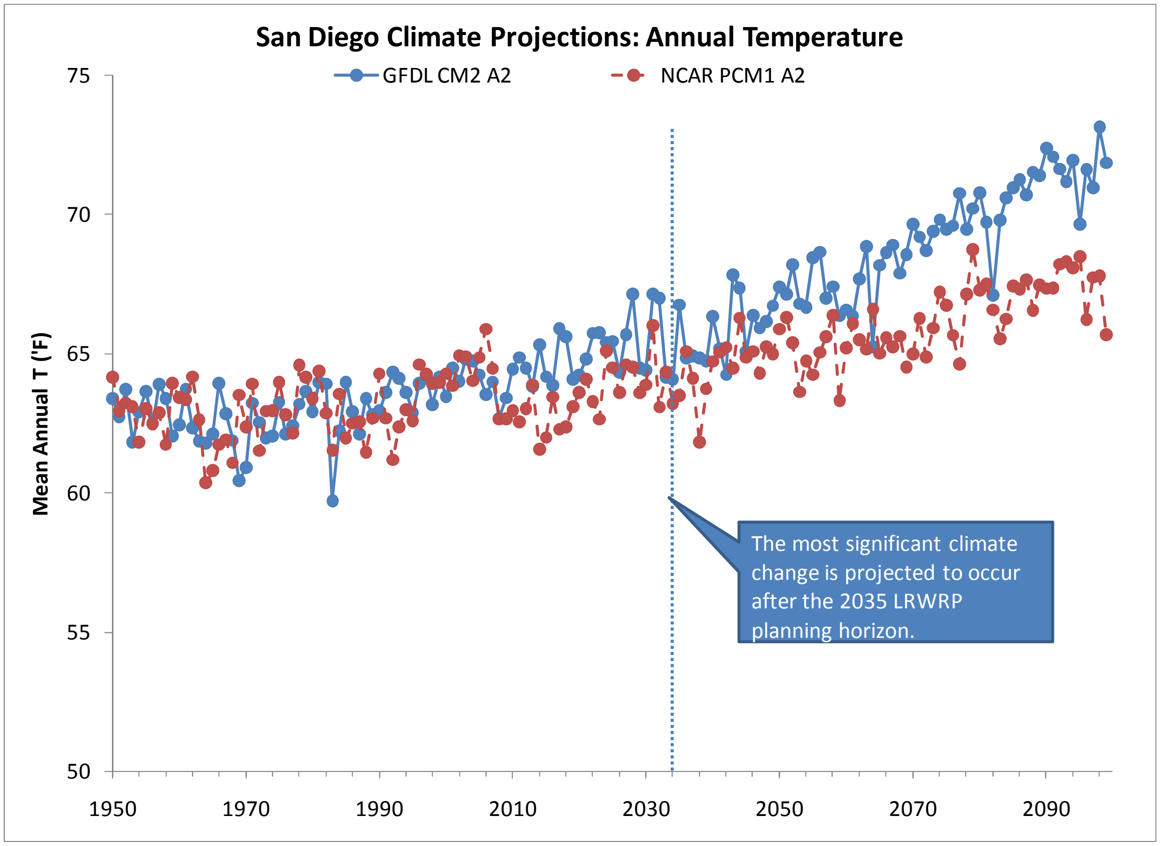


Figure E-2
Climate Change Impacts to Local Temperature over Time

Projected Change in Local Precipitation

Figure E-3 shows a comparison of the two climate change models, NCARPCM and GFDLCM2, and the long-term historical average for total monthly precipitation. As shown, the NCARPCM predicts significantly higher average monthly precipitation occurring in winter months (mainly January), while the GFDLCM2 model predicts monthly precipitation totals significantly lower than average. Generally, the climate change models predict close to average monthly precipitation totals during the spring, summer, and fall months and very abnormal monthly precipitation totals during the winter months.

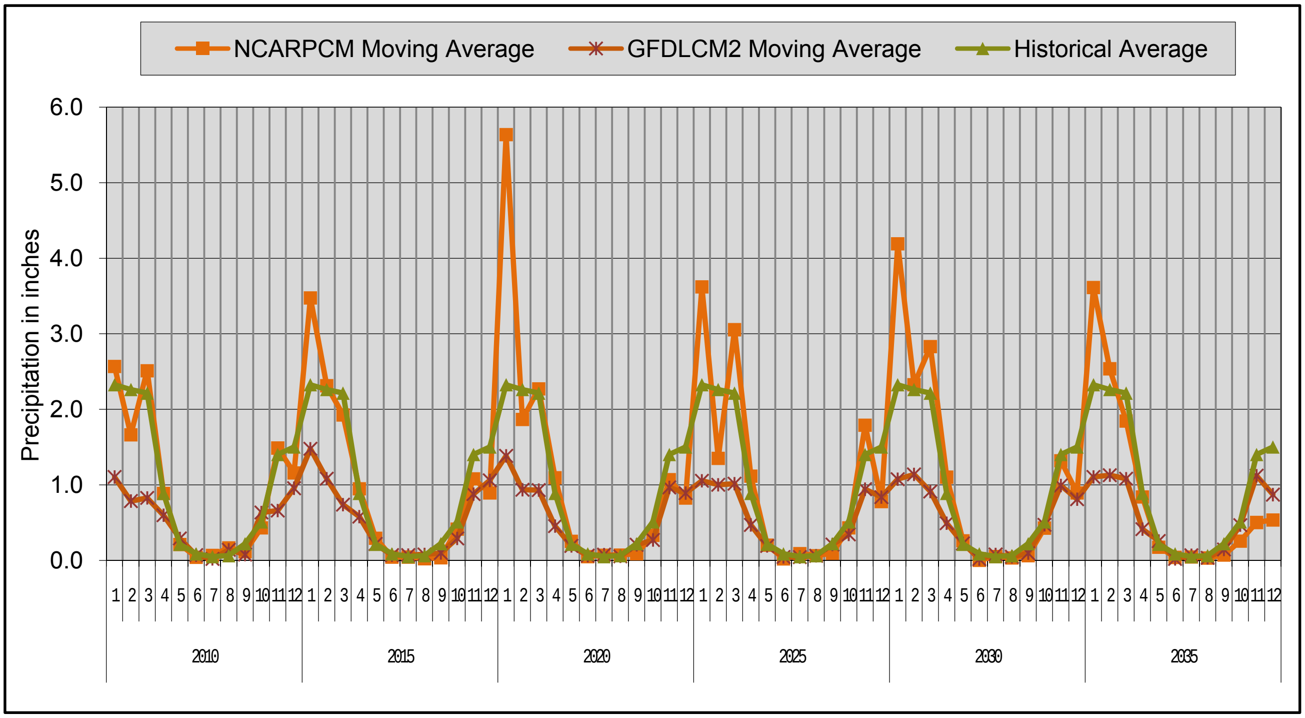


Figure E-3
Average Monthly Precipitation: Comparison of Historical Average and GCMs

Summary

In summary, the GFDLCM2 model temperatures peak significantly higher in the summer months than historical average temperatures in 2035. The NCARPCM model shows temperatures that are similar to historical in 2035; however, it is important to recognize that this is not the case in later forecast years beyond 2035 when temperatures are expected to increase more significantly.

Rainfall patterns also differ significantly between the GCMs in 2035. The NCARPCM model predicts more rainfall during the winter months and the GFDLCM2 model predicts less than average rainfall during the winter months.

E.2.1.1 Demands

Methodology

The City has already estimated potential climate change impacts to demand patterns in its June 2010 *Update of Long-term Water Demand Forecast.* For this effort, changes to monthly demands were estimated using demand forecast models developed based on normal weather conditions, and keeping all variables the same except future weather variables. Therefore, the following variables remain the same in the climate change scenario forecast as they are in the normal weather forecast:

- Single-family and multifamily occupied housing units.
- Single-family and multifamily housing density.
- Median household income.
- Employment variables.

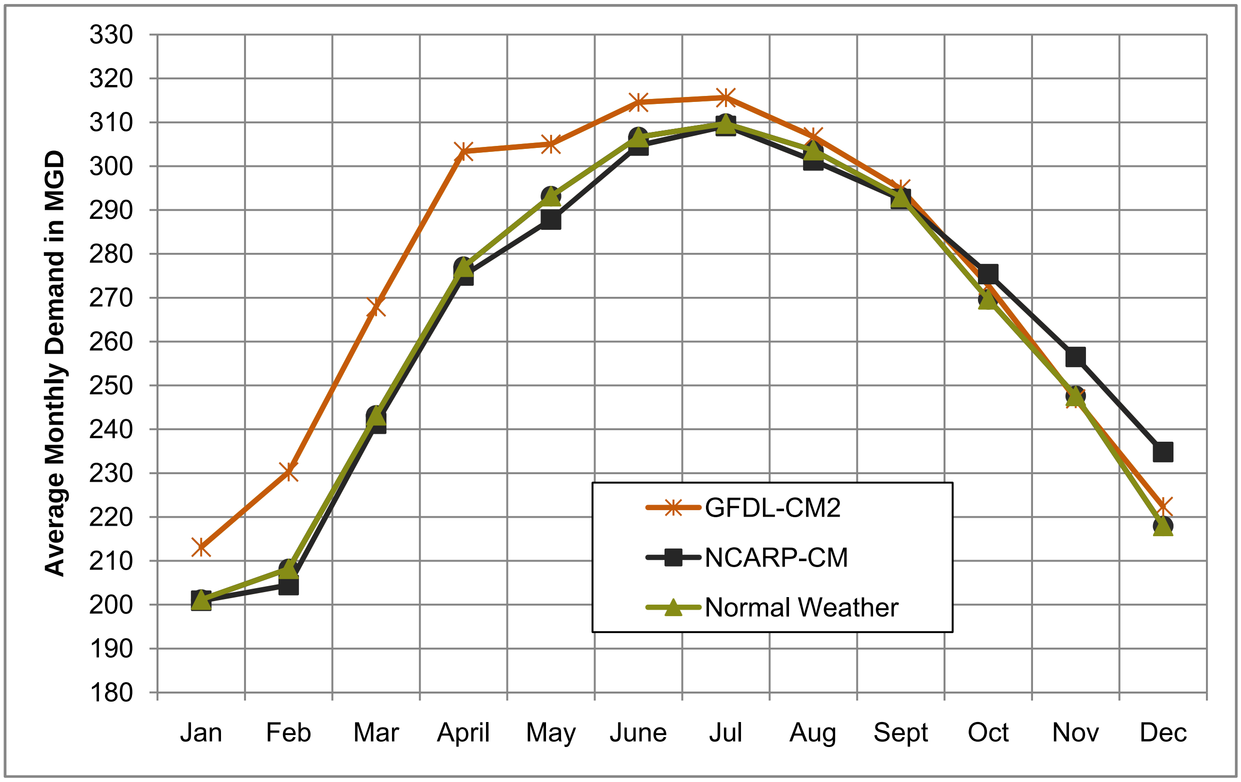
- Marginal price of water and sewer.
- Base year weather variables.
- Conservation savings.

Climate Change Impacts

Figure E-4 compares average monthly demand in 2035 under normal weather conditions and the two climate change models. Note that the forecasts presented in **Figure E-4** include retail demand, wholesale demand, NRW estimates, and a reduction due to conservation.

As shown, the seasonal distribution of annual demands differs between the GFDLCM2 model and the normal weather and NCARPCM models. The GFDLCM2 model peaks higher during the summer months and has higher demands during the first quarter of the year. The seasonal patterns of the NCARPCM and normal weather models are similar with only slight variations in the last months of the year.

These 2035 modified monthly demand factors were applied in the SDSIM systems model. It should be noted that the systems model accounts not only for seasonal fluctuations in demands, but also year to year fluctuations with weather (for historical period from 1922-1998). The annual weather factors were not adjusted for this evaluation. In other words, year to year fluctuations in demands are assumed to be the same as historical (refer to **Appendix B**).



Source: City of San Diego June 2010 Update of Long-term Demand Forecast

Figure E-4
Forecast Scenario Comparison of Average Monthly Demand in 2035 (MGD)

E.2.1.2 Local Surface Runoff

Methodology

Projections of City of San Diego local surface water supplies, impacted by climate change, were developed for the 2035 planning horizon. Mean monthly supply modification factors were quantified based on the two global climate model projections described previously. In order to simulate local hydrologic conditions associated with the targeted planning horizon, each set of monthly factors were applied to baseline monthly historical reservoir inflow. Additionally, mean monthly evaporation modification factors were developed, for the same two climate change scenarios, and applied to historical evaporation rates to capture projected changes in evaporation due to climate change.

To develop climate change modification factors for local supply, relationships between local hydrology and climate were required. Historical climate data were used to develop empirical regression relationships between air temperature and precipitation and key water supply planning model input parameters at the three primary local supply reservoirs: Sutherland, El Capitan, and San Vicente. Regression analyses were performed using approximately 40 to 50 years of monthly stream flow vs. precipitation data and approximately 30 years of monthly evaporation vs. air temperature data. Historical precipitation, temperature, and evaporation data were obtained from the National Climatic Data Center (NCDC) for local climate stations. Historical monthly steam inflows into each reservoir were already established in the SDSIM model. Careful attention was paid to matching the reservoir data with the most appropriate weather station for the regression analyses. Microsoft *Excel's* statistical package was used for this analysis.

Statistically significant ($p < 0.01$) regression models were developed describing stream flow as a function of precipitation for each month and each of the three reservoir inflow locations (**Table E-1**). The independent variables in the models are either (1) the direct month's total precipitation (e.g. January flows are a function of January precipitation) or (2) the preceding cumulative water year precipitation (e.g. July flows are a function of the preceding cumulative water year precipitation). Generally speaking, for wet season months the significant predictor variable was found to be the given direct month's precipitation. For the dry season months, the predictor variable was generally the preceding cumulative water year total precipitation. This implies that the upstream storage (in soils and aquifers) of wet season water is critical to subsequent observed dry season flows. An example precipitation regression model is shown in **Figure E-5**.

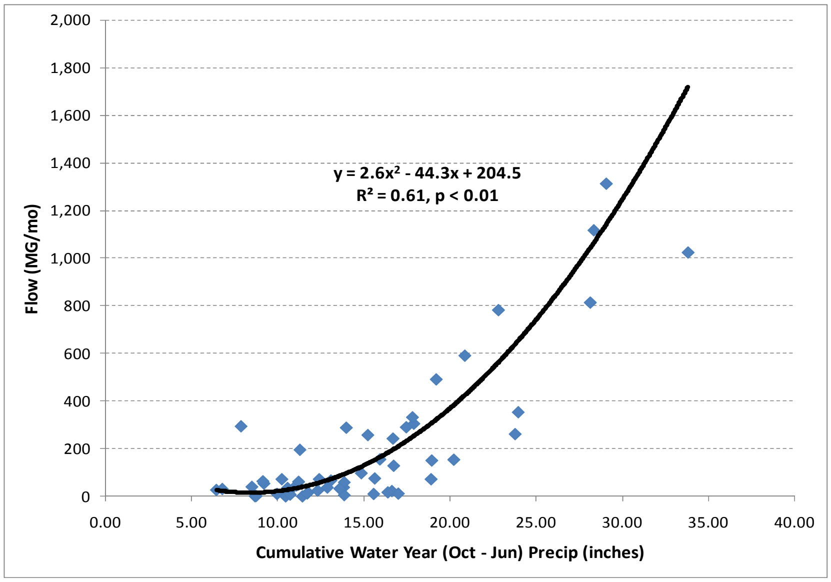


Figure E-5
Example Regression Model: June Stream Flow vs. Water Year Precipitation, El Capitan Reservoir

Table E-1. Summary of Empirical Regression Hydrologic Models

Month	***Equation y = flow(MG/mo); x = precip (in.)***	***Water Year?****	***R^2***	***p***	***n***
Sutherland Reservoir:					
Jan	$y = 11.061x^2 - 63.889x + 137.37$		0.90	< 0.01	36
Feb	$y = 65.098x^2 - 423.23x + 543.13$		0.92	< 0.01	37
Mar	$y = 47.957x^2 - 203.37x + 338.07$		0.57	< 0.01	38
Apr	$y = 0.1119x + 108.26$	√	0.60	< 0.01	36
May	$y = 0.7759x^2 - 17.471x + 107.72$	√	0.90	< 0.01	36
Jun	$y = 0.3287x^2 - 9.1534x + 78.48$	√	0.63	< 0.01	36
Jul	$y = 0.0799x^2 - 0.3476x - 9.943$	√	0.64	< 0.01	35
Aug	$y = 2.6422x - 41.475$	√	0.23	< 0.01	36
Sep	$y = 0.0496x^2 - 0.5055x - 1.176$	√	0.30	< 0.01	36
Oct	$y = 0.0689x^2 - 1.9724x + 18.797$	√	0.57	< 0.01	36
Nov	$y = 3.8976x^2 - 2.9897x + 8.2828$		0.73	< 0.01	37
Dec	$y = 12.217x^2 - 25.291x + 32.522$		0.78	< 0.01	37
El Capitan Reservoir:					
Jan	$y = 218.74x - 68.911$		0.38	< 0.01	57
Feb	$y = 958.79x - 1406.6$		0.43	< 0.01	57
Mar	$y = 70.327x^2 + 506.28x - 353.88$		0.55	< 0.01	57
Apr	$y = 390.77x^2 - 821.93x + 985.18$		0.73	< 0.01	57
May	$y = 12.566x^2 - 309.75x + 1924.5$	√	0.82	< 0.01	55
Jun	$y = 2.6308x^2 - 44.347x + 204.54$	√	0.61	< 0.01	55
Jul	$y = 1.633x^2 - 24.816x + 96.629$	√	0.39	< 0.01	54
Aug	$y = 1.6499x^2 - 33.406x + 183.29$	√	0.31	< 0.01	54
Sep	$y = 0.9346x^2 - 22.203x + 152.87$	√	0.51	< 0.01	55
Oct	$y = 1.1833x^2 - 23.83x + 131.74$	√	0.62	< 0.01	55
Nov	$y = 58.591x + 35.352$		0.26	< 0.01	56
Dec	$y = 40.83x^2 - 59.624x + 112.9$	√	0.69	< 0.01	56
San Vincente Reservoir:					
Jan	$y = 16.938x^2 - 49.312x + 88.404$		0.82	< 0.01	48
Feb	$y = 479.82x - 732.03$		0.46	< 0.01	49
Mar	$y = 84.67x^2 - 237.69x + 248.66$		0.76	< 0.01	49
Apr	$y = 1.7413x^2 - 7.0968x - 59.216$	√	0.73	< 0.01	49
May	$y = 23.901x - 245.63$	√	0.55	< 0.01	47
Jun	$y = 13.139x - 127.46$	√	0.31	< 0.01	47
Jul	$y = 11.894x - 114.08$	√	0.28	< 0.01	47
Aug	$y = 7.5947x - 72.583$	√	0.17	< 0.01	47
Sep	$y = 7.5405x - 65.319$	√	0.19	< 0.01	47
Oct	$y = 17.51x + 17.079$		0.16	< 0.01	47
Nov	$y = 33.953x + 14.665$		0.37	< 0.01	48
Dec	$y = 87.065x - 57.921$		0.41	< 0.01	48

***** = if checked, independent variable is the cumulative preceding water year total

For reservoir evaporation rates, significant ($p < 0.01$) regression models were developed as a function of mean monthly temperature for the three reservoirs described above (Figure E-6). Historical reservoir evaporation estimates were obtained from monthly flow balance calculations for each of the three reservoirs from previous SDSIM modeling efforts. Historical monthly mean temperatures used in the regression analyses were obtained from weather stations at El Capitan Dam (El Capitan, and San Vincente reservoirs) and Ramona Fire Department (Sutherland reservoir).

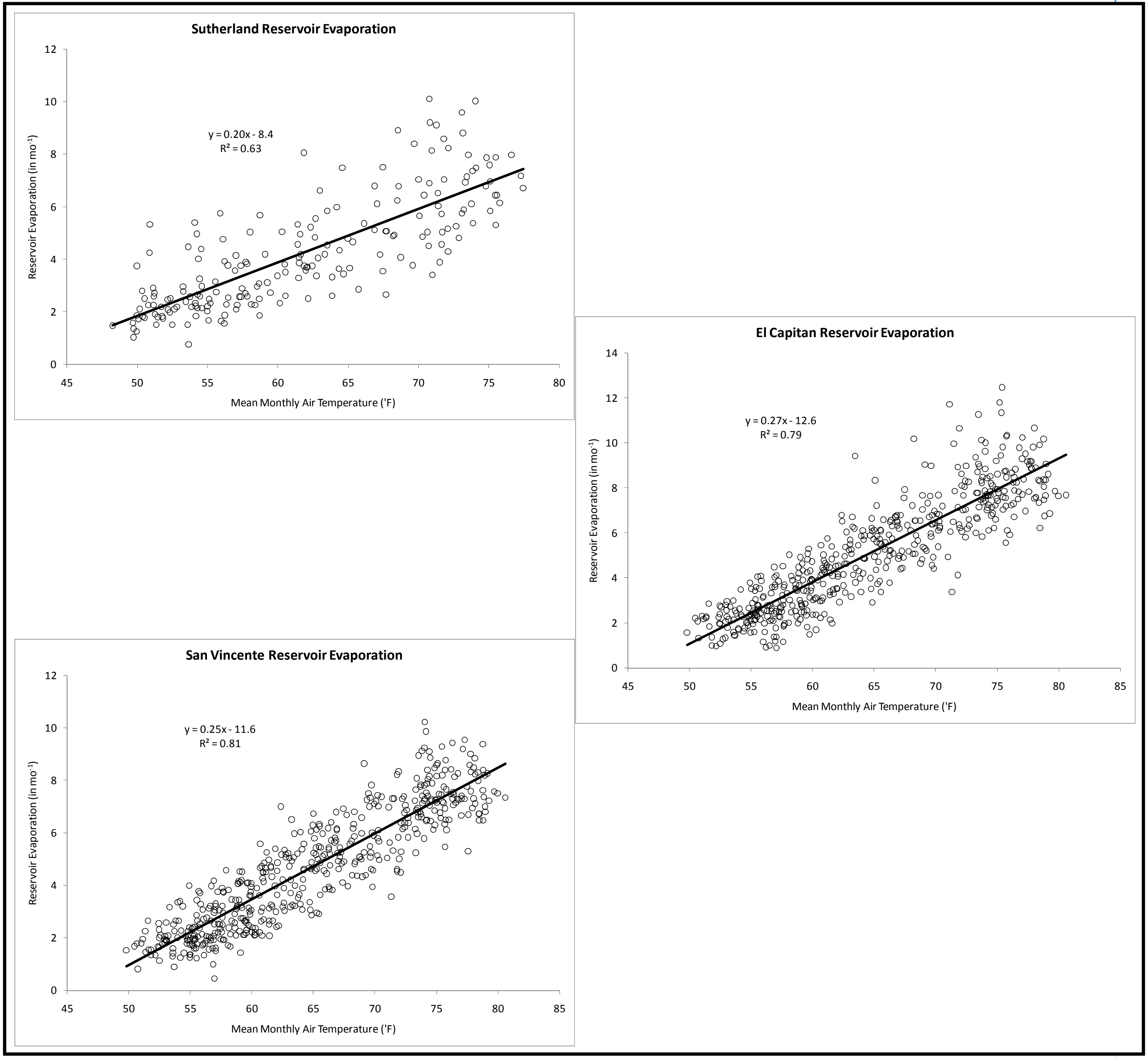


Figure E-6
Local Reservoir Evaporation Regression Models, Developed Using Historical Data

Climate Change Impacts

The regression models described above were used to generate sets of mean monthly perturbation factors for both reservoir inflows and evaporation losses. Monthly climate change perturbation factors calculated for each of the three primary local supply reservoirs are summarized in **Tables E-2** through **E-5**. The perturbation factors are unitless multipliers to the monthly reservoir runoff inflows evaporation outflows, which are tracked in units of acre-feet per month. Therefore, perturbation factors greater than 1 represent an increase in runoff or evaporation, and perturbation factors less than 1 represents a decrease.

In general, the GFDLCM2 model projects less water availability than the NCARPCM model. The GFDLCM2 model projects small reductions in mean monthly flow for the majority of the year for Sutherland and El Capitan reservoirs. For San Vincente, the GFDLCM2 modeling predicts small increases in flow for the majority of the months. Results for the GFDLCM2 model generally show lower perturbation factors (reduced flows) for the summer months and higher perturbation factors in the winter months.

NCARPCM model projections generally show considerable increases in mean monthly flow values for each of the three reservoirs. This is attributable to the increased precipitation projected by the NCARPCM model. The model does project large decreases in December precipitation for the study region and consequently large reductions in December local inflows.

All projections of evaporation rates show an increase in reservoir evaporation due to climate change. This is expected given the consensus among climate models projecting an increase in air temperature in the future due to climate change. Greater warming, and consequently greater increases in reservoir evaporation, is predicted for the GFDLCM2 model compared to the NCARPCM model.

Table E-2. Summary of Climate Change Perturbation Factors: Local Reservoir Inflow, 2035 GFDLCM2 A2 Projection

	Sutherland	El Capitan	San Vincente
Jan	1.20	1.01	1.19
Feb	0.38	0.97	0.94
Mar	1.37	1.12	1.37
Apr	0.96	0.68	0.95
May	0.86	0.85	1.04
Jun	0.87	0.89	1.03
Jul	0.91	0.90	1.02
Aug	0.98	0.87	1.02
Sep	0.92	0.89	1.02
Oct	0.87	0.87	1.01
Nov	2.25	1.47	1.49
Dec	0.99	1.32	0.85
Average	**1.05**	**0.99**	**1.08**

Table E-3. Summary of Climate Change Perturbation Factors: Local Reservoir Inflow, 2035 NCARPCM A2 Projection			
	Sutherland	**El Capitan**	**San Vincente**
Jan	4.12	1.69	4.13
Feb	1.35	1.22	1.22
Mar	1.12	1.21	1.21
Apr	2.08	0.98	1.78
May	1.92	2.22	1.64
Jun	1.47	1.88	1.60
Jul	2.10	1.87	1.59
Aug	2.12	1.93	1.56
Sep	1.92	1.79	1.44
Oct	1.30	1.79	1.23
Nov	1.19	1.16	1.16
Dec	0.56	1.18	0.51
Average	**1.77**	**1.58**	**1.59**

Table E-4. Summary of Climate Change Perturbation Factors: Local Reservoir Evaporation, 2035 GFDLCM2 A2 Projection			
	Sutherland	**El Capitan**	**San Vincente**
Jan	1.19	1.40	1.38
Feb	1.10	1.20	1.19
Mar	1.14	1.24	1.24
Apr	1.20	1.30	1.29
May	1.21	1.29	1.29
Jun	1.14	1.17	1.17
Jul	1.14	1.17	1.16
Aug	1.15	1.17	1.17
Sep	1.12	1.15	1.15
Oct	1.12	1.16	1.16
Nov	1.13	1.18	1.18
Dec	1.14	1.28	1.27
Average	**1.15**	**1.23**	**1.22**

Table E-5. Summary of Climate Change Perturbation Factors: Local Reservoir Evaporation, 2035 NCARPCM A2 Projection			
	Sutherland	**El Capitan**	**San Vincente**
Jan	1.09	1.23	1.22
Feb	1.17	1.39	1.38
Mar	1.13	1.25	1.25
Apr	1.09	1.16	1.15
May	1.06	1.10	1.10
Jun	1.07	1.11	1.10
Jul	1.06	1.08	1.08
Aug	1.03	1.05	1.05
Sep	1.06	1.08	1.08
Oct	1.08	1.11	1.11
Nov	1.05	1.10	1.10
Dec	1.12	1.27	1.26
Average	**1.09**	**1.16**	**1.16**

The monthly perturbation factors above were applied to the historical baseline inputs within the SDSIM model for the period of 1922-1998. For those reservoirs in the model without site-specific data and hydrologic models, one of the three primary reservoirs described above was identified as a surrogate based on geographic location. The monthly supply and evaporation perturbation factors from the surrogate reservoir were used to modify the corresponding smaller reservoir's hydrologic inputs in SDSIM.

The combined effect of changes to runoff and evaporation to the City's annual local surface supply availability is shown in **Figure E-7**. As shown, the GFDL model results in a slight decrease in runoff and the NCAR PCM model results in an increase in local runoff. The increase in local runoff resulting from the NCAR PCM model is primarily driven by the overall increase in precipitation for the San Diego area.

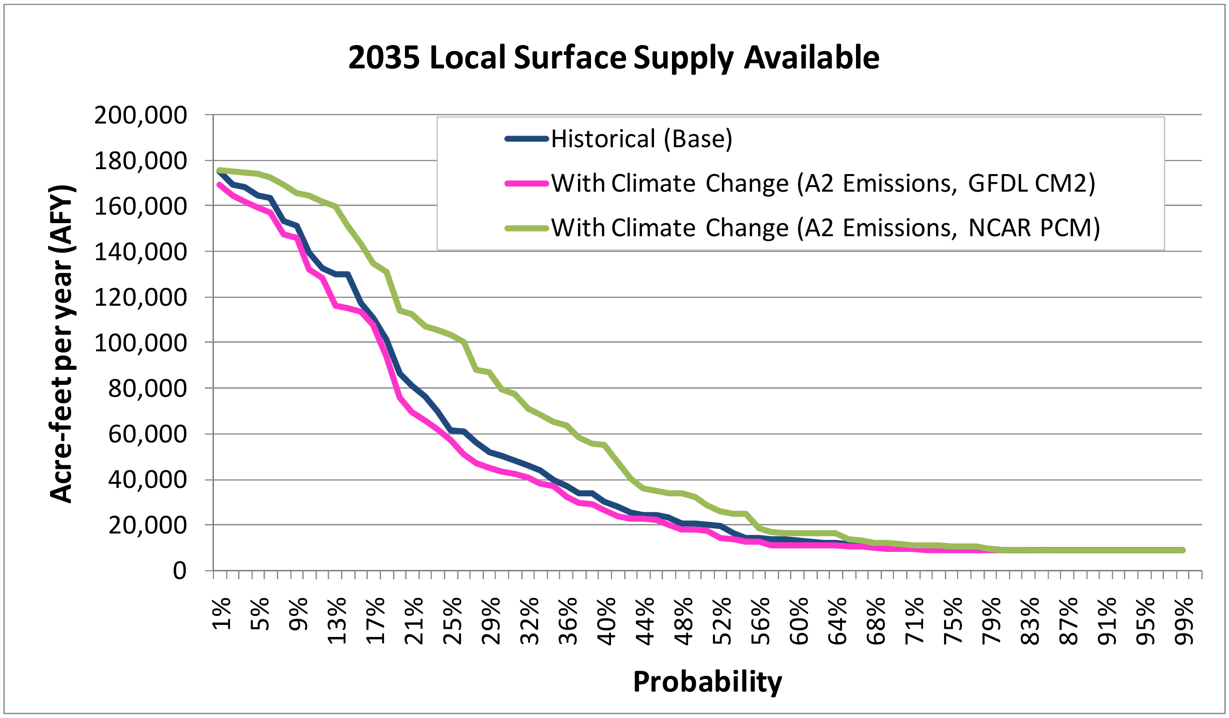


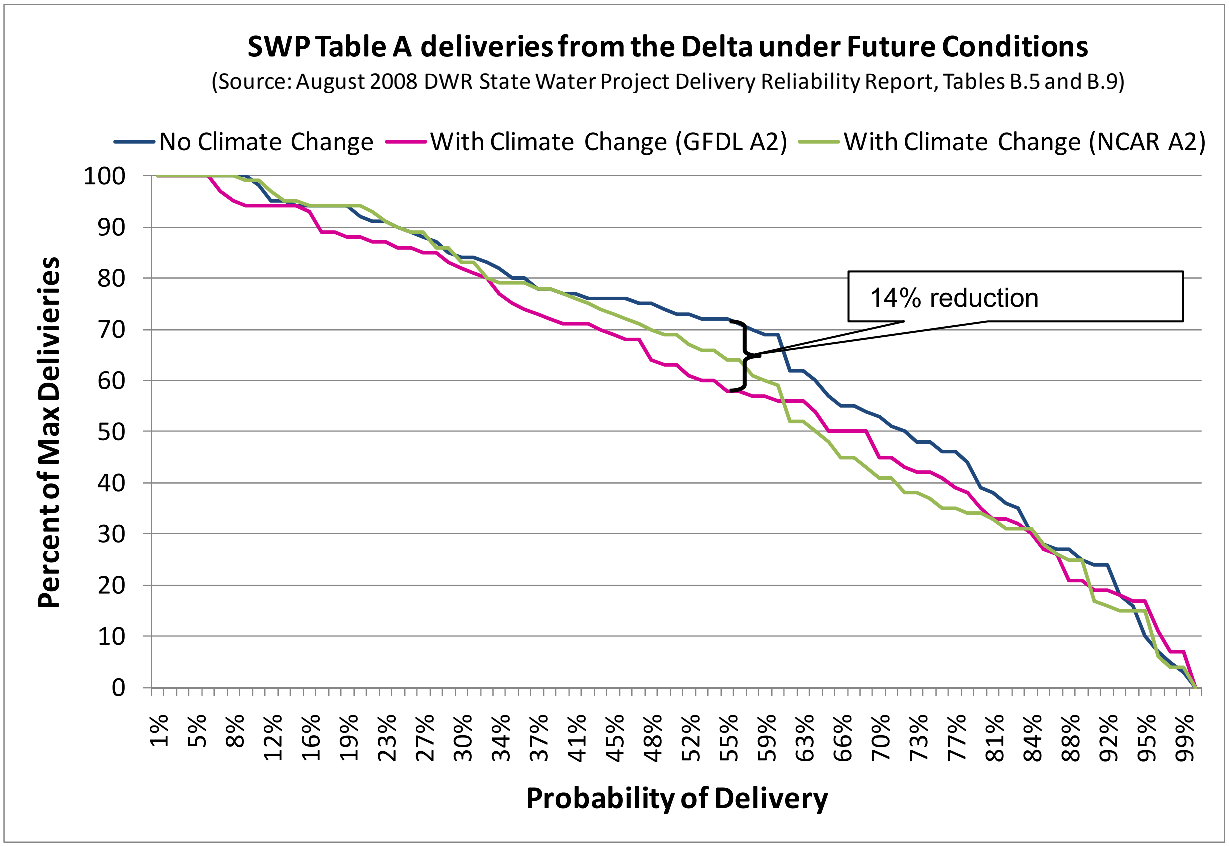
Figure E-7
Projected Climate Change Impacts to Local Surface Supply

E.2.2 Climate Change Impacts to Imported Water Supply

Methodology

Most of the studies on climate change impacts to California's imported water supply have been conducted for the Northern California region. The California Department of Water Resources (DWR) releases a bi-annual State Water Project (SWP) Delivery Reliability report (Reliability report) which specifically analyzes changes in volume of water available with consideration of climate change. In recent years (2009 and 2011 DWR Reliability reports), DWR's approach has been to use a single climate change scenario representative of the median climate change impacts. For consistency with the City's planning approach to evaluate the range of possible outcomes, the 2007 DWR report was used for the climate change analysis. The 2007 DWR report included a high environmental flow target scenario and, compared with the 2011 report, shows less water available for supply delivery during low flow conditions but more water available during high flow conditions. Therefore, the 2007 DWR report is conservative for evaluating shortages during low flow conditions.

In the 2007 report, DWR predicted that SWP deliveries could be reduced by as much as 14 percent in some cases (see **Figure E-8**). The changes to SWP deliveries are not very significant in wetter years (when percent of maximum deliveries are greater than 80 percent) or dry years (when percent of maximum deliveries are less than 30 percent). The most significant changes to SWP deliveries occur during the normal deliveries between 40-80 percent of the maximum.



SWP Table A deliveries from the Delta under Future Conditions

(Source: August 2008 DWR State Water Project Delivery Reliability Report, Tables B.5 and B.9)

14% reduction

Figure E-8
Projected Climate Change Impacts to SWP Imported Water Deliveries (from Northern California)

In order to estimate potential changes to MWD supply reliability with climate change, a simple mass balance model was developed using information from 1) the DWR's 2007 SWP Reliability Report, 2) MWD's 2010 Regional Urban Water Management Plan (RUWMP), and 3) projected MWD shortages from the IRPSIM model[1]. Similar to the portfolio evaluations for the City of San Diego's 2012 Long Rang Water Resources Plan (LRWRP), the reliability scenario in which a comprehensive Delta "fix" is not reached within the planning horizon is assumed for the climate change analysis (refer to Section 2 of the 2012 LRWRP).

For the base reliability condition, which is historical hydrology conditions, a mass balance of MWD annual demands and supplies including SWP deliveries, storage, and other supplies was calculated based on the assumptions in **Table E-6**, which indicates parameter names and number identifications [ID] for explaining the model logic.

---

[1] Provided to the City by Grace Chan (MWD) on August 10, 2011. Data is based on IRPSIM model output developed for MWD's 2010 Integrated Resources Plan.

There are two overall mass balance equations in the model:

1) Shortage [10] = Demand [1] – SWP Deliveries to Demand [3] – Other Supplies to Demand [6] – Use of Storage [8]

2) Storage [9]$_{t}$ = Storage [9]$_{t-1}$+ SWP Deliveries to Storage [4]$_{t}$ + Other Supplies to Storage [7]$_{t}$ – Use of Storage [8]$_{t}$

where:

t = current annual time step
t-1 = previous annual time step

Table E-6. MWD Demand and Supply Mass Balance Assumptions

# ID	Mass Balance Parameter	Assumption
[1]	Demand	Given[1]
[2]	SWP Deliveries to MWD	Given[2]
[3]	To Demands	Calculated: If Use of Storage [8] is greater than zero, then assume all SWP deliveries [2] are used to meet demands. Otherwise, calculate the amount of SWP used to meet demands as the minimum of what is available [2] or what is needed, where the need for water is equal to: Demand [1] – other supplies to demands [6] – use of storage [8] – shortage [10].
[4]	To Storage	Calculated: Equal to total SWP deliveries to MWD [2] minus the amount delivered to demands [3]
[5]	Other Supplies	
[6]	To Demands	Calculated: Minimum of what is available or what is needed to meet demands, where the need for water is equal to Demand [1] – SWP Deliveries to MWD [2] – Use of Storage [8] – Shortage [10]. The amount of other supplies available is based on MWD's RUWMP.[3] If it is a year in which Use of Storage [8] is equal to zero, use the all other supplies available in order to maximize replenishment from SWP deliveries (recharge years occur when there is no use of storage).
[7]	To Storage	Assumed: A steady recharge correction factor was applied in order to calibrate the model to match IRPSIM output.
[8]	Use of Storage	Given[4]
[9]	Storage	Mass balance tracking inputs and outputs from storage.[5]
[10]	Shortage	Given[6]

[1] MWD's 2010 Regional Urban Water Management Plan. Assumed to be 4.5 million acre feet per year in 2035.

[2] DWR's 2007 SWP Reliability Report provides the percentage of maximum SWP deliveries, which is applied to MWD's SWP allocation of 2.2 million acre-feet per year.

[3] Assumed to be 3.124 million acre-feet per year on average in 2035.

[4] MWD's IRPSIM output, based on MWD's 2010 Integrated Resources Plan Update. Maximum supply from storage is approximately 400,000 acre-feet per year.

[5] Assumes maximum storage of 2.375 million acre-feet based on MWD's 2010 Regional Urban Water Management Plan.

[6] MWD's IRPSIM output, based on MWD's 2010 Integrated Resources Plan Update.

An example of the calculations is shown in **Table E-7** for the period from 1992-1927. Note that these calculations were performed for the entire available hydrologic record from 1922-2003, although not all years are shown for illustrative purposes.

Table E-7. Example MWD Supply and Demand Mass Balance

#ID:	[1]	[6]	[7]	[2]	[3]	[4]	[8]	[9]	[10]
Year	Demand	Other Supply to Demand	Other Supply to Storage (Calibration Factor)	Total SWP Deliveries to MWD	SWP Deliveries to Demand	SWP Deliveries to Storage	Use of Storage	Storage	Shortage
1922	4,500,000	2,454,596	245,000	1958000	1,958,000	0	87,404	2,375,069	0
1923	4,500,000	2,474,812	245,000	1,584,000	1,584,000	0	374,591	2,245,478	66,597
1924	4,500,000	3,082,613	245,000	66,000	66,000	0	359,434	2,131,044	991,953
1925	4,500,000	3,054,070	245,000	836,000	836,000	0	391,353	1,984,691	218,577
1926	4,500,000	2,947,197	245,000	1,056,000	1,056,000	0	372,972	1,856,719	123,831
1927	4,500,000	3,124,000	245,000	1,980,000	1,376,000	604,000	0	2,375,069	0
…… 2003	4,500,000	2,406,077	245,000	1,518,000	1,518,000	0	345,268	1,762,080	230,655

Note: Supply and demand mass balance calculations were performed for the entire period of record (1922-2003), although not all years are show in this illustrative example.

While this mass balance model does not account for all the complexities of operating MWD's complex water system, the estimates provide some insight as to the potential order of magnitude of the supply and demand balance, and how it might vary with climate change. For the climate change scenario, the mass balance model accounts for:

1. Increases in MWD service area demands, which are assumed to increase slightly more than the San Diego area to account for inland parts of MWD's service area that are projected to have more significant increased temperature and decreased precipitation on average.[2]
2. Changes to SWP deliveries based on the 2007 DWR SWP Reliability report

While several research efforts have shown that climate change will reduce Colorado River flows[3], there is not currently sufficient information available to account for overall system operations and quantify the potential changes in supply to California. The United States Bureau of Reclamation (USBR) conducted a Colorado River Basin Water Supply and Demand Study (Colorado River Study), which will define current and future imbalances in water supply and demands in the Colorado River Basin and the adjacent areas of the seven Colorado River Basin states that receive Colorado River water, accounting for effects of future climate change. The final Colorado River Study can be found at: http://www.usbr.gov/lc/region/programs/crbstudy/finalreport/Study%20Report/CRBS_Study_Report_FINAL.pdf

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[2] Assumed to increase by 5% on an annual basis for the GFDLCM2 model and 3 % on an annual basis for the NCARPCM model. Based on the City of San Diego's 2010 *Update to the Long-term Water Demand Forecast*, San Diego demands are expected to increase by 3.8% on an annual basis for the GFDLCM2 model and 0.4% on an annual basis for the NCARPCM model. As a representative inland area, Eastern Municipal Water District's July 2011 Integrated Resources Plan shows an 8% increase in demands for the NCARPCM model, which is a much more significant increase in demands than the coastal San Diego area. These increases are based on the A2 emissions scenario.

[3] The USBR Colorado River Basin Water Supply and Demand Study, Technical Report B – Water Supply Assessment dated February 2012 (Table B-3) reports that climate change will reduce mean annual flows for the Colorado River at Lees Ferry, Arizona from historical records (1906-2007) by approximately 7.5% for the 2011-2040 time period and 12.4% for the 2066-2095 time period.

Without this information, the current analysis does not account for changes to the Colorado River (which are part of 'Other Supplies') and could be underestimating potential shortages to some degree. As such, the City will need to monitor information regarding climate change impacts to Colorado River supply to California as information becomes available in the future.

Climate Change Impacts

The estimated change in projected MWD shortages with climate change is shown in **Figure E-9**. This reduction in normal year SWP deliveries has significant impacts on MWD's accumulation of water in storage and ability to sustain supply in drought periods. As a result of reduced water in storage, as well as increased demands, MWD shortages are typically expected to be up to 10 percent higher, except for the extreme shortages conditions which only go up by 5 percent.

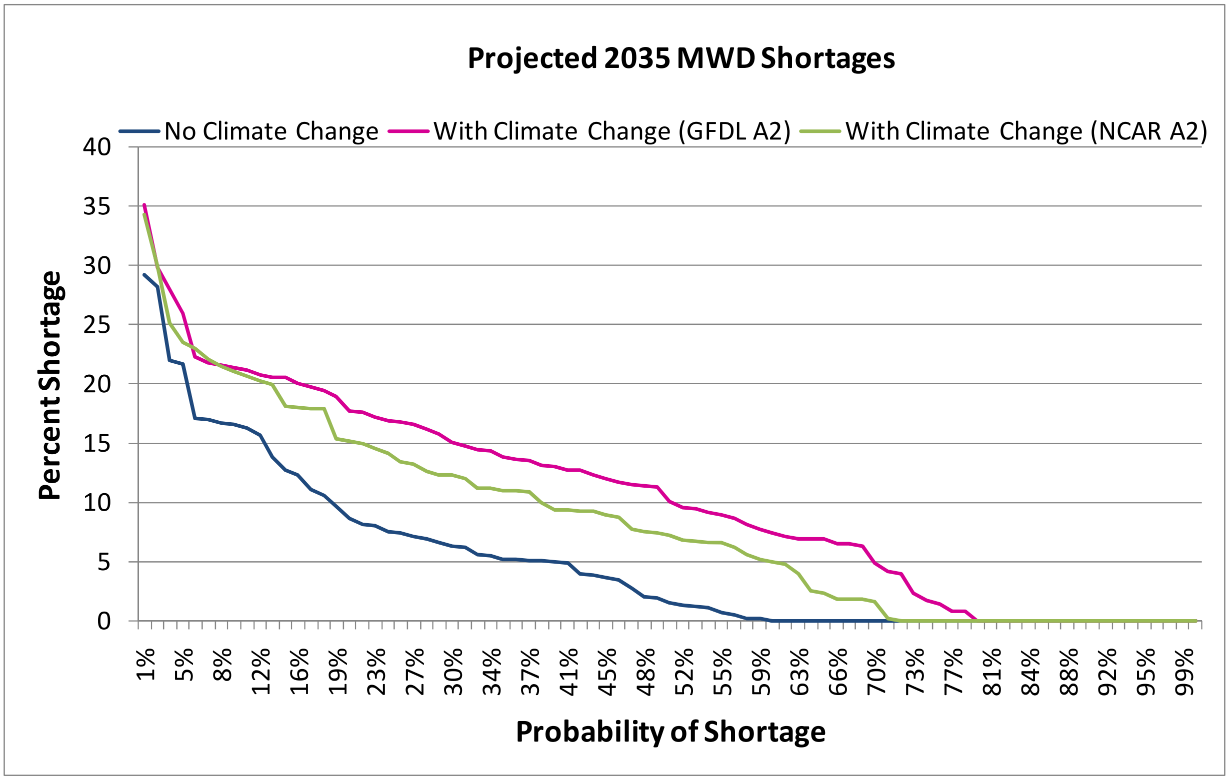

Figure E-9
Projected Climate Change Impacts to Imported Water Available from MWD

Accounting for planned projects by SDCWA that would help offset some of these shortages, the change in imported water supply available to the City is presented in **Figure E-10**. As shown, the amount of imported water available would be less than historical hydrology conditions about 70 percent of the time, and in some cases the amount of imported water available will be up to 20 percent less than historical hydrology conditions.

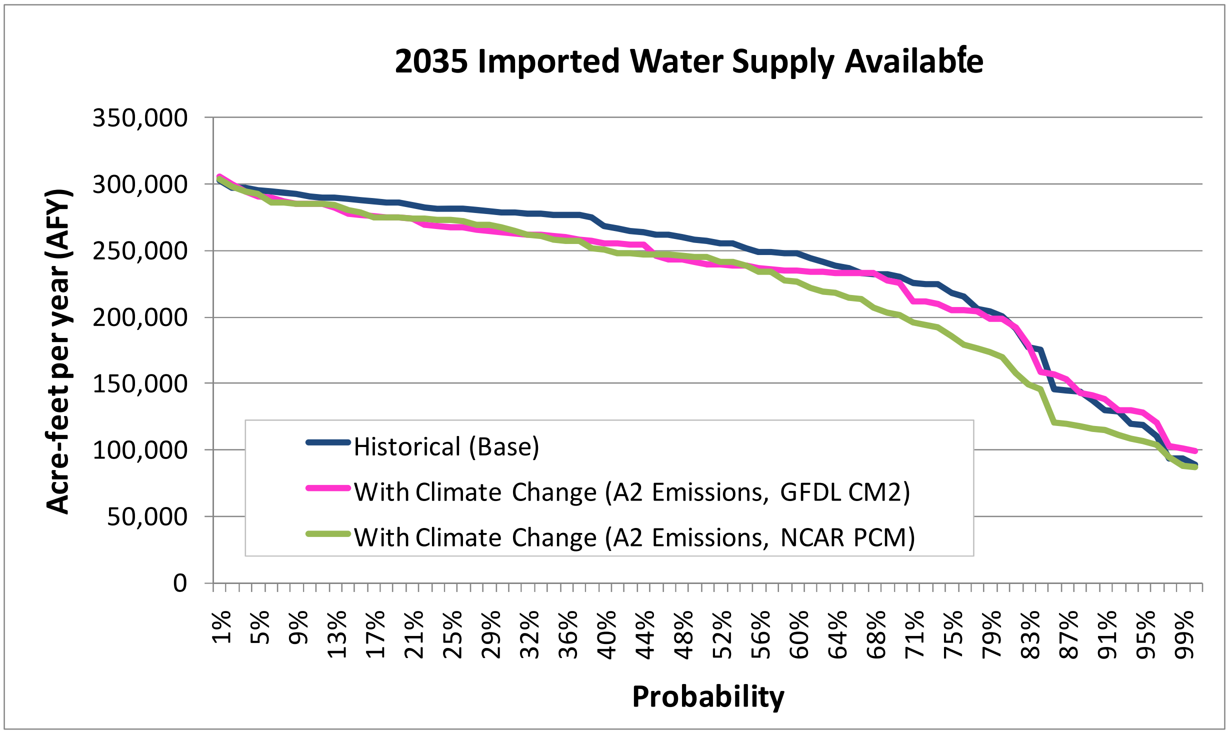

Figure E-10
Expected Imported Water Supply Delieveries from MWD under Climate Change

E.3 Climate Change Impacts and Adaptation Strategies

The overall effect of climate change to the City's water supply was evaluated by combining the changes to demands, local supplies, and imported water supplies into the SDSIM model. The primary inputs to the SDSIM systems model are shown in **Figures E-4**, **Tables E-2** through **E-5**, and **Figure E-9**.

Projected 2035 shortages for the status quo (no additional projects or programs) is shown in **Figure E-11.** The results show that, with stronger warming projected by the GFDL CM2 model, climate change could not only increase the magnitude of shortages but also the frequency of shortage – which increases from 40 percent probability to 100 percent probability. Since the NCAR PCM model is showing an increase in local surface supply availability, the changes in shortages are less although still significant.

In order to measure the magnitude of the City's potential adaptation capabilities in reducing water shortages caused by climate change, two portfolios were analyzed: Hybrid 1 and Hybrid 2. These portfolios are among the top three portfolios based on the ranking analysis in Section 6.2. The other portfolio in the top 3 is Maximize Water Use Efficiency, which is expected to have similar climate change adaptation capabilities as Hybrid 2 based on the scores for the climate change resilience in Table 6-1.

Figure E-12 shows the climate change adaptation capabilities of Hybrid 1 and Hybrid 2, respectively. The results show that Hybrid 1 significantly improves climate change adaptation capabilities, and Hybrid 2 would resolve almost all water shortages making the City's water supply very reliable even in the face of climate change.

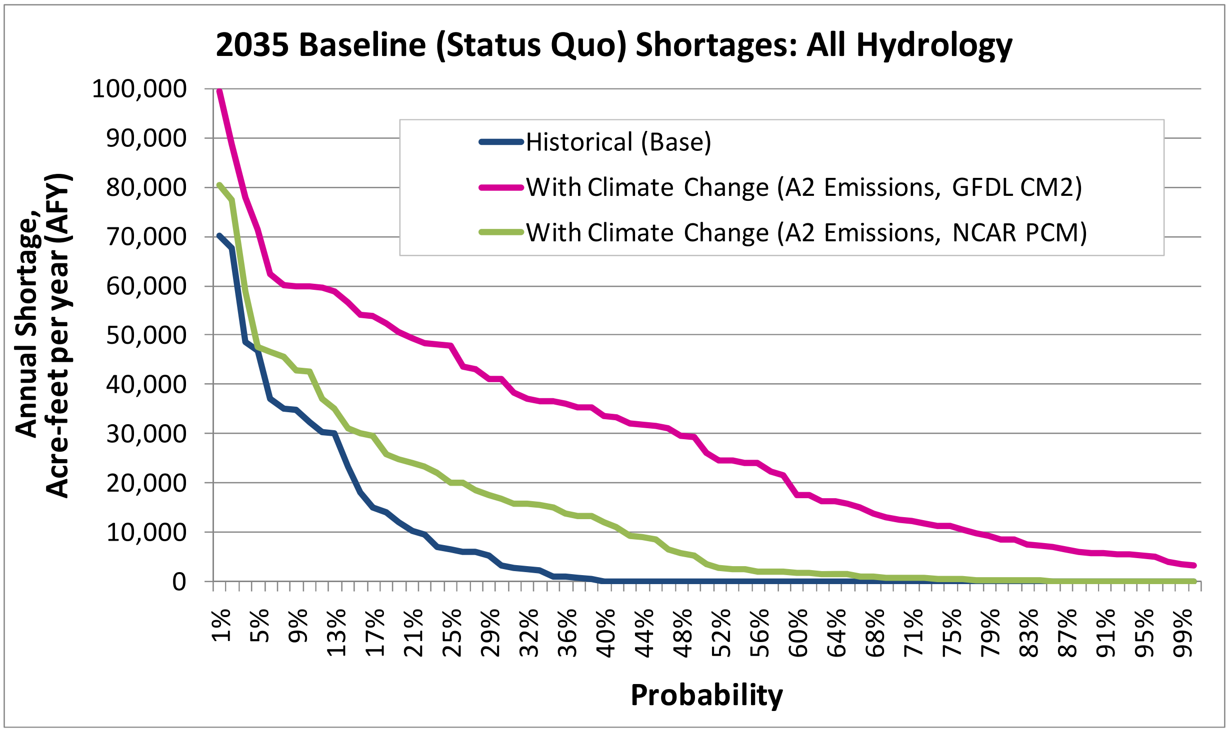

Figure E-11
2035 Climate Change Impacts on Baseline (Status Quo) Portfolio

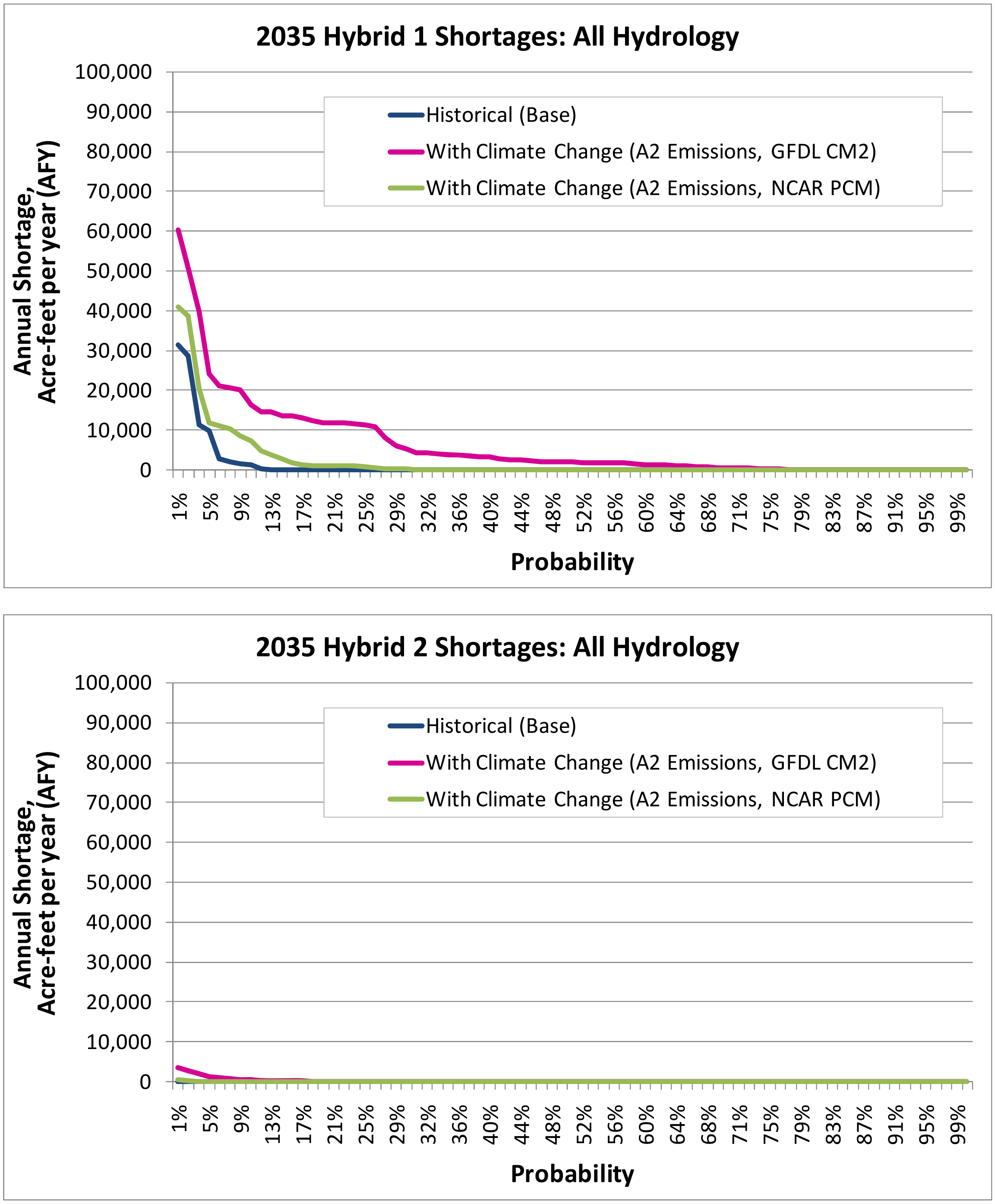

Figure E-12
Hybrid 1 and 2 Climate Change Adaptation Capabilities for Supply Reliability

Appendix F Stakeholder Survey Summary

Appendix F

Stakeholder Survey Summary

Section 5 of the 2012 Long-Range Water Resources Plan (LRWRP) provides an overview of the 2012 LRWRP process and stakeholder involvement. As mentioned in Section 5, one-on-one conversations were held with all of the stakeholders after the 3rd Stakeholder Committee meeting, which covered portfolio evaluations and the approach for moving forward. During the one-on-one conversations, several questions were asked about the process up to that point, to ascertain whether the information provided to date was understandable, fair, objective and useful in the context of developing the 2012 LRWRP. The results of these one-on-one stakeholder conversations are summarized in Table F-1.

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Table F-1. 2012 LRWRP Stakeholder Discussion Matrix

Question	Participants and Responses										
	Stakeholder 1	Stakeholder 2	Stakeholder 3	Stakeholder 4	Stakeholder 5	Stakeholder 6	Stakeholder 7	Stakeholder 8	Stakeholder 9	Stakeholder 10	Stakeholder 11
Do you feel like you were able to express your opinions, ideas and suggestions in the 2012 LRWRP process?	**Yes** Thought was very open, informative.	**Yes**	**Yes** Yes it was good. Limited to the one meeting	**Yes**	**Yes** Not a water expert but has been involved with finance and management. Concerned about recycled water not being prioritized. Telling purple pipelines being expensive isn't enough, need to present detail, backup analysis.	**Yes** No obstacles for expressing opinions. Thought process was great so far.	**Yes** Absolutely	**Yes** Absolutely	**Yes** Thought all participants expressed freely their thoughts and suggestions.	**Yes**	**Yes** Really good dialogue.
Do you feel like all feasible supply options were considered in the 2012 LRWRP?	**Yes** Missed last meeting, but from what recalled all options were considered.	**Yes** But probably some not feasible	**Yes** Thought there was a constructive discussion on the alternatives.	**Yes** Appears so.	**Yes** Far-fetched options and well put.	**Yes** Thinks we covered them.	**Yes**	**Yes** Yes in general, but would have liked it if Direct Potable Reuse could have been considered more. Realized now may not be the timing but perhaps in the next round.	**Yes** Was glad that all options were on the table.	**Yes** But did notice a challenge with new members on their understanding of what decisions were made in previous stakeholder workshops.	**Yes** Wants to make sure we going to maximize groundwater for the plan. Is there a way to do both purple pipeline and indirect potable reuse? Concerned about short-term reliability.
At our last stakeholder meeting there was a general consensus that the City should implement elements in the Hybrid 1 portfolio, and then based on the outcome of certain future triggers consider implementing options included in Hybrid 2 portfolio (see adaptive management section). Are you supportive of this recommendation?	**Yes** Did not attend last meeting. [gave the essence of the findings]. After quick briefing, really supports the idea of adaptive management.	**No comment.** Was not present at last (3rd) stakeholder meeting.	**No** Concerned that if the city starts with low-cost solution the City may not move toward more expensive options even if needed. Leans towards Max Water Use Efficiency.	**Yes** Wants to know more about what adaptive management plan is? Will be curious to know about it in next stakeholder meeting. Thinks the options have enough flexibility	**No** Reluctant to support IPR being the preferred option while purple pipeline is ignored. Need numbers to see if purple pipelines are costly. Demo project seems overwhelmingly significant but we are talking about it happening in probably 10 years. What if IPR doesn't work, it will cost everyone a lot.	**Yes** Recalled that Hybrid 1 provided good benefits, but substantially cheaper. So would be hard to sell more expensive alternatives without seeing how the future unfolds. Uncertainties in water demands, Delta fix or not, water rates, are out there. So adaptive management is a good strategy. But good that you move head and not stay with status quo.	**No** Not right now, wants to see to outcome of the adaptive management. Still would like see some optimization of options within the portfolio.	**Yes** Hopes we are aggressive in the recommended implementation. Worried about the future cost of water and that if we wait too long to make the needed investments, they will become cost-infeasible.	**Yes** Very supportive of the concept. Still would like to see some presentation in the report on water rate impacts, realizes that this might have to be some type of index or something.	**Yes** Absolutely.	**Yes** Supportive of concept.
Have you had a chance to review the Adaptive Management Primer?	**Yes** Thought it made sense.	**No** Wanted to know how adaptive mgmt different than classic procedures. Agreed that because of possible substantial changes in near future, the portfolio has to be revisited and assess the reality.	**Yes**	**No** Not in Depth	**Yes** Looks like good decision model	**Yes** Broad primer. Fine with it. But needs to see specifics.	**Yes** It was clear and understandable.	**Yes** It made sense.	**No** Will read before May 1st meeting	**Yes** Makes sense.	**No** Will read before next stakeholder meeting.

Table F-1. 2012 LRWRP Stakeholder Discussion Matrix

Question	**Participants and Responses**										
	Stakeholder 1	**Stakeholder 2**	**Stakeholder 3**	**Stakeholder 4**	**Stakeholder 5**	**Stakeholder 6**	**Stakeholder 7**	**Stakeholder 8**	**Stakeholder 9**	**Stakeholder 10**	**Stakeholder 11**
If called upon, would you be willing to advocate your support for the LRWRP?	**Yes** Probably. Anticipates so.	**Yes** Absolutely! Can't think of better ways than how the plan is being developed. Still thinks political factor might affect the plan's outcomes	**Yes** Maybe/Depends Will have the support of Coast Keepers.	**Yes** Will brief boss but definitely support it. Thinks that pragmatically, Colorado river is reuse water, so why not our own reuse water. Though thinks IPR project still has challenges to overcome public's 'toilet to tap' perspective	**Yes Maybe/Depends** Sure! Hopeful that the above concerns will be incorporated	**Yes**	**Yes**	**Depends/Maybe** Would want to make sure Environmental concerns addressed	**Yes**	**Yes**	**Yes**
Do you have any other comments or suggestions you would like to share with us regarding the 2012 LRWRP?	Impressed with the planning so far. Suggestion, how do we move from the small stakeholder group to a bigger public advocacy? Thinks we should have public meetings after the plan is done. This would enable our political leaders to move	Key value of the plan is that it helps people in putting perspective that alternate supply options are identified and are viable. The supply cost is not going to get cheaper. Water should be treated as commodity rather than considering costs only for treatment process. It's important getting people understand supply options vs treatment vs rate.	Thinks the process is a viable one. Good process.	Really wants IPR to work as water availability/cost, is a key factor to building industry. Thinks IPR should be outreached to public through expert in the field (simplified message, right messenger). It has to be outcome driven not process driven. All options should be laid out but comes down to cost, water availability and water quality. Should educate people (rate payers) through simplistic demo such as all water are reused, whether its from bay Delta, Colorado river.	Not enough emphasis given on infrastructure transporting water. Even If IPR is successful likely in 10 years, the already deteriorated pipelines will be needing upgrades- more maintenance cost! , which has been ignored	Thought the process was good, and thought City did a good job. Did have some concerns about detailed costs. But understood the plan was broader in nature, and that details were probably not appropriate.	Seeing all types of costs at a project level (financial, reliability, environmental) would have made it more helpful in evaluating the portfolios. But recognizes this was beyond the scope/resources of project.	Conservation is really important, if we don't do conservation we will pay top dollar for. Need to look at other places over the world to see how conserve. We need to think long term!	Was concerned with City Council's own initiative to develop a water resources strategy, thinks City staff should meet with Councilwoman Lightner to go over our plan.	This is second time went through something like this with the City (participated in 2005 UWMP). Very comfortable with process so far. Glad the experts (city and consultant) were leading this.	Really wants the IPR demo project done and hopes the larger project will be implemented within next 10 yrs or sooner.
Do you think this process has been valuable?	**Yes** Really liked the process, very transparent, comprehensive, open and logical.	**Yes** Essential to do this. It identifies long investment time, long education time. Thinks that IPR will be driven by political factor.	**Yes** Process is as important as the people participating. But liked it so far.	**Yes** All handouts are sufficient to know about the process	**Yes** Absolutely! Can't ignore what we are doing.	**Yes** Real pleased with participation and dialogue, but it was good to hear different perspectives.	**Yes** Liked the process so far, glad that City/consultant tried to address concerns.	**Yes** Learned a lot, gave good insights into water issues.	**Yes** Thought process was great and enjoyed being a part of it.	**Yes** But thinks the process would have benefited with some additional stakeholders, expanded outside of IROC. Good process to educate the public.	**Yes** Really glad was involved.

Appendix G Recycled Water Cost Updates

Appendix G

Recycled Water Cost Updates

During the development of the 2012 Long-Range Water Resources Plan (LRWRP), the costs of recycled water options were refined in other parallel studies being conducted by the City. Table G-1 summarizes the yield and cost of the recycled water options used for the 2012 LRWRP, which was the best information available at the time of modeling analyses. Table G-2 summarizes the most recent cost information available as of August 2012. In both Table G-1 and G-2, the capital costs shown include assumed costs to customers for on-site retrofits.

Comparing the costs in Tables G-1 and G-2, the recycled water options with updated costs include 1) non-potable reuse with satellite plants and 2) indirect potable reuse (IPR) Phase 1. The 2012 LRWRP portfolios that included these options are summarized in Table G-3.

Table G-1. Recycled Water Option Costs used in 2012 LRWRP Analyses

Option	2035 Yield, AFY	Capital Cost, $	Annual O&M Cost, $/year	Source
Non-potable Reuse: Satellite Plants	5,475	$712.6M	$13.5M	Brown and Caldwell et al., 2011. City of San Diego 2010 Recycled Water Master Plan Update, August 2011.
Non-potable Reuse: Existing Facilities	2,700	$47.6M	$2.5M	Brown and Caldwell et al., 2011. City of San Diego 2010 Recycled Water Master Plan Update, August 2011.
Indirect Potable Reuse: Phase 1	16,800	$285.2M	$15.9M	RMC, 2011. City of San Diego Water Purification Demonstration Project Draft Planning Level Cost Estimate for Long-Range Plan Technical Memorandum prepared by RMC dated December 21, 2011.[1]
Indirect Potable Reuse: Phase 2	16,800	$748.4M	$28.5M	Brown and Caldwell et al., 2011. Recycled Water Study Technical Memorandum 8: Financial Analysis of recycled Water Project Alternatives, August 26, 2011.
Indirect Potable Reuse: Phase 3	59,000	$1,100.0M	$53.9M	Brown and Caldwell et al., 2011. Recycled Water Study Technical Memorandum 8: Financial Analysis of recycled Water Project Alternatives, August 26, 2011.

AF: Acre-foot; AFY: Acre-feet per year; O&M: Operation and Maintenance; M: Million; NA: Not available.
Refer to Table G-2 for the latest information.

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[1] This represented the most recent information for costs of Phase 1 IPR at the time of 2012 LRWRP analyses, and differs from the costs in the Recycled Water Study which in August 2011 estimated the cost of Phase 1 IPR to be $415.4 million capital costs and $18.5 million annual operation and maintenance costs.

Table G-2. Updated Recycled Water Option Costs as of August 2012

Option	2035 Yield, AFY	Capital Cost, $	Annual Supply O&M Cost, $/year	Source
Non-potable Reuse: Satellite Plants	5,475	$620.2M[1]	$13.5M	Brown and Caldwell et al., 2011. City of San Diego Recycled Water Master Plan, May 2012.
Non-potable Reuse: Existing Facilities	2,700	$47.6M[1]	$2.5M	Brown and Caldwell et al., 2011. City of San Diego Recycled Water Master Plan, May 2012.
Indirect Potable Reuse: Phase 1	16,800	$375.0M	$12.6M	RMC et al., 2012. Water Purification Demonstration Project, Draft Report, August 2012.
Indirect Potable Reuse: Phase 2	16,800	$467.4M	$22.9M	Brown and Caldwell et al., 2012. Recycled Water Study Technical Memorandum 8: Financial Analysis of recycled Water Project Alternatives, July 2012.
Indirect Potable Reuse: Phase 3	59,000	$1,168.0M	$60.5M	Brown and Caldwell et al., 2012. Recycled Water Study Technical Memorandum 8: Financial Analysis of recycled Water Project Alternatives, July 2012.

AF: Acre-foot; AFY: Acre-feet per year; O&M: Operation and Maintenance; M: Million; NA: Not available.

[1] The Recycled Water Master Plan cost estimates represent the cost to the City and do not include assumed capital cost to customers for on-site retrofits, plan checking, meter fees, cross-connection testing, and soft costs. For the 2012 LRWRP, the total capital cost includes these costs to customers which are estimated to be approximately $47.6 million for non-potable reuse with existing facilities, and $72 million for non-potable reuse with new satellite plants.

Table G-3. Portfolios with Updated Recycled Water Option Costs

	Portfolio							
Option	1 Baseline (Status Quo)	2 Max Reliability	3 Min Cost	4 Min Local Env Impacts	5 Max Local Control	6 Max Water Use Efficiency	7 Hybrid 1	8 Hybrid 2
Non-potable Reuse with Satellite Plants				X		X		
Indirect Potable Reuse: Phase 1		X			X	X	X	X
Indirect Potable Reuse: Phase 2		X			X	X		X
Indirect Potable Reuse Phase 3		X			X	X		X

For the 2012 LRWRP, portfolio costs are estimated using a complex, dynamic systems model (described in Appendix B). The systems model accounts for inflation, and annual portfolio costs are analyzed over the entire planning horizon through 2035 and discounted back to present value (PV).

Annual portfolio costs include:

- **Annual Capital Costs:** Includes amortized capital cost of new supply development and Point Loma WWTP upgrades, which vary depending on the magnitude of wastewater offloaded by the options in a portfolio.
- **Supply O&M:** This is the cost to produce the water resource, including supply operation and maintenance (O&M) costs.
- **Distribution O&M:** The variable cost of distribution is included where applicable. Some supply options require distribution to customers, while others don't such as conservation, graywater, and rainwater harvesting.
- **Wastewater System O&M Costs:** The operational cost to collect and treat wastewater is included where applicable. Some options such as conservation, graywater, and recycled water reduce the amount of wastewater to Point Loma WWTP and may reduce potential operational costs of the wastewater system.
- **Imported Water Costs:** Includes fixed and variable (based on volumetric rate) costs to purchase imported water from SDCWA.

In-lieu of re-running the dynamic systems model, a simple proxy can be used to estimate the effects of the updated recycled water option costs on the portfolio cost performance. Table G-4 summarizes the changes in costs of the satellite plant and IPR Phase 1 options, and the cumulative effect of costs over a 15 year period. This period is assumed because the options would likely not be implemented for 5-10 years, and the 2012 LRWRP planning period is through 2035. The costs in Table G-4 are in today's dollars and do not account for inflation or discount factors.

Table G-4. Total Cumulative Change in Cost

		Indirect Potable Reuse			
Option:	**Satellite Plant for Non-Potable Reuse**	**IPR Phase 1**	**IPR Phase 2**	**IPR Phase 3**	**Net Change for Combined IPR Phases 1, 2 and 3**
Change in Capital Cost:	$(92,400,000)	$89,800,000	$(281,000,000)	$68,000,000	$(123,200,000)
Change in annual supply O&M Cost:	$0	$(3,300,000)	$(5,600,000)	$6,600,000	$(2,300,000)
Cumulative supply O&M Cost (15-years):	$0	$(49,500,000)	$(84,000,000)	$99,000,000	$(34,500,000)
Total Cumulative Change in Cost (Capital Cost, plus O&M over 15 years):	**$(92,400,000)**	**$40,300,000**	**$(365,000,000)**	**$167,000,000**	**$(157,700,000)**

Note: Parenthetical enclosures represent negative values.

Based on these rough approximations, the revised total present value of the portfolios is presented in Figure G-1. All portfolios that include either (1) satellite plants for non-potable reuse or (2) IPR Phases 1, 2, or 3 should show some change in costs (based on Table B-3, this includes all portfolios except Status Quo and Minimize Cost). However, because the total cumulative costs of portfolios over the planning horizon range from **$7.1-12.6 billion** (accounting for total cost of supply, including other options, imported water, distribution, wastewater system costs, etc.), the changes of **$40-160 million** from Table G-4 do not have a significant effect on the results. The changes to total present value costs are less than 2 percent, and would not change the outcome of the 2012 LRWRP evaluations presented in Sections 6 and 7.

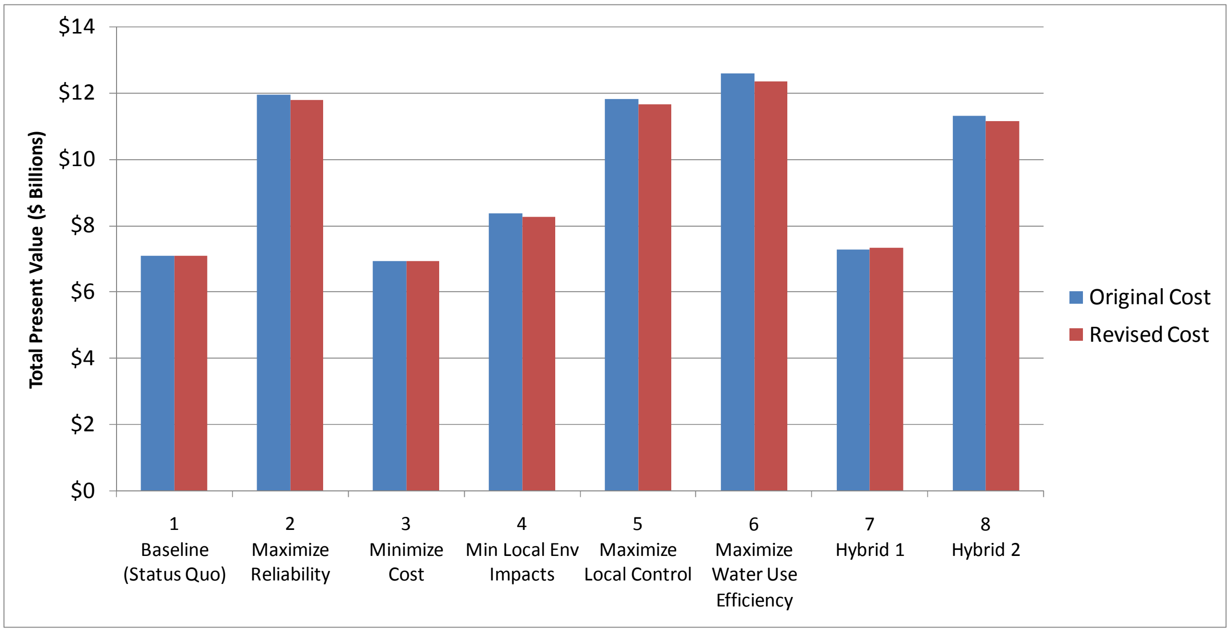

Figure G-1. Original and Revised Total Present Value of Portfolios

Appendix H References

Appendix H

References

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Appendix I City Council Resolutions

12|10|13
Item# 126-A

(R-2014-11)
COR.COPY

RESOLUTION NUMBER R- 308636

DATE OF FINAL PASSAGE DEC 24 2013

A RESOLUTION OF THE COUNCIL OF THE CITY OF SAN DIEGO ADOPTING THE 2012 LONG-RANGE WATER RESOURCES PLAN FINAL DRAFT REPORT

WHEREAS, in accordance with state regulations and City policies, the Council by Resolution No. R-289102 in August 1997 approved the City's strategic plan for water supply, and by Resolution No. R-297484 in December 2002 approved the 2002 Long-Range Water Resources Plan (LRWRP); and

WHEREAS, in March 2009 by Resolution No. R0394714, the Council authorized the preparation of the LRWRP for 2012; and

WHEREAS, the Final Draft of the 2012 LRWRP has been prepared for adoption by the Council, as summarized in Report to the City Council No. 13-55 dated June 7, 2013;

NOW, THEREFORE,

BE IT RESOLVED, by the Council of the City of San Diego, that the Council adopts the Draft 2012 LRWRP dated June 2013, as set forth in the City of San Diego Public Utilities Department 2012 Long Range Water Resources Plan, Final Draft, on file with the City Clerk as Document No. RR- 308636.

APPROVED: JAN I. GOLDSMITH, City Attorney

By ____________________

Raymond C. Palmucci
Deputy City Attorney

RCP:mb
07/10/13
09/30/13Cor.Copy
Or.Dept:Water
Doc.No:595894

I hereby certify that the foregoing Resolution was passed by the Council of the City of San Diego, at its meeting of DEC 10 2013.

ELIZABETH S. MALAND, City Clerk

By ______________________
Deputy City Clerk

Approved pursuant to Charter section 265(i)

____
Date

____
TODD GLORIA, Council President

Passed by the Council of The City of San Diego on DEC 10 2013, by the following vote:

Councilmembers	Yeas	Nays	Not Present	Recused
Sherri Lightner	☑	☐	☐	☐
Kevin Faulconer	☑	☐	☐	☐
Todd Gloria	☐	☐	☑	☐
Myrtle Cole	☑	☐	☐	☐
Mark Kersey	☑	☐	☐	☐
Lorie Zapf	☑	☐	☐	☐
Scott Sherman	☑	☐	☐	☐
David Alvarez	☐	☐	☑	☐
Marti Emerald	☑	☐	☐	☐

Date of final passage DEC 24 2013.

(Please note: When a resolution is approved by the Council President as interim Mayor, the date of final passage is the date the approved resolution was returned to the Office of the City Clerk.)

AUTHENTICATED BY:

TODD GLORIA, COUNCIL PRESIDENT
as interim Mayor of The City of San Diego, California.

(Seal)

ELIZABETH S. MALAND
City Clerk of The City of San Diego, California.

By Mary Zamaya, Deputy

Office of the City Clerk, San Diego, California

Resolution Number R- 308636

12/10/13
Item #
126-B

(R-2014-12)
COR.COPY

RESOLUTION NUMBER R-308637

DATE OF FINAL PASSAGE DEC 24 2013

A RESOLUTION OF THE COUNCIL OF THE CITY OF SAN DIEGO DETERMINING THAT APPROVAL OF THE CITY'S LONG-RANGE WATER RESOURCES PLAN FINAL DRAFT REPORT IS STATUTORILY EXEMPT FROM THE CALIFORNIA ENVIRONMENTAL QUALITY ACT PURSUANT TO CEQA GUIDELINES SECTION 15262.

WHEREAS, the Public Utilities Department has prepared for Council adoption the Final Draft Report for the 2012 Long-Range Water Resources Plan (LRWRP); and

WHEREAS, the California State Legislature, through the California Environmental Quality Act (CEQA), Public Resources Code sections 21000-21177, has determined that CEQA does not apply to various types of projects listed therein; and

WHEREAS, CEQA section 21084 states that the CEQA Guidelines shall list those classes of projects which have been determined not to have a significant effect on the environment and which shall be exempt from CEQA; and

WHEREAS, pursuant to that authority, CEQA Guidelines sections 15260-15285 list the statutory exemptions promulgated by the California State Legislature; and

WHEREAS, after having considered the written record regarding the LRWRP as well as public comment, if any, the City Council has determined based on its independent judgment that CEQA Guidelines section 15262, Feasibility and Planning Studies, covers the LRWRP; NOW, THEREFORE, BE IT RESOLVED, by the Council of the City of San Diego, that the Final Draft Report for the 2012 Long-Range Water Resources Plan – June 2013, is exempt from CEQA pursuant to CEQA Guidelines section 15262.

APPROVED: JAN I. GOLDSMITH, City Attorney

By ______________________
Raymond C. Palmucci
Deputy City Attorney

RCP:mb
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Or.Dept:Water
Doc.No:595902

I hereby certify that the foregoing Resolution was passed by the Council of the City of San Diego, at its meeting of DEC 10 2013.

ELIZABETH S. MALAND, City Clerk

By ______________________
Deputy City Clerk

Approved pursuant to Charter section 265(i)

____
Date

____
TODD GLORIA, Council President

Passed by the Council of The City of San Diego on DEC 10 2013, by the following vote:

Councilmembers	Yeas	Nays	Not Present	Recused
Sherri Lightner	☑	☐	☐	☐
Kevin Faulconer	☑	☐	☐	☐
Todd Gloria	☐	☐	☑	☐
Myrtle Cole	☑	☐	☐	☐
Mark Kersey	☑	☐	☐	☐
Lorie Zapf	☑	☐	☐	☐
Scott Sherman	☑	☐	☐	☐
David Alvarez	☐	☐	☑	☐
Marti Emerald	☑	☐	☐	☐

Date of final passage DEC 24 2013.

(Please note: When a resolution is approved by the Council President as interim Mayor, the date of final passage is the date the approved resolution was returned to the Office of the City Clerk.)

AUTHENTICATED BY:

TODD GLORIA, COUNCIL PRESIDENT
as interim Mayor of The City of San Diego, California.

(Seal)

ELIZABETH S. MALAND
City Clerk of The City of San Diego, California.

By ______________________, Deputy

Office of the City Clerk, San Diego, California

Resolution Number R-308637