RECLAMATION

Managing Water in the West

Los Angeles Basin Stormwater Conservation Study

Task 2 Water Supply & Water Demand Projections

U.S. Department of the Interior
Bureau of Reclamation

County of Los Angeles
Department of Public Works

Los Angeles County
Flood Control District

December 2014

Mission Statements

The mission of the County of Los Angeles Department of Public Works is to provide public infrastructure and municipal services to protect and enrich the daily lives of over 10 million people in Los Angeles County.

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Cover Photo: Morris Dam along the San Gabriel River, Los Angeles County, California.

Los Angeles Basin Stormwater Conservation Study

Task 2. Water Supply & Water Demand Projections

December 2014

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Acronyms and Abbreviations

AFY	acre-foot per year
AWT	Advanced Water Treatment
CA DOF	California Department of Finance
CMIP5-BCSD	Bias Correction and Spatial Disaggregation Coupled Model Intercomparison Project, Phase 5
DPR	Direct Potable Reuse
DWR	Department of Water Resources
CRA	Colorado River Aqueduct
GCM	Global Climate Model
GHG	Greenhouse Gas
GIS	Geographic Information System
GLAC	Greater Los Angeles County
gpcd	gallons per capita per day
IPR	Indirect Potable Reuse
IRP	Integrated Resources Plan
IRWM	Integrated Regional Water Management
IRWMP	Integrated Regional Water Management Plan
LAA	Los Angeles Aqueduct
LA Basin Study	Los Angeles Basin Stormwater Conservation Study
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LADWP	Los Angeles Department of Water and Power
LID	Low Impact Development
MGD	million gallons per day

MWD	Metropolitan Water District of Southern California
PRWUS	Perth Residential Water Use Study
Reclamation	U.S. Department of Interior, Bureau of Reclamation
SCAG	Southern California Association of Governments
SCMP	Stormwater Capture Master Plan
SWP	State Water Project
UWMP	Urban Water Management Plan
West Basin MWD	West Basin Municipal Water District

Glossary

Aquifer Class 1: Aquifer under Los Angeles Department of Water and Power (LADWP) control.

Aquifer Class 2: Aquifer under regional control, but still potentially usable for the City of Los Angeles.

Aquifer Class 3: Aquifer that is perched or where recharge is unlikely to be usable for the City of Los Angeles.

Available Supplies: All water supply volumes that could theoretically be used to meet demands if sufficient facilities, need, and other factors existed to make use of the supplies (i.e., potential supplies).

Basin Study Watersheds (Study Area): The Los Angeles River, San Gabriel River, Ballona Creek, South Santa Monica Bay, North Santa Monica Bay, Malibu Creek, and Dominguez Channel/Los Angeles Harbor watersheds.

Bioswale: A vegetated form of onsite stormwater retention that partially treats water quality, attenuates flooding potential, and conveys stormwater.

Block Group: Geographic units used by the United States Census Bureau to present data and control block numbering. Block groups are generally defined to contain between 600 and 3,000 people.

Centralized Stormwater Capture for Recharge: Precipitation and run-off water that is captured from natural and engineered drainage systems and stored in centralized facilities such as spreading basins and recharge basins for the managed replenishment/recharge of local groundwater basins.

Cistern: A tank or container that holds water.

Decentralized Stormwater Capture for Recharge: Precipitation and run-off water that is retained on site (prior to entering a storm drain system) long enough to infiltrate into and replenish/recharge local groundwater basins. Examples of decentralized recharge projects include permeable pavement and bioswales.

Decentralized Stormwater Capture for Direct Use: Precipitation and run-off water that is captured and stored on site (prior to entering a storm drain system) and subsequently used on site to meet non-potable direct use needs.

Desalinated Ocean Water: Water that originates from the ocean and is treated for potable direct use.

GLAC IRWM Subregions: Subdivisions of the Greater Los Angeles County Integrated Regional Water Management (GLAC IRWM) Region that acknowledge both geographic and demographic variations. GLAC IRWM subregions include the North Santa Monica Bay, South Bay, Lower San Gabriel and Los Angeles Rivers, Upper Los Angeles River, Upper San Gabriel and Rio Hondo Rivers subregions.

Gpcd: Gallons per capita per day is a water use rate that accounts for reductions in water demand due to water conservation, but does not include recycled water use credits, graywater, or decentralized stormwater capture for direct use that reduce potable demand but not overall water use.

Graywater: Wastewater generated on site from a washing machine, shower or bathroom sink that can be subsequently used on site without further treatment to meet non-potable demands.

Groundwater Pumped: Water pumped from local groundwater basins for distribution by the water agencies as a direct supply regardless of the method or original source of supply that was recharged to the basin.

Groundwater Natural Safe Yield: Water that naturally percolates through permeable surfaces without the assistance of engineered facilities. Groundwater natural safe yield can be partially composed of existing decentralized stormwater capture for recharge, as defined in this report, in some basins. A Metropolitan Water District of Southern California (MWD) document defines it as “the yield of a basin without active recharge” (MWD 2007).

Imported Water: Water provided by MWD from the State Water Project (SWP) and Colorado River Aqueduct (CRA) to local water retailers to meet potable demands, as well as water provided by LADWP from the Los Angeles Aqueduct (LAA).

Imported Water for Recharge: Water purchased from MWD by local agencies to replenish groundwater basins either through spreading or injection.

Integrated Resources Plan: Long term planning document that provides a detailed analysis of future water resources available to a water agency or Region.

Limited and Fully Used Supplies: Water supplies that have a defined upper limit; and that upper limit is assumed to be completely utilized with existing, implemented project facilities.

Limited but Not Fully Used Supplies: Water supplies that have a finite upper limit, but that upper limit has not been reached.

Local Surface Water: Water that flows within local watersheds and is diverted for direct potable use.

Recharge Capacity: The maximum volume of water that a recharge facility is able to infiltrate into an aquifer.

Recharge Facility: An engineered facility, typically a basin, constructed to collect water and artificially recharge water to an underlying groundwater aquifer.

Recycled Water: Wastewater that is treated at a water reclamation plant for non-potable direct uses.

Recycled Water for Recharge: Wastewater that is treated at a reclamation plant to replenish/recharge groundwater basins either through spreading or injection.

Replenishment Supply: Water injected or allowed to infiltrate through the soil to replace pumped groundwater supplies.

Spreading Ground (Basin): Recharge facility in which water is spread out over a large surface area and water infiltrates through the soil to the aquifer.

Unclassified Aquifer: Areas that do not have an underlying aquifer, such as mountainous areas.

Unlimited Supplies: Water supplies that are not restricted by total water volume available for use and are only limited by facilities development, environmental concerns, costs and/or other factors.

Used Supplies: That portion of available water supplies that are actually used to meet water demands because facilities and other factors are in place that enable water agencies and end users to access them. This term is used in this report to distinguish between available (i.e., potential) supplies and available supplies that are actually used to meet demands.

Watershed: Surface drainage area upstream of a specified point on a watercourse. A geographical portion of the Earth's surface from which water drains or runs off to a single point.

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Executive Summary

The Los Angeles County Flood Control District (LACFCD) partnered with the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) to collaborate on the Los Angeles Basin Stormwater Conservation Study (LA Basin Study). The purpose of the LA Basin Study is to study long-term water conservation and flood control impacts from projected climate conditions and population changes in the Los Angeles Basin. The LA Basin Study will recommend potential changes to the operation of stormwater capture systems, modifications to existing facilities, and development of new facilities that could help resolve future water supply and flood control issues. The recommendations will be developed through identifying alternatives and conducting trade-off analyses.

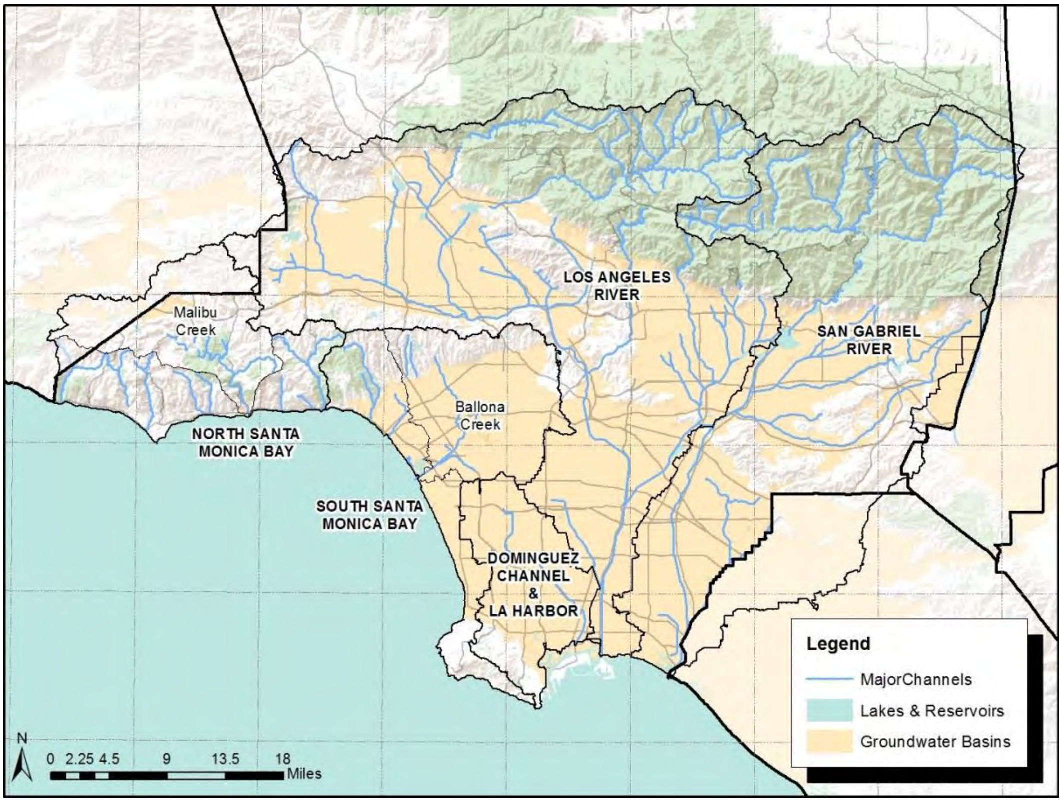
For Task 2 of the LA Basin Study, Water Supply and Water Demand Projections, existing and projected water supplies and demands were characterized for the LA Basin Study Area (Study Area) out to 2095, with consideration of projected climate change effects. It is important to note that this Task 2 report inventories projected available supplies (i.e., potential supplies), and does not make assumptions for the volume of each supply source that will actually be used to meet projected demands, nor the facilities necessary to access and serve those supplies. This determination would require more in-depth integrated supply and demand planning to predict and analyze the multitude of factors that influence water supply and use decisions such as policy, cost, environmental factors, reliability, etc. This Task 2 report is intended to provide a supply and demand basis for understanding the potential need and benefit of additional stormwater capture systems that could be implemented across the region by the LACFCD and its partners. Given that stormwater is a local and relatively inexpensive source of supply, it must be a critical and substantial part of the LA Basin water supply portfolio that could help meet demands through 2095 and beyond.

Water Supply and Water Demand

The methodologies used in the LA Basin Study center on the use of existing information and documents as references, including the 2014 Greater Los Angeles County Integrated Regional Water Management Plan, the 2010 Metropolitan Water District of Southern California Integrated Resources Plan, and the 2014 Los Angeles Department of Water and Power Stormwater Capture Master Plan (Technical Memorandum 2.1). Most of the recent water supply and demand documents available had planning horizons that only extended through 2035 and 2040, so the 2095 projections provided in this report were calculated from these 2035/2040 projections using a variety of assumptions to predict how water management and supply availability might change in that 60 year period. These assumptions were discussed and reviewed through a stakeholder process with the LA Basin Study Stakeholder Technical Advisory Committee (STAC).

The Task 2 report divides the Study Area into seven major watersheds as shown in Figure ES-1.

Figure ES-1. Los Angeles Basin Study Area



For each of these watersheds and for the Study Area as a whole, calculations were performed to determine 2010 demands and supplies, which represent "existing" actual demands and supplies based on the planning documents named above. The report then uses the same references as the basis for projections of water demands and supplies in 2035.

Projections for demands and supplies in 2095 were developed using a different set of methodologies and assumptions. Demands were estimated based on assumed values for gallons per capita per day (gpcd) combined with population projections. Three scenarios for demand projections were developed: a "high" scenario based on the assumption that 2035 values will be maintained, a "medium" scenario based on the assumption that the Region could attain the City of Long Beach target gpcd as listed in its 2010 Urban Water Management Plan, and a "low" scenario based on the assumption that the Region could duplicate and surpass the urban demand management achievements in Perth, Australia by making additional progress on outdoor conservation measures. As a final step, these three gpcd values were decreased by one percent to reflect the influences of potential increases in precipitation on water demand using a basic climate change model. The 2095 values for the three demand scenarios, adjusted for climate change, are:

- "High" demand scenario – 136 gpcd
- "Medium" demand scenario – 99 gpcd
- "Low" demand scenario – 63 gpcd

Supply projections for 2095 were completed for eleven categories as listed in Figure ES-2 below. These eleven categories fall into two broader groupings: 1) direct use supplies that are directly delivered to end users; 2) replenishment/ recharge supplies that are not delivered directly but will later be served to end users as pumped groundwater. Available stormwater supplies were divided into three categories: 1) centralized stormwater capture for recharge, 2) decentralized stormwater capture for recharge, and 3) decentralized stormwater capture for direct use. Information from existing documents was used to estimate the impacts of climate change on each of the categories of supplies in 2095.

Projection Results in 2095 by Watershed

Figure ES-2 illustrates the supply and demand projections for each watershed in the LA Basin in 2095. The "high", "medium", and "low" demand scenarios can be seen as sets of three horizontal bars for each LA Basin watershed. The two groupings of supplies are represented as bold colors for direct supplies and lighter colors for replenishment/recharge supplies. The recycled water replenishment/ recharge estimates are depicted as a range in Figure ES-2, with a "high" estimate shown as cross hatching above a "low" estimate in lavender.

In general, Figure ES-2 shows that the potential supply availability exceeds projected demands in the Study Area. This is the case under all three demand scenarios and for both "high" and "low" recycled water supply scenarios for each of the watersheds, except for the North Santa Monica Bay watershed where the "high" demand scenario exceeds available supplies.

Figure ES-2 also indicates the significantly higher supply availability (and demands) present in the Los Angeles River and San Gabriel River watersheds compared to the other five watersheds. This is due to their larger geographic areas and populations (for population-generated supplies such as recycled water and graywater) as well as their location relative to headwaters and recharge zones. These larger watersheds also have greater potential for stormwater capture. It should be noted that capture of stormwater and use of recycled water for replenishment/recharge is dependent on having the necessary soils, facilities, conveyance systems, etc. for additional replenishment/recharge. The Los Angeles River and San Gabriel River watersheds overlie the largest groundwater basins in the Study Area. Smaller, coastal watersheds, particularly the Malibu Creek and

North Santa Monica Bay watersheds, have little to no potential for additional replenishment/recharge. Therefore their available supply numbers are representatively smaller—which puts a larger emphasis on direct capture and use for maximizing stormwater as a form of supply. It should also be noted that the overall implementation of supply projects also depends on public policy, environmental, water rights, and other potential factors.

Projection Results in 2010, 2035, and 2095 for Entire LA Basin

Figure ES-3 depicts the progression of demands and supplies in the LA Basin from 2010 to 2095. Overall, available supplies in 2035 and 2095 exceed demands. Imported water supplies first increase in 2035 as reliability improvements are implemented; they then decrease due to the impacts of climate change. Recycled water availability increases from 2010 to 2035 as recycled water systems expand and recycled water for direct use is assumed to be maximized in 2035. From 2035 to 2095, recycled water for recharge increases according to the “low” and “high” scenarios. Graywater is projected to increase assuming a 15 percent implementation rate in the Study Area by 2095; and stormwater capture is projected to increase for all three categories used in this Study: centralized stormwater capture for recharge, decentralized stormwater capture for recharge, and decentralized stormwater capture for direct use. Desalinated ocean water supplies are assumed to remain at 2035 levels in 2095, whereas local surface water supplies are assumed to increase by approximately 13 percent based on projected runoff values determined in the LA Basin Study, Task 3.2 Hydrologic Modeling Report.

Figure ES-2: 2095 Available Water Supplies and Water Demands (with "High", "Medium", and "Low" Demand Scenarios)

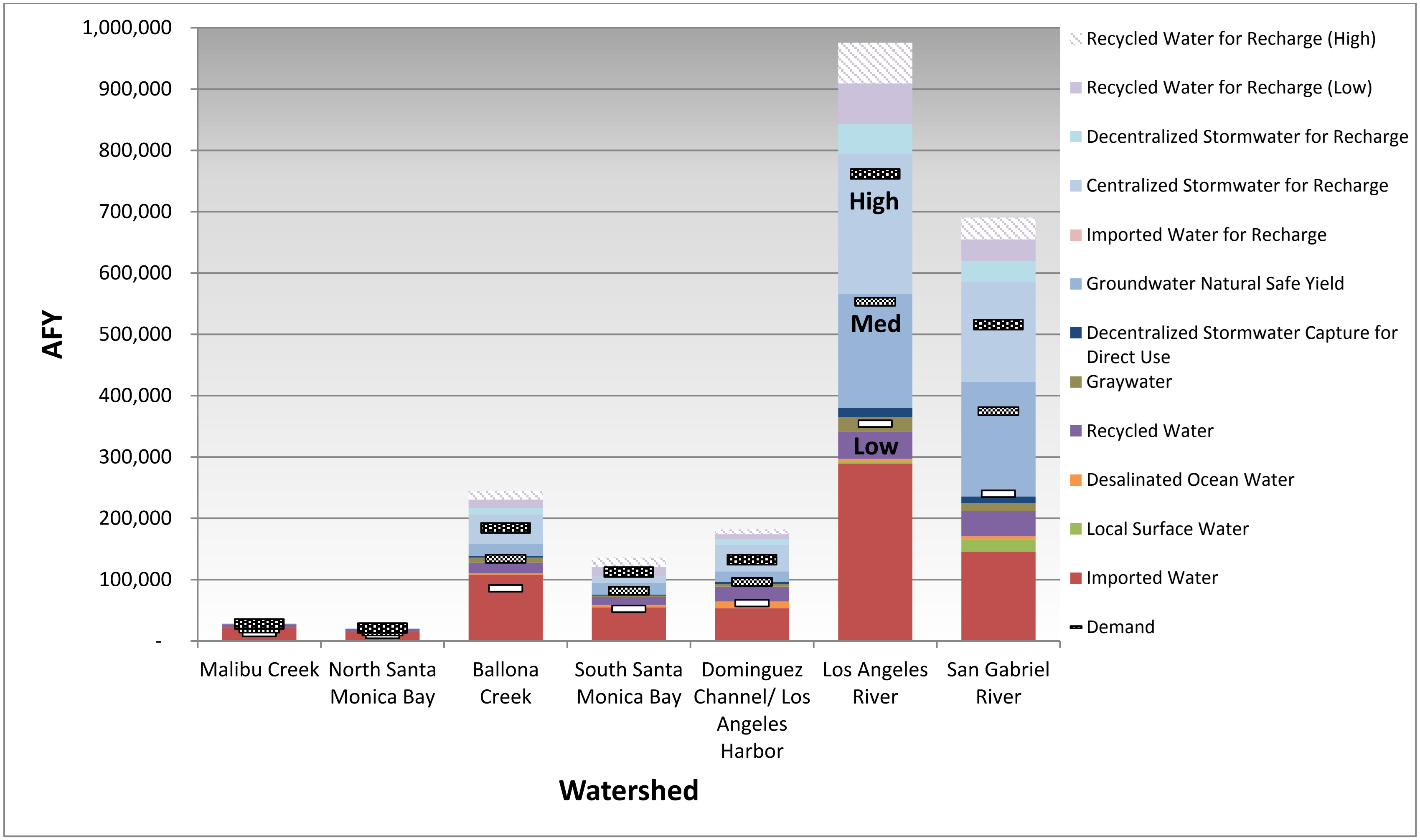
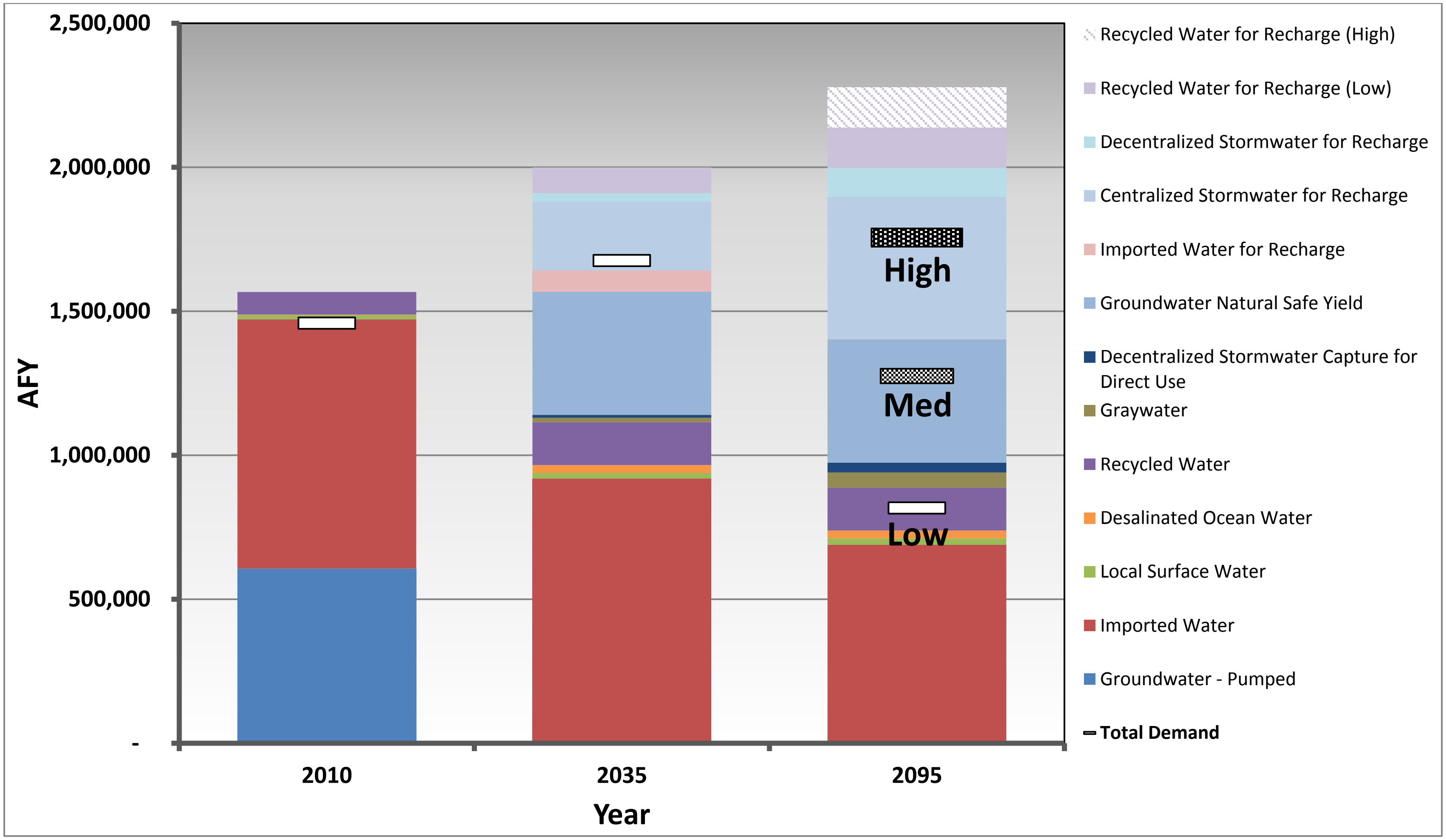


Figure ES-3: Available Supply and Demand for 2010 Through 2095 for the LA Basin Study Area



1. Introduction

1.1. Study Purpose

The purpose of the Los Angeles Basin Stormwater Conservation Study (LA Basin Study) is to address long-term water conservation and flood control impacts from projected climate conditions and population changes in the Greater Los Angeles area. The LA Basin Study will recommend potential changes to the operation of stormwater capture systems, modifications to existing facilities, and development of new facilities that could help resolve future water supply and flood control issues. The recommendations will be developed through identifying alternatives and conducting trade-off analyses.

1.2. Study Background

The Los Angeles County Flood Control District (LACFCD) has been considering the possibility of large-scale enhancement of its water conservation capabilities through the study of long-term projected needs and future climate conditions. Informal discussions have occurred between the LACFCD and several major water agencies on the same subject. As a result, this interest was the driving force for creating a partnership between the LACFCD and U.S. Department of the Interior, Bureau of Reclamation (Reclamation) under the Reclamation Basin Studies Program (Reclamation 2009).

The LA Basin Study is utilizing the latest climate science and hydrologic modeling tools to create a vision of the near-term and long-term future of stormwater capture in Los Angeles County. The LA Basin Study offers the opportunity for multiple water management agencies to participate in a collaborative process to plan for future local water supply scenarios; and examine opportunities to enhance existing LACFCD and its Study partners' facilities, operations, and propose new facilities that demonstrate direct benefits to water agencies and local communities.

The LA Basin Study utilizes, to the greatest extent practicable, existing information on the availability and suitability of various open space and underdeveloped parcel opportunities as infiltration sites. It evaluates potential infiltration sites for soil characteristics, groundwater basin condition, conveyance/diversion/outlet requirements, site remediation requirements, property valuation and availability, environmental impact, regulatory requirements, community impact, multiuse potential, and other factors deemed necessary to assess a potential site.

The LA Basin Study considers technical viability of implementing innovative facility concepts that show a prospective for increasing infiltrative capacity to recharge groundwater. A trade-off analysis will be conducted in a later Task to help evaluate the regional impacts and the economic costs and benefits of the various stormwater capture alternatives.

Additionally, the Study is looking at the costs of attaining different goals through a cost-effectiveness analysis. The final outcome and recommendations of the Study will yield concept development and trade-off analyses that will serve as a guiding document for further local water supply development planning, financing strategy, and policy adoption by the LACFCD and other LA Basin Study partners.

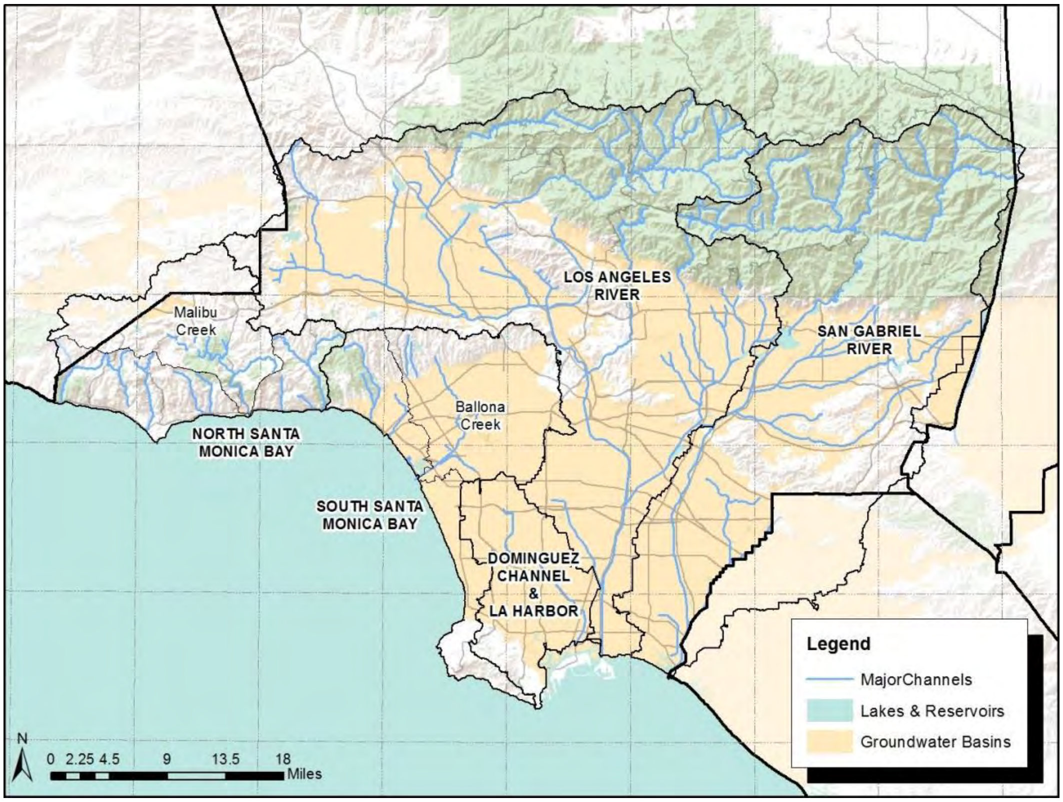
1.3. Description of Study Area

The Los Angeles River, San Gabriel River[1], South Santa Monica Bay, North Santa Monica Bay, Ballona Creek, Malibu Creek, and Dominguez Channel/Los Angeles Harbor watersheds (Basin Study Watersheds) are featured in the LA Basin Study Area (Study Area) and shown in Figure 1. This Study incorporates the entire watershed boundaries noted, including those where they extend beyond Los Angeles County.

The Study Area includes several large groundwater basins, including the Central Basin, Main San Gabriel Basin, Raymond Basin, San Fernando Valley Basin, Six Basins, and West Coast Basin (Figure 2). The LACFCD's 14 major dams and reservoirs are located in the front range of the San Gabriel Mountains stretching more than 40 miles from the San Fernando Valley on the west to the eastern edge of the San Gabriel Valley (Los Angeles County Department of Public Works [LACDPW] 2013). The largely undeveloped watershed area upstream of the LACFCD dams is approximately 400 square miles and the majority of it is within the Angeles National Forest. Spreading grounds—which serve to infiltrate stormwater runoff—are located in areas of high permeability downstream from the LACFCD dams. Rubber dams are located within the natural bottom portions of a river and help to retain and percolate stormwater through the river bottom.

[1] For the purposes of this Study, the Los Cerritos Channel watershed is included as part of the San Gabriel River watershed.

Figure 1. Los Angeles Basin Stormwater Conservation Study Watersheds



The LA Basin Study watersheds include more than 9 million people and cover approximately 1,900 square miles. More than 95 percent of Los Angeles County's population resides within the Study Area. This population concentration also accounts for more than one-fourth of the State of California's population. Presently, California's population is 37.3 million people and Los Angeles County's population is nearly at 9.8 million people (U.S. Census 2010). By 2050, the populations of California and the County of Los Angeles are projected to reach approximately 50.3 million and 11.4 million people, respectively.

According to the California Department of Finance, the State's population as a whole is projected to increase by more than 34 percent, while Los Angeles County's is projected to increase by approximately 16 percent between 2010 and 2050 (Department of Finance 2013). Projected larger population growth rates outside of Los Angeles County indicate there will be enormous pressure and competition for imported sources of water and the need for increased development of local water supply sources. At present, Los Angeles County accounts for the largest amount of water demand of any urbanized county in California. Total water usage within the Los Angeles County portion of the Metropolitan Water District of Southern California (MWD) service area—an area wholly served by the LACFCD—exceeded 1.54 million acre-feet in fiscal year 2011-12 (MWD 2012).

1.4. Purpose of Task 2

The LA Basin Study is composed of several inter-related tasks. This Interim Report (report) constitutes the methodologies and findings for Task 2 – Water Supply and Water Demand Projections. The purpose of the Task 2 report is to characterize existing and projected water supply and demand within the Study Area.

This report contains an inventory of current and future water demands, an inventory of current and future water supplies, an assessment of contributions from the LACFCD water conservation system to the overall water supply, and assessments of basin-wide inventories of current water demands and supplies and future water demands and supplies.

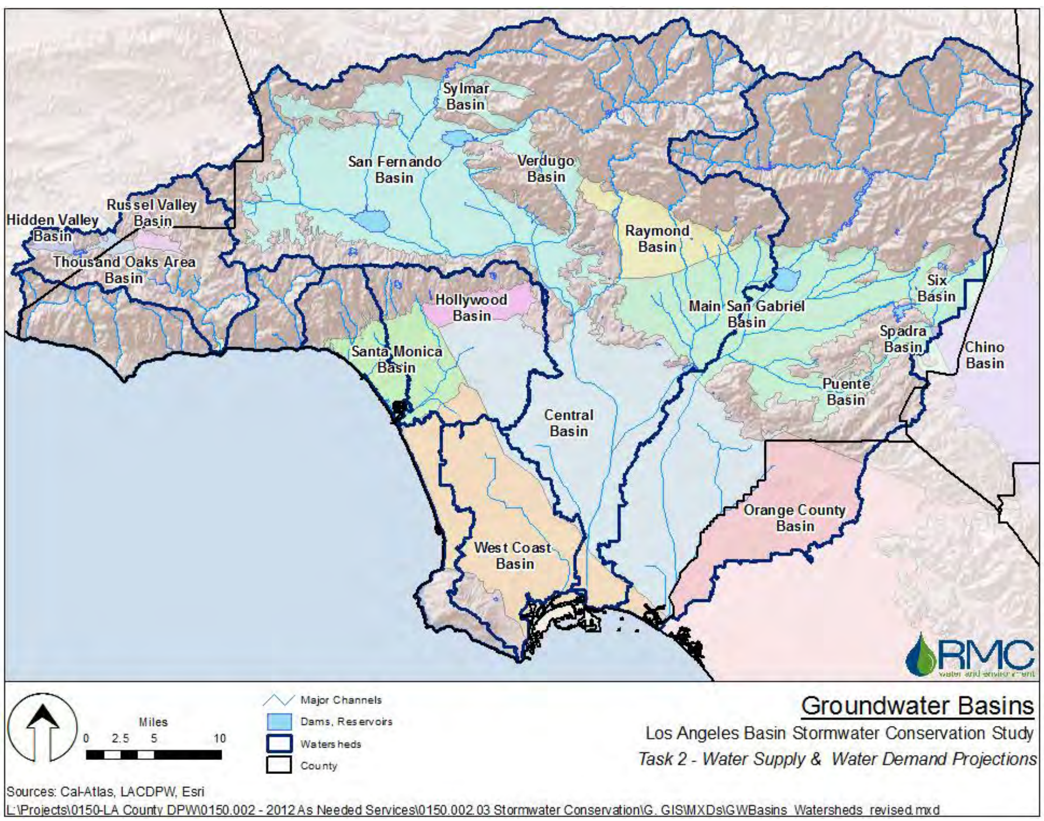
The report uses existing documents as references for projecting supplies and demands, including the Greater Los Angeles County (GLAC) Integrated Regional Water Management Plan (IRWMP), the Metropolitan Water District of Southern California (MWD) Integrated Resources Plan (IRP), and the Los Angeles Department of Water and Power (LADWP) draft Stormwater Capture Master Plan (SCMP). Where references were not available to assist in projecting water supplies and demands to 2095, assumptions were made regarding how supplies and demands may reasonably be expected to change between 2035 and 2095. These assumptions were discussed and reviewed through a stakeholder process with the LA Basin Study Stakeholder Technical Advisory Committee (STAC).

2. Water Demand

The purpose of this section is to estimate the water demand for 2010 and projected water demand for 2035 and 2095 in the seven watersheds within the Study Area. These watersheds include the Los Angeles River, San Gabriel River[2], South Santa Monica Bay, North Santa Monica Bay, Ballona Creek, Malibu Creek, and Dominguez Channel/Los Angeles Harbor watersheds as shown in Figure 2.

Since the information in this report is organized by watershed, it is important to note that these watersheds represent geographic areas that may encompass more than one groundwater basin, parts of multiple basins, or no groundwater basins as is the case with the North Santa Monica Bay watershed. The relationship between watersheds and groundwater basins is also shown in Figure 2.

Figure 2. LA Basin Study Major Groundwater Basins



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[2] For the purposes of this Study, the Los Cerritos Channel watershed is included as part of the San Gabriel River watershed.

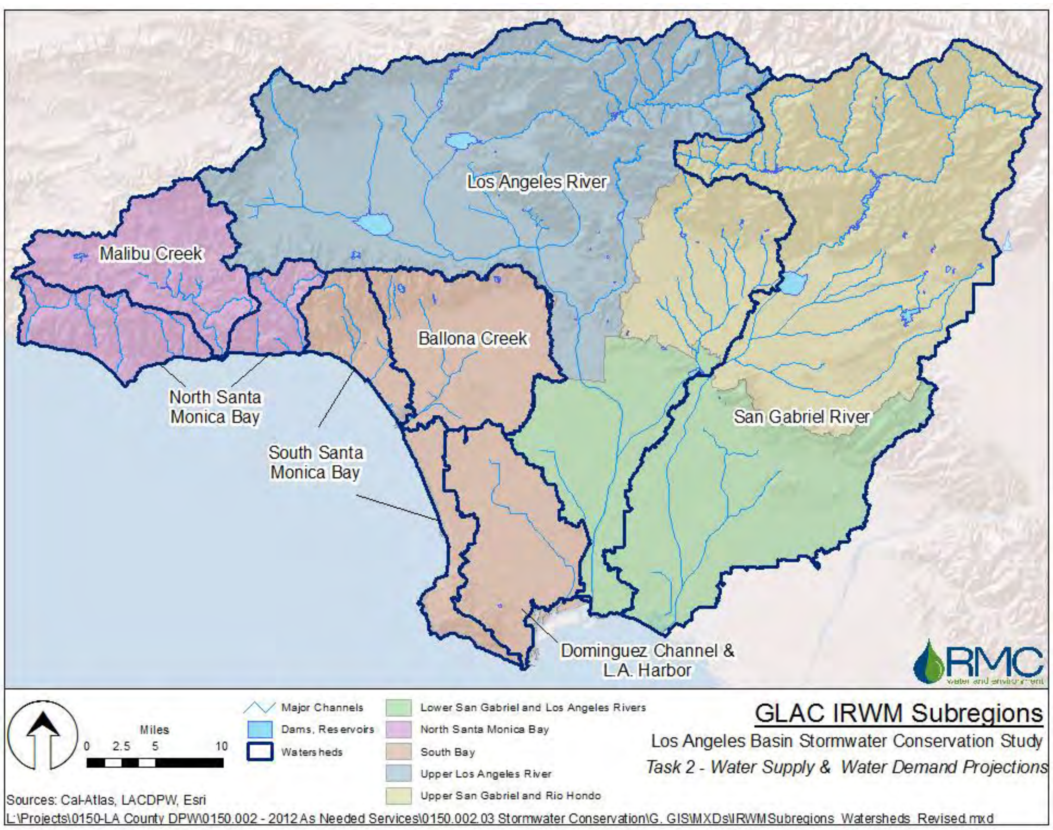
2.1. Methodology

Demand estimates for 2010 and projections for 2035 utilize data from the GLAC IRWMP. Projections for 2095 build off of the 2035 projections and apply assumed “low”, “medium”, and “high” per capita per day water use values to population projections derived from the 2010 U.S. Census, as explained in the sections below. Potential climate change impacts to demands were also incorporated into the 2095 projections.

2.1.1. Water Demands for 2010 and 2035

Water demand for the years 2010 and 2035 were estimated using data compiled in the GLAC IRWMP. This data originates from 2010 Urban Water Management Plans (UWMPs) for water agencies with service areas within the Study Area. The GLAC IRWMP distributed the reported demands *by IRWM subregion*; but because the LA Basin Study investigates supply and demand *by watershed*, these demand values were redistributed by watershed. The juxtaposition of the five IRWM subregions and seven Basin Study Watersheds is shown in Figure 3. GIS layers representing the various water agency service areas were used to assign proportions of demands within each watershed. This is the same methodology that was used in the GLAC IRWMP to assign demands for each of the subregions.

Figure 3. LA Basin Study Watersheds and GLAC IRWM Subregions



The GLAC IRWMP included "water conservation" as a separate supply to remain consistent with the majority of UWMPs which also report conservation as a supply. However, for the purposes of the LA Basin Study, water conservation is considered to be a reduction in demand rather than an additional supply. The GLAC IRWMP water conservation volumes for each watershed were therefore subtracted from the total projected demands in each watershed. The reason that conservation is handled in this manner is to provide consistency in subsequent calculations involving per capita demands, expressed as gallons per capita per day (gpcd). In other words, the gpcd projections used in this report to estimate 2095 demands already incorporate water conservation measures; so demand estimates for 2010 and 2035 need to incorporate conservation in a similar manner.

One further refinement is worth noting—in the context of this report, "water conservation" refers to all demand management measures except for graywater and decentralized stormwater capture for direct use. These types of measures are considered to be supplies, as explained in Section 3.

2.1.2. Water Demands for 2095

2.1.2.1. Population Projections

The 2010 populations for each of the seven Basin Study Watersheds were estimated using block groups[3] from the 2010 U.S. Census. To estimate population out to 2035 and 2095, projections for Los Angeles County from the California Department of Finance (CA DOF 2010) were used to calculate the percent change in population for all seven watersheds combined. This percent change was then applied to the 2010 population for each of the seven watersheds to obtain proportional increases in population from 2010 to 2060 in five-year increments. Next, the trend in percentage growth between 2040 and 2060 for Los Angeles County was used to extrapolate the percentage change in growth between 2060 and 2095, also in five year increments. Finally, these percent changes were applied to each watershed to obtain population projections between 2060 and 2095. Table 1 and Figure 4 summarize the results of the projections. The overall increase in Los Angeles Basin population from 2010 to 2035 was estimated to be approximately 13 percent, and the increase from 2035 to 2095 was estimated to be approximately 6 percent as the geographic constraints on infill slow the rate of growth.

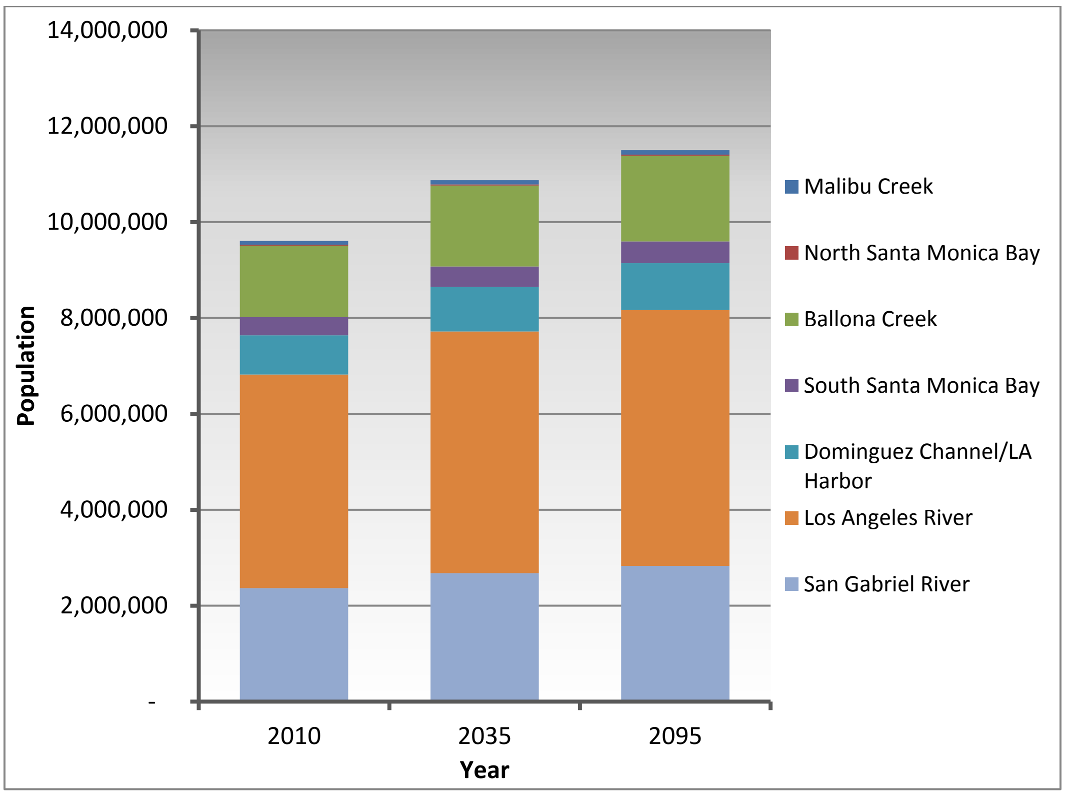
[3] Block Groups are geographic units used by the United States Census Bureau to present data and control block numbering. Block groups are generally defined to contain between 600 and 3,000 people.

Table 1. Population Projections for Watersheds in the Los Angeles Basin

Watershed	2010	2035	2095
Malibu Creek	78,700	89,000	94,200
North Santa Monica Bay	20,100	22,800	24,100
Ballona Creek	1,491,500	1,688,100	1,785,400
South Santa Monica Bay	379,000	429,000	453,700
Dominguez Channel/Los Angeles Harbor	818,000	925,800	979,100
Los Angeles River	4,455,300	5,042,700	5,333,100
San Gabriel River	2,365,000	2,676,900	2,831,000
Total for LA Basin	**9,607,600**	**10,874,300**	**11,500,600**

Note: Values rounded to the nearest 100.

Figure 4. Population Projections for the LA Basin Study Area



2.1.2.2 2095 Demand Projections

To project water demands out to the year 2095, assumed "low", "medium", and "high" regional gpcd estimates were used in combination with the population projections for each watershed. Climate change impacts were then applied to the regional gpcd estimates based on the analysis described in Appendix B – Climate Change Impacts on Demands. Future water conservation efforts (but not graywater or decentralized stormwater capture for direct use) were assumed to be incorporated into the estimated gpcd range, as discussed above.

Regional Demand Estimates - Before Incorporating Climate Change Impacts

For the "high" water demand estimate, per capita use was assumed to remain constant at 2035 levels (based on GLAC IRWMP), with overall demands changing only through population growth. The average per capita water demands for 2035 in the Los Angeles Basin were approximated at 138 gpcd. The gpcd for each individual watershed varied based on the specific combination of demand and population projections. For the purposes of this report, it is assumed that the 138 gpcd value does not incorporate the benefits of graywater implementation or decentralized stormwater capture for direct use. These quantities are accounted for as supplies in Section 3 of this report.

For the "medium" 2095 per capita water use projection, it was assumed that the Los Angeles Basin could achieve the 100 gpcd 20x2020 per capita demand target set by the City of Long Beach (Long Beach Water Department UWMP 2010). The City of Long Beach has one of the lowest per capita water use targets in the Los Angeles Basin, and it represents an attainable goal for the actual climatic conditions in the region. Unlike many water agencies in the Study Area, the Long Beach target does not include recycled water credits and thus is comparable to the definition of gpcd used in this report. The use of the 100 gpcd assumption results in an overall reduction of approximately 27 percent in per capita demands as compared to the 2035 gpcd [0.73*138 = 100 gpcd]. For the purposes of this report, it is assumed that the 100 gpcd value does not incorporate the benefits of graywater implementation or decentralized stormwater capture for direct use. These quantities are accounted for as supplies in Section 3 of this report.

To assign a "low" gpcd estimate to the Los Angeles Basin, a documented water use rate for Perth, Australia was assumed to represent an aggressive per capita demand target for water conservation in the Study Area. As documented in the 2008/2009 Perth Residential Water Use Study (PRWUS), Perth, Australia has an economic structure and Mediterranean climate similar to the Los Angeles Basin and has a history of large-scale water conservation efforts driven by persistent drought conditions and water shortages (Water Corporation 2010). While other areas of Australia have lower reported gpcd values, Perth is located in southwest Australia where climate patterns are most similar to the Los Angeles Area.

Data and results from the PRWUS were used to develop gpcd values for indoor and outdoor water use categories (Table 2). The PRWUS reported an average water demand of approximately 77 gpcd for Perth. This water use rate represents water delivered to residences by a water agency, which requires that an assumption and some adjustments be made for the purposes of this report. First, it is assumed that this 77 gpcd estimate can be used as an approximation to represent all types of demands across the LA Basin, not just residential. And second, because this PRWUS demand value for Perth incorporates graywater implementation, decentralized stormwater capture for direct use, and shallow groundwater pumped from garden bores, it must be adjusted upward in order to "remove" those components and allow them to be accounted for as separate supplies.[4]

Water use values for these three supplies were estimated using data from the PRWUS and were used to adjust the Perth gpcd as described in the five steps below.

Table 2. Perth, Australia Water Demands Met by Water Purveyor

Water Use	gpcd
Washing Machine	5.8
Shower	19.5
Bathroom Sink	1.8
Kitchen and Laundry Room Sinks	2.5
Toilet	7.2
Dishwasher	0.7
Evaporative Air Conditioner	2.9
Leaks	2.9
Total Indoor Demand (including leaks)	**43.4**
Irrigation	29.7
Pool/spa	1.4
Handwatering	2.2
Total Outdoor Demand	**33.3**
Total Demand	**76.7**

Source: Water Corporation, 2010. Perth Residential Water Use Study (PRWUS).

First, the gpcd value is adjusted for shallow groundwater supplies. PRWUS estimates that 32 percent of properties have access to garden bores, which draw water from shallow aquifers to use for irrigation. Since LA Basin does not utilize shallow groundwater obtained from garden bores, this represents water that would be provided by another supply source; therefore, it must be "added back in" to the demand estimate. The PRWUS states that approximately 32 percent of households in the study had access to a garden bore and that 47.2 percent less water is delivered to those residences. This implies that the average per capita demand for irrigation is 15 percent less [(0.47)*(0.32)] due to garden bores. Using this water savings rate applied to the numbers in Table 3, outdoor irrigation demands are increased by approximately 5.2 gpcd [(29.7)/(0.85) – 29.7] to adjust for the effects of garden bores (Table 3).

Second, the gpcd value is adjusted for implementation of graywater from showers and bathroom sinks. The PRWUS indicates that approximately 7 percent of

[4] Shallow groundwater pumped from garden bores is not assumed to be an available supply for the LA Basin in this report.

households in Perth reported owning a graywater system of this type. These systems typically reuse water from bathroom sinks and showers for outdoor irrigation. Using the average gpcd values from Table 2 and applying an implementation rate of 7 percent, outdoor irrigation demands are increased by 1.5 gpcd [(19.5+1.8)*(0.07)] to adjust for the effects of implementing graywater from showers and bathroom sinks.

Third, the gpcd value is adjusted for implementation of graywater from washing machines. The PRWUS states that 60 percent of households reported "periodically" reusing washing machine water to irrigate lawns. Assuming that "periodically" can be interpreted as 25 percent of the time for 60 percent of households, outdoor irrigation demands are increased by 0.9 gpcd [(5.8)*(0.60)*(0.25)] to adjust for the effects of implementing graywater from washing machines. Together with showers and bathroom sinks, this represents an increase of 2.4 gpcd to adjust for the effects of implementing graywater (Table 3).

Fourth, the gpcd value is adjusted for decentralized stormwater capture for direct use. The PRWUS indicates that 8 percent of households in Perth own a rainwater tank. The average rainwater tank in Perth yields between 2,600 to 6,900 gallons per year, according to the PRWUS. The average household size in Perth according to the 2011 Census of Population and Housing from the Australian Bureau of Statistics is 2.6. Using these values, outdoor irrigation demands are increased by 0.4 gpcd [(2,600+6,900)/2 * (0.08)/(365*2.6)] to adjust for the effects of decentralized stormwater capture for direct use (Table 3).

Table 3. Perth, Australia Total Outdoor Water Demands

Water Use	gpcd
Irrigation	29.7
Pool/spa	1.4
Handwatering	2.2
Outdoor Water Demand Delivered by Purveyor	**33.3**
Garden Bores	5.2
Graywater	2.4
Rainwater Tanks	0.4
Additional Outdoor Water Demand Met by User	**7.8**
Total Outdoor Water Demand	**41.1**

Altogether, these adjustments increase the Perth per capita outdoor water demands from 33.3 gpcd to approximately 41.3 gpcd (Table 3).

As a fifth and final step, the Perth outdoor water demand gpcd value was further adjusted by assuming that significant additional reductions will be realized by 2095, due to landscape ordinances and other conservation measures. This adjustment assumes that outdoor water use will be reduced by an additional 50 percent compared to the Perth, Australia numbers. Using this assumption, the outdoor water use projection is reduced to approximately 20.7 gpcd.

When combined with the Perth indoor demands of 43.4 gpcd from Table 2, the total household water use is approximately 64.1 gpcd. A water balance for Perth, Australia based on the values in the PRWUS and adjusting for additional assumed reductions in outdoor water use is shown in Figure 5. This 64 gpcd estimate is assumed to be an appropriate "low" water use rate projection for the LA Basin in 2095 (assuming that some watersheds would be above this average and some below). The use of the 64 gpcd assumption results in an overall 54 percent reduction in per capita demands as compared to the 2035 gpcd [0.46*138 = 64 gpcd].

Figure 5. Water Balance Using Per Capita Values for Perth, Australia and Adjusting for Additional Reductions in Outdoor Use

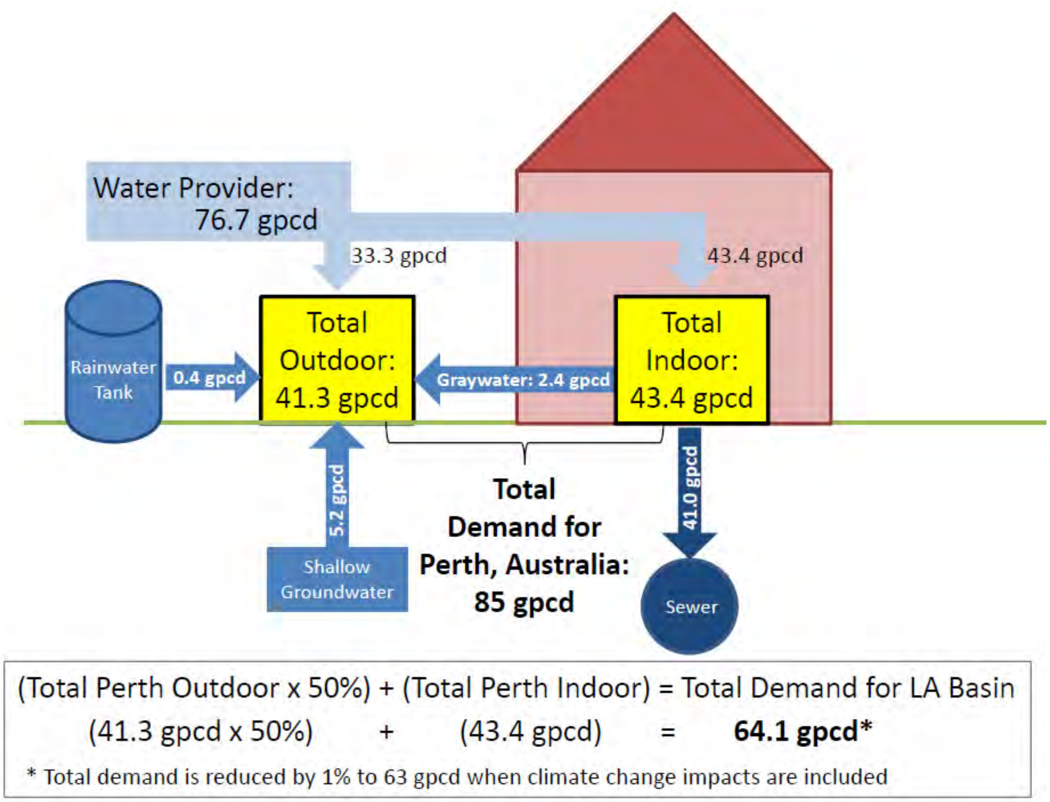


Table 4 shows the estimated "high", "medium", and "low" 2095 gpcd projections for each of the watersheds in the Los Angeles Basin before climate change impacts are incorporated. These estimated projections reflect average gpcd values for each of the watersheds as well as combined gpcd values for the entire Study Area. For comparison purposes, the 2035 gpcd calculated values are included.

It should be noted that gpcd values for 2010 are not included in Table 4 for two reasons. First, the 2010 gpcd values are not needed to explain the progression to

2095 estimated values. And second, the data used to calculate gpcd values for this report are different than the data used by individual urban water suppliers in their 2010 UWMPs (the commonly-accepted reporting document for gpcd values). In general, population numbers from the Census and DOF used in this report were lower than the numbers that had been used in 2010 UWMPs. This presents a dilemma. To provide values for 2010 in Table 4, either the more recent Census and DOF data would have to be used (which would not match the reported values in 2010 UWMPs) or the 2010 UWMP data would have to be used (which would cause gpcd values to appear to increase between 2010 and 2035). For these reasons and to avoid confusion, 2010 values for gpcd are not included.

Table 4. GPCD Estimates for the Basin Study Watersheds Before Climate Change Impacts are Incorporated

Watershed	2035 gpcd	2095 gpcd High	2095 gpcd Medium	2095 gpcd Low
Malibu Creek	266	266	193	124
North Santa Monica Bay	789	789	573	367
Ballona Creek	93	93	68	43
South Santa Monica Bay	223	223	162	104
Dominguez Channel/Los Angeles Harbor	122	122	89	57
Los Angeles River	129	129	94	60
San Gabriel River	164	164	119	76
Total Demand	**138**	**138**	**100**	**64**

Note: Values for 2010 gpcd are not included because the population numbers used in this report are updated from population numbers already reported in 2010 UWMPs.

Regional Demand Estimates - After Incorporating Climate Change Impacts

A separate climate change analysis was performed to estimate the impacts of climate change on water demand in the Study Area in 2095. The overall approach first developed a simple model of demand as a function of temperature and precipitation for the Los Angeles Basin Study Area. The model was then used to introduce new values for temperature and precipitation after incorporating the influence of climate change. The results of the analysis indicated a potential one percent decrease in demand. This percent increase was applied to the three 2095 gpcd demand scenarios to adjust for the impacts of climate change. The methods and results of this analysis are discussed in more detail in Appendix B.

Table 5 shows the estimated “high”, “medium”, and “low” 2095 gpcd projections for each of the watersheds in the LA Basin after potential climate change impacts have been incorporated.

Table 5. GPCD Estimates for the Basin Study Watersheds After Climate Change Impacts are Incorporated

Watershed	2095 High gpcd	2095 Medium gpcd	2095 Low gpcd
Malibu Creek	263	191	123
North Santa Monica Bay	781	567	364
Ballona Creek	92	67	43
South Santa Monica Bay	221	161	103
Dominguez Channel/Los Angeles Harbor	121	88	56
Los Angeles River	127	93	59
San Gabriel River	163	118	76
Total Demand	**136**	**99**	**63**

2.2. Water Demand Findings

The findings of the water demand projections are shown below for the Malibu Creek watershed (Figure 6), the North Santa Monica Bay watershed (Figure 7), the Ballona Creek watershed (Figure 8), the South Santa Monica Bay watershed (Figure 9, on page 16), the Dominguez Channel/Los Angele Harbor watershed (Figure 10, on page 16), the Los Angeles River watershed (Figure 11, on page 17), and the San Gabriel River watershed (Figure 12, on page 17).

Figure 6. Water Demand in the Malibu Creek Watershed

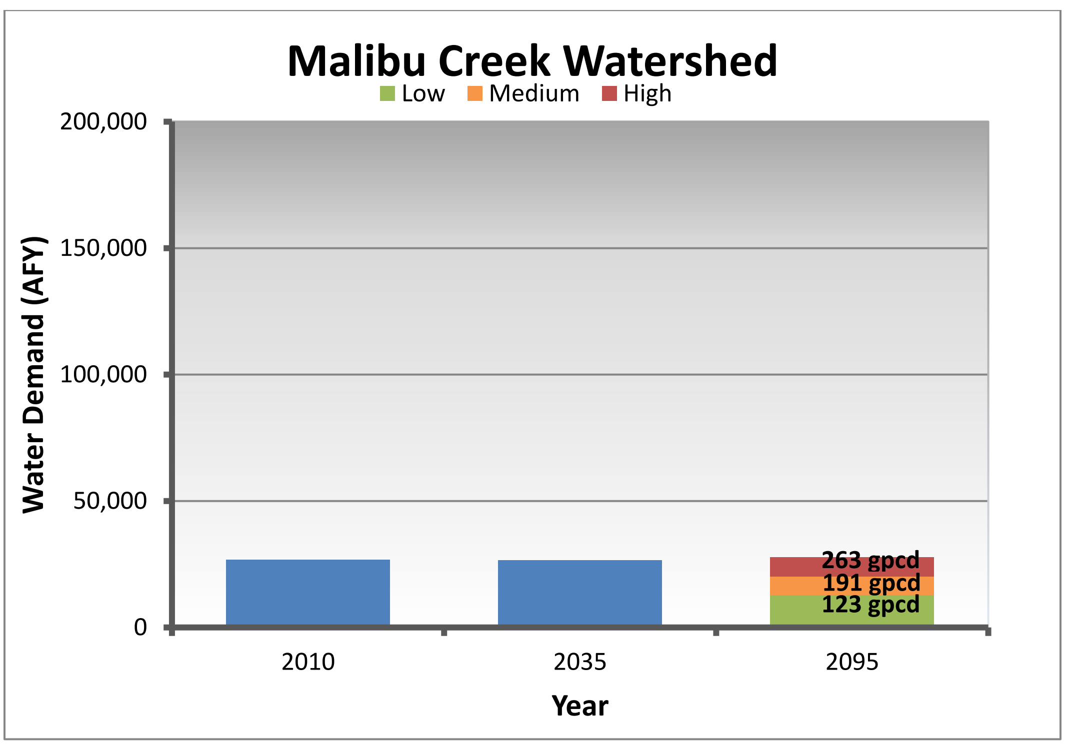


Figure 7. Water Demand in the North Santa Monica Bay Watershed

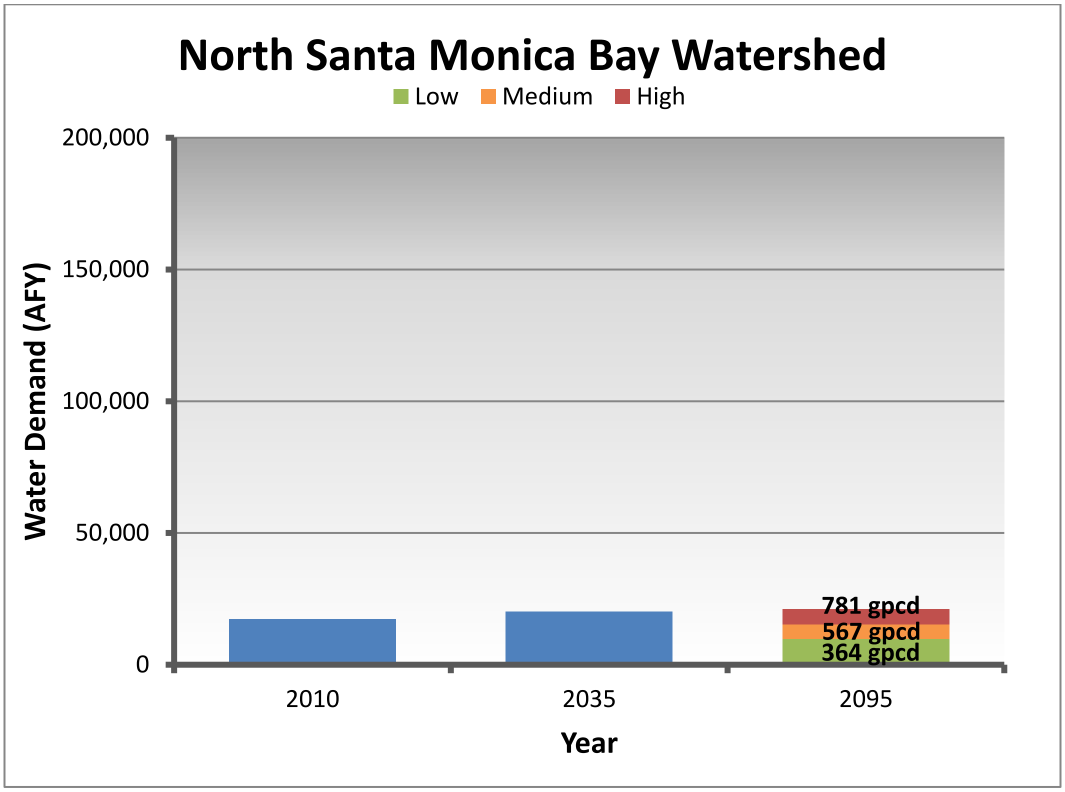


Figure 8. Water Demand in the Ballona Creek Watershed

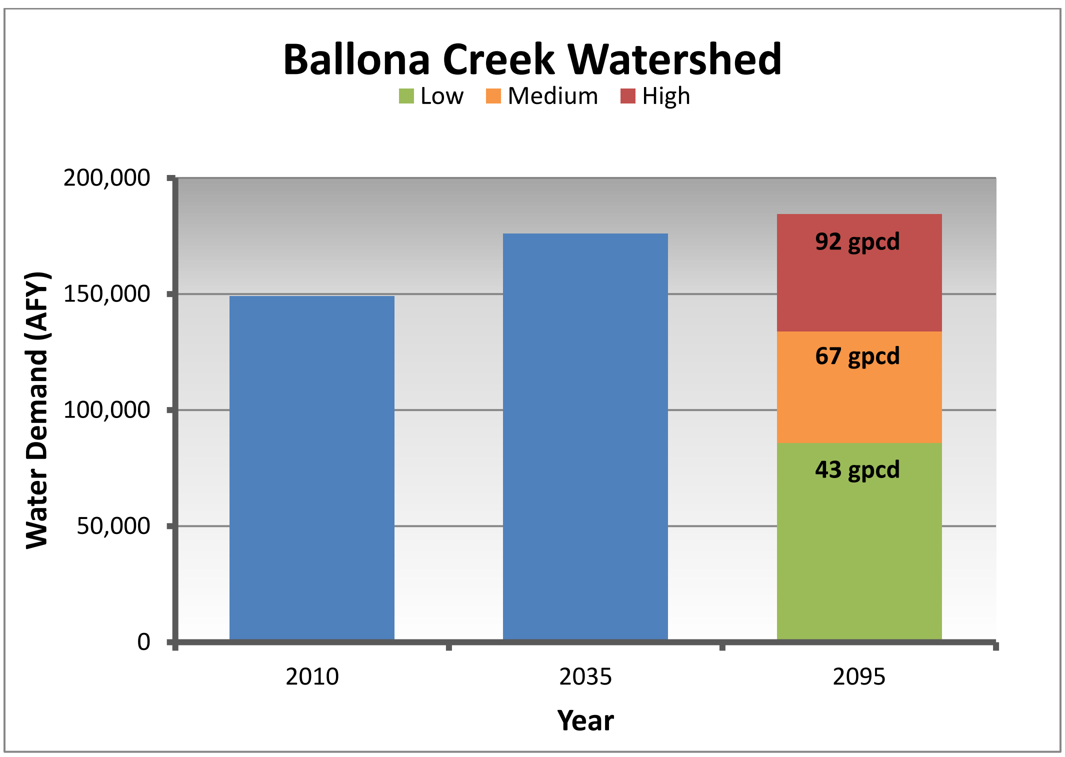


Figure 9. Water Demand in the South Santa Monica Bay Watershed

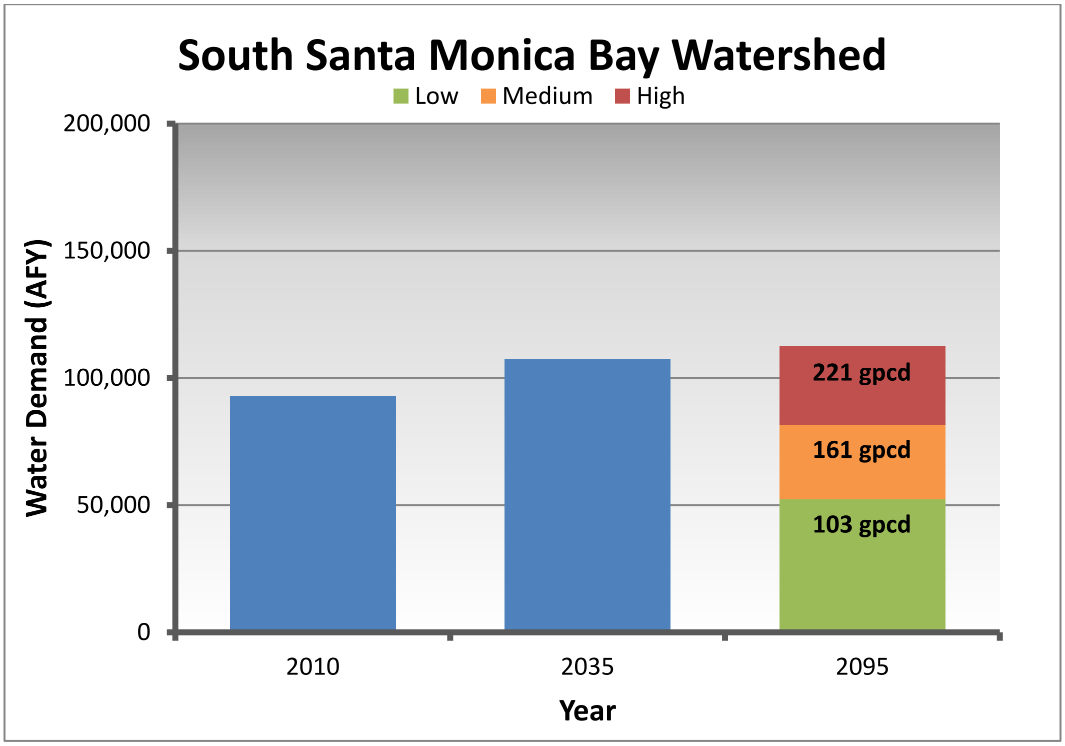


Figure 10. Water Demand in the Dominguez Channel/Los Angeles Harbor Watershed

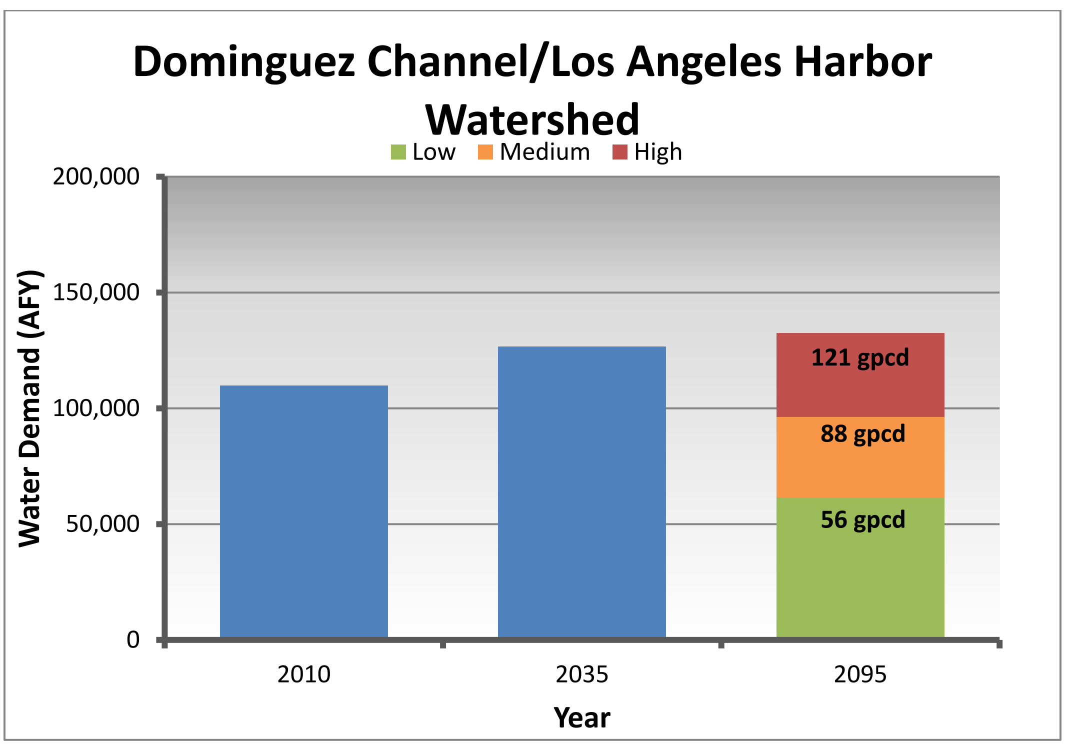


Figure 11. Water Demand in the Los Angeles River Watershed

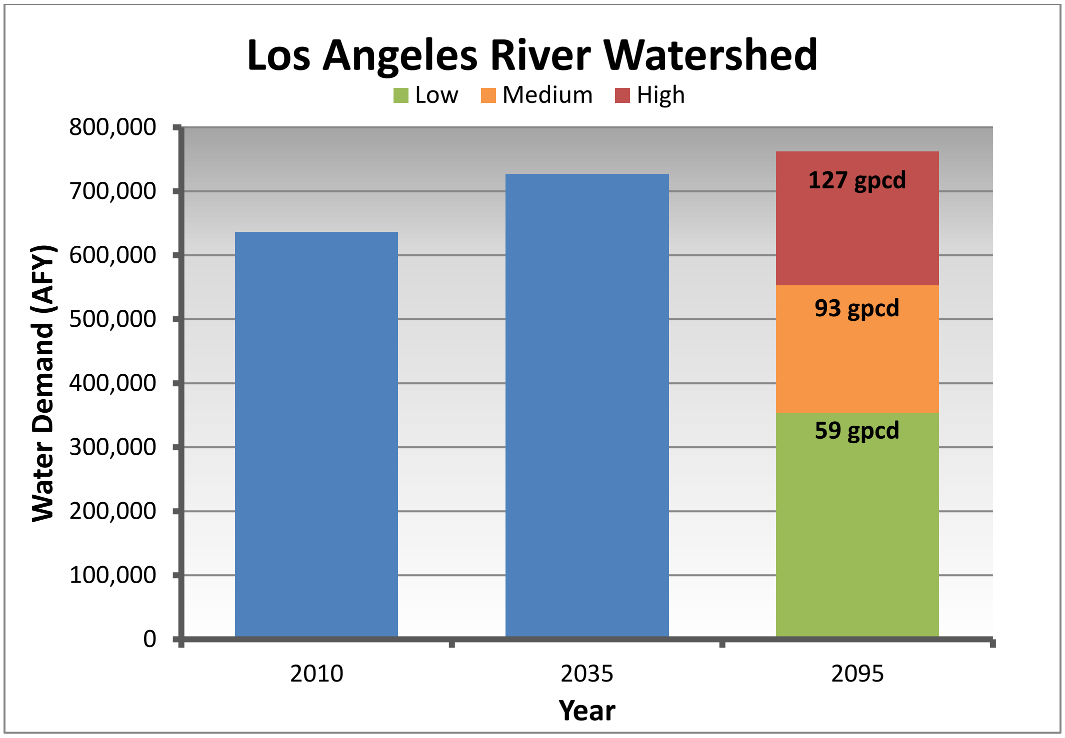
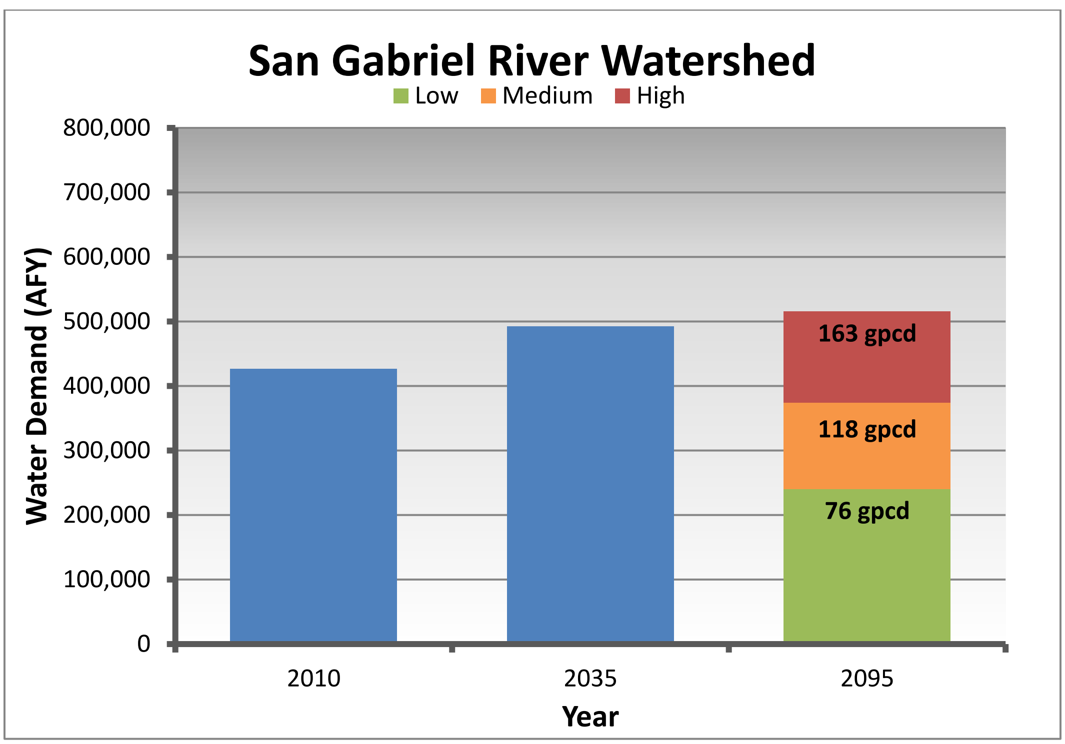


Figure 12. Water Demand in the San Gabriel River Watershed



2.3. Conclusions

The "high", "medium", and "low" water demand projections presented in this report for 2095 are intended to show a range in potential water use estimates for the LA Basin based on three assumed future values for gpcd. The initial values are based on different sets of starting assumptions and are then adjusted by an estimated one percent decrease to account for climate change impacts on outdoor irrigation demands. The development of the three values is summarized as follows:

- **"High"** – Assumes that the 2035 value of 138 gpcd for the LA Basin remains constant until 2095; this value is then adjusted to 136 gpcd to account for the impacts of climate change.
- **"Medium"** – Assumes that the target of 100 gpcd, based on conservation goals documented in the City of Long Beach's 2010 UWMP, can be achieved in the LA Basin by 2095; this value is then adjusted to 99 gpcd to account for the impacts of climate change.
- **"Low"** – Assumes that the target of 64 gpcd, based on conservation efforts in Perth, Australia (where intense drought has driven more extreme water use efficiency programs) and adjusting for additional reductions in outdoor water use, can be achieved in the LA Basin by 2095; this value is then adjusted to 63 gpcd to account for the impacts of climate change.

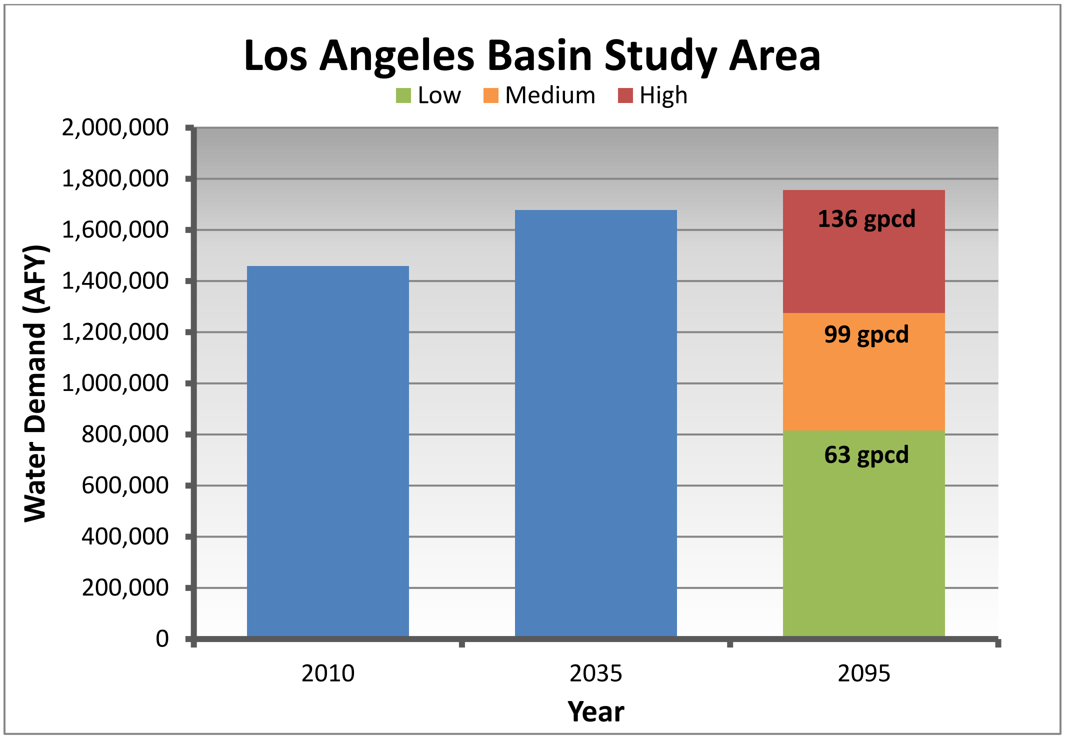
Table 6 summarizes the demand projections for all watersheds in 2010, 2035, and 2095. Figure 13 summarizes the projected demands for the entire Study Area in 2095. Values for the "high", "medium", and "low" gpcd estimates are indicated in each graph to reflect the three water conservation projection scenarios.

Table 6. Demand Projections for the Basin Study Watersheds

Watershed	2010 (AFY)	2035 (AFY)	2095 Low (AFY)	2095 Medium (AFY)	2095 High (AFY)
Malibu Creek	26,800	26,500	12,900	20,200	27,800
North Santa Monica Bay	17,300	20,100	9,800	15,300	21,100
Ballona Creek	149,000	176,100	85,800	133,900	184,400
South Santa Monica Bay	93,000	107,300	52,300	81,700	112,400
Dominguez Channel/Los Angeles	109,800	126,600	61,700	96,300	132,600
Los Angeles River	636,600	727,100	354,400	553,100	761,600
San Gabriel River	426,300	492,500	240,100	374,700	515,900
Total Demand	**1,458,800**	**1,676,200**	**817,000**	**1,275,200**	**1,755,800**

Note: Values are in AFY and rounded to the nearest 100.

Figure 13. Water Demand in the LA Basin Study Area



3. Water Supply

The purpose of this section is to identify the current and projected water supplies in the Los Angeles Basin. The supplies discussed include groundwater, imported water, local surface water, desalinated ocean water, recycled water, graywater, and stormwater. These supplies are further separated into supplies for direct use and supplies used to replenish/recharge[5] groundwater. Water conservation, though sometimes reported as a type of supply, is treated as a reduction in demand as explained in Section 2.1.1.[6] The categories of supplies that are discussed in the following sections are defined below:

Direct Use Supplies

The following supplies are "direct use" supplies because they are delivered directly to end users by water providers or are captured on site by end users.

- **Groundwater Pumped:** Water pumped from local groundwater basins for distribution to end users by the water agencies, regardless of the method or original source of supply that replenished/recharged the basin (e.g., imported, recycled water and storm/surface water).

- **Imported Water:** Water provided by the Metropolitan Water District of Southern California (MWD) from the State Water Project (SWP) and Colorado River Aqueduct (CRA) to local water retailers, as well as water from the Los Angeles Aqueduct (LAA) delivered to the Los Angeles Department of Water and Power (LADWP), who distribute it to end users.

- **Local Surface Water:** Water that flows within local watersheds and is diverted for delivery to end users (e.g., water from San Antonio Creek in the San Gabriel watershed that is treated and used for supply by the City of Pomona).

- **Desalinated Ocean Water:** Water that originates from the ocean and is treated for potable use and delivered to end users.

[5] The terms "replenishment" and "recharge" are used interchangeably in this report.

[6] The GLAC IRWMP includes "water conservation" as a type of "supply" to remain consistent with the majority of UWMPs used to develop the IRWMP. However, for the purposes of this report, water conservation is considered to be a reduction in demand rather than an additional supply. The reason that conservation is handled in this manner is to provide consistency in subsequent calculations involving per capita demand assumptions for 2095, which already incorporate water demand measures.

- **Recycled Water:** Wastewater that is treated at a water reclamation plant and then delivered to end users for non-potable uses, such as lawn irrigation.

- **Graywater:** Wastewater generated on site from a washing machine, shower or bathroom sink that can be subsequently used on site (i.e., at the "end user") without further treatment.

- **Decentralized Stormwater Capture for Direct Use:** Precipitation and run-off water that is captured and stored on site (i.e., at the "end user") prior to entering a storm drain system and is subsequently used on site to meet non-potable demands. Examples include stormwater capture using rain barrels and cisterns. In some instances, stormwater capture for direct use may be used to meet potable demands as well.

Replenishment Supplies

The following supplies are "replenishment" supplies because they are used to replenish/recharge groundwater basins prior to being delivered to end users. This includes some supplies that are captured on site (at end user locations) but are allowed to percolate to the groundwater basin instead of being used directly by the end user. Replenishment/recharge of groundwater basins is a typical strategy for managing groundwater supplies in the context of seasonal and long-term fluctuations in other types of supplies.

- **Groundwater Natural Safe Yield:** Water that naturally percolates through permeable surfaces to replenish/recharge the groundwater basin without the assistance of engineered facilities. The Natural Safe Yield may also include return flows from irrigation and underflow from other groundwater basins. Groundwater natural safe yield can be partially composed of existing decentralized stormwater for recharge, as defined in this report, in some basins. A MWD document defines it as "the yield of a basin without active recharge" (MWD 2007).

- **Imported Water for Recharge[7]:** Water purchased from MWD by local agencies to replenish/recharge groundwater basins either through engineered spreading or injection facilities.

- **Recycled Water for Recharge:** Wastewater that is treated at a water reclamation plant and then used to replenish/recharge groundwater basins either through engineered spreading or injection facilities.

[7] The terms "replenishment" and "recharge" are used interchangeably in this report.

- **Centralized Stormwater for Recharge:** Precipitation and run-off water that is captured from natural and engineered drainage systems and stored in centralized facilities such as spreading basins and recharge basins for the managed replenishment of local groundwater basins.

- **Decentralized Stormwater for Recharge:** Precipitation and run-off water that is retained on site (at end user locations) prior to entering a storm drain system and long enough to infiltrate into and replenish local groundwater basins. Examples of decentralized recharge projects include permeable pavement and bio-swales.

3.1. Existing 2010 Water Supply

3.1.1. Methodology

Given that many recent water supply documents use 2010 as the baseline year for existing supply and demand conditions and given the long planning horizon of the LA Basin Study through 2095, 2010 was considered to represent "existing" conditions for this report. As such, "existing" and "2010" are used interchangeably in the discussion below.

Slightly different methodologies were used in this report to estimate 2010 supplies versus supplies for 2035 and 2095. The 2010 supply estimates were based on the GLAC IRWMP which includes actual reported values for 2010. The IRWMP developed summaries of existing (2010) supplies used in the five GLAC subregions for both "direct use" and groundwater replenishment.[8] The "direct use" summaries in the IRWMP were a combination of the supplies reported in individual water agencies' 2010 UWMPs that were then reviewed and vetted by GLAC stakeholders. In addition to "direct use" supply summaries, the GLAC IRWMP provides summaries of water supplies used to replenish groundwater basins, developed as a separate exercise by water agencies and groundwater basin Watermasters.[9] The reason that replenishment supplies were accounted for separately in the IRWMP is because it was understood that there is some overlap between supplies used for groundwater replenishment and supplies designated as "groundwater pumped" (i.e., the pumped groundwater is coming from the same aquifer where replenishment/ recharge water percolates to). The IRWMP includes both summaries for 2010 to provide a thorough and complete accounting of water supplies.

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[8] The GLAC IRWMP is organized as five subregions, as opposed to this report which is organized as seven Basin Study Watersheds. See Figure 3 for a graphical representation of the relationship between the five GLAC subregions and the seven Basin Study Watersheds.

[9] A Watermaster is typically a person, board, judge, or other entity appointed by a court to administer and enforce provisions of a groundwater adjudication judgment. Adjudication judgments establish water rights and responsibilities for efficient management of groundwater supplies from a particular basin.

Since the GLAC IRWMP is being used as the primary reference for articulating existing (2010) supplies in this report, only the "direct use" supplies (i.e., not replenishment/recharge supplies) are shown in Figure 14 for 2010 to avoid double-counting. Also for 2010, "groundwater pumped" is a special category, borrowed from the IRWMP, that was not used again for 2035 and 2095 projections in this report (projections for 2035 and 2095 use "replenishment/recharge" supplies in lieu of "groundwater pumped" for reasons explained in the sections that follow). The supply categories for 2010 include "groundwater pumped" as well as "imported water", "local surface water", "desalinated ocean water", "recycled water", and "decentralized stormwater capture for direct use". Graywater was not included as a supply in the GLAC IRWMP but is included in this report as a direct use supply. For 2010, graywater was assumed negligible in this report due to the lack of documented permitted systems.[10] Estimates of graywater supply contributions are, however, incorporated into future supplies for 2035 and 2095 and are discussed further in the sections that follow. Decentralized stormwater capture for direct use (e.g., using rain barrels, etc.) was also considered negligible for 2010 based on numbers reported in the GLAC IRWMP.

While the overall boundary of the GLAC IRWM Region is identical to this Study Area, the IRWM subregion boundaries are not identical to the LA Basin Study's watershed boundaries as shown in Figure 3 on page 6. Therefore, the volumes for each category of supply reported in the GLAC IRWMP were reapportioned to better reflect the watershed organization of the LA Basin Study.

[10] UWMPs used to develop the GLAC IRWMP did not have volumes for graywater as supplies, and MWD's 2010 Integrated Resources Plan (IRP) only listed two households with graywater systems in the City of Santa Monica.

3.1.2. Results

Table 7 on page 25 and Figure 14 on page 26 show the "direct use" supplies for 2010 in the Malibu Creek, North Santa Monica Bay, Ballona Creek, South Santa Monica Bay, Dominguez Channel/Los Angeles Harbor, Los Angeles River, and San Gabriel River watersheds. "Direct use" of imported water is a primary supply source for all of the seven watersheds in Study Area. Groundwater pumped is a significant supply in all watersheds except the Malibu Creek and North Santa Monica Bay watersheds. For example, the Los Angeles and San Gabriel watersheds overlie large groundwater basins like the Central and Main San Gabriel basins as was shown in Figure 2 on page 5; therefore a large portion of the supply in these watersheds can be provided through groundwater pumping. However, it is important to recognize that the basins underlying these watersheds are dependent upon engineered replenishment/recharge of imported, recycled and stormwater supplies to achieve those groundwater pumping levels. This further illustrates how "direct use" and replenishment/recharge supplies are inter-related. The 2010 breakdown of imported, recycled, and stormwater replenishment/recharge supplies used in each of the watersheds is discussed further in Section 4.

For local surface water, the Los Angeles and San Gabriel watersheds are also the only two watersheds in the Study Area with enough local annual surface water to justify treatment and infrastructure for direct use supply.

Recycled water supplies are used in all of the watersheds to meet non-potable demands (i.e., mainly landscape irrigation). This recycled water comes from a number of water reclamation plants that are located mainly along the Los Angeles and San Gabriel Rivers. For this reason, most of the recycled water supplies are used in the Los Angeles River and San Gabriel River watersheds.[11]

The only ocean desalination supplies in 2010 were provided from West Basin Municipal Water District's (West Basin MWD's) small pilot plant located in the City of El Segundo. Supplies from this plant were distributed in adjacent portions of West Basin MWD's service area for this report. Ocean desalination supplies are therefore shown mainly in the Dominguez Channel/Los Angeles Harbor watershed but also in the Ballona Creek and South Santa Monica Bay watersheds, according to the percentage of area in the watershed served by West Basin MWD.

[11] Water reclamation plants include those owned and operated by the City of Los Angeles, the Los Angeles County Sanitation Districts, the City of Burbank, the City of Glendale, and Las Virgenes Municipal Water District.

Graywater and "decentralized stormwater capture for direct use" are considered negligible in all watersheds for 2010; however, they have been included in projections for future years.[12]

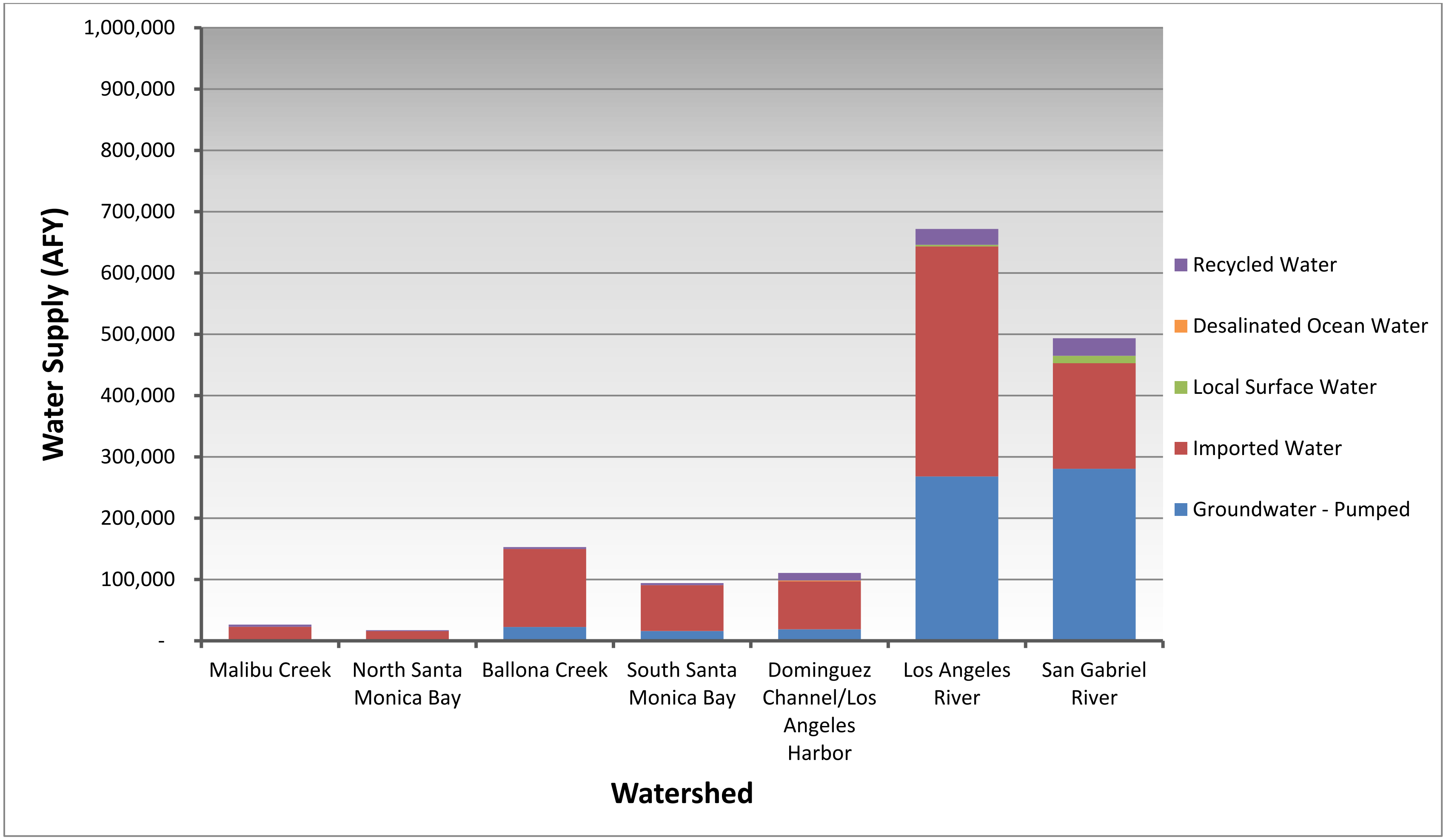
Table 7. 2010 Water Supplies (AFY) by Watershed

Water Supply	Malibu Creek Watershed	North Santa Monica Bay Watershed	Ballona Creek Watershed	South Santa Monica Bay Watershed	Dominguez Channel/Los Angeles Harbor Watershed	Los Angeles River Watershed	San Gabriel River Watershed
Groundwater Pumped	100	500	22,600	16,000	18,800	268,100	280,600
Imported Water	22,700	15,300	127,200	74,700	78,300	375,300	172,200
Local Surface Water	-	-	-	-	-	2,600	12,100
Desalinated Ocean Water	-	-	100	100	1,400	-	-
Recycled Water	3,600	1,600	3,100	3,300	12,300	25,800	28,600
Graywater	-	-	-	-	-	-	-
Decentralized Stormwater Capture for Direct Use	-	-	-	-	-	-	-
Total Supply	**26,400**	**17,400**	**153,000**	**94,100**	**110,800**	**671,800**	**493,500**

Note: Values are in AFY and rounded to the nearest 100.

[12] Graywater was assumed negligible in this report for 2010 due to the lack of documented permitted systems. Decentralized stormwater capture for direct use (e.g., using rain barrels, etc.) was also considered negligible for 2010 based on numbers reported in the GLAC IRWMP.

Figure 14. 2010 Water Supplies by Watershed



3.2. Projected 2035 Water Supply

3.2.1. Methodology

The methodology for developing projected 2035 water supplies included both "direct use" and "replenishment/recharge" supplies. This is where the methodology for 2035 differs from 2010. Rather than using "groundwater pumped" (which is an actual, known value composed of numbers reported by water agencies and Watermasters), groundwater supplies were divided into the following supply categories: groundwater natural safe yield[13], imported water for recharge, recycled water for recharge, and stormwater for recharge. This distinction between the "groundwater pumped" supplies used in 2010 and the supply categories used for groundwater in 2035 is important for the subsequent discussion about 2095 supplies. For the purposes of this Study, every unit of replenishment/recharge water is assumed to be available for supply, though it is important to note that some losses do occur through the replenishment process as water evaporates from various water surfaces. These evaporative losses are assumed to be negligible.

Other than the previously noted distinction, the methodology for 2035 was similar to 2010. The 2035 supply projections are based on the 2013 GLAC IRWMP as the primary reference, and the GLAC IRWMP numbers are based on the 2010 UWMPs which project supplies to 2035. Replenishment/recharge supplies were accounted for separately in the IRWMP because it was understood that there is some overlap between supplies used for groundwater replenishment and supplies designated as "groundwater pumped" (i.e., the pumped groundwater is coming from the same aquifer where replenishment/ recharge water percolates to). The IRWMP included both summaries for 2035 to provide a thorough and complete accounting of water supplies.

Since more recent documents have provided more specific projections and targets for both "direct use" and replenishment/recharge supplies, this report incorporated as many of these updates as possible into the 2035 supply projections. These more current references and methodologies that were used are detailed below within each of the following supply classifications.

[13] "Groundwater natural safe yield" is defined as water that naturally percolates through permeable surfaces without the assistance of engineered facilities. This is water that is then available for pumping and eventual consumption by end users.

3.2.1.1 Groundwater Natural Safe Yield

As opposed to the 2010 category of "groundwater pumped", "groundwater natural safe yield" supply is water that that could be pumped up to the natural safe yield (i.e., natural recharge) of the basins that exist within each watershed. This volume consists of percolation, underflow, irrigation return flows, and other natural pathways for water to reach aquifers and is exclusive of engineered replenishment of imported, recycled, and stormwater supplies. This report uses quantified values for groundwater natural safe yield to avoid double counting with other supplies. MWD's 2007 Groundwater Assessment Study was used to estimate the natural recharge occurring in the basins for each watershed in the report. The natural safe yield values for groundwater basins that are only partially in the Study Area were reduced based on the percent area inside the Study Area. Several of the basins underlie more than one watershed as shown in Figure 2 on page 5. Additionally, groundwater pumped from these basins is made available to multiple watersheds based on the water agency responsible for the pumping along with the geography of the distribution system they operate. To apportion supply distribution between the watersheds, a combined natural safe yield for the full and partial groundwater basins within the Study Area was redistributed to each watershed—this was based upon the proportion of groundwater pumping within a watershed compared to the entire Study Area. The combined natural safe yield volume for all watersheds is assumed to remain constant, on average, from 2010 to 2035 as there is no documentation of long-term average changes to the sources of natural recharge for the basins. Additional supplies to account for groundwater pumping and storage in excess of the natural safe yield include engineered recharge with imported water, stormwater, and recycled water. The methods for determining these replenishment/recharge supplies are discussed in the sections below.

3.2.1.2 Imported Water

Imported water supplies are divided into two categories:

- **Imported Water for Direct Use:** Using the same methodology as the 2010 imported water category, this is defined as water provided by MWD from the SWP and CRA to local water retailers to meet direct use demands, as well as water from the LAA to meet direct use demands and reflects the volumes reported in the GLAC IRWMP.

- **Imported Water for Recharge:** This is defined as the amount of water that is expected to be purchased from MWD by local agencies or used by LADWP from the LAA to replenish/recharge groundwater basins in 2035 as reported in the GLAC IRWMP.

3.2.1.3 Local Surface Water

Local surface water represents water that flows from creeks and streams within local watersheds and is diverted for direct use. The local surface water projections in this report for 2035 are based on the 2035 projections for the same category in the GLAC IRWMP.

3.2.1.4 Desalinated Ocean Water

Desalinated ocean water originates from the ocean and is treated for direct use. The 2035 projections assume that a full-scale West Basin MWD desalination plant is operational by 2035 and produces 20 million gallons per day (MGD). This assumption is based on West Basin MWD's 2010 UWMP and on the GLAC IRWMP supply projections. The 20 MGD supply was apportioned by area to each of the Study's watersheds that lie within West Basin MWD's service area according to the percentage area of West Basin MWD's service area within each watershed. This includes the Dominguez Channel/Los Angeles Harbor, South Santa Monica Bay, Ballona Creek, and North Santa Monica Bay watersheds. Additionally, the Long Beach Water Department is planning to build a 10,000 AFY ocean water desalination plant by 2035, as stated in their 2010 UWMP. This desalinated ocean water supply was distributed to the Los Angeles River and San Gabriel River watersheds based on Long Beach Water Department's service area.

3.2.1.5 Recycled Water

Recycled water supplies are divided into two categories:

- **Recycled Water for Direct Use:** Using the same methodology as the 2010 recycled water category, this is defined as water provided through the treatment of wastewater for non-potable direct uses and reflects the volumes reported in the GLAC IRWMP.

- **Recycled Water for Recharge**: This is defined as water provided through the treatment of wastewater for replenishment/recharge and reflects the volumes reported in the GLAC IRWMP.

3.2.1.6 Graywater

Graywater is wastewater generated on site that can be subsequently reused on site without further treatment or with minimal treatment for non-potable direct use, primarily irrigation. Since there were no graywater supplies estimated in the GLAC IRWMP, this report estimates 2035 supplies by starting with the 2095 projected graywater values and then interpolating linearly back to 2035. The 2095 graywater supply values were projected using water demands for washing machines, bathroom sinks and showers/baths from the PRWUS and assuming a graywater system implementation rate of 15 percent by 2095. The methodology for estimating the 2095 graywater supply volumes is described in more detail in Section 3.3.

3.2.1.7 Stormwater

Stormwater is runoff captured and used as supply through direct use or replenishment/recharge. The replenishment/recharge may be centralized or decentralized. For the purposes of the LA Basin Study, "centralized stormwater capture" is defined as the capture of runoff on a subwatershed/watershed-scale in an engineered facility (that has as its primary purpose the capture of stormwater); while "decentralized stormwater capture" is defined as capture of stormwater on a much smaller scale, typically within a single parcel or a few parcels. It is important to note that decentralized stormwater capture may be difficult to distinguish from "groundwater natural safe yield" since natural safe yield for a basin typically includes some historical decentralized stormwater capture that has been documented and formalized in a groundwater adjudication judgment.[14] As described in Section 3.2.1.1, "groundwater natural safe yield" is assumed to be fixed over time for this report. This means that the values include historical decentralized stormwater capture but not new decentralized stormwater capture. These new decentralized stormwater capture volumes are included as a separate supply category for 2035 and 2095.

This report focuses on the capture of stormwater through centralized recharge, decentralized recharge, and decentralized capture for direct use. Stormwater supply for 2035 was estimated using the following methodologies:

Centralized stormwater capture for recharge: Projected by starting with 2010 stormwater replenishment/recharge estimates based on the GLAC IRWMP and adding supply values from a current list of conceptual water conservation projects provided by LACFCD. It is assumed that the supply numbers for these conceptual projects are not included in the centralized stormwater capture for recharge estimates provided in the GLAC IRWMP. Additional information on this list of conceptual projects can be found in Section 4. The total centralized stormwater supply for the Study Area was then redistributed between watersheds based on population proportions.

Decentralized stormwater capture for recharge: Projected by starting with the 2095 decentralized stormwater capture for direct use values and then interpolating linearly back to 2035. The methodology for estimating the 2095 values is based on LADWP's draft SCMP and is described in Section 3.3.

Decentralized stormwater capture for direct use: Projected by starting with the 2095 decentralized stormwater capture for recharge values and then interpolating linearly back to 2035. The methodology for estimating the 2095 values is based on LADWP's draft SCMP and is described in Section 3.3.

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[14] Adjudication judgments establish water rights and responsibilities for efficient management of groundwater supplies from a particular basin.

It is assumed that all stormwater replenished/recharged through both centralized and decentralized methods will be available for supply.

3.2.2. Results

Table 8 and Figure 15 on page 33 show the projected water supplies in the Study Area for the year 2035. Overall supplies increase substantially from 2010; however, it should be noted that the supplies here reflect a combination of projected available supplies. These projected available supplies may be in excess of what would actually be accessible through the implementation of new projects that allow use of those supplies.

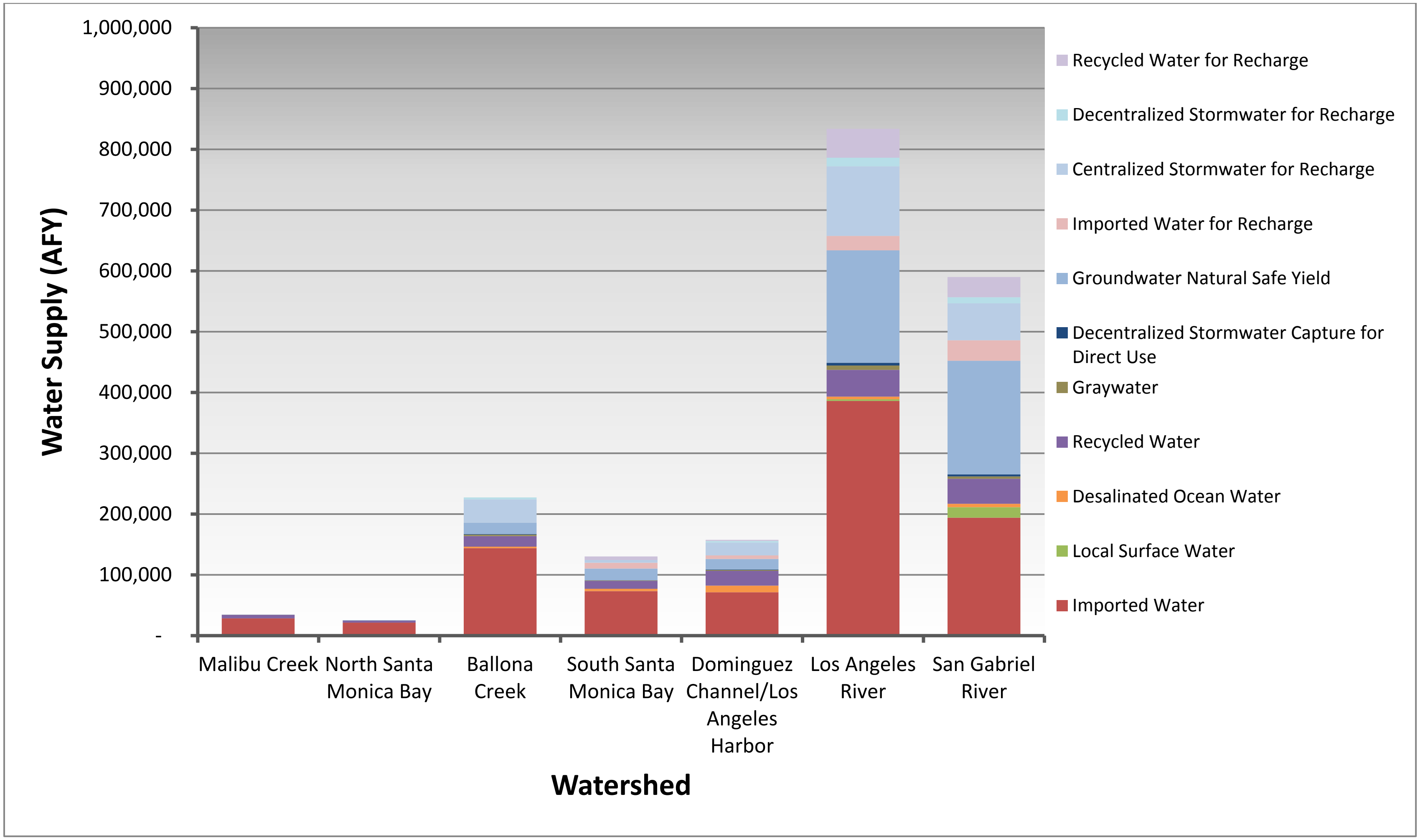
Table 8. 2035 Projected Water Supplies (AFY) by Watershed

Water Supply	Malibu Creek Watershed	North Santa Monica Bay Watershed	Ballona Creek Watershed	South Santa Monica Bay Watershed	Dominguez Channel/Los Angeles Harbor Watershed	Los Angeles River Watershed	San Gabriel River Watershed
Direct Use Supplies							
Imported Water	28,400	21,400	144,000	73,300	71,400	386,100	194,100
Local Surface Water	-	-	-	-	-	2,700	17,200
Desalinated Ocean Water	-	-	2,400	3,900	10,800	4,400	5,600
Recycled Water	5,900	3,400	17,300	12,900	24,400	44,100	41,200
Graywater	100	-	2,400	600	1,300	7,100	3,800
Decentralized Stormwater Capture for Direct Use	100	-	1,000	500	900	4,500	3,200
Replenishment Supplies[1]							
Groundwater Natural Safe Yield	100	500	18,900	19,300	17,500	185,000	187,100
Imported Water for Recharge	-	-	-	9,500	5,800	23,700	33,600
Centralized Stormwater for Recharge	-	-	38,300	4,600	21,000	114,400	60,700
Decentralized Stormwater for Recharge	-	-	3,000	-	2,700	14,200	10,100
Recycled Water for Recharge	-	-	-	5,900	1,800	47,700	33,300
Total Supply	**34,600**	**25,300**	**227,300**	**130,500**	**157,600**	**833,900**	**589,900**

Notes: Values are in AFY and rounded to the nearest 100.
(1) "Replenishment Supplies" are assumed to represent the same set of supplies that "Groundwater Pumped" represents for 2010 (Table 7).

Unlike the 2010 supplies shown in Figure 14 on page 26, Figure 15 on the next page shows the projected breakdown of planned available replenishment/recharge supplies that are assumed to replace the "groundwater pumped" category that was used for 2010 in this report. Natural recharge through precipitation, runoff, and underflow that naturally percolates to the aquifers (represented by "groundwater natural safe yield") is a large source of groundwater replenishment/recharge in all watersheds. Planned recycled water development for recharge and expected imported water purchases for recharge make up a smaller portion of replenishment supplies. These supplies are assumed to be distributed to the watersheds based on total demand within each watershed as water distribution systems generally cross watershed boundaries. The planned LACFCD centralized stormwater capture facilities used to calculate the 2035 centralized stormwater replenishment contribution make up a significant portion of potential replenishment volumes. Approximated decentralized stormwater for recharge is the smallest contribution to replenishment/recharge of groundwater supplies.

Figure 15. 2035 Water Supplies by Watershed



3.3. Projected 2095 Water Supply

3.3.1. Methodology

The GLAC IRWMP did not prepare supply projections past 2035, which is typical of other available planning documents. The only effort in the Study Area that is developing specific projections for the 2095 timeframe is the City of Los Angeles' draft SCMP.[15] Since the draft SCMP was not yet completed during the development of this report, an interim technical memorandum from the draft SCMP, coupled with other documents and planning assumptions, were used to develop the water supply projection methodologies for 2095. The draft SCMP projects stormwater supplies for 2099. These projected supplies are used in this report for the stormwater supply categories. Because projections for 2095 are based heavily on planning assumptions, these supplies represent projected available supply (i.e., potential supply) rather than projected supplies that are actually used (i.e., supplies made accessible for use through the construction and operation of facilities).

3.3.1.1 Groundwater Natural Safe Yield

Groundwater natural safe yield is assumed to remain constant at 2035 levels to 2095. Natural safe yield is a physical process but also a legal definition that is determined by courts in adjudication judgments.[16] While this value is assumed to remain constant, changes in the amounts of other types of replenishment/recharge will likely occur by 2095. These changes are incorporated in the imported water, stormwater, and recycled water replenishment/recharge supplies described below. Climate change is assumed not to influence the natural safe yield (i.e., it is held constant) as impacts to precipitation will be reflected in the stormwater volumes available for replenishment/recharge.

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[15] The draft SCMP has a planning horizon of 2099. For the purposes of this report, this is assumed to be the same timeframe as 2095.

[16] Changes in natural safe yield would be dictated by courts with the authority to change adjudicated values for the various groundwater basins in the Study Area. Estimating changes in the values for natural safe yield is beyond the scope of this report.

3.3.1.2 Imported Water

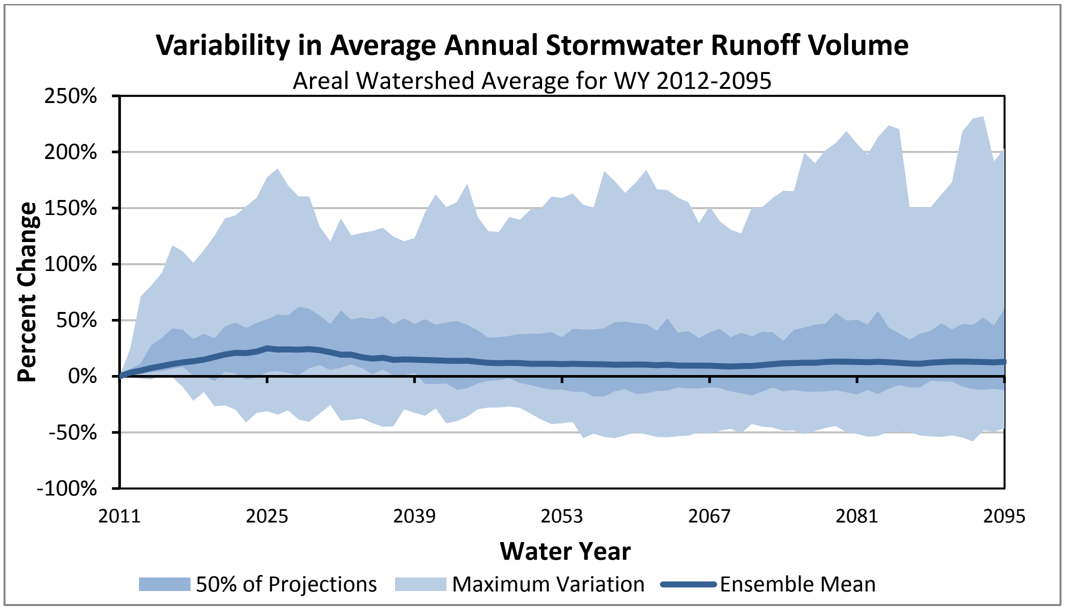
Prior to incorporating the impacts of climate change (which are handled in a subsequent step), imported water supplies for direct use in 2095 are assumed to stay at 2035 volumes. MWD is currently investing in water reliability programs to ensure that existing direct use deliveries can be maintained indefinitely. This projection also assumes that estimations of LAA supply in the GLAC IRWMP are realized by 2035 (GLAC IRWMP 2013). Imported water for replenishment/ recharge is assumed to drop to zero AFY due to continued efforts by local agencies in the Study Area to offset imported water replenishment through expanded replenishment/recharge of stormwater and recycled water. The Water Replenishment District of Southern California is one agency that has already begun the shift away from using imported water for replenishment in the West Coast Basin and Central Basin. Upper San Gabriel Valley Municipal Water District is another. This planned shift away from imported water for replenishment is accounted for in the 2010 planning documents used to project 2035 water supplies in the GLAC IRWMP. A complete offset of imported replenishment water with recycled water and stormwater is assumed to have occurred by 2095 in all the watersheds noted in the Study Area. Imported water is anticipated to become a more expensive supply compared to other replenishment supplies, and enhancements to recycled water and stormwater capture and treatment systems are currently being expanded along with increased regulatory support.

Building on the assumption that 2035 volumes of imported water for direct use will remain constant to 2095 before including the effects of climate change, climate change impacts may then be applied to imported water in the following manner. A 25 percent reduction was applied to the 2035 imported water supplies for direct use to reflect potentially adverse climate change impacts. This reduction represents the maximum value for climate change impacts mentioned in studies by Reclamation for the CRA (Reclamation 2012) and the Department of Water Resources (DWR) for the SWP (DWR 2012). UCLA is currently developing a study that will provide estimates on the impacts of climate change to portions of the Sierra Nevada that supply water to the LAA. When complete, this UCLA study could help refine assumptions on imported water supplies from the LAA. There are several factors other than climate change that are expected to potentially affect imported water availability, such as court rulings and habitat issues in the Bay-Delta, but it is difficult to isolate these impacts and there are no documented projections on how future policies will affect imported water supplies in the year 2095.

3.3.1.3 Local Surface Water

For this report, local surface water diversion projections for 2095 are set at 2035 levels. The Task 3 – Downscaled Climate Change & Hydrologic Modeling of the LA Basin Study projected an approximate 13 percent increase in average annual stormwater runoff volume within the Los Angeles Basin due to climate change (though ensemble means for the different projection subsets ranged from -10% to 50%). The Task 3 modeling results for the average annual increase in total runoff are shown in Figure 16 below indicates that while this increase does not necessarily mean that local diversion rights will increase to capture this volume, an average 13 percent increase in the 2035 local surface water volumes is appropriate to reflect climate change impacts for local surface water in 2095.

Figure 16. LA Basin Variability in Average Annual Stormwater Runoff Volume



Source: LACFCD, 2014. Los Angeles Basin Conservation Study Task 3.2 Hydrologic Modeling Report.

3.3.1.4 Desalinated Ocean Water

Desalinated ocean water is, conceptually speaking, an unlimited supply source available to the Los Angeles Basin that may be explored further. However, this is highly dependent on cost, environmental issues, and other implementation factors that must be considered relative to other supply options available. Since there is currently no reference available to justify a plant expansion beyond the build out of the proposed West Basin MWD and Long Beach Water Department plants by 2035, the 2095 desalinated water supplies are maintained at 2035 levels for this report.

While climate change may drive ocean desalination projects in the future (due to the need for local supplies), it is assumed that climate change will not influence the supply available. Desalination supplies will primarily be limited by technology, cost, and the willingness to implement projects. For these reasons, no climate change impacts were applied to the 2095 available desalinated ocean water supplies.

3.3.1.5 Recycled Water

Recycled water available supplies for 2095 were estimated in several steps. The first step estimated wastewater generation rates for each watershed using per capita wastewater generation rates and population projections. Specifically, a 39 gpcd indoor wastewater generation rate (derived from the PRWUS) was applied to the projected 2095 populations for each watershed. The 39 gpcd value was determined using the estimated indoor water use from the PRWUS and deducting estimated graywater supplies which do not get diverted to the sewer system. Specifically, the overall indoor water demand of 43 gpcd for Perth, Australia was adjusted by 4 gpcd to account for graywater implementation. Methodology for estimating the graywater supplies is described in Section 3.3.1.6. The resulting value of 39 gpcd was assumed to represent available wastewater supplies in the LA Basin for 2095.

The second step in estimating recycled water supplies for 2095 was to develop assumptions about how wastewater supplies will ultimately be used in terms of non-potable direct use versus replenishment/recharge. Recycled water for non-potable direct use (i.e., "purple pipe" systems) was assumed to be maximized (i.e., fully exploited) by 2035 and it was assumed that these levels will be maintained through 2095. This assumption was based on the increasing costs of developing recycled water pipeline distribution systems and the general trend of recycled water development toward potable reuse in the Los Angeles Basin. Generally, pipeline construction costs increase significantly with distance; and end users that are located further and further away from recycled water supply sources are more expensive to serve.

The remaining recycled water supplies after 2035 that are not used for direct use were assumed to be used for replenishment/recharge[17]. It is important to note that recycled water could eventually be used for direct potable reuse (DPR) as an alternative to replenishment/recharge.

[17] Recycled water for replenishment/recharge is also referred to as "indirect potable reuse (IPR)".

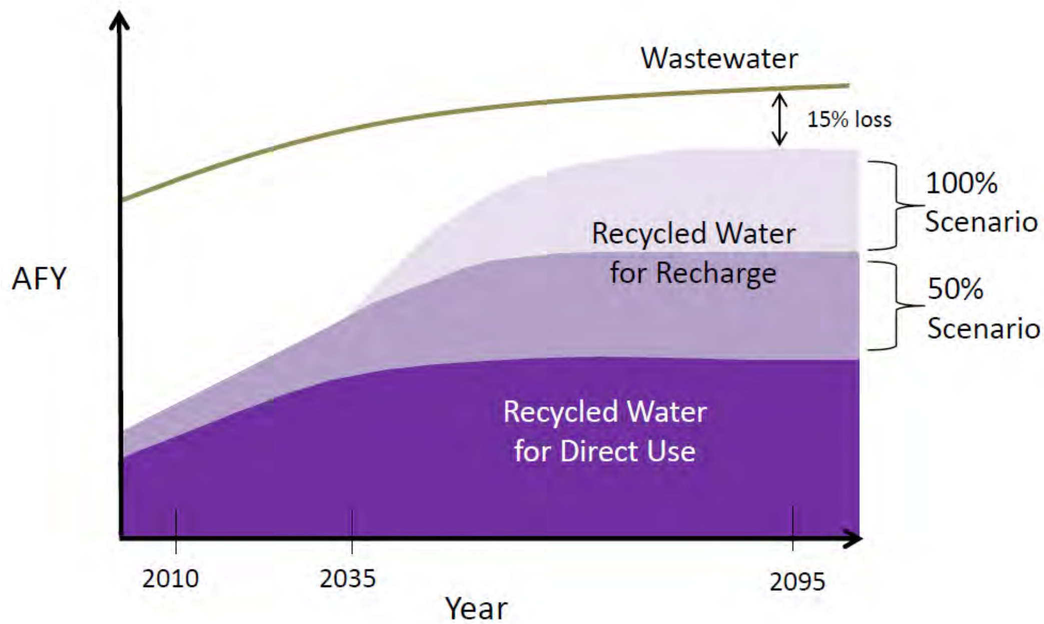
The third step in the recycled water supply methodology was to deduct environmental flows from available non-potable direct use supplies. LADWP has an approximate 27 MGD flow commitment to maintain three lakes that are fed by recycled water from the Donald C. Tillman Water Reclamation Plant (LADWP 2012). This amounts to approximately 30,200 AFY discharged to the Los Angeles River rather than used for replenishment in the watershed. No other environmental flow commitments were documented at the time of this report.

The fourth step in estimating recycled water supplies was to adjust the volumes assumed for replenishment/recharge by deducting brine concentrate losses to account for treatment processes that will likely be needed. Specifically, the recycled water methodology assumed that advanced water treatment (AWT) technology will be required to meet the regulatory requirements for replenishment/recharge and/or for DPR projects. AWT technology employs microfiltration, reverse osmosis, and advanced oxidation; and it produces a brine concentrate waste stream that requires discharge. To account for this brine concentrate waste stream, the total wastewater volume was further reduced by 15 percent (LADWP 2012). The remaining quantity was considered to be the total recycled water available for either replenishment/recharge or DPR.

The fifth step in the recycled water supply methodology was to develop two scenarios that would encompass a broad spectrum of implementation for replenishment/recharge (and/or DPR) projects. After recycled water non-potable direct use and environmental flow volumes were removed from the total available recycled water supplies, two scenarios were developed for 2095: (1) 100 percent of available recycled water replenishment/recharge supplies will be used; or (2) 50 percent of the available recycled water replenishment/recharge supplies will be used. This range is arbitrary and is not based on reference documents that indicate a specific capacity for future replenishment/recharge projects.

The last step in the methodology addressed complications arising out of the assumption that all imported water for replenishment/recharge would be replaced with recycled water by 2095. This was needed specifically on a watershed basis. As a result of this assumption, some watersheds did not have sufficient available recycled water to account for imported water decreases in replenishment/recharge. In these watersheds, available recycled water volumes from neighboring watersheds were shifted to account for the gap. It is important to note that resulting ranges in recycled water supplies available for replenishment/recharge are meant to represent maximums. In order to use the available recycled water as a supply, appropriate conditions would need to exist to allow for successful groundwater recharge (i.e., facility capacity, natural hydrogeologic conditions, water rights, etc.). Figure 17 conceptually illustrates the recycled water supply methodology, including wastewater generated, non-potable reuse and environmental flow supplies, and two replenishment/recharge scenarios that assume losses for brine concentrate.

Figure 17. Conceptual Recycled Water Supply Methodology



Climate change is not expected to impact recycled water volumes. Recycled water supply is primarily dependent on population and conservation-related behavior, not climate, so no adjustments were applied to the 2095 calculated range.

3.3.1.6 Graywater

To project graywater supplies in 2095, total potential graywater generation was estimated and an implementation rate for the entire Study Area was applied. A recent UCLA study about the potential of graywater as a supply source (Cohen 2009) highlighted the practice of reusing water from washing machines, bathroom sinks, and showers/baths as feasible for the Southern California area. This type of graywater implementation is referred to as “light graywater” and does not require a treatment system under the 2007 California Plumbing Code if used for subsurface or covered irrigation (excluding irrigating food crops). Using the combined average water demands for washing machines, bathroom sinks and showers/baths reported in the PRWUS (Table 2) and incorporating a 15 percent implementation rate for the Study Area, the amount of per capita supply available from graywater in 2095 was estimated at approximately 4 gpcd [(27.1)*(0.15)]. [18] Climate change impacts were not applied to graywater supplies for 2095 as there is no basis or documentation available at this time to estimate them.

[18] The implementation rate of 15 percent is based on the Graywater Awareness & Usage Study conducted by the NPD Group that indicates a potential graywater implementation rate in the LA Basin area of 13.9 percent.

3.3.1.7 Stormwater

Stormwater supply availability is expected to increase through 2095 as more stormwater capture projects are implemented. Methods for estimating total supply availability for the various types of stormwater capture are summarized below and described in more detail in Section 4. The methodology used in this report is primarily based on the draft SCMP developed by LADWP (Geosyntec 2014). The draft SCMP defines and quantifies a range of stormwater capture in the City of Los Angeles, and tributary areas, to determine the volume of stormwater that could potentially be captured for direct use and replenishment/recharge at both centralized and decentralized facilities.

This report defines three types of stormwater capture based on similar categories used in LADWP's draft SCMP. These three types are estimated using the methodologies described below:

- **Centralized stormwater capture for recharge:** Projected using the "centralized stormwater capture" category in the draft SCMP for the City of Los Angeles and tributary areas. These values were then extrapolated to other watersheds in the Study Area.
- **Decentralized stormwater capture for recharge:** Projected using the "decentralized stormwater capture" category in the draft SCMP, focusing on aquifers "suitable for recharge" in the City of Los Angeles and tributary areas. These values were then extrapolated to other watersheds in the Study Area.
- **Decentralized stormwater capture for direct use[19]:** Projected using the "decentralized stormwater capture" category in the draft SCMP, focusing on aquifers "not suitable for recharge" in the City of Los Angeles and tributary areas. These values were then extrapolated to other watersheds in the Study Area.

Again, a more detailed description of this methodology is included in Section 4. Note that the stormwater supplies shown in this report reflect the total supply available and are not necessarily limited by facility capacity available to replenish/recharge the supply.

[19] This methodology for "decentralized stormwater capture for direct use" differs from the methodology in Section 2 which estimated decentralized stormwater volumes for the sole purpose of adjusting demand values.

Preliminary climate change studies have shown that while climate change may not greatly affect total precipitation, it is predicted that the total volume and frequency of storms will change and that temperatures will rise. Such impacts can reduce the effectiveness of centralized stormwater recharge facilities as explained in the draft SCMP (Geosyntec 2014). No references were available to document to what degree climate change would influence decentralized stormwater capture for recharge or decentralized stormwater capture for direct use, so no climate change impacts were incorporated into the 2095 supply projections for these stormwater supplies at this time. Centralized stormwater capture for recharge (i.e., centralized facilities) are adjusted by an increase of 9 percent based on the Task 3.2 Hydrologic Modeling Report findings for stormwater recharge volumes in 2095.

3.3.2. Results

Table 9 and Figure 18 show the projected water supply availability for the seven watersheds in the Los Angeles Basin for the year 2095. Supply volumes reflect climate change impacts where appropriate as described in the previous sections. The range of recycled water replenishment/recharge (and/or DPR) implementation assumed for this Study is reflected at the top of each bar chart, with the lavender block representing the “low” range (50% use) and the hashed lavender block representing the “high” range (100% use). These results show that there is a significant increase in available supply potential compared to 2035, but it does not reflect which of these supplies would actually be implemented to meet demands in 2095. The relationship between Los Angeles Basin supplies and demands is further discussed in Section 5.

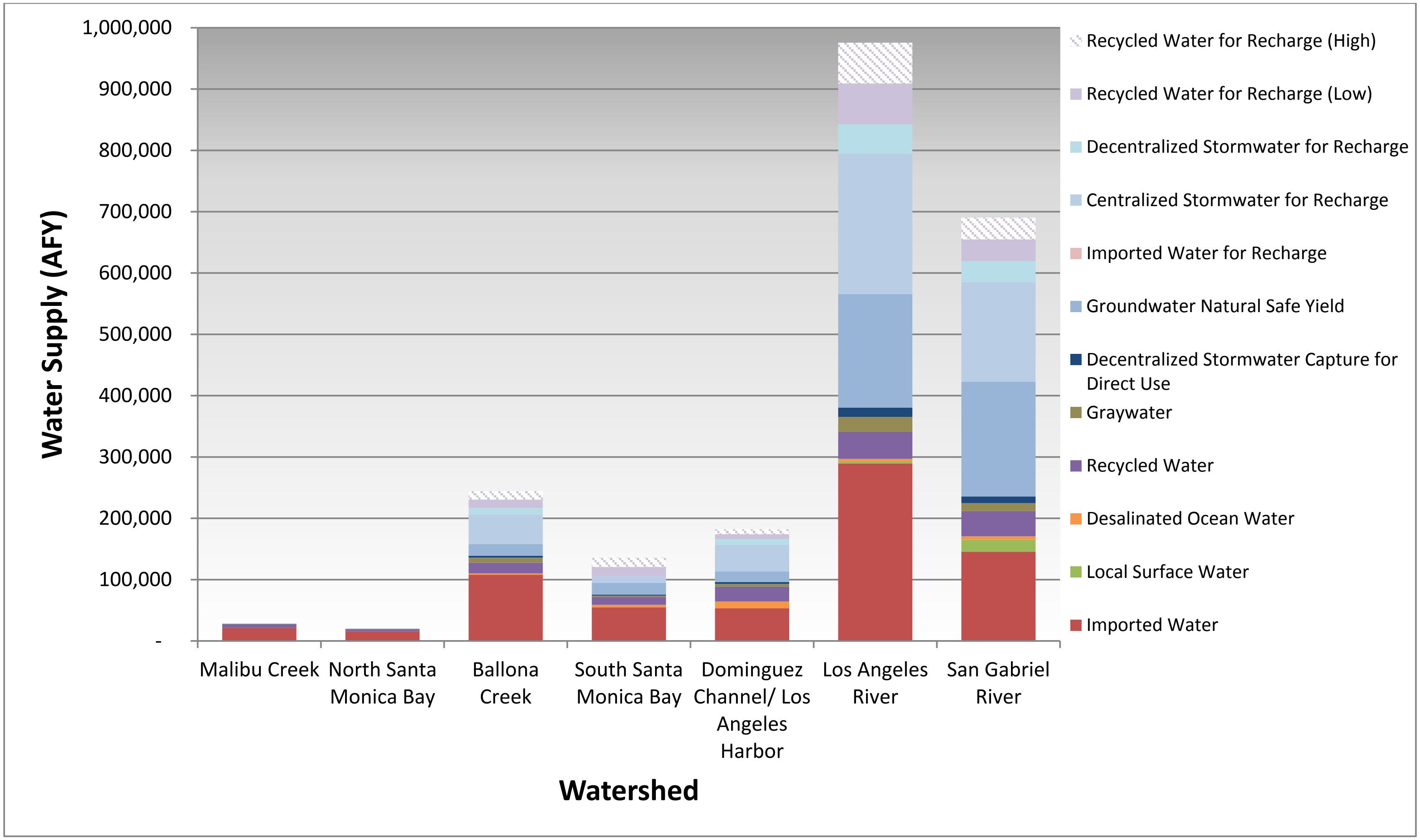
The results show the assumed reductions in imported supply due to climate change and development of local supplies in excess of the volumes available for previous years. All watersheds also reflect a more diversified portfolio of supplies available to meet demands.

Table 9. 2095 Projected Water Supplies (AFY) by Watershed

Water Supply	Malibu Creek Watershed	North Santa Monica Bay Watershed	Ballona Creek Watershed	South Santa Monica Bay Watershed	Dominguez Channel/Los Angeles Harbor Watershed	Los Angeles River Watershed	San Gabriel River Watershed
Direct Use Supplies							
Imported Water	21,300	16,100	108,000	54,900	53,600	289,600	145,600
Local Surface Water	-	-	-	-	-	3,000	19,500
Desalinated Ocean Water	-	-	2,400	3,900	10,800	4,400	5,600
Recycled Water	5,900	3,400	17,300	12,900	24,400	44,100	41,200
Graywater	400	100	8,100	2,100	4,500	24,300	12,900
Decentralized Stormwater Capture for Direct Use	400	200	3,200	1,700	2,900	15,200	10,800
Replenishment Supplies[1]							
Groundwater Natural Safe Yield	100	500	18,900	19,300	17,500	185,000	187,100
Imported Water for Recharge	-	-	-	-	-	-	-
Centralized Stormwater for Recharge	-	-	48,700	10,700	43,500	228,800	162,500
Decentralized Stormwater for Recharge	-	-	10,200	-	9,200	48,200	34,200
Recycled Water for Recharge (Low)	-	-	13,700	15,300	8,000	66,500	35,400
Recycled Water for Recharge (High)[2]	-	-	13,700	15,300	8,000	66,500	35,400
Total Supply	**28,100**	**20,300**	**244,200**	**136,100**	**182,400**	**975,600**	**690,200**

Notes: Values are in AFY and are rounded to the nearest 100.
(1) “Replenishment Supplies” are assumed to represent the same set of supplies that “Groundwater Pumped” represents for 2010 (Table 7).
(2) “Recycled Water for Recharge (High)” represents the extra increment of AFY to get from 50% to 100% available recycled water supply for recharge.

Figure 18. 2095 Water Supplies by Watershed



3.4. Conclusions

Table 10 and Figure 19 show the combined available water supplies for the entire Los Angeles Basin for 2010, 2035, and 2095. In comparing these three “snapshot” years, it is important to note that the categories of supply are slightly different from the baseline year (2010) to the projected years (2035 and 2095) with respect to “groundwater pumped” and “replenishment/recharge” supplies. Also, since this report is based on existing reference documents which do not necessarily project supplies to 2095, certain categories of water supplies for 2095 remain unchanged from 2035 volumes.

It is likely that policy changes over this century will influence which water supplies become more cost-effective and which supplies decrease in use, but these changes cannot be readily forecasted based upon planning efforts completed to date. Also, several water supplies have physical limits, such as local surface water and imported water, while other supplies are only limited by how cost-effective they are and what environmental regulations are in effect to limit their use at the time of implementation, such as desalinated ocean water. In addition, costs and increasing regulatory support for recycled water recharge will need to be considered relative to the seasonal and increasingly “peaky” variability of local stormwater (due to climate change) when estimating the balance of recharge in implemented facilities. Future studies that identify available supplies, trends in use, and climate change impacts will be needed to improve these supply projections in the future.

Table 10. Water Supplies (AFY) for the Entire LA Basin Study Area

Water Supply	2010	2035	2095
Groundwater – Pumped[1]	606,700	N/A	N/A
Groundwater Natural Safe Yield	N/A	428,300	428,300
Imported Water for Recharge	N/A	72,600	-
Centralized Stormwater for Recharge	N/A	239,000	494,200
Decentralized Stormwater for Recharge	N/A	29,900	101,800
Recycled Water for Recharge (Low)	N/A	88,700	138,900
Recycled Water for Recharge (High)[2]	N/A	-	138,900
Subtotal (High):	**606,700**	**858,500**	**1,302,100**
Imported Water	865,600	918,800	689,100
Local Surface Water	14,700	19,900	22,500
Desalinated Ocean Water	1,500	27,000	27,000
Recycled Water	78,200	149,200	149,200
Graywater	-	15,400	52,400
Decentralized Stormwater Capture for Direct Use	-	10,100	34,400
Total Supply	**1,566,700**	**1,998,900**	**2,276,700**

Notes: Values are in AFY and are rounded to the nearest 100.
(1) "Groundwater Natural Safe Yield" is included in the "Groundwater – Pumped" value for 2010.
(2) "Recycled Water for Recharge (High)" represents the extra increment of AFY to get from 50% to 100% available recycled water supply for recharge.

Figure 19 shows an overall trend of replacing imported supplies with local supplies, largely made possible through substantial groundwater replenishment/ recharge programs that will be limited only by the availability and feasibility of facilities to recharge and store those supplies. Figure 20 shows the relative proportions of each of the available supply categories for the entire Los Angeles Basin in 2010, 2035, and 2095.

Figure 19. Water Supply for the Entire LA Basin Study Area

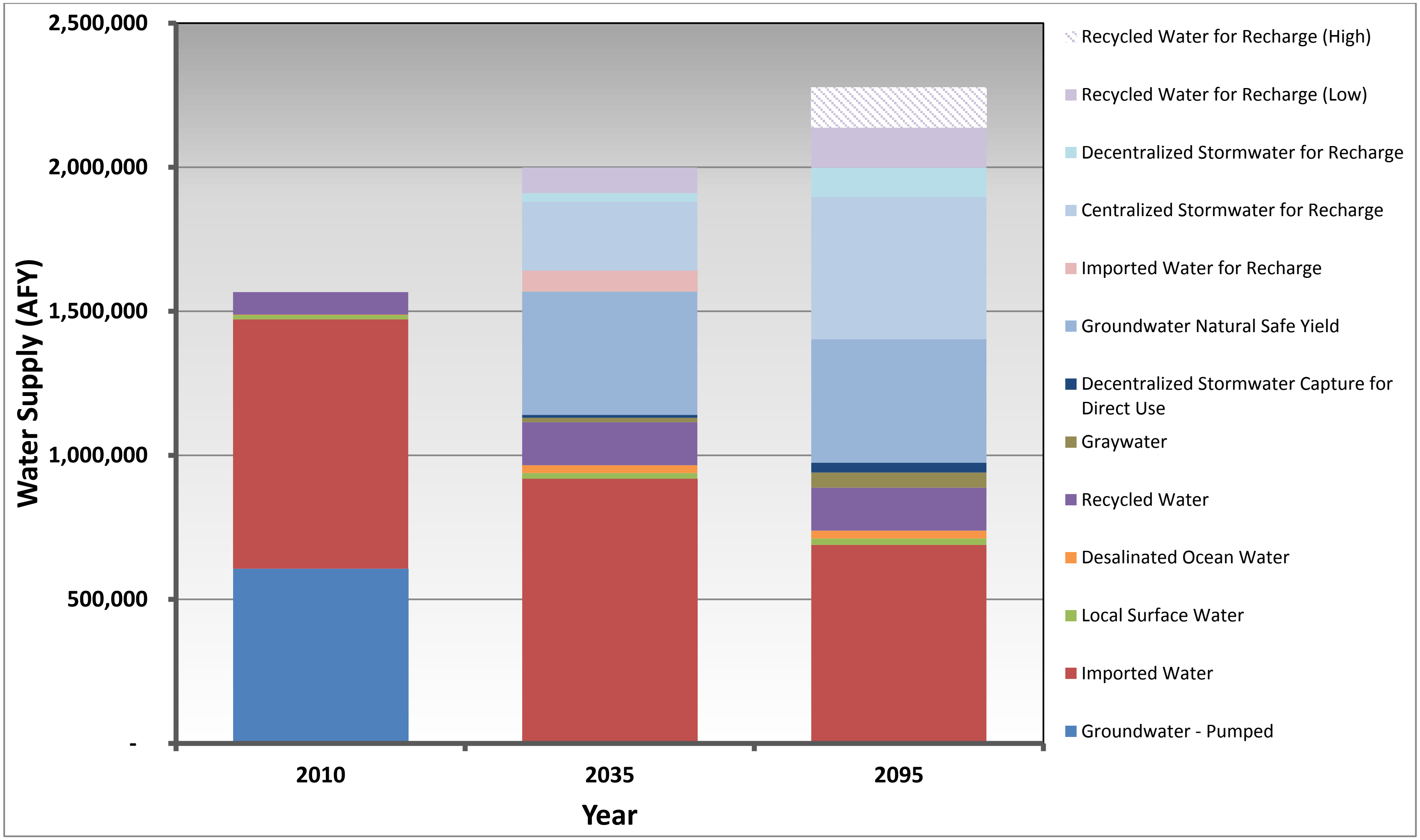
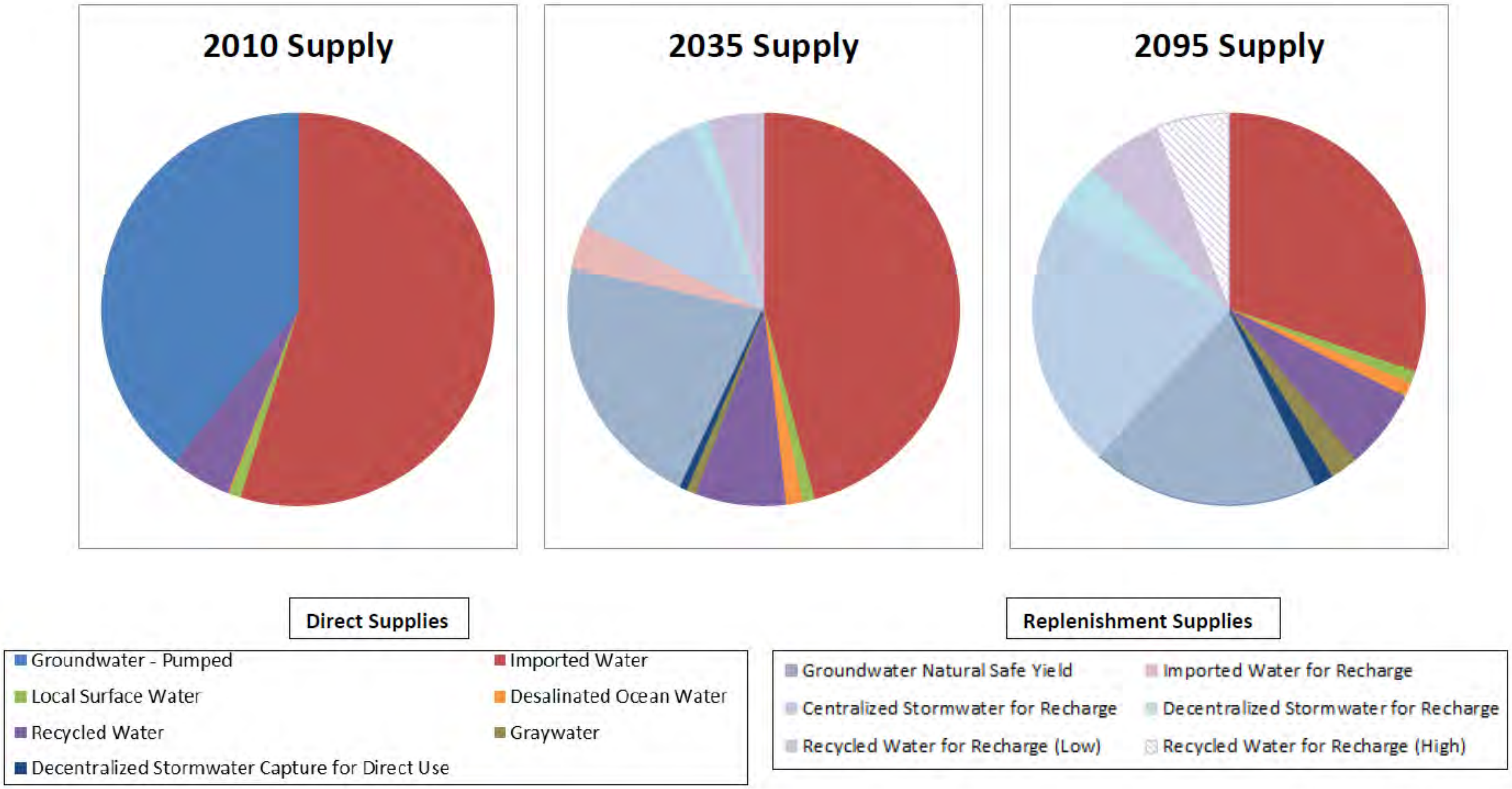


Figure 20. Pie Diagrams of Water Supply Proportions in 2010, 2035, and 2095



4. LACFCD Water Conservation System Contributions

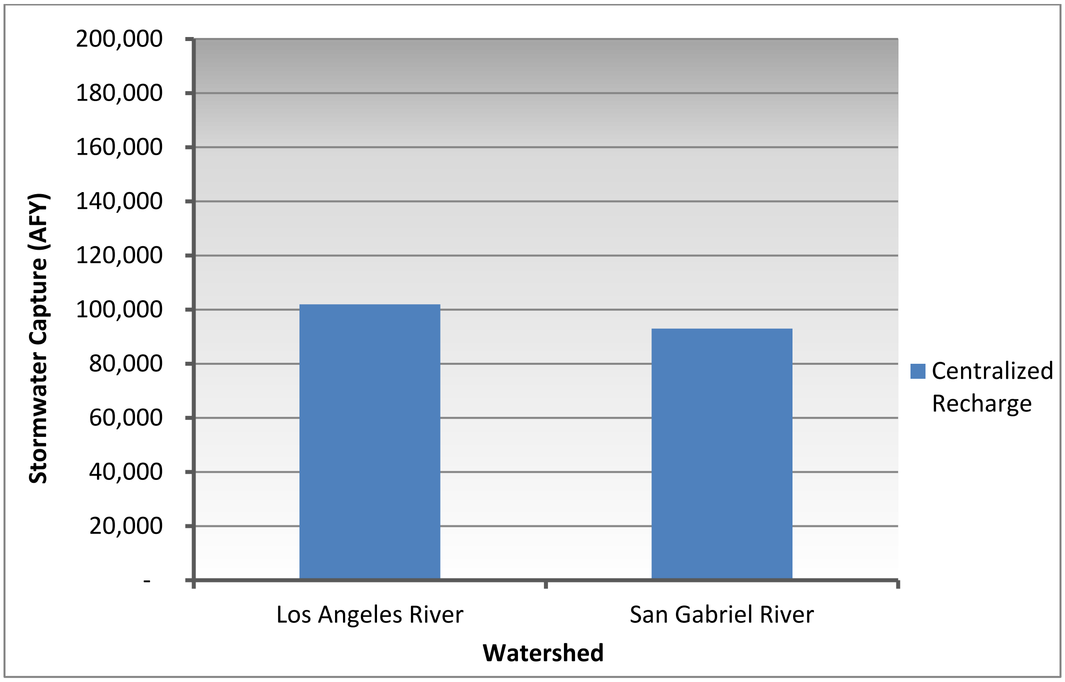
The purpose of this section is to define stormwater contributions to the Los Angeles Basin in terms of both available stormwater supply and facility capacity for use. The three types of stormwater capture explored are centralized capture for recharge, decentralized capture for recharge, and decentralized capture for direct use. “Centralized capture for recharge” refers to large engineered projects, primarily spreading grounds or basins, that have as their primary purpose the percolation of stormwater, imported water, and/or recycled water to groundwater basins. “Decentralized capture for recharge” refers to smaller-scale projects, such as pervious pavement or bioswales, that allow stormwater runoff to infiltrate to groundwater basins onsite. “Decentralized capture for direct use” refers to small-scale projects that collect water for direct use onsite, such as rain barrels, cisterns, rain grading, rain gardens, and parkway basins.

4.1. Existing Contributions/Use

Existing stormwater supplies and use are based on average stormwater capture as reported in Los Angeles County Department of Public Works (LACDPW) monitoring data and 2010 UWMPs. Average centralized stormwater recharge was estimated for the Study Area using reported stormwater recharge volumes monitored by LACDPW from the years 2000/2001 to 2010/2011. It was found that, on average, the LACDPW has recharged 195,000 AFY of stormwater. The hydrologic reports indicate recharge volumes for different source water types at the groundwater basin level, while total recharge (i.e., not distinguished by source water type) is reported down to the individual spreading basin level. Given that centralized stormwater capture for recharge is reported by the LACDPW’s spreading ground monitoring data by groundwater basin and the LA Basin Study is exploring water supplies by watershed, it was necessary to apportion centralized stormwater capture for recharge by watershed using total recharge by spreading basin, according to the watershed where the spreading basin is physically located. Existing centralized stormwater capture for recharge is shown in Figure 21.

Existing decentralized stormwater capture for recharge and decentralized stormwater capture for direct use are assumed to be negligible for 2010 given that the 2010 UWMPs for water suppliers in the Los Angeles Basin did not report these as a supply. Therefore, existing decentralized stormwater capture for direct use and recharge are reported here as 0 AFY. It is assumed that existing decentralized stormwater capture currently contributes to the native safe yield of the groundwater basins as previously explained (see Section 3.2.1.1 for the methodology used for calculating groundwater natural safe yield).

Figure 21. 10-year Average Centralized Stormwater Capture for Recharge in the LA Basin Study Area



4.2. Recharge Facility Capacity

Assessing the potential for additional stormwater recharge requires an analysis of unused recharge facility capacity. To determine the remaining capacity in existing groundwater recharge facilities, the estimated maximum capacity for each facility was first calculated and then compared to average recharge amounts of stormwater, imported water and recycled water. The maximum capacity of each of the LACFCD's spreading basins (shown in Figure 22) was estimated using the percolation capacity listed in the annual hydrologic reports. These values were then multiplied by the basin area, and it was assumed that spreading basins would be utilized for 7 months out of the year. Note that spreading basins are only found in the Los Angeles River and San Gabriel River watersheds. The next step involved subtracting average recharge amounts for stormwater, imported water, and recycled water from the maximum facility capacity. Note that imported water and recycled water recharge are reported by groundwater basin in the LACDPW's annual hydrologic reports in the same manner as stormwater. Therefore, recycled water and imported water were apportioned to each watershed using the same method described in Section 4.1 of this Report (i.e., by physical location of spreading facilities).

The results of this analysis are shown in Figure 23, which indicates that existing Los Angeles County spreading basins have, on average, approximately 385,000 AFY of unused recharge capacity. This analysis is limited in that it uses annual average recharge and does not account for individual years which may fluctuate widely. An analysis of monthly data may show that seasonality decreases the recharge capacity available for supplemental sources (imported and recycled water) in years when high volumes of stormwater use a large amount of the available recharge capacity. In addition, the total spreading basin capacity is based on reported percolation capacities that represent observed values derived from field calculations.

MWD's Groundwater Assessment Study (2007) estimates groundwater basin storage, including available storage, for all groundwater basins within the Study Area. In total, there was approximately 1.2 million acre-feet of unused storage space available for supplemental storage in 2005/2006. Based on this high-level analysis, it appears likely that spreading basin facilities inside the Study Area will have, on average, sufficient capacity to capture additional available stormwater flows.

Figure 22. Spreading Grounds in the LA Basin Study Area

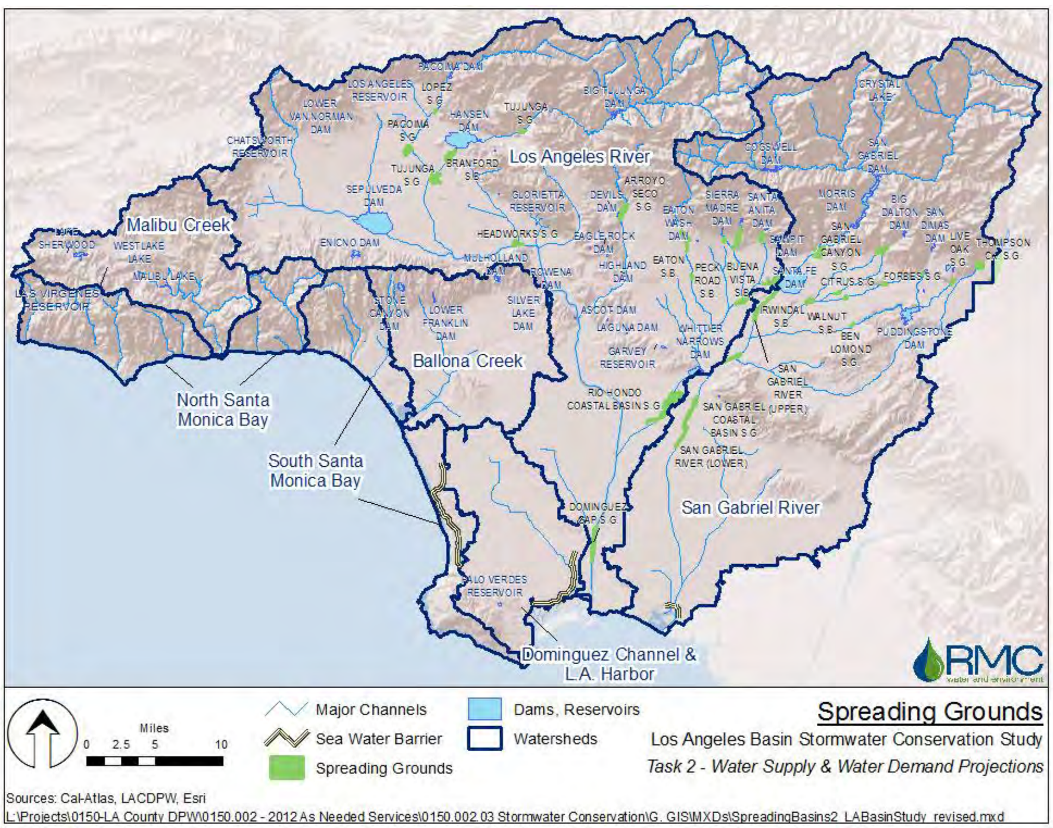
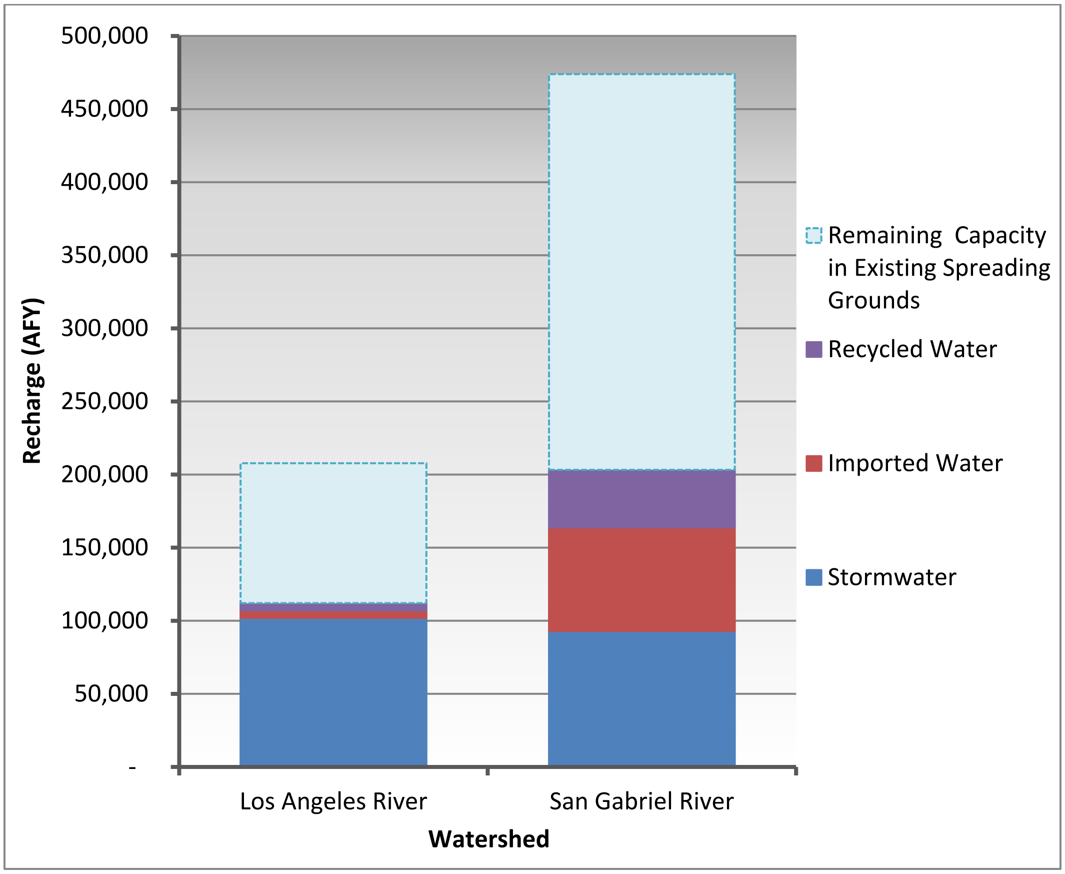


Figure 23. 10-year Average Recharge in LACFCD Recharge Facilities and Potential Facility Capacity



4.3. Future Stormwater Capture

Future stormwater capture was estimated for the years 2035 and 2095, and includes the three categories of centralized stormwater capture for recharge, decentralized stormwater capture for recharge, and decentralized stormwater capture for direct use.

4.3.1. 2035 Projected Stormwater Capture

Centralized stormwater capture for recharge for the year 2035 was estimated using a current list of conceptual water conservation projects provided by the LACFCD and adding their planned capacities to the 2010 centralized stormwater capture for recharge values from the GLAC IRWMP. This list contained AFY values for "estimated water conservation benefit" that were used to calculate new stormwater conservation amounts for 2035. Table 11 shows the projects included in this methodology. The total 2035 centralized stormwater supply for the Study Area was then redistributed between watersheds based on population proportions.

Table 11. LACFCD Centralized Stormwater Conservation Projects to be Implemented by 2035 (Capture for Recharge)

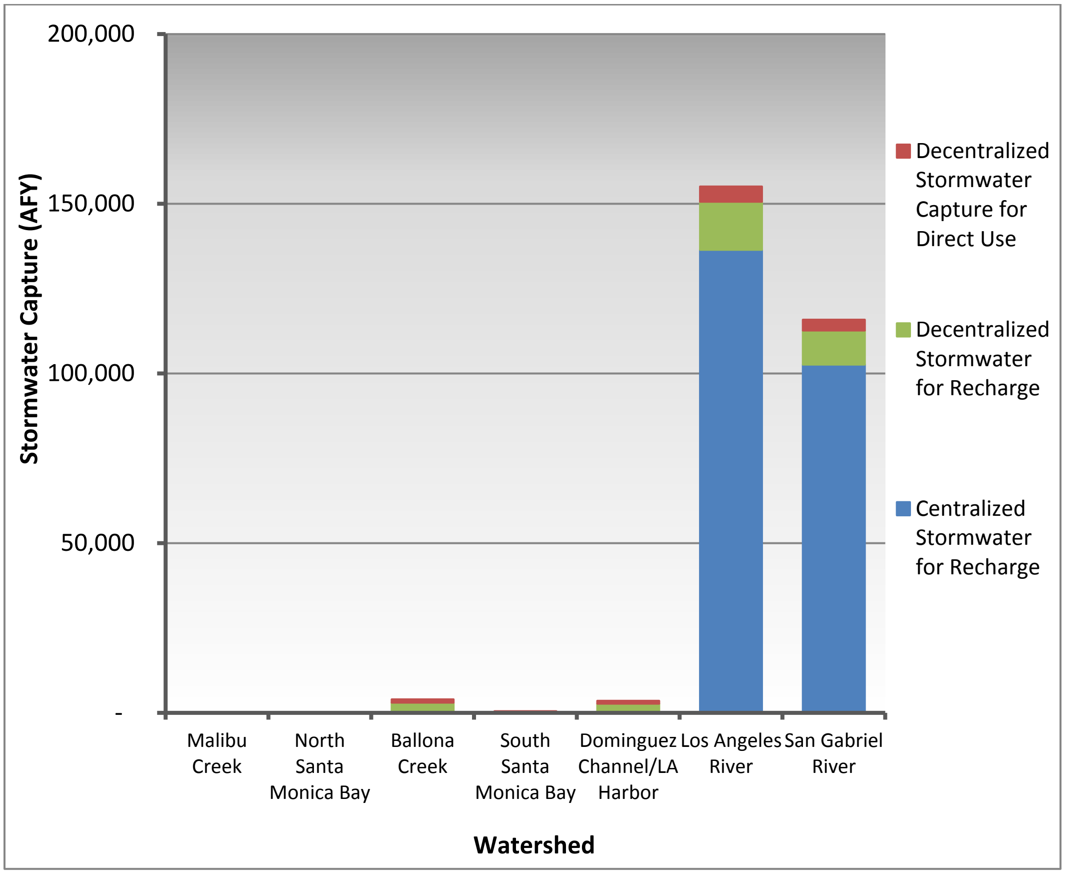
Agency	Project	Estimated Water Conservation Benefit (AFY)
LACFCD	Big Dalton SG Improvements	300
LACFCD & LADWP	Big Tujunga Reservoir Sediment Removal Project	4,500
LACFCD & LADWP	Branford SB Pump Station	575
LACFCD & LADWP	Bull Creek Diversion - Rubber dam and pipeline	800
LACFCD	Devil's Gate Reservoir Sediment Removal and Water Conservation Project	4,500
LACFCD	Dominguez Gap Westside Improvements	500
LACFCD & LADWP	Hansen Dam Water Conservation Study	3,500
LACFCD	Little Dalton SG Improvements	100
LACFCD & TVMWD	Live Oak SG Improvements	500
LACFCD & LADWP	Lopez Spreading Grounds Improvements	500
LACFCD & LADWP	Pacoima Spreading Grounds Improvements	10,500
LACFCD	Rory M Shaw Wetlands Park Project (Strathern)	600
LACFCD	San Gabriel Spreading Grounds Levee Stability	5,000
LACFCD	Santa Anita Headworks Improvements	500
LACFCD	Santa Anita SG Improvements	500
LADWP & LACFCD	Tujunga Spreading Grounds Improvements	8,000
LACFCD	Walnut Creek SB cleanout	300
LACFCD & WRDSC	Whittier Narrows Dam Water Conservation Study	2,900
	Total	**44,075**

It should be noted that additional stormwater quality and capture projects in the Study Area are currently being developed as part of the Enhanced Watershed Management Plan (EWMPs) process in the LA Basin, as required by the Los Angeles County Municipal Separate Storm Sewer System (MS4) permit. At the time of this report, the EWMP projects are still in the process of being developed, so the potential supply benefits are not included. However, it should be noted that many of these projects will become operational prior to 2035 and will contribute to both water supply and quality benefits.

In addition, other future centralized facilities such as projects that make use of the extensive network of channelized streams and rivers in the region for stormwater capture may contribute to future supply availability in the region. These types of large-scale facilities and others will be examined in more detail in subsequent phases of the LA Basin Study (planned for Task 5).

Decentralized stormwater capture for recharge and decentralized stormwater capture for direct use were estimated based on a linear interpolation of decentralized stormwater capture from 2010 (0 AFY for both types of decentralized capture) to 2095 (see Section 4.3.2. for volumes). Decentralized stormwater capture projects that are being developed for the EWMPs are assumed to be incorporated in the 2035 projections. This approximate assumption is based upon the LADWP draft SCMP methodology which capture at a minimum the 85th percentile, 24-four storm depth and in turn, EWMPs capturing this same event. Figure 24 indicates the breakdown of potential stormwater supplies for 2035 by watershed and by each of the three types of stormwater supply.

Figure 24. Estimated 2035 Stormwater Capture in the LA Basin Study Area by Watershed



4.3.2. 2095 Projected Stormwater Capture Availability

Centralized stormwater recharge for the year 2095 was estimated using preliminary results from the LADWP's draft SCMP. The SCMP is being undertaken by LADWP to quantify the stormwater capture in the City of Los Angeles and tributary areas to determine the volume of stormwater that could potentially be captured for direct use and replenishment/recharge at both centralized and decentralized facilities. This study takes into account geophysical and anthropogenic constraints, opportunities, and priorities in the analysis of stormwater capture potential. The draft SCMP's preliminary results provide "conservative" and "aggressive" stormwater capture volumes for both centralized and decentralized facilities in order to show a range in recharge potential. However, for the purposes of the LA Basin Study, only the "aggressive" scenario was utilized to extrapolate stormwater supplies. It was assumed that by 2095, the Los Angeles Basin would be actively pursuing stormwater capture and that the aggressive scenario volumes will more accurately reflect available stormwater supplies. Table 12 shows the draft SCMP's values for an "aggressive" stormwater capture scenario. The aquifer classes shown in this table indicate the ability for the City of Los Angeles to access the water after it has percolated into the aquifer and are designated as follows:

- Class 1: Aquifer is under LADWP control
- Class 2: Aquifer is under regional control, but still potentially usable for the City of Los Angeles
- Class 3: Aquifer is perched or recharge is unlikely to be usable for the City of Los Angeles
- Unclassified: Area does not have an underlying aquifer

Table 12. Total City of Los Angeles Stormwater Capture, Aggressive Scenario (2014 LADWP Draft SCMP)

Capture Type	Aquifer Class (AFY)			
	Class 1	Class 2	Class 3	Unclassified
Centralized – Total	**120,300**	**15,600**	**35,300**	**0**
Existing	29,400	0	0	0
Potential	90,900	15,600	35,300	0
Decentralized – Total	**57,900**	**16,300**	**18,600**	**21,900**
Existing	29,900	5,100	10,300	17,700
Potential	28,000	11,300	8,200	4,200

For the purposes of estimating potential stormwater capture for the Study Area, the volumes shown in Table 12 were first reorganized by aquifer class (Classes 1, 2, and 3 used in the draft SCMP and described above) and combined to estimate basin-wide stormwater use according to the stormwater terms used in the LA Basin Study: “centralized stormwater capture for recharge”, “decentralized stormwater capture for recharge”, and “decentralized stormwater capture for direct use”.

The draft SCMP classes and capture types listed in Table 12 were reorganized and combined in this report as follows:

- **Centralized stormwater capture for recharge:** Summed total potential centralized recharge amounts discussed in the draft SCMP under aquifer classes 1, 2 and 3 for the aggressive scenario to develop a maximized potential centralized stormwater capture for recharge values.

- **Decentralized stormwater capture for recharge:** Summed total potential distributed stormwater capture amounts in the draft SCMP under aquifer classes 1 and 2 for the aggressive scenario.

- **Decentralized stormwater capture for direct use:** Summed total potential distributed stormwater capture amounts in the draft SCMP under aquifer class 3 and unclassified aquifers. This methodology assumes that recharge is not optimal in these aquifer classes due to geological constraints and that stormwater is only available for direct use.

Note that for decentralized stormwater capture, only “potential capture” is used from the draft SCMP estimates since it is assumed that existing decentralized stormwater capture already contributes to the natural safe yield of the groundwater basins (the methodology for calculating groundwater natural safe yield is explained in Section 3 of this report).

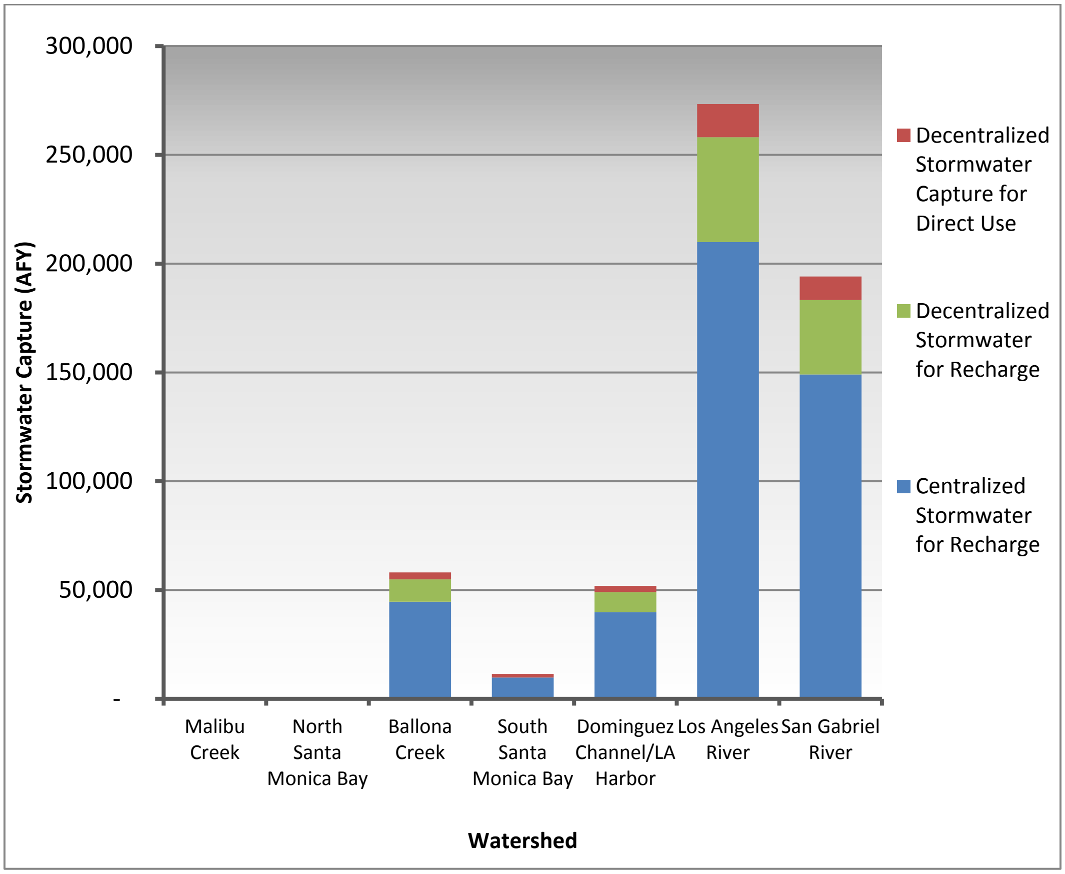
Next, these reclassified stormwater amounts were converted to “AFY per acre” values for the Study Area. These estimates were calculated by dividing the AFY value for each stormwater category by the total urban acreage inside the Study Area. The urban area acreage was obtained by using the total watershed area and removing the open space area as reported in the 2013 GLAC IRWMP. It was assumed that future stormwater capture projects could only be implemented in urban areas.

Finally, the AFY per acre values were applied to the estimated urban areas within each watershed to apportion stormwater flows by category and by watershed.

The results of these calculations are shown in Figure 25. It was assumed that centralized recharge would not be feasible in the Malibu Creek and North Santa Monica Bay watersheds as the draft SCMP did not account for centralized recharge for stormwater capture in these watersheds. Therefore, the values for centralized recharge in these watersheds were set to zero AFY.

It should also be noted that values for stormwater capture based on the LADWP draft SCMP may be over-estimated because the methodology from the draft SCMP incorporates stormwater flows that run into the Los Angeles city area from outside the city area.

Figure 25. Estimated 2095 Stormwater Capture



As mentioned previously, stormwater recharge can vary seasonally. In addition, recharge can vary annually based on local stormwater conditions, imported water availability, and economic conditions. For the timeframe between 2000/2001 and 2009/2010, stormwater recharge contributions have varied between 45 percent and 300 percent of average, which reflects the variability in precipitation received in Southern California on an annual basis. This seasonal variability results in changes in the availability of capacity in recharge facilities, reducing the volume of imported or recycled water that can be recharged. Over the last 10 years, imported water recharge has varied between 15 percent and 150 percent of average. Additionally, economic conditions may affect the ability of agencies in the region to procure adequate revenue for spreading ground maintenance, reducing the volume of water that can be recharged in centralized facilities. Economic conditions could also impact the ability of entities in the Study Area to fund decentralized stormwater capture programs, such as rain barrel programs and LID projects.

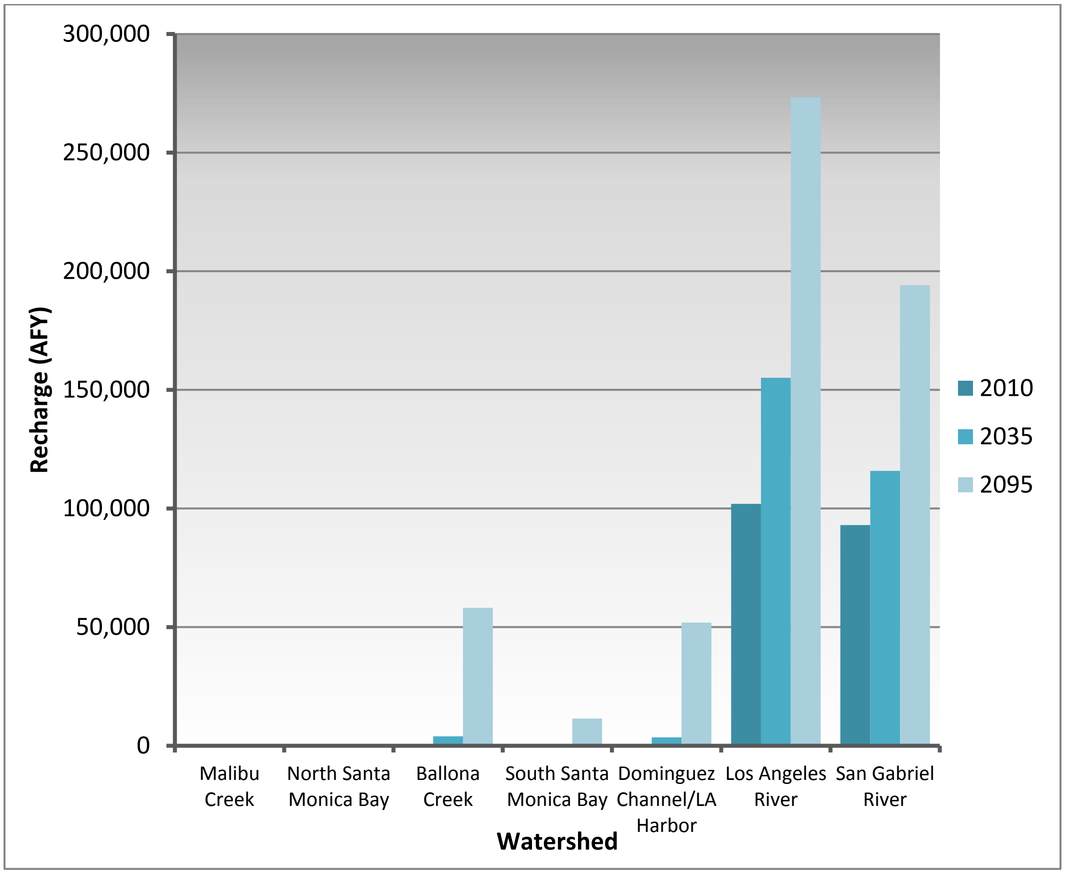
Climate change is expected to impact local stormwater supplies in the future, as indicated in Task 3 of the LA Basin Study and the draft SCMP. Preliminary climate change studies have shown that while climate change may not greatly affect total precipitation, it is predicted that the total volume and frequency of storms will change and that temperatures will rise. Such impacts can reduce the effectiveness of centralized stormwater recharge facilities as explained in the draft SCMP, Technical Memorandum 2.1 (Geosyntec 2014). No references were available to document the degree to which climate change would influence decentralized stormwater capture for recharge or decentralized stormwater capture for direct use, so no climate change impacts were incorporated into the 2095 supply projections for these stormwater supplies at this time. The Task 3.2 Hydrologic Modeling Report indicates a 9 percent increase in stormwater recharge volumes by 2095, suggesting a comparable increase in centralized stormwater capture for recharge supply. This impact is reflected in the 2095 centralized stormwater capture for recharge supply volumes in Section 3 of this report.

4.4. Conclusions

The Los Angeles Basin has a large potential for stormwater recharge, both in terms of runoff available and existing facility capacity, as shown in Figure 26. The 2035 estimates for stormwater recharge indicate that there could be an additional 84,000 AFY of stormwater captured for supply, and up to an additional 310,000 AFY beyond that in 2095. As described in Section 4.2, there is groundwater storage space available for these supplies on the order of three times the average volume of stormwater available for recharge in a given year.

It should be noted that while this Study reports stormwater recharge by watershed, this water may be available as a groundwater supply for other watersheds that overlie the groundwater basins due to hydrologic communication (underflow) with adjacent groundwater basins. Section 3 includes this assumption in its supply availability analysis. The findings from the analysis of potential stormwater capture and recharge availability will be analyzed further in Section 5. Note that the draft SCMP did not address stormwater capture for direct use.

Figure 26. Estimated Total Stormwater Capture for Recharge in the LA Basin Study Area by Watershed



5. Analysis of Water Supply and Demand

The purpose of this section is to present a comparison of supplies and demands identified in the previous sections of this report and discuss several scenarios for potential "gaps" in 2095. The comparison discussion will include supplies and demands by watershed, and it will include the overall Study Area as a whole with recommendation on how to apply the findings of this report to the overall LA Basin Study.

5.1. Supply Framework

The following considerations were described in Sections 1 through 4 and are summarized here to provide context for the comparison discussion. It should be noted that certain assumptions may have the effect of compounding small inaccuracies over time, resulting in a degree of uncertainty about values projected in 2095. For example, future technologies may make it possible to use brine concentrate as a supply source, which would increase the overall available supplies for the Los Angeles Basin. There may also be inaccuracies in the apportionment of supplies by watershed throughout the Los Angeles Basin.

It should be noted that this report reveals that the potential "gaps" in 2095 do not exist between supplies and demand. Instead, they exist between "available supplies" and "available supplies that are actually used". Facilities, along with public policy, permitting, environmental review, public support, water rights, and other potential factors, are needed to increase the use of available supplies to meet demands.[20] Current (2010) supply use meets demands, resulting in no gap between the 2010 water demands and 2010 water supplies. Future use of available supplies to meet demands will be dependent on implementation of facilities.

[20] It is important to note that the 2095 supply projections in this report incorporate assumptions about facility implementation. For some, the assumption is that only partial implementation will occur (e.g., graywater). For others, the assumption is that full implementation will occur (e.g., the "100% recycled water scenario").

5.1.1. Supply Availability

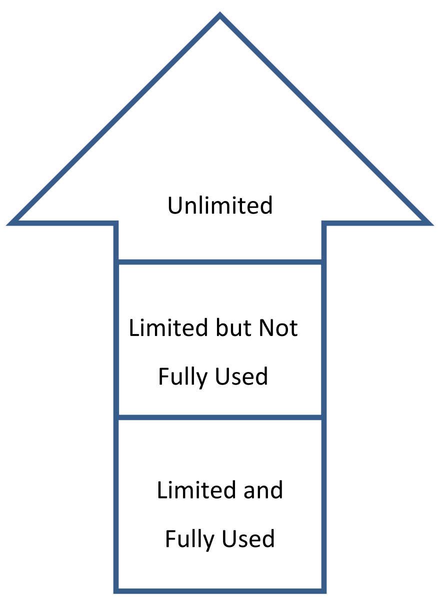
Supplies are limited by several factors, the first of which is availability (i.e., the ability to physically use a water supply given its close proximity to the Study Area or given existing facilities). This concept of supply availability is broken into three categories for this report: “unlimited”, “limited but not fully used”, and “limited and fully used”. These categories are defined below and shown graphically in Figure 27:

- **Unlimited Supplies:** These supplies are not restricted by total volume available for use and are only limited by facilities and the other factors described in Section 5.1.2 below. The only “unlimited” supply in this Study is desalinated ocean water due to the vast supply of the Pacific Ocean available in very close proximity to the Study Area. Use is not restricted by quantity which is practically infinite, but rather by facility development and the associated restraints on its development associated with cost and environmental impacts.

- **Limited but Not Fully Used Supplies:** These supplies have a finite upper limit (dependent on population) but that upper limit has not been reached in the Study Area. Examples of such supplies include recycled water, stormwater, and graywater.

- **Limited and Fully Used Supplies:** These supplies have a defined upper limit, and that upper limit is assumed to be completely exploited with existing, implemented project facilities in the Study Area. Examples of these supplies include natural safe yield to the groundwater basins, imported water, and local surface water.

Figure 27. Types of Available Supplies



5.1.2. Use of Supplies

Once the availability of a given supply is established, there are other factors that can constrain the ability of the region to fully use that supply. These constraints will influence the incremental order of implementation for each supply over time by affecting decision-makers in the Study Area.

1. **Facilities:** The extent to which agencies in the Study Area build, operate, and maintain facilities to capture, treat, convey, and use water supplies influences the degree of use of those supplies with respect to total available supplies. Storage facilities for groundwater will also play a critical role in the region's ability to utilize a diverse portfolio of water supplies.

2. **Economics:** Both the general strength of the economy and the cost-effectiveness of individual projects influence the degree to which supplies can be used. The general economy affects the availability of grant, loan, bond, and capital improvement funds that can be used to implement projects; whereas the cost-effectiveness of the projects themselves influences the relative appeal of implementing one project versus another in terms of costs and monetized benefits.

3. **Public Perception:** Public perception influences the degree to which controversial or poorly-understood water supply sources can be used.

4. **Regulatory:** Regulatory constraints can take the form of existing limits that affect the degree of implementation for a given project (e.g., water quality limits, pumping rights/restrictions, blending requirements, monitoring requirements, entitlement limits, etc.), and they can also take the form of future limits or regulations that have not been established (e.g., direct potable reuse guidelines). Regulatory limits are particularly influential for recycled water projects, both for non-potable reuse and indirect potable reuse.

5. **Groundwater Basin Capacity:** Use of the groundwater basins as a tool for the management of water supplies is dependent on the basin capacities to recharge, store, and produce all types of water supplies.

6. **Environmental Impacts:** Use of a supply source can have detrimental impacts on habitat, native species survival, and environmental sustainability. Over extraction of surface water and groundwater affects habitat, and the development of facilities such as ocean desalination plants can affect nearby species. Potential environmental impacts also influence several other constraints such as public perception and regulatory actions that can further restrict the development of a supply for use.

These factors impact the ability of agencies in the Study Area to implement project facilities that enable use of the available supplies. The extent to which a given available supply is used depends on a combination of these factors that is unique for each type of supply and for the facilities required to use it.

5.2. Supply and Demand Scenarios

Supply and demand quantities for 2010, 2035, and 2095 are shown below based on the findings noted in Sections 2 through 4. The graphics in the sections that follow indicate values for each type of supply, including the “high” and “low” recycled water scenarios, and for the three demand scenarios (“high”, “medium”, and “low”) in 2095.

5.2.1. 2010 Available/Used Supply and Demand

Supply and demand values for the year 2010 are summarized in Table 13 and Figure 28. The values indicate a good degree of consistency between the various watersheds, with available supplies essentially matching demands in the Malibu Creek, North Santa Monica Bay, Ballona Creek, South Santa Monica Bay, and Dominguez Channel/Los Angeles Harbor watersheds. This indicates that available supplies match used supplies for these watersheds. Available supplies for 2010 are higher than the demands in the Los Angeles River and San Gabriel River watersheds, suggesting that not all of these supplies were used.

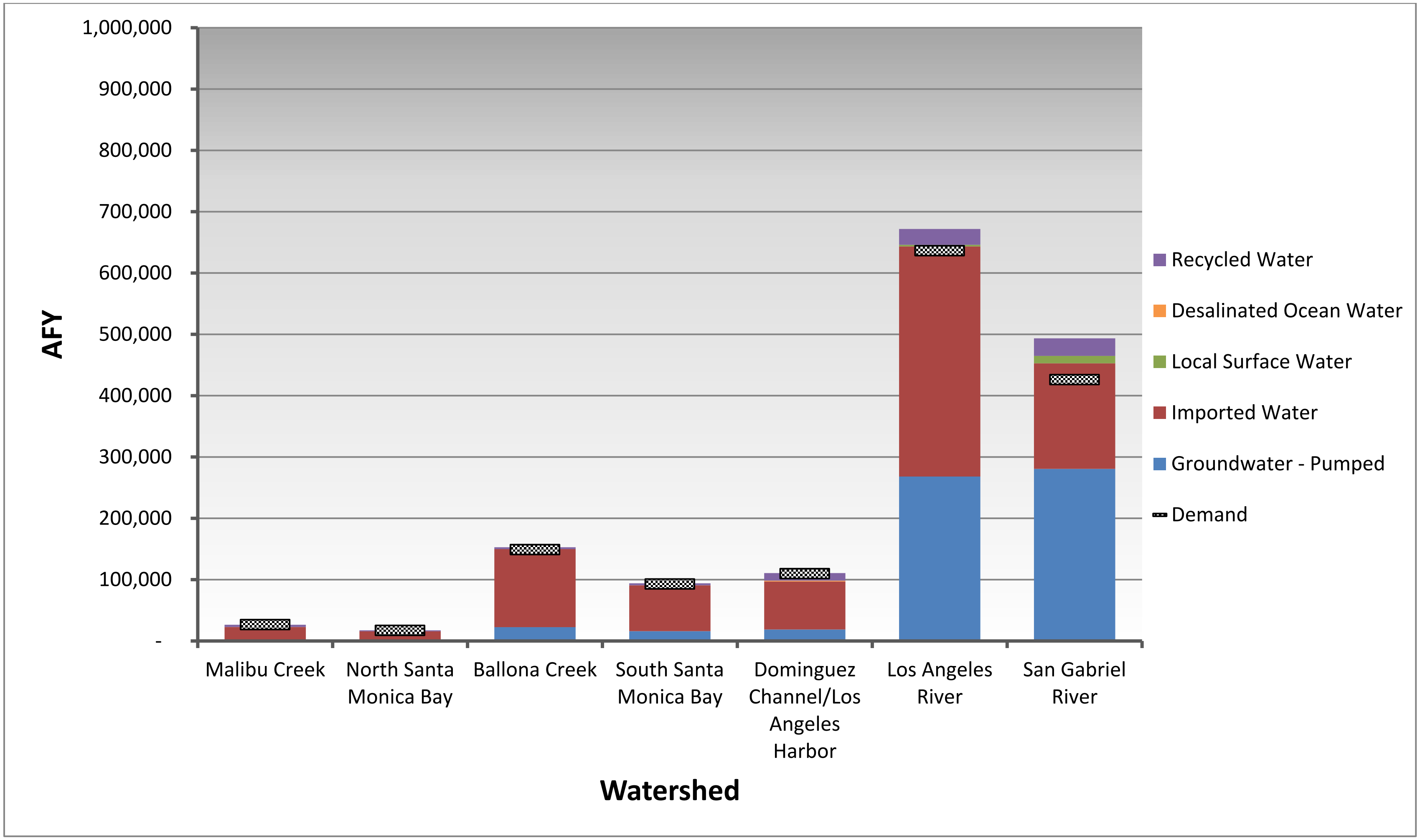
As discussed in Section 3, the values for available supplies and demands in 2010 were obtained from the GLAC IRWMP and reflect numbers reported in the various UWMPs for the Study Area. Graywater and decentralized stormwater capture for direct use are considered negligible in 2010, and conservation is included as a reduction in demands (rather than a distinct supply as in the GLAC IRWMP). Values were redistributed from a subregional level of organization (GLAC IRWMP) to a watershed level of organization to meet the needs of this report. Some supply numbers were reported in UWMPs as “accessible” supply volumes rather than volumes that were actually used, resulting in supply numbers for some watersheds that exceed demands.

Table 13. Available and Used Water Supply and Demand in 2010

Water Supply	Malibu Creek Watershed	North Santa Monica Bay Watershed	Ballona Creek Watershed	South Santa Monica Bay Watershed	Dominguez Channel/Los Angeles Harbor Watershed	Los Angeles River Watershed	San Gabriel River Watershed
Groundwater Pumped	100	500	22,600	16,000	18,800	268,100	280,600
Imported Water	22,700	15,300	127,200	74,700	78,300	375,300	172,200
Local Surface Water	-	-	-	-	-	2,600	12,100
Desalinated Ocean Water	-	-	100	100	1,400	-	-
Recycled Water	3,600	1,600	3,100	3,300	12,300	25,800	28,600
Graywater	-	-	-	-	-	-	-
Decentralized Stormwater Capture for Direct Use	-	-	-	-	-	-	-
Total Supply	**26,400**	**17,400**	**153,000**	**94,100**	**110,800**	**671,800**	**493,500**
Demand	**26,800**	**17,300**	**149,000**	**93,000**	**109,800**	**636,600**	**426,300**

Note: Values are in AFY and rounded to the nearest 100.

Figure 28. 2010 Available Water Supply and Water Demand



5.2.2. 2035 Available Supply and Demand

Supply and demand values for the year 2035 are summarized in Table 14 and Figure 29. The values for available supplies and demands in 2035 were obtained from the GLAC IRWMP and reflect reported numbers in the various UWMPs for the Study Area.

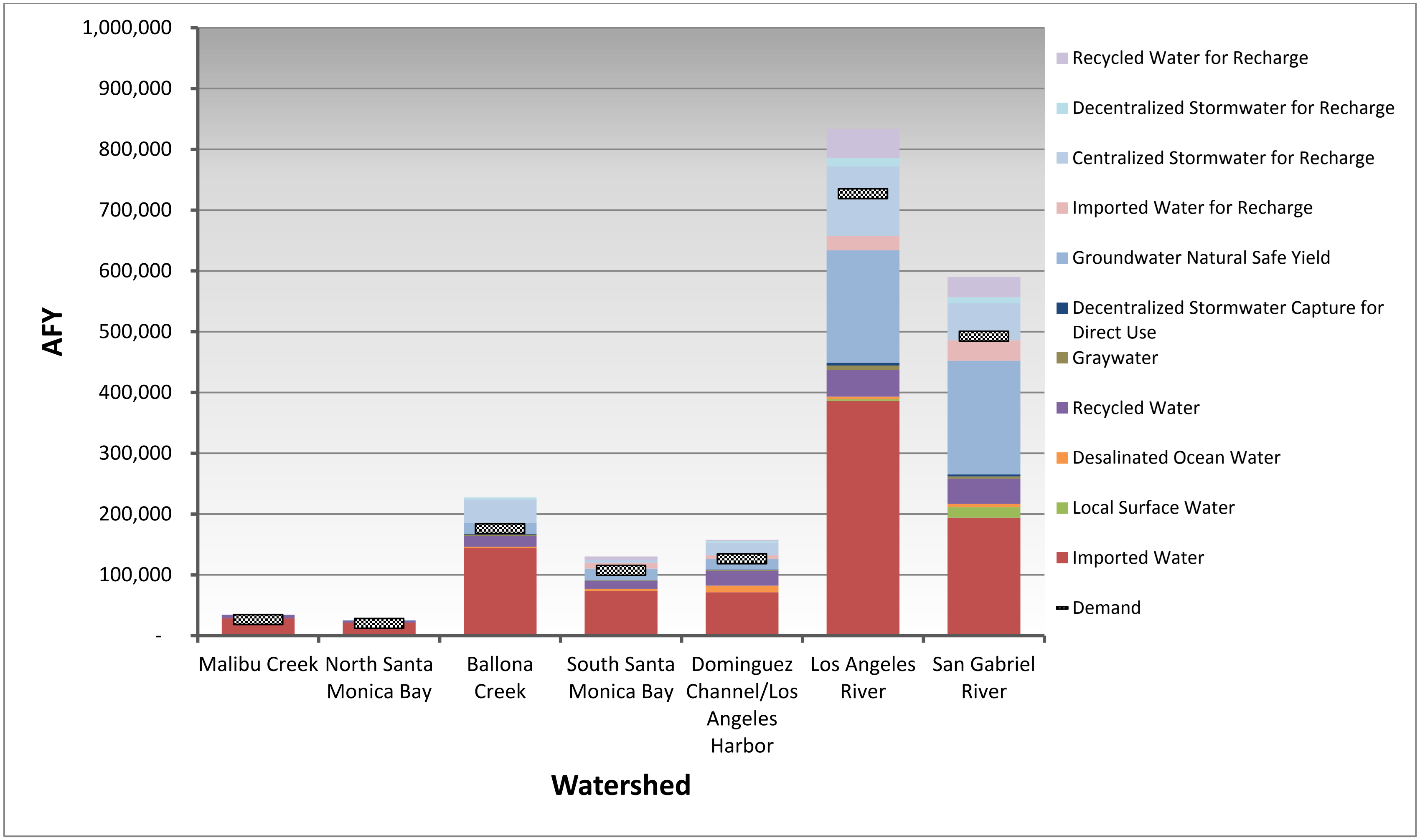
For 2035 projections (and 2095), the “pumped groundwater” category was replaced with “groundwater natural safe yield” and various replenishment/ recharge volumes that are assumed to contribute to groundwater supplies. In addition, stormwater capture was redefined as three separate categories, based on the draft SCMP. Two of these stormwater categories constitute recharge supplies and one is a direct use supply. These LADWP draft SCMP stormwater volumes are more optimistic than the values that were reported in the GLAC IRWMP, partially contributing to available supply values exceeding demands for 2035. In general, available supplies exceed projected demands in all of the watersheds in the Study Area.

Table 14. Available Supply and Demand in 2035

Water Supply	Malibu Creek Watershed	North Santa Monica Bay Watershed	Ballona Creek Watershed	South Santa Monica Bay Watershed	Dominguez Channel/Los Angeles Harbor Watershed	Los Angeles River Watershed	San Gabriel River Watershed
Direct Use Supplies							
Imported Water	28,400	21,400	144,000	73,300	71,400	386,100	194,100
Local Surface Water	-	-	-	-	-	2,700	17,200
Desalinated Ocean Water	-	-	2,400	3,900	10,800	4,400	5,600
Recycled Water	5,900	3,400	17,300	12,900	24,400	44,100	41,200
Graywater	100	-	2,400	600	1,300	7,100	3,800
Decentralized Stormwater Capture for Direct Use	100	-	1,000	500	900	4,500	3,200
Replenishment Supplies(1)							
Groundwater Natural Safe Yield	100	500	18,900	19,300	17,500	185,000	187,100
Imported Water for Recharge	-	-	-	9,500	5,800	23,700	33,600
Centralized Stormwater for Recharge	-	-	38,300	4,600	21,000	114,400	60,700
Decentralized Stormwater for Recharge	-	-	3,000	-	2,700	14,200	10,100
Recycled Water for Recharge	-	-	-	5,900	1,800	47,700	33,300
Total Supply	**34,600**	**25,300**	**227,300**	**130,500**	**157,600**	**833,900**	**589,900**
Total Demand	**26,500**	**20,100**	**176,100**	**107,300**	**126,600**	**727,100**	**492,500**

Notes: Values are in AFY and rounded to the nearest 100.
(1) "Replenishment Supplies" are assumed to represent the same set of supplies that "Groundwater Pumped" represents for 2010 (Table 13).

Figure 29. 2035 Available Water Supply and Water Demand



5.2.3. 2095 Available Supply and Demand

Supply and demand values for the year 2095 are summarized in Table 15 and Figure 30 on the following pages. Demand values shown represent three scenarios, "high", "medium", and "low". For the "high" 2095 water demand estimate, per capita use was assumed to remain at 2035 levels with demand increasing only through population growth. For the "medium" 2095 water demand estimate, it was assumed that the average gpcd in the Los Angeles Basin would reflect the 100 gpcd 20x2020 target of the City of Long Beach for the entire Study Area (Long Beach Water Department UWMP 2010). For the "low" 2095 water demand estimate, a gpcd target was set for the entire Study Area that based on an adjusted water use rate in Perth, Australia and an additional 50 percent reduction in outdoor water use assumed. Climate change impacts were applied to the three 2095 water use scenarios which decreased the gpcd estimates by approximately one percent.

The table and figure indicate an overall trend in replacing imported supplies for recharge with local supplies largely made possible through substantial groundwater replenishment/recharge programs, limited only by the availability and feasibility of facilities to recharge, store, and deliver those supplies.

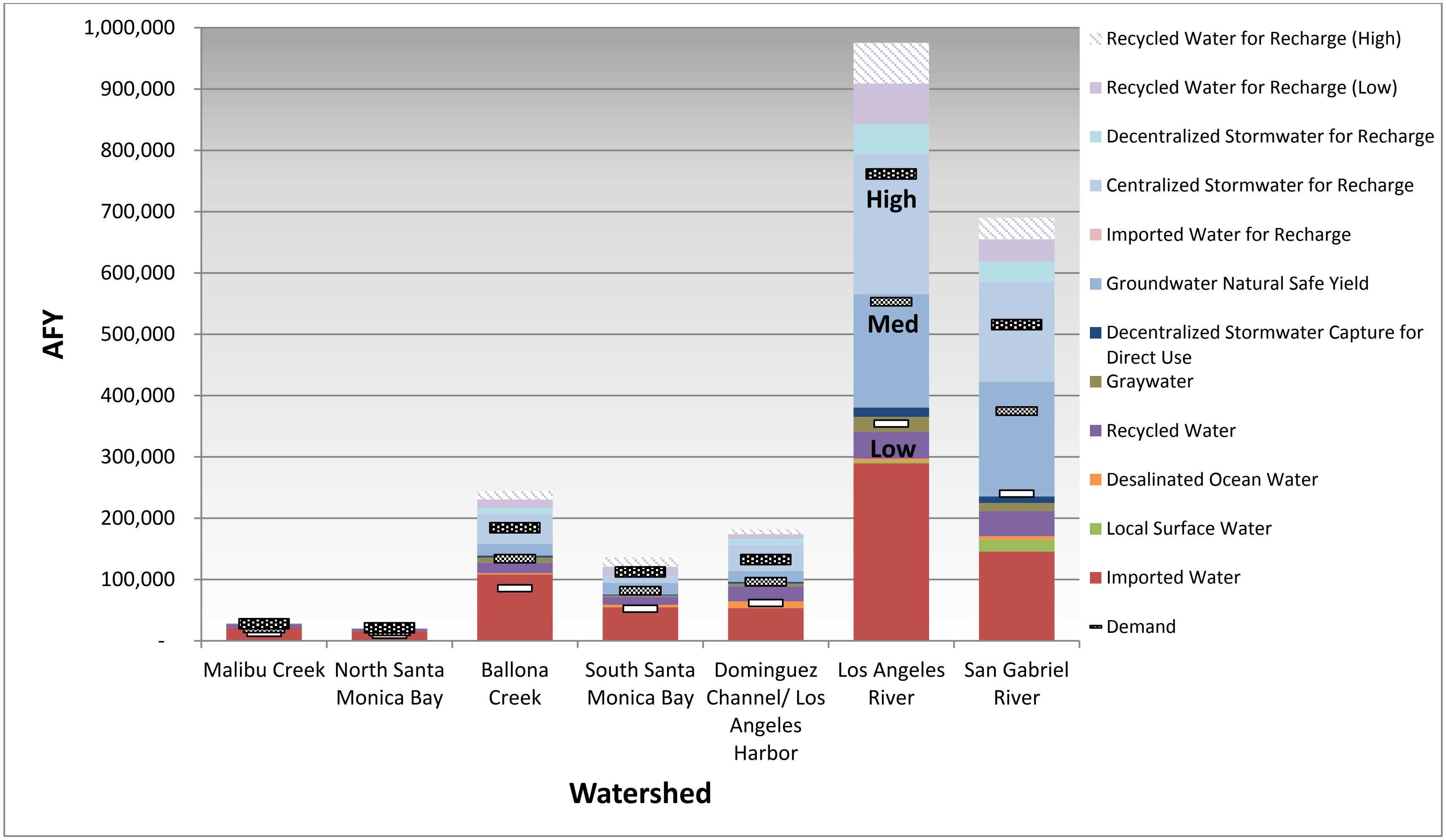
In 2095, available supplies exceed projected demands for all watersheds in the Study Area except for North Santa Monica Bay. This is the case under all three demand scenarios and for both recycled water scenarios. In the North Santa Monica Bay watershed, the "high" demand scenario exceeds available supply.

Table 15. Available Supply and Demand in 2095

Water Supply	Malibu Creek Watershed	North Santa Monica Bay Watershed	Ballona Creek Watershed	South Santa Monica Bay Watershed	Dominguez Channel/Los Angeles Harbor Watershed	Los Angeles River Watershed	San Gabriel River Watershed
Direct Use Supplies							
Imported Water	21,300	16,100	108,000	54,900	53,600	289,600	145,600
Local Surface Water	-	-	-	-	-	3,000	19,500
Desalinated Ocean Water	-	-	2,400	3,900	10,800	4,400	5,600
Recycled Water	5,900	3,400	17,300	12,900	24,400	44,100	41,200
Graywater	400	100	8,100	2,100	4,500	24,300	12,900
Decentralized Stormwater Capture for Direct Use	400	200	3,200	1,700	2,900	15,200	10,800
Replenishment Supplies(1)							
Groundwater Natural Safe Yield	100	500	18,900	19,300	17,500	185,000	187,100
Imported Water for Recharge	-	-	-	-	-	-	-
Centralized Stormwater for Recharge	-	-	48,700	10,700	43,500	228,800	162,500
Decentralized Stormwater for Recharge	-	-	10,200	-	9,200	48,200	34,200
Recycled Water for Recharge (Low)	-	-	13,700	15,300	8,000	66,500	35,400
Recycled Water for Recharge (High)(2)	-	-	13,700	15,300	8,000	66,500	35,400
Total Supply	**28,100**	**20,300**	**244,200**	**136,100**	**182,400**	**975,600**	**690,200**
Demand (Low)	**12,900**	**9,800**	**85,800**	**52,300**	**61,700**	**354,400**	**240,100**
Demand (Medium)	**20,200**	**15,300**	**133,900**	**81,700**	**96,300**	**553,100**	**374,700**
Demand (High)	**27,800**	**21,100**	**184,400**	**112,400**	**132,600**	**761,600**	**515,900**

Notes: Values are in AFY and rounded to the nearest 100.
(1) “Replenishment Supplies” are assumed to represent the same set of supplies that “Groundwater Pumped” represents for 2010 (Table 13).
(2) “Recycled Water for Recharge (High)” represents the extra increment of AFY to get from 50% to 100% available recycled water supply for recharge.

Figure 30. 2095 Available Water Supply and Water Demand ("High", "Medium", and "Low" Demand Scenarios)



5.3. Analysis of Available Supply and Demand for the Los Angeles Basin

Supply and demand values for the entire LA Basin Study time period are summarized in Table 16 and Figure 31. For the Los Angeles Basin as a whole, available supplies exceed projected demands in 2010, 2035, and 2095. This is true for all three demand scenarios and both recycled water scenarios.

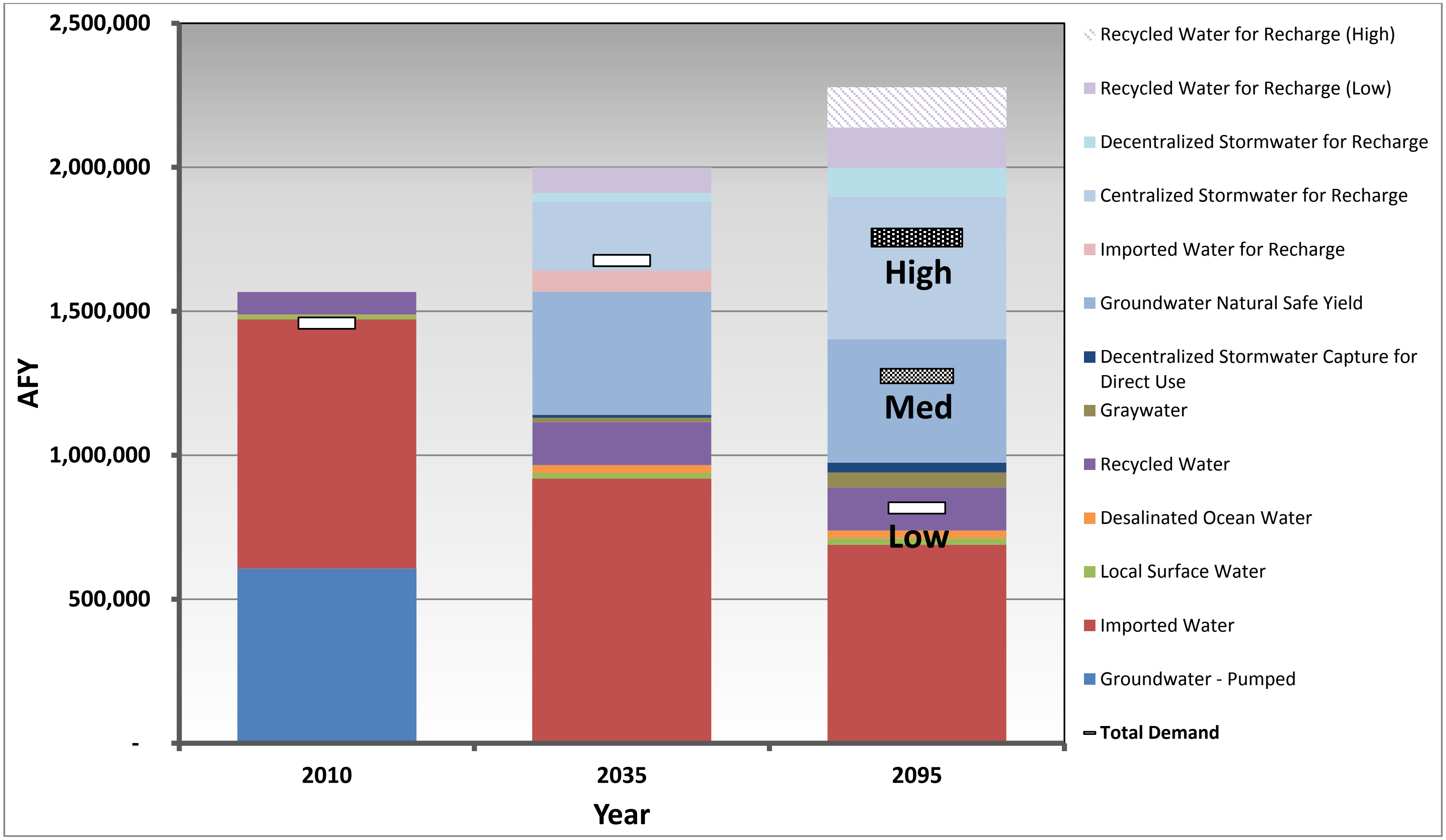
It should be noted that this report reveals that the potential “gaps” in 2095 do not exist between supplies and demands. Instead, they exist between available supplies and used supplies. Stormwater implementation projects could be a likely “first choice” water supply to accommodate these gaps, but implementation of stormwater capture facilities (as opposed to other types of supply facilities) would depend on the various factors discussed above in Section 5.1. In addition, conservation measures will continue to play a critical and expanded role in Los Angeles Basin efforts to meet growing demands through future population growth with available supplies.

Table 16. Available Supply and Demand for 2010 Through 2095 for the LA Basin Study Area

Water Supply	2010	2035	2095
Groundwater – Pumped(1)	606,700	N/A	N/A
Groundwater Natural Safe Yield	N/A	428,300	428,300
Imported Water for Recharge	N/A	72,600	-
Centralized Stormwater for Recharge	N/A	239,000	494,200
Decentralized Stormwater for Recharge	N/A	29,900	101,800
Recycled Water for Recharge (Low)	N/A	88,700	138,900
Recycled Water for Recharge (High)(2)	N/A	-	138,900
Subtotal (High):	**606,700**	**858,500**	**1,302,100**
Imported Water	865,600	918,800	689,100
Local Surface Water	14,700	19,900	22,500
Desalinated Ocean Water	1,500	27,000	27,000
Recycled Water	78,200	149,200	149,200
Graywater	-	15,400	52,400
Decentralized Stormwater Capture for Direct Use	-	10,100	34,400
Total Supply	**1,566,700**	**1,998,900**	**2,276,700**
Total Demand (Low)	**1,458,800**	**1,676,200**	**817,000**
Total Demand (Medium)	**1,458,800**	**1,676,200**	**1,275,200**
Total Demand (High)	**1,458,800**	**1,676,200**	**1,755,800**

Notes: Values are in AFY and are rounded to the nearest 100.
(1) "Groundwater Natural Safe Yield" is included in the "Groundwater – Pumped" value for 2010.
(2) "Recycled Water for Recharge (High)" represents the extra increment of AFY to get from 50% to 100% available recycled water supply for recharge.

Figure 31. Available Supply and Demand for 2010 Through 2095 for the LA Basin Study Area



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RECLAMATION

Managing Water in the West

Los Angeles Basin Stormwater Conservation Study

Task 2 Water Supply & Water Demand Projections Appendices

U.S. Department of the Interior
Bureau of Reclamation

County of Los Angeles
Department of Public Works

Los Angeles County
Flood Control District

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Appendix A: Percent Area and Total Demand of Water Districts used for Demand Distribution

Table A-1 below shows the area percentage and total demand reported for each water district used to calculate 2010 demand in the LA Basin Study Task 2 – Water Supply and Demand Projections report. Some water districts' area percentages do not add up to 100 percent as they either overlap other water districts already counted as part of demand, or because their service areas extend outside of the LA Basin Study Area.

Table A-1. Percent Area of Water Districts within the Basin Study Watershed

	Percent Area of Water District within Watershed							
Water District	Malibu Creek	North Santa Monica Bay	Ballona Creek	South Santa Monica Bay	Dominguez Channel/Los Angeles Harbor	Los Angeles River	San Gabriel River	Total Demand
Las Virgenes	53%	34%				13%		**25,958**
LA County Waterworks No. 29 (City of Malibu)		65%						**5,355**
California Water Services Co. Westlake	100%							**8,052**
Lake Sherwood	100%							**1,503**
Triunfo Sanitation District (Oak Park area)	100%							**3,343**
City of Santa Monica				100%				**13,855**
LADWP		1%	22%	9%	5%	63%		**555,477**
West Basin MWD			11%	18%	39%			**154,987**
City of Beverly Hills			100%					**11,562**
City of Torrance					100%			**25,203**
City of Glendale						100%		**27,691**
Foothill MWD						100%		**10,090**
City of Burbank						100%		**25,651**
City of San Fernando						100%		**3,395**
Central Basin MWD						41%	59%	**244,393**

Water District	Percent Area of Water District within Watershed							Total Demand
	Malibu Creek	North Santa Monica Bay	Ballona Creek	South Santa Monica Bay	Dominguez Channel/Los Angeles Harbor	Los Angeles River	San Gabriel River	
City of Long Beach						44%	56%	**54,128**
City of Compton						100%		**8,929**
South Pasadena						100%		**4,738**
City of Alhambra						100%		**10,423**
California American Water Co.						34%	11%	**15,514**
San Gabriel County WD						100%		**6,378**
San Gabriel Valley Water Company						15%	28%	**37,476**
City of Arcadia						100%		**15,798**
City of Sierra Madre						100%		**2,750**
City of Monrovia						92%	8%	**7,411**
Valley County Water District						6%	94%	**8,313**
California Water Service Company - Dominguez						10%		**42,566**
Azusa Light and Water							100%	**21,546**
Three Valleys MWD							100%	**103,421**
Suburban Water Systems (San Jose Hills)							100%	**28,300**
City of Fullerton							100%	**27,860**
Orange County Water District							11%	**485,311**

Appendix B: Climate Change Impacts on Demands

Water demands are a function of many different factors, two of which are temperature and precipitation. Given the projected changes in these two variables in southern California as a result of climate change (USGCRP, 2009), water demands are likely to be affected. A cursory analysis was performed to estimate climate change impacts on demands in the LA Basin Study Area. This Appendix describes the methods and results from that analysis.

Climate change analysis requires an understanding of the information used, particularly the temperature and precipitation values forecasted by Global Circulation Models (GCMs), and the uncertainty associated with that information. More than twenty GCMs are available, providing rigorous forecasts, yet values vary between models for a given time period and region. Additionally, the downscaling method used for the performance of location-specific analysis such as this one, can also impact the magnitude of the results. There are several uncertainties associated with the state of the atmosphere in the future, both in terms of the concentration of greenhouse gas (GHG) concentrations and the hydroclimatic response of the planet to the different atmospheric concentrations of GHGs. Given these kinds of uncertainty, this climate change analysis was designed to provide a quantitative and plausible value for future demand with references to the information sources and assumed scenarios. The results of this analysis can be useful as a first step in the assessment of demand vulnerability to climate change and as a reproducible quantification of impacts. The method described below and the results of this analysis point to specific models and scenarios used to clarify the context of the forecast.

Methods

The overall approach included two main steps: 1) developing a simple model of demand as a function of temperature and precipitation, specifically for the LA Basin Study Area, and 2) introducing the new values of temperature and precipitation under climate change to obtain the demand impacts. For this approach, historical data were used to develop a simple statistical model, and GCM output from several GCMs was used as the input to the model under climate change. This analysis was developed on an annual scale, but daily data sets were used in support of the annual analysis, consistent with Task 3 – Downscaled Climate Change & Hydrologic Modeling of the LA Basin Study.

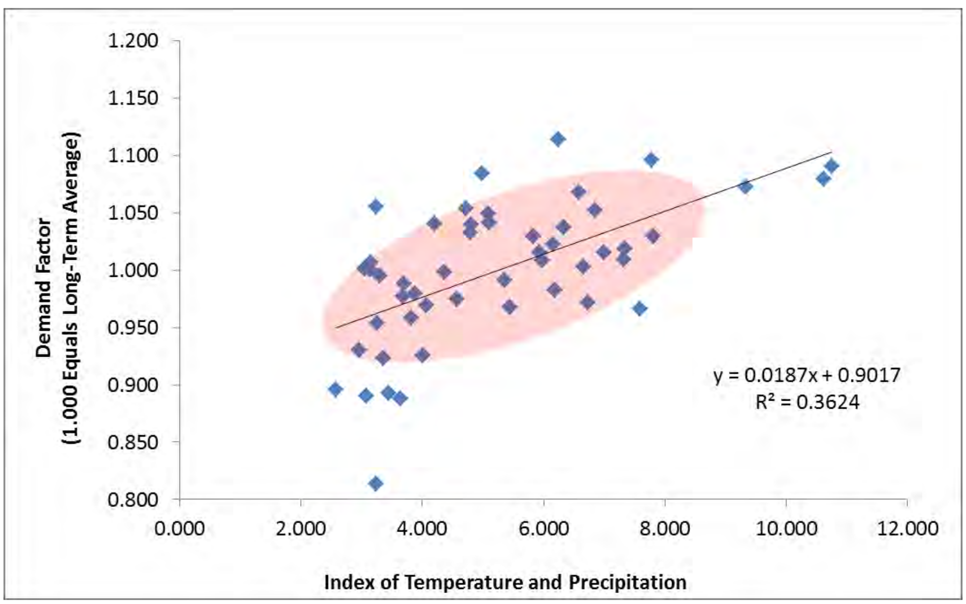
Historical precipitation and temperature data for the Los Angeles area (Los Angeles civic center) were obtained from National Weather Service records and the archive of climate and hydrology projections for the United States[21] (observed data only) for the period between 1950 and 1999.

[21] Web Archived maintained by USBOR, NCAR, UGSG, LLNL, Santa Clara University, Climate Analytics Group, Climate Central, USACE, and Scripps Institution of Oceanography. Accessible: http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html

Annual demand factors for MWD's urban water demands were obtained for the same period of record. These factors reflect the variability of demand due mostly to hydrology and temperature. The time series of demand factors was obtained from a WEAP model database for a publically available Total Water Management model developed by USEPA Office of Research and Development. These demand factors increase or decrease the annual average demand to account for temperature and precipitation.

Simple regressions were developed for average temperatures in relation to demand factors, resulting in poor agreement that was considered to be too low to constitute a valid statistical model for this report. Additional correlations were then developed with a transformation of temperature as the temperature of selected months during the year in relation to demand factors with improved correlation coefficients, but the agreement was still considered too low for this report. Another transformation was added to include precipitation with an index for temperature (in selected months) and precipitation[22] in relation to demand factors. While the correlation coefficient is still relatively low, for the purposes of this report this version of the model was selected for climate change determinations. Additional studies could improve the statistical model by rigorous validation and depuration of data as well as more sophisticated transformations and regressions. Figure B-1 shows the regression analysis.

Figure B-1: Statistical Model for Demand Factor Based on Temperature and Precipitation



Climate change impacts were applied to the model using new temperature and precipitation values obtained from multiple GCMs. The selected GCMs and scenarios were the same as used in Task 4 of the LA Basin Study where high, medium and low scenarios were identified in relation to hydrology. The rationale and analysis driving the use of the specific high, medium

[22] Transformation to a temperature and precipitation index. Index = (Temperature in April + Temperature in June + Temperature in July)/Annual Precipitation

and low scenarios can be found in the technical memorandum for Task 4 – Existing Infrastructure Response & Operations Guidelines. The six GCM/Emission Scenario data sets used are listed in Table B-1.

Table B-1: Six Data Sets Used for the Climate Change Analysis

Bounding Target	Projection
High 1	CMIP5-BCCA-RCP8.5 cnrm-cm5.1.rcp85
High 2	CMIP5-BCCA-RCP8.5 mri-cgcm3.1.rcp85
Middle 1	CMIP5-BCCA-RCP8.5 csiro-mk3-6-0.1.rcp85
Middle 2	CMIP5-BCCA-RCP2.6 ccsm4.1.rcp26
Low 1	CMIP5-BCCA-RCP2.6 bcc-csm1-1.1.rcp26
Low 2	CMIP5-BCCA-RCP2.6 miroc5.1.rcp26

Note: See Technical Memorandum No. 86-68210-2013-05, Los Angeles Basin Stormwater Conservation Study Task 3.1 Development of Climate-Adjusted Hydrologic Model Inputs for further description of climate scenarios.

Downscaled data for the LA County area (Los Angeles Civic Center for consistency with the statistical model) were obtained for temperature and precipitation for the six scenarios listed in Table B-1, and an ensemble average was computed. The 2095 ensemble average of results of this model output processing are 42 degrees centigrade as the maximum annual temperature and 21 inches of precipitation per year.

Historical maximum temperature corresponds to 31 degrees centigrade and about 15 inches per year of precipitation based on the dataset used in this analysis. The climate change ensemble averages thus correspond to an approximate 35 percent increase in maximum temperature by the end of the century, with an increase in precipitation of 40 percent.

This study did not assess the sensitivity of results to the uncertainties discussed in the introduction to this Appendix, or the sensitivity of the results to the level of accuracy of the statistical model. Additional studies should include the analysis of sensitivity to these factors.

<u>Results</u>

Applying the temperature and precipitation projections from the processed climate change downscaled data results in a one percent decrease in average demand for the Study Area. The one percent decrease in demand is driven by the increase in precipitation. A multi-year running average of annual demand around the year 2095 would be one percent lower, with demand variability still occurring on a month-to-month and year-to-year basis.