SUSTAINABLE WATER MASTER PLAN UPDATE

DECEMBER 2018

City of
Santa Monica

City of Santa Monica

Introduction

The City of Santa Monica (City) has historically served residential and business customers by implementing bold efforts to secure community resiliency and self-sufficiency. Traditionally, the City's water portfolio has been a combination of local groundwater and imported Northern California (State Water Project) and Colorado River water purchased from the Metropolitan Water District of Southern California (MWD). In recent years, the City also has implemented an innovative water conservation program to stretch local supplies and reduce the use of imported water.

Given the growing statewide challenges associated with maintaining a safe and reliable water supply, the City Council in 2011 directed staff to develop a water self-sufficiency plan with the goal of meeting 100 percent of Santa Monica's water demand using local water sources. Since that time, several actions have occurred: the City stepped up its aggressive conservation plan in 2015 in response to statewide drought conditions, the State of California adopted stringent new drinking water regulations relating to groundwater contamination in December 2017, and staff prepared and the Council adopted a Sustainable Water Master Plan (SWMP) in November 2018.

The primary objective of this SWMP Update is to bridge the gap between the August 2018 SWMP (prepared by a consultant, Black & Veatch) and subsequent feasibility analysis conducted by staff to issue the final SMWP recommendations to Council in November 2018. The subsequent feasibility analysis conducted by Water Resources Division staff refined Chapter 5 – Future Water Supply Options of the August 2018 SWMP prepared by Black & Veatch in order to update recommended projects to achieve water self-sufficiency. Therefore, the recommended pathway to achieve water self-sufficiency, as presented in the November 2018 Staff Report, and summarized in this report supersedes the recommendations of the August 2018 SWMP. In November 2018, Water Resources staff presented Council with an Updated SWMP, which outlines measures to achieve Water Self-Sufficiency by 2023. This SWMP Update highlights the updated SWMP (November 2018) that refined the pathway to achieve water self-sufficiency by 2023, references the previous SWMP efforts, and provides links to the reports and investigations discussed herein.

BENEFITS TO SELF SUFFICIENCY

Becoming water self-sufficient offers the City three major benefits:

1. Long- term cost protection for water ratepayers.
2. A diverse, sustainable, and drought-resilient local water supply.
3. A reduced water supply energy footprint.

Water self- sufficiency equates to approximately 99 percent locally-sourced water. One percent of the City's water supply will still be purchased from MWD to maintain the imported water connections for emergency purposes.

Background

The City is a recognized leader in California for its progressive environmental and water conservation policies. The City implements an aggressive water conservation program and operates a water system comprised of groundwater basins, treatment facilities, and imported water connections. In January 2011, City Council directed staff to develop a water self-sufficiency plan with the goal of meeting all of the City's water demand using local water sources by 2020. In October 2014, Council adopted the SWMP, which outlines a comprehensive plan to achieve water self-sufficiency. The SWMP is an innovative plan with a combination of water demand reduction strategies and increased development of local water supplies. Water reduction is achieved through implementation of various water conservation and efficiency programs designed to permanently reduce residential and commercial water use. Development of new sustainable local water supplies comes from (i) alternative water sources such as captured rainwater and municipal wastewater for non-potable uses, (ii) increased efficiency of the City's water treatment systems, and (iii) additional pumping from existing wells and new wells in the local groundwater basin.

Between 2014 and 2018, several elements of the SWMP moved forward, including completion of a preliminary Sustainable Yield Analysis (SYA) of the Santa Monica Groundwater Basin and finalization of plans for the Sustainable Water Infrastructure Project (SWIP) to recharge local groundwater supplies with purified water. Staff initiated a comprehensive update of the SWMP in 2017 to incorporate new information regarding local groundwater resources, new regulatory requirements, and new water conservation programs and alternate water supply opportunities.

Table 1 presents a summary of the City's water supply portfolio and recommended actions necessary to attain water self-sufficiency. The first column of the table lists the percentage of the City's demand met by each source received in 2017. In addition to the facilities described in the table, a substantial portion of the City's water demand is met through water conservation, which accounted for approximately 18 percent of the City's water supply portfolio in 2017.

Table 1. Overview of City of Santa Monica's Water Supply Portfolio

SYSTEM/ PERCENTAGE	FACILITIES	SELF-SUFFICIENCY REQUIREMENTS
Local Groundwater Basins 52 percent	**Charnock, Arcadia, and Olympic Sub-basins** Major sources of local groundwater with nine active wells and a tenth well undergoing permitting. The local groundwater treatment facilities currently consists of: • **Charnock Treatment Unit -** Provides biological granular activated carbon (GAC) treatment for contaminated wells, followed by additional treatment at Arcadia. • **Arcadia Water Treatment Plant (WTP) -** Provides reverse osmosis (RO) treatment to soften the City's groundwater supply. **Other Sub-basins** The Coastal sub-basin will be maintained as a water supply reliability reserve. Initial exploration and investigation efforts to quantify water quality and yield for the Coastal sub-basin is being conducted. **Issues** From 1997 – 2010, the City's largest groundwater wellfield, Charnock wellfield, was shut down due to third party contamination. An agreement with the responsible parties provided settlement funds, which to date have funded an upgrade to the Arcadia Water Treatment Plant (WTP) and new treatment facility at Charnock. Production from the Olympic Sub-basin is currently limited due to contamination by a third party. The Olympic Wellfield will be restored with a new treatment facility as proposed in the SWMP.	To achieve water self-sufficiency, the City will be looking to: 1) restore the Olympic sub-basin with a new advanced water treatment facility to meet the new regulatory requirements and maximize groundwater production, 2) produce more water from the existing WTP, and 3) reduce the amount of RO brine concentrate currently discharged to the sanitary sewer through production efficiency upgrades at the Arcadia WTP.
Imported Water 29 percent	**MWD Connections** The City receives imported water at two connections with MWD, turnouts capable of delivering up to 100 percent of the local water needs. **Issues** The cost of imported water is predicted to increase at a rate of four to seven percent every year.	Once water self-sufficiency is achieved, the City will maintain these imported water connections, for water security, in case of a natural disaster or other emergency.
Conservation 18 percent	**Local Conservation Efforts** In response to state wide drought conditions in 2015, the City implemented various water conservation measures that resulted in a permanent water demand reduction of approximately 18 percent or approximately 2,500 acre-feet per year (AFY). The average annual water consumption was reduced from 140 gallons per capita per day (gpcd) to 110 gpcd. **Issues** A diversified, drought resilient water supply portfolio is necessary for the City to achieve water self-sufficiency as conservation alone will not be sufficient.	Existing conservation efforts will be enhanced through the Optimal Conservation Plan to reduce water demand by an additional 600 AFY of water demand reduction by 2023 and 1,000 AFY by 2030.

SYSTEM/ PERCENTAGE	FACILITIES	SELF-SUFFICIENCY REQUIREMENTS
Recycled Water 1 percent	**Recycled Water (Alternative Water supply)** The City currently captures and treats dry weather urban runoff at the Santa Monica Urban Runoff Recycling Facility (SMURRF) to produce recycled water that is used for irrigation and toilet flushing to offset potable water demand.	Upgrade and expand alternative water supplies to increase recycled water use and recharge local groundwater aquifers to offset imported water purchase.

In January 2018, staff reported to Council that further analysis was needed to assess whether the City could meet its water self-sufficiency goal by 2020. A Draft SWMP was prepared for the City by Black & Veatch Corporation and issued in August 2018 (See Attachment A). Key report findings from the August 2018 SWMP are described in Table 2. Subsequent to completion of the August 2018 SWMP, Water Resources Division staff incorporated additional information (treatment feasibility study findings for the Olympic Wellfield and production efficiency enhancements for the Arcadia Water Treatment Plant) to refine the pathway to achieve water self-sufficiency and final recommendations were released through a staff report to the Council in November 2018 (See Attachment B).

Table 2. Key Findings of August 2018 Sustainable Water Master Plan Update (Attachment A)

TOPIC	DESCRIPTION	SELF-SUFFICIENCY IMPLICATIONS
Historical and Current Water Use	***Chapter 2 of August 2018 SWMP*** **Review of Historic Water Use and Water Demand** Analysis of historic water use (monthly water production and billing records for 2012-2017). **Review of Historic and Current Water Demand by Customer Type** Assessment of residential, commercial/institutional, landscape/ irrigation, recycled water, and fire service usage. **Review of Factors Affecting Water Use** Analysis of population, economic activity, weather and climate change, climate change vulnerability, saltwater intrusion/water quality, and flooding/storm surges. **Review of Impact of Historical Water Conservation** Analysis of drought and policy mandates, creation of Water Conservation Unit (CSU), and 2014-2017 water conservation programs and policies.	Identified trends and captured changes in water use and customers within the City and assessed measures to support self-sufficiency such as new enhancements to existing programs and ordinances for new development and water waste.

TOPIC	DESCRIPTION	SELF-SUFFICIENCY IMPLICATIONS
Current Water Sources and Supplies	***Chapter 3 of August 2018 SWMP*** **Hydraulic Analysis of System** Review of City's hydraulic model for the water distribution system capacity. **Review of Imported Water Characteristics and Challenges** Review of imported water deliveries from MWD including water connections (turnouts) and assessment of Tier 1 rate allocations and drought impacts. **Review of Santa Monica Groundwater Basin** Analysis of current sub-basin activities, groundwater production (1988 – 2017), characteristics, and challenges including contamination and treatment. **Review of Non-Potable Water and Historical SMURRF Production** Review of SMURRF operations, recycled water operations, and impact of conservation efforts on dry weather runoff.	Determined improvements needed to wells, treatment facilities, and distribution pipelines to meet future supply and water use requirements.
Future Water Use	***Chapter 4 of August 2018 SWMP*** **Potable Water Use Analysis** Review of water use trends, including conservation and comparison of future water demand based on water conservation program projections. **Population Growth Projections** Projection of 2030 population projection reflecting information from the City's Plan and Downtown Community Plan. **Potable Water Demand Projection** Calculated future potable water demands from the potable water use analysis and population projections.	Develop a clear understanding of the City's future water needs to eliminate reliance on imported water.

Other work completed in parallel with the August 2018 Update included analysis to validate preliminary SYA estimates of the local groundwater basin, drilling of exploratory water wells in the Coastal sub-basin to evaluate potential new local water production, completion of technical studies to evaluate the cost and viability of increasing the production efficiency of the Arcadia WTP, evaluation of the impact of new State drinking water regulations (e.g., maximum contaminant level [MCL] for 1,2,3 trichloropropane [TCP]) on groundwater extraction from the Olympic Sub-basin or Wellfield, and evaluation of the cost and viability of additional water conservation programs as requested by the Santa Monica Task Force on the Environment.

Based on all of this information, a revised water self-sufficiency achievement goal of 2023 was established (See Figure 1).

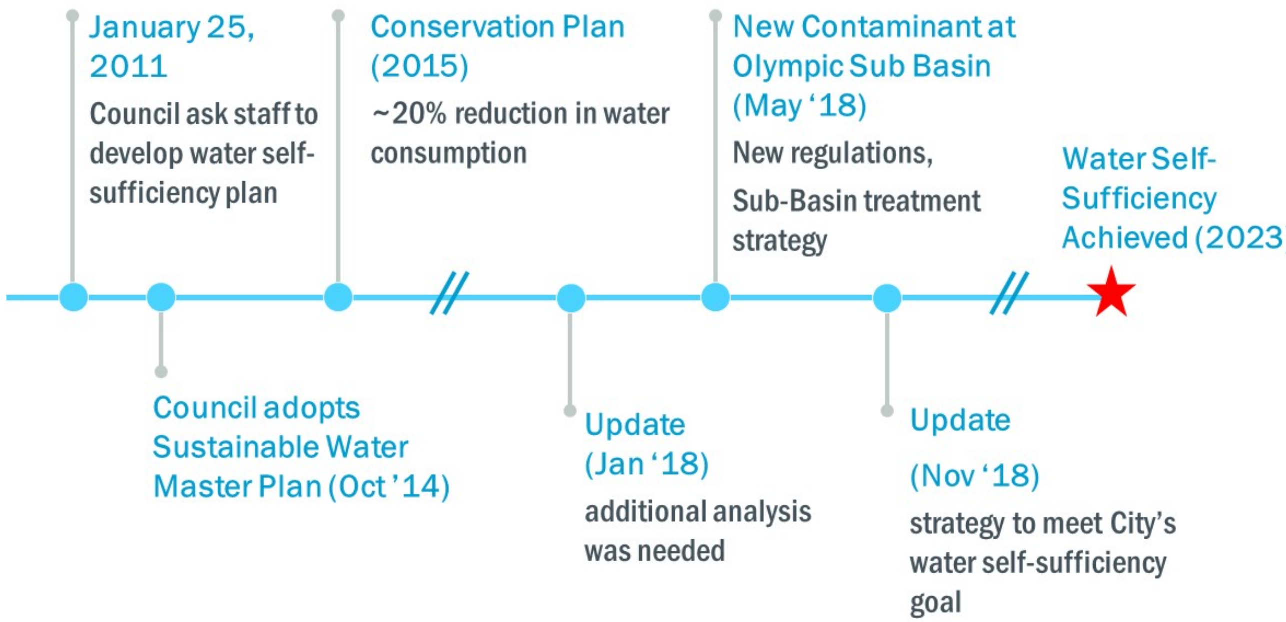

Figure 1. Self-Sufficiency Timeline

With imported water purchase costs from MWD expected to increase annually from 3 to 7 percent over the next ten years, the primary focus of the updated SWMP is to develop water self-sufficiency scenarios that are both sustainable and economical compared to the continued purchase of imported water from MWD.

Adopted Pathway to Self-Sufficiency

The City's water supply portfolio has progressively transformed since 2011, with the community making significant strides toward water self-sufficiency and reduced reliance on the purchase of imported water to supplement local water resources. After completion of the Charnock Wellfield Restoration Project in 2010, the City was able to meet approximately 51 percent (~6,700 acre-feet per year [AFY]) of its water supply demand through local groundwater resources and reduce the purchase of water from MWD to approximately 48 percent (~6,400 AFY).

To achieve water self-sufficiency by 2023, the SWMP proposes replacing imported water purchases through three components:

- Component 1 - Increasing water conservation efforts to permanently reduce water demand.
- Component 2 - Developing sustainable and drought resilient alternative water supplies.
- Component 3 - Expanding local groundwater production within sustainable yield limits.

As shown in Figure 2, these three components, when combined with current water conservation efforts and use of local groundwater supplies, will eliminate the City's reliance on imported water purchases from MWD and provide the City with a diversified, drought resilient water supply portfolio that offers greater cost control over water rates.

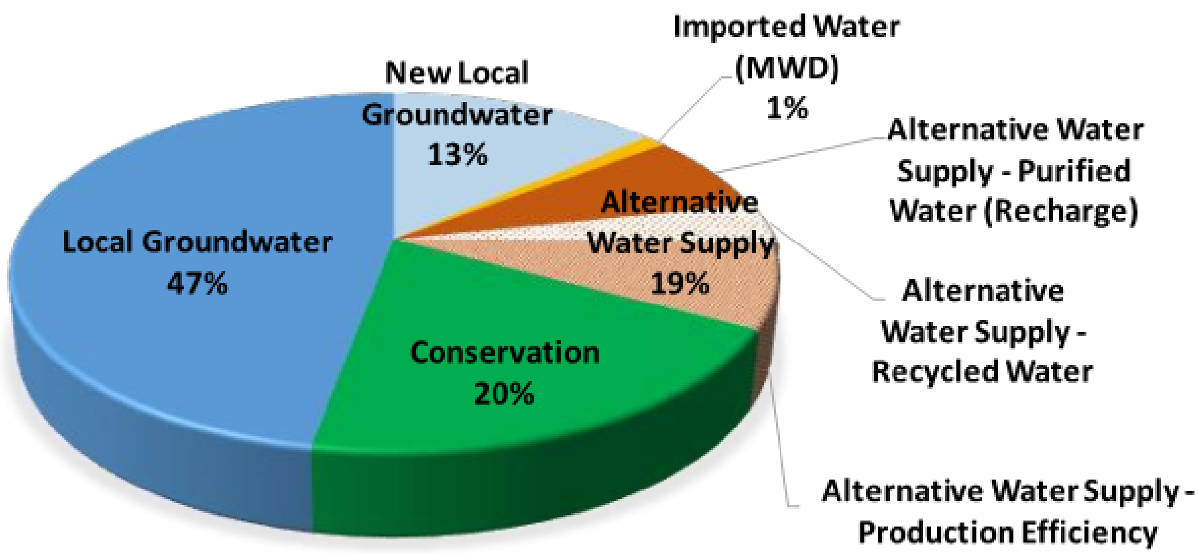

Figure 2. Sustainable Water Portfolio

Figure 3 illustrates how the three components of the SWMP would work together to provide local Water Self-Sufficiency by 2023.

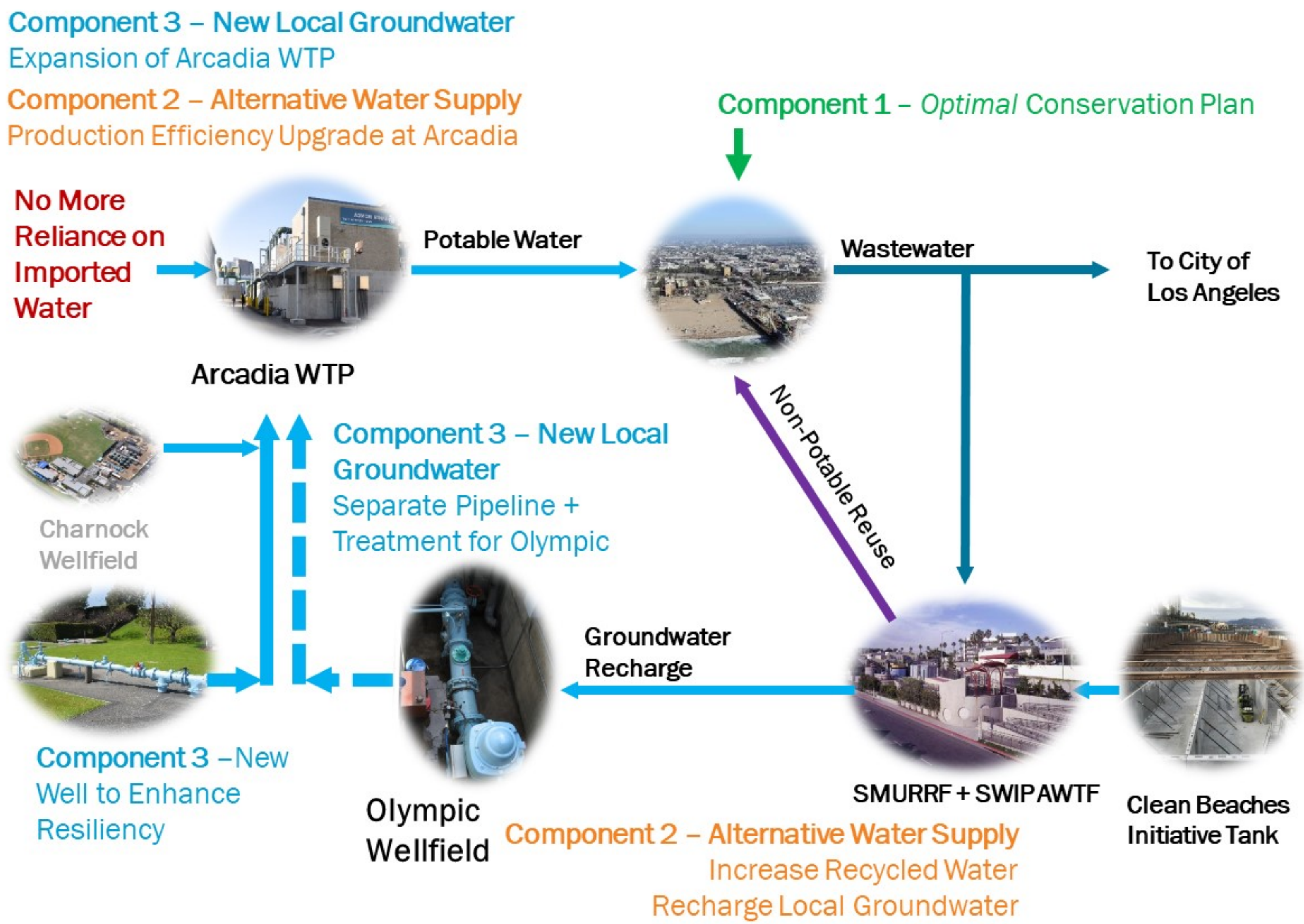

Figure 3. Synergy to Provide Water Self Sufficiency

COMPONENT 1 – INCREASING WATER CONSERVATION (38 PERCENT REDUCTION IN IMPORTED WATER PURCHASES)

The City initiated its Water Efficiency Strategic Plan in 2002 and in 2004 began implementing various conservation programs including No Water Waste and Green Building Ordinances. Continuation of existing, and implementation of proposed, conservation measures are essential for the City to eliminate reliance on imported water. Conservation will play a critical role in the City's march toward water self-sufficiency by continuing to reduce overall use even in the face of demand from new housing and from the commercial and institutional sectors of the local economy.

In 2014, Council authorized the significant expansion of staffing and funding to augment the City's water conservation efforts to address the state-wide drought and help the City meet its self-sufficiency goal. This contributed to a water demand reduction of approximately 20 percent from 2015 – 2017, which equates to savings of approximately 2,500 AFY. Implementation of the existing conservation programs with the addition of supplemental conservation efforts is expected to continue this trend of water demand reduction through 2040.

2015– 2017 CONSERVATION EFFORTS

2015

- Water Use Allowances
- Water Use Allowance Exceedance Citations
- Water School
- Water Use Consultations
- Enhanced Landscape Rebate Program
- Landscape Consultations
- Sustainable Landscape Trainings
- Enhanced Water Waste Patrols
- Enhanced MWD Water Conservation Rebate Incentive Program
- Free Water Saving Items
- Marketing and Outreach
- Customer Support

2016

Water Efficient Landscape and Irrigation Standards (updated Green Building Ordinance)

2017

Water Neutrality Ordinance

In developing the water conservation plan to reach and maintain water self-sufficiency, the City evaluated the potential for further water efficiency and conservation in all customer sectors. This included an assessment of the current level of water fixtures, as well as identifying where the greatest opportunities for reducing water consumption existed. Based on this analysis, a program plan was developed to reach the City's long-term objectives via existing and new conservation programs. City staff modeled three conservation plans: Optimal, Enhanced, and 90 gpcd. Staff met with industry experts to review and receive input on the modeling effort and the proposed conservation programs. A panel of outside experts supported both the Optimal and Enhanced conservation plans and the proposed programs that comprise them.

Based on the modeling, the City selected the Optimal conservation plan, which continues the successful ongoing programs and increases water conservation in untapped areas such as funding of retrofits in Santa Monica-Malibu Unified School District facilities and landscapes, commercial sector fixture retrofits and enhanced rebates, coin-operated laundry machine retrofits, increase in Water Neutrality offsets and direct installation of water efficient fixtures, rebates for new technologies, enhanced water conservation education and enforcement, additional sustainable landscape conversions, additional outreach to assist customers, new marketing and outreach programs, and incorporating limited-term employees as part of the water conservation team. Projected water savings from the new conservation programs are shown below in Table 3.

Table 3. Summary of Optimal Conservation Programs and Projected Water Savings for 2018 – 2023

CUSTOMER CLASS	CONSERVATION MEASURES	TOTAL ACTIVITIES 2018 – 2023	PROJECTED SAVINGS (AF) 2018 - 2023
Single Family	Rebates, water use consultations, graywater system incentive, direct installs.	5,440	345
Multi-Family	Direct installs, rebates, water use consultations	5,975	308
Institutional	School Education Program, direct installs, weather-based irrigation controller incentive, landscape initiative	2,658	52
Commercial and Institutional	Rebates, direct installs, water use consultations, performance pays	5,376	831
Various	Soil moisture sensor rebates for multi-family, commercial, and institutional customers	75	7
All	Water-saving faucet aerators, water-saving showerheads, communication and outreach, pilot projects	13,458	491
TOTAL	**Average Water Savings (Acre-Feet/Year): 610** **Cost of Savings per Unit Volume ($/Acre-Foot): $708**	**32,982**	**2,034**

The Optimal Conservation Plan is expected to reduce the City's total water demand by approximately 20 percent even after factoring in demand increases associated with expected population growth through 2025. ***The recommended Optimal conservation plan will contribute approximately 3,100 AFY to the City's water supply portfolio in 2023 and reduce imported water purchases by roughly 38 percent.*** Water conservation or water demand reductions are estimated based on current conservation savings of 2,500 AFY plus projected increase in water demand savings by an additional 600 AFY by 2023, total of approximately 3,100 AFY in water demand reduction by 2023. Water demand reduction from the Optimal Conservation Plan will continue to increase until the various conservation measures mature in 2040.

COMPONENT 2 – MAXIMIZING ALTERNATIVE WATER SUPPLIES (35 PERCENT REDUCTION IN IMPORTED WATER PURCHASES)

To further diversify the City's water supply portfolio and increase overall resilience, **three alternative water supply projects are proposed that will collectively offset imported water purchases from MWD by 35 percent (approximately 2,900 AFY)**. These projects include:

- **Increase Recycled Water Production.** Upgrade the existing Santa Monica Urban Runoff Recycling Facility (SMURRF) as part of the SWIP project to increase recycled water production for non-potable uses in the City and offset imported water purchases from MWD. Approximately 560 AFY of recycled water will be produced to offset potable water demand or imported water purchase from MWD.
- **Recharge Local Groundwater Aquifers.** Increase recycled water production through the Sustainable Water Infrastructure Project (SWIP). The SWIP project will provide a sustainable and drought resilient water supply by providing purified water (approximately 1,100 AFY) through a new Advanced Water Purification Facility (AWPF) to recharge local groundwater aquifers. In return, the aquifer recharge that will be provided by the SWIP will allow the City to maximize groundwater pumping, within sustainable yield limits, from the Olympic Sub-basin.
- **Production Efficiency Enhancement at Arcadia WTP.** Increase overall treated water production through implementation of new treatment technology to increase treatment efficiency to greater than 90 percent, adding an additional 1,200 AFY of treated water. This will also result in a reduction of RO concentrate discharge to the sewer system. The Arcadia WTP is currently capable of treating up to approximately 11,300 AFY or 10 million gallons per day (mgd) and produce 9,900 AFY (8.9 mgd) of treated water (approximately 82 percent recovery or efficiency). The proposed expansion and addition of new technologies to increase production efficiency at the Arcadia WTP will increase its treatment capacity to approximately 14,700 AFY (13 mgd) and production to 13,400 AFY (12 mgd) of treated water (>90 percent recovery or efficiency).

Existing SMURRF that will be Upgraded as Part of SWIP to Increase Recycled Water Production

SWIP will upgrade the existing SMURRF and construct a new AWPF to produce purified water that will be used to offset imported water purchase and recharge local groundwater aquifers. The upgraded SMURRF will treat stormwater, brackish groundwater, and dry weather urban runoff to increase in recycled water production and offset imported water purchased from MWD by approximately 560 AFY.

Recharge Local Groundwater Aquifers with Purified Water Will Maintain Sustainable Yield

Aquifer Recharge will occur through the addition of purified water from the new AWPF constructed as part of SWIP. The new AWPF with a proposed treatment train consisting of membrane bioreactor (MBR), reverse osmosis (RO), and advanced oxidation with ultraviolet (UV) disinfection and peroxide will provide purified water that meets or exceed drinking water quality requirements. The purified water will be used to recharge groundwater aquifers in the Olympic Sub-basin and offset imported water purchases by approximately 1,100 AFY.

Incorporating the Latest Treatment Technologies Will Increase Production Efficiency to Greater than 90 Percent at the Arcadia WTP

Production Efficiency Upgrade and Expansion of the Arcadia WTP through the addition of Closed Circuit Reverse Osmosis (CCRO) to treat the RO concentrate stream, which is currently discharged to the sewer system. This will increase the overall treatment efficiency of the plant from the current 82 percent to 90 percent or greater. The addition of the CCRO would offset imported water by approximately 1,200 AFY.

COMPONENT 3 – EXPANDING LOCAL GROUNDWATER PRODUCTION (25 PERCENT REDUCTION IN IMPORTED WATER PURCHASES)

To offset the remaining imported water, ***local groundwater production would need to be increased*** and resiliency measures would need to be implemented to maintain reliable production year round. ***This would reduce imported water purchases from MWD by approximately 25 percent (approximately 2,100 AFY).***

Staff developed and analyzed several scenarios to expand the City's groundwater production and carefully vetted each scenario internally and with outside industry experts. The recommended scenario was Expansion of Arcadia WTP with CCRO combined with a Separate Olympic Wellfield Pipeline and a new advanced water treatment facility for the Olympic Wellfield to be collocated at the Arcadia WTP site. This scenario was determined to be the most cost-effective solution to achieve self-sufficiency and maximize local water resources by restoring the Olympic Wellfield. The recommended scenario includes the following elements:

- Expansion of the Arcadia WTP to increase treatment capacity and accommodate future 2040 water demands. Plant capacity would be expanded through upgraded pumps, blowers, cartridge filters, etc. to accommodate increased groundwater production and new technologies, such as the CCRO described in Component 2.
- Additional groundwater well(s) to enhance resiliency. Measures would include increasing groundwater pumping from existing wells, completing the equipping and permitting of one recently installed well, and constructing a replacement well to increase local production from the Olympic Wellfield, within sustainable yield levels. An additional well in the Charnock Sub-basin would also enhance resiliency and maintain production during routine maintenance or unforeseen downtimes of groundwater wells, while aggressively pumping within the sustainable yield.
- Restoration of the Olympic Wellfield through (1) a new pipeline separating Olympic Wellfield water and conveying it independently to the Arcadia WTP and (2) a separate contamination treatment facility at the Arcadia WTP for the Olympic Wellfield. This approach results in a smaller treatment facility to remove contaminants from the Olympic Wellfield and reduce overall treatment cost.

The Olympic Wellfield plays a key role in achieving the City's water self-sufficiency goal as it could provide up to 3,200 AFY of groundwater and is also the location where purified water from the SWIP will be recharged to sustain this pumping rate. However, the Olympic Wellfield contains several contaminants that would require additional treatment to meet drinking water standards.

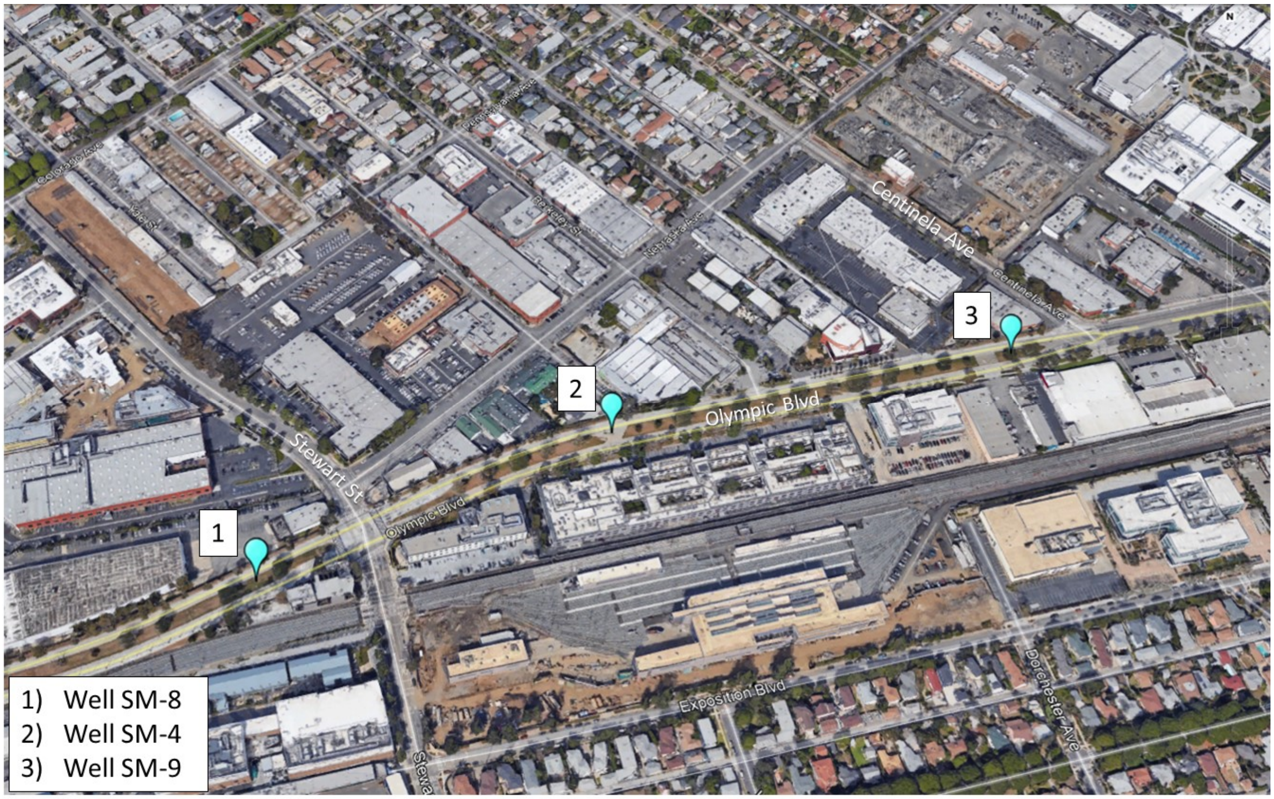

Figure 4. Olympic Wellfield – Well Locations

Further analysis of treatment options for the Olympic Wellfield was required due to a newly established drinking water regulation in December 2017 that established a maximum contaminant level (MCL) for 1,2,3 TCP at 5 parts per trillion (ppt) and monitoring detecting 1,4 Dioxane levels above California Notification Level requirements. An analysis performed by an outside consultant developed recommendations for improvements to maximize groundwater production and comply with the new regulations on the key contaminants of concern. The consultant's report recommended construction of a new contamination treatment facility for only the Olympic Wellfield flows with a proposed treatment train consisting of advanced oxidation with UV and peroxide plus granular activated carbon. The new treatment facility will provide high-quality drinking water that meets current and future regulatory standards.

Investing in Water Self-Sufficiency

The proposed SWMP components represent a considerable investment towards the City's future resiliency and achieving water self-sufficiency by 2023. In consideration of the capital investment and impacts to water rates, staff evaluated potential alternatives to reduce capital expenditures to potentially provide relief to potential water rate increases. Staff also considered delaying the self-sufficiency goal to beyond 2023 and differing capital expenditures to ease rate increases over the next five years. However, postponing implementation may result in increasing overall project cost, due to inflation, and negate any potential up front capital savings.

A cost summary for the proposed SWMP components to achieve self-sufficiency by 2023 is presented in Table 4. Staff also will aggressively pursue funding programs to help offset the capital expenditures. Outside funding opportunities include: MWD's Local Water Resources Program, California Department of Water Resources Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1) Grants, United States Bureau of Reclamation programs, and County of Los Angeles Measure W funding.

Table 4. Projected Investment Costs to Achieve Water Self-Sufficiency

PROJECTS	ESTIMATED CAPITAL COST
Arcadia WTP: Expand Capacity and Production Efficiency	$30 Million
Additional Well and Improvements: Increase Resiliency and Groundwater Production	$8 Million
Olympic Wellfield Restoration: New Advanced Water Treatment Facility and Pipeline[1]	$20.5 Million

[1]Funding for the Olympic Wellfield Restoration is from settlement funds received from the responsible party for the contamination. The settlement funds will also be used for annual operation/treatment costs, but is not included in this table.

Development of cost-effective local, sustainable, and drought-resilient water supplies will provide Santa Monica water ratepayers with cost benefits over the long term and give the City greater cost certainty on water rates compared to the continued purchase of imported water. A comparison of the annual average water production cost once water self-sufficiency is achieved versus imported water costs is provided in Table 5. As tabulated in Table 5, the City and its ratepayers will begin to see a return on its investment to achieve water self-sufficiency in just three years after 2023 when the average local water production cost is estimated to be lower than imported water cost. This analysis assumes imported water cost from MWD will increase at an annual rate of 5 percent.

Table 5. Comparison of Average City Water Production Cost Versus Imported Water Cost Once Water Self-Sufficiency is achieved in 2023

YEAR	AVERAGE CITY WATER PRODUCTION COST (($/AF)	IMPORTED WATER COST ($/AF)	DIFFERENCE
2023	$1,336	$1,248	$88
2024	$1,357	$1,310	$47
2025	$1,378	$1,376	$2
2026	$1,400	$1,445	($45)

Schedule to Achieve Self-Sufficiency by 2023

Implementing the SWMP and reaching water self-sufficiency by 2023 entails numerous interrelated capital projects, as shown in Figure 5. Several well projects have already been approved and are on track to be completed by 2021. A portion of the projects are in the City of Los Angeles and require installation of new pipelines. The design, construction, and permitting of improvements at the Arcadia WTP, including efficiency upgrades, are expected to be completed in 2023. The schedule includes a contingency of approximately six months to account for unforeseen conditions or new regulations.

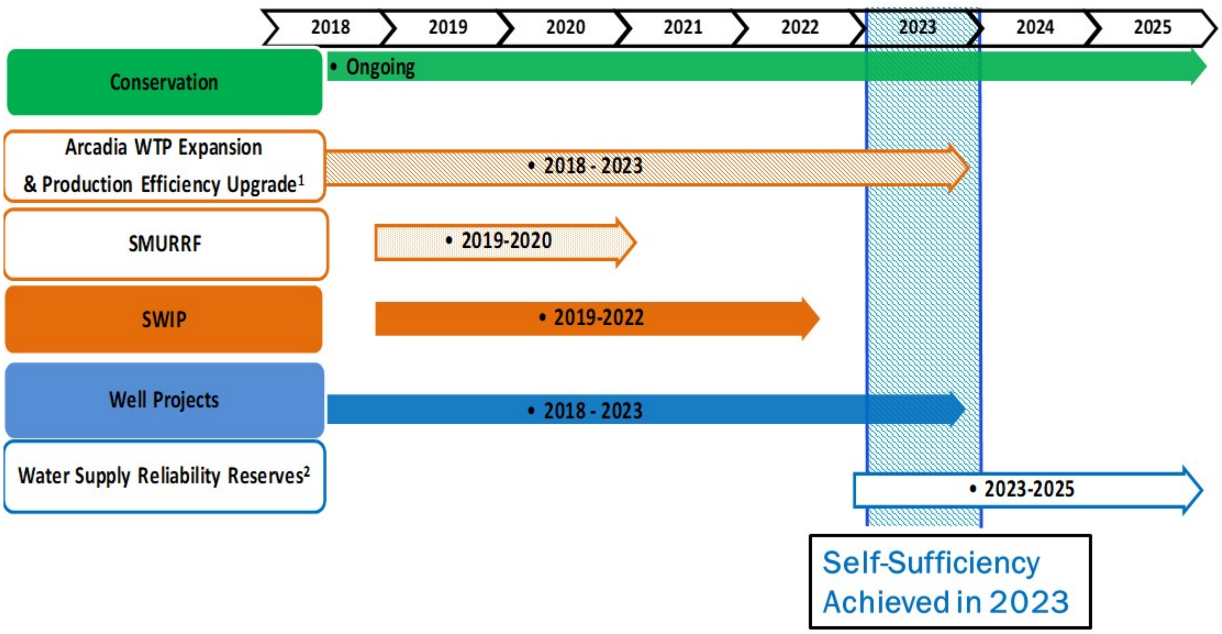

Figure 5. Proposed Implementation Schedule to Achieve Self-Sufficiency by 2023

ATTACHMENT A

Draft Sustainable Water Master Plan
(Black & Veatch, August 2018)

SUSTAINABLE WATER MASTER PLAN UPDATE

B&V PROJECT NO. 196444

PREPARED FOR

City of Santa Monica

21 AUGUST 2018

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BLACK & VEATCH
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Acronyms and Abbreviations

AF	acre-feet
AFY	acre feet per year
AWTP	advanced water treatment plant
BMP	best management practice
CBI	Clean Beaches Initiative
City	City of Santa Monica
CoSMoS	Coastal Storm Modeling System
DCP	Downtown Community Plan
EWMP	Enhanced Watershed Management Plan
GAC	granular activated carbon
gpcd	gallons per day per capita
gpm	gallon per minute
gpf	gallon per flush
ISTEA	Intermodal Surface Transpiration Efficiency Act
MGD	million gallons per day
MG	million gallons
LUCE	Land Use and Circulation Element
MOU	Memorandum of Understanding Regarding Urban Water Conservation in California
MSL	mean sea level
MTBE	methyl tertiary butyl ether
MWD	Metropolitan Water District
NCEI	National Centers for Environmental Information
NRC	National Resource Council
OSE	Office of Sustainability and the Environment
SBx7-7	California State Legislature 2009 Water Conservation Act
SCADA	Supervisory Command and Data Acquisition
SCAG	Southern California Association of Governments
SF	square-feet
Slade	Richard Slade & Associates
SM 1	Santa Monica 1 (well)
SMGB	Santa Monica Groundwater Basin
SMURRF	Santa Monica Urban Runoff Recycling Facility
SWIP	Sustainable Water Infrastructure Project
SWMP	Sustainable Water Master Plan
SWRCB	State Water Resources Control Board
TINS	Triangular Irregular Network System
UWMP	Urban Water Management Plans
USGS	United States Geological Survey
VFD	variable frequency drive
VOC	volatile organic compound
WUA	Water Use Allowance
WCU	Water Conservation Unit
WSRP	Water Shortage Response Plan

1.0 Introduction

The City of Santa Monica (City) is a recognized leader in California for its environmental and water conservation policies. The City has been actively implementing water efficiency programs since 1988 and is one of the original signatories to the State's Memorandum of Understanding Regarding Urban Water Conservation in California (MOU), adopted in 1991 and amended in 2008. In 2014, the City adopted a Sustainable Water Master Plan (SWMP) with the goal of achieving water supply self-sufficiency in 2020 by eliminating reliance on imported water from the Metropolitan Water District (MWD). Since the adoption of the SWMP, the City has been actively implementing new water supply and conservation programs and policies. Due to strong community cooperation in response to drought-related State and City-mandated conservation policies and participation in conservation programs, the City has achieved a 12.5% reduction in potable water demand from 13,036 acre-feet per year (AFY) in 2014 to 11,498 AFY in 2017 while the population has remained relatively unchanged. The reduction of water use and a renewed reliance on local groundwater supply has allowed the City to lower its use of imported water from 49% in 2012 to an average of 25-30%.

This update to the Sustainable Water Master Plan details progress made over the past four years and provides a pathway to water self-sufficiency by 2023 through examination of four key strategies:

- Evaluation and incorporation of key water supply and demand factors, including an update to the Santa Monica Groundwater Basin sustainable yield (e.g. how much groundwater can be pumped on a sustainable basis); further studies and modeling efforts to understand local groundwater aquifer recharge; and future water use projections including anticipated population growth, development, climate change and other factors;
- Potable water demand reduction through enhanced conservation programs and policies;
- Expansion of alternative sources of supply via infrastructure upgrades including reuse of treated stormwater, brackish groundwater and municipal wastewater; and
- Increasing potable supplies by improving the efficiency and capacity of the City's water treatment facilities; and improving existing or constructing new water supply wells.

Sections 2 through 5 of the 2017 SWMP Technical Memorandum have been updated in order to expand on the City's adaptive management strategy for local groundwater. The next update to the SWMP is planned for 2020.

2.0 Historical and Current Water Use

Evaluation of historical water records provides an understanding of water trends and customer behavior. In this update, years 2012 to 2017 were evaluated to daylight recent water trends and capture changes in water use and customer behavior within the City.

2.1 HISTORICAL WATER USE

To understand the City's recent water trends, monthly water production and billing records for the years 2012 to 2017 were analyzed. The total volume of potable water supply delivered to its treatment system is taken from the City's monthly potable water production records. The total potable water supply is a combination of treated local groundwater, imported water from MWD, and stored water. As a result of additional local groundwater pumping and State and City drought-related conservation mandates reducing water demand, the City, under normal operating conditions, has realized a steady decrease in imported water since 2012 as shown in Figure 2-1, except for 2017, when a production well was shut down for repairs, requiring approximately 650 acre-feet in additional imports.

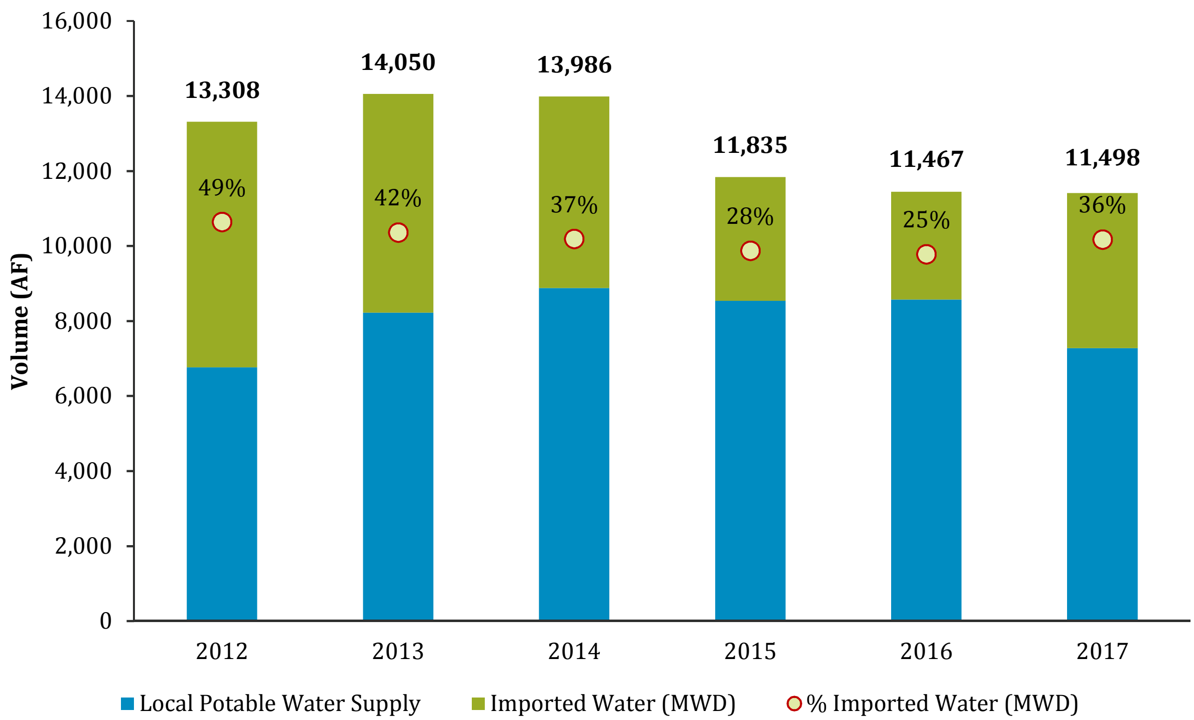

Figure 2-1 Annual Potable Water Supply

Billing records reflect billed water consumption and is generally referred to as the "water demand." Water loss is typical in all water distribution systems due to small leaks, firefighting activities, and system testing and maintenance activities. This water loss is termed as "non-revenue water". The City has actively implemented water efficiency programs for 30 years. The City's past water conservation efforts discussed in this report include a combination of innovative policy, incentive programs, community outreach and education, and regulatory enforcement programs. In addition, the City responded to the declaration of a drought state of emergency in 2014 by conserving over 2,000 AFY in 2015 and 2016.

2.2 HISTORICAL AND CURRENT WATER DEMAND BY CUSTOMER TYPE

The City provides water to approximately 18,000 metered service connections. The mix of connections by meter type is shown in Figure 2-2.

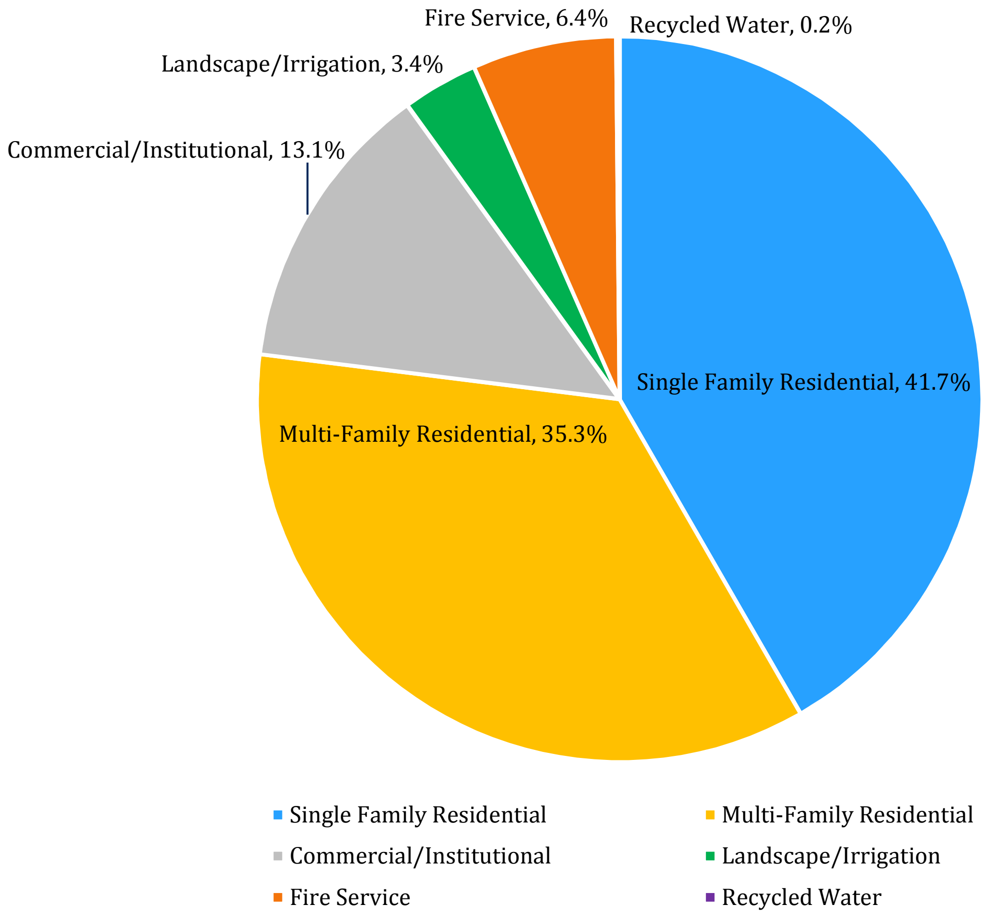

Figure 2-2 2017 Service Connections by Customer Type

In Table 2-1, the annual average for water demands from billing records are summarized by customer connection type for years 2012 to 2017. Water consumption by customer type is approximately:

- 65.8% Residential
- 29.1% Commercial/Institutional
- 3.7% Landscape/Irrigation
- 0.8% Recycled Water
- 0.06% Fire Service

Table 2-1 Historical and Current Annual Water Consumption

CUSTOMER TYPE	2012	2013	2014	2015	2016	2017
Single Family Residential	3,116	3,141	3,216	2,546	2,656	2,642
Multi-Family Residential	5,525	5,539	5,445	4,972	4,971	4,990
Commercial/Institutional	3,595	3,780	3,784	3,413	3,388	3,428
Landscape/Irrigation	494	553	590	416	448	433
Recycled Water	93	96	134	81	89	98
Fire Service	28	3	2	2	4	5
Total Potable + Recycled (AF)	**12,851**	**13,112**	**13,170**	**11,431**	**11,557**	**11,596**
Total Potable (AF)	**12,758**	**13,015**	**13,036**	**11,349**	**11,467**	**11,498**

Water demand dropped approximately 14% from 2014 to 2015, with 68% of the reduction attributed to residential savings. From 2015 to 2017, water demand slightly increased from 11,349 to 11,498 but has not returned to the 2014 demand level.

To better understand the historical water demand trends, the City's total potable water demands from 2007 to 2017 are shown in Figure 2-3.

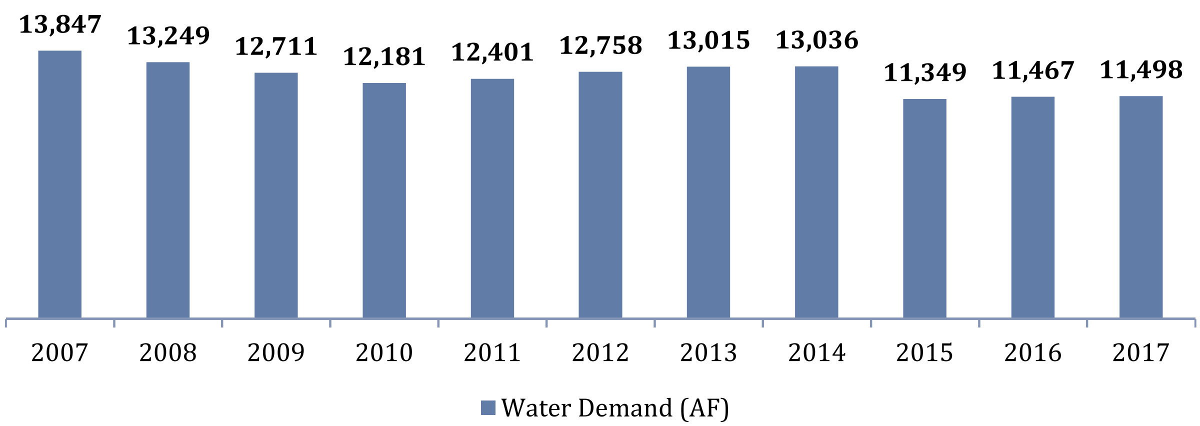

Figure 2-3 2007-2017 Historical Water Demand

The maximum annual water demand for the City was 13,847 AF in 2007. From 2007 to 2010, the City's demand decreased and then gradually increased from 2010 to 2014 but has not returned to the 2007 demand level. The largest reduction in water demand was in 2015. The reduction was a result of new water conservation programs and policies implemented since the adoption of the original SWMP in 2014. The City and the community are strongly committed to continuing its water conservation efforts.

Historical Per Capita Water Use

To calculate approximately how much water is used within the City, the aggregated annual water use (all categories of users) is divided by the corresponding residential population for a given year. This yields the historical aggregated water use per person (unit water rate), shown in Figure 2-4.

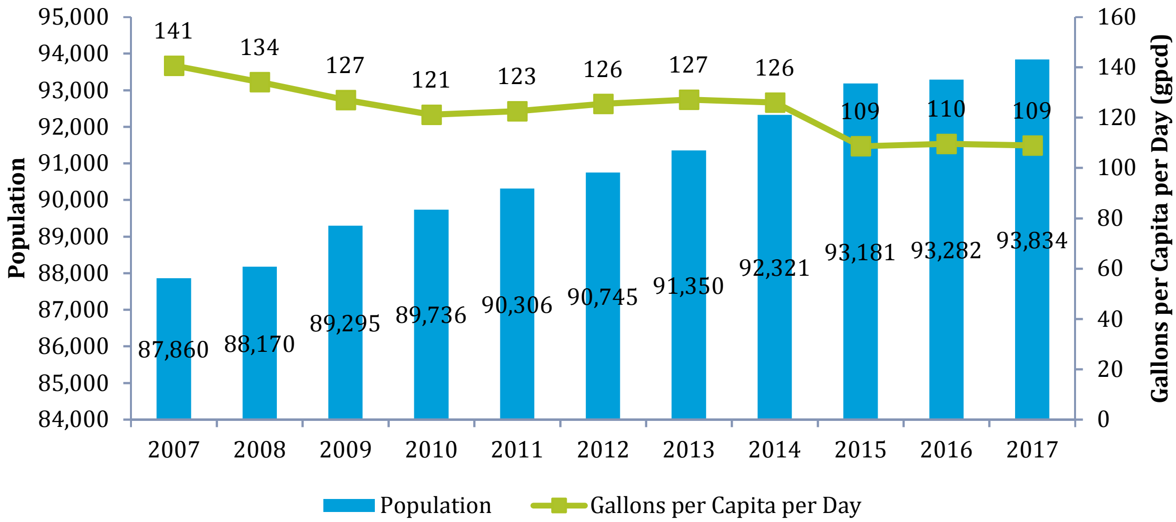

Figure 2-4 Historical Per Capita Water Use

This graph shows the decrease in aggregated per capita water use from 2007 to 2017. Overall, the City has seen an approximate 25.5% reduction in per capita water use from 141 gallons of water per capita per day (gpcd) in 2007 to 109 gpcd in 2017. Estimates of per capita use are significantly lower (~74 gpcd in 2017) when only the City's metered residential (single family and multi-family) use is considered.

The California State Legislature drafted the Water Conservation Act of 2009 (SBx7-7) to protect statewide water sources. The legislation called for a 20% reduction in water use in California by the year 2020 and amended the water code to require water agencies to establish 2020 and 2015 per capita water use targets in their 2010 Urban Water Management Plans (UWMPs). These per capita targets included both residential and non-residential accounts. To satisfy the provisions of SBx7-7, the City set water use targets for 2015 and 2020 at 139 and 123 gpcd, respectively. The City dropped below its 2020 target in 2015 and has stayed below target at ~110 gpcd for the past three years.

2.3 FACTORS AFFECTING WATER USE

Various factors can impact water demands from year to year. In the 2014 and 2017 SWMP, the following factors were considered when analyzing water demands: population growth, climate conditions, economic activity, and water conservation. Impacts from these factors are discussed in the following sections.

2.3.1 Population

Typically, population growth increases water demand. As shown in Figure 2-5, however, over the last five years the water savings, as a result of the City's water conservation program and policies, have more than offset the potential for impact by population growth. The population data was obtained from the State of California Department of Finance.

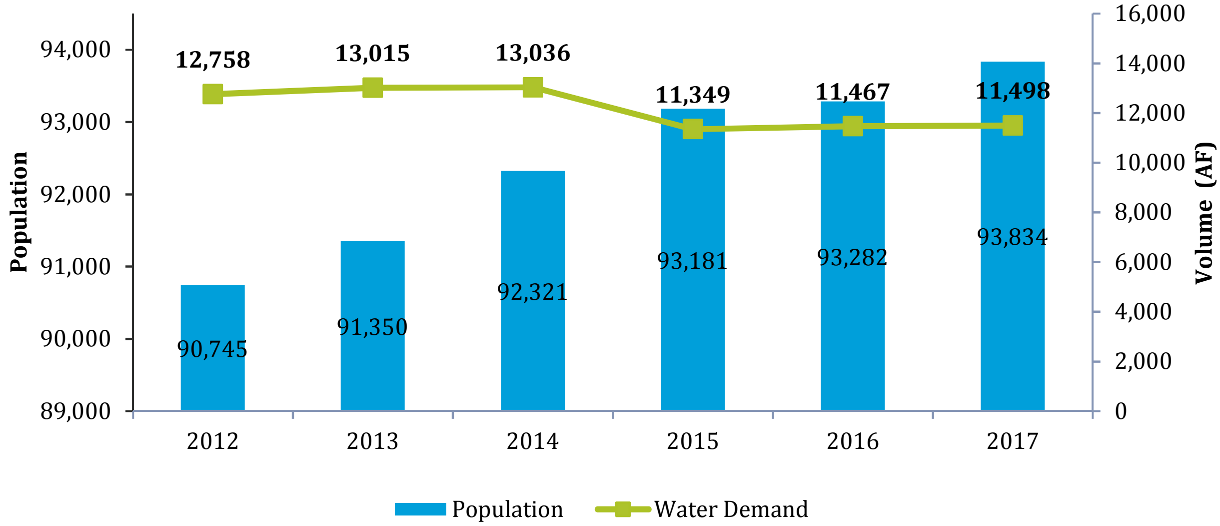

Figure 2-5 Historical Population and Water Demand

It is important to note that as the City's conservation programs become more established, there will be correspondingly fewer opportunities for further conservation-based savings. In effect, future population growth will likely result in a measurable increase in water demand. To mitigate increases in water demands resulting from new developments, the City recently enacted a Water Neutrality Ordinance, which is detailed below in Section 2.4.3.3.

2.3.2 Economic Activity

It is not unusual, during poor economic conditions and increased unemployment rates, to see a reduction in water demand. When the economy recovers and employment levels increase, there is generally a rebound in water use. Figure 2-6 shows the City's monthly unemployment rates and corresponding water demands over the last few years.

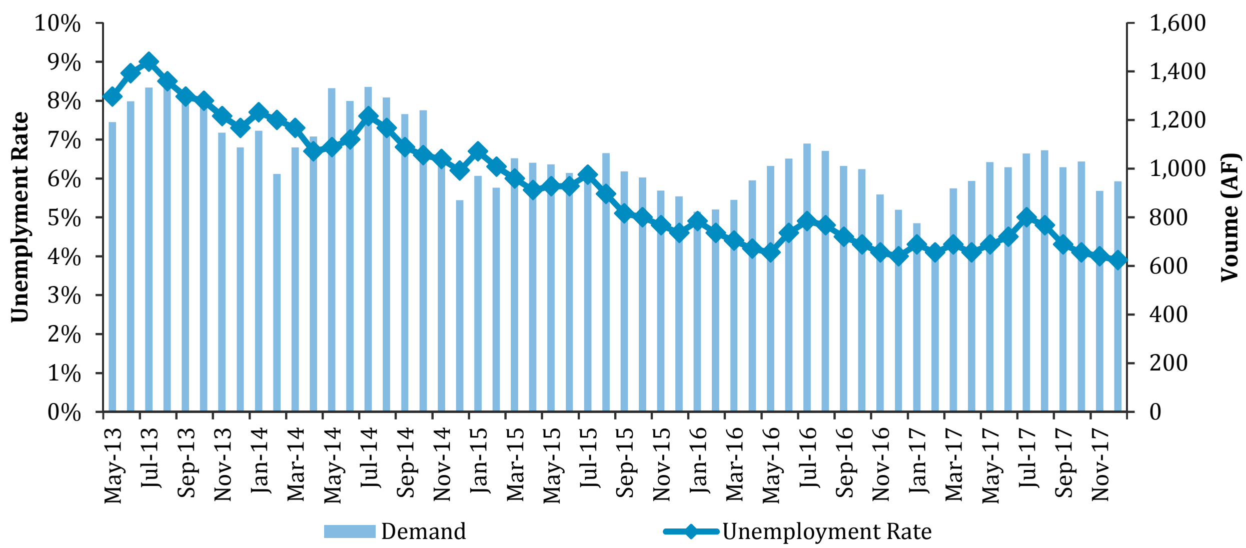

Figure 2-6 Monthly Unemployment Rates and Water Demand

This data shows that overall, the community has continued to conserve, even with the improving economy (as based on unemployment rates). This suggests that the sustained reduction in demand could be attributed to enlightened behavioral changes with regard to water conservation. The increase in use that is evident starting in 2016 corresponds with a drop in the unemployment rate. Water use also tracks with media messaging during this same time period that suggested the drought in California was subsiding in severity, particularly in northern California. Long-term, it is expected that the trends will begin to converge again as the City's water conservation programs and focused media messaging become fully established.

2.3.3 Weather and Climate Change

It is common for water demand to increase as the days get warmer and decrease as the weather cools down. During summer months, people water their lawns more, use swimming pools, and consume more water. Figure 2-7 shows the average monthly City temperature in degrees Fahrenheit and the corresponding monthly water demand.

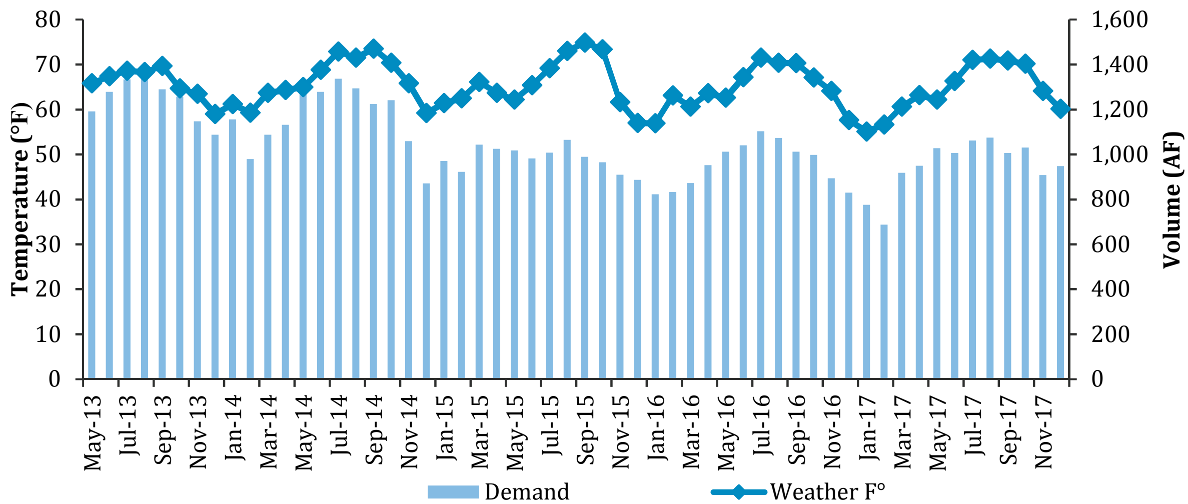

Figure 2-7 Monthly Weather and Water Demand

Historical weather information was obtained from the National Centers for Environmental Information (NCEI) and shows the correlation in demand and weather temperature. The data also shows that the City's conservation efforts in response to its sustainability objectives and the recent drought have generally acted to dampen the amplitude of seasonal fluctuations in water use via continued reductions in overall demand.

Climate change models for southern California forecast continued increases in ambient temperature, with a possible shift in precipitation events towards later in the regional wet season of October to April. Sea level and storm wave run up are also predicted to increase, with 12 – 61 cm (5-24 inches) of sea level rise expected by 2050 along the southern California coast. Knowing these factors will affect long-term water resource planning and existing coastal water infrastructure vulnerability, the City has implemented a review of climate change factors for new water utility capital projects. To further refine its evaluation of potential climate change impacts to its water supply, the City is exploring robust decision-making methods to model a focused suite of likely climate change scenarios, developed in consultation with the City's Office of Sustainability and

Environment and recognized climate change experts with local knowledge. These climate stress-test scenarios will be utilized to assess how to best ensure the reliability and resiliency of the City's water supply.

2.3.4 Climate Change Vulnerability

Climate change in the coming decades is expected to test the City's ability to sustainably manage its water resources. However, along with these challenges come the opportunities for the City to apply innovative thinking and solutions to mitigate those components of climate change that most directly affect sustainable water. Chief among these are greenhouse gas emissions/energy, drought, temperature rise, sea level rise, saltwater intrusion/water quality, and flooding/storm surges.

2.3.4.1 Greenhouse Gas Emissions/Energy

Water, and especially imported water from distant watersheds, is a carbon intensive resource. In 2010, the Santa Monica City Council adopted the objective of the City achieving water sustainability by eliminating its dependence on environmentally costly imported water for use as a potable supply. Currently, the City produces approximately 70 - 75 percent of its water supply from local groundwater. By using local groundwater, the City is offsetting the energy and emissions typically associated with water imported from Northern California and the Colorado River. To further reduce its water-related carbon footprint, the City has implemented various conservation programs all designed to reduce demand.

The City has audited its water infrastructure to ensure it is energy efficient by upgrading equipment and right-sizing pumps. In addition, the City is applying innovative approaches to infrastructure such as below grade construction of critical facilities to allow for alternative uses for surface areas such as parks, and the inclusion of solar panels to projects in order to reduce energy consumption.

2.3.4.2 Drought and Temperature Rise

As previously discussed, increased seasonal temperatures and cyclical periods of drought of varying duration are expected to have a measurable influence on the City's water supply strategy and long-term demand. As currently evident in summer months, warmer temperatures typically give rise to increased water demands. Accordingly, further city-wide reductions in water demand will greatly assist the City in maintaining its water use at levels which will support water self-sufficiency. Further assistance in meeting this challenge is the City's broadening of its water portfolio to include local groundwater and treated non-conventional water resources such as dry and wet weather runoff, municipal wastewater and brackish groundwater as discussed in Section 5. By not relying on any one source of water, the City will lower its vulnerability to drought and other natural disasters as it moves to meet its sustainability goal.

2.3.4.3 Sea Level Rise

Per the recommendations of the *2015 California Coastal Commission Sea Level Policy Guidance*, the City considered the findings of the National Resource Council (NRC) 2012 report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future,* in its planning for this SWMP update. According to the 2012 NRC report, for the California coast south of Cape Mendocino, and the separate projections for the Los Angeles region, sea level rise is expected to be on the order of 12 - 61cm (5 - 24 inches) by 2050, and 42-167 cm (1.4 ft. - 5.5 ft.) by 2100. The projection for the Los Angeles coast is 29 ± 9 cm (11 ± 4 inches) by 2050 and 93 ± 25 cm (3 ft. ± 10 inches) by 2100. Other recent studies propose alternative sea level rise with the average rise for the Pacific Coast estimated to be between 0.6 - 1.0 m (2.0 - 3.3 ft.) by 2100. If sea level rises as predicted by the currently available studies, the City would have ample time to adapt to the potential risk to any water-related infrastructure near the beach by implementing mitigation measures such as natural dune barriers, engineered hardening of some infrastructure, or by implementing adaptive retreat from areas of higher risk whereby infrastructure would be relocated landward.

2.3.4.4 Saltwater Intrusion/Water Quality

If current NRC sea level projections are proven to be accurate, saltwater intrusion may be expected to change the quality of the shallow groundwater zones immediately adjacent to the coast and those low-lying areas where wave run-up would likely be higher. A recent 2017 exploratory boring drilled at Santa Monica City Hall, located approximately 1,200 feet northeast of the Santa Monica Pier, determined that highly brackish-saline groundwater conditions do not occur at that location until approximately 540 feet below ground surface. Future changes to water quality from the groundwater zones the City currently pumps from are not expected through 2050. This is primarily because the City's principal water supply wellfields are located inland and remote from the coast. Overall, salinity intrusion due to climate change is expected to be gradual, allowing enough time to modify the City's reverse osmosis treatment facilities in response. Therefore, vulnerability to salt-water intrusion is considered to be low as various adaptive engineering measures are available.

2.3.4.5 Flooding/Storm Surges

With increases in sea level, an increased vulnerability to flooding and storm surges can be expected. Along the coast, flooding and storm surge can be exacerbated by sea level rise attributed to poor drainage conveyance systems, melting continental and sea ice, and volume expansion of the oceans due to thermal warming, winds, and tides. To assess for such vulnerability, the City consulted the *USGS Coastal Storm Modeling System 3.0 (CoSMoS 3.0)* during its SWMP development process. The CoSMoS 3.0 has generated a series of figures showing potential impact to various coastal areas, including the Santa Monica Beach and Pier, caused by varying increases in sea level rise and a coinciding 100-year storm event. As with the general effects of expected sea level rise, the City can adapt to the potential increase in storm surge or flooding attributable to the predicted gradual rise of sea level by implementing engineering mitigation measures. Based on this intrinsic ability, City topography, and the CoSMoS 3.0 modeling output, the risk of flooding or a storm surge adversely impacting water related infrastructure, including the Clean Beaches Initiative (CBI) Project and the Sustainable Water Infrastructure Project (SWIP), is considered to be low. However, the City simultaneously recognizes that large rogue storm events are possible.

2.4 IMPACT OF HISTORICAL WATER CONSERVATION

Water conservation includes all the policies, programs, and activities developed to sustainably manage and reduce water use to meet current and future water demand. Active conservation occurs through efforts such as rebate and incentive programs, system audits and repairs, outreach, education and more. Passive conservation occurs as a result of legislation and plumbing code changes when customers are required to replace or upgrade water wasting products and processes. The factors shaping Santa Monica's water conservation efforts have historically been and continue to be:

- The City's goal of water self-sufficiency
- Repeated droughts
- Mandatory water usage reductions and water conservation requirements issued by the State

- Permanent water conservation regulations in the aftermath of the recent water drought

2.4.1 The Drought and Policy Mandates

The City has been actively implementing water conservation programs since 1988. Detailed information regarding water conservation efforts from 2001 to 2014 can be found in the City's 2014 SWMP. Information regarding water conservation efforts prior to 2001 can be found in the City's 2002 Water Efficiency Strategic Plan. Since the adoption of the SWMP in 2014, the City has been enhancing its existing water conservation programs/policies and implementing new ones. Of all the factors shaping Santa Monica's water conservation programs since the initial SWMP, the most significant has been the recent five-year (2012-2017) California drought and the resultant mandatory water use reductions and water conservation requirements issued by both the State and the City. These actions include:

State Actions

- January 17, 2014: Facing severe water deficits during one of the driest years in California's recorded history, Governor Brown proclaimed a Drought Emergency, asking all Californians to voluntary reduce water usage by 20%.
- March 1, 2014: The Governor signed Senate Bill 104, state legislation which implemented numerous drought relief measures.
- July 15, 2014: The State Water Resources Control Board (SWRCB) adopted an Emergency Regulation for Statewide Urban Water Conservation, which required urban retail water agencies like Santa Monica, to implement all requirements and actions of their water shortage response plans that impose mandatory outdoor irrigation restrictions and prohibit certain water wasting activities.
- April 1, 2015: Following the lowest Sierra snowpack measurement ever recorded, Governor Brown issued Executive Order B-29-15, which, for the first time in state history, directed the SWRCB to implement mandatory water reductions. The SWRCB placed each water supplier in a conservation tier ranging from 4% to 36%, to achieve a statewide aggregate reduction in urban water use of 25% from June 2015 to February 2016.
- April 7, 2017: Following a winter of record abundant rainfall, the Governor issued Executive Order B-40-17 ending the Drought State of Emergency in most of California and rescinding state-mandated water use reductions.
- In addition, state agencies issued a plan to "Make Water Conservation a California Way of Life" as directed by Governor Brown's previous Executive Order B-37-16 (May 9, 2016). The plan requires state agencies to establish permanent, long-term water conservation measures, water use targets, and improved planning for more frequent and severe droughts. Until the plan's permanent requirements are in place, portions of the drought emergency regulations that prohibit certain wasteful water practices along with monthly water use reporting by water agencies to the SWRCB continue to be in effect.

Santa Monica Actions

- June 9, 2009: The Santa Monica City Council adopted the Water Shortage Response Plan in response to drought conditions at the time (note: since 2007, with the exception of 2011-12, California has been in a drought).

- January 29, 2014: Following the Governor's proclamation of a statewide Drought State of Emergency, Council increased the City's voluntary reduction from 10% to 20%.
- August 12, 2014: The Santa Monica City Council declared a Stage 2 Water Supply Shortage, which shifted the City's 20% reduction in water use from voluntary to mandatory.
- January 13, 2015: The Santa Monica City Council set a deadline of December 31, 2016 to achieve the mandatory 20% reduction in water use from 2013 levels.
- January 2018, the City's Stage 2 Water Supply Shortage and the mandatory 20% reduction are still in effect with a cumulative savings from June 2014 of 12.5%.

2.4.2 City Water Conservation Unit

To meet both the State and City mandated 20% reductions in water use along with adhering to the State's emergency drought regulations, the City created the Water Conservation Unit (WCU) within the Office of Sustainability and the Environment (OSE). Comprised of OSE permanent staff and four additional hires (limited term through June 30, 2022), the WCU was launched in the spring of 2015, successfully achieving both the State and City reduction targets while applying the State's drought emergency regulations locally.

The WCU continues to implement the City's overall water conservation strategies, policies, incentives and programs to not only execute the City-mandated 20% reduction requirement still in effect, but also to assist in achieving – and sustaining – water self-sufficiency. The WCU is also charged with permanently establishing water conservation as the new normal in the City along with implementing the legislative requirements that are anticipated from the State's "Making Water Conservation a California Way of Life" framework (Executive Order B-37-16).

2.4.3 Water Conservation Programs/Policies (2014-2017)

The City's past and current water conservation efforts include a combination of incentive programs, forward looking policy, community outreach and education, and regulatory enforcement. For the 2014-2017 period, the programs and policies that the WCU has implemented can be categorized as follows:

- 2014 SWMP programs/policies
- New enhancements to existing programs
- Ordinances for new developments and water waste

2.4.3.1 2014 SWMP Water Programs

Although WCU staff resources were devoted primarily to new water conservation efforts in response to the 2012-2017 California water drought period, ten of the programs defined in the initial SWMP were initiated with significant progress. Estimated savings for these programs is 316.5 AFY with a total cost of $3,089,876 for the period between April 2015 to July 2017 as shown in Table 2-2. It is anticipated that several of the remaining programs will be launched in 2018 providing additional significant water reductions to help reach and maintain water self-sufficiency.

Table 2-2 Water Conservation Objectives and Outcomes 2015-2017

Conservation Activity	Class	Estimated Number of Activities Implemented by 2020	Actual Number of Activities Implemented Apr15 - Jul17	Estimated Conservation in 2020 (AFY)	Estimated Conservation (AFY) for Activities Implemented Apr15 - Jul17	Estimated Average Annual Cost	Estimated Total Cost Through 2020	Actual Cost for Activities Implemented Apr15 - Jul17
Residential HE Clothes Washer Rebate	Single Family	880	212	30	7.1	$24,100	$216,600	$39,885
Residential HET Rebate	Single Family	3568	339	77	8.3	$14,400	$129,700	$3,377
Residential WBIC Rebate	Single Family	1920	155	79	60.8	$29,300	$263,800	$5,328
City's Cash for Grass Rebate Program	Single Family	1,100,000 sf	823,399	51	38.2	$209,900	$1,889,100	$2,212,093
City's Drip Irrigation Rebate Program	Single Family	1,100,000 sf	N/A (see note #1)	24	0	$139,900	$1,259,400	$0
City's HE Nozzle Rebate Program	Single Family	550,000 sf	N/A (see note #2)	7	0.1	$52,500	$472,300	$30
Water Smart Software - 5% Reduction in Water Use	Single Family	3,040 accounts	5,818	8	34	$26,600	$239,300	$68,971
0.8 gpf Toilets (Direct Installation)	Multi Family	5,496	2,108	73	78.6	$174,800	$1,573,100	$670,172
Residential HE Clothes Washer Rebate	Multi Family	544	N/A (see note #3)	19	0	$9,800	$88,600	$0
Residential HET Rebate	Multi Family	4,000	2,055	13	76.7	$16,200	$145,400	$0
Laminar Flow Restrictors for St. John's Medical Center	Commercial	664	N/A (see note #4)	6	0	$1,500	$13,600	$0
Commercial Dry Vacuum Pump Rebate	Commercial	40	0	3	0	$1,400	$12,600	$0
Commercial Connectionless Food Steamer Rebate	Commercial	2	0	1	0	$100	$500	$0
Commercial Zero Water Urinal Rebate	Commercial	4	12	0	1.5	$25	$200	$500
Commercial Ultra-Low Volume Urinal Rebate	Commercial	544	3	8	0.4	$3,500	$31,100	$0
Commercial Conductivity Controller Rebate	Commercial	2	0	4	0	$0	$0	$0
Commercial HET Rebate	Commercial	200	442	5	10.9	$2,500	$22,900	$18,520
CII Cooling Tower Treatment - Zero Blowdown	Commercial	2	0	1	0	$200	$1,400	$0
Coin-Operated Laundry Machine Retrofit	Commercial	45	N/A (see note #5)	360	0	$3,500	$31,800	$0
HETs for St. John's Medical Center	Commercial	10	N/A (see note #4)	0	0	$100	$1,100	$0
0.125 gpf Urinals for St. John's Medical Center	Commercial	7	N/A (see note #4)	0	0	$40	$400	$0
1.5 gpm Faucet Aerators for St. John's Medical Center	Commercial	158	N/A (see note #4)	0	0	$800	$6,900	$0
SMMUSD Audits & Retrofits	Institutional	TBD	Audits completed	5	0	$94,400	$849,400	$71,000
Total Active Water Savings				**774**	**316.5**	**$805,565**	**$7,249,200**	**$3,089,876**
Total Passive Savings				418				
Reduction in Unaccounted for Water				250				
Total Reduction in Demand				**1442**				

1) This program is no longer active. Drip conversion has been incorporated in the main "Cash for Grass" Sustainable Landscape Rebate program that was revamped/relaunched in April 2015.
2) This program is no longer active. Rebates for rotating nozzles are provided through MWD's Water Conservation Rebate Incentive program for which Santa Monica provides supplemental funding.
3) Clothes washer rebates are only available for Single-Family Residential accounts.
4) St. John's declined to participate in this program in 2015. Staff will re-engage customer in 2018 to potentially begin program implementation.
5) The Laundry Machine retrofit program but was placed on hold due to re-directing resources to the City's drought response.

2.4.3.2 2015 – 2017 New and Enhanced Water Conservation Programs

In 2015, the WCU staff began implementation of a wide-array of new and enhanced water conservation programs as part of the City's drought response and drive towards water self-sufficiency. These programs continue to be executed to meet water self-sufficiency and to establish aggressive water conservation as a standard paradigm in the City. Significant new and enhanced programs include:

- **Water Use Allowances (WUAs):** The WUA is a component of the Water Shortage Response Plan (WSRP) and is the mechanism to implement the mandatory reduction required by a Water Supply Shortage. WUAs represent the amount of water that can be used by a water customer without risk of receiving an exceedance citation (see below). The WUA for the current Stage 2 Water Supply Shortage is 20% below the amount of water used in 2013. Every water customer in the City receives a WUA uniquely calculated for each billing period.

A water customer can apply for an adjustment to their WUA if an Exceedance Citation is received and they cannot consistently meet their allowance.

- **WUA Exceedance Citations:** A water customer can receive an administrative citation for exceeding their WUA for any given billing period. Citation fees are $250 for the first exceedance, $500 for the second exceedance (within 12 months of the first) and $1,000 for the third exceedance (within 12 months of the second).

- **Water School:** A water customer can have the citation fee waived for the first WUA exceedance by completing either an online or in-person Water School. The online Water School, created and maintained by the WCU staff, is an educational course with quizzes on Santa Monica water along with indoor and outdoor water conservation. The in-person Water School is conducted onsite at the customer's property by WCU staff, which includes an audit of indoor water fixtures, the outdoor irrigation system and leak detection using the water meter and toilet dye tabs.

- **Water Use Consultations:** WCU staff make onsite visits to customers to comprehensively audit indoor water use (measuring flush and flow fixtures, appliances, checking for leaks, behaviors), outdoor water use (irrigation system, checking for leaks, behaviors), along with a meter check. Recommendations for saving water are documented and sent to the customer. Consultations have resulted in the discovery and repair of major leaks, adjustment of irrigation system timers, installation of low-flow devices (aerators and showerheads (free), toilets and urinals (rebates)), and water-use behavior changes. This program is free of charge for any Santa Monica water customer.

- **Enhanced Landscape Rebate Program:** The City's most successful rebate program (converting turf grass to climate appropriate sustainable landscapes and removing sprinklers, or "cash for grass") was revised to provide more incentives for customer participation, to more effectively conserve water, to provide successful and maintainable projects, and to ensure an aesthetically pleasing landscape. Updates include:
  - Yard conversion: $3.50/sf rebate (up to $4,500)
  - Parkway conversion: $3.50/sf rebate (up to $1,500)
  - Rain Gardens & Rock Gardens: $1,000 rebate each for incorporating these rainwater harvesting features into a sustainable landscape project.
  - Unlimited Commercial: Commercial converted area above the above Yard and Parkway limits are rebated at $1/sf no maximum.

- **Landscape Consultants:** The WCU has partnered with professional landscape professionals who meet with potential landscape rebate customers at their property and provide expert advice on sustainable landscaping and completing a rebate. This service is $50 for a two-hour consultation.

- **Sustainable Landscape Trainings**: WCU staff coordinated with the City's Public Works, Airport, and Public Landscape on the installation of parkway landscaping and a rain garden at the Airport Demonstration Garden where hundreds of residents have participated in one-on-one sustainable landscape trainings since 2015.

- **Enhanced Water Waste Patrols**: WCU staff enforces SMMC 7.16.020, the "No Water Waste" ordinance (adopted in 1993, see below). Responses to inbound water waste complaints are handled immediately, and proactive patrols in the community have been increased. Notices of Violations are followed up to ensure resolution of water waste issues with Citations issued as needed.

- **Enhanced MWD Water Conservation Rebate Incentive Program**: As a member-agency of the Metropolitan Water District, the City of Santa Monica participates in their program to provide rebates to Santa Monica Water customers for high efficiency toilets, urinals, clothes washers, restaurant appliances, irrigation devices and other devices. Since 2015, the WCU increased the supplemental funding added to MWD's base rebate amounts to further incentivize installation of these water-conserving devices.

- **Free Water Saving Items:** WCU staff has distributed thousands of water saving items to Santa Monica water customers since 2015. These items include low-flow faucet aerators, low-flow showerheads, automatic shut-off hose nozzles, toilet leak-detection dye tabs, shower buckets, flow-rate bags, and reusable canvas bags. The WCU also provides free tent cards and door hangers for hotels/motels to encourage water conservation by guests through reusing towels and sheets. These free items are available in the OSE office and are also distributed at outreach events.

- **Marketing and Outreach:** An informative, entertaining, and well-received marketing campaign featuring fun, whimsical ways to conserve water during the drought (e.g. "Doggy Dishwasher") was launched in 2015. The campaign also promoted the phrase "We Love Santa Monica: Save Water. Show Your Love." In addition, a water conservation website was created (smgov.net/water) to provide a one-stop online location for water conservation recommendations and all the information for the Sustainable Landscape Rebate program. WCU staff has attended over 25 events since 2015 to educate and inform the public about water conservation.

- **Customer Support:** WCU staff provides excellent customer phone support every workday regarding any water conservation issue or program. Approximately 2,500 phone calls from Santa Monica water customers have been received by WCU staff since 2015.

2.4.3.3 2014-2017 New Ordinances for New Developments and Water Waste

A new ordinance and a significant update to an existing ordinance provide codified means to ensure the most efficient water use by new developments in Santa Monica and to help achieve and sustain water self-sufficiency. Also, a long-standing "No Water Waste" ordinance continues to be enforced by City staff.

- **Water Neutrality Ordinance**: On July 1, 2017, the City's Water Neutrality Ordinance went into effect and capped water use for new developments to the average five-year historical use for that individual parcel. If the projected annual water use for the development is greater than existing parcel's annual average over the past five years, the increased amount must be offset by water-efficient retrofits of existing building somewhere else in the City. Offset retrofits currently include low-flow indoor fixtures (toilets, showerheads, aerators). The ordinance applies to pools, ponds, spas and other water features as well. This ordinance was developed and is implemented by WCU staff. (SMMC 7.16.050)

- **Water Efficient Landscape and Irrigation Standards** - Green Building Ordinance Update: Santa Monica has had a Green Building Ordinance with irrigation components since 2008. In December 2016, the ordinance was significantly updated to reduce the amount of outdoor water use for new developments. In particular, overhead spray irrigation is banned for all new developments and for new landscape on existing developments. In addition, turf grass is banned on new commercial developments and is limited to 20% of landscaped area for new residential developments. (SMMC 8.108).

- "**No Water Waste" Ordinance:** Initially adopted in 1993, the WCU actively enforces this ordinance by patrolling the city looking for violations such as irrigation overspray and runoff, hosing of hardscapes, watering during prohibited times of the day and leaks (SMMC 7.16.020). Prohibited water wasting activities include:
    - Watering of lawns or landscapes between the hours of 10:00 a.m. and 4:00 p.m. on any day exception for drip irrigation, maintenance, hand watering
    - Runoff from irrigation into streets, alleys, driveways, sidewalks or storm drains at any time
    - Hosing down of hardscape such as sidewalks, driveways, patios, alleys, and parking areas or other "hardscapes"
    - Water used to fill or maintain levels in decorative fountains, ponds, lakes or displays unless a recycling system is used
    - Swimming pools filled or emptied unless it is a first filling of a new pool, or necessary leak repair work is being performed
    - Water leaks from exterior or interior plumbing; must be repaired immediately
    - Washing of vehicles of any kind except with a hand-held bucket or a hose equipped with a shut-off nozzle. No runoff permitted
    - Water served at restaurants except upon request

2.4.4 Water Conservation Results (2014-2017)

The City's aggressive water conservation programs along with exceptional community response have resulted in reduced water use even with incremental residential population growth. For 2014-2017, water use reduction was ~12.5% as shown in Table 2-3:

Table 2-3 Water Conservation Results from 2014-2017

METRIC	YEAR		REDUCTION
	2014	2017	AMOUNT
Annual Water Demand (AF)	13,036	11,498	1,538
Gallons per Capita per Day (gpcd)	126	109	17

Viewed in another way, the City's recent water conservation efforts have resulted in meeting major policy-level reduction targets as shown in Table 2-4.

Table 2-4 Policy-Level Water Reduction Targets

POLICY	TARGET	RESULTS	NOTES
CA Emergency Drought Regulation	20% reduction	✓20.7% Reduction	Cumulative reduction from 2013 for June 2015 to Feb. 2016
Santa Monica WSRP Stage 2 Water Supply Shortage	20% reduction	✓20% Reduction	Cumulative reduction from 2013 for June 2015 to Dec. 2016
SBx7-7[1]	123 gpcd	✓110 gpcd	Target date 2020. Goal met in 2016.

[1]Senate Bill SBx7-7 (Water Conservation Act of 2009), enacted in November 2009, requires all water suppliers to increase water use efficiency. The legislation sets an overall goal of reducing per capita urban water use by 20% by December 31, 2020. Failure to comply with the final target reduction would make the City ineligible for grants and loans from the State necessary to achieve the City's goal of water self-sufficiency (the City has received as much as $300,000 in recent years for conservation programs). SBx7-7 presented four options for determining the 2020 water use target. Council adopted the option of a straight 20% reduction from the baseline period (1996-2005 citywide water consumption) which set the target corresponding to this method at 123 gallons per capita per day (gpcd). The City met this target in 2016 with a 110 gpcd.

Additional metrics for the new and enhanced programs are shown in Table 2-5:

Table 2-5 New and Enhanced Water Conservation Programs

ITEM	RESULT APR 2015 – JUL 2017
Customers Meeting their Water Use Allowance	75%
No. of Water Use Allowance Exceedance Citations Issued	908
No. of Water School Sessions Completed	205
No. of Water Waste Notice of Violations/Citations	1,041
No. of Water Waste Complaint Follow-ups	1,254
No. of Water Use Consultations	370
No. of Landscape Consultations	563
No. of Sustainable Landscapes Completed and Rebates Issued	606
No. of High Efficiency Water Device Rebates through MWD	3,241
Water Saving Products Distributed	14,340
No. of page views at smgov.net/water	53,182

2.4.4.1 Summary

Water conservation programs implemented by the Water Conservation Unit have significantly reduced water demand since the 2014 SWMP. The programs and ordinances described above are shown as a timeline in Figure 2-8.

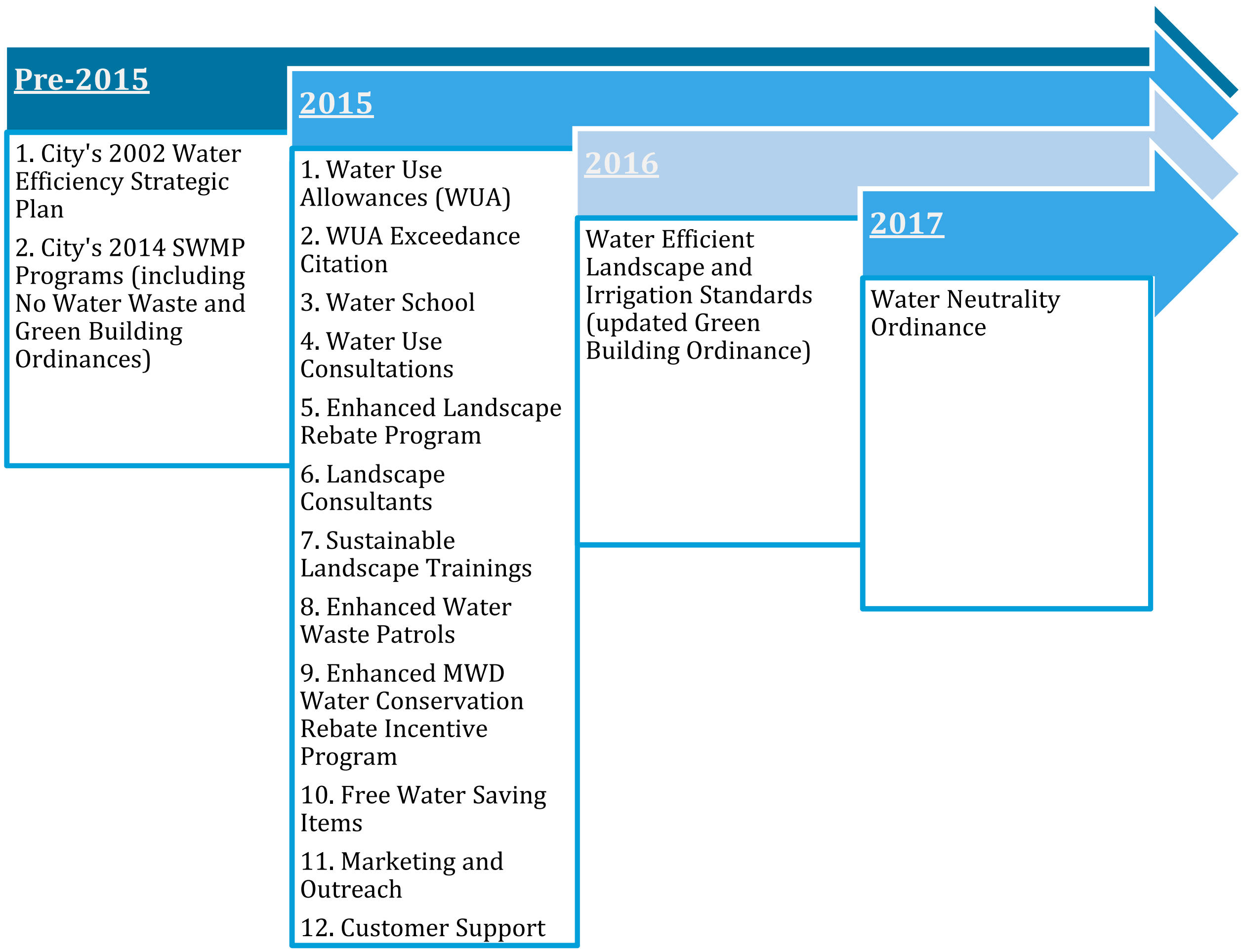

Figure 2-8 Water Conservation Programs/Policies

The water use reductions achieved in the City since the 2014 SWMP are as follows:

- Total annual demand shrank by approximately 1,538 AF from 2014 to 2017. Because the SWMP water conservation programs implemented to date have an estimated 317 AFY savings, the additional 1,221 AFY in savings can be primarily attributed to new water conservation programs along with enhancements to long-standing legacy programs.
- Drought response reduction targets of 20% mandated by the State and the City were met.
- The City's Stage 2 Water Supply Shortage and the requirement for 20% reduction in water use remains in effect (via Water Use Allowances and Exceedance Citations) and the City continues to meet this target even with the Drought State of Emergency rescinded and the media spotlight no longer on the drought.
- The SBx7-7 2020 target (123 gpcd) was surpassed in 2015 with when average demand was 109 gpcd.

The potential exists for further reductions in water demand through increased water conservation in untapped areas such as:

- Yet to be implemented programs from the 2014 SWMP (most notably the SMMUSD retrofits, commercial sector fixture retrofits, and coin-operated laundry machine retrofits)

- Increased focus on the commercial sector for rebates on water-saving devices (especially flush valve toilets and urinals)
- Continued water conservation education and enforcement
- Additional Sustainable Landscape conversions
- Outreach program assisting customers to properly adjust their irrigation timers
- New marketing and outreach campaign focusing on instilling permanent conservation objectives within the community consistent with the State's forthcoming framework for "*Making Water Conservation a California Way of Life.*"

Overall, water conservation programs are critical for the City to achieve and sustain water self-sufficiency and to establish water efficiency as the new norm in Santa Monica.

3.0 Current Water Sources and Supplies

The City's current water supply consists of local groundwater, purchased imported water, and a small amount of non-potable recycled dry weather urban runoff. Historically, groundwater has made up the majority of the City's water supply portfolio. In 1997, third party methyl tertiary butyl ether (MTBE) contamination was discovered in the Charnock subbasin, the location of one of the City's main groundwater supply fields. As a result, the City was forced to shut down five Charnock groundwater wells and purchase the majority of its water supply from MWD. With the commissioning of the upgraded Arcadia Advanced Water Treatment Plant (AWTP) in 2010, groundwater production from the Charnock subbasin was restarted. In addition to local groundwater and purchased imported water, the City treats a small volume of dry weather urban runoff at its Santa Monica Urban Runoff Recycling Facility (SMURRF). The treated SMURRF water is utilized for non-potable applications by other City departments and by various commercial users in the City.

3.1 SYSTEM HYDRAULIC ANALYSIS

As part of the December 2014 SWMP, Kennedy/Jenks used GIS data provided by the City to assess and construct a water distribution model for the City's system. The purpose of this analysis was to identify potential hydraulic and operational deficiencies and recommend capital improvement projects for both current and future demand conditions. This information was discussed in Section 6 of the 2014 SWMP. A working water distribution model was provided to the City and it will be updated and maintained periodically as changes occur throughout the City's water distribution system.

3.2 IMPORTED WATER

MWD receives a negotiated allotment of water from the Colorado River and the Sacramento-San Joaquin Delta. These allotments are then distributed among its 26 member agencies, of which the City is one.

Between the mid-1990s and 2010, the majority of the City's water came from imported water purchased from MWD. With the restoration of the City supply wells and the completion of the Charnock and Arcadia Water Treatment facilities in 2010, the City has been able to gradually reduce the need for imported water supplies. With optimization of the treatment facilities and conservation, the City reduced its need for imported water to less than 30% of the City's total water supply in 2015 and 2016. In 2017, a temporary well closure resulted in slightly higher usage. Figure 3-1shows the City's imported water purchases since 2005.

Based on the City's most recent MWD invoice, the City's Tier 1 rate allocation from MWD is currently 7,406 AFY, which is the amount of water the City is entitled to purchase at the lower cost Tier 1 rate. MWD Tier 2 water is also normally available to the City. However, the unit cost of Tier 2 water is higher, and there is less availability and reliability of Tier 2 water in periods of drought. As indicated in Figure 3-1, the City has not exceeded its current Tier 1 rate over the past 7 years.

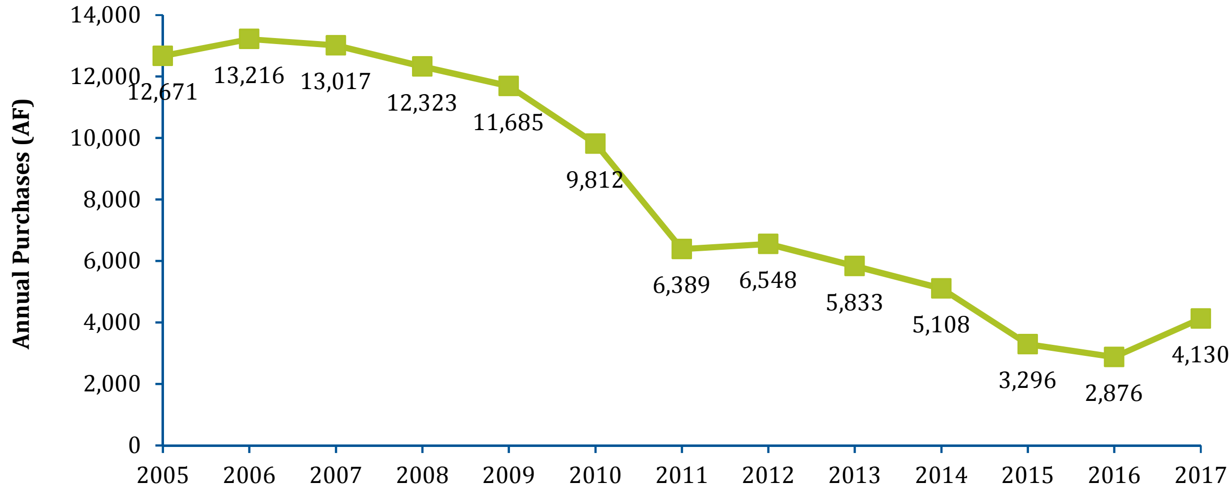

Figure 3-1 Historical Imported Water Supplies

The City receives imported water at two turnouts. Both of these connections are 24 inches in diameter and are capable of delivering 100% of the City's water needs. The hydraulic grade of the MWD water is high enough to deliver water to all three pressure zones within the City's service area without additional pumping. For water security, the City will maintain these turnouts going forward in case of a natural disaster or other emergency. The capacities of these connections are shown in Table 3-1.

Table 3-1 Santa Monica's MWD Connection Capacities

MWD CONNECTION	CAPACITY (AFY)
SM-1	21,720
SM-2	18,100
Total Capacity	**39,820**

3.2.1 Characteristics and Challenges

Fluctuation of available imported supply and drought conditions have and will likely continue to impact southern California's water supplies. Imported water is both expensive and variable, and in times of drought, becomes even more scarce and uncertain. To compound the reduced availability of water during times of drought, dry conditions also increase water demand due to increased outdoor water use. The reliability and increasing costs of imported MWD water is a major source of concern and risk for most water agencies. Because of this, and the environmental impacts of importing water from distant watersheds, it is the City's goal to significantly reduce and eventually eliminate imported water for day-to-day potable use.

3.2.2 Reliability

The reliability and availability of imported water is affected by a myriad of factors that are outside of the City's control and will, in all likelihood, continue to impact California in the future. Reliance on imported water to help meet its total water demands means the City must continually examine the various risk elements associated with that supply. This assessment of risk is essential in understanding the importance of developing any water resources plan. Although the City's imported water supplies have been fairly reliable in the past, a number of factors suggest that it will become more difficult to ensure that imported water remains reliable in the future.

Foremost among the risk factors associated with this supply is the magnitude of competing interests for imported water from the State Water Project and the Colorado River. This demand, coupled with periods of below-normal rainfall, have resulted in supply shortages over the past 30 years and culminated in a State drought declaration on January 17, 2014. Although the drought impacted surface waters and other agencies that used water for agriculture more significantly, the City was also affected by the drought, primarily due to reduced groundwater replenishment, and the reduced reliability of imported water. While the requirements of SBx7-7 may support a suppression of future demands, overall growth in southern California will continue to strain the reliability of MWD's water supply to its member agencies, including the City. As a result of these continued challenges to its water supplies, MWD and its member agencies, have developed new projects to increase the diversity and capacity of imported water supplies while encouraging its member agencies, including the City, to develop local supply projects to meet the needs of their customers.

3.3 LOCAL GROUNDWATER

In addition to providing a majority of the City's existing potable water supply, local groundwater offers the potential for future development of additional supplies. Local groundwater has, until recently, been underutilized due to the shutdown of five Charnock wells contaminated by MTBE in 1997. Since the completion of Charnock and Arcadia treatment facilities in 2010, the City has been able to bring the five Charnock wells back online. The following is a summary of the City's recently completed Sustainable Yield Analysis report prepared by Richard C. Slade & Associates LLC (Slade), June 2018. A copy of the Sustainable Yield Analysis is provided in Appendix A.

The City obtains its groundwater supply from the Santa Monica Groundwater Basin (SMGB). The SMGB is located in western Los Angeles County and underlies the entire City, as well as Culver City, Beverly Hills, and portions of western Los Angeles. The SMGB has a surface area of 50.2 square miles and consists mostly of flat to mildly hilly terrain. The SMGB is bounded by the impermeable rocks of the Santa Monica Mountains to the north, the Ballona Escarpment (Bluffs) to the south, the Newport-Inglewood fault to the East, and the Pacific Ocean to the West. Extensive faulting within the SMGB separates it into five subbasins as shown in Figure 3-2.

Figure 3-2 Santa Monica Groundwater Basin and Subbasins

The five subbasins within the SMGB are the Arcadia subbasin, the Crestal subbasin, the Charnock subbasin, the Olympic subbasin and the Coastal subbasin. Of these, the City currently only extracts groundwater from the Arcadia, Charnock and Olympic subbasins. The City recently completed an exploratory drilling program to assess the presence and quality of groundwater in the Coastal subbasin. This work resulted in the City confirming the existence of groundwater in commercial quantities in the Coastal subbasin, and the completion of a new supply well at the Santa Monica Airport. The City is planning future drilling in the Coastal subbasin to help reduce its dependence on imported water. The City has no plans to explore the Crestal subbasin in the immediate future. Based on recent drilling data and the completion of two studies related to natural recharge and a satellite-based study of basin topographic elevations, the City has updated the 2017 Preliminary Sustainable Analysis Report.

The Lakewood formation is a significant aquifer formation within some areas of Los Angeles County and is present in the Arcadia and Olympic subbasins in the northern half of the SMGB. However, the San Pedro Formation, which directly underlies the Lakewood formation, is the main potable production aquifer in the SMGB. Groundwater is replenished by percolation of precipitation falling on the land surface and by runoff along the front of the Santa Monica Mountains. The SMGB receives a regional average annual precipitation of about 12-14 inches. A significant amount of natural recharge to the SMGB occurs along the interface with the Santa Monica Mountains. Here, strata typically found at deeper depths in the basin tend to ramp up at shallower depths along the mountain front providing a more direct pathway for recharge of these sediments. Since the early-1900s, urbanization of the entire region has greatly reduced the amount of rainfall runoff that is able to percolate directly through the surface soils and into the underlying aquifer systems. The built-out environment of the City and fine-grained surface soils preclude recharge through much of the area and prevent the use of engineered recharge structures such as surface spreading basins.

Currently, the City extracts groundwater from ten active groundwater wells. Five of these wells are located in the Charnock subbasin, three are located in the Olympic subbasin, and two are located in the Arcadia subbasin. Table 3-2 presents the current well capacities for the City's active wells.

Table 3-2 Active Groundwater Well Capacities

SUBBASIN	WELL NAME/NO.	WELL CAPACITY[1] (gpm)
Charnock	Charnock 13	1,300
	Charnock 16	1,300
	Charnock 18	1,400
	Charnock 19	1,400
	Charnock 20	1,150
Arcadia	Arcadia 4	135
	Arcadia 5	95
	Santa Monica 1	200
Olympic	Santa Monica 3	250
	Santa Monica 4	750
	Santa Monica 8[2]	600
Coastal	Airport 1[2]	300

[1] Note that the total capacities of the wells are not the total pumping capacities because not all wells can pump simultaneously due to their close proximity.
[2] Not yet Active

As previously mentioned, the Charnock and Arcadia Wellfields had been shut down from approximately 1997 to 2010 due to MTBE contamination. Groundwater production during that period was greatly reduced and occurred primarily in the Olympic subbasin. Table 3-3 presents the historical groundwater production total for each sub-basin as reported in the 2018 Updated Preliminary Study of the Sustainable Yield of the Groundwater Subbasins within the Santa Monica Basin.

Table 3-3 Groundwater Production Totals (1988-2017)

YEAR	SUBBASIN PRODUCTION (AF)			
	ARCADIA	CHARNOCK	OLYMPIC	TOTAL
1988	372	8,111	387	8,871
1989	357	6,363	457	7,177
1990	389	4,132	469	4,990
1991	417	4,728	387	5,531
1992	396	6,486	981	7,862
1993	390	6,153	2,867	9,409
1994	419	5,906	3,126	9,450
1995	542	6,322	3,176	10,039
1996	370	2,284	3,044	5,697
1997			2,820	2,820
1998			2,642	2,642
1999			2,937	2,937
2000			2,912	2,912
2001	387		2,809	3,196
2002	467		1,824	2,291
2003	455		593	1,047
2004	137		385	522
2005	395		1,495	1,890
2006	387		1,365	1,752
2007	374		1,619	1,993
2008	360		1,663	2,023
2009	340		1,722	2,062
2010	290	593	2,436	3,320
2011	447	5,168	2,317	7,932
2012	450	5,277	2,636	8,363
2013	434	7,824	1,609	9,867
2014	714	8,377	1,591	10,682
2015	620	8,114	1,961	10,695
2016	698	8,311	1,992	11,001
2017	708	7,588	1,720	10,016
Total Production	**11,315**	**101,737**	**55,942**	**168,994**
Total Average Production (AFY)[1]	**435**	**5,985**	**1,865**	**5,633**

[1] For the Arcadia and Charnock subbasins, the average does not include those years for which no pumping was conducted.

3.3.1 Characteristics and Challenges

There are several challenges within the local subbasins, including, contamination, potential for saltwater intrusion, and recharging of the aquifers.

3.3.1.1 Contamination and Treatment

In 1997, the Charnock and Arcadia Wellfields were shut down for a number of years due to third-party MTBE pollution from leaking underground fuel tanks. In 2006, the City reached an agreement with the parties responsible for the MTBE contamination to restore the Charnock and Arcadia Wellfields so that they could once again provide drinking water to the community. This restoration came in the form of the upgraded Arcadia Advanced Water Treatment Plant (AWTP), and the new Charnock Treatment Unit at the Charnock Well Field, which provides granular activated carbon (GAC) filtration. The Charnock treatment system uses filtration with GAC to treat water from the three contaminated wells at the Charnock Wellfield, followed by additional treatment at the Arcadia AWTP, which includes reverse osmosis. In addition, water from one well located in the Arcadia subbasin (Santa Monica 1), is treated with chlorine at the wellhead and blended directly into the distribution system.

During treatment, water is lost as a result of filter backwash and rejected water from reverse osmosis. The amount of water loss can vary depending on the flow, raw water quality, and the condition of the reverse osmosis process units. This reject water, referred to as brine concentrate, is disposed to the sanitary sewer. In the last six years, water treatment losses have ranged from 15 to 25%. The City has adjusted the treatment process to stabilize brine concentrate losses at approximately 18% of total water treated by the Arcadia AWTP.

The City is currently evaluating options to maximize treatment efficiencies at the Arcadia AWTP in order to produce more potable supply. The City is assessing new engineering modifications that will reduce the amount of brine concentrate to approximately 10%, thereby increasing the volume of treated water available for distribution to the City. Figure 3-3 shows the City's historical groundwater production in terms of raw or pumped water and the actual potable water produced and distributed into the City's water system, also called demand.

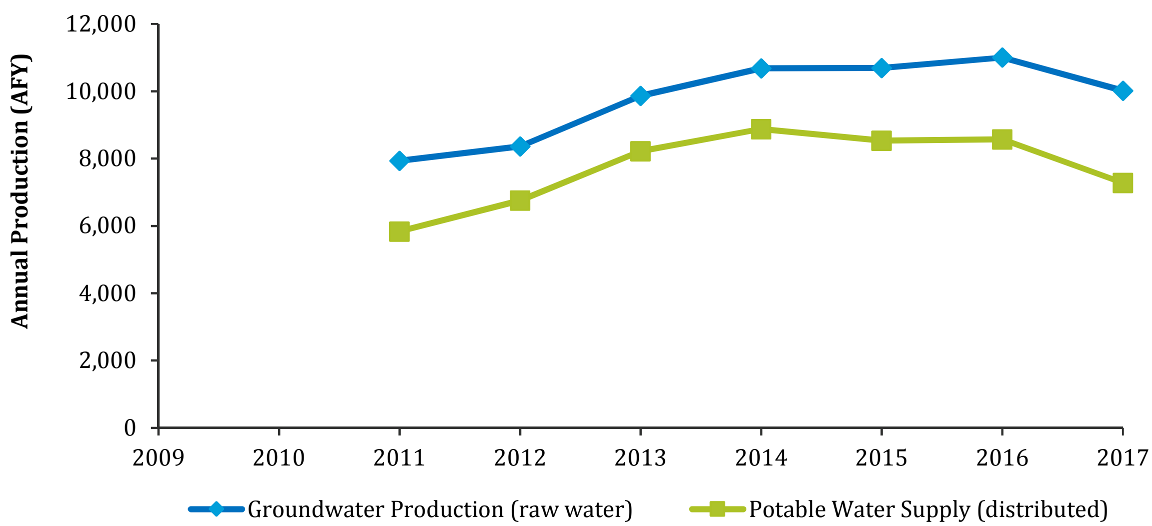

Figure 3-3 Historical Santa Monica Groundwater Production

In addition to water quality issues in the Charnock and Arcadia subbasins, groundwater quality in the Olympic subbasin has been historically impacted by several industrial users over the years. The City successfully negotiated a multi-million dollar financial settlement with the responsible parties. Some of the components of this residual contamination present challenges for treatment.

3.3.1.2 Saltwater Intrusion

The City currently has no active supply wellfields near the Coast, and therefore there has been no widespread intrusion of seawater into the City's aquifer systems due to pumping. Results from a recent well drilled at the City Hall determined that the base of freshwater at that location was approximately 520 feet below ground surface.

3.3.2 Reliability

A Preliminary Sustainable Yield Study, which assessed the sustainable yield of the various subbasins within the SMGB, was prepared by Richard C. Slade & Associates (Slade) in 2017. The sustainable yield of a basin is defined as the rate at which groundwater can be withdrawn on an annual basis, under specified operating conditions, without producing an undesired result.

A recent exploratory drilling program completed by the City confirmed the presence of groundwater in the Coastal subbasin and provided additional information about subsurface sediments. As a result of this work, the City has updated the 2017 Preliminary Sustainable Yield Study. Table 3-4 is a summary of the updated estimated sustainable yields for the five subbasins. It should be noted that these data are conservative and do not include an estimate of sustainable yield for the Crestal subbasin. In addition, all estimates of sustainable yield are transitory, due to the myriad of the associated climatic and hydrogeologic factors that are constantly in flux. Going forward, the City is planning to update the sustainable yield analysis every two years.

Table 3-4 Estimated Sustainable Yield for the SMGB

SUBBASIN	2018 SUSTAINABLE YIELD STUDY		PREVIOUS STUDIES
	ESTIMATED LOWER LIMIT YIELD (AFY)	ESTIMATED UPPER LIMIT YIELD (AFY)	ESTIMATED YIELD (AFY)
Charnock	6,410	8,080	4,420 – 8,200
Olympic	2,360	3,145	3,275
Arcadia	870	920	2,000
Coastal	1,160	1,450	4,225
Crestal	N/A	N/A	2,000
Mountain Front Recharge	1,000	1,130	N/A
Total	**11,800**	**14,725**	**13,920 – 19,700**

3.3.2.1 Charnock Subbasin (Charnock Wellfield)

The City's largest wellfield is the Charnock Wellfield, which is located approximately 5,000 feet southeast of the southeastern boundary of the City in the Charnock subbasin. Though only five wells are currently active, this site has had 20 wells throughout its history. The five supply wells are operated as necessary using variable frequency drives (VFDs) to serve fluctuating treatment plant demand. Under normal operation, four of the five wells are operating at one time. Wells are cycled on and off to keep well locations healthy and prevent over pumping of well locations. Based on recent data, Slade's 2018 report estimated this range to be 6,410 to 8,080 AFY for the Charnock subbasin.

3.3.2.2 Olympic Subbasin (Olympic Wellfield)

The Olympic Wellfield is located along and around Olympic Boulevard in what is sometimes referred to as the Olympic Corridor. As many as seven wells have been constructed in this wellfield, with only two remaining in operation today. Those two wells are Santa Monica 3 and Santa Monica 4. A third well (Santa Monica 7) has been idled since 1984 due to sand migration into the well casing. This well was abandoned and replaced with a new supply well (Santa Monica 8) in early 2018. Santa Monica 3 and 4 are both operated using VFDs as necessary to serve demand at the Arcadia AWTP. Santa Monica 8 is currently in the regulatory permitting process. The City plans to have this well in production in 2020. Slade's 2018 report estimated the sustainable yield to be in the range of 2,360 to 3,145 AFY.

3.3.2.3 Arcadia Subbasin (Arcadia Wellfield)

The Arcadia Wellfield is located at the Arcadia AWTP, just outside of the eastern edge of the City at Bundy Drive and Wilshire Boulevard. As many as ten wells have been drilled at this location with only the following two wells remaining in operation today: Arcadia 4 and Arcadia 5. A third well, Santa Monica 1, is located in a traffic median along San Vicente Blvd. A previous study had estimated the subbasin's sustainable yield to be around 2,000 AFY. However, based on recent data, Slade's 2018 report estimated the sustainable yield to be in the range of 870 to 920 AFY for the Arcadia subbasin.

3.3.2.4 Coastal Subbasin

The Coastal subbasin underlies the southern portion of the City. This subbasin has not been utilized as a groundwater source to date. In its 2013 Memorandum, *Review and Evaluation of Historic Perennial Yield Values, Santa Monica Groundwater Basin,* Slade assigned a value of 4,225 AFY for the Coastal subbasin, which was largely based on prior studies by others. Beginning in fall 2017 and continuing through the winter, the City drilled three deep exploratory borings to begin the process of gathering the necessary data to define the sustainable yield in the Coastal subbasin. As a result of the drilling program, the City completed a new water supply well in the Coastal subbasin. The City is in the process of permitting this well and has plans for at least two more in the near future. Based on new data, the sustainable yield of this subbasin is estimated to be on the order of 1,160 to 1,450 AFY.

3.3.2.5 Crestal Subbasin

The City does not overlay the Crestal subbasin and has not used this subbasin as a water supply. In the 2017 Preliminary Sustainable Yield Report, Slade noted that the previous sustainable yield value of 2,000 AFY was chiefly defined in a City of Los Angeles Department of Water and Power report dated April 1991, which assigned a range of values of 1,000 and 3,000 AFY for the sustainable yield of this subbasin. In its March 27, 2013 report, Slade selected the midpoint of that range (i.e. 2,000 AFY) as the preliminary sustainable yield value for this subbasin. Until additional data are obtained for the Crestal subbasin, the previous value of 2,000 AFY may be valid. There are currently no plans by the City at this time to explore the Crestal subbasin as that subbasin lies entirely outside of City limits, and the City does not presently have ownership or access to viable drilling locations.

3.3.2.6 SMGB Recharge

As noted previously, due to the local geology and the highly urbanized nature of the City, there are no spreading basins in the SMGB. During the 1980s, the City recharged up to 2,148 AFY of imported water from MWD into the Charnock subbasin using an aquifer storage and recovery well. The City, however, ceased this operation in 1990, and the City does not currently provide additional groundwater recharge into the SMGB. Based on two recent studies conducted by the City, it is estimated that approximately 1,000 – 1,030 AFY of precipitation is naturally recharged to the basin. In addition, a satellite-based study being conducted by the City is investigating potential undocumented pathways for natural recharge that appear to follow ancestral LA River channels. The City is also in the process of planning the drilling and permitting of a new artificial recharge well as part of the Sustainable Water Infrastructure Project (SWIP), discussed later in this report.

3.3.3 Sustainable Groundwater Management Act of 2014

The SMGB is currently unadjudicated and the City is currently the only municipality with a history of pumping significant volumes of water in the basin. The SMGB has not been identified as being in overdraft conditions in the most recent Department of Water Resources Bulletin 118. The California SWRCB's Division of Drinking Water and the Regional Water Quality Control Board provide additional oversight of the SMGB's groundwater quality and help monitor contaminant levels. In cooperation with the Cities of Los Angeles, Culver City and Beverly Hills, and Los Angeles County, the City has coordinated formation of a Groundwater Sustainability Agency (GSA), and is in the process of preparing a Groundwater Sustainability Plan as required by Sustainable Groundwater Management Act (SGMA) by January 2022. As the GSA moves forward with the SGMA process, the Sustainable Yield Analysis for the Santa Monica Groundwater Basin will be a key component in preparing the Groundwater Sustainability Plan and will be subject to review and approval by the Department of Water Resources.

3.4 NON-POTABLE WATER

The City commissioned the Santa Monica Urban Runoff Recycling Facility (SMURRF) in 2001. The primary objectives of this facility are to eliminate contamination of Santa Monica Bay caused by dry weather urban runoff, and to provide cost-effective treatment for producing water acceptable for reuse in landscape irrigation and indoor plumbing. The SMURRF project was funded by the following: the City, a State Water Resources Control Board (SWRCB) loan, the City of Los Angeles, an MWD recycled water rebate program, federal Intermodal Surface Transpiration Efficiency Act (ISTEA) grant funds, and Los Angeles County Proposition "A" grants. The SMURRF is operated by the City, although operating costs and revenues are shared jointly with the City of Los Angeles.

The SMURRF, which is currently considered a stormwater best management practice (BMP), treats dry weather urban runoff from the City's Pico-Kenter and Santa Monica Pier drainage areas. The SMURRF is designed to effectively treat up to 0.5 MGD of urban runoff that was previously discharged into Santa Monica Bay. The treated water is pumped through a reclaimed water ("purple pipe") distribution system that serves parks, medians, Woodlawn Cemetery, and dual-plumbed buildings. Treated water is also used by City operations for street sweeping, sewer jetting, and pressure washing.

In addition to reducing pollutants entering Santa Monica Bay and increasing supply reliability, the SMURRF was designed to increase public awareness of Santa Monica Bay pollution and alternative water uses. The SMURRF is located in a prominent tourist location adjacent to the Santa Monica

Pier and provides a new access to the beach through a walkway from which visitors can view the facility. As a walk-through facility, visitors can see the array of the equipment at two separate overlook points. Each piece of equipment is laid out in a logical format and water is day lighted at five separate points allowing visitors to view the purification process. Educational material about the workings of the facility is also available. Due to its strategic location, the SMURRF has enhanced community awareness of water conservation and reuse.

There are approximately 27 recipients of the SMURRF's recycled water, of which two include commercial/institutional users receiving recycled water for indoor use through a dual-plumbed system. Current dual-plumbed and landscape uses include the City's Public Safety Facility and the RAND Corporation. The Water Gardens, an office-professional campus near the City's eastern boundary with Los Angeles, accepts recycled water for its water features and landscape areas. Recent additional users include Tongva Park, City Hall, Colorado Ave., and Esplanade landscape areas among others.

From 2010 to 2017, recycled dry weather urban runoff has accounted for less than 1% of the City's overall water supply (potable plus recycled). Table 3-5 lists the total production (effluent) from the SMURRF from 2010 through 2017.

Table 3-5 Historical SMURRF Production

Year	Production (AFY)	Year	Production (AFY)
2010	91	2014	134
2011	79	2015	81
2012	93	2016	89
2013	96	2017	98
Average			**95**

The SMURRF has maximum production capacity of 560 AFY (0.5MGD). However, the City's most recent conservation efforts have significantly reduced the dry weather runoff reaching the SMURRF. Current treated water production at the SMURRF is around 98 AFY. The City has had to supplement the runoff influent with potable water to meet existing City needs and third-party contracts for treated SMURRF water as well as for keeping the equipment operational. Due to recent restrictions on public landscape irrigation and conservation by other users, the production volume of SMURRF water has dropped measurably. The need for supplemental potable water is currently averaging around 8% of total daily SMURRF production. This results in an average of 87 AFY runoff generated influent and 8 AFY of influent that is comprised of potable water supply. Efforts are underway to secure more reliable sources of water for the SMURRF and to increase the average production-to-capacity ratio. These are discussed in more detail in Section 5.

4.0 Future Water Use

To meet its water self-sufficiency goals and eliminate its reliance on imported water, the City requires a clear understanding of its future water needs. The objective of this section is to project annual potable water use needs for planning years 2020, 2025, 2030, 2035, and 2040. Potable water demand projections are based on historical water demand unit rates, population growth projections, and estimates of non-revenue water. Underpinning the City's ability to produce sufficient volumes of local groundwater necessary to meet projected demand and water self-sufficiency is the estimated sustainable yield for the Santa Monica Basin discussed in Section 4.2.

4.1 POTABLE WATER USE ANALYSIS

The City water use trends from Section 2.2 show that the City's implementation of the water conservation programs/policies from 2015 through 2017 has resulted in a significant reduction in potable water use, even with increases in residential population. While it is possible that the City's currently estimated per capita use can be reduced further through additional focused conservation messaging and new water conservation programs, for planning purposes it is assumed that the City's future water usage will be similar to 2015 to 2017 demand (i.e. 110 gpcd). For comparison, this plan also discusses future water demand based on water conservation program projections.

4.2 POPULATION GROWTH PROJECTIONS

The City has two planning documents, the Land Use and Circulation Element (LUCE) of the City's General Plan and the Downtown Community Plan (DCP), both identifying City zoning by year 2030. The DCP is guided by the same vision as the LUCE and focuses on the Santa Monica downtown region. These plans consider future population growth to ensure sufficient capacity for new housing. Population projections used to project future water demands were provided by the City's Planning Department based on projections from Southern California Association of Governments (SCAG) and its planning documents. The 2030 population projections reflect the projections from the LUCE and DCP.

4.3 POTABLE WATER DEMAND PROJECTION

As noted above, future water projections are estimated based on the most recent per capita water use of 110 gpcd. Based on this unit rate, and the projected population, future potable water demands were calculated and are summarized in Table 4-1.

Table 4-1 Potable Water Projections Based on Residential Population

PROJECTIONS	2020	2025	2030	2035	2040
Unit Water Use Rate (gpcd)	110	110	110	110	110
Population[1]	95,315	97,429	102,726	103,038	103,440
Potable Water Demand (AFY)	11,744	12,005	12,657	12,696	12,745
Non-Revenue Water[2] (AFY)	587	600	633	635	637
Adjusted Potable Water Demand (AFY)	**12,332**	**12,605**	**13,290**	**13,331**	**13,383**

[1] Population data provided by the City's Planning Department
[2] Non-Revenue Water Loss Rate for the City is 5%

As shown in Figure 4-1, a majority of the population growth is projected to occur by 2030, with a more gradual growth between 2030 and 2040. From 2020 to 2040, the potable water demand is projected to increase at an average rate of approximately 2% and water conservation is estimated to reduce projected water demand by 3% - 5%. Note that the projected potable water use reflects an average annual amount and does not account for seasonal peak, maximum day variations, or water losses due to reverse osmosis treatment. These volumes of water are discussed and included in the upcoming sections.

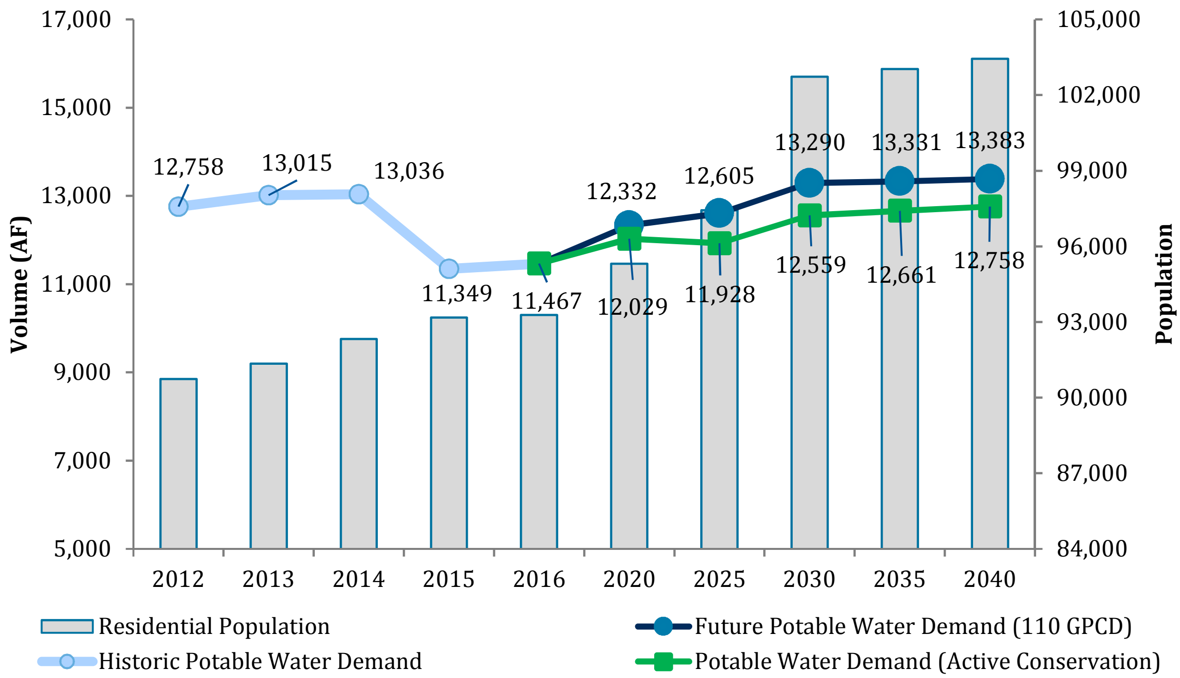

Figure 4-1 Potable Water Demand Projections

4.4 WATER CONSERVATION ANALYSIS AND EFFECT ON FUTURE DEMANDS

In the 2014 SWMP, the City used the Alliance for Water Efficiency's Water Conservation Tracking Tool to model and evaluate opportunities to conserve water in the future. This model was used by the City to select conservation programs and policies that would position the City for self-sufficiency and to estimate implementation costs of these programs. The details of this model can be found in the 2014 SWMP. An updated list of conservation programs since the 2014 SWMP was provided by the City using its conservation model and is shown in Table 2-2 Water Conservation Objectives and Outcomes 2015-2017

In addition, for this SWMP update, a water conservation model was used to project future demand reduction through conservation program activities. A summary of these projections is provided below in Section 5.4.

5.0 Future Water Supply Options

In conjunction with the City's extensive water conservation efforts, additional water resources are required for the City to become independent from imported water provided by MWD. This section presents possible local water supply options and a timeline to allow the City to achieve its water self-sufficiency goal. Additional water resources include increased production of local groundwater and non-potable water supply by doing the following: optimizing existing groundwater treatment processes at the Arcadia AWTP to reduce water loss, new wells to increase local groundwater production, and the harvesting, treatment, and reuse of nonconventional water resources, such as dry and wet weather runoff, municipal wastewater and brackish groundwater. As part of the City's commitment to the adaptive management of its water resources, the City recognizes that the vagaries of projected population growth and climate change support the increased future reliance on the reuse of its nonconventional resources, with a corresponding reduction in reliance on groundwater.

5.1 WATER SELF-SUFFICIENCY SUPPLY REQUIREMENTS

In 2010, the Santa Monica City Council directed staff to develop a plan to reach a 100% sustainable water supply (100% water self-sufficiency from local sources) by 2020. In a March 2011 study session with the City Council, staff presented preliminary concepts and principles that would be involved in achieving the water self-sufficiency goal by the year 2020. These included conservation, expanded use of local groundwater, and enhanced reuse of stormwater.

Table 5-1 summarizes the City's existing local groundwater supplies in comparison to the projected water demand (i.e. needed potable water production). Until the City achieves full sustainability, some continued use of import water will be necessary. However, it is expected that the amount of imported water utilized will steadily decrease between now and 2023.

Assuming no changes in the 2018-estimated sustainable yield and recently updated estimates of associated groundwater production, the estimated local supply needed to achieve self-sufficiency is approximately 12,495 AFY by 2023 and 13,383 AFY by 2040. In addition, peak summertime water usage will need to be accounted for in terms of supply production capacity, as the projections shown in Table 5-1 are only average annual estimates.

It should be noted that if the low end of the sustainable yield estimate is assumed, future demand may exceed what could sustainably be pumped from the basin. This could preclude the City from withdrawing additional groundwater under the Sustainable Groundwater Management Act of 2014 (SGMA). Should this occur, the City would need to continue purchasing imported water from MWD to meet its potable water demand.

The potential limitations on future groundwater withdrawals from the City's active subbasins indicate that the City's approach of additional water supply wells, efficiency upgrades at the Arcadia AWTP, pursuing nonconventional resources, and continuing conservation are necessary for the City to achieve and sustain its long-term objective of independence from costly imported water. The limitations also support proposed biennial updates to the sustainable yield analysis, conservation programs, and working jointly with the United States Geological Survey (USGS) to refine the hydrogeologic model. Details for this water self-sufficiency strategy are provided below.

Table 5-1 Comparison of Projected Demand and Local Supplies

PROJECTED DEMAND/SUPPLIES	PROJECTED DEMAND/SUPPLY (AFY)					
	2020	2023	2025	2030	2035	2040
Projected Demands						
Projected Potable Water Demand (110 GPCD)	12,332	12,495	12,605	13,290	13,331	13,383
Projected Potable Water Demand (w/ Conservation)	12,029	11,928	11,928	12,559	12,611	12,758
Projected Water Demand Range	**12,029 - 12,332**	**11,928 - 12,495**	**11,928 - 12,605**	**12,559 - 13,290**	**12,611 – 13,331**	**12,758 - 13,383**
Supplies						
Arcadia Water Treatment Plant (RO)	9,603	9,525	10,932[2]	10,932[2]	10,932[2]	10,932[2]
Closed Circuit Reverse Osmosis (CCRO)	-	2,812	2,812	2,812	2,812	2,812
Recycled Water	560	560	560	560	560	560
Imported Water[3]	1,866 - 2,169	170	170	170	170	170
Groundwater Recharge						
Groundwater Recharge from SWIP[1]	-	1,030	1,030	1,030	1,030	1,030

[1] SWIP recharge well will assist with maintaining the Santa Monica Groundwater Basin.
[2] This value includes additional wells that may be required to sustain water self-sufficiency.
[3] The City will maintain its MWD connection for emergency purposes. Imported water usage will be minimal and be required for maintenance of the City's connection.

5.2 ADDITIONAL LOCAL GROUNDWATER OPPORTUNITIES

As noted in the previous section, at present, the City obtains its local water from the SMGB via the following three subbasins: Charnock, Olympic, and Arcadia. The SMGB also includes the Coastal and Crestal subbasins, which are currently not used for production by the City. Over the years, there have been a number of scientific literature reviews performed to assess potential groundwater sustainable yield levels. Historically, preliminary estimates of sustainable yield for the SMGB have ranged between approximately 7,500 AFY to 19,000 AFY. These disparate estimates have produced a level of variability that the City will need to further assess over time and, to the extent feasible, reduce in order to be able to plan more effectively. To this end, the City is planning to collect additional hydrogeologic boring data to update and refine future sustainable yield reports. The following sub-sections describe the plans related to each of the currently productive subbasins in more detail.

5.2.1 Charnock Subbasin (Charnock Wellfield)

The City has determined that wellfield groundwater monitoring data, which shows reduced third-party VOC contamination, warrants a change in groundwater monitoring frequency. In addition, the

City is evaluating the cost benefit of completing or acquiring another supply well in the subbasin, which would provide for additional operational flexibility.

The City currently has a calibrated numerical groundwater flow model of the wellfield. To better quantify sustainable yield estimates going forward for all of the City's wellfields, and the SMGB writ large, the City is planning to work cooperatively with the USGS to incorporate City data into the USGS model for the SMGB. These studies will begin in 2018.

5.2.2 Olympic Subbasin (Olympic Wellfield)

Today, only the Santa Monica 3 and Santa Monica 4 wells are in operation within the Olympic subbasin. The City recently completed a new well (Santa Monica 8) which is planned to go into production in 2020. This well has an estimated production rate of 600 gpm. In addition, the City is planning to abandon Santa Monica 3 and replace it with a new well (Santa Monica 9) capable of a higher production rate. Santa Monica 3 previously experienced sand migrating into the well casing. To ameliorate this condition, a liner was installed in the well casing. This corrected the sand issue but also resulted in lower production rates. Completing the two new wells (Santa Monica 8 and Santa Monica 9) allows the City to produce more groundwater, and provides the flexibility to take a well offline for repair without a significant reduction in current production levels.

Similar to the Charnock Wellfield, the City also has a calibrated numerical groundwater flow model of the Olympic Wellfield. To better quantify sustainable yield estimates going forward for this wellfield this data will also be incorporated in the USGS model. Doing so will assist the City in its water resource planning.

5.2.3 Arcadia Subbasin (Arcadia Wellfield)

The Arcadia subbasin has three wells in operation currently: Arcadia 4 and 5 and Santa Monica 1 (SM 1). Degradation of the SM 1 well has led to significantly decreased yields. To illustrate the capacity degradation of SM 1, when it was originally drilled it produced a yield of 850 gpm, more than three times the current yield. Due to the lack of production, as well as quality issues experienced at SM 1, the City has considered re-drilling this well. Successful re-drilling of this well would provide additional data for future updates to the sustainable yield estimate for this subbasin, while simultaneously improving groundwater production.

5.2.4 Coastal Subbasin

The Coastal subbasin is not currently utilized by the City for water supply. Previous studies estimated a yield of 4,225 AFY. The most recent 2018 sustainable yield analysis estimates an annual yield of 1,160 – 1,450. Recently, the City completed a new water supply well in the Coastal subbasin at the Santa Monica Airport (Airport 1). The estimated production rate of this well is 300 gpm. The well is currently in the regulatory permitting process and will be placed into future production once the necessary conveyance pipelines are in place. Based on the data obtained from this boring, the City plans to drill up to two additional wells in the Coastal subbasin.

5.2.5 Crestal Subbasin

There are currently no plans at this time to explore the Crestal subbasin as it lies entirely outside of City limits, and the City does not have ownership or access to viable drilling locations.

5.2.6 Arcadia Treatment Facility

As part of its self-sufficiency planning, the City is currently evaluating options to maximize treatment efficiencies at the Arcadia AWTP. If implemented, the modifications at Arcadia may allow for the double benefit of increasing the total overall treatment capacity of the facility, while simultaneously squeezing more potable water out of the existing treatment waste stream, thus improving facility efficiency by reducing the amount of the reject water sent to the sewer by the current reverse osmosis system. As envisioned, the Arcadia finished water production capacity would increase from the current 8.85 MGD to around 12 MGD by 2023. The amount of reverse osmosis reject water would decrease from the current 18% to 8% (i.e. ~92% efficient facility).

Beyond 2023, it is projected that demand may require a second, small standalone treatment facility in order to meet City needs. The necessity for the distributed treatment facility is being weighed against several criteria including, but not limited to, cost, non-behavior based conservation goals that could permanently reduce demand, community acceptance, resiliency goals, and the sustainable yield of the City's aquifers.

5.3 NON-POTABLE REUSE OPPORTUNITIES

Currently, the only source of non-potable water supply within the City is the dry weather runoff that is captured and treated at the SMURRF. The City does not have the capability to harvest, treat, and reuse stormwater or municipal wastewater at this time. Wastewater generated in the City is sent to the City of Los Angeles' Hyperion Wastewater Treatment Plant for treatment. Understanding the need for conjunctive reuse, the City has embarked on constructing several forward-looking projects that will correct this gap in its water portfolio.

Conjunctive reuse is generally defined as an integrated approach for water resource resiliency that utilizes managed conservation, aquifer pumping, aquifer recharge and storage, and the recycling of all available water resources, including non-conventional resources such as dry and wet weather runoff, municipal wastewater, and brackish groundwater. This approach is not only desirable from an environmental perspective, but is also a critical component to the City's future self-sufficiency planning. To address the lack of conjunctive reuse in the City's water supply, the City has leveraged existing infrastructure such as the SMURRF, and integrated these resources with two very innovative projects discussed in the following subsections.

5.3.1 Sustainable Water Infrastructure Project (SWIP)

The City's SWIP is comprised of three integrated project elements to improve drought resiliency, increase water supply, and enhance flexibility in the management of the City's water resources. The SWIP is currently moving into the first stages of the design-build process. The project construction is expected to be completed by late 2020. Figure 5-1 shows the location of the three SWIP project elements.

Figure 5-1 SWIP Locations

SWIP Element 1 involves the installation of a containerized brackish/saline reverse osmosis unit at the SMURRF. SWIP Element 1 is designed to integrate with the Clean Beaches Initiative (CBI) stormwater harvest tank project as described below. The CBI is currently in construction and will be completed in fall 2018. When operational, the containerized reverse osmosis unit would be utilized to advance treat non-conventional water resources such as dry and wet weather runoff and brackish groundwater. The City plans to expand its non-potable system to serve an additional 100 AFY to customers along San Vicente Boulevard. When fully operational, SWIP Element 1 will provide supply to both the non-potable system and for groundwater recharge, when properly permitted. Element 1 will be completed in2020.

SWIP Element 2 includes the construction of a below ground AWTP at a location beneath the Civic Center Parking Lot. The AWTP would advance treat approximately 1.0 MGD (1120 AFY) of municipal wastewater for non-potable reuse and, when properly permitted, for groundwater recharge. Treatment processes would include, among other things, a membrane bioreactor, membrane filtration, reverse osmosis, UV disinfection, and advanced oxidation.

SWIP Element 3 consists of two below grade stormwater harvest tanks. One tank (3.0 million gallons [MG]) would be constructed beneath Memorial Park. The other below grade tank (1.5 MG) would be located adjacent to the AWTP described in SWIP Element 2. Project elements to be located under the Civic Center Parking Lot would be constructed to accommodate future development on the site. The harvested stormwater will be utilized as a supplemental feed source for treatment at the AWTP described in Element 2 and will be connected to the AWTP by SMART technology and Supervisory Command and Data Acquisition (SCADA) systems. Elements 2 and 3 are schedule to be completed in2020.

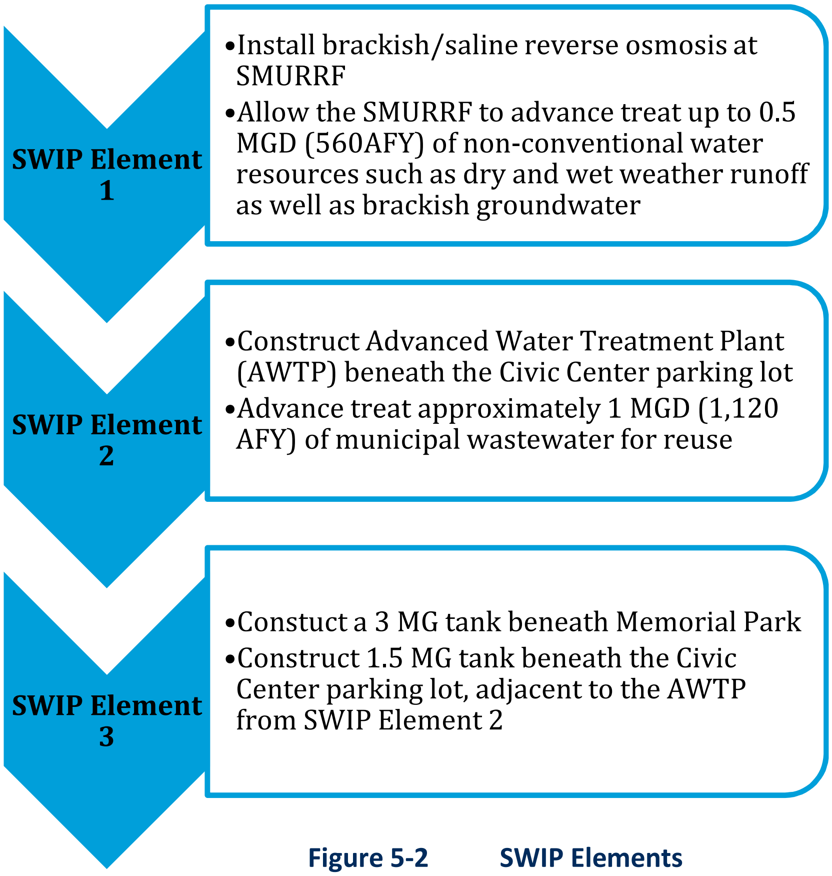

Figure 5-2 SWIP Elements

Combined, the SWIP and the CBI will produce approximately 1.5 MGD (1,680 AFY) of water for immediate non- potable reuse, and when properly permitted, for indirect potable reuse via aquifer recharge. All non-potable treated water would be distributed via the City's existing non-potable water "purple pipe" system. Benefits of the SWIP include capturing stormwater and urban runoff for treatment and reuse, improving beach water quality and complying with SWRCB's Enhanced Watershed Management Plan (EWMP) requirements. The SWIP, by diverting up to 1 MGD (1,120 AFY) of sewage for treatment, will also free up some additional hydraulic capacity in a portion of the City's sewer collection system. This could allow for future savings and/or redirection of future capital improvement priorities and expenditures. Figure 5-2 summarizes the various elements of SWIP.

5.3.2 Clean Beaches Initiative (CBI) Project

The CBI Project includes the installation of a subgrade 1.6 MG stormwater harvest tank on the north side of the Santa Monica Pier to capture runoff from the downtown Promenade Area. The harvested stormwater will be routed to the SMURRF for treatment and non-potable reuse. During dry weather, a set of horizontal sub drains beneath the CBI harvest tank will collect shallow brackish groundwater, which will be routed to SMURRF for treatment and permitted reuse. The continuous routing of wet weather and dry weather flow to SMURRF will maintain its peak treatment capacity of 0.5 MGD (560 AFY) and prevent structural damage to the buried tank due to high groundwater levels. In conjunction with SWIP Element 1, the CBI Project will be able to supply water to meet the full capacity of the SMURRF and thus eliminate the need to supplement the system with potable water. The CBI Project will also improve beach water quality at the stormwater outfall beneath the Santa Monica Pier and provide for water resiliency. Figure 5-3 summarizes the major components of the CBI project.

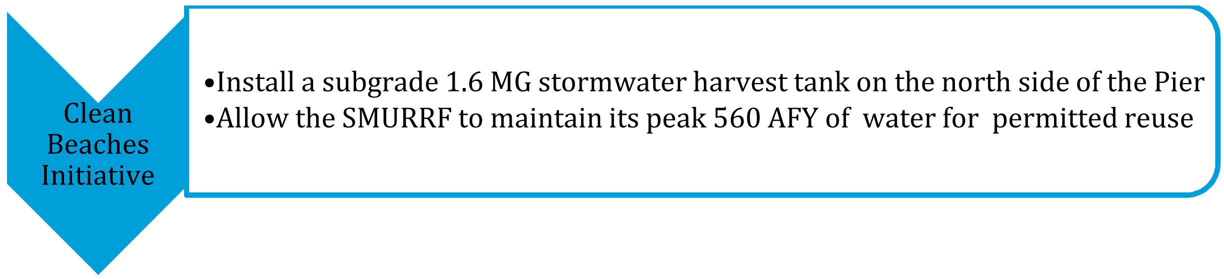

Figure 5-3 Clean Beaches Initiative

5.3.3 Future Groundwater Recharge Opportunities

With continued advances in treatment and monitoring technologies and increasing experience with potable reuse projects in California, it is likely that California will continue to adapt or modify regulations that will expand the opportunities for the further development of potable reuse projects. By implementing innovative projects like the CBI and SWIP, the City will be well positioned to take advantage of these potential regulatory changes to conjunctive reuse as they evolve. These projects will provide a template for future projects in other parts of the City where there is an adequate supply of wastewater and runoff to treat and use for recharge via new or existing wells.

Some challenges with such projects that will need to be addressed include the energy requirements, the need to dispose of the brine-concentrate flows that result from the reverse osmosis treatment processes, and the costs associated with treating these waste streams. As currently planned, brine-concentrate will be disposed to the sewer for further treatment at the City of Los Angeles Hyperion wastewater treatment plant. However, for a full picture of project economics one would also need to consider the energy requirements of the project compared to those associated with the transport of imported water from distant watersheds, and the offset cost benefits of reducing the City's wastewater flows to the City of Los Angeles.

5.4 FUTURE DEMAND REDUCTION THROUGH CONSERVATION OPPORTUNITIES

In developing the water conservation plan to reach and maintain self-sufficiency, the City evaluated the potential for further water efficiency and conservation within the service area. This included an assessment of the current level of low water use and CalGreen efficiency fixtures in the City, as well as identifying where the greatest opportunity for reducing water consumption exists. Based on this analysis, a program plan was developed to reach the City's long-term objectives.

5.4.1 Market Saturation Assessment

The City reviewed the estimated saturation levels of indoor water using fixtures and appliances within the various customer classes or sectors to identify remaining water saving opportunities for fixture and appliance replacement. Based on this assessment there is still significant opportunity for water savings through fixture replacement in all sectors. From 1990 to 2001, 46,977 ultra-low flush toilets (ULFTs) that use 1.6 gallons per flush (gpf) were installed through the direct install, rebate or other incentive program. Table 5-2 shows the number of toilets installed per sector, saturation rate, and number of high water using toilets estimated in Santa Monica.

Table 5-2 Saturation of 1.6 gpf Toilets in the Customer Sectors

CUSTOMER TYPE	TOTAL TOILETS (2002)	TOTAL ULFT INSTALLED	TOTAL NATURAL ATTRITION REPLACEMENT	PERCENT SATURATION	POTENTIAL HIGH WATER USING TOILETS
Single Family	17,002	6,513	5,043	68%	5,446
Multi-Family	58,086	38,181	16,428	94%	3,477
Commercial	33,165	2,283	15,759	54%	15,123
Total	108,255	46,977	37,230	78%	24,046

Although a significant percent of high water using toilets have been replaced with 1.6 gpf models, there still is significant opportunity, particularly in the commercial sector. In addition, many of the fixtures upgraded over the years are outdated compared to new CalGreen standards and technologies in the market. For example, from 1990 to 2013 the City of Santa Monica provided incentives or direct install to replace old 3.0 gallon per flush toilets with 1.6 gpf models. Then in 2013 the City began programs for the replacement of toilets using 1.6 gpf toilets with 1.28 gpf and eventually only incentives for toilets using 1.06 gpf or less. Given the substantial improvement in toilet flush efficiency, 1.6 gpf toilets could be again replaced with 0.80 gpf resulting in up to a 50% reduction in water usage from those toilets. A similar pattern of replacement and standard improvements has occurred for showerheads and bathroom and kitchen faucet aerators. Since 1992, the standard for showerhead flow rates has gone from over 2.5 gallons per minute (gpm) to 2.0 gpm under CalGreen with many available EPA Water Sense vetted showerheads with flow rates as low as 0.80 gpm. Similar trends are seen with kitchen faucet aerators that went from over 2.5 gpm to CalGreen standard of 1.8 gpm and as low as 0.50 gpm for bathroom faucet aerators. Based on these findings, the City proposes to continue a combination of direct install programs, rebate incentives, and free devices to capture the potential water savings from fixture replacement.

Impact of Tourism and Job Population

The City's overall per capita water consumption is 110 gpcd, while the per capita use for single family and multifamily residential usage is only 73 gpcd. This shows that Santa Monica residents have made significant efforts to improve water efficiency at their property. Key areas with the highest potential for water use reduction include the downtown commercial and multifamily sites. In 2016, 8.4 million visitors came to Santa Monica[1]. This significant surge of visitors into the City greatly impacts the overall water demand in the City and offers an opportunity for demand reduction. Based on a study on tourism and water usage, domestic water use per tourist per day is

[1] https://www.santamonica.com/wp-content/uploads/2015/04/2-Page-Annual-Econ-Imp-Summary-2016.pdf

29.5[2] gpcd with the average length of stay in Santa Monica at 1.37 days, resulting in nearly 1,000 AF of water use per year or 9% of the total water usage in the City.

As noted previously, the City's conservation and enforcement efforts have reduced the aggregated average per capita water use to 110 gpcd, which is the unit rate used to project future water demand in Section 4. When just residential use is considered, the City's per capita use is around 73 gpcd. With the continued efforts by the City and community writ large, it may be possible to conserve additional water and lower the aggregated water usage down to 90 gpcd by 2025 or 68 gpcd for the residential sector. To reach this objective, the City proposes to continue the current programs and staff levels implemented during 2012 to 2017 to sustain the water saving trends, as well as implement new highly strategic projects and programs to target previously unreached opportunities.

An aggressive ramp up of fixture replacements over a 3-year period complimented with stringent enforcement of the Retrofit on Resale ordinance as well as an enhancement of the Water Neutrality ordinance are needed to reach a gpcd of 90 by 2025. An estimated $30 million in additional program funding would be necessary to complete the 3-year fixture replacement plan and fund outreach efforts and the necessary staff to manage the program and enforcement.

5.4.2 Continuing Programs

Santa Monica will continue several of the current successful programs into the future. This includes the rebate incentive programs for fixtures, high water using landscape replacement incentive, partnership program with SMMUSD, water use consultations and community outreach efforts. Table 5-3 shows the projected level of activity over the next 10 years for each of these programs as part of the overall plan to reach water self-sufficiency. The projected level of program participation is based on historical trends, available market of opportunity, and strategic community engagement campaigns to increase programs over multi-year periods.

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[2] https://www.researchgate.net/publication/236018306_Tourism_and_Water_Use_Supply_Demand_and_Security_-_An_International_Review

Table 5-3 Projected Activity for Ongoing Water Conservation Programs

CURRENT MEASURES	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	TOTAL
SF PHET Rebates	300	300	300	300	300	300	300	300	300	300	3,000
SF HECW Rebates	250	250	250	250	250	250	250	250	250	250	2,500
SF WBIC Rebates	100	100	100	100	100	100	100	100	100	100	1,000
Water Use Consultation SF	120	120	120	120	120	120	120	120	120	120	1,200
Water Use Consultation MF	0	150	150	150	150	150	150	150	150	150	1,350
Water Saving Devices FA	1,540	1,540	1,540	1,540	1,540	1,540	1,540	1,540	1,540	1,540	15,400
Water Saving Devices SH	700	700	700	700	700	700	700	700	700	700	7,000
Soil Moisture Sensor Rebate	0	15	15	15	15	15	15	15	15	15	135
Water Use Consultations CII	0	60	60	60	60	60	60	60	60	60	540
MF PHET Rebates	0	225	225	225	225	225	225	225	225	225	2,025
CII WBIC Rebate	0	60	60	60	60	60	60	60	60	60	540
SF Soil Sensor Rebate	0	50	50	50	50	50	50	50	50	50	450
CII PHET Rebate	150	150	150	150	150	150	150	150	150	150	1,500
CII 0.125 gpf Urinal Rebates	0	75	75	75	75	75	75	75	75	75	675
CII Waterless Urinal Rebate	25	25	25	25	25	25	25	25	25	25	250
CII Ice Machine Rebate	2	2	2	2	2	2	2	2	2	2	20
SF Landscape Rebate	60	100	100	100	75	75	75	75	75	75	810
MF Landscape Rebate	0	10	10	10	10	10	10	10	10	10	90
CII Landscape Rebate	0	11	11	11	11	11	10	10	6	6	87
Community Outreach & Education	-	-	-	-	-	-	-	-	-	-	0
Total	**3,247**	**3,943**	**3,943**	**3,943**	**3,918**	**3,918**	**3,917**	**3,917**	**3,913**	**3,913**	**38,572**

5.4.3 New Programs

To meet self-sufficiency and the long-term goal of 90 gpcd for the entire City, Santa Monica has identified additional areas of water saving opportunity that requires the development of new incentive and outreach programs. Table 5-4 summarizes the programs and projected implementation level for each one. Additional program details are also provided below.

Table 5-4 Incentives and Programs

NEW MEASURES	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
MF HECW Incentive	50	50	50	50	50	50	50	50	50	50
WN MF PHET 0.80 gpf	2,450	365	200	200	200	200	200	200	200	200
WN SF PHET 0.80gpf	0	0	0	0	0	0	0	20	20	20
WN CII PHET 0.80 gpf	0	0	70	70	70	70	70	70	70	70
WN SMMUSD PHET 0.80 gpf	0	525	0	0	0	0	0	0	0	0
WN SMMUSD Tank PHETs	0	8	0	0	0	0	0	0	0	0
WN SMMUSD Urinals	0	4	0	0	0	0	0	0	0	0
School Education Program	90	400	400	400	400	400	400	400	400	400
CII Direct Install PHET	0	350	350	350	350	350	350	350	350	300
CII Direct Install Urinals	0	250	250	250	250	250	250	250	250	250
WN MF PHET 1.28 gpf	35	20	20	20	20	20	20	20	20	20
Performance Pays	0	0	1	1	1	1	1	1	1	1
SMMUSD WBIC Incentive	0	22	0	0	0	0	0	0	0	0
Pilot Projects	0	0	0	1	0	1	0	1	0	1
Graywater System Incentive	0	0	10	10	20	20	20	30	30	30
SMMUSD Landscape Incentive	4	5	0	0	0	0	0	0	0	0
Total	**2,629**	**1,999**	**1,351**	**1,352**	**1,361**	**1,362**	**1,361**	**1,392**	**1,391**	**1,342**

Santa Monica Unified School District Partnership for Improving Water Efficiency and Sustainability in District Locations

Continuing the partnership with Santa Monica Malibu Unified School District (SMMUSD), the City will provide funding for irrigation and landscape upgrades based on potential water savings. Phase one of the program will include upgrading irrigation timers at nine SMMUSD sites to a weather-based central control irrigation system. This advanced technology will allow SMMUSD to improve in managing their irrigation and reduce the response time in identifying and repairing leaks. The second phase will include a variety of landscape and irrigation upgrades including turf replacement, rain capture and reuse, and improvements in the irrigation operations.

Clothes Washer Incentive for Multi-family

A study of water usage in the multi-family sector completed by the University of Florida Environmental Engineering Sciences showed water usage for clothes washers made up 18 to 28% of the water usage for the property[3]. Unlike in-home or in-unit clothes washers that process 6 to 8 loads per week, common area washers process an average of 20 to 50 loads a week[4]. Given most coin-operated clothes washers in common areas use 35 to 45 gallons per load compared to water efficient models using as low as 15 gallons per load, the water savings opportunity is significant.

The City proposes to develop an incentive program that specifically targets multi-family common area laundry facilities by offering an incentive to replace their current clothes washers with models with a Water Factor of 4 (using 20-15 gallons per load). The upgrade could result in a 50% water savings or more per load. For property owned washers, the City would provide a one-time rebate incentive to make the upgrade. The incentive would be based on the potential water savings not to exceed the cost to upgrade the washers. The second and most common washers in multi-family are leased machines. With lease machines, property owners or management companies lease the machines in contract intervals from 3 to 7 years. In this scenario, the City would identify the lease cost difference for a property owner to upgrade to a high efficiency model with a Water Factor of 4. The incentive would be based on the years of the lease agreement. The longer the property owner agrees to lease high efficient washer models, the great the potential savings and therefore the greater the incentive.

The City proposes to start this program in fiscal year 18/19 with 10 clothes washers upgraded through the incentive program. The following fiscal year the City would target to upgrade 30 clothes washers and then thereafter 50 each year. The number of clothes washers at each site varies depending on the number of units and whether there is a mix of units with clothes washers and dryers in their units. Overtime, the City will expand the incentive program to other facilities that have common area laundry including mobile home parks, motels, homeless shelters, hostels

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[3] http://www.conservefloridawater.org/publications/WaterUseDemandManagementMulti-FamilyResidentialSector-1.pdf

[4] http://www.allianceforwaterefficiency.org/laundromats.aspx

and commercial laundromats. The focus for commercial laundromats would be on multiple load models that can wash using up to half of the water of traditional coin-operated top-loader models.

Performance Pays

Within the commercial sector there are opportunities for water savings in water using processes that do not fit into the standard water fixture incentive programs. This can include water used in process operations for food preparation and production, manufacturing, and cooling. The potential savings from efficiency improvements is not standardized and requires a customized program that incentivizes businesses with cost-effective incentives based on projected water savings. In developing this new program, the City will model the program after similar programs that have been successful, including the Los Angeles Department of Water and Power's (LADWP's) Technical Assistance Program (TAP) and the Metropolitan Water District of Southern California's Water Savings Incentive Programs. Both programs provide a portion of upfront incentive funding based on calculated water savings estimates of an efficiency improvement project. Upon completion of the project and a monitoring period, the remaining incentive is provided based on actual water savings results. Thus, the incentive is driven by the effective performance of the project to reduce water usage. This program is applicable to upgrades for industrial scale laundry equipment, commercial kitchen sanitary systems, and onsite wastewater reuse technology, to name a few.

Pilot Project Program for Innovative Technologies

New technologies in water efficiency are coming on the market quickly both in the United States and around the world. For the City to leverage potential innovative technologies, Santa Monica has incorporated an innovative technologies Pilot Program in the plan. This program will allow the City to pilot upcoming technologies in water use efficiency and water loss management. These small-scale projects would have a 2-year timeline with the average pilot project cost up to $20,000 based on estimated annual savings achieved.

Expansion of Water Neutrality Offsets and Applicability

In fiscal year 2018/19, the City will begin the direct install portion of the Water Neutrality Ordinance for development projects that paid in lieu fees to offset their water usage. The City will coordinate with the SMMUSD to upgrade over 500 toilets and urinals at school sites, funded through the Water Neutrality in lieu fee funds. Additional focus will be on low-income multi-family and high-volume use toilets in the commercial sector.

Currently the Water Neutrality Ordinance requires a 1:1 offset in new water demand from new development and new pools/spas. In fiscal year 2018/19, the City will be updating the ordinance to clarify the ordinance objectives and what types of water usage in development should be captured including tenant improvement projects that result in an increase in new water demand at the property. To ensure the City meets and continues to be water self-sufficient and the long-term goal of 90 gpcd, Water Neutrality may need to evolve to Water Positive by requiring new developments to not just offset their new water demand, but help in the conservation effort to reduce current demand. That means a new positive offset greater than 1:1.

Meter Replacement with AMI "Smart Meters"

In fiscal year 2016/17, the City began a pilot installation program to install advanced meter infrastructure (AMI) or "smart meters." AMI meters interface directly with the billing system and reads water usage in real time to identify water use peaks and patterns of increased water usage. The City then utilizes the Water Smart online software to communicate to customers on their water usage and alert them of potential water leaks or other increases in water usage. In fiscal year

2018/19 the City will continue to monitor the pilot's effectiveness in communicating water efficiency to customers and addressing leaks to consider expanding the AMI technology throughout the service area.

Datalogger Analysis for Water Usage Analysis

To address real time potential leaks or unknown spikes in water usage, the Water Conservation Unit is utilizing a flow meter and datalogger. The Meter Master Model 100EL is designed to specifically log and provide data analytics for customer water usage. This provides an important tool for the Water Conservation Unit to help identify leaks and educate the customer on their water usage. The Meter Master flow recorders permit demand data logging from most existing water meter installations, regardless of meter make or size. It uses a strap-on magnetic sensor to digitize a meter's highly accurate magnetic drive signal without any meter alteration or service interruption. The flow recorder has a companion software for downloading, graph and report generation, and exporting to other software applications.

The datalogger would be attached to a meter for 7 to 10 days to monitor water usage in 5 second intervals. The data is then downloaded into the software to analyze water usage patterns and volume. Through the software analysis, leaks, changes in irrigation timer settings and other water usage increases can be identified to best help customers resolve the high-water consumption. This technology will be used in compliment with the water use consultation services and water waste ordinance enforcement.

School Education Program

The City will partner with the Discovery Science Center of Los Angeles to implement a pilot level school program to educate students on the importance of water conservation and the impacts on our water supply and local watershed. Students in fifth grade will participate in a grade-specific, standards-aligned assembly that focus on water use efficiency and conservation in an interactive and dynamic way. At the start and end of the assembly, students will complete a quiz on their knowledge on water conservation, Santa Monica water supply, and our watershed. This will provide valuable data to show the impacts of the program as well as gauge the level of knowledge on water conservation. The City will work with the Discovery Science to develop a Santa Monica specific booklet to provide to participating students to take home and share with their family. The program will run at a pilot level through the end of FY 18/19. Based on the results and feedback from students and teachers, the program will be expanded to all fifth graders within Santa Monica.

Tree Replacement and Incentive Program

Towards the goal of lower aggregated per capita use, the City has recently implemented a tree replacement program to remove trees with roots that interfere with the sewer collection system. Replacement trees will have a much lower water demand than the existing trees.

To encourage a full watershed approach to landscape transformations, the City will be providing incentives to residents and businesses to add native and other appropriate tree species into their non-parkway landscapes. Additional trees have been found to help reduce heat effects, filter urban pollutants and fine particulates, regulate water flow and improve water quality, and absorb carbon dioxide helping to mitigate climate change[5]. In addition, they provide a local source of food and nutrients while encouraging healthy bio systems.

Greywater System Incentives

Currently Santa Monica residents and businesses, through the permitting process, can install greywater systems that capture and filter graywater from washing machines and faucets to reuse for irrigation or other approved uses. The use of graywater on site is less energy intensive than treating wastewater and can be a cost-effective alternative water supply for irrigation and other uses. To further encourage the use of graywater on site, the City proposes to offer incentives to residents and businesses to install City approved systems on their property.

Passive Water Conservation Savings

Water savings through passive water conservation will be addressed in a future memorandum.

5.4.4 Summary

Through the currently established programs and proposed new programs, the City can potentially save an estimated 677AF per year by 2025 and as much as 732 AF per year in 2030.

5.5 PATHWAY TO WATER SUPPLY SELF-SUFFICIENCY

To assess the City's self-sufficiency goals, projected demands and supplies are compared through the 2040 planning horizon.

5.5.1 Projected Water Supply Needs

In 2017, potable water use was 11,498 AFY and non-potable use was 98 AFY, totaling 11,596 AFY of water use in the City. To meet these demands, the City produced 7,276 of treated groundwater supply and approximately 98 AF from the SMURRF, relying on imported water from MWD (36%) to make up the rest of its water supply needs. Projected water demand and supply needs through 2040 are provided in Figure 5-4.

The following are key future water supply assumptions:

- Current estimate of groundwater sustainable yield will remain relatively stable through 2025 and is sufficient to support planned additional aquifer pumping.
- Proposed new wells are capable of estimated production rates.
- Modifications at the Arcadia AWTP increase production capacity from the current 8.85 MGD to 12.1 MGD, and the percentage of system reject water is reduced from the current 18% to 8% (i.e. 92% facility efficiency is achieved).
- Modifications at SMURRF, and integration of the adjacent CBI Project, increase daily treated water production for reuse to 0.5 MGD (560AFY) in 2020.

[5] http://www.fao.org/resources/infographics/infographics-details/en/c/411348/

- SWIP Elements 2&3 provide an additional 1.0 MGD (1,120 AFY) of advanced treated water for various reuse in 2022.

The projected future water supplies discussed above and shown graphically in Figure 5-4 are based on an aggregated (residential plus commercial/industrial) per capita consumption rate of 110 gallons/day. Sustained lower per capita consumption would contribute to a lower future demand. It is projected that by 2023, the City will need to supply 12,495 AFY of water to become self-sufficient and not rely on MWD. However, even with continued success with conservation efforts, including the Water Neutrality Ordinance, by 2025 and beyond, the City will likely need additional sources of supply to maintain its self-sufficiency. This is primarily due to projected population increases.

To achieve water resiliency, the City will need to address peak demands during months when higher water is typically required. As part of the road to sustainability, the City's goals are first to focus on meeting average annual demand needs and a second focus would be to meet peak demand periods, which may be addressed in part with permanent non-behavior based conservation methods such as low-flow toilet rebates, turf replacement, and the City's Water Neutrality Ordinance. Increased reuse of non-conventional resources could also help decrease peak demand.

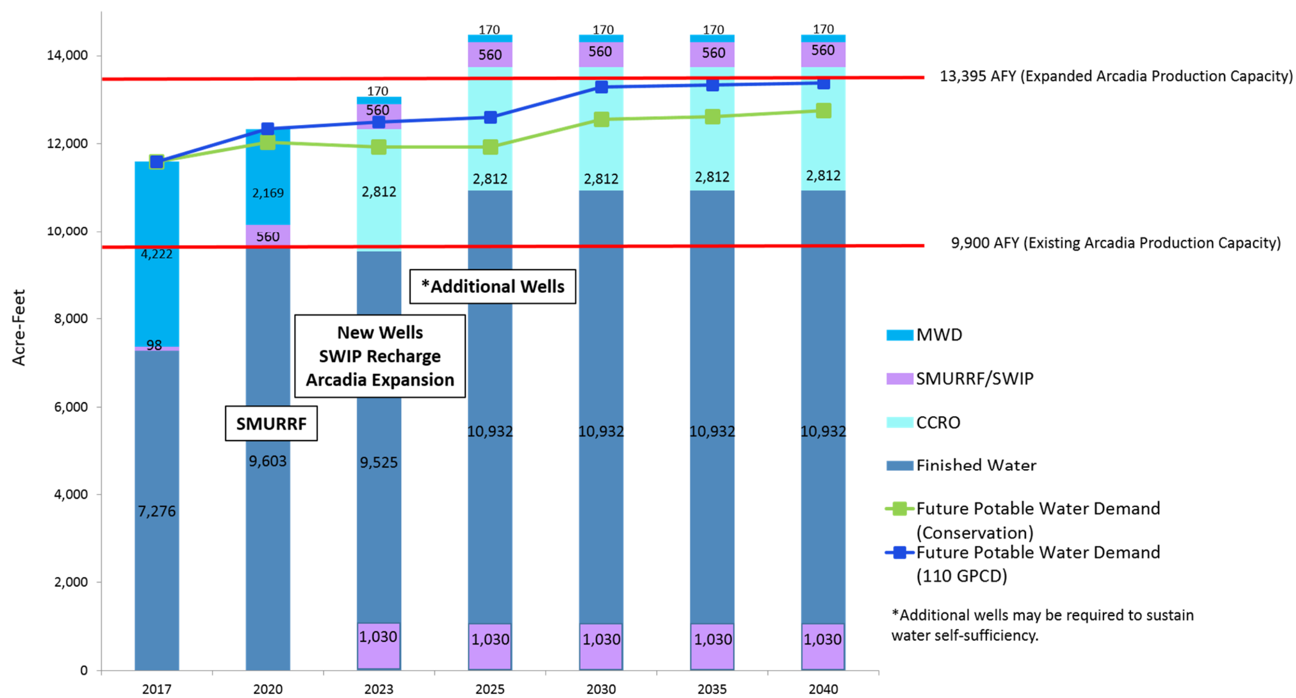


Figure 5-4 Future Water Supply Options

5.5.2 Summary and Recommendations

Through its water conservation efforts, the City has measurably reduced its reliance on imported water. The City and the community are committed to reducing water use in the future to help achieve the City's water self-sufficiency goal by 2023. Along with the further focused conservation efforts, the City understands the need for a diversified water portfolio to meet its 2023 self-sufficiency goal, and to achieve and maintain water security, resiliency and independence over the long-term. These goals are obtainable but they will require continued innovation, as well as the ready and lasting commitment of resources to be successful.

Below is a set of recommendations for water self-sufficiency and resiliency by 2023. These recommendations are but a critical first step in what will be an ongoing strategic program for the adaptive management of the City's water resources. Combined, the estimated cost for the water treatment enhancement projects is approximately $45.5 M. This cost does not include the drilling or acquisition of additional groundwater supply wells. A table summarizing the treatment enhancement projects and a tentative water self-sufficiency schedule are provided in Appendix B.

- Conservation
  - Continue public outreach, education and water conservation messaging with a focus on commercial/industrial users to maintain community water awareness and the current levels of conservation success achieved to date.
  - Adopt the State's water conservation paradigm for the City, i.e. "*Making Water Conservation a Santa Monica Way of Life".*
  - Coordinate City expertise and resources to develop a holistic strategy for reducing the City's aggregated per capita use rate from the current 110 gpcd to 90 gpcd.
  - Review and update City conservation results every two years to expedite response to developing trends and help refine future conservation metrics and forecast strategies.
  - Develop and model various risk-based climate change scenarios designed to help focus ongoing conservation programs and forecast potential challenges to water supply reliability.

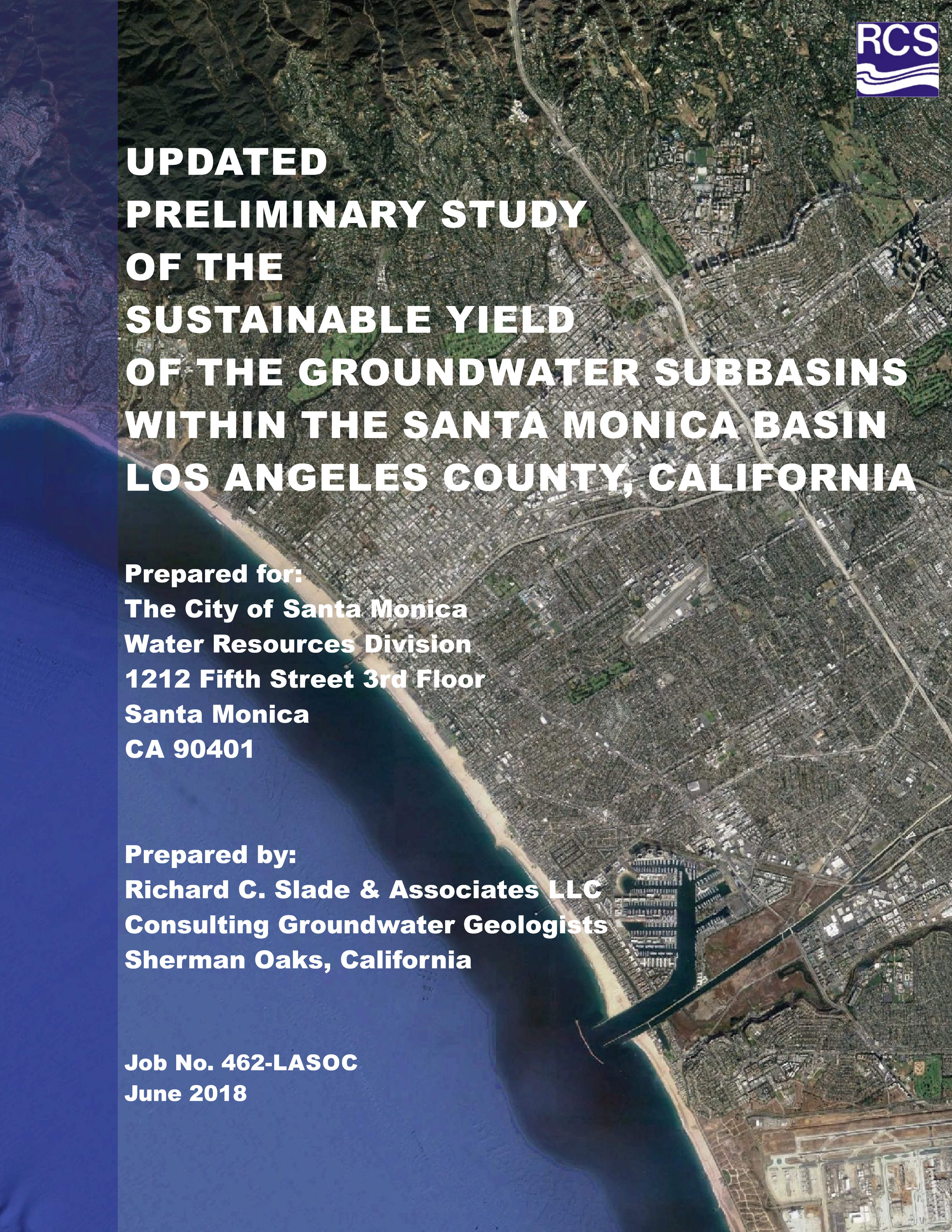
- Groundwater Supply
  - Update the Sustainable Yield Analysis and Sustainable Water Master Plan every two years in lieu of the current five-year update cycle to more effectively manage the City's groundwater resources and assist in strategic planning for water supply reliability and resiliency.
  - Work with the City's SGMA partners to develop the Sustainable Groundwater Plan in accordance with SGMA requirements.
  - Drill or acquire up to four new water supply wells by 2023. Half of the new wells should be constructed prior to 2020 to achieve the City's self-sufficiency objectives through increased local groundwater production.
  - Drill and permit a deep nested monitoring well and a separate aquifer recharge well, both in support of the SWIP by 2020.
  - Work cooperatively with the USGS to evaluate and model the hydrogeology of the SMGB to more sustainably manage the City's groundwater resources.
  - Implement a feasibility study to assess options and costs for a small-scale standalone water treatment facility to be constructed in 2023 or beyond depending on demand.
  - Implement a study and maintain a database to identify available properties for possible acquisition within the City that could be utilized for future groundwater wells or distributed treatment facilities.

- Non-Potable Supply
  - Complete SWIP construction and integration of the CBI project by late 2020, and permit the produced water for immediate non-potable reuse. Complete regulatory

testing and permitting for indirect potable reuse of SWIP treated water via aquifer recharge by 2022.
    - Implement a feasibility study by no later than 2020 for additional distributed projects, similar to the CBI and SWIP, that harvest non-conventional resources for conjunctive reuse to enhance the City's future water reliability, thereby further reducing the City's primary reliance on local groundwater.

- Treatment Enhancements
    - New reverse osmosis technologies are available to recover more potable water from the treatment process. A pilot test of the CCRO technology will be conducted. If successful, this project would install a 3-MGD CCRO at the Arcadia Water Treatment Plant.
    - Focused modifications at the Arcadia Water Treatment Plant could provide increased treatment capacity of approximately 12-MGD. If feasible and effective, the treatment system modifications would be completed by 2023. This project goes hand in hand with the CCRO project above.

APPENDIX A



UPDATED PRELIMINARY STUDY OF THE SUSTAINABLE YIELD OF THE GROUNDWATER SUBBASINS WITHIN THE SANTA MONICA BASIN LOS ANGELES COUNTY, CALIFORNIA

Prepared for:
The City of Santa Monica
Water Resources Division
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Consulting Groundwater Geologists
Sherman Oaks, California

Job No. 462-LASOC
June 2018

RCS

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CONSULTING GROUNDWATER GEOLOGISTS

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LIST OF ABBREVIATIONS/ACRONYMS USED IN REPORT

The following provides a list of abbreviations that may be used more than once throughout this report and is provided for the convenience of the reader.

Abbreviation	Description
AF	acre-feet
AFY	acre-feet per year
b	symbol used for saturated aquifer thickness in an equation
BCC	Brentwood Country Club
brp	below reference point
bgs	below ground surface
Cl	Chloride
DWR	California Department of Water Resources
GRA	Groundwater Resources Association
GSP	Groundwater Sustainability Plan
KJC	Kennedy/Jenks Consultants
LACC	Los Angeles Country Club
LADWP	City of Los Angeles Department of Water and Power
LACFCD	Los Angeles County Flood Control District
msl	mean sea level
MWD	Metropolitan Water District of Southern California
PGC	Penmar Golf Club
PWL(s)	pumping water level(s)
RCC	Riviera Country Club
RCS	Richard C. Slade & Associates LLC, Consulting Groundwater Geologists
RWQCB-LA	Regional Water Quality Control Board – Los Angeles Region
S	storativity (storage coefficient of an aquifer)
S_{gw}	groundwater in storage
ΔS	change in water levels for the baseline period
S_s	Specific Storage
S_y	specific yield
SBBM	San Bernardino Baseline and Meridian
SGMA	Sustainable Groundwater Management Act
SMGB	Santa Monica Groundwater Basin
SMURRF	Santa Monica Urban Runoff Recycling Facility
SWL(s)	Static water level(s)
TDS	Total Dissolved Solids
ULARA	Upper Los Angeles River Area
WCB	West Coast Groundwater Basin
WRCC	Western Regional Climate Center

Measurements/Units Abbreviations

gpd	gallons per day; gpm = gallons per minute
gpm/ft ddn	gpm per foot of drawdown; gpy = gallons per year
mg/L	milligrams per Liter; µg/L = micrograms per liter
sq mi	square miles

EXECUTIVE SUMMARY

INTRODUCTION

In support of the City of Santa Monica's (City) efforts to achieve water self-sufficiency, the City has retained Richard C. Slade & Associates LLC, Consulting Groundwater Geologists (RCS) to assess the sustainable yield of the five subbasins within the Santa Monica Groundwater Basin (SMGB). These groundwater subbasins, as identified by others, include the Arcadia, Charnock, Coastal, Crestal, and Olympic subbasins. The City currently has active water wells and pumps groundwater from three of these five subbasins, namely the Arcadia, Charnock and Olympic subbasins. In addition, the City has recently completed a new water supply well (Airport No. 1) in the Coastal subbasin at a location at the City's Santa Monica Airport. The City plans up to two additional wells at the Airport and is currently in the process of permitting the new well for use as drinking water supply. The City has never had any water-supply wells in the fifth subbasin in the SMGB, the Crestal subbasin.

The assessment of the quantity and extent of groundwater in the subsurface and the amount of water that can be sustainably extracted for use is dependent on the understanding and monitoring of a myriad of complex natural system factors, none of which can be determined with absolute certainty. This is because all of these systems are interrelated in some fashion and most transitory through time. The RCS calculations herein for the changes in groundwater in storage for the three subbasins in the Santa Monica Groundwater Basin for which key data are available, are therefore a conservative estimate that will change through time based on the vagaries of climate, geology, natural and artificial recharge, well location and pumping by the City and existing/future third parties. Refining these calculations will be an ongoing exercise that will typically require the latest climate information, water level data, groundwater withdrawal data and subsurface geologic information.

In this current update, the potential sustainable yield of the Olympic, Charnock and Coastal subbasins of the SMGB have been revised, based on data from wells and exploratory borings recently constructed in these subbasins by the City. Thus, this updated report contains the information and data presented in the previous July 2017 report, along with additional data for 2017 regarding rainfall, geology, static water levels in key wells, and groundwater withdrawals from active City wells and known private pumpers. Further in 2017, in addition to the new Airport No.1 well, the City also successfully completed a new municipal-supply well (Santa Monica No. 8, SM-8) in the Olympic subbasin. This well is a replacement for the defective Santa Monica Well No. 7 (SM-7), which was destroyed following completion of SM-8. As part of the City's recent exploratory drilling program a third location, at the City's Colorado Maintenance Yard, was completed as a new groundwater monitoring well in the Coastal subbasin. It should be noted that because these wells have been only recently constructed, no long-term water level data have been generated and such data remains to be collected and evaluated later. Because our evaluations and conclusions presented in this report are based on newly-acquired data, this Updated report supersedes any/all versions generated prior to the date of this current report.

SUSTAINABLE YIELD

Sustainable yield of an aquifer or basin is currently accepted to mean the rate at which groundwater can be withdrawn (pumped) on a perennial basis under specified operating conditions without producing an undesired result. Such undesirable results can include, among other things, the unsustainable reduction of the water resource, degradation of water quality (e.g., salt water intrusion), land subsidence, and uneconomic pumping conditions. The pumpage and change-in-storage method has been used in this evaluation to calculate the sustainable yield values herein. This method basically involves determining the change in static water levels (SWLs) in key water wells and computing the related change in the groundwater in storage, over a representative period of precipitation, known as a hydrologic baseline period; and then deriving an estimated sustainable yield from known annual groundwater withdrawal data that induced those water level changes. The net change in groundwater in storage occurring between the beginning and the end of this selected base period was determined and an average annual change in storage was calculated. The long-term average annual sustainable yield represents the algebraic sum of the calculated values of average annual withdrawals by pumping and average annual storage change for each subbasin.

Storativity is defined as the amount of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit of change in head. Groundwater in storage was calculated using the ground surface area of each groundwater subbasin, the estimated specific yield of the aquifer(s) in which the existing water wells are perforated, and the average thickness of the aquifer systems in each respective subbasin.

A 30-year baseline period from 1988 through 2017 was established to help determine and update sustainable yield values, based on more current hydrologic and hydrogeologic data. Because the City did not pump for several years in the Arcadia Subbasin (4 years) and the Charnock subbasin (13 years), this rendered a level of complexity to the calculation of changes in groundwater in storage in these subbasins for a 30-year baseline period. To overcome this complexity, the change in groundwater in aquifer storage (ΔS) was calculated by assessing a split baseline period in the Arcadia and Charnock subbasins because of the years during which the City did not extract any groundwater from these two subbasins. City wells in the Olympic subbasin were continuously pumped over the entire baseline period and hence, there was no need to split the baseline period for this subbasin

Thus, updated average subbasin withdrawals by the City over the 30-year baseline period are as follows:

- Arcadia subbasin
  440 AFY (wellfield shutdown, and hence no pumping in 4 out of those 30 years)
- Charnock subbasin
  6,290 AFY (wellfield shutdown, and hence no pumping in 13 out of those 30 years)
- Olympic subbasin
  1,860 AFY (continuously pumping during the entire 30-year baseline period)

For comparison, when the recent subbasin withdrawals solely for the 5-year period from 2013 through 2017 are assessed, the average volumes of groundwater pumped solely by the City were:

- Arcadia subbasin: 635 AFY
- Charnock subbasin: 8,042 AFY
- Olympic subbasin: 1,775 AFY

In addition to City withdrawals, there are two golf courses in the Arcadia subbasin, and one golf course in the Crestal subbasin that pump groundwater for irrigation purposes. When these private golf course groundwater withdrawals are included (a total of approximately 570 AFY combined for the two courses in the Arcadia subbasin) the total groundwater withdrawals from the Arcadia subbasin are estimated be on the order of 1,010 AFY over the 30-year baseline period, and approximately 1,200 AFY over the last five years. Potential pumpage by the golf course in the Crestal subbasin is unknown, but could be expected to be on the same order as the other two courses. Taking these withdrawals into account, total combined average annual withdrawals from the three above-listed subbasins has been approximately 9,200 AFY over the extended 30 year baseline period.

The City plans to construct two additional municipal-supply wells in the Coastal subbasin not far from the recently completed Airport No. 1 well. Combined, these three wells would theoretically be able to produce a minimum of approximately 1,450 AFY. In addition, the City is planning to purchase another water-supply well in the Charnock subbasin from a third party. This well reportedly has the capacity to produce another 1,450-1,610 AFY. In the Olympic subbasin, the City is planning to replace a poorly performing well (SM-3), which also has casing problems. When completed this new replacement well is expected to produce approximately 1,368 AFY, which is roughly 360 AF greater than the current supply capacity from the deficient SM-3. The City also plans to bring the new SM-8 well online within the next year. This well replaced SM-7, which has casing problems and was never placed into active production. SM-8 is expected to produce 970 AFY of additional water. Perhaps more importantly, the City is scheduled to begin construction in 2019 on the Sustainable Water Infrastructure Project (SWIP). The SWIP will harvest and treat non-conventional water resources such as runoff, brackish groundwater and municipal wastewater for beneficial conjunctive reuse. When completed, and properly permitted, the SWIP is expected to provide approximately 1,100 AFY of highly treated water for aquifer recharge in the Olympic subbasin, further enhancing the long-term yield of this important subbasin.

Based on the planned water supply improvements discussed above and the total amounts extracted from the three subbasins, and the calculated change in groundwater storage, RCS was able to determine estimated ranges of the sustainable yield for each of the four groundwater subbasins in which the City has water supply wells.

The following table lists: the current estimated yields based on the pumping and change in storage method described elsewhere in this report; the ranges of possible sustainable yield if additional factors such as new wells; storativity in confined aquifers (which is generally higher than that of unconfined aquifers); and mountain front recharge were considered; and previous estimates of sustainable yield values for those portions of the subbasins currently subject to pumping by the City. As noted earlier, the City has never owned or operated any municipal-supply wells in the Crestal subbasin. The estimates below also assume that City wells are pumped on a continuous operational mode (i.e. 24hours per day annually).

GROUNDWATER SUBBASIN	ESTIMATED SUSTAINABLE YIELDS (AFY)	PREVIOUSLY CALCULATED SUSTAINABLE YIELD (AFY)
Arcadia	870 to 920	2,000
Charnock	6,410 to 8,080	4,420 to 8,200
Olympic	2,360 to 3,145	3,275
Coastal	1,160 to 1,450	4,225
Crestal	Yet to be Determined	2,000
Subtotal	**10,800 to 13,595**	**15,920 to 19,700**
Recharge Value	1,000 to 1,130	NA
Total	**11,800 to 14,725**	**NA**

Note: Data from one private golf course in the Crestal subbasin are not included in the above table. The Recharge Factor is a conservative percentage of the estimated annual natural recharge to the SMGB from adjacent and distal mountain front areas derived from USGS data.

The potential for limitations on future groundwater withdrawals from the City's active subbasins presented by the estimated sustainable yields indicates that the City's approach of replacing underperforming wells, investigating additional water supply in the Coastal subbasin and the pursuit of nonconventional resources and indirect potable reuse via aquifer recharge from its planned SWIP are both prudent and necessary for the City to achieve and sustain its long-term objective of independence from environmentally-costly imported water. Importantly, it is recommended that the City continues its heretofore successful water conservation programs, pursues the acquisition of the third party well in the Charnock subbasin, and expedites the further assessment of the Coastal subbasin. Identification of additional viable groundwater reserves in the Coastal subbasin will help alleviate the current heavy reliance on the three subbasins currently providing groundwater supply and could facilitate the implementation of adaptive pumping measures where individual wells or wellfields could be periodically rested to allow for natural recharge.

Based on detailed modeling work conducted jointly by the USGS and the Water Replenishment District of Southern California (2016), and a recent Technical Memorandum prepared by ICF Consulting on behalf of the City (2018), potential recharge to the SMGB via rainfall and underflow in the subsurface from adjacent and more distal mountain front area was estimated to range from 12,131 to 12,722 AFY. Assuming a conservative estimate of 8% of the total amount of annual recharge estimated by the USGS and ICF reports is available to augment basin recharge from local precipitation volumes, then a supplemental recharge factor of 1,000 to 1,130 AFY could conceivably be applied to the currently-calculated sustainable yield, providing a potential upper sustainable value of 11,800 to 14,725 AFY for the City's four primary groundwater subbasins (see table above). The City has engaged Earth Consultants International (ECI) to further assess pathways for basin recharge from mountain front areas utilizing innovative approaches such as Differential Interferometer Synthetic Aperture Radar (DInSAR) data generated by satellite-based platforms.

INTRODUCTION

BACKGROUND

The City of Santa Monica (City) is a general law city, incorporated in November 1886, and is authorized to engage in the provision of water service to its residents and customers, pursuant to California Water Code Section 38730 et seq; it is a "local agency," as defined in California Water Code Section 10753(a). The City provides retail water service through the operation of its City-owned Water Resources Division and its associated groundwater production and treatment facilities that are located both within the City and within proximal areas that lie within the adjoining City of Los Angeles. The City Water Resources Division is currently the sole municipal-supply producer of groundwater from the SMGB; which covers approximately 50 square miles, and underlies and extends beyond the entire 8.3 square mile boundary of the City of Santa Monica. The City's water system serves a resident population of around 93,834 via 17,847 connections. The City's residential population is projected to grow by approximately 1.6% per annum through 2030. Considered a world class tourist destination, the City's visitors can swell the residential population daily by 100,000 persons or more, particularly during the summer months.

As a charter member of the Metropolitan Water District of Southern California (MWD), the City is currently purchasing imported water to augment its local supply. Recent data from 2017 shows the City imports around 25 to 30% of its supply, with the remainder coming from local groundwater. For the long term, the City is committed to eliminating its dependence on imported water. The City seeks to achieve this objective through continued community engagement and water conservation, the sustainable pumping of its local aquifers, and the treatment and reuse of other non-conventional water resources, such as brackish groundwater, dry weather and storm-water runoff, and treated municipal wastewater. Part of this effort which the City is pursuing at present is to site, design and construct additional municipal-supply water wells in certain of the local groundwater subbasins. As an additional element of the City's effort to reduce its dependence on imported MWD water, the City is implementing an ongoing program of sustainable groundwater management in conformance with California's Sustainable Groundwater Management Act (SGMA) of 2014. Towards this goal Santa Monica is the lead agency in the newly-created Santa Monica Basin Groundwater Sustainable Yield Agency

(SMGBSA). The SMBGSA comprises the Cities of Santa Monica, Los Angeles, Beverly Hills, Culver City, and Los Angeles County.

SUSTAINABLE GROUNDWATER MANAGEMENT

In 2014, and in part as a response to State-wide drought conditions commencing around 2010, the State Legislature passed SGMA legislation. Generally, and as described by the California Department of Water Resources (DWR), this act "…*empowers local agencies to adopt groundwater management plans that are tailored to the resources and needs of their communities. Good groundwater management will provide a buffer against drought and climate change, and contribute to reliable water supplies regardless of weather patterns. California depends on groundwater for a major portion of its annual water supply, and sustainable groundwater management is essential to a reliable and resilient water system*" (DWR, Website 2017 at http://www.water.ca.gov/cagroundwater/).

In accordance with SGMA, both the DWR and the State Water Resources Control Board (SWRCB) have been given the responsibility of developing regulations and reporting requirements needed to carry out SGMA for all groundwater basins in the State, except those in which pumping rights have been determined by the courts (i.e., in adjudicated groundwater basins). The DWR has been tasked to determine boundaries of the numerous groundwater basins in the State, to establish a priority ranking of those basins (in terms of such items as total groundwater withdrawals, water level trends, and possible "overdraft"), and to develop regulations for groundwater sustainability. The SWRCB has been tasked to set fee schedules, data reporting requirements, probationary designations, and interim sustainability plans for the basins.

To carry out its duties about SGMA, the DWR has consequently established a program to implement the provisions of the act. To this end, the DWR has set out five basic objectives of that program, namely:

- Develop regulations to revise groundwater basin boundaries.
- Adopt regulations for evaluating and implementing Groundwater Sustainability Plans (GSPs) and coordination agreements.
- Identify basins subject to critical conditions of overdraft.
- Identify water available for groundwater replenishment.
- Publish best management practices for the sustainable management of groundwater.

Recently, the DWR has adopted a Draft Strategic Plan (DWR, 2015) to help achieve those five stated objectives. In its Draft Strategic Plan, the DWR outlined the following elements that the plan will attempt to accomplish:

- A description of current groundwater conditions in the State, demonstrating the unsustainable nature of current management practices and framing the need for action.
- The identification of legislation and other drivers of policy. This includes the SGMA, the California Water Action Plan, and the Proposition 1 Water Bond.
- The identification of "success factors" in addressing the key challenges facing groundwater management in the State.
- Description of the goals and objectives of the plan necessary for program implementation and DWR actions to address these items.
- Presentation of an initial plan for the DWR regarding communication and outreach to partnering, regional and local agencies, stakeholders, and the public.

In the 2015 Draft Strategic Plan (p.5), the DWR cited recent groundwater conditions regarding declines of water levels in many groundwater basins in the State and especially those prone to large-volume withdrawals in support of agriculture. According to the DWR, factors leading to declines in water levels include:

- "Chronic long-term pumping of groundwater more than the *safe yield* of the groundwater basin. Population growth, expansion of agricultural practices, allocation of water to environmental resources and restrictions to protect threatened species all have contributed to either increased water demand or decreased availability of surface water supplies in California. In response, many water users pump groundwater to offset the reduction in surface water supply."
- "Short-term increase in groundwater pumping in drought years. Drought conditions in the last three years have exacerbated the groundwater conditions in many basins as more people use groundwater to meet their needs."
- "Changes in irrigated land use. During the last two decades, more agricultural lands have been converted from annual crops to permanent crops, such as vine, nuts, and fruit trees, resulting in water demand hardening. Permanent crops require irrigation during the drought, while in the past many acres of annual crops were left idle through drought years."
- "Climate change, resulting in reduced snowpack, will exacerbate the water supply and demand imbalance."

SGMA was promulgated for defined groundwater basins in the State, as shown and described in DWR Bulletin 118 (1975, and its 2003, 2004, 2013 and 2016 updates). Under SGMA, the

"DWR was to consider, to the extent available, all of the data components" needed for prioritization of the groundwater basins. DWR is to consider the following elements:

1. "Population overlying the basin".
2. "Rate of current and projected growth of the population overlying the basin".
3. "Number of public supply wells that draw from the basin".
4. "Total number of wells that draw from the basin".
5. "Irrigated acreage overlying the basin".
6. "The degree to which persons overlying the basin rely on groundwater as their primary source of water".
7. "Any documented impacts on the groundwater within the basin, including ***overdraft***, subsidence, saline intrusion, and other water quality degradation".
8. "Any other information determined to be relevant by DWR".

This current study attempts to address Item Nos. 3, 4, and part of Item No. 7, regarding impacts of pumpage on groundwater in the subbasins within the SMGB. The focus of this current RCS report is, thus, on changes in groundwater levels over time in the local subbasins for which adequate data are available.

DISCUSSION OF "PERENNIAL YIELD," "SAFE YIELD," & "SUSTAINABILITY" TERMS

Estimates of the "safe yield" or "perennial yield" of the individual subbasins within the SMGB have been generated for the City by prior investigations. This current study is an attempt to help establish updated values for the perennial (or sustainable) yield, so that the City can determine, for purposes of future planning, the approximate amounts (i.e., volumes) of groundwater that can be pumped on a sustainable basis from each of its local groundwater subbasins, without inducing a negative impact on the groundwater resources within those subbasins for which a sustainable yield can be determined at this time.

The term "safe yield" of a groundwater basin was originally defined as the "rate at which water can be withdrawn from an aquifer for human use without depleting the supply to such an extent that withdrawal at this rate is no longer economically feasible" (Meinzer, 1923). Later, other studies, like Todd (1959, p. 363), noted that the term "safe yield" has been taken by some investigators to imply a "fixed quantity of extractable water [that is] limited to the average annual basin recharge". In our professional opinion, the term "safe yield", if used, should be restricted, strictly to those groundwater basins for which the pumping rights have been adjudicated by the courts. The SMGB has not been adjudicated. An example of a nearby region which has previously been adjudicated by the courts, and where the term "safe yield" is used, is the nearby Upper Los Angeles River Area (ULARA). In this current RCS report, the term "*sustainable yield*," rather than "safe yield" or "perennial yield" shall be used.

Todd (1959, p. 363) also defined the term "perennial yield" as the "rate at which water can be withdrawn perennially under specified operating conditions without producing an undesired result". Such undesired results listed by Todd included:

a) Progressive reduction of the water resource.
b) Development of uneconomic pumping conditions.
c) Degradation of groundwater quality.
d) Interference with water rights.
e) Land subsidence caused by lowered groundwater levels.

Thus, the term "perennial yield" generally refers to a condition that is dependent upon changing groundwater conditions, of which reduction of the groundwater supply and degradation of the groundwater quality in any groundwater basin would be important issues. In essence, "perennial yield" can be considered a dynamic value, which can change under varying conditions of groundwater withdrawals and rainfall recharge.

More recently, the term "sustainable yield" has come into the vernacular as related to groundwater resource potential and supply. Sustainable yield as defined by the DWR is "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result" (DWR, 2017, Sustainable Groundwater Management Act website). Thus, such a definition appears synonymous with the slightly older term "perennial yield," and this current study has been conducted in general accordance with methods that are used to conduct typical "perennial yield" studies. As previously stated, RCS shall use the term "sustainable yield" in the current study to reflect the change to this more commonly accepted term for "perennial yield."

PREVIOUS SUSTAINABLE YIELD VALUES

In an Updated Draft Memorandum (dated March 27, 2013), prepared by RCS for Kennedy Jenks Consultants (KJC) and the City, an initial review was performed of historic reports that had presented sustainable yield values for the subbasins within the SMGB. That 2013-dated

RCS document was utilized by the City as a potential starting point for water resource supply and planning purposes. Specifically, in that Memorandum, RCS tabulated sustainable yield values that had been estimated in previous studies of the groundwater subbasins, as follows:

Groundwater Subbasin	Sustainable Yield Value by Others (AFY)
Arcadia	2,000
Charnock	4,420 to 8,200
Olympic	3,275
Coastal	4,225
Crestal	2,000
Total	**15,920 to 19,700**

Further refinement of those previous values, to the extent permitted by currently available data, was an important objective of this current study.

CALCULATION OF SUSTAINABLE YIELD

Introduction

RCS (1986) cited typical methods of determining the perennial (or sustained) yield of an aquifer system(s) in a groundwater basin. The traditional or classical assessment of sustainable yield is based on evaluation of the key factors of the basic hydrologic water balance equation, where the movement, flows and quantities of groundwater are governed by the equation: Inflow-Outflow = Change in Storage (ΔS). The hydrologic water balance equation is controlled by several variables, as shown in the following equation:

> Surface water recharge (via percolation of rainfall and stream flows and imported water) + Groundwater underflow + Decreases in surface water and groundwater in storage = Surface water discharges + Groundwater outflows + Consumptive use + Export of water from the basin + Increase in surface water storage + Increase in groundwater in storage.

Inflow into a groundwater basin typically consists of: groundwater underflow from upgradient groundwater basins and from adjoining hill and mountain areas; deep percolation of surface water runoff; infiltration of rainfall directly on the ground surface; deep percolation of water in artificial spreading basins; deep percolation of excess irrigation (irrigation return); and direct injection of water into the subsurface. Outflow from a groundwater body typically consists of: subsurface outflow; groundwater extractions by water wells; and spring flow and evapotranspiration of shallow groundwater. When inflow is greater than outflow, the amount of groundwater in storage will increase (and groundwater levels will rise). Conversely, when outflow is greater than inflow, the volume of groundwater stored in the aquifer systems will decrease (and water levels will decline). Thus, if outflow (e.g., pumping from wells) exceeds inflow over time, then water levels will show a gradual decline over time (a decline in ΔS). Such a reduction in groundwater in storage necessitates better management of the groundwater uses to help stabilize water levels whereby water level declines may be reversed to a more stable condition (i.e., no ΔS over time).

The individual data components of the traditional water balance solution of sustainable yield consist of the following:

Specific Inflow elements (recharge) include:

1. Deep percolation of rainfall.
2. Infiltration runoff in rivers, streams and creeks.
3. Deep percolation at spreading basins.
4. Direct use of recharge wells.
5. Deep percolation of imported water (i.e., spreading basins).
6. Groundwater underflow from adjacent basins.
7. Irrigation returns.

Specific Outflow elements (discharge) include:

1. Surface outflow from streams and creeks.
2. Groundwater outflow.
3. Springs (direct surface outflow).
4. Evapotranspiration.
5. Pumpage from wells.
6. Sewer and storm drain system discharges from basin.
7. Export of water resources to another basin.

In the development of a sustainable yield “model” for the SMGB, the following specific elements could be considered for each subbasin for which the required data are available:

1. Selection of an appropriate baseline period for data, based on precipitation records.
2. Collection of available data for wells, such as water levels, representative withdrawals, etc.
3. Calculating groundwater in storage.
4. Calculating the inflows into each subbasin.
    a. Groundwater underflow.
    b. Estimates of direct recharge via precipitation.
    c. Estimates of recharge from surface water runoff and excess irrigation.

d. Estimates of returns from excess irrigation, and from possible subsurface sewage disposal.

e. Annual volumes of imported water.

5. Calculation of outflows from the basin:

   a. Pumpage from City wells.

   b. Flow from University High School Springs

   c. Stream gages (not available for SMGB, thus flows can only be grossly estimated).

   d. Estimated irrigated areas and potential evapotranspiration.

   e. Groundwater underflows (e.g., flow of springs/seeps into ocean); groundwater flow directions and gradients in each subbasin are required.

   f. Per capita/household use of water.

   g. Amounts of local water exported to the Hyperion Treatment Plant.

However, Bredehoeft et al (1982) noted that there is a common misconception among water resources managers about determining the water balance of an area and that certain basic hydrologic principles are being overlooked. Those investigators approached their re-examination of the issue on a purely mathematical basis. They cite that computation of the average water level drawdown can be done through the following basic equation, assuming a water table or unconfined aquifer system:

$$S = \Delta V/(S_y * A)$$

Where: S = the basin-wide average drawdown.

ΔV = the volume removed from storage (discharged and/or “captured”)

S_y = the specific yield of the sediments (i.e., that amount of water that can be removed from storage by gravity).

A = the area of the basin

Because groundwater in the aquifer systems of the SMGB might be under different hydrogeologic conditions (e.g., unconfined, semi-confined or confined), it is recognized that estimates of sustainable yield derived by utilizing the change in storage method could be conservative and that additional compensating factors would need to be considered. An example of one such factor could be the increase in volume of water following release (pumping) of groundwater in storage under confined conditions. However, such an increase in volume could also be relatively minor, compared to total volumes pumped.

Regarding conducting a traditional water balance analysis of the SMGB, historic and current data for each of the items described in the text above were, until recently, generally lacking for the subbasins of the SMGB. However, in 2017 the City began an integrated hydrogeologic data acquisition program that, when fully realized, will allow for transition towards a more traditional water balance analysis in future biennial updates to the sustainable yield of the SMGB subbasins for the purpose of comparing and planning future aquifer management strategies. The results of this current updated study are based primarily on pumpage and change in groundwater in storage, and include a discussion of SMGB recharge from a separate study in 2018 conducted by ICF Corporation (ICF).

In this study, only the physical aspects of groundwater in the aquifer systems have been evaluated, in terms of the potential pumping that could be conducted over the long term without permanently lowering groundwater levels in the local subbasins. Compensating factors include new hydrogeologic data collected by the City and potential recharge to the SMBG from areas previously not considered, such as adjacent and distal mountain front areas. Groundwater quality, another factor to consider that could impact the supply of potable water to the City, is not addressed in this report, because the City is currently treating its pumped groundwater to comply with existing State and Federal regulations in terms of the established Maximum Contaminant Levels (MCLs) that exist for certain constituents in raw groundwater and drinking water. Also, not addressed in this updated report are water rights, primarily because pumping rights in the SMGB have not been adjudicated by the courts, although the City has long been the only significant pumper in the SMGB.

Potential land subsidence caused by historic or future pumping is not within the expertise of RCS and therefore is not addressed. However, anticipating this concern, the City has commissioned a separate satellite-based Differential Interferometer Synthetic Aperture Radar (DInSAR) study to assess various subbasin characteristics, including subsidence. DInSAR technology is capable of detecting minute changes in surface topography caused by groundwater withdrawal, geologic faulting and other natural and anthropogenic forces. A DInSAR study conducted in 2017 by Earth Consultants International (ECI) concluded there were no indications of basin-wide subsidence due to groundwater withdrawal. A supplemental DInSAR study is currently being conducted by the City to assess for potential seasonal near surface pathways for basin recharge from mountain-front areas adjacent to, and possibly distal from, the SMGB. The City is also in the process of working with recognized climate change experts to define a scope of work for conducting climate change stress-tests of its biennial updates to its sustainable yield analysis and conservation programs in order to assist in the adaptive management of all its water resources, and to aid in water related capital improvement project planning and construction.

Summary of Methods for Calculating Sustainable Yield

The pumping and change-in-storage method basically involves deriving sustainable yield from pumpage data and from the change in the volume of groundwater in storage, over a representative period of precipitation and water well operations. To employ this method, the geology of the groundwater basin must be well defined, as to the areal extent and thickness of the water-bearing deposits, and the average specific yield (i.e. related to porosity and permeability) of those materials. After the hydrogeologic characteristics of the basin have been defined, a representative rainfall period (i.e., baseline period) is selected, from which pumpage and the change in groundwater in storage values can be derived. The selected baseline period should not be preceded by a hydrologically high rainfall period to avoid so-called water-in-transit problems. Following selection of a representative rainfall baseline period, and assuming representative water well operations, the volume of pumped groundwater during that period is totaled and an average annual pumpage volume is calculated for this baseline period. The net change of groundwater in storage occurring between the beginning and the end of the selected baseline period is then determined and an average annual change in groundwater in storage is calculated. The annual sustainable yield is then the algebraic sum of the calculated values of average annual pumpage and average annual change in groundwater in storage.

Generally, storativity (or storage coefficient) is the degree to which an unconfined or confined aquifer system yields water to a well; i.e., it is the amount of groundwater in storage that can be provided to a well and is governed by the equation: $S = S_s b + Sy$

Where: S = the storativity
S_s = the specific storage
b = the aquifer thickness.
S_y = the specific yield (that amount of water yielded only by gravity drainage)

Because the pumping and change-in-storage method relies on the specific yield of an aquifer, then for unconfined alluvial aquifers the specific yield is approximately equal to the storativity (the water that can be provided to a well by gravity drainage). However, for confined aquifers the storativity can be greater, because water is supplied to a well not only by gravity drainage but also by that delivered by an increase in the volume of the water pumped from storage, due to lowering the amount of head (pressure) in an aquifer. Thus, as noted previously, the change-in-storage method is considered to provide conservative results for a confined aquifer system, which could yield lower values. Thus, actual changes in groundwater in storage are difficult to quantify, but uncertainty in the calculated values can be reduced by further characterization of the hydrogeologic conditions through the application of additional hydrogeological data such as geophysical logs, pumping tests of local wells, and reasonable compensating factors, such as future recharge volumes not previously considered.

Recognizing the likelihood of lack of available hydrogeologic data and the inherent uncertainties in those data that are available, the pumpage and change-in-storage method is still applicable for estimating the sustainable yield of the subject subbasins, because the City has sufficient data on SWLs and groundwater extraction volumes from each of its wells, and estimates can be made for the known private-party pumping in at least one of the subbasins of the SMGB. Accordingly, the only items required to be analyzed when applying the pumping and change-in-storage method to evaluate the sustainable yield of the local subbasins are the following.

- Precipitation over the study area, as obtained from a representative rain gage.
- Volume of groundwater in storage, as calculated from estimates of the specific yield of the sediments and the total footage of saturated aquifer systems, as identified by evaluation of available electric logs of the boreholes for water wells and wildcat oil/gas wells.
- Representative annual groundwater withdrawals obtained directly from City records and from estimates of pumpage by others.
- Recognition that both unconfined and confined aquifer conditions exist in the SMGB, and therefore resulting estimates of sustainable yield are conservative.

FINDINGS

GROUNDWATER BASIN AND SUBBASIN BOUNDARIES

Figure 1, “Location Map of Study Area”, in Appendix 1, shows the setting of the City of Santa Monica, relative to the State of California. Figure 2, “Map of Groundwater Basins”, in Appendix 2, illustrates the boundaries of the City relative to those of the SMGB and other groundwater basins that adjoin the SMGB. The SMGB, which is currently non-adjudicated, encompasses a surface area of approximately 50 square miles (sq mi). The current surface boundary of the SMGB (and those of the adjoining groundwater basins) is based primarily on published DWR studies (1961, 1965 & 2016). The boundaries of this basin underlie the entire City limits and extend beyond City boundaries into those of the City of Los Angeles on the north, east and south.

Even though this report discusses and provides estimates of the sustainable yield of the five locally-known subbasins identified previously by others within the SMGB, the following is to be noted: the Santa Monica Basin, as defined by DWR Bulletin 118 Update (2016), is known as the “Coastal Plain of Los Angeles – Santa Monica Basin (Basin No. 4-011-01). As such, two key DWR components of the definition of this basin and its boundaries are:

1. No individual subbasins were recognized within the SMGB by DWR.
2. The entire eastern boundary of SMGB was taken by DWR to be along the general northwest-southeast alignment of the Newport-Inglewood fault zone (in fact, DWR has shown this fault to extend northward to the bedrock at the toe of the south flank of the Santa Monica Mountains).

The MWD published a study in 2007 to describe the numerous groundwater basins within its large service area. In that study, the MWD (2007) delineated five separate subbasins within the SMGB, namely the Arcadia, Charnock, Coastal, Crestal, and Olympic subbasins. Figure 3A, “Groundwater Subbasin Boundary Map,” in Appendix 1, illustrates the names and approximate locations of the five groundwater subbasins identified in that MWD study within the SMGB. The basis for the delineation of these groundwater subbasins and their respective boundaries are unknown, as there does not appear to be any available reports that specifically identify when and how those subbasins and their names/boundaries were first formulated. However, the subbasin boundaries appear to loosely coincide with major geological structural features (e.g., faults) in the SMGB, but in some cases certain subbasin boundaries do not follow the reported ground surface traces of such features. For example, the southern boundary of the Olympic subbasin does not exactly follow that of the Santa Monica fault zone, and the eastern border of the Charnock subbasin appears not to follow the ground surface alignment of the Overland Ave fault (see Figure 3A).

As of April 2018, there are 17 existing municipal-supply water wells owned by the City in the SMGB. Of these wells, 10 are being pumped on an active basis to help meet the current water demand of its residents and customers. The other seven City wells are either inactive or are otherwise not in operation. Table1, “Summary of Well Construction Data for Historic and Existing City Wells Used in this Study” in Appendix 2, provides the construction data available for each existing City water-supply well. Figure 3B, “Map of City Well Locations,” shows: the locations and names of existing City wells; the DWR-defined (2016) basin boundaries for the SMGB; and other pertinent information.

GENERAL GEOLOGIC/HYDROGEOLOGIC CONDITIONS

RCS (2013) prepared a report for the City to provide its professional opinions regarding the subsurface hydrogeologic conditions throughout the SMGB; thus, the reader is referred to that report for a detailed discussion of those conditions. For the purposes of this study, only a summary of the hydrogeologic conditions provided in that RCS 2013 report is presented herein, because the focus of this study is to provide estimates of the sustainable yield of the subject subbasins for which requisite data are available.

Figure 4A, “Generalized Geologic Map of the Santa Monica Area,” and its companion, Figure 4B “Generalized Geologic Map Legend & Symbols,” illustrate the geologic conditions as mapped at ground surface by others throughout the SMGB (as identified by DWR, 2016), and provide the legend to the geologic symbols shown on Figure 4A, respectively. Figure 5, “General Stratigraphic Section for the Coastal Plain of Los Angeles County,” shows the stratigraphic relationships and basic geologic framework of the different geologic formations shown in Figure 4A, as mapped by the DWR (1961). Specifically, the sediments/rocks within and beneath the SMGB portion of the City of Santa Monica are divided into two broad groups: 1) a potentially water-bearing sediments group (these deposits tend to be readily capable of absorbing, storing, transmitting and yielding groundwater to water wells); and 2) a non-water-bearing rocks group which underlies the water-bearing sediments and which are comprised by geologically old, lithified, or cemented sedimentary rocks and/or crystalline rocks of low permeability. These two groups of earth materials are described below.

Water-Bearing Sediments

Recent (Holocene) Alluvium

Alluvium, which is of the Recent or Holocene in geologic age, occurs along and within the relatively narrow mountain front canyons and creek channels that drain across the SMGB. These Recent alluvial deposits are geologically young and likely attain a maximum thickness of only perhaps 50 to 150 ft in the Santa Monica area. In general, these earth materials are relatively shallow deposits of unconsolidated to poorly consolidated, complexly inter-layered and inter-fingered deposits comprised by gravel, sand, silt and clay. Permeability ranges from moderate in the coarser-grained sand units to relatively low in the clay-rich layers. Groundwater, where present in this shallow aquifer system, is considered to occur under water table conditions (unconfined), and, thus, this groundwater occurs strictly within the void spaces between the gravel and sand grains in each layer. Because of their limited areal (spatial) extent and their limited thickness, these alluvial deposits are not a viable source of groundwater for the City.

Lakewood Formation

The Lakewood Formation, which is of upper Pleistocene age, lies directly beneath the various alluvial deposits in the region. The upper portion of this formation is of continental origin (i.e., its sediments were shed from the north and east by the erosion of the Santa Monica Mountains and other, local but smaller highland areas). In contrast, the lower portion of this formation reportedly contains sediments of marine origin (sediments deposited by the ocean). Overall, this formation is comprised by layers and lenses of poorly consolidated gravel, sand, silt and clay.

The DWR (1961) has identified and named several aquifers in the Lakewood Formation in the Coastal Plain area of Los Angeles County. These aquifers include: the "Palos Verdes Sand;" the Exposition aquifer; the Gage aquifer; and the Gardena aquifer (see Figure 5). Each of these sandy and/or gravelly aquifers is separated by fine-grained, silty and/or clayey strata known as aquicludes; such aquicludes have only limited permeability and are not considered usable as potential sources of groundwater. However, these aquifers have not been documented by the DWR or others to be present in the SMGB. Thus, these strata were either never originally deposited in the basin, or the original formation sediments were subsequently removed by erosion following their deposition. Hence, groundwater from this formation would not be available to the City for any future water wells.

San Pedro Formation

Directly underlying the Lakewood Formation is the San Pedro Formation of lower Pleistocene age. According to DWR (1961 and 1965), this formation may attain a maximum thickness of from 100 to 280 ft in the Santa Monica area, whereas it may attain a thickness up to 300 ft in the Ballona Gap to the south.

Key aquifers identified and named by DWR (1961; see Figure 5) within this formation include, from "top" to "bottom," the following: the Hollydale aquifer, the Jefferson aquifer, the Lynwood aquifer, the Silverado aquifer, and the Sunnyside aquifer (which is very near the base/bottom of the entire formation). Once again, these aquifers are separated by various thicknesses of intervening fine-grained, clay-rich aquicludes of much lower permeability. The Silverado aquifer is well known because it is pumped by many water wells across the entire Coastal Plain of Los Angeles County. In SMGB, many of the stratigraphically higher (shallower and younger) aquifers have been removed by erosion after their deposition, and only the Silverado aquifer is interpreted by the DWR (1961) to exist. It is possible, however, that the Sunnyside aquifer may also be present and, if so, it would form the base of the aquifer systems available to new wells in the local groundwater subbasins.

One notable consideration for some of the aquifers in the San Pedro Formation is that they often contain uniform, fine-grained sands, which if not properly accounted for during the design and construction of a new water well, tend to enter the perforated sections of the well casing whenever the well is pumped; this leads to sand in the groundwater pumped from a well (i.e., such a well is known as a "sander, such as the former SM-7 which was recently replaced by the City with well SM-8. Another notable consideration for these aquifers, and for the San Pedro Formation as a whole, is that they have been impacted over time by geologic forces, mainly faults, which have offset and displaced the earth materials and created possible barriers to groundwater flow. In addition, folds are present which have "bent" or "warped" the sedimentary layers into different inclinations from the horizontal.

Driller's logs of water wells and available geophysical electric logs (E-Logs) of water wells and wildcat oil wells have been acquired and reviewed by RCS. Those efforts reveal that the San Pedro Formation is comprised by moderately consolidated and stratified layers and lenses of fine-grained gravel, sand and silt which contain various amounts of clay (RCS, 2013). Colors in these layers and lenses vary from tan to buff to yellow brown in the upper portions of the formation; such colors indicate an oxidizing environment. Older portions, nearer the base of the formation, tend to be of marine origin, tend to have a gray to gray black color, and often contain fossil marine shells. Those darker colors indicate an anaerobic, or reducing, environment.

As noted above, only the lower (and somewhat more consolidated) portion of the San Pedro Formation exists in the SMGB. Further, correlation of available E-logs reveals the overall thickness of this formation is essentially zero along the front of the Santa Monica Mountains on the north side of SMGB, and thickens to perhaps 300 to 400 ft on the south side of the basin. Importantly, this formation supplies nearly all the groundwater being pumped by existing (and future) water wells in SMGB.

Non-water-Bearing Rocks

Immediately beneath the San Pedro Formation (i.e., the bottom of which is generally considered to form the base of fresh water in the SMGB) is the Pico Formation of upper Pliocene age. Even though this formation may contain some groundwater, it is generally considered to be not capable of yielding water to wells in sufficient quantities and of adequate quality for municipal-supply purposes; hence it is also considered herein to be "non-water-bearing;" albeit a few wells in the Lakewood area have been reported to obtain usable groundwater from the Pico

Formation (DWR, 1961). Local examples are Arcadia Well Nos. 4 and 5, which appear to have at least some of their perforations (in the lower portion of each well) placed into the upper portion of the Pico Formation.

Strata within the Pico Formation tend to be well-bedded and well-consolidated, and to consist principally of interbedded deposits of clay, silt, sand and gravel of marine origin. Individual beds of gravels and sands are reported to range in thickness from 20 to 100 feet and are separated by thicker beds of clay and micaceous siltstone (by DWR, 1961). The Pico Formation is also known to contain petroleum and/or natural gas (often methane) at greater depths.

Below not only the base of the water-bearing sediments which form the SMGB, but also beneath the Pico Formation, and as also exposed at ground surface in the Santa Monica Mountains to the north, are a series of geologically older, lithified and/or cemented, sedimentary rock formations and various crystalline metamorphic and igneous rocks. Because of their lithified and/or cemented and/or crystalline character, these rocks do not contain free water in the interstices between the individual sand or gravel grains or within the matrix of the rock. Rather, the groundwater in these rocks is contained solely within fractures, joints, and/or along bedding planes. Hence, the groundwater storage capacity of these rocks is low, and their long-term ability to yield groundwater to water wells is poor. Consequently, only limited quantities of water are available to wells from these types of rocks. Moreover, electric log signatures of the sedimentary rocks in this group, as encountered in deep wildcat oil/gas wells in and around the SMGB, suggest the contained groundwater is brackish in character and non-potable. It is likely the original connate water in the existing sedimentary rocks was never flushed by percolating fresh water over time. For these reasons, these rocks are classified as non-water-bearing in the Santa Monica region and, therefore, these older formations and rocks are the local bedrock (or basement rock), and they are also not a part of the SMGB.

Geologic Structures

There are several significant geologic structures, consisting chiefly of faults, that occur throughout the Los Angeles Coastal Plain region and a few of these occur in and proximal to the SMGB. These structures can impact the movement and direction of groundwater and have been selected by others to form the boundaries between adjoining groundwater basins in the Coastal Plain, and even between the subbasins (as defined by others) which comprise the SMGB (as defined by DWR). A more detailed discussion of these local faults was provided in RCS (2013) and is presented herein strictly for information purposes, regarding the SMGB and its subbasin boundaries. It is not within the scope of services for this project to describe or evaluate the relative movement of these faults and/or their history of or potential for movement. Figure 6, "Map of Watershed and Local Drainages," shows, among other things, the approximate locations of the faults described herein.

Key structures mapped by others to define the boundaries of the SMGB and its subbasins, include the following:

- The Hollywood-Brentwood fault system, which traverses the area in a general east-west direction across the northern edge and north-central portion of the SMGB. This fault system forms the northern boundary of the Olympic subbasin (i.e., the southern boundary of the Arcadia subbasin).
- The Santa Monica fault system, which extends across the basin in a general east-west direction, forms the northern boundary of the Coastal subbasin (or the southern boundary of the Olympic subbasin). Based on modeling conducted by the City, an alternative interpretation is that this fault may not extend upward into the shallower sediments nearer ground surface in the Olympic subbasin. This scenario could provide a pathway for recharge from the Olympic subbasin into the Coastal subbasin.
- The Newport-Inglewood fault zone, which traverses in a general southeast to northwest direction across the Coastal Plain, is considered to form the eastern boundary of SMGB and its Crestal subbasin. As seen on Figure 4A, DWR has extended this fault northward to the southern edge of the Santa Monica Mountains. Thus, this fault (per DWR) forms the boundary between the SMGB on the west and the Hollywood Groundwater Basin and the Central Groundwater Basin on the east.
- The Overland Ave fault, which is an en-echelon fault associated with the Newport-Inglewood fault zone, which creates the eastern boundary of the Charnock subbasin.
- The Charnock fault parallels both the Overland Ave fault and the Newport-Inglewood fault zone and forms the eastern boundary of the Coastal subbasin (or western boundary of the Charnock subbasin).
- The Santa Monica Mountains delineate the northern boundary of the SMGB whereas the Ballona Escarpment demarks the southern boundary of the SMGB (see figures 3A & 4A).
- The westerly boundary of the SMGB is the Pacific Ocean.

WATERSHED AREA

There are several canyons located along the front of the Santa Monica Mountains that drain in a general southerly direction from those mountains into the SMGB. Figure 6 illustrates the locations and names of the key local drainages and the main watershed divide along/near the crest of the Santa Monica Mountains, north of the City. The watershed boundary has been adapted from a watershed map prepared by the Interagency Watershed Mapping Committee (October 1999). Also shown on Figure 6 are: the City limits; the boundaries for DWR's SMGB; and the names and boundaries for the subbasins within the SMGB, as identified by others. As noted above, some of these faults have been taken by others to form the boundaries between those individual subbasins.

Figure 6 illustrates only that watershed area where the local streams can drain directly into and across the SMGB. Rainfall falling within this watershed will have the potential to directly recharge the aquifer systems underlying the northern and central portions of this basin. Thus, the aquifers underlying the SMGB are recharged in part by deep percolation of direct runoff in streams crossing the Santa Monica area. Another component of recharge to the shallow aquifer systems would also occur by percolation of direct precipitation on the topographically flatter portions of the local subbasins (i.e., the areas located south of the Santa Monica Mountains). One other recharge component is deep percolation of excess irrigation on: residential lawns; golf course turf; park areas; and even landscaped street medians.

Based on Figure 6, the area of the watershed, including the mountain/hillside areas and the SMGB itself, was calculated to be approximately 86 sq mi. Of this, approximately 36 sq mi are comprised by the largely undeveloped hillsides on the south flank of the Santa Monica Mountains, whereas the remaining 50 sq mi are occupied by the surface area of the SMGB which extends south to the northern boundary of the West Coast Groundwater Basin (WCB; see Figure 6).

There is likely an additional input of recharge to the SMGB from the Hollywood and Central groundwater basins on the east, and perhaps also from the WCB on the south (minor amounts of rainfall recharge from this basin occur, due to drainage from the Ballona Escarpment area). Recharge to SMGB from these adjoining groundwater basins would occur via subsurface underflow (see locations of these adjoining groundwater basins on Figure 3A and/or Figure 6A). While the amounts of such underflow are unknown, the aforementioned USGS modeling report and the related ICF Technical Memorandum pertaining to mountain front recharge suggests these volumes of underflow could be significant. Furthermore, a portion of surface water runoff along Ballona Creek can recharge the sediments of the shallow Ballona aquifer, but most of the surface runoff along this creek eventually drains to the Pacific Ocean. The magnitude of the amount of recharge along Ballona Creek to the deeper aquifer systems, such as the Palos Verdes sand, the Silverado aquifer, and/or the Sunnyside aquifer, is unknown.

The Newport-Inglewood fault zone along the east side of the SMGB is, at least, a partial barrier to groundwater flow from the east to the west. Thus, additional inputs of recharge water to deeper aquifer systems along this boundary, such as the Palos Verdes sand, and the Silverado and the Sunnyside aquifers may not be significant. Further, because these aquifer systems generally dip from north to the south across the SMGB, and this dip direction continues southward into the WCB, any recharge along Ballona Creek (in the southern portion of SMGB) would likely flow southward and, therefore, it would not add to the groundwater in storage beneath the City.

NATURAL RECHARGE

The aquifer systems underlying the City are generally replenished by rainfall falling directly on the surface of the land, through infiltration of stream runoff along canyons/streams and gullies, especially along the front of the Santa Monica Mountains, and by irrigation return water. Recharge along the front of the Santa Monica Mountains and into the sediments of the Sawtelle Plain are likely significant along major canyons, such as Rustic, Santa Monica/Sullivan, Mandeville, Kenter, Sepulveda, Dry and Stone canyons.

To better quantify recharge in the SMGB, the City retained ICF to determine potential recharge based on a detailed study on the subject prepared jointly by the United States Geological Survey (USGS) and the Water Replenishment District of Southern California (WRD) titled; *Estimating Spatially and Temporally Varying Recharge and Runoff from Precipitation and Urban Irrigation in the Los Angeles Basin, Scientific Investigations Report 2016-5068.* As part of this detailed study, the USGS assessed the amount of water that can be attributed to natural recharge from precipitation, runoff and urban irrigation (USGS, 2016) for the Los Angeles (coastal) basin, which includes the SMGB. The USGS study also included all the surface water drainages bordering the SMB (e.g., mountain-front areas) that could potentially contribute recharge to the adjacent sediments in the basin. The USGS developed a model which incorporated a new method for estimating recharge from residential and commercial landscape irrigation based on land use and the percentage of pervious land area. The USGS model also assessed climate data from over 200 monitoring sites, including monthly precipitation and maximum and minimum air temperatures. It also included data for land use type, land cover, soil, vegetation and surficial geology. The model was calibrated to available stream flow records.

Based on their review of the USGS data, ICF found that the potential combined average mountain-front and urban inflow into the SMGB was on the order of 11,212 AFY, not including recharge from the estimated volume of non-revenue City water which is currently thought to range between 2% and 5% of the total treated water placed into distribution within the City's water system. Thus, for 2017, the volume of non-revenue water could be approximately 226 to 565 AFY. Recognizing that the valleys and ridges of the mountain-front represent a three-dimensional terrain that contains additional surface area not accounted for in a traditional two-dimensional area calculation, the City had a LiDAR base map prepared and then overlaid a Triangular Irregular Network System (TINS) on the topography which allowed a computer algorithm to calculate the surface area as if the mountain ridges were flattened out. An analysis of the TINS data by Earth Consultants International (ECI) estimated an approximate 12% increase of mountain-front recharge area. When this information is factored into the USGS inflow average, the annual inflow could be on the order of 11,927 AFY, or a range of 12,153 to 12,492 AFY when the estimate of non-revenue water inflow (226 to 565 AFY; see above) is added to the overall USGS inflow volume. A copy of the ICF Technical Memorandum is provided in Appendix 3.

Preliminary DInSAR data compiled by ECI suggests that other inflow may be occurring in the near subsurface from mountain-front areas outside of the SMGB. If confirmed by the ongoing Supplemental DInSAR study, the estimated inflow from these distant recharge areas could increase the total inflow into the SMGB by perhaps an additional 716 to 1,000 AFY, bringing the range of the average potential SMGB inflow to be 12,869 to 13,492 AFY.

Outflow from the SMGB to the northern end of the West Coast Basin (WCB) appears to be indicated in Figure 2.1 of the "Regional Groundwater Monitoring Report for Water Year 2015-2016," as published by WRD; that figure is reproduced herein as Figure 7, "Groundwater Elevation Contours of the West Coast & Central Groundwater Basins." Review of Figure 7, which shows contours of the equal elevation of groundwater for Fall 2017, reveals that due to pumping within the WCB, the overall direction of groundwater flow at the northwestern portion of that basin, and in the area between the Charnock fault and the Newport-Inglewood fault zone, is generally towards the southeast. This can be seen by groundwater contours being between mean sea level (msl) and 10 ft below msl in the area southwest of the Charnock fault and between 20 to 70 ft below msl in that area between the Charnock fault and the Newport-Inglewood fault zone (see Figure 7).

To assess these possible outflow conditions and how they relate to the Coastal subbasin and the overall sustainable yield of the SMGB, the City is planning to work in close consultation with the USGS on a phased project to, among other things, integrate the City's existing groundwater flow data that is wellfield-specific, into the broader USGS flow modeling for the SMGB. When completed, the integrated flow model will provide the City with a powerful tool for the adaptive management of its groundwater resources. Current plans are to have a preliminary version of the integrated flow model by the USGS available by 2020.

ARTIFICIAL RECHARGE AND CONSERVATION

Introduction

Artificial recharge can be important to the overall water balance and is typically conducted by either directly injecting properly-treated water into the subsurface via recharge (injection) wells, or by allowing water to percolate into the subsurface sediments by diverting surface water into artificially-constructed basins known as spreading grounds.

Because of the degree of urbanization within the City and the surrounding groundwater subbasins, there is insufficient available land area to support artificial recharge on the scale necessary to derive maximum benefit via the construction of spreading basins at ground surface in the SMGB. Further, the surface sediments in many parts of the City are fine-grained, with a high percentage of poorly permeable silt and clay, making surface water percolation in those areas less feasible.

According to available records, the City conducted limited subsurface recharge of imported MWD water at one of its wells in the Charnock wellfield for a period of approximately 13 years (between 1975 and 1988). However, the amount of water injected was relatively small and ranged only from 0.3 AF in 1977 to 2,533 AF in 1979 (see RCS, 2013). Specifically, the City's Charnock Well No. 12 was used to inject the imported MWD water to help replenish the aquifer systems in this Charnock wellfield area. However, that well was destroyed in the 1990s and water is no longer being injected by the City into any well at its Charnock wellfield (or any other City wellfield) at this time

As discussed earlier in this report, a key objective of the City's SWIP is to produce highly treated water that, when properly permitted, could provide as much as approximately 1,100 AFY of new water for aquifer recharge at the Olympic wellfield. The SWIP is scheduled to begin construction in 2019, and the City has already embarked on the permitting process for SWIP treated water applications with the LARWQCB, State Water Board Division of Drinking Water (DDW), and the LACDPH.

Sustainable Water Master Plan

Santa Monica is a recognized leader in California for its environmental and water conservation policies. The City has been actively implementing water efficiency programs since 1988 and is one of the original signatories to the State's Memorandum of Understanding Regarding Urban Water Conservation in California (MOU) adopted in 1991 and amended in 2008. In 2014, the City adopted a Sustainable Water Master Plan (SWMP) with the goal of achieving water supply self-sufficiency in 2020 by eliminating reliance on imported water from the Metropolitan Water District (MWD). Since the adoption of the SWMP, the City has been actively implementing new water supply, water reuse and conservation programs and projects to achieve this objective. Two City conservation programs that influence both local water demand and irrigation, and hence, the sustainable yield of the subbasins within the SMGB are:

Water Neutrality Ordinance

On July 1, 2017, the new Water Neutrality Ordinance went into effect capping water use for new developments to the average five-year historical use for that individual parcel. If the projected annual water use for the development is greater than the existing annual average for that parcel over the past five years, the increased amount must be offset by water-efficient retrofits of an existing building somewhere else in the City. Offset retrofits currently include low-flow indoor fixtures (toilets, showerheads, and aerators). The ordinance applies to pools, ponds, spas and other water features as well. This ordinance was developed and is currently being implemented by the City (SMMC 7.16.050).

Water Efficient Landscape and Irrigation Standards

Green Building Ordinance Update: Santa Monica has had a Green Building Ordinance with irrigation components since 2008. In December 2016, the ordinance was significantly updated to reduce the amount of outdoor water use for new developments. Overhead spray irrigation is banned for all new developments and for new landscape on existing developments. In addition, turf grass is banned on new commercial developments and is limited to 20% of landscaped area for new residential developments. (SMMC 8.108).

Taken together, these two programs, along with other permanent non-behavior-based conservation programs (e.g., low flow toilets, washing machine replacement at multi-family units etc.), are estimated to be able to conserve approximately 1.5 to 3.0% of the total water demand of the City by 2020. Reduction in total future demand by either conservation or reuse will result in savings in local groundwater production and helps support the City's twin long-term objectives of protecting and sustaining the strategic yields of its groundwater resources and water self-reliance.

HYDROLOGIC BASELINE CONDITIONS

Rainfall Totals

As discussed in previous sections, direct rainfall both local and on adjacent mountain front areas and its subsequent runoff and deep percolation has a very important impact on groundwater levels and, hence, on the effect of recharge to groundwater in the local SMGB. Further, ongoing conservation programs that provide for permanent water savings and aquifer recharge via the SWIP will reduce demand and contribute towards offsetting natural potential outflow from the SMGB. To help calculate the estimated sustainable yield, RCS utilized information provided in the ICF Technical Memorandum and acquired available rainfall data through the website of the Western Regional Climate Center (WRCC) for the Desert Research Institute at the University of Nevada, Reno for several (four) rain gages within and around the SMGB, to compare the data from each of the gages. The rain gages assessed in this study are:

- Gage WR047953 at the Santa Monica Pier (however, no data are available after 2016 for this gage).
- Gage WR044214 in the Center of Culver City
- Gage WR049152 at the University of California, Los Angeles (UCLA).
- Gage WR045114 at Los Angeles International Airport (LAX) which is located south of and outside of the SMGB and, thus, is not directly applicable to conditions affecting the Santa Monica area. It is used herein only for the purposes of comparison.

These rain gages are generally located on the west, south of, in the southeast portion, and in the northeast portion of the SMGB. The approximate locations of these rain gages, as provided by the WRCC, are shown in Figure 6.

Figure 8A, "Annual Rainfall Totals", in Appendix 1, illustrates the annual rainfall totals as a bar graph for all four rain gages; these data span a maximum period of record from 1934 through 2017 (depending on the rain gage, because the beginning and ending years for each rain gage are different, as shown thereon). Based on these rainfall data, the following are notable:

- The long-term average annual rainfall for the four rain gages from this period of record (1937 through 2017) ranges from 10.91 inches (through 2016) at the Santa Monica Pier rain gage, to 16.22 inches at the UCLA rain gage located near the northeastern corner of the SMGB.
- The highest annual rainfall totals generally occurred at the UCLA rain gage, whereas the lowest annual rainfall totals typically occurred at the Santa Monica Pier rain gage. This phenomenon is likely attributable to the effects of orographic lifting which causes moist air to cool and induce precipitation as it moves up and over the Santa Monica Mountains, thus accounting for the higher totals at the UCLA gauge and along the mountain front in general.

Accumulated Departure of Rainfall

Figure 8B, "Accumulated Departure of Rainfall" (Appendix 1), shows the local annual patterns in rainfall for the period of record of the various rain gages and is used to ascertain if there is a correlation between wet periods and wellfield water levels (i.e., recharge). The accumulated rainfall departure values on the figure are plotted relative to the long-term average annual rainfall for each of the rain gages and their respective period of record. The accumulated departure curve illustrates temporal trends in the rainfall data and helps to identify local long-term patterns (or trends) in rainfall over time. This figure reveals the following:

- Those portions of the curve ascending towards the right-hand side of the graph (positive slopes) indicate a series of years when the annual rainfall was generally at or above the long-term average. Thus, this defines a generally "wet" period, when the accumulated precipitation totals were increasing, relative to the long-term mean value. Conversely, the slopes of the curves declining to the right-hand side of the graph (negative slopes) indicate those years where accumulated precipitation totals were declining, relative to the long-term average; these declining trends represent general periods of deficient rainfall or a "dry hydrologic period" (i.e., a drought). These "wet" and "dry" periods are specifically denoted on Figure 8B for the rain gage data evaluated herein.
- Based on the data, three rain gauges more or less correlate with each other. Those gauges are Culver City, LAX, and UCLA. Data from the fourth gage, Santa Monica Pier, appears skewed, and therefore was not considered further. Of the three remaining

gages, the Culver City gage was selected for use in this study due to its proximity and compliance with the selection criteria listed below.

Selection of Baseline Hydrologic Period

A key step in determination of the sustainable yield utilizing the pumpage and change in storage method is the selection of hydrologic baseline period for rainfall that would be representative of long-term conditions, as obtained from an accumulated departure curve. These data would then be correlated to static (non-pumping) water levels at/near the City's wellfields.

In selecting such a baseline period from the selected accumulated departure curve, the following criteria were utilized:

- The period includes both hydrologically wet and dry cycles.
- The period ends near the present for which historical data are available.
- The accumulated departure from mean annual precipitation is similar for the beginning and end of the period.
- Cultural conditions are similar at the start and end of the period.
- Adequate data on water levels and groundwater extractions are available throughout the identified baseline period.

Review of Figure 8B shows that the rain gages at LAX and UCLA display very similar trends over time, with respect to their accumulated departure percentages. The Culver City gage, although it has similar trends as those for the LAX and UCLA gages from the early-1980s onward, displayed different trends than those two gages prior to the early-1980s. Figure 9, "Selected Baseline Period," shows that the 30-year period from 1988 through 2017 satisfies the above criteria, particularly for the Culver City and LAX rain gages, as follows:

- The 30-year period for these two rain gages includes both a hydrologically wet cycle and a hydrologically dry cycle. The years 1992 through 2010 may be considered a "wet" cycle, whereas the years 1988 through 1992 and 2010 through 2016 constitute a "dry" cycle. However, there is a slight deviation from this in the Santa Monica Pier and UCLA rain gages, which show that the "wet" cycle at the outset of 1988 in the previous two curves commences a year before.
- Sufficient historical data are available for pumping withdrawals and static water levels for the new 30-year period (1988 through 2017).
- The accumulated departure from mean annual precipitation occurs at approximately the same "level" in 1988 as it does in 2017 for the two key rain gages (Culver City and LAX). However, and particularly for the Santa Monica Pier rain gage but also somewhat for the UCLA rain gage, the accumulated departure differs considerably.

The following compares the average historic rainfall to the average rainfall for the 1988 through 2017 for the LAX and Culver City gages:

Rain Gage	Rainfall Average, Period of Record (inches)	Rainfall Average 1988 - 2017 (inches)
Culver City	12.02	11.88
LAX	11.77	11.60

- The differences in average rainfall for the 30-year baseline period between the Culver City and LAX rain gages are 0.14 inches and 0.17 inches, respectively.
- Current cultural conditions in the SMGB (population, developed area, etc.) are similar to what they were in 1990, although the population has increased slightly, from approximately 86,900 in 1990 (US Bureau of the Census, 1992) to the current 93,000. This is an increase of around 6,100 over 27 years
- There is sufficient historical data available from the various City wells, for annual rainfall conditions, and for groundwater withdrawals by the City over the 30-year baseline period. However, reliable static water levels not available for all City wellfields; this may be particularly true for the Charnock wellfield.

For this study, the accumulated departure of rainfall curve for Culver City was selected as a "best fit." Thus, these data were used to help discern possible trends in the SWLs in City water-supply wells, as discussed later herein.

GROUNDWATER WITHDRAWALS

<u>Withdrawals by the City</u>

Available data for the total historic groundwater production from each City-owned wellfield have been tabulated, along with RCS estimates of private pumpage by others, on Table 2, "Groundwater Production from City Wells and Other Wells (1988 through September 2017)." The tabulated values for historic total annual groundwater withdrawals during this 30-year period were those available from: City reports and Excel spreadsheet data provided to RCS by the City for its wells in the Arcadia, Charnock, and Olympic subbasins; from another third party water company well owner, for its limited production from its Charnock wellfield up through 1996; and from RCS estimates of groundwater withdrawals for irrigation-supply from private wells located at two known golf courses in Arcadia subbasin. There have never been any active, City-owned, municipal-supply wells in the Coastal or Crestal subbasins and, thus, there are no City withdrawal data for these two subbasins.

Table 2 presents data for the period of 1988 through 2017 hydrologic baseline period and shows the following:

a) The Arcadia wellfield has historically been the least productive of the three existing City wellfields. Minimum and maximum annual groundwater production at this wellfield has ranged from 0 AF for at least 4 years (1997 through 1999) to 714 AF in 2014. The average annual groundwater production by active wells at this wellfield was approximately 440 AFY during the 30-year baseline period. By way of comparison, groundwater extracted for the recent five year period between 2013 and 2017, the average was 635 AFY at that wellfield.

b) The Charnock wellfield continues be the most productive of the City's three wellfields. Minimum and maximum groundwater withdrawals have been: 0 AFY in the 13-year period 1997-2009, inclusive, which was caused by problems relating to third party groundwater contamination at and near this wellfield; and 8,377 AF in 2014. For the 30 years of data on Table 2, discounting the 13 years when the entire wellfield was purposely shut down, the long-term average annual withdrawal was approximately 6,290 AF. However, given the fact that various wells are known to have had mechanical and/or regulatory limitations that have affected wellfield production, it is likely that the estimated sustainable production rate for the wellfield has been previously underestimated, especially when estimates of basinwide recharge are considered. For the five year period between 2013 and 2107 the average withdrawal was 8,048 AFY. In further recognition of this supposition, the City is exploring the acquisition of an existing but currently unused water-supply well on an adjacent property owned by a third party. That "new" well would likely increase overall production by the City from the Charnock wellfield region by 1,450 to 1610 AFY.

c) The Olympic wellfield represents the second most productive of the three City's existing wellfields. As seen on Table 2, the minimum annual groundwater production from this wellfield was 385 AF in 2004, whereas its largest annual production volume was 3,176 AF in 1995. The average annual production from this wellfield during the 30-year baseline period was 1,860 AF. Like the Charnock wellfield, the Olympic wellfield has also experienced periods of mechanical problems and regulatory limitations related to is overall annual production rates and volumes, and thus when the estimates of basin inflow are considered, the sustainable production capacity of this wellfield is likely greater than the current annual average extraction value. Examples of operational limitations include restricted production in 2003-2004 due to nearby leaking underground fuel storage tanks, and well casing problems in SM-3 that required a new liner to be installed. This casing liner had the effect of significantly reducing the amount of water that could be pumped from this well. Recently the City has constructed a new well (SM-8) that is believed to be capable of producing approximately 970 AFY of additional water. The City also plans to replace the deficient SM-3 well. That new well, when completed later this year, is anticipated to be capable of producing approximately 750 gpm, or ±1,200 AFY. Lastly, when properly permitted, highly-treated water from the SWIP can be artificially recharged into the aquifer systems near SM-8; the overall production from that well and available groundwater yield from this wellfield should increase.

The total groundwater withdrawals from the three subbasins in which the City has had its active wells has ranged approximately from 522 AF in 2004, to 11,001 AF in 2016. The average annual production during the 30-year baseline period has been on the order of 8,590 AFY for all City-owned wells. This average production includes only those years in which pumping was performed by the City from the three subbasins, which eliminates the 4 years of non-pumping conditions in the Arcadia subbasin (from 1997 through 2000), and the 13 years of non-pumping conditions from the Charnock subbasin (from 1997 through 2008). As noted above, it does not consider documented mechanical or regulatory limitations that may have adversely affected production rates; see Table 2.

It should be noted that a few City wells, namely Arcadia Nos. 4 and 5, Santa Monica No. 3, and Charnock No. 13, reportedly had wire-wrapped steel liners installed inside the original well casing at some time after the original construction of the well. Such casing liners are needed when, for example, the original well begins to pump sand. The typical impact of these liners on each well is to reduce the overall specific capacity of the wells, thereby increasing the amount of drawdown in the well and/or limiting the ability of the wells to pump at its former rates. However, it does not necessarily limit the ability of the wells to produce the same volume of water prior to liner installation, because the same water volume can be pumped if the newly-lined well pumps for a longer duration, but at its lower rate. As noted elsewhere herein, the City has plans to replace SM-3 with a new well in the future.

Groundwater Withdrawals by Others

The only other existing groundwater withdrawals that currently occur in the SMGB subbasins are from one privately-owned residential irrigation well, and irrigation wells at three golf courses, namely the Brentwood Country Club (BCC), the Riviera Country Club (RCC), and the Los Angeles Country Club (LACC). Because the three golf courses lie mainly within the City of Los Angeles, it can be assumed that Los Angeles provides potable water for all domestic needs at those golf courses. Thus, the onsite water wells at each golf course are assumed herein to provide sufficient groundwater to meet the entire annual irrigation demands of each golf club (i.e., none of the water supplied by the City of Los Angeles is assumed to be used for irrigation-supply). Two other golf courses exist in the SMGB, the Bel Air Country Club and the Penmar Country Club. However, neither of these courses reportedly has any existing onsite water-supply wells at this time.

Historically, there have been other wells that were known to have formerly been used to extract groundwater for municipal-supply from the SMGB. These wells are owned by a third party and were reported to include the following:

- Wells at that third party's Charnock wellfield in the Charnock subbasin; the last wells in this wellfield were shut down at the end of 1996 due to the presence of MTBE contamination in the groundwater being pumped by the City's Charnock wells located to the northeast. In the last two years of active use, those remaining third party-owned Charnock wells pumped a total of approximately 570 AFY. This average value has been listed in Table 2 for each of the years in which these wells were reportedly pumping during the baseline period. One of these wells, Charnock No. 10, reportedly had a pumping capacity of 900 to 1,000 gpm (1,450- 1,610 AFY).
- A few wells at its Sepulveda Plant in the Charnock subbasin, which terminated production in ±1960, and hence, this production precedes the onset of our 30-year baseline period.
- A few wells at its Manning Plant in the Crestal subbasin, but these wells were all destroyed during the construction of the I-10 Freeway, which pre-dates the baseline period being studied for this updated project.
- Data are sparse, but reportedly only a limited number of wells existed at its former Pacific Plant, Lincoln Plant, PenMar Plant, and Zanja Plant, all of which were in the Coastal subbasin. These wells and wellfields no longer exist and, although the date of the most recent production by any of these wells is unknown, it is highly likely that none were active at any time during the baseline study period for this project.

Actual groundwater production data from the wells at the known golf courses are not available to the City for this study. To assess the magnitude of the groundwater extractions at the golf courses listed above, RCS used computer methods and Google Earth® imagery and estimated that the total irrigated areas of turf on those "local" golf courses are on the order of 105 acres for the BCC golf course, 125 acres for the RCC golf course, and 170 acres at LACC (note, there are two, 18-hole courses at this latter country club). Further, in coastal areas of southern California, it is reasonable to assume that each acre of golf course turf requires on the order of 2.5 AF of water for irrigation each year.

Furthermore, the amount of groundwater pumped on an annual basis by the known small diameter irrigation well located at the residence along San Vicente Blvd. However, using the above estimate for the golf courses, and estimating an irrigated acreage of slightly greater than one acre on this residential lot, then it is estimated that a maximum of about 2 AF of water per year would likely be pumped by that privately-owned residential well. This annual volume is considered by RCS to be insignificant for this update of the sustainable yield analysis and will not be considered further herein.

Based on the assumptions above, and the above-approximated irrigated acreages and unit irrigation demands for typical coastal-area golf courses in southern California, the assumed total annual irrigation demands supplied by groundwater pumped by wells at those three golf courses could be as follows: 260 AFY for BCC; 310 AFY for RCC; and 450 AFY for LACC (note that these values assume that any/all golf course wells at those golf courses have been in active use throughout the entire 30-year baseline period being used herein). Thus, private groundwater withdrawals by others for irrigation-supply in the Arcadia subbasin would total ±570 AFY (for the BCC and RCC), whereas those in the Crestal subbasin would be ±450 AFY (as noted above, LACC has two, 18-hole golf courses on its property). It is not known whether UCLA and/or the Veterans Administration facilities, which are also in the Crestal subbasin area, have any active water-supply wells at this time.

WATER LEVELS

Water Level Hydrographs

Graphs of water levels versus time were used to help discern trends in SWLs over time in City water-supply wells within SMGB. Thus, these hydrographs were used to determine in which portions of the subbasins where the City has active wells, water levels are rising or declining over time and which areas of those subbasins may be more influenced directly by rainfall recharge. Figures 10A through 10C provide graphs of water levels versus time (i.e., hydrographs) for the wells with available data in each City wellfield (or subbasin) in which the City has water wells. These hydrographs have been plotted along with the accumulated departure of rainfall for the base period using the Culver City rain gage, to illustrate the possible correlation between changes in water levels and changes in rainfall over time. Recharge as underflow from the adjacent mountain front areas is not included in these estimates but was accounted for in the estimates of sustainable yield, via changes in water levels. In addition, the same horizontal and vertical scales have been used for each graph to show comparative differences between the hydrographs, which had to be expanded due to the limited amplitude of water level fluctuations in the wells in the subbasin over time. For this current study, historic SWL data from the previous RCS (2013) report were updated with more recently obtained data, updated through 2017 for City wells, as provided by City staff. It should be noted that there are likely some inherent discrepancies in the accuracy of the SWL data reported over the 30 year baseline period, as the method of collecting data in the field can and often does vary over time. Therefore, the use of hydrographs from these wellfields for estimating sustainable yield likely result in estimates that are conservatively low. Review of the hydrographs reveals the following:

- Arcadia Wellfield/Subbasin. Water level data are available for five City wells in the Arcadia subbasin. These wells include the three Arcadia wells (Nos. 2, 4, and 5; Well No. 2 has been destroyed, and only Well Nos. 4 and 5 are active) and two Santa Monica wells (Nos. 1 and 5). Updated SWLs were available only for Santa Monica Well Nos. 1 and 5 (through December 2017) and Arcadia Well No. 4 (through March 2017). Review of Figure 10A, "Arcadia Wellfield/Subbasin Hydrographs," shows that the three Arcadia wells all have similar water level depths and similar water level trends over time. Most SWLs in these three wells over their respective periods of record were typically at depths in the range of 10 ft to ±60 ft bgs; a few water levels for these wells are anomalously deep and are likely pumping water levels.

  In comparison, for Santa Monica Well Nos. 1 and 5, even though their water levels are similar, the water level depths in these two wells differ considerably from those in the Arcadia wells. Specifically, during their respective periods of available data, SWL depths in Santa Monica Well Nos. 1 and 5 were typically at depths in the range of 90 ft to ±140 ft bgs (not including the anomalously deep wells). Generally, Santa Monica Well Nos. 1 and 5 are located west of the City's Arcadia wellfield (see Figure 3) and have slightly different hydrogeologic conditions.

  Relative to the accumulated departure of rainfall curve for the Culver City rain gage on Figure 10A, a clear correspondence between patterns in SWLs and rainfall is difficult to discern in the Arcadia wellfield wells. This may be due to the possibility that pumping water levels (or even non-representative SWLs taken shortly following shutdown of the pump in the wells) have been recorded as SWL data, and/or that it is difficult to obtain accurate SWLs in any of these wells because wells in this wellfield are closely spaced, thereby inducing water level drawdown interference on one another when pumping. However, where there are relatively consistent SWL data (such as in 1943 through 1950), then a trend can be seen to emerge: the SWLs in the Arcadia wells appear to be acting in concert with the accumulated departure of rainfall curve within that period. However, the water level data for Santa Monica Well No. 5 reveal a much greater degree of agreement with the accumulated rainfall departure curve on Figure 10A. That is, yearly changes in its SWLs appear to be mimicking changing rainfall trends.

  Also notable on the Figure 10A hydrograph for the Arcadia wells is that none of the SWLs over time attain a depth that is shallower than about ±5 to 7 ft bgs, regardless of the amount of antecedent rainfall. This suggests that these water levels represent a "spill point" for Arcadia subbasin at/near this wellfield. That is, once water levels rise to this depth, the groundwater may "spill" over the nearby fault and into the adjacent Olympic subbasin to the south.

- Charnock Wellfield/Subbasin. Figure 10B, "Charnock Wellfield/Subbasin Hydrographs," illustrates the water level data for seven City wells in this wellfield (see

Table 1 for construction data for the five currently-active wells in this wellfield); note, over the years, at least 20 wells have been constructed for the City at this wellfield, which lies west of Sawtelle Blvd in the City of Los Angeles (refer to Figure 3B for well locations). Because the City's Charnock wells tend to have similar depths and similar perforated intervals, and are located very near one another, their water level depths and trends over time are, as expected, seen to be similar on Figure 10B. Notably, Well No. 7 has the longest period of available water level data of any well shown on Figure 10B. Based on the operational use of this wellfield, and on a review of the Charnock hydrographs on Figure 10B, the following are noted:

a. Many of the water level data prior to the mid-1990s may be considered as being impacted by a wellfield pumping depression. That is, the various wells, when actively pumping, would tend to create water level drawdown interference on those wellfield wells that were not pumping at the time; hence, a monitored water level in a non-pumping well would tend to be lower than a true static level.

b. During the period of the wellfield shutdown from the mid-1990s through ±2010, water levels in all the wells showed a long-term and continuous period of rise; this water level trend also matched a concomitant period of increased rainfall (a "wet" period).

c. Once pumping in the wellfield resumed in ±2010, wellfield water levels exhibited a rapid and relatively steep decline. This decline also was consistent with the ongoing drought (as reduced recharge in direct local precipitation) in southern California at this same time.

It is apparent on Figure 10B that the water level in the Charnock wellfield show some response to changes in rainfall. For example, water levels for Well No. 7 between 1937 and 1955 appear to show general correspondence to rises and declines in the accumulated departure of rainfall curve for the Culver City rain gage. However, starting in 1955, and continuing until 1975, measured water levels appear to decline whereas the accumulated departure of rainfall shows increasing rainfall conditions. This anomaly may be explained by changes in wellfield operations that may have affected pumping water levels (e.g., increased production rates, or recording pumping water levels as SWLs). Between 1970 and 1995 the data are inconsistent and lacking (possibly again due to vagaries in pumping rates and individual wells potentially interfering with one another when pumping). However, in 1996 the water level data for most of the wells become consistent, and all show a slow and continuous rise over time. This phenomenon is basically a long-term record for the recovery of all water levels in this entire wellfield, because these wells were all inactive from ±1996 through ±2010, due to third party MTBE contamination within/near the City's Charnock wellfield. This unified response is likely the only true record of static water levels for the wellfield and suggests that the other slight deviations from matching the accumulated departure curve could be the result of various wellfield operation activities and the monitoring of water levels that may not have been true static water levels because they could have been impacted by nearby pumping. Further supporting this hypothesis is the fact that since the pumps in the seven active wells were turned back on in ±2011, water levels in those wells have generally declined rapidly, and in unison.

- Olympic Wellfield/Subbasin. Historically there have been three City wells in this wellfield (Santa Monica Well Nos. 3, 4, and 7); each of these wells is located within a median along Olympic Blvd (see Figure 3B). Two of these, Santa Monica Well Nos. 3 and 4, are currently active. In April 2018, construction of a new well for the City was completed. This new well (SM-8) will serve as a replacement for well SM-7, which was recently destroyed. New SM-8 has yet to be provided with a permanent pump, but once permitted, it is expected to produce around 600 gpm.

  Figure 10C, "Olympic Wellfield/Subbasin Hydrographs", graphically depicts the available water level data for the three historic wells over time. The data indicate that the water levels from the three wells have had similar depths and trends over time. SM-7, which has been out of production since 1989 except for a few brief periods of pumping, was destroyed in 2018. Prior to that, it was used for static water level monitoring. At least some of the water level data from SM-3 and SM-4 could be considered water levels that have been impacted by nearby pumping. Water level data from SM-7 has tended to exhibit slightly deeper water levels than those in the other two wells. This could be because SM-7 is located down gradient from SM-3 and SM-4 and thus pumping at these two wells may be acting to dampen the water level response measured in the former SM-7. In other words, inflow in to the subbasin is possibly being diverted into the two producing wells before it reaches SM-7. Comparing the SWLs to the accumulated departure of rainfall for the Culver City rain gage for the period 1979 through 2017 for the wells shows that the data generally correspond, but there is a noticeable amount of offset (i.e., a delay) between changes in rainfall and a corresponding change in SWLs. For example, the accumulated departure of rainfall curve indicates rising rainfall totals started in 1992 and continued until 1998. However, a rise in water level in these wells does not commence until around 1996. Thus, there appears to be a three- to four-year lag between changes in rainfall and changes in water levels However, this may be attributed to the fact there was an increase in production levels at the Olympic wellfield beginning around 1993 and continuing through much of this period. Complicating this analysis is the down gradient location of SM-7 from SM-3 and SM-4 and overall proximity of the wells to one another, two of which were producing continuously for more or less the entire 30-year base line period.

- Coastal Subbasin. There are five existing wells in this subbasin; three of these are inactive, and the remaining two are groundwater monitoring wells. Two of these inactive wells, Saltwater Well Nos. 1 and 2, are located near Santa Monica Beach near the west terminus of Pico Blvd. Saltwater Well Nos. 1 and 2 formerly produced brine for a former treatment system at the City's Arcadia Water Treatment facility, but they are no longer used. The third well, Airport Well No. 1, was successfully constructed as a municipal-supply well in April 2018, but it has yet to be equipped with a permanent pump. This well is expected to produce around 300 gpm when it is permitted for production. The City has plans to construct at least two other water-supply wells in the future at the Santa Monica Airport.

  The two groundwater monitoring wells include the Marine Park well, which is located near the PGC at Marine Park, and the newly-constructed Colorado Yard No.1 well, which was completed in November 2017. Except for the Airport Well No. 1 water-supply well and the Colorado Yard monitoring well, the older wells are not representative of subbasin aquifer conditions, including usage for water level monitoring because they are either too shallow, or in the case of the Salt Water wells, they are too close to the beach, and therefore potentially subject to tidal influences.

Water Level Hydrographs – “Key” Well Concept

In comparing the water level data in the wells to the baseline period and, ultimately, to estimate the amount of change in storage in the subbasins for which data are available, RCS did not need to use water level data for every City well, especially when such wells are located proximal to each other in the three respective City wellfields. For example, there are several City wells at the Charnock wellfield, all of which are perforated within the same aquifer systems and to similar depths. As such, only one key well needed to be selected to be representative for this individual wellfield. Measured water level data for this key well reflects water level changes that are similar to those in other adjacent wells. To the extent possible, the selected key well also had the longest and most complete period of record for the baseline period, in comparison to the other wells in the same wellfield.

Figures 11A through 11C (in Appendix 1) provide graphs of the available water level data versus time for “key” selected City wells in those groundwater subbasins of the SMGB, for which data are available for City wells, for the 1988 through 2017 hydrologic baseline period. These key wells were selected as being representative of changes in water levels over their period of record and this selection was based on their geographic location, on the completeness of their measured water level record, and on the length of their perforated intervals (that is, wells with the longest length of perforation intervals would obtain their supply from multiple aquifer systems).

Further, a schematic diagram of each selected “key” well is included on its respective figure (Figures 11A through 11C) to illustrate the casing depth and the depths of the perforation intervals in those wells (if the requisite casing data were available), in relation to the historical water level data. The recorded water levels have been plotted based on their measured depth from a base reference point (brp), which is assumed to be approximately at ground surface for each well.

Arcadia Subbasin Key Well Hydrograph

Figure 11A, “Key Well Hydrograph, Santa Monica Well No. 5”, is a hydrograph of this key City well to show SWLs vs time for the 30-year baseline period (located in the central portion of the Arcadia subbasin, in the northern portion of the City). Data from this well, which was selected as being representative of changes in static water levels in the Arcadia subbasin, have been plotted along with the accumulated departure of rainfall for the Culver City rain gage (as adapted from Figure 9) for comparative purposes. Note that the accumulative departure for each year represents the entire span for that year, and not just the point on which the curve falls. Thus, for example, the accumulated departure value for 2017 is based on the rainfall total through the end of that year. Figure 11A reveals the following:

- The response of the measured water levels to increases in rainfall is illustrated by the successive “up & down” patterns (i.e., rises and declines), noted by the sawtooth pattern in water levels for Santa Monica Well No. 5. On an annual basis, groundwater levels tend to be shallower in the early part of the year and deeper near the end of each year. This graph illustrates that the response between changes in rainfall is immediate and that changes in rainfall recharge and changes in water levels have been relatively rapid; Figure 4 shows the well is located near a stream, and the well has relatively shallow perforations (145 to 235 ft bgs). Thus, the nature of the water level responses could indicate that this well contains at least part of its perforations within a shallow, unconfined (water table) aquifer system that is responding to seasonal runoff in the stream bed that is percolating into the subsurface. Also, of interest is that the water levels in this well has never risen above a depth of ±108 ft bgs during its period of record, regardless of the trend in the rainfall departure curve.
- In evaluating the total change in SWLs (represented by the symbol ΔS on the graph) during the baseline period, then the difference in the water levels between the beginning and the end of the 30-year baseline period can be defined. This difference amounts to approximately -8 ft on the graph; this represents an overall decline in the measured water levels between the beginning and the end of the baseline period. This calculation and its significance are discussed in greater detail in the section below titled “Subunit/Subbasin Changes in Groundwater in Storage Calculations”.

Charnock Subbasin Key Well Hydrograph

For this subbasin, there was only one well, namely Charnock Well No. 16, which had adequate available historic data to permit an evaluation of the water levels for the baseline period; the resulting data are shown in Figure 11B, “Key Well Hydrograph for Charnock Well No. 16 & No. 20.” Note that nearly all the plotted water level data on the figure are for Well No. 16, except for data from 2016- 2017, which includes data from the adjacent well No. 20. Review of Figure 11B reveals the following:

- o Notable on this figure is the existence of the long-term and continuous rise in water levels in this well that occurred between mid-1996 and late-2010. This is the time during which the City's entire Charnock wellfield was shut down due to contamination of local groundwater by a third party and it is likely the only period during which actual static water levels were recorded. This continuous rise in water levels represents a long-term water level recovery period for this subbasin. However, starting in late-2010, and after construction of the treatment plant for this wellfield had been completed and pumping of the active wellfield had resumed, water levels once again began to experience a steep and rapid decline (to depths of 155 to 156 ft brp) by late-2016. This result is likely due to the resumption of wellfield pumping involving numerous wells located very near one another.
- o The wellfield start-up happened to coincide with a marked decline in precipitation for several subsequent years. This same relationship, a decline in precipitation and measured water levels, for the period starting in late-2010 and continuing until late-2016 is also seen on Figures 11A (Arcadia wellfield) and 11C (Olympic wellfield).

  Thus, it appears that water level responses in the various subbasins are potentially affected by pumping wells that are sited very near one another, and that the observed water level changes are prone to the vagaries of water level recording methodology and how frequent actual SWL measurements versus pumping water levels were and are being collected.
- o The total change in water levels during the baseline period at this Charnock well, represented by the symbol ΔS which is the difference in measured water levels (combination of pumping and static) at the beginning and the end of that period, amounts to +12 ft; this represents a water level rise between the beginning and the end of the baseline period. This significance of this calculation, which because of the admixture of water levels types may be conservative, is discussed in greater detail in the section below titled "Subunit/Subbasin Changes in Groundwater in Storage Calculations Olympic Subbasin Key Well Hydrograph."

Olympic Subbasin Key Well Hydrograph

There are only three City wells in this subbasin for which there are available water level data. Those data for Santa Monica Well No. 7 are considered to be more representative than the other two wells as an indicator of SWL changes in this subbasin for the baseline period because the well was not pumped for an extended time, making the collection of actual static water levels possible. However potentially countervailing this benefit, SM-7 was in proximity and down gradient from two active pumping wells in the subbasin (SM-3 and SM-4). The location of this well raises the possibility that water level records may be conservatively low, as the upgradient production wells may have influenced local water levels. Figure 11C, "Key Well Hydrograph for Santa Monica Well No. 7," illustrates the water level changes. From roughly 1993 until ±2017, SWLs in SM-7 have generally responded to longer-term trends in the accumulated rainfall departure curve for the Culver City rain gage (see Figure 11C), even though shorter-term changes cannot be discerned as readily. Additional review of the figure indicated the following:

- There are a few periods for which SWLs appear "depressed" (in the years 1988 to 1989 and late-1994 to early-1998), as shown by the symbol "P," indicating that these specific "SWLs" may have been measured during actual pumping of the well, or that they were heavily influenced by recent pumping of the well (such as a measurement taken shortly after pump shutdown). Thus, it is difficult to determine an actual SWL that was not influenced by pumping. Nonetheless, if we take the point in mid-1995 as representing a "representative" deep SWL, then total water level change has amounted to 45 ft. In addition, the SWLs could have also been influenced by pumping of nearby Santa Monica Well Nos. 3 and 4, located east of Santa Monica Well No. 7. Note also on Figure 11C that SWL depths in Well No. 7 have never declined to the depth to its uppermost perforations during the baseline period.
- The SWLs in Well No. 7 also appear to show responses of the SWLs to longer-term changes in rainfall, even though it is difficult to discern shorter term changes like those for Santa Monica Well No. 5 in the Arcadia subbasin. This fact is particularly noticeable after 2010, when both rainfall and SWLs show a declining trend through to the end of the baseline period. However, correlation of SWLs to trends in rainfall is not well-defined prior to that date. Further complicating this analysis is the fact that mapping of the geology in the Olympic wellfield indicates the possibility of faulting in the subsurface which, if confirmed, could act as a barrier to block or delay some natural recharge from upgradient areas.
- The total change in water levels in this well during the baseline period (symbol ΔS), is noted to be -30 ft, representing a decline in water levels between the beginning and the end of the baseline period. The significance of this calculation is discussed in greater detail in the section below titled "Subunit/Subbasin Changes in Groundwater in Storage Calculations". It should be noted that the operational limitations discussed in this section, such as pumping wells being located in proximity to each other may have resulted in increasing the amount of water level change over time, which in turn would result in a conservative estimate of sustainable yield.

Coastal Subbasin Key Well Hydrographs

There are no active City water-supply (production) wells within the Coastal subbasin, although the City does own two local water level observation wells near the beach: Salt Water Well Nos. 1 and 2. However, these two wells are not useful because the tidal changes from the nearby ocean appear to be the principal cause of changes in SWLs in these wells, and because they are too shallow to provide useful information for estimating sustainable yield of this subbasin.

Notably, the City has recently constructed two new production wells in this subbasin. One such new well, City Hall Well No. 1, can produce at rates ranging from 8-10 gpm and was constructed to be used solely meet the limited water demands at the new City Services Building in the future. Specifically, this new well is for use by a special City sustainable building project, which reportedly will require only approximately 10,000 gallons/day. City Hall Well No. 1 is very shallow and was cased to a depth of only 160 ft bgs, with perforations being placed continuously between 60 and 160 ft bgs (see Table 1). Because this well is new, there are clearly no long-term SWL data for this well. Hence, SWL data from this well have very limited use regarding determination of ΔS for this subbasin. However, useful hydrogeologic data were obtained during the drilling, construction, and testing of this new City well. That is, the borehole for this well was drilled to a depth of approximately 652 ft bgs, and the new electric logs indicate that in addition to the two water-bearing zones that were perforated in this shallow well, there was another deeper, potentially water-bearing zone at a depth of approximately 280 ft to 300 ft bgs. The base of fresh water in this area was identified on the new electric logs to be at a depth of approximately 540 ft bgs.

The second new production well in this subbasin, Airport Well No. 1, was drilled and constructed to a depth of 610 ft bgs in April 2018; this well has perforations set between the depths of 190 and 590 ft bgs (see Table 1). When tested, this well produced water at a sustained pumping rate of 300 gpm. The City is also planning to construct two additional wells in the Airport area, and it is anticipated that each of these two wells could also be able to produce water at a rate of ±300 gpm. The results of the pumping from new Airport Well No. 1 will be extrapolated to the two proposed wells and the combined flows from the three wells will be used later in this report to provide an initial estimate of the sustainable yield of this groundwater subbasin.

Crestal Subbasin Key Well Hydrograph

Currently, there are no readily available data on water levels for water-supply wells or groundwater monitoring wells within this subbasin. Thus, trends and/or changes in SWLs cannot be determined at this time; and, hence, there is no calculation herein for the ΔS in this subbasin.

GROUNDWATER IN STORAGE

Storage Subunits and Parameters

The locations and alignments of several faults in the SMGB, as mentioned in various geologic publications and in the RCS (February 2013) report, were originally used by others (such as MWD, 2007) to subdivide this groundwater basin into the five distinct subbasins. The faults may or may not comprise barriers to groundwater flow. If these faults do define complete barriers, groundwater could be discretely contained and/or compartmentalized within each subbasin. As such, each of the five subbasins could conceivably comprise its own groundwater subunit. . Recent studies conducted by the City by ICF (2018) and Earth Consultants International (ECI, 2017) to assess natural recharge into the SMGB have found that recharge from mountain-front areas adjacent to the SMGB are a significant source of subsurface inflow. Further, a preliminary DInSAR study conducted by ECI suggests that inflow from mountain-front areas outside of the SMGB may also be occurring under certain conditions. These hypotheses are being tested in a supplemental DInSAR study that is currently underway. Together, these studies have begun to provide a basic understanding of how the individual subbasins are being recharged, how they may be interacting, and what might be better approaches for sustainable and adaptive management of these important groundwater resources.

Boundaries of the City of Santa Monica overlie portions of the Arcadia, Olympic and Coastal subbasins; City limits do not overlie any portion of the Charnock or Crestal subbasins (indeed, the City's Charnock and Arcadia wellfields lie outside the City boundaries and within those of the City of Los Angeles). However, because the City does derive a part of its supply from its Charnock wellfield, the groundwater in storage has also been defined for this subbasin. The Crestal subbasin was not evaluated at this time because the City has never, and does not currently, obtain any of its groundwater supply from this subbasin.

To assess the volume (amount) of groundwater in storage in the subbasins, the following data are needed:

- Groundwater Storage Subunits: The surface area of each of these subunits should be defined where hydrogeologic/hydrologic boundaries do or are considered to occur. Such boundaries may consist of: boundary faults (especially if these faults are barriers to groundwater flow); streams or creeks that occur along the edges of the basin and that may form a divide; and where bedrock/basement rocks meet alluvial sediments. In addition, where applicable, it is conservatively assumed (to help preclude seawater intrusion) that the western boundary of these subbasins generally occurs in a buffer zone between the coast and Lincoln Blvd. Data from the City Hall

No.1 well where the base of fresh water was encountered below a depth of 500 ft indicates that salt water intrusion has not occurred in this buffer zone

Thus, the groundwater storage subunits defined for this study were considered to represent the specific regions (i.e., the usable areas) where groundwater could potentially be available to current and future City water-supply wells. In this current report, the locations and names of the usable groundwater storage subunits are shown in Figure 12, "Usable Areas of Groundwater Storage Subunits."

- Saturated Thickness: This is a time-dependent value and is based on the depth to SWLs (for a specific period) and on the actual depth to the base of fresh water and/or the depth of the base of the water-bearing aquifer systems in the local subbasin. The thickness of the water-bearing sediments herein is generally based upon geologic cross sections which show the approximate base of fresh water, as noted in the RCS report (2013). Calculations of the saturated thickness were based on water level conditions during the baseline period. Thus, the calculation of the volume of groundwater in storage is valid for any one point in time, because the amount of groundwater in storage changes with either rising or declining water levels; i.e., groundwater in storage must be recognized as a time-dependent variable in a groundwater subbasin/basin.
- Specific Yield: This quantity is generally defined as the percentage of groundwater in the void spaces (i.e., in the pore space) within the potentially water-bearing sediments that will drain by gravity toward a well. Specific yield is primarily dependent upon the characteristic type of the earth materials in a subbasin. For example, clay or clayey sands tend to have a much lower specific yield (ranging from 2 to 7%) compared to that for gravelly sands (often 20% to 25%).

Calculation of Groundwater in Storage

The calculation of the theoretical volume of groundwater in storage (S_{gw}) was performed by RCS (February and March 2013) using the following formula:

S_{gw} = (A) (b) (S_y), where:

A = The surface area of each subunit considered, in units of square miles (sq mi), which is equal to the approximate width of the surface area times the approximate length of the surface area. In the case of this current study, each subunit was considered as being that region of the subbasin from which groundwater could be available to existing or future City wells. The units of surface area had to be converted from square miles to acres for the final calculation. The surface areas used for each of the subbasins are shown on Figure 12.

b = The saturated thickness of potentially water-bearing sediments, in units of feet. The fault boundaries (by others) between the various subbasins/subunits have been assumed herein to be vertical planes. In this study, because RCS is not calculating the total amount of groundwater in storage, but only the change in storage in each subbasin (with requisite data) over the baseline period, then this quantity is replaced by the change in water levels, or ΔS value.

S_y = The assigned specific yield of the sediments, which was based on our interpretation of the predominant type of sediments as listed on available drillers' logs for wells constructed in each subbasin.

The above factors determined the amount of groundwater in storage in each subbasin, in units of cubic feet (ft^3) of water, and these ft^3 values were then converted into acre feet (AF).

SUBUNIT/SUBBASIN CHANGES IN GROUNDWATER IN STORAGE CALCULATIONS

The following provides the basic calculations for the changes in the amount of groundwater in storage, over the baseline period, in each subbasin for which requisite data are available. Subbasin boundaries have been adjusted slightly since the RCS (2013) report, regarding calculating the area of usable groundwater in storage. That is, generally, Lincoln Blvd was conservatively selected by RCS to be the westernmost boundary for the available groundwater in storage in the region, whereas the southern boundary was selected to be along Washington Blvd. Figure 12 shows the approximate boundaries of the "usable" groundwater storage subunits delineated for this current study.

The method of determining the amount of change in groundwater in storage used in this evaluation was calculated based on the changes in water levels during the entire 30-year baseline period. However, pumping of the wells in the Arcadia and Charnock Subbasins was not continuous, because the wells were shut down for various extended time periods. In the case of the Arcadia subbasin, pumping at the Arcadia wellfield was shut down for four years whereas for the Charnock subbasin, pumping at the City's Charnock wellfield was shut down for approximately 13 years. In the Olympic wellfield, pumping from City wells was conducted during the entire 30-year baseline period. There are no current pumping data for the Coastal subbasin, as the City is in the process of permitting its new Airport No. 1 well.

Change in Groundwater Storage

Arcadia Groundwater Storage Subunit/Subbasin

Only a small portion of the City overlies the Arcadia subbasin and five City wells currently extract groundwater from this subbasin. Of these five wells, Santa Monica Well No. 5 was used for the key hydrograph for this subbasin, primarily because this well was not pumped during the hydrologic baseline period and, thus, its data provide a relatively reliable picture of SWL changes in the subbasin. The following discusses the methodology for calculating the amount of change of groundwater in storage for this groundwater subunit/subbasin:

- Area of Subunit: The entire area calculated for this subunit was based on that region of the subbasin that was available to the City for withdrawal of groundwater. The western border of this area is taken along Lincoln Blvd, whereas its northern border is along the front of the Santa Monica Mountains; the usable area of this subunit was measured to be approximately 6.6 sq mi.
- Change in Water Levels (ΔS): For this subbasin, the change in the water levels was determined by review of the water level hydrograph for the key City well in the subbasin, namely Santa Monica Well No. 5, for the hydrologic baseline period. This well was representative of the change in SWLs over time in this entire subbasin. The change in groundwater is storage is the difference between the SWL at the beginning of the hydrologic baseline period (in 1988) and the end of the baseline period (end of 2017).

  The hydrograph for this well (Figure 11A) indicates that ΔS, the change in water levels over the baseline period for Santa Monica Well No. 5 was on the order of -8 ft (i.e., SWLs declined by 8 ft over the baseline period). It should be noted that this change is a negative quantity, because SWLs were shallower at the beginning of the period (in 1988), than at the end of 2017.
- Specific Yield: As discussed in the RCS (2013) report, the sediments that are perforated in the existing wells in the Arcadia Subbasin were variously described on the available drillers' logs as ranging from interbedded clay and gravel to fine-grained silty sands and gravel to hard sandstone and rock. Based on our re-review of those driller's logs, Sy values for this subunit were assigned to be on the order of 8% to 12%.
- Table 3, "Preliminary Calculations of Change in Groundwater in Storage During the Baseline Period for the Arcadia, Charnock and Olympic Groundwater Subbasins," lists the resulting RCS calculations the changes in storage during the baseline period, based on the assumptions and parameter values listed above for the usable area in each subbasin for which adequate data are available and in which the City has or could have its water-supply wells. It should be noted that no values for the change in storage in the Coastal or Crestal Subbasins have been provided because of the lack of data at this time.

Charnock Groundwater Storage Subunit/Subbasin

The Charnock subbasin occurs east of and outside of the City's boundaries; currently active City wells include Charnock Well Nos. 13, 15, 16, 18, 19 and 20. Of these six wells, Well No. 16 was chosen as the key well hydrograph to represent changing water levels over time, because it had data throughout most of the baseline period (see Figure 11B); recent data points for Well No. 20 were added to that graph, because Well No. 16 did not have any new data after early-2016 (pumping in that well has been continuous), whereas Well No. 20 did have SWL data after that date. Because the two wells are near each other within the same wellfield, then the SWLs for Well No. 20 can be considered representative and, thus, useful for inclusion into the Well No. 16 graph.

- o Area of Subunit: This groundwater storage subunit, as measured for this current study, has a usable surface area of approximately 3.7 sq mi, based on a southern boundary along Washington Blvd.
- o Change in Water Levels (ΔS): Figure 11B, the key well hydrograph for Charnock Well No. 16 and No. 20, shows that at the beginning of the baseline period the SWL was 158 ft bgs, whereas at the end of the baseline period, the SWL was higher at 146 ft bgs. This represents a total change in water levels of ±12 ft, or an increase over the baseline period.
- o Specific Yield: As mentioned in the RCS (2013) report, the lithology of this subbasin generally consists of interbedded brown clay to sand and gravel and blue clay, sand to hard sand, and fine-grained sand to gravel. Additional review of the driller's logs for this study suggests that a reasonable range of S_y values is 12% to 18% for this subbasin.

Table 3 shows that the change (in this case an increase as denoted by a positive set of numbers in Table 3) in the groundwater in storage for the 1988 through 2017 hydrologic baseline period for the Charnock Subbasin is on the order of 3,400 to 5,100 AF. For the 30-year baseline period, the average annual increase has been on the order of 120 to 180 AFY.

Olympic Groundwater Storage Subunit/Subbasin

The Olympic subbasin transects the central portion of the City, from the coastline on the west to the Charnock fault on the east. Currently, only two wells, Santa Monica Well Nos. 3 and 4, are used by the City to extract groundwater from the defined groundwater storage subunit within this subbasin; Santa Monica Well No. 7 is used as a water level observation well. For the purposes of this study, the hydrograph for Santa Monica Well No. 7 was selected as the key well to represent changes in water levels over time, because it has a relatively complete and continuous record of water levels. The following summarizes the requisite parameters for this groundwater storage subunit:

- o Area of Subunit: The area of this subunit was conservatively estimated, for this current study, to be approximately 3 sq mi; the western boundary was selected at Lincoln Blvd to help preclude seawater intrusion.
- o Change in Water Levels (ΔS): The Figure 11C hydrograph for Santa Monica Well No. 7 reveals a SWL of 118 ft bgs, in early-1988. However, by the end of the baseline period, the SWL was 148 ft bgs by late-2017. Thus, ΔS amounts to approximately -30 ft in that well for the hydrologic baseline period.

The negative number reveals a decline in the change in water levels across this subbasin during the baseline period.

- Specific Yield: Based on additional review of the driller's logs for wells in this subbasin, average S_y values were considered to range from 10% to 15%.

Table 3 shows that the change (decline) in the groundwater in storage for the 1988 through 2017 hydrologic baseline period for the Olympic subbasin shows 5,900 to 8,800 AF. For the 30-year baseline period, the average annual decline has been on the order of 200 to 300 AFY.

Coastal Groundwater Storage Subunit/Subbasin

Based on the results of the drilling and construction of municipal-supply Airport Well No. 1 and a new groundwater monitoring well at the City's Colorado Yard, it appears that the Coastal subbasin can support production wells. Based on pumping tests of Airport Well No. 1, pumping rates are likely to be on the order of ±300 gpm. The City has plans for two additional water-supply wells within the Santa Monica Airport in this subbasin.

Sustainable yield estimates for the Coastal subbasin are very preliminary because of the lack of long-term SWL data. Future pumping from this subbasin will provide the data needed to refine the potential range of sustainable yield for this subbasin. At this time the results of pumping tests conducted at the end of the construction of the Airport Well No. 1 have been used and extrapolated to the two additionally-planned City wells; the combined value for the three wells could be used as a conservative baseline value for the sustainable yield of this subbasin, until long-term SWL data become available and can be evaluated.

The City has a new, successfully-constructed well, Airport Well No. 1 that pumped at a sustained rate of 300 gpm during its recent constant rate pumping test. Below are preliminary estimates of the various hydrogeologic parameters for this subbasin. Regardless, long-term water level and pumpage data will still need to be obtained to calculate the changes in storage in this subbasin over time. As this will require additional years of pumpage and water level monitoring, and should a future well ever be constructed at any of the three exploratory borehole sites, then other methods will likely be needed to provide an estimate of the sustainable yield of this subbasin. The current hydrogeologic parameters of the Coastal subbasin are as follows:

- Area of Subunit: The area measured for the usable portion of the Coastal subbasin, from Lincoln Blvd on the west and along the edge of the wetlands for Ballona Creek, was determined to be approximately 7.1 sq mi. It should also be noted that the recent well drilled and constructed at City Hall within this subbasin demonstrated that the usable area for fresh water occurrence could possibly be extended south of Lincoln Boulevard to an east-west line perhaps marked by 4th Street. If this modification were to be included, it would add approximately 700 acres (about 1.1 square miles) to the overall usable area of the subbasin (for a total of 8.2 sq mi).
- Saturated Thickness: A maximum thickness of the potentially water-bearing sediments is estimated to be approximately 460 ft in this subbasin.
- Change in Storage: Due to a lack of available water level data, a ΔS value cannot be determined at this time for the Coastal subbasin.
- Specific Yield: A range of average S_y values of 12 to 16% has been preliminarily assigned to the earth materials in this subbasin, based on our review of drill cuttings and geophysical logs from the recent drilling of Airport Well No. 1.

Currently, a change in groundwater storage cannot be calculated for the Coastal subbasin, as there are no long-term SWL or associated groundwater extraction data. When several years of groundwater extraction data become available and can be reconciled with changes in SWLs, then the changes in groundwater in storage over a specific baseline period may be preliminarily estimated for this Coastal subbasin. An analysis of this remains for a future update of this current report.

PRELIMINARY CALCULATIONS OF SUSTAINABLE (PERENNIAL) YIELDS

As previously mentioned, sustainable yield is essentially analogous to perennial yield, and it is a dynamic value, which can change under varying conditions of annual pumping and trends in natural recharge over time. Thus, if sufficient groundwater withdrawal data and SWL data are available, then the sustainable yield for each subbasin with requisite data can be determined in the following manner:

(1) Selecting a baseline hydrologic period.

(2) Determining the average annual volume of groundwater extracted by the City (and any known, privately-owned wells) during the baseline period.

(3) Computing the difference between the volume of groundwater in storage at the beginning and at the end of the baseline period.

(4) Determining the average annual change of groundwater in storage from (3) above.

(5) Computing the algebraic sum of the average annual change of groundwater in storage and the average volume of annual groundwater withdrawals by known water wells.

Table 4, "Updated Preliminary Calculations of Sustainable Yield, Three Santa Monica Subbasins," provides the calculated values for sustainable yield, based on the available data for the entire 30-year baseline period. These data show that sustainable yield values determined based on the entire baseline period range from as low as 870 AFY for the Arcadia subbasin, to as high as 6,470 AFY for the Charnock subbasin (note that these values have been rounded to the nearest 10 AF).

A preliminary sustainable yield value for the Coastal subbasin can be roughly estimated, based on the results of pumping of the recently-constructed Airport Well No. 1 (April 2018). During its final pumping tests, this well was pumped at a rate of 300 gpm. If the well were to continue to produce at that rate on a year-round basis (i.e., a 100% operational pumping basis), the total production from that one well would amount to 483 AFY. Extrapolating this to two additional City wells that are in the planning stages for the Coastal subbasin, then the total that might be produced from all three wells could be on the order of 1,450 AFY. Currently, if the assumption is made that the Coastal subbasin were to be able to sustainably support the pumping of these three new wells, without adversely impacting local SWLs over time, then this value could potentially be used as the preliminary sustainable yield of this subbasin at this time. However, it is cautioned that due to the complete lack of supporting data (such as long-term changes in SWLs and, thus, a calculated value for the change in groundwater storage over a specific time period), then any future calculated sustainable yield value for the Coastal subbasin could be either higher or lower than this newly-estimated value. A possible range for the preliminary sustainable yield for the Coastal subbasin currently is 1,160 to 1,450 AFY.

DISCUSSION OF HISTORICAL VALUES BY OTHERS

Comparison of Sustainable Yield Values

Table 5, "Comparison of Calculated Sustainable Yield Values, Santa Monica Subbasins," tabulates and compares the updated results of this study to the results of previous studies conducted by RCS (2013) and others. The table shows the comparison of the sustainable yields as follows:

- Arcadia subbasin: 870 to 920 AFY vs a previously-estimated value of 2,000 AFY by others.
- Charnock subbasin: 6,410 to 6,470 AFY vs the previously-determined values of 4,420 to 8,200 AFY by others.

- Olympic subbasin: 1,560 to 1,660 AFY, vs the previous value of 3,275 AFY estimated by others.
- Coastal subbasin: 1,160 to 1,450 AFY, vs the previous value of 4,225 AFY by others.

As noted above, sustainable yield values for the Crestal subbasin could not be determined in this current study because of the lack of available data. A previous estimate by others for the Crestal subbasin was 2,000 AFY.

Arcadia Subbasin

In 1992, Kennedy Jenks Consultants (KJC, June 1992) prepared a groundwater management plan for the City for its Charnock and Coastal subbasins. In that study, KJC derived a sustainable yield value for a region that currently encompasses most/all the Arcadia, Coastal and Olympic subbasins. In that groundwater management plan, KJC performed a statistical evaluation of sustainable yield values. This was essentially the first type of “modeling” study conducted for the SMGB and for the Charnock and Coastal subbasins. However, it should be noted here that the “Charnock basin,” as defined by KJC, also consisted of the present Arcadia and Olympic subbasins, whereas their Coastal subbasin boundaries are like the current ones.

In its model, changes in water levels were compared to groundwater withdrawal volumes by KJC to determine the sustainable yield of the SMGB and its subbasins. KJC’s stated assumptions were that under constant withdrawal rates, if water levels remain at a relatively constant depth, then the pumping can be assumed to be within the sustainable yield limits of the subbasin. Conversely, if water levels continued to decline under constant withdrawal rates, then the sustainable yield of that subbasin was being exceeded.

KJC’s statistical evaluation involved plotting water levels versus groundwater withdrawal rates and fitting a least-squares line (i.e., linear regression curve) through the plotted points. There were a few types of statistical methods used:

- Water level elevations vs groundwater withdrawal volumes (in AFY).
- Annual withdrawals (in AF) and water level elevations vs date (years).
- Average annual water level elevations and pumping rates (in AF) vs date (years).

In addition, KJC also performed a groundwater basin budget evaluation, which consisted of examining subsurface groundwater inflows and outflows, amounts of water imported into the SMGB, groundwater recharges and discharges, determining groundwater flow directions and gradients (using the USGS MODFLOW computer modeling program), and groundwater in storage.

Using the above analyses/estimation techniques for KJC's combined Charnock and Coastal subbasins, KJC determined the following:

- A sustainable yield value of between 5,500 and 7,000 AFY for the Charnock subbasin (now the present Arcadia, Olympic and Charnock subbasins) via their statistical analysis of the data. Using their groundwater basin budget estimation, a range of 1,190 to 9,940 AFY, and a "probable yield" of 4,420 AFY were suggested by KJC.
- No sustainable yield for the Coastal subbasin was calculated by KJC because of a lack of data, and because the then-named "Potrero Canyon fault" (i.e., Brentwood fault on Figure 3B) and the Santa Monica fault were considered to create a disruption in groundwater flow patterns.

In late-1991 (contemporaneous with and based on the ongoing KJC study at that time), the City, in an internal memorandum (August 23, 1991), assigned a value of 9,500 AFY for an entire area termed therein as the "Santa Monica subbasin" (i.e., the combined Arcadia and Olympic subbasins). Thus, the previous preliminary value of 2,000 AFY estimated by RCS (March 27, 2013) was based on a split of the difference between the 1991/1992 value for the "Santa Monica subbasin" and the 1992 KJC value for only the Coastal subbasin. However, based on this current study by RCS, a value of 870 to 920 AFY has been calculated to be the current sustainable yield of the Arcadia subbasin.

<u>Charnock Subbasin</u>

The City (August 23, 1991) assigned a value of 6,000 AFY for the Charnock subbasin, based on the results of the KJC study at that time. RCS review of the KJC (June 1992) report indicates KJC provided a range of 6,000 to 6,500 AFY for this subbasin (June 1992, pg. 7-11). Thus, the City appears to have assigned the lower value for sustainable yield for the KJC-noted range. However, Komex H2O Science, Inc, (Komex, August 2001) provided a more recent estimate for the "safe yield" of the Charnock subbasin using the following two methods:

- A "Direct Correlation" approach, which estimated changes in groundwater elevations with changes in groundwater production. In this method, observed changes in average groundwater elevations were plotted against average annual production amounts. A linear regression curve was then applied to the plot. Points that fall on this line were considered to correspond to a no net inflow or a no net outflow, whereas points below the curve indicated average net inflow was lower than the average production; points above the curve indicated that average net inflow was higher than the production. Using this method, Komex arrived at a value of 9,244 AFY for net inflow of the Charnock subbasin.

- In addition, a three-dimensional numerical model of the Charnock subbasin was prepared, using software based on the USGS MODFLOW program. Their model was also based on withdrawal data for the 1931 through 1950 periods. The average annual production during that period was listed at 9,077 AFY, with a peak production of 12,500 AFY in 1941. Based on their numerical model, Komex calculated a sustainable yield value of 8,200 AFY for the Charnock subbasin using this approach, as seen on Table 5.

It is important to note that Komex also conducted "overdraft" modeling scenarios to determine the amount of groundwater that could be extracted from this subbasin. Key points of the Komex modeling of the Charnock subbasin included:

- A "baseline" production capacity for the subbasin of approximately 8,200 AFY could be maintained whereby water levels in the Silverado aquifer could be lowered to an elevation of 120 ft below mean sea level (msl). This represents a water level depth of approximately 217 ft bgs, based on an average ground surface elevation of 97 ft above msl for the Charnock wellfield. The RCS-calculated water level decline was 98 ft during our baseline period, whereas the Komex decline was 142 ft; thus, this partially accounts for the difference in the two sustainable yield calculations.
- Komex noted that water levels could be drawn down to an elevation of 200 ft below msl (or 297 ft below msl), which is roughly the equivalent to 50% of the thickness of the Silverado aquifer in this subbasin. After this, there would be a rapid water level decline and depletion of the groundwater resource. Komex considered this to be the "critical water level elevation."
- Komex cited that the Charnock subbasin had a large storage capacity, using an assigned specific yield value of 12% and a surface area of 4,200 acres for this subbasin. Based on this, they also concluded that "…short-term fluctuations in recharge that occur over a few to several years are damped out and do not appear to affect the overall production capabilities or the average safe yield of the Sub-Basin."

Based on their simulations, Komex provided a "best estimate" of the average "safe yield" of 8,200 AFY, with an "overdraft" protection of 10,500 AFY for the Charnock subbasin. This latter "overdraft" protection value could be maintained for at least five years"…*without lowering water levels in the subbasin "beyond reasonable levels.*" However, the actual depth (or elevation) of a "reasonable" water level was not identified in their report. It should be noted that their modeling was based on prior groundwater withdrawal values and SWL depths for the 1931 through 1950-time period (Komex, 2001, p. 3). Notably, such "early" SWL data for the region are rare, and the Komex study period is much earlier that that being used by RCS for this updated report.

In March 2013, RCS, using a pumpage approach, estimated a preliminary sustainable yield of the Charnock subbasin to conform to the Komex 2001 estimate of 8,200 AFY. Based on this approach, the range of the estimated sustainable yields for the Charnock subbasin (derived by RCS) is 6,410 AFY to an upper value of 8,080 AFY; this latter value is based on the earlier Komex-derived value (refer to Table 6, "Potential Sustainable Yield Values, Santa Monica Subbasins").

As previously noted herein, the privately-owned third party well is known to have historically constructed 10 wells at its own Charnock wellfield. None of these are currently in operation, and only two of those wells still exist; the remaining eight third party wells have reportedly been destroyed. Groundwater withdrawals from this third party-owned wellfield have been included in our calculation of the updated sustainable yield of this subbasin, but only through 1996, because production from their last two active wells was terminated at the end of 1996 due to known MTBE contamination at the City's Charnock wellfield, which lies to the northeast. Thus, the period of groundwater withdrawals by this private company from the Charnock subbasin unfortunately includes only the first few years of the 30-year baseline study period used herein. The City is interested in acquiring the former third party Well No.10 and rehabilitating it for use as a municipal-supply well for the City. Historically, this well was reportedly able to produce between 800 to 1,000 gpm.

Olympic Subbasin

A previously estimated value by RCS (March 27, 2013) of 3,275 AFY had been assigned to this subbasin. This estimate was based in part on the City's Internal Memorandum (April 1991) and KJC's value (June 1992) for the Charnock subbasin. As shown on Table 6, the current (updated) value by RCS of 2,360 to 3,145 AFY was estimated based on observed changes in measured groundwater levels, recent data obtained during the drilling and construction of the new SM-8, average groundwater extraction values over the hydrologic baseline period, and aquifer recharge plans proposed by the City.

Coastal Subbasin

In its 2013 Memorandum, RCS assigned at a value of 4,225 AFY for the Coastal subbasin, which was largely based on prior KJC studies. Recently-generated pumping test data from a new City well in this subbasin (Airport Well No. 1), an updated, preliminary sustainable yield value ranging from 1,160 AFY to 1,450 AFY is estimated, and these values are based on a total of three City wells, each pumping at a rate of 300 gpm, and at operational bases of 80% to 100% in the future. However, there are only limited available data on changes in SWLs from prior production wells or groundwater monitoring wells within the Coastal subbasin. Thus, a more refined estimate for the current sustainable yield of this subbasin is not possible until such data for long-term changes in SWLs can be documented and reconciled with groundwater extraction records. Pending such data, the current estimated sustainable yields may change to a higher or lower value, based on the future impact of pumping of the wells on local SWLs over time.

Crestal Subbasin

The previous sustainable yield value of 2,000 AFY was chiefly defined in a City of Los Angeles Department of Water and Power (LADWP) report dated April 1991 which assigned a range of values of 1,000 and 3,000 AFY for the sustainable yield of this subbasin. In RCS, (March 27, 2013), the midpoint of that range (i.e. 2,000 AFY) was selected as the preliminary sustainable yield value for this subbasin. This current (updated) study herein has not been able to arrive at a range of values, because of the lack of available data. Until additional data are obtained for the Crestal Subbasin, the previous value of 2,000 AFY may be valid. As noted elsewhere herein, it is probable that LACC may extract ±450 AFY of groundwater by its own private onsite, irrigation-supply water wells in this subbasin.

FUTURE PLANNED WITHDRAWALS AND INJECTION

City staff plans to increase the production of groundwater from the Charnock and Olympic subbasins, through the construction of additional water-supply wells, and also plans to increase the volume of groundwater in storage using at least one new injection well. In the Charnock subbasin, the plan is to add (utilize) an additional well, through the City's acquisition of third party-owned Charnock Wellfield Well No. 10, located 900 ft southwest of the City's Charnock wellfield. The City plans to pump this well at a rate of approximately 900 gpm in the future.

In the Olympic subbasin, the City plans to replace existing Santa Monica Well No. 3 and pump the new replacement well (SM-9) at a rate of 600 gpm. In addition, if pumping of the newly-constructed SM-8 is added to this (at a continuous rate of 600 gpm), then the total pumpage from these two wells would be 1,200 gpm. Furthermore, the City is also planning to construct an aquifer recharge well designed to inject up to 1,120 AFY of highly treated water from the

City's SWIP project. When completed, this well will help sustain the long-term yield of this subbasin.

EVALUATION OF RAINFALL RECHARGE TO THE SANTA MONICA BASIN

ICF (May 2018) utilized a 2016 USGS report to estimate the amount of underflow and other recharge entering the SMGB from various sources, including adjacent mountain front areas. The ICF-estimated average potential recharge to the SMGB ranged from 12,131 to 12,722 AFY. A significant portion of this volume was underflow in the subsurface from higher elevations (mountain fronts) and from excess irrigation on residential properties. Assuming a conservative estimate of 8% of this recharge would be able to deep percolate into the SMGB, where it would tend to increase subbasin water levels, the range of sustainable yield for the SMGB could be on the order of 11,800 to 14,725 AFY. Table 7, "Potential Lower and Upper Sustainable Yield Values, Santa Monica Subbasins," shows the sustainable yield values for each of the subbasins, including the ICF recharge factors. The City is conducting a supplemental DiNSAR study to further assess this recharge potential from ICF.

CONCLUSIONS & RECOMMENDATIONS

Average subbasin withdrawals by known pumpers (i.e., the City, local golf courses and other third parties) over the 30-year baseline period analyzed for this updated report, based on average annual withdrawals over that baseline period are:

- Arcadia subbasin: 1,010 AFY
- Charnock subbasin: 6,290 AFY
- Olympic subbasin: 1,860 AFY

A separate calculation for the Coastal subbasin was performed and is based on future planned withdrawals from new City wells to be constructed within the subbasin. These planned withdrawals are preliminarily estimated to be 1,450 AFY. However, the effect of these planned withdrawals on the change in storage in this subbasin will need to be evaluated later.

Based on available water level and groundwater withdrawal data, the results of this current study show that the sustainable yields of the portions of the three subbasins of the SMGB that are currently subject to City pumping and for which requisite data are available, are as follows: 870 to 920 AFY for the Arcadia subbasin; 6,410 to 8,080 AFY for the Charnock subbasin; 2,360 to 3,145 AFY for the Olympic subbasin; and 1,160 to 1,450 AFY for the Coastal subbasin (preliminarily based on recent pumping tests of a new well in this subbasin). The total sustainable yield from the four subbasins were calculated to be 10,800 to 13,595 AFY. If a portion of the recharge to the SMGB estimated by others (ICF, 2018) is utilized, then the sustainable yield could conceivably be as great as 11,800 to 14,725 for the SMGB. The Crestal subbasin has not been included in this estimate because of the lack of available data to quantify the sustainable yield in this subbasin.

Even though it has been shown (above) that up to 13,595 to 14,725 AFY could conceivably be an upper limit for the sustainable yield, the potential impact on water levels and water quality are temporal and require monitoring. Thus, the City must be diligent in obtaining reliable data on SWLs, total annual groundwater extractions, and groundwater quality in the four subbasins and in determining changes in storage, in order to preclude lower water levels that could ultimately result, for example, in the intrusion of seawater into the SMGB.

It should be noted here that increased production from the City's Charnock wellfield was made possible by the recovery of water levels into the area during the non-pumping period from 1996 through 2010. While there may be additional groundwater in storage throughout the SMGB, such as that identified in the USGS and ICF reports that would allow for some greater amount of groundwater withdrawals from the various subbasins, it may only be for short periods of time. Such pumping, if conducted over too long of a period, could also lead to other conditions, such as: a need to lower pump depth settings in existing wells; upwelling of poorer quality groundwater from deeper earth materials; and the creation of cascading water conditions when the wells are being pumped. The City must continue to be diligent about is ongoing program to monitor and record SWLs (and total pumped groundwater withdrawals) for each of its wells in the Arcadia, Charnock, Coastal and Olympic subbasins to update and refine the estimates of sustainable yield.

Through the establishment of a network of both production wells and groundwater monitoring wells and the ongoing, regular recording, monitoring and evaluation of resultant and reliable data regarding SWLs and water quality [especially total dissolved solids (TDS) and chloride (Cl) concentrations], then any changes indicating sea water intrusion can be determined, and the pumping of the wells can be adjusted to reverse possible increases in TDS and Cl concentrations. As such, the sustainable yields calculated in this current study will be further refined over time.

RCS, as stated previously, recommends an operational pumping basis for active wells of ±80% (i.e., actively using a well for 18 to 19 hours each day), instead of a 100% operational basis wherein a well is never shut down. Such 100% continuous pumping (or injection) will tend to create downwell problems and will not allow for routine operation and maintenance procedures.

Future groundwater withdrawals from the three active subbasins, within the limitations presented by the estimated sustainable yields reported herein, indicate that the City's approach of investigating the water supply potential of the Coastal subbasin, and the pursuit of indirect potable reuse from its planned Sustainable Water Infrastructure Project (SWIP), are both prudent and necessary for the City to help achieve its long-term objective of independence from imported water. It is recommended that the City continue its heretofore successful water conservation programs, and to expedite the assessment of the Coastal subbasin. Identification of viable groundwater reserves in the Coastal subbasin will help alleviate the current heavy reliance on the three other subbasins which currently provide groundwater supply to the City. These Coastal subbasin groundwater reserves could also facilitate the implementation of adaptive pumping measures, where individual wells or wellfields could be periodically rested to allow for natural recharge.

Another key component to drought resiliency and water sustainability is the treatment and reuse of non-conventional resources such as dry weather and storm-water runoff, brackish/saline groundwater and municipal wastewater. The City is in the process of completing construction of its Clean Beaches Project which will install a below grade 1.6 million-gallon storm-water harvest tank north of the Santa Monica Pier. This innovative project will capture runoff from the Pier Drainage Area for treatment at the City's Santa Monica Urban Runoff Recycling Facility (SMURRF). When runoff is scarce it will harvest brackish ground water from a gallery of horizontal sub drains built beneath the tank. It is estimated that when complete this project will help generate approximately 560 AFY of new water for immediate non-potable reuse and, when properly permitted, it could likely be used for indirect potable reuse via aquifer recharge.

The SWIP is comprised of three integrated elements that once constructed will produce approximately 1,100 AFY of new water from dry and wet weather runoff and municipal wastewater. Water generated by the SWIP will be utilized primarily for aquifer recharge. The SWIP is currently scheduled for completion in 2020. The City should expand the distributed water strategy (i.e. stand alone, small scale) demonstrated by the Clean Beaches Project, SMURRF and the SWIP to increase conjunctive reuse of all water resources, and especially non-conventional resources, available to the City. As additional water resources are identified, and the necessary infrastructure constructed, the use of imported water will continue to be reduced.

REFERENCES REVIEWED

Bredehoeft, J.D., Papadopulos, S.S., and Cooper, H.H., 1982, *Groundwater: The Water Budget Myth,* in Scientific Basis of Water-Resources Management, Studies in Geophysics, Washington D.C. National Academy Press. Pp. 51-57.

California Department of Water Resources (DWR), February 2017. *Sustainable Groundwater Management* Web Site at: http://www.water.ca.gov/groundwater/sgm/definitions.cfm

_____, December 22, 2016, *California's Groundwater, Working Toward Sustainability*. Bulletin 118 Interim Update 2016. 44 pp.

_____, April 15, 2015, *California's Groundwater, Update 2013, A Compilation of Enhanced Content for California Water Plan*. Arranged in Multiple Sections.

_____, October 2003; *California's Groundwater.* Bulletin No. 118-Update to 1975 version.

_____, February 2004; *California's Groundwater, Coastal Plain of Los Angeles Groundwater Basin, Santa Monica Basin.* Bulletin No. 118 Online Update.

_____, March 9, 2015, *Sustainable Groundwater Management Program Draft Strategic Plan*. 31 pp.

_____, June 1961, *Planned Utilization of the Ground Water Basins of the Coastal Plain of Los Angeles County - Appendix A, Ground Water Geology.* Bulletin No. 104. 181 pp.

_____, October 1965, *Water Well Standards, Central Hollywood, Santa Monica Basins, Los Angeles County, Bulletin No. 74-4*. 62 pp.

_____, September 1975, *California's Ground Water.* Bulletin No. 118. 135 pp.

City of Santa Monica, August 23, 1991, Untitled Single Page Internal File Memo.

Farvolden, R.N., 1967, *Methods of Study of the Ground-Water Budget in North America*. General Assembly of Bern. pp 108-125.

ICF Corporation, May 25, 2018*, Final Draft: Evaluation of Recharge and its Effect on Sustainable Yield in the Santa Monica Basin*. 12 pp.

Earth Consultants International, 2017, Map generated using LIDAR topography.

Interagency Watershed Mapping Committee, October 1999, *California Watersheds*. Version 22.

Los Angeles Department of Water and Power, April 1991, *Development of the Santa Monica and Hollywood Groundwater Basins as a Water Supply Source for the City of Los Angeles.* 26 pp.

Kennedy/Jenks Consultants, June 1992; *Santa Monica Groundwater Management Plan, Charnock and Coastal Sub-Basins*, Final Report; for the City of Santa Monica

Komex H2O Science, Inc, August 10, 2001, *Estimates of Safe Yield for the Charnock Sub-Basin*. 6 pp.

Meinzer, O.E., 1923, *Outline of Groundwater Hydrology*, U.S. Geological Survey Professional Paper 494. 71 pp, Metropolitan Water District of Southern California, September 2007, *Groundwater Assessment Study.* Report No. 1308, Chapter IV. Pgs. 5-1 to 5-12.

Report of Referee, July 1962, The City of Los Angeles, plaintiff, vs. The City of San Fernando et al, defendants. Superior Court of the State of California in and for the County of Los Angeles Case No. 650079. Referee; State Water Rights Board. Two Volumes.

Richard C. Slade & Associates LLC, March 27, 2013, *Review and Evaluation of Historic Perennial Yield Values, Santa Monica Groundwater Basin, Los Angeles County*. 8 pp.

_____, February 2013, *Conceptual Groundwater Basin Model and Assessment of Available Groundwater Supplies, Santa Monica Groundwater Basin*. 119 pp. 14 plates.

_____, December 1986, *Hydrogeologic Investigation, Perennial Yield and Artificial Recharge Potential of the Alluvial Sediments in the Santa Clarita River Valley of Los Angeles County, California*. Report prepared for Upper Santa Clara Water Committee. 120 pp. 14 Plates.

Todd, D.K. 1059. *Ground Water Hydrology.* 535 pp.

USGS, 1999, *Sustainability of Ground-Water Resources*. Circular 1186 79 pp.

USGS, 2016, *Estimating Spatially and Temporally Varying Recharge and Runoff from Precipitation and Urban Irrigation in the Los Angeles Basin, California*. Scientific Investigations Report 2016-5068. 192 pp.

US Bureau of the Census, 2010, *Summary Population and Housing Characteristics 2010*. Census of Population and Housing. Chps. 1-6.

US Bureau of the Census 1992, 1*990 Census of Population General Population Characteristics California Section 1 of 3.* U.S. Department of Commerce, Economics and Statistics Administration.

Water Replenishment District of Southern California (WRD), March 2017, *Regional Groundwater Monitoring Report, Water Year 2016-2017*, *Central and West Coast Basins, Los Angeles County, California.*

APPENDIX 1
FIGURES

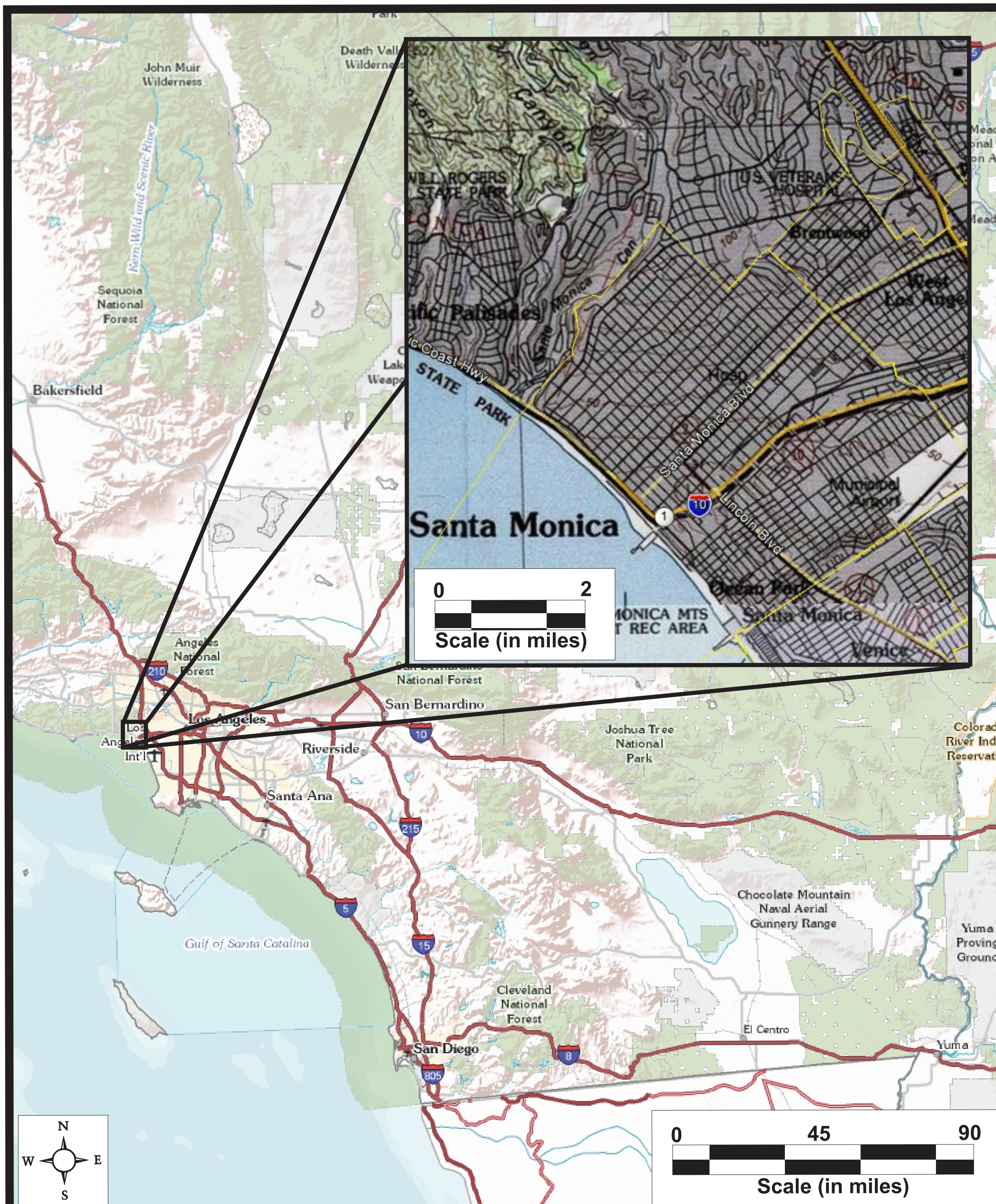

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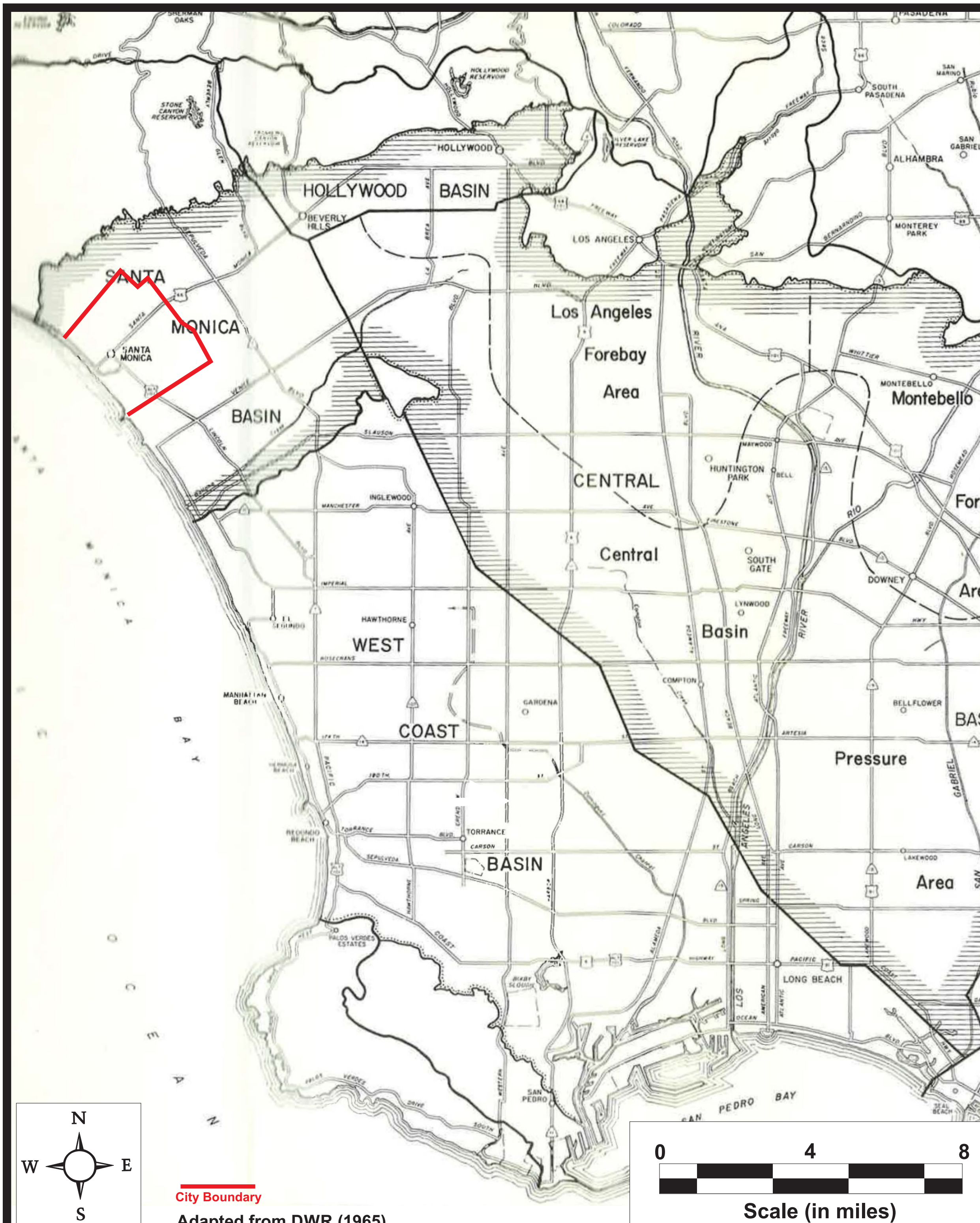
FIGURE 1
LOCATION MAP OF STUDY AREA

RCS Job No. 462-LASOC

June 2018



Adapted from DWR (1965)

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FIGURE 2
MAP OF DWR
GROUNDWATER BASINS

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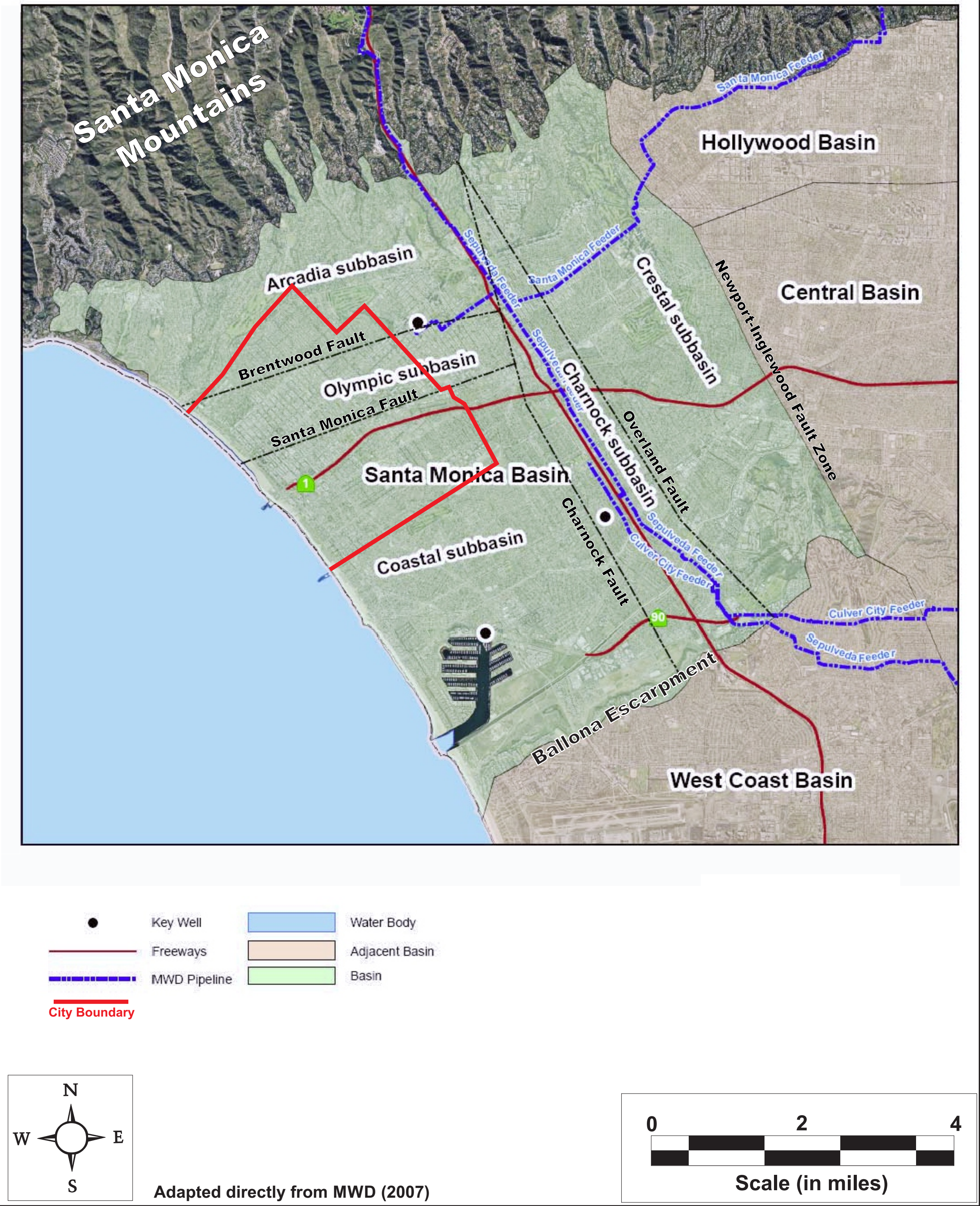

Adapted directly from MWD (2007)

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FIGURE 3A
GROUNDWATER SUBBASIN BOUNDARY MAP

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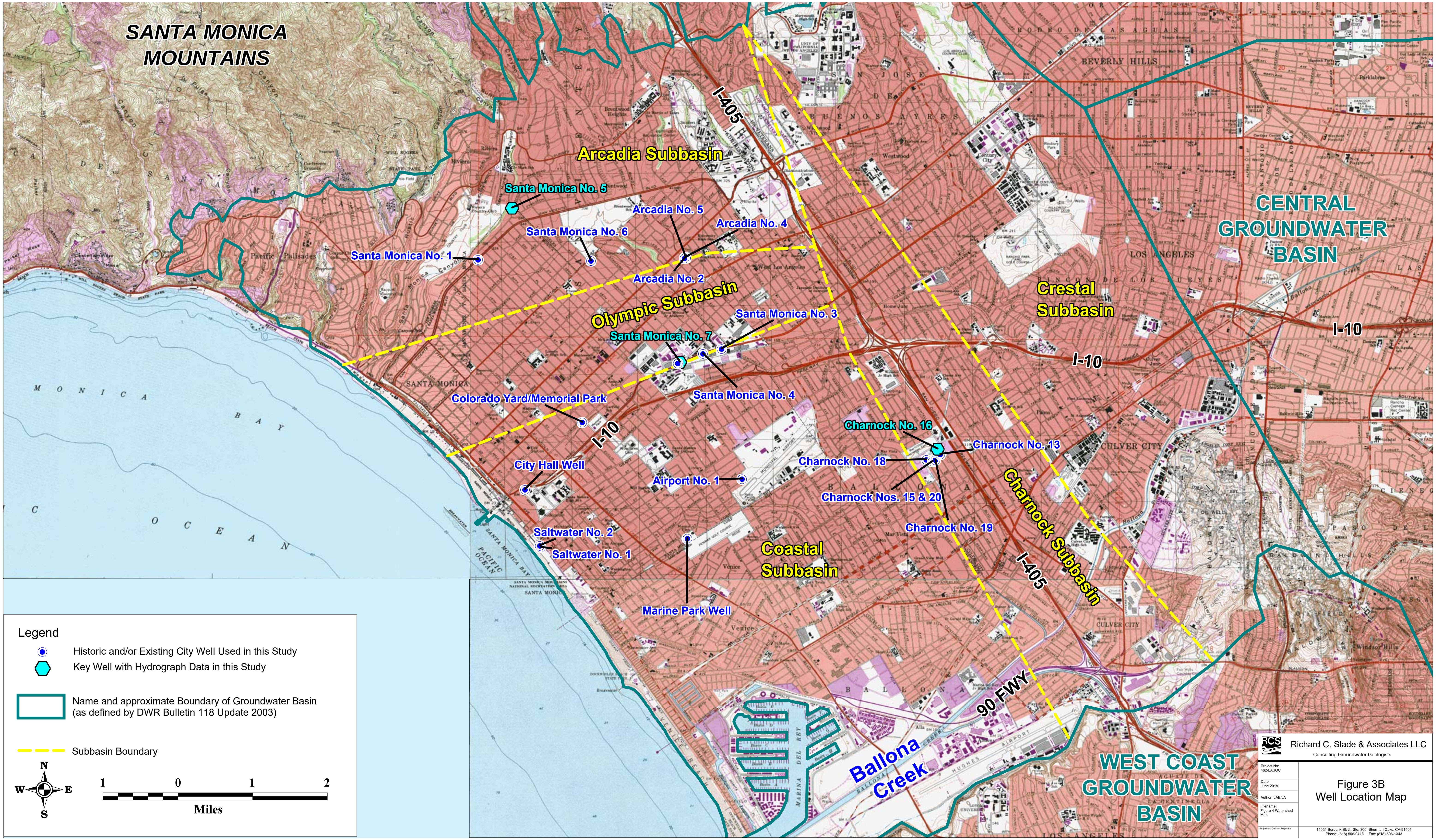

Figure 3B
Well Location Map

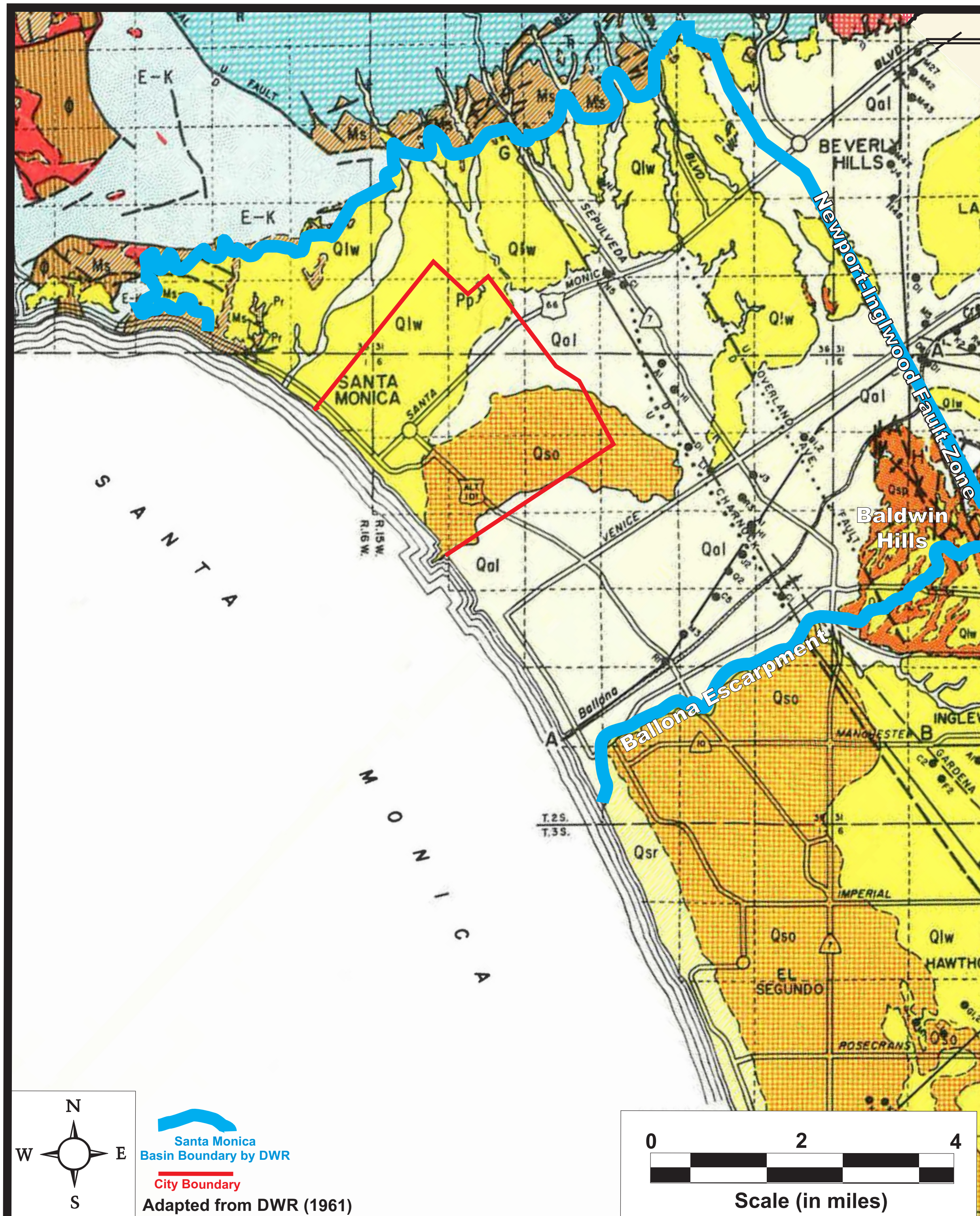

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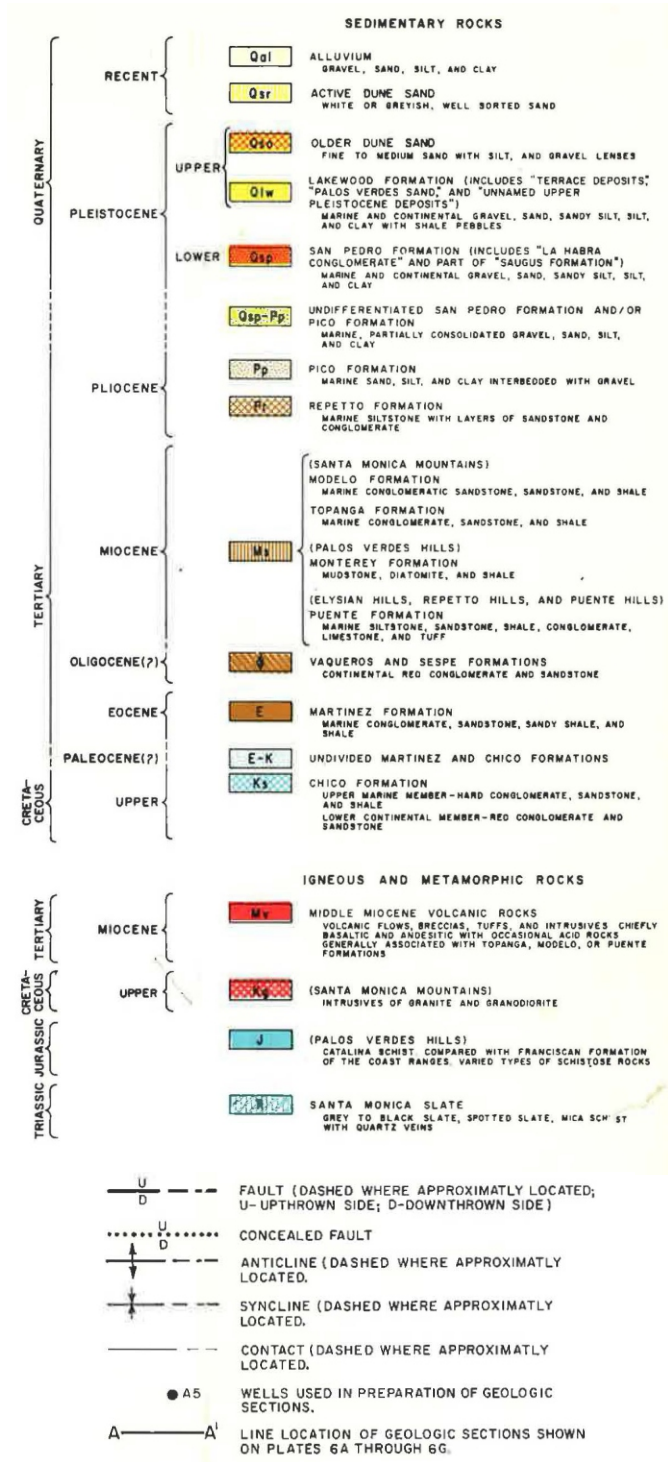
FIGURE 4A
GENERALIZED GEOLOGIC MAP OF THE SANTA MONICA AREA

RCS Job No. 462-LASOC   June 2018



Adapted from DWR (1961)

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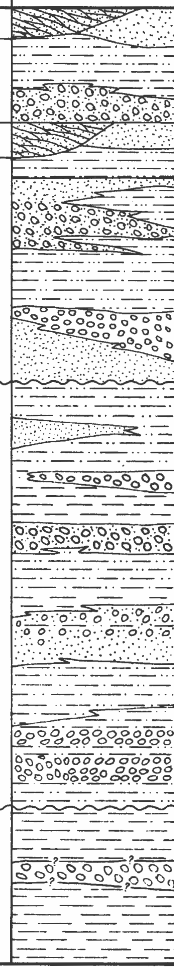
FIGURE 4B
GENERALIZED GEOLOGIC MAP LEGEND & SYMBOLS

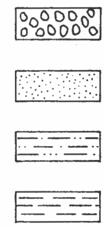
RCS Job No. 462-LASOC June 2018

SYSTEM	SERIES	FORMATION	AQUIFER AND AQUICLUDE	MAX. THICKNESS (FEET)	PREVIOUS FORMATION NAMES*	PREVIOUS AQUIFER NAMES*
QUATERNARY	RECENT	ACTIVE DUNE SAND	SEMIPERCHED	60	ALLUVIUM	SEMIPERCHED†
		ALLUVIUM	BELLFLOWER AQUICLUDE	140		
			GASPUR	120		GASPUR†
			BALLONA	40		"50 FOOT GRAVEL"
	UPPER PLEISTOCENE	OLDER DUNE SAND	SEMIPERCHED	200	TERRACE COVER	
		LAKEWOOD FORMATION	BELLFLOWER AQUICLUDE		PALOS VERDES SAND	SEMIPERCHED†
			EXPOSITION ARTESIA	140	UNNAMED UPPER PLEISTOCENE	
			GARDENA	160		GARDENA†
			GAGE	160		"200 FOOT SAND"
		UNCONFORMITY			LOCAL UNCONFORMITY	
	LOWER PLEISTOCENE	SAN PEDRO FORMATION	HOLLYDALE	100	SAN PEDRO FORMATION	
			JEFFERSON	140		
			LYNWOOD	200		"400 FOOT GRAVEL"†
			SILVERADO	500		SILVERADO †
			SUNNYSIDE	500		
		LOCAL	UNCONFORMITY			
TERTIARY	UPPER PLIOCENE	PICO FORMATION	UNDIFFERENTIATED		PICO FORMATION	

LITHOLOGY



LEGEND OF LITHOLOGY



* DESIGNATIONS AND TERMS UTILIZED IN "REPORT OF REFEREE" DATED JUNE 1952 PREPARED BY THE STATE ENGINEER COVERING THE WEST COAST BASIN

† DESIGNATED AS "WATER BEARING ZONES" IN ABOVE NOTED REPORT OF REFEREE

Modified from DWR Bulletin 104 (1961)

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FIGURE 5
GENERALIZED STRATIGRAPHIC SECTION FOR THE COASTAL PLAIN OF LOS ANGELES COUNTY

RCS Job No. 462-LASOC

June 2018

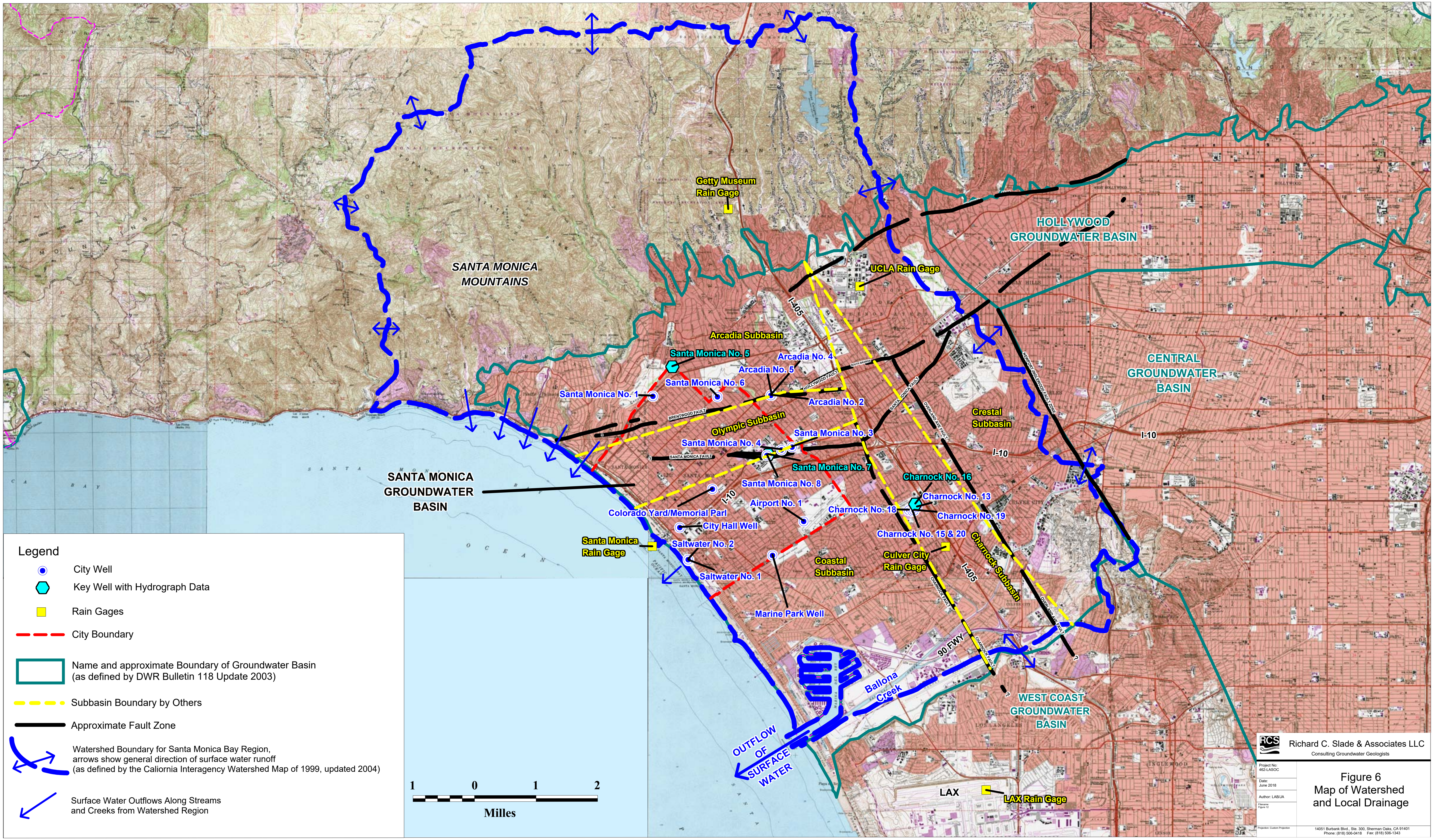

Figure 6
Map of Watershed and Local Drainage

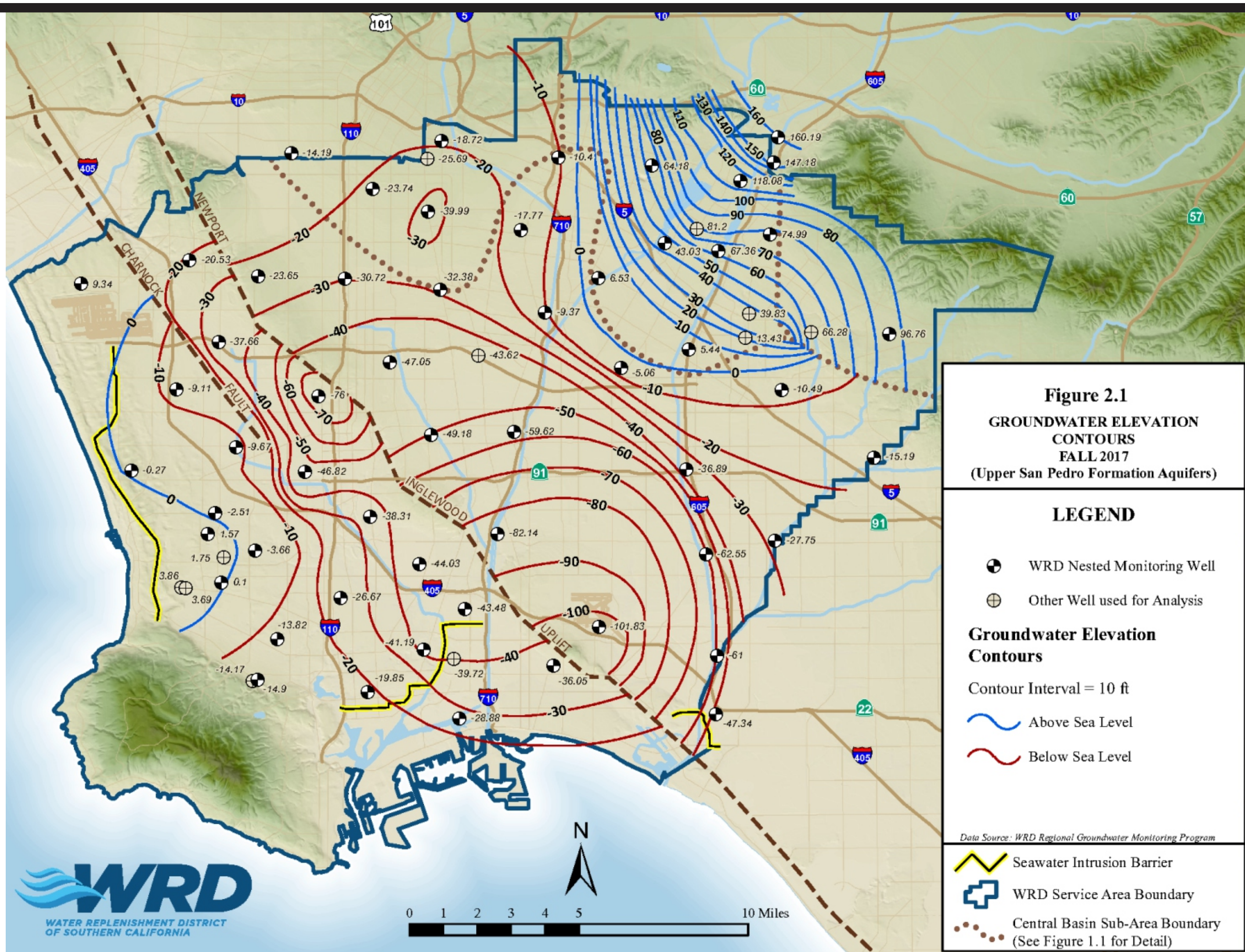

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FIGURE 7
GROUNDWATER ELEVATION CONTOURS OF THE WEST COAST & CENTRAL GROUNDWATER BASINS

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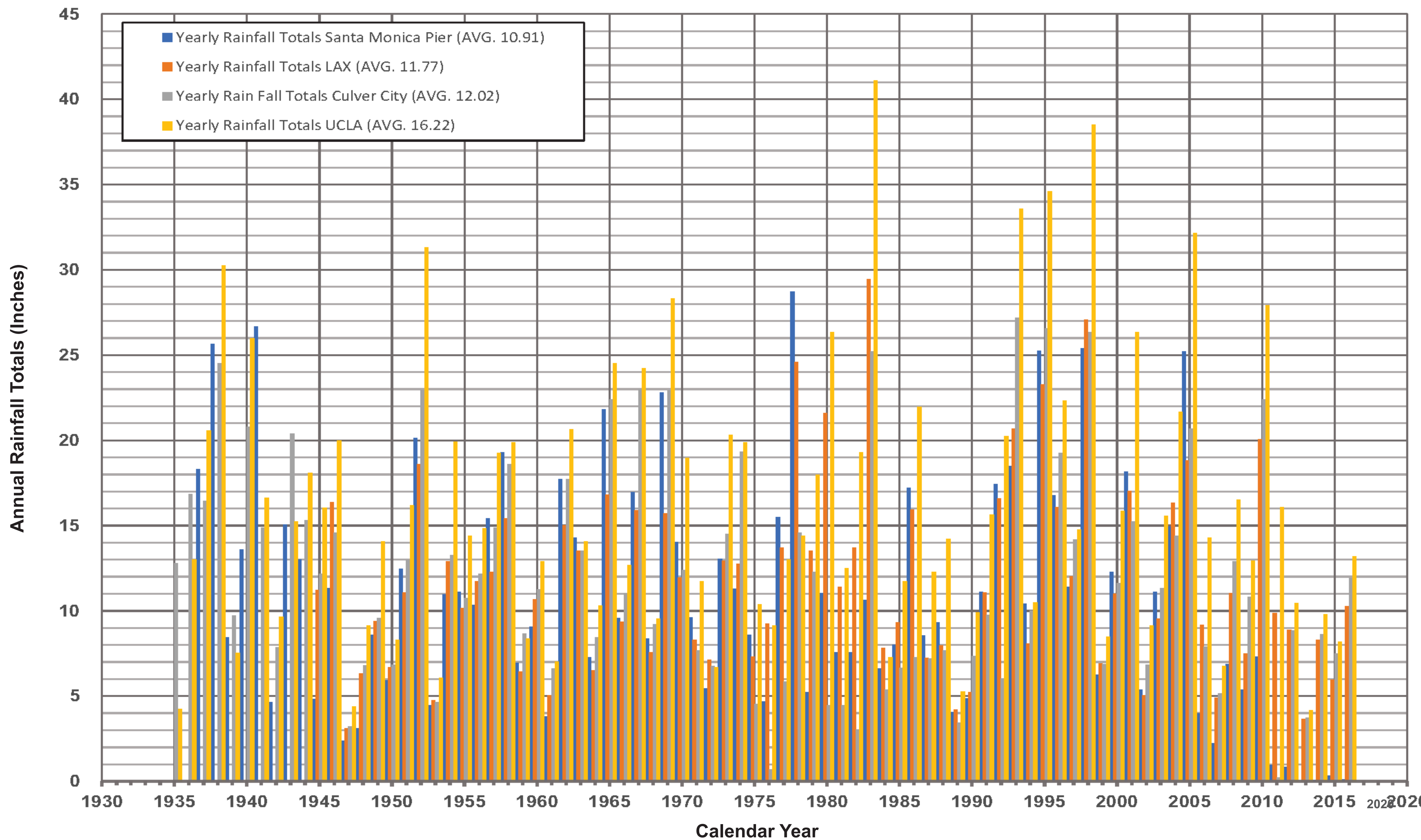

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FIGURE 8A
ANNUAL RAINFALL TOTALS
VARIOUS RANGE GAGES

Job No. 462-LASOC

June 2018

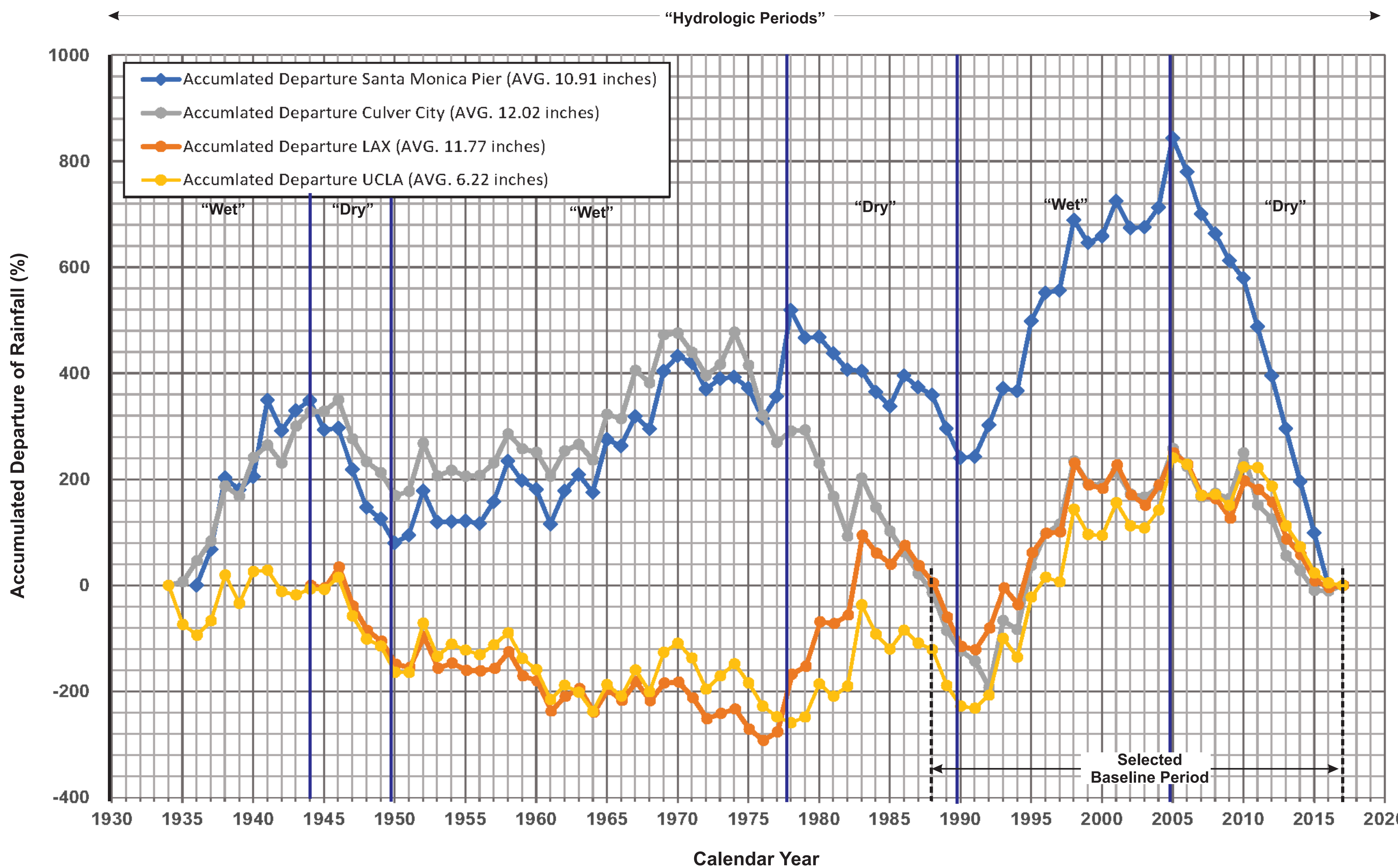

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FIGURE 8B
ACCUMULATED DEPARTURE OF RAINFALL

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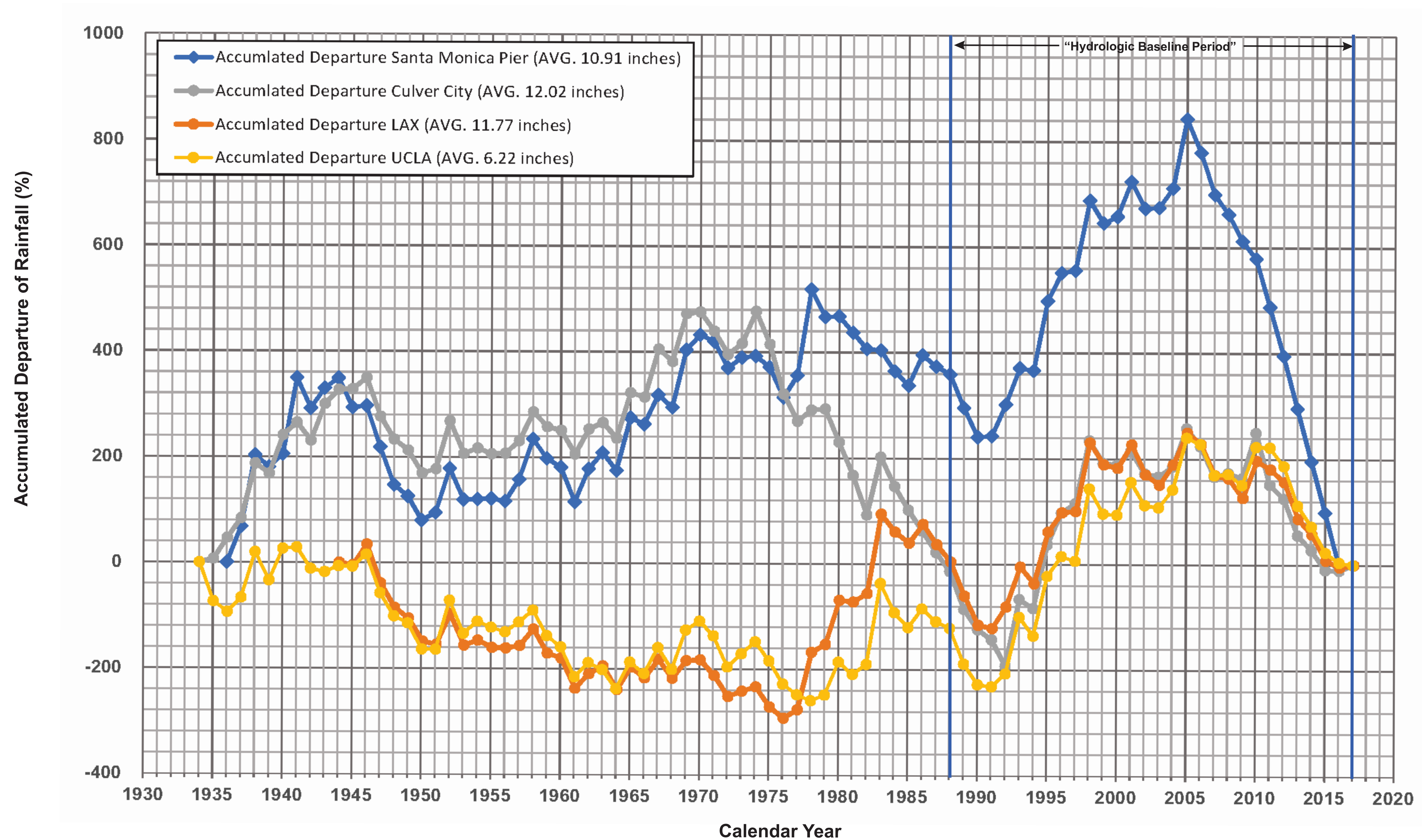

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FIGURE 9
SELECTED BASELINE PERIOD

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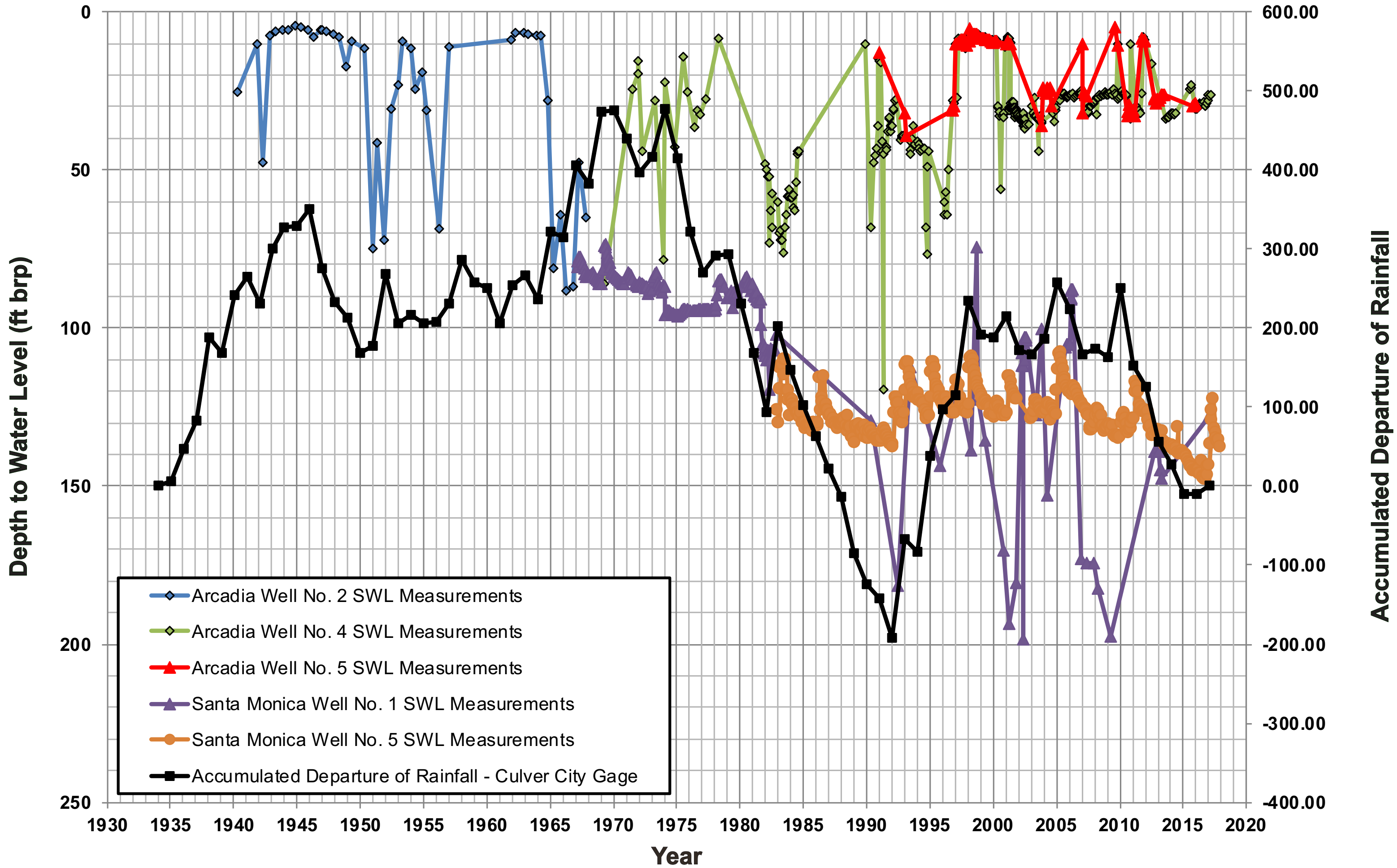

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FIGURE 10A
ARCADIA WELLFIELD/SUBBASIN
HYDROGRAPHS

Job No. 462-LASOC

June 2018

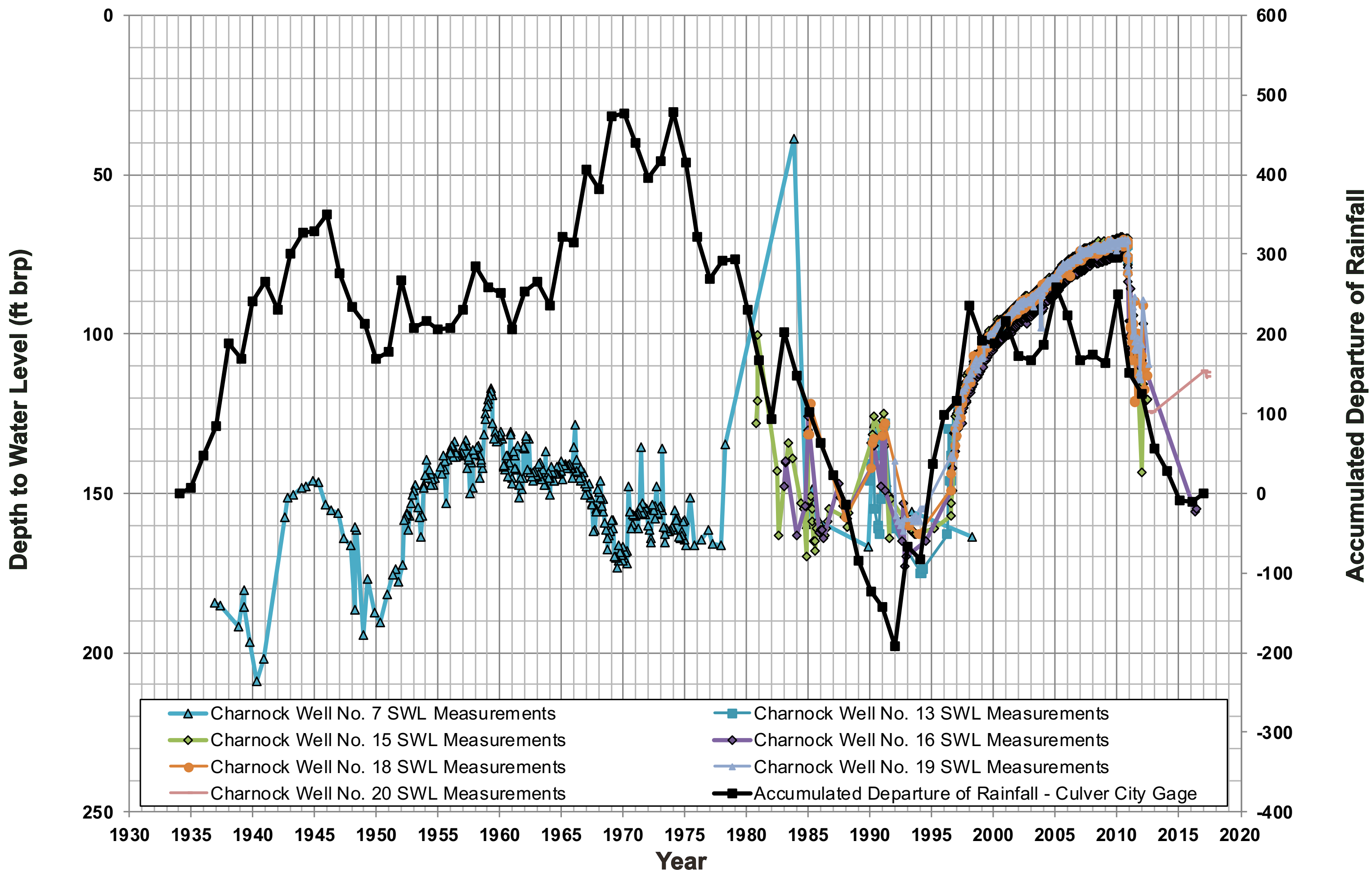

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FIGURE 10B
CHARNOCK WELLFIELD/SUBBASIN HYDROGRAPHS

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June 2018

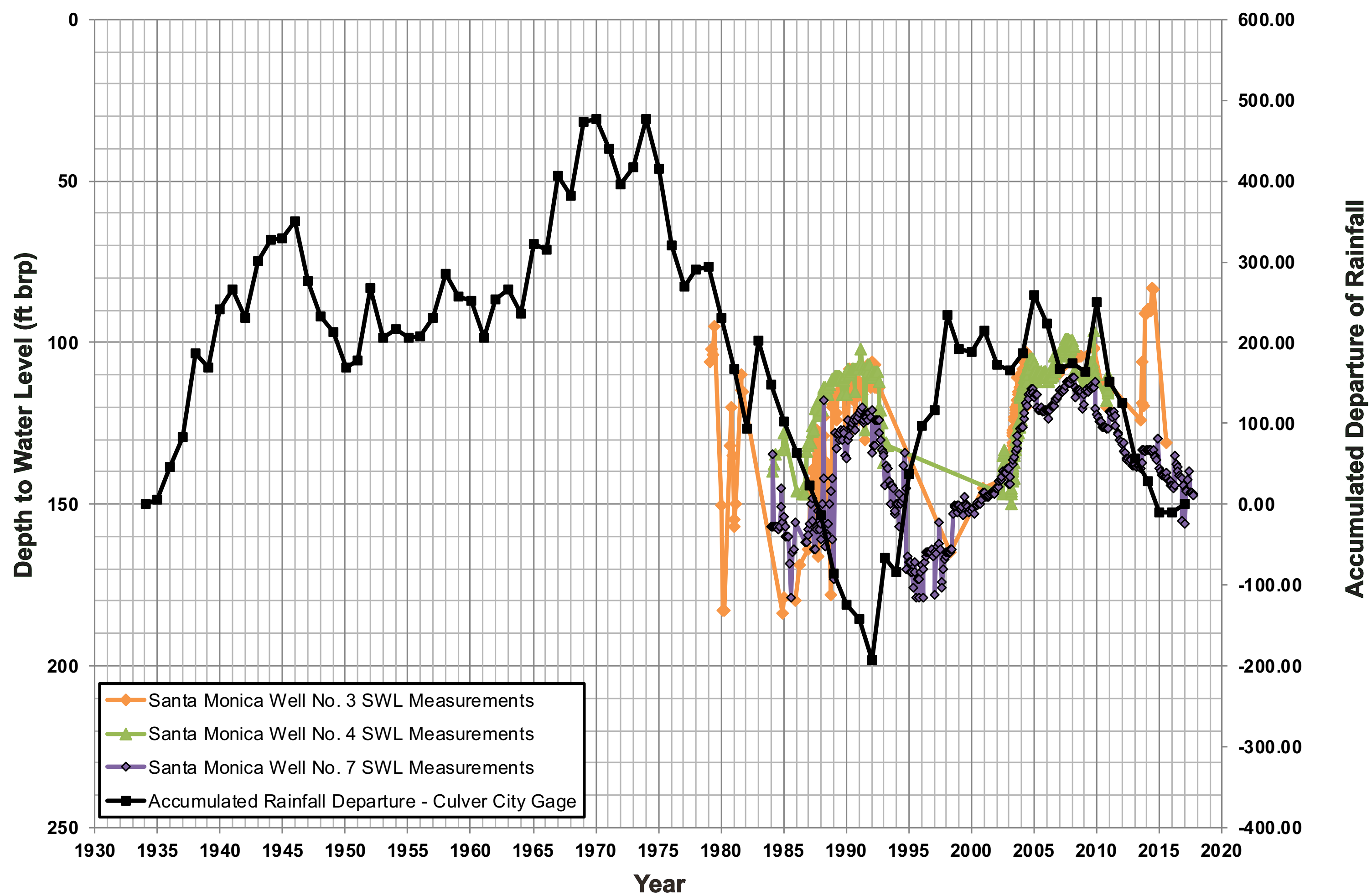

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FIGURE 10C
OLYMPIC WELLFIELD/SUBBASIN HYDROGRAPHS

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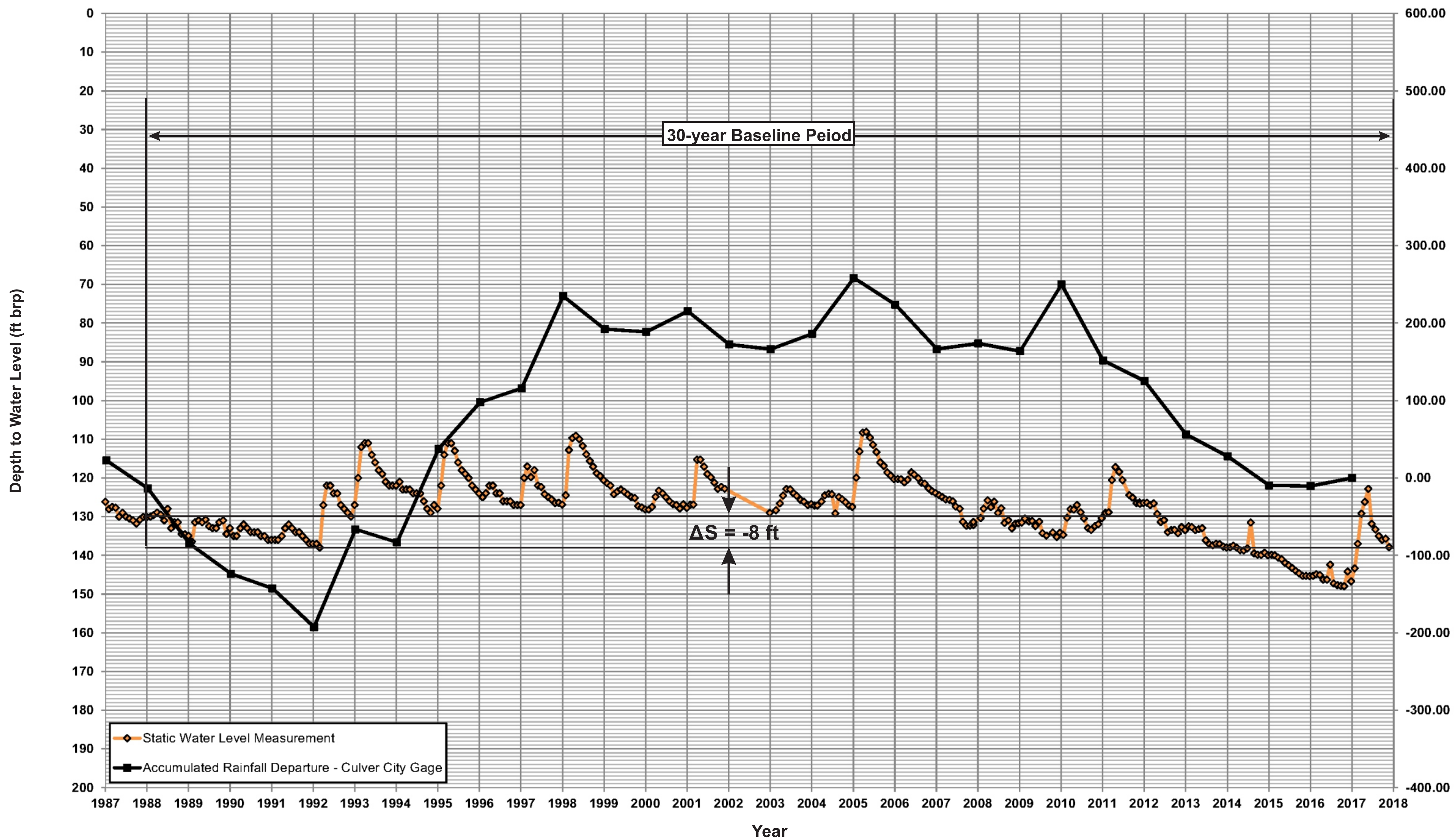
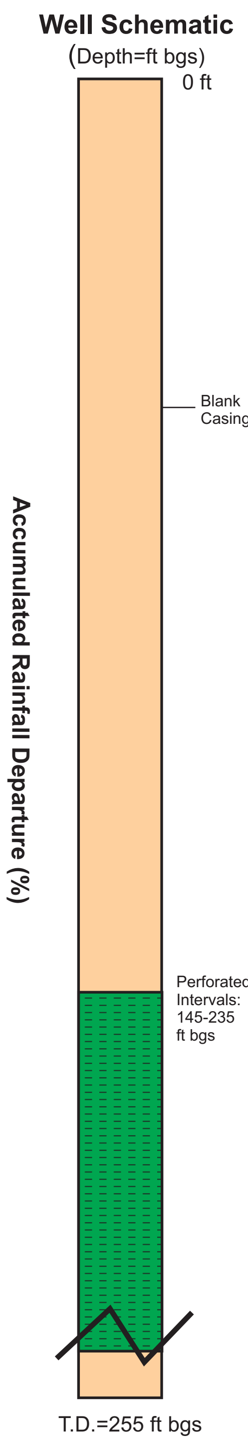
June 2018





Note: Reference Point = 378.08 ft above msl

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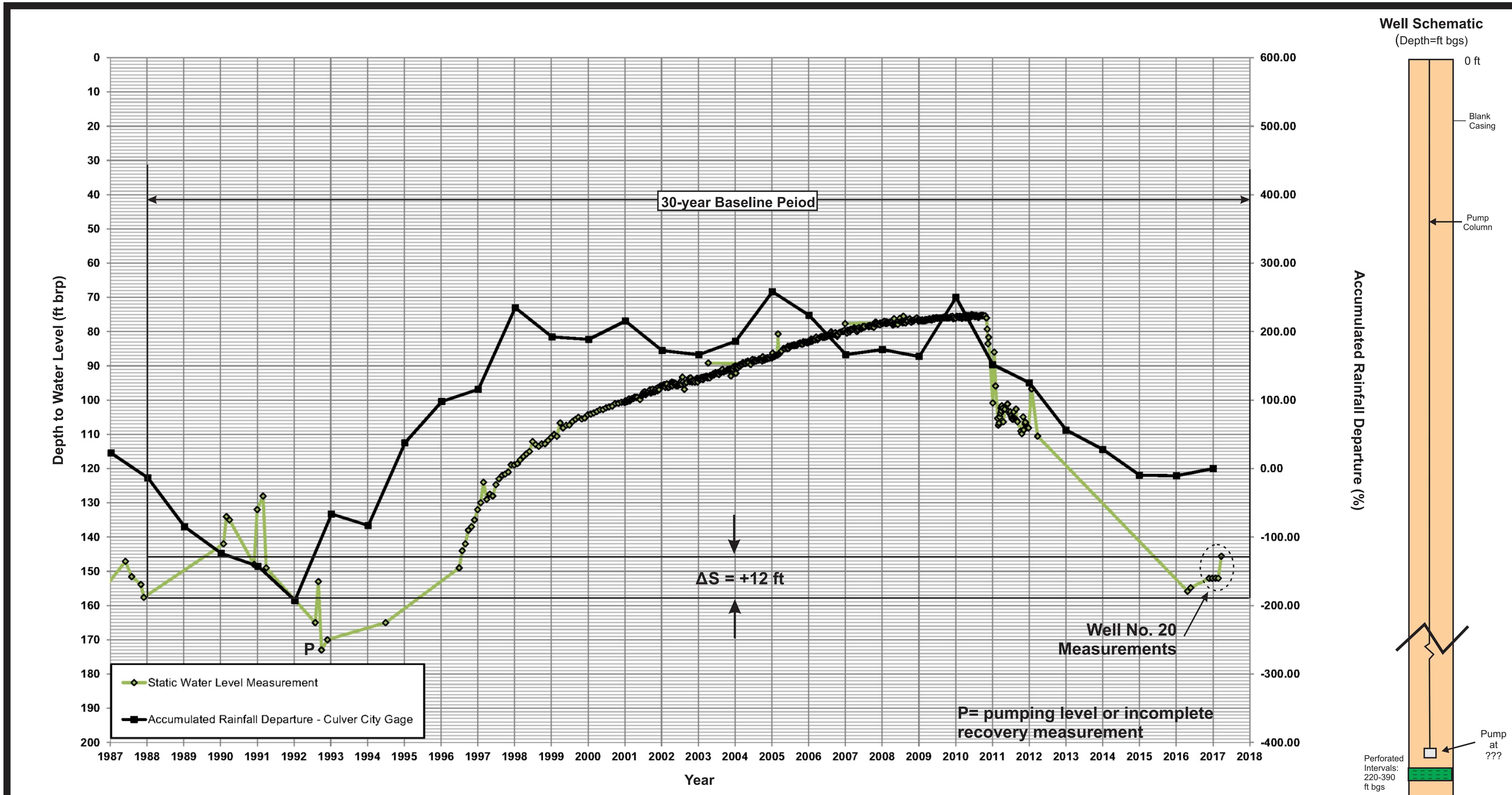
FIGURE 11A
KEY WELL HYDROGRAPH
SANTA MONICA WELL NO. 5
ARCADIA SUBBASIN, TOTAL CHANGE IN STORAGE

Job No. 462-LASOC

June 2018



Note: Reference Point = 105.83 ft above msl

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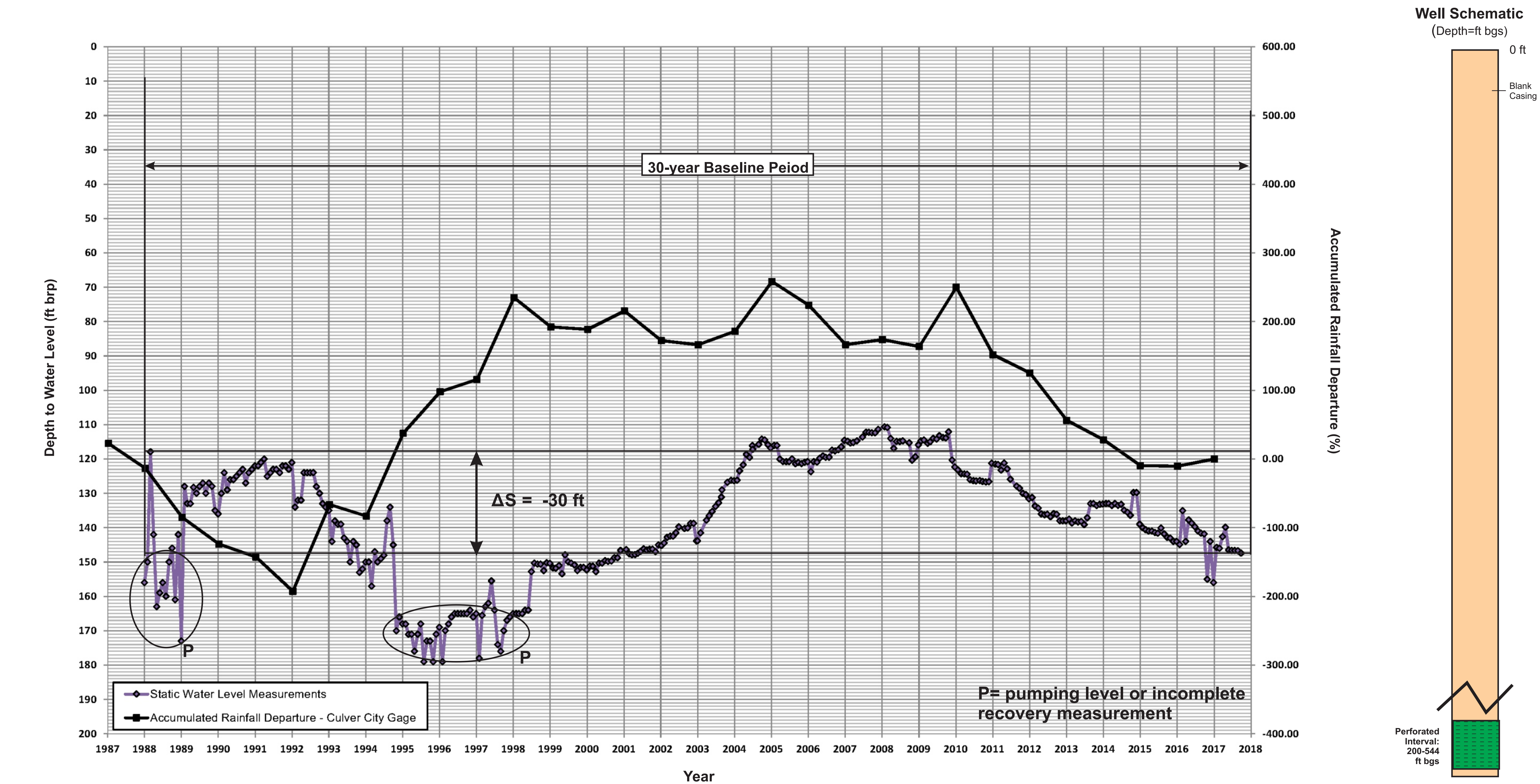
FIGURE 11B
KEY WELL HYDROGRAPH
CHARNOCK WELL NO. 16 & NO. 20
CHARNOCK SUBBASIN, TOTAL CHANGE IN STORAGE

Job No. 462-LASOC

June 2018



Note: Reference Point = 150.46 ft above msl

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FIGURE 11C
KEY WELL HYDROGRAPH
SANTA MONICA WELL NO. 7
OLYMPIC SUBBASIN, TOTAL CHANGE IN STORAGE

Job No. 462-LASOC

June 2018

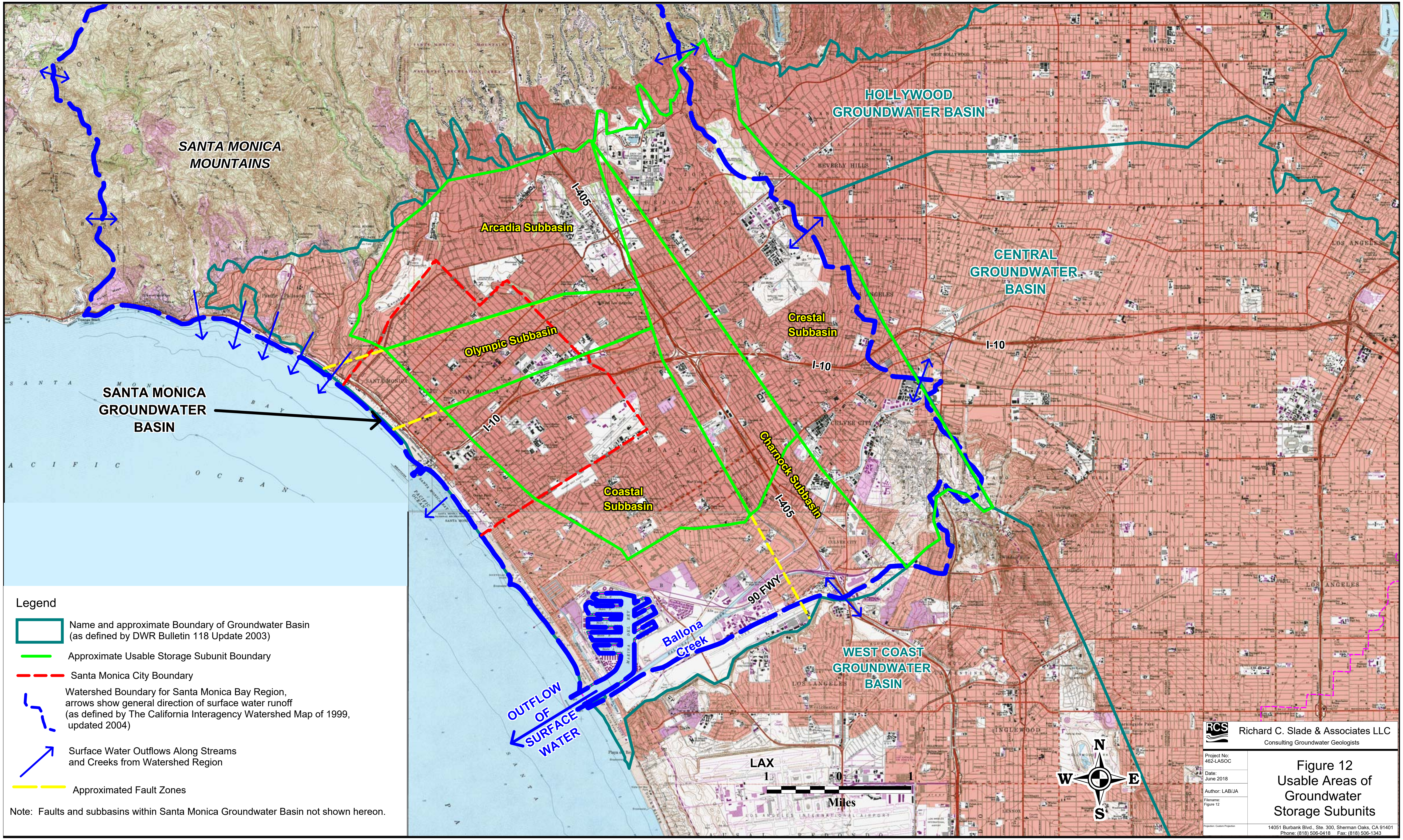

Figure 12
Usable Areas of Groundwater Storage Subunits

APPENDIX 2
TABLES

TABLE 1
SUMMARY OF WELL CONSTRUCTION DATA
FOR HISTORIC AND EXISTING CITY WELLS USED IN THIS STUDY

Well No.	State Well No.	State Well Completion Report No. (E-log Date)	Date Constructed	Method of Drilling	Pilot Hole Depth (ft)	Casing Type & Depth (ft)	Casing Diameter (in)	Borehole Diameter (in)	Sanitary Seal Depth (ft)	Perforation Intervals (ft)	Type of Perforations	Slot Opening of Perforations (in)	Type of Gravel Pack	Current Status
Arcadia Subbasin														
Santa Monica No. 1	1S/15W-31E1	31208	4/1966	Cable Tool	283	Steel, 250	14	14	None	I5I-250	Moss hydraulic louvers	0.158 (5/32")	None	Active
Santa Monica No. 5 (AKA La Mesa Well)	2S/15W-30P1	093782 (E-log dated 6/1/80)	6/1980	Reverse Circulation	290	Steel, 255	14	30	50	145-235	louvers	0.094 (3/32")	minus 3/8"	Observation Well
Santa Monica No. 6	1S/15W-32E2	093781 (E-log dated 6/11/80)	6/1980	Reverse Circulation	160	Steel, 140	20	30	50	80-120	louvers	0.094 (3/32")	3/8"	Destroyed in 1980s
Arcadia No. 2	1S/15W-32A2	2535F	4/1940	Cable Tool	250	Steel 250	16 to 14	16	none	38-52 162-210	Moss hydraulic knife cut	0.75 (3/4")	none	Destroyed 1962 or 1967?
Arcadia No. 4	1S/15W-32A5	90447	8/1964	Cable Tool	235	Original: Steel to 235 Casing Liner: Low Carbon Steel to 225	14 Liner: 12	14	none	85-218 Liner: 110-215	Moss hydraulic louvers Liner: wire-wrapped screen	0.125 (1/8") Liner: 0.090	None	Active; Casing liner added in 2000
Arcadia No. 5	1S/15W-32A6	294163 E-log performed but not found	3/1989	Mud Rotary	250	Original: Steel, 250 Casing Liner: Low Carbon Steel to 238	16 Liner: 12	30	120	122-222 Liner: 110-235	louvers Liner: wire-wrapped screen	0.094 (3/32") Liner: 0.090	#5	Active; Casing liner added in 2000 (?)
Charnock Subbasin														
Charnock No. 13	11C17	31233	9/1966	Direct Rotary	423	Original: Steel to 410 Casing Liner: 304L Stainless Steel to 200 ft	16 Liner: 14	No Data	49	200-390 Liner: 197-388	louvers Liner: wire-wrapped screen	0.125 (1/8) Liner: 0.040	ND	Active; casing liner added in 1991
Charnock No. 16	11C19	093780	7/1980	Reverse Circulation	430	Steel, 410	20	30	190	220-390	louvers	0.094 (3/32)	3/8" minus	active
Charnock No. 18	11C22	229720	5/1984	Reverse Circulation	480	Steel, 480	18	30	100	240-455	wire-wrapped screen	0.050	Monterey 6X12 & 8X16	active
Charnock No. 19	11C21	294165	11/1988	Reverse Circulation	550	Steel, 510	18	30	150	200-450	louvers	0.094 (3/32)	#5 LG	active
Charnock No. 20	11C23(?)	e0160867	9/2012	Reverse Circulation	450	304 Stainless Steel, 405	16	26	150	242-295 315-385	louvers	0.065	Tacna 6x20	active
Olympic Subbasin														
Santa Monica No. 3	2S/15W-4C2	50813 (E-log dated 9/16/69)	10/1969	Reverse Circulation	570	Original: Steel to 550 Casing Liner: 316L Stainless Steel to 498	16 Liner 14 to 297 12 to 498	28	50	210-270, 300-380 410-430, 490-530 Liner: 207-498	louvers Liner: wire-wrapped screen	0.125 (1/8") Liner: 0.040	minus 3/8"	Active; Casing liner added in 2014
Santa Monica No. 4	2S/15W-4A1	093785 (E-log dated 12/6/81)	12/1981	Reverse Circulation	560	Steel, 560	20	32	200(?)	200-410 470-540	louvers	0.094 (3/32")	#4 & #5	Active
Santa Monica No. 7	1S/15W-30P1	21833 (E-log dated 8/28/82)	11/1982	Reverse Circulation	530	Steel, 564	16	28	100	200-544	louvers	0.094 (3/32")	#5	Destroyed 4/2018 (formerly located 100 ft east of new well SM-8
Santa Monica No. 8	N/A	N/A (Elog dated 11/7/2017)	4/2018	Reverse Circulation	600	Type 304L Stainless Steel 480	14	28 to 210 24 to 490	150	210-265 295-325 335-345 360-460	Ful-flo louvers	0.060	6 X 20	Inactive (awaiting equipping)
Coastal Subbasin														
Salt Water No. 1	2S/15W-7Q1	40854	11/1967	Reverse Circulation	140	304 Stainless Steel 120	12	24	20	60-120	louvers	0.125 (1/8")	ND	Inactive
Salt Water No. 2	2S/15W-7Q2(?)	50802 E-log performed but not available.	5/1969	Reverse Circulation	186	304 Stainless Steel (?) 120	12(?)	ND	20	20-120	louvers	0.125 (1/8")	ND	Abandoned
Marine Park Well	2S/15W-9N9	E-log performed but not available	4/1970	Mud Rotary	180	Steel (?), 156	4	ND	ND	125-135	ND	ND	ND	Observation Well
Colorado Yard/Memorial Park Groundwater Monitoring Well	N/A	N/A E-Log dated 10/10/2017	11/2017	Reverse Circulation	607	Schedule 80 PVC	6	16	60	85-245	slotted screen	0.032	8 X 16	Observation Well
City Hall Well No. 1	N/A	N/A (E-log dated 9/24/16)	11/2016	Mud Rotary	652 backfilled to 180' with 10.3-sack cement	PVC	6	16¼	50	60-90 120-160	slotted screen	0.030	8 X 16, 50'-100' 16 X 30,110'-180'	Inactive (awaiting equipping)
Airport Well	N/A	N/A (E-log dated 10/6/17)	4/2018	Reverse Circulation	600	Type 304L Stainless Steel 610	14	28 to 190 24 to 622	139	190-245 440-490 505-530 560-590	wire-wrapped screen	0.035	10 X 30	Inactive (awaiting equipping)

Notes: ND = No data
N/A = data available (not listed) on log
*Prior to construction of Well No. 2 in 1940, there were a total of nine wells constructed at the Arcadia plant dating back to 1903 and records for these wells are sparse.

TABLE 2
GROUNDWATER PRODUCTION FROM CITY WELLS AND OTHER WELLS
(1988 THROUGH 2017)

TOTAL ESTIMATED GROUNDWATER PRODUCTION BY SUBBASIN (in AF)						
YEAR	SUBBASIN					TOTAL PRODUCTION (Extractions Per Year)
	ARCADIA[1]	CHARNOCK[2]			OLYMPIC	
	CITY WELLS	CITY WELLS	GOLDEN STATE WATER COMPANY	TOTAL	CITY WELLS	
1988	372	8,111	570	8,681	387	**9,441**
1989	357	6,363	570	6,933	457	**7,747**
1990	389	4,132	570	4,702	469	**5,560**
1991	417	4,728	570	5,298	387	**6,101**
1992	396	6,486	570	7,056	981	**8,432**
1993	390	6,153	570	6,723	2,867	**9,979**
1994	419	5,906	570	6,476	3,126	**10,020**
1995	542	6,322	570	6,892	3,176	**10,609**
1996	370	2,284	570	2,854	3,044	**6,267**
1997	0	0	0	0	2,820	**2,820**
1998	0	0	0	0	2,642	**2,642**
1999	0	0	0	0	2,937	**2,937**
2000	0	0	0	0	2,912	**2,912**
2001	387	0	0	0	2,809	**3,196**
2002	467	0	0	0	1,824	**2,291**
2003	455	0	0	0	593	**1,047**
2004	137	0	0	0	385	**522**
2005	395	0	0	0	1,495	**1,890**
2006	387	0	0	0	1,365	**1,752**
2007	374	0	0	0	1,619	**1,993**
2008	360	0	0	0	1,663	**2,023**
2009	340	0	0	0	1,722	**2,062**
2010	290	593	0	593	2,436	**3,320**
2011	447	5,168	0	5,168	2,317	**7,932**
2012	450	5,277	0	5,277	2,636	**8,363**
2013	434	7,824	0	7,824	1,609	**9,867**
2014	714	8,377	0	8,377	1,591	**10,682**
2015	620	8,114	0	8,114	1,961	**10,695**
2016	698	8,311	0	8,311	1,992	**11,001**
2017	708	7,585	0	7,585	1,720	**10,013**
TOTAL PRODUCTION (Per Subbasin)	**11,310**	**101,730**	**5,130**	**106,860**	**55,940**	**174,120**
TOTAL AVERAGE PRODUCTION (AFY)*	**440**	**6,290**			**1,860**	**8,590****
RIVIERA GOLF COURSE (TOTAL AF)						
TOTAL ESTIMATED (AF)*	**9,300**					
TOTAL AVERAGE (AFY)	**310**					
BRENTWOOD GOLF COURSE (TOTAL AF)						
TOTAL ESTIMATED (AF)*	**7,800**					
TOTAL AVERAGE (AFY)	**260**					
AVERAGE ANNUAL PRODUCTION/EXTRACTIONS (AFY)*	**1,010**	**6,290**			**1,860**	**5,800 (over all 30 years)**

NOTES:
1. 2001 groundwater production from Arcadia Wellfield could instead be 353 AF, per email to RCS from Ms. Myriam Cardenas formerly of the City of Santa Monica, 1/7/2013
2. Based on preliminary data submitted by third party well ownder, an average value of 570 AFY was calculated for that water company's extractions until its wells were removed from service at end of 1996.
3. City has had no wells in the Coastal or Crestal subbasins of the SMGB; it is known that LACC does have active irrigation-supply wells in the Coastal subbasin.

* Numbers rounded to nearest 10. For the Arcadia and Charnock subbasins, the average does not count those years for which no pumping was conducted (i.e., zero extraction years).

** This number respresents the average for only those years in which the wells were pumping.

NA = Not applicable

TABLE 3
PRELIMINARY CALCULATIONS OF CHANGE IN GROUNDWATER IN STORAGE DURING BASELINE PERIOD FOR THE ARCADIA, CHARNOCK AND OLYMPIC GROUNDWATER SUBBASINS

ARCADIA GROUNDWATER STORAGE SUBUNIT - KEY WELL HYDROGRAPH SANTA MONICA WELL NO. 5 (FIGURE 11A)	
Usable Surface Area of Subbasin (mi^2)	6.6
Estimated Range of Specific Yield of Sediments	8% to 12%
Static Water Level at Beginning of Baseline Period (ft bgs)	130
Static Water Level at End of Baseline Period (ft bgs)	138
Change in Static Water Level for Baseline Period (ft)	-8
Change in Groundwater in Storage in Subunit (AF)*	**-2,700 to -4,100**
Average Annual Change in Storage (AFY)	**-90 to -140**
CHARNOCK GROUNDWATER STORAGE SUBUNIT - KEY WELL HYDROGRAPH CHARNOCK WELL NO. 16 (FIGURE 11B)	
Usable Surface Area of Subbasin (mi^2)	3.7
Estimated Specific Yield of Sediments	12% to 18%
Static Water Level at Beginning of Baseline Period (ft bgs)	158
Static Water Level at End of Baseline Period (ft bgs)	146
Change in Static Water Level for Baseline Period (ft)	12
Change in Groundwater in Storage in Subunit (AF)*	**3,400 to 5,100**
Average Annual Change in Storage (AFY)	**120 to 180**
OLYMPIC GROUNDWATER STORAGE SUBUNIT - KEY WELL HYDROGRAPH SANTA MONICA WELL NO. 7 (FIGURE 11C)	
Usable Surface Area of Subbasin (mi^2)	3.1
Estimated Specific Yield of Sediments	10% to 15%
Static Water Level at Beginning of Baseline Period (ft bgs)	118
Static Water Level at End of Baseline Period (ft bgs)	148
Change in Static Water Level for Baseline Period (ft)	-30
Change in Groundwater in Storage in Subunit (AF)*	**-5,900 to -8,800**
Average Annual Change in Storage (AFY)	**-200 to -300**
TOTAL CHANGE IN STORAGE IN THE THREE SUBUNITS (in AF)*:	**-5,200 to -7,800**
AVERAGE CHANGE IN STORAGE IN THE THREE SUBUNITS (in AF)*:	**-170 to -260**

Note: See text section Titled "Subunit/Subbasin Changes in Groundwater in Storage Calculations," for explanation and derivation of parameters and values.

*Numbers rounded to nearest 10 AF

The resulting change in storage values in each of the three columns on the right side of the table result from using the "estimated range of specific yields of sediments" for each subunit.

TABLE 4
UPDATED, PRELIMINARY CALCULATIONS OF SUSTAINABLE YIELD
THREE SANTA MONICA SUBBASINS

SUBBASIN	AVERAGE ANNUAL CHANGE IN STORAGE DURING BASELINE PERIOD (ΔS in AFY)	AVERAGE ANNUAL EXTRACTIONS DURING BASELINE PERIOD (AFY)*	UPDATED RANGE OF SUSTAINABLE YIELD (AFY)*
Arcadia	-90 to -140	1,010	870 to 920
Charnock	120 to 180	6,290	6,410 to 6,470
Olympic	-200 to -300	1,860	1,560 to 1,660
TOTALS*:	**-170 to -260**	**9,160**	**8,840 to 9,050**

Note: City has no wells in Crestal or Coastal subbasins and, thus, these subbasins are not considered herein.
*Numbers rounded to nearest 10 AF

TABLE 5
COMPARISON OF CALCULATED SUSTAINABLE YIELD VALUES
SANTA MONICA SUBBASINS

SMGB SUBBASIN	CURRENT (UPDATED) STUDY (AFY)	PREVIOUS STUDIES (AFY)
Arcadia[(1)]	870 to 920	2,000 [(2, 3)]
Charnock	6,410 to 6,470	4,420 to 7,500[(4)] and 8,200[(5)]
Olympic	1,560 to 1,660	3,275[(3)]
Coastal[(6)]	1,160 to 1,450	4,225[(3)]
TOTALS:	**10,000 to 10,500**	**13,920 to 17,700**
Crestal	TBD	2,000[(7)]

Notes/Sources of the numbers:

1) The number derived for the Arcadia subbasin is for all wells pumping in this subbasin and does not necessarily reflect what is available to the City for future pumpage
2) City (August 23, 1991)
3) RCS March 27, 2013
4) From KJC, June 1992, for the combined Arcadia, Olympic & Charnock subbasins.
5) From Komex, 2001; this Komex value was accepted by RCS in its March 2013 Memorandum.
6) This value estimated based on testing of Airport Well No. 1 in April 2018
7) This is the midpoint value of the LADWP (1991) assigned value of 1,000 to 3,000 AFY

TBD = To Be Determined.

TABLE 6
POTENTIAL SUSTAINABLE YIELD VALUES
SANTA MONICA SUBBASINS

GROUNDWATER SUBBASIN	CURRENT (UPDATED) STUDY (AFY)	ARTIFICIAL RECHARGE (AFY)	TOTAL POTENTIAL SUSTAINABLE YIELD (AFY)	PREVIOUS STUDIES (AFY)
Arcadia(1)	870 to 920	NA	870 to 920	2,000 (2, 3)
Charnock	6,410 to 8,080	NA	6,410 to 8080(6)	4,420 to 7,500(4) and 8,200(5)
Olympic	1,560 to 1,660	800 to 1,000	2,360 to 3145(6)	3,275(3)
Coastal(7)	1,160 to 1,450	NA	1,160 to 1,450	4,225(3)
TOTALS:	**10,000 to 12,110**		**10,800 to 13,595**	**13,920 to 17,700**
Crestal	TBD	TBD	TBD	2,000(8)

Notes/Sources of the numbers:

1) The number derived for the Arcadia subbasin is for all wells pumping in this subbasin and does not necessarily reflect what is available to the City for future pumpage

2) City (August 23, 1991)

3) RCS March 27, 2013

4) From KJC, June 1992, for the combined Arcadia, Olympic & Charnock subbasins.

5) From Komex, 2001; this Komex value was accepted by RCS in its March 2013 Memorandum.

6) This value was adjusted in accordance with previous estimates.

7) This value estimated based on testing of Airport Well No. 1 in April 2018

8) This is the midpoint value of the LADWP (1991) assigned value of 1,000 to 3,000 AFY

TABLE 7
POTENTIAL LOWER AND UPPER SUSTAINABLE YIELD VALUES SANTA MONICA SUBBASINS

GROUNDWATER SUBBASIN	LOWER LIMIT (AFY)	UPPER LIMIT (AFY)	PREVIOUS STUDIES[1] (AFY)
Arcadia	870	920	2,000
Charnock[2]	6,410	8,080	4,420 to 8,200
Olympic[3]	2,360	3,145	3,275
Coastal[6]	1,160	1,450	4,225
Crestal	NA	NA	2,000
Subtotals:	**10,800**	**13,595**	**15,920 to 19,700**
ICF Recharge Factor:	1,000	1,130	NA
TOTALS:	**11,800**	**14,725**	**15,920 to 19,700**

Notes/Sources of the numbers:

1) See Table 6 for explanation of these previous values.

2) Upper Limit based on potential pumping from GSWC Charnock Well No. 10 and Komex Analysis (see Komex, 2001, pg. 85 2nd paragraph, see Appendix 3)

3) Based on Well No. 3 Replacement and SWIP injection on this subbasin.

APPENDIX 3

ICF MAY 25, 2018 MEMORANDUM

ICF

Memorandum

To: Tom Watson, PG, City of Santa Monica

From: Gary Clendenin, PG, ICF
Norm Colby, PG, CHg, CGC Environmental, Inc.

Date: May 25, 2018

Re: Evaluation of Recharge and its Effect on Sustainable Yield in the Santa Monic Basin

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Introduction

The City of Santa Monica (City) has been a leader among California cities in sustainably managing its available water resources. Sustainable management involves the practice of balancing water demands with water supply. The City has set an objective of eliminating its reliance on environmentally costly imported water by 2020. To achieve and maintain this goal the City's strategy for adaptive management must consider the vagaries of climate change, population growth, and future development. Recognizing these challenges, the City has engaged in forward thinking conservation policies and programs to reduce demand and enhance its water treatment technology to develop more potable water out of its current supply. The City has also conducted several studies over the past several years to more precisely quantify the amount of water in the Santa Monica Basin (SMB) that can be pumped sustainably. To estimate that volume it is imperative to know how much water is entering the basin as recharge (inflow).

The purpose of this memorandum is to evaluate the amount of water that may be added to the SMB resulting from direct recharge and mountain-front recharge and ultimately to assess the effect this recharge may have on previously calculated sustainable yield estimates. This remainder of this memorandum includes a background, analysis of available data, and findings and conclusions.

Background

The City supplies potable water to approximately 93,000 residents covering an area of 8.3 square miles. In 2011, the Santa Monica City Council adopted a goal of water self-sufficiency by eliminating reliance on imported water from the Metropolitan Water District of Southern California (MWD) by 2020. The City currently imports approximately 30% of its total annual demand from the MWD.

In 2014, the City retained Kennedy/Jenks Consultants (KJ) to develop an integrated Sustainable Water Master Plan (SWMP). The SWMP combined relevant components of existing plans with an evaluation of a broad range of water supply and demand management options to assist the City in meeting its goals. The KJ report included an analysis of supply and demand management options to cost effectively reduce future water use and mechanisms to enhance local water supply production capabilities. In 2017, the City retained Black & Veatch Corporation (BV) to begin the process of updating the SWMP. A key consideration in developing long-term water management options is a detailed understanding the hydrogeolgy of the SMB, including the basin-wide sustainable yield. Sustainable yield is generally defined as the rate at which groundwater can be pumped perennially under specified operating conditions without causing an undesired result. Sustainable yield is typically is expressed in units of acre-feet (AF) which are equivalent to approximately 326,000 gallons.

Historically, the City has funded several studies to evaluate sustainable yield, including a recent study[1] to update previous investigations. Sustainable yield can be estimated using a variety of methods, with the most common method being a water-balance approach. This method compares the amount of water that recharges into a basin (inflow) from a wide range of sources (natural and anthropgenic) with the amount of water leaving the basin (outflow) from losses caused by pumping, evapotranspiration, basin outflow etc. to estimate sustainable yield. The purpose of this study is to assess the range of potential recharge to the SMB in order to assist the City with developing strategies for adaptive management of its groundwater resources and facilitate future updates of the SMB sustainable yield analysis.

The SMB is subdivided into five subbasins: Arcadia, Charnock, Olympic, Coastal, and Crestal; it has an areal extent of approximately 50 square miles. Portions of several municipal jurisdictions lie within the boundaries of the SMB, including the cities of Santa Monica, Beverly Hills, Culver City, Los Angeles, and the County of Los Angeles. The City currently produces its groundwater supply from the Arcadia, Olympic and Charnock subbasins. In early 2018, the City completed a new supply well at a location at the Santa Monica Airport, within the Coastal subbasin. It is expected that this well (Airport #1) will be placed into production by 2020. Additionally, there are future plans to drill up to two additional supply wells in the Coastal subbasin. The SMB is non-adjudicated (no assigned water rights); however, the City is currently the only entity withdrawing water for municipal delivery. For fiscal year 2016-2017 the City pumped a total of approximately 10,190 AF of local groundwater.

[1] Draft Preliminary Study of the Sustainable Yield of the Santa Monica Groundwater Basins, Richard C. Slade and Associates, July 2017

Analysis

To develop refined estimates of sustainable yield it is imperative to understand the volume of water entering the SMB via recharge. Several studies were reviewed and considered while conducting the recharge analysis that is discussed in the following section. The sources include:

- *Baseline Study to Evaluate the Value of Using Differential Interferometry Synthetic Aperture Radar (DInSAR) to Monitor Land Elevation Changes Related to Groundwater Extractions and Recharge for the Santa Monica Basin*, Earth Consultants International, September 15, 2017.
- A 2017 map prepared by Earth Consultants International (ECI) which was generated by LiDAR topography and computer- based Triangular Irregular Network Surface (TINS) analysis showing a "flattened" surface area of a portion of the Santa Mountains that provides recharge to the Santa Monica Basin.
- A 2018 ECI supplemental Differential Interferometer Synthetic Aperature Radar (DInSAR) study of the basin that measured minute changes in seasonal basin surface topography due to basin recharge and outflow.
- *Estimating Spatially and Temporally Varying Recharge and Runoff from Precipitation and Urban Irrigation in the Los Angeles Basin, California*, Scientific Investigations Report 2016–5068, U.S. Geological Survey, Joseph A. Hevesi and Tyler D. Johnson, 2016.

Estimating Recharge from Unpaved Areas and Public Open Space

Recharge occurs in the SMB from infiltration of precipitation, surface water runoff and urban-related sources such as irrigation, storm drains and non-revenue water. Non-revenue water is water that leaks from distribution pipelines and meters and is "lost" before it reaches the customer. The accepted industry standard for non-revenue water is approximately 2-5% of the total water volume placed into distribution. The volume placed into the distribution network is referred to as "demand". In fiscal year 2016- 2017 the demand volume for the City was approximately 11,273 acre-feet (AF). This demand was met by a combination of of imported water and local groundwater.

Sources of natural recharge are commonly known as spatially-distributed direct recharge. This type of recharge is in addition to recharge that occurs at the northern margins of the SMB from surface-water drainages, also known as mountain-front recharge. Within the SMB boundaries, direct recharge from precipitation, mountain front runoff and irrigation occurs primarily in areas that are pervious and unpaved, where water can directly infiltrate the underlying soil. Surface water recharge from urban runoff is limited in the SMB because most of the larger streams and storm drain channels are either concrete-lined or diverted underground. Thus, most of the direct recharge in the SMB is a result of infiltration from mountain front runoff and urban irrigation.

To better quantify recharge in the Los Angeles Basin (which includes the SMB), the USGS developed a computer model that simulates the amount of water that contributes to recharge from precipitation, runoff and urban irrigation (USGS, 2016). The model also included all the surface water drainages bordering the SMB that potentially contribute recharge. The USGS model incorporated a new method for estimating recharge from residential and commercial landscape irrigation based on land use and the percentage of pervious land area. The computer model incorporated climate data from over 200 monitoring sites, including monthly precipitation and maximum and minimum air temperatures. It also included data for land use type, land cover, soil, vegetation and surficial geology. The model was calibrated to available stream flow records.

Based on their research and the model results, the USGS concluded that urban irrigation is an important component of overall spatially distributed recharge in the Los Angeles Basin (including the SMB), contributing an average of 56 percent of the total recharge within the study area. The USGS study noted that the amount of urban irrigation applied to landscaping across the entire area of the Los Angeles basin can be large, exceeding natural rainfall in some places. Studies have shown that more than 50 percent of the water used in a typical household is applied as irrigation (USGS, 2016). Ideally, most of the water applied for irrigation would be used by plants, but over-watering is very common because it is difficult for the average home owner or business to estimate and adjust for the exact seasonal water demand. Therefore, some of the irrigation water contributes to recharge and some becomes runoff. Urban irrigation can also increase recharge from natural precipitation because of the wet antecedent soil conditions caused by the irrigation. In the City there are polices to prevent runoff of irrigation and these are strictly enforced.

The USGS model also estimated the amount of recharge as a function of unpaved area (pervious areas) and percentage of plant-canopy cover (vegetation density). Impervious surfaces (e.g. roadways, rooftops, parking lots) were estimated using the 2001 National Land Cover Data (NLCD) which has a grid resolution of 30 meters. The average imperviousness for the Los Angeles Basin area writ large was 33.7 percent. In the SMB, the percentage of impervious area ranged from approximately 1 to 10 percent in the northern areas and in public open spaces, to almost 100 percent in the more densely developed areas of Santa Monica and Culver City (USGS, 2016). The model incorporated general soil type, soil thickness, land surface slope and aspect and other factors to arrive at an average annual recharge for the area that includes the SMB.

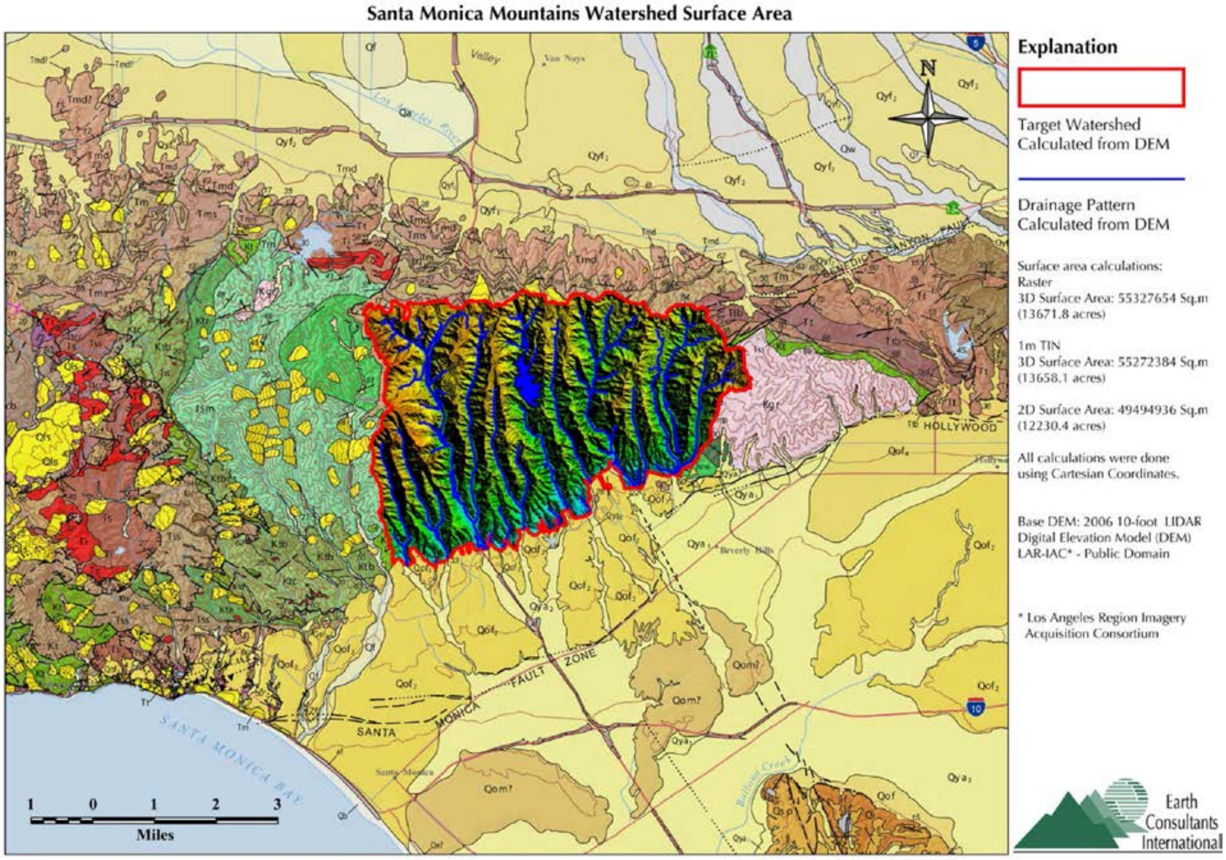
The USGS estimated annual average direct recharge of 35 mm/year (1.4 inches/year) in the Los Angeles Basin study area, which includes the SMB. (USGS, 2016). This represents about 10 percent of the annual precipitation rate and about 7 percent of the total combined inflow from precipitation, surface-water inflow and urban irrigation. In low-lying urbanized areas, relatively high recharge rates of more than 50 mm/year (approximately 2 inches/year) were estimated in heavily irrigated areas with frequent inflows from upstream impervious areas. However, this volume was found to vary significantly depending on the amount of unpaved and open area. For most low-lying urbanized areas, the USGS estimated very low recharge (less than 1 mm/year). In the SMB, simulated recharge ranged from 20 – 50 mm/year in areas adjacent to the Santa Monica Mountains and in some areas of Santa Monica and Culver City, presumably based on identified public open spaces and the potential for irrigated residential areas (USGS, 2016). The model also indicated that a relatively large portion of the SMB has negligible recharge because of dense development, with little or no pervious areas.

Estimating Recharge from Mountain Front Areas

Groundwater recharge entering the SMB from the canyons and streams flowing from the Santa Monica Mountains, which border the basin to the north-northwest, is commonly referred to as mountain-front recharge. Mountain-front recharge enters the SMB as lateral inflow of groundwater directly into the subsurface (underflow) originating from surface-water drainages in the Santa Monica Mountains. Unlike stream channels in the urbanized areas of the SMB, which are mostly concrete-lined which can reduce the amount of inflow, the natural stream channels in the Santa Monica Mountains allow runoff from precipitation to percolate directly into the underlying sediments and ultimately recharge groundwater. This groundwater then flows downgradient into and across the SMB.

The 2016 USGS recharge model incorporated mountain-front recharge in estimates of total recharge for the SMB and other basins in the Los Angeles region. The USGS recharge estimates for mountain-front recharge accounted for precipitation, air temperature, soil type and thickness, root zone thickness, slope angle, slope aspect, vegetation type and degree of imperviousness. The modeling indicated that mountain-front recharge contributes, on average, approximately half as much water as direct recharge in the Los Angeles Basin. However, in the SMB, mountain-front recharge forms a significant percentage of total recharge. The Santa Monica Mountains had the highest 5-year average recharge for almost all the water years simulated in the USGS model. The average potential mountain front recharge to the SMB from the Santa Monica Mountains was 82 mm/year (3.3 inches/year) compared to a total average recharge of 116 mm/year when direct recharge is included (i.e. recharge from precipitation and urban irrigation). Thus, mountain-front recharge represents about 71 percent of the average total recharge entering the SMB. The USGS points out that mountain-front recharge is highly variable depending on precipitation, with dry years resulting in much lower recharge to the SMB. At the request of the City, Earth Consultants International (ECI), recently completed an analysis of surface area in the watershed that drains to the SMB. ECI calculated the total surface area of the watershed in three dimensions vs. a standard two-dimensional approach to account for the steep slope angles in the Santa Monica Mountains. ECI's analysis, which used triangular irregular network surface (TINS) methods with a LiDAR dataset from 2006, indicated an increase in surface area of approximately 12 percent when accounting for three-dimensional topography. This higher surface area would generally correlate to greater recharge since there is a larger surface area for water infiltration. This is in agreement with and seemingly validates the relatively high percentage of recharge entering the SMB as mountain-front recharge calculated by the USGS.

Santa Monica Mountains Watershed Surface Area



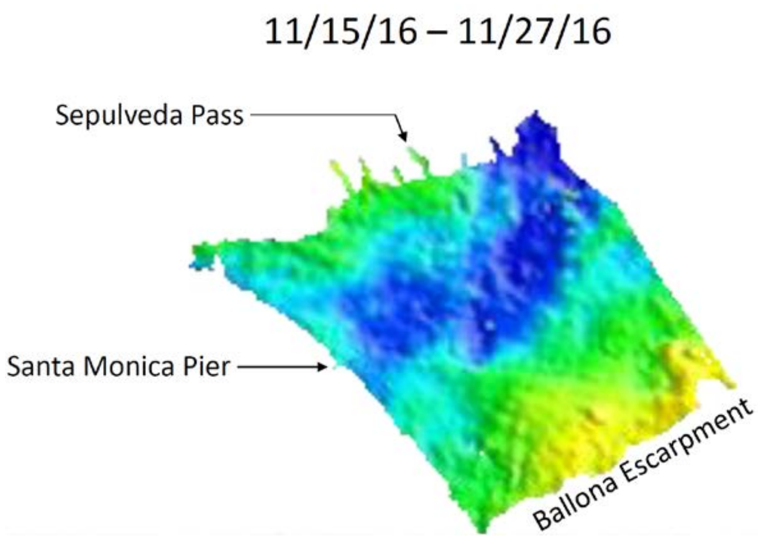
Scale: 1:120,000

Watershed 3-Dimensional Surface Area Calculated with TINS

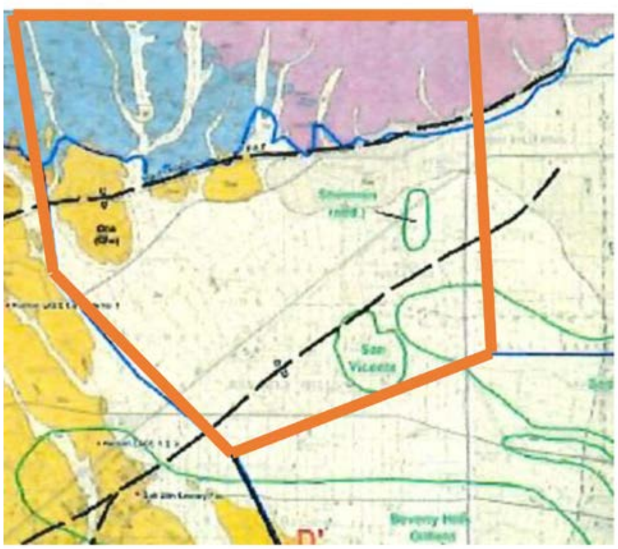
In a separate study, the City commissioned ECI to conduct a Differential Interferometry Synthetic Aperture Radar (DInSAR) study to assess whether historic pumping activities may have caused wide spread sediment compaction in the various subbasins in the SMB (ECI, September 15, 2017). Significant sediment compaction, caused by historic pumping of groundwater, can reduce the amount of available groundwater in storage. When this condition occurs, measurable subsidence of the surface topography can result. The ECI study determined there was no evidence of significant wide-spread of basin sediment compaction or surface subsidence due to the City's historic localized groundwater pumping, with the possible exception of some areas immediately around the City's well fields located in the Arcadia and Charnock subbasins, which was thought to have occurred historically when pumping was greater and water levels were reportedly very low.

A review of the individual stacked interferometer images utilized for this study from the period January 1, 2015 through November 27, 2016 identified a potential mechanism for recharging the groundwater aquifers in the SMB that does not appear to have been previously identified in the geologic literature.

In 2018 the City engaged ECI to conduct a supplemental DInSAR study focused on this potential recharge phenomenon. Preliminary data from this new study strongly indicates that under certain conditions a seasonal positive flux in regional topography centered on ancient erosional pathways, such as abandoned river beds carved by the LA River, can be observed as illustrated in the figure below. ECI believes that these events of topographic inflation may be caused by recharge underflow into the SMB from nearby mountain front areas that lay outside the boundaries of the SMB. The data show an area in the northeast corner of the basin that seems to exhibit a positive topographic deflection caused by the transmission of groundwater in shallow sediments that originate to the east of the Crestal subbasin in the Hollywood Basin, and possibly extending down gradient to the Pacific Ocean. In the figure below blue colors indicate a positive deflection (inflation) of topography above a measured baseline. Green colors are more or less neutral, with yellow and warmer colors being representative of negative deflections (deflation) from the baseline. This innovative information will be utilized in planned SMB groundwater modeling work to be conducted in consultation between the City and the USGS.



The area bounded in orange in the figure below shows the additional mountain-front area that is external to the boundaries of the SMB that could be the source of additional recharge. This area covers approximately 4 square miles of mountain-front.



According to the USGS recharge model, the average mountain-front recharge to the Hollywood Basin was estimated to be 2,862 AF per year, with 100-year maximum and minimum recharge estimates of 11,163 and 227 AF per year, respectively. Based on length of the mountain-front boundary identified in the ECI study noted above, we estimate that approximately 25-35 percent of this mountain-front recharge may be directed toward the SMB as underflow. This would represent an average inflow of approximately 715 – 1000 AFY, with 100-year maximum and minimum recharge estimates of approximately 2,791 and 57 AFY, respectively. This recharge volume could potentially increase the overall average mountain-front water budget for the SMB.

This recharge estimate is preliminary at this point and will be revisited based on the final ECI analysis and hydrogeologic assessment.

Climate change has the potential to impact recharge in the SMB by affecting temperature and precipitation rates in the region. Increased temperature could affect evapotranspiration rates, while variations in precipitation (increases or decreases) would affect direct recharge. Urban irrigation, which has been shown to be a significant source of direct recharge, would likely be affected by climate change. A future decrease in recharge from precipitation may be offset by an increase in urban irrigation unless abated by City conservation programs. Mountain-front recharge, which is directly correlated to precipitation rates, would be most likely to be unaffected by climate change for the immediate future as most climate general circulation models forecast approximately the same volume of annual precipitation for the Santa Monica area for the next several decades. One change in the precipitation cycle that is anticipated through 2030 is a shift towards a majority of the annual precipitation in the SMB occurring later in the October to April wet season, and it being associated with fewer, but more intense storms. Any decrease in mountain-front recharge could significantly affect the rate of groundwater recharge in the SMB and argues for and supports the City's recent shift toward the innovative treatment and reuse of non-conventional resources such as municipal waste water and brackish groundwater. To assess the effects of climate change on its water resources, the City is in the process of engaging a team of recognized climate change experts to develop a suite of possible climate change scenarios that will be utilized to conduct biennial simulated climate change stress-tests on the City's sustainable yield analysis, conservation programs and planned water-related capital improvement projects.

Findings and Conclusions

The amount of water entering the SMB as direct recharge and mountain-front recharge, as described in the prior sections, constitute a significant portion of overall recharge entering the basin. The 2016 USGS recharge study quantified these recharge components along with other recharge inputs and outputs. The total average potential recharge for the SMB was estimated from the USGS recharge model, as well as the maximum and minimum recharge for the basin over the 100-year modeling period. These values are summarized in the following table.

Summary of average inflows, outflows, and changes in storage for the Santa Monica Groundwater Basin

USGS Los Angeles Basin Watershed Model

		Inflows			Outflows						
	Potential ET	Precip.	Surface Water	Urban Irrigation	Runoff	ET	Direct Recharge	Surface Water	Change in Storage	Potential Mountain-Front Recharge	Total Potential Recharge
Average	119,692	35,501	6,405	14,568	12,582	34,382	3,259	18,978	-154	7,953	**11,212**
Max	127,004	83,859	--	14,601	30,288	43,948	15,501	30,288	14,374	26,404	**41,913**
Min	109,566	7,775	--	14,601	2,546	23,843	259	2,546	-9,599	462	**1,167**

All values reported in acre-feet per year

The inflow and outflow estimates shown above indicate that a substantial portion of average annual recharge to the SMB results from mountain front recharge, with direct recharge representing a smaller overall contribution. The 100-year average of total potential recharge in the SMB is 11,212 AFY, with maximum and minimum recharge values of 41,913 AY and 1,167 AFY, respectively. The addition of an average volume of recharge from non-revenue water ranging from 204 AFY to 510 AFY (representing approximately 2-5 % of average water demand) may increase the range of average total potential recharge to between 11,416 AFY and 11, 722 AFY.

When the estimated underflow from areas identified by the preliminary DInSAR study are included, the 100-year average potential recharge for the SMB is approximately 12,131 to 12,722 AFY, with 100-year maximum and minimum recharge values of 44,704 to 1,224 AF/Y, respectively.

The City is in the process of permitting a new well for aquifer recharge as art of its Sustainable Water Infrastructure Project (SWIP). When operational, this well will be capable of artificially recharging the City's aquifers with approximately another 1,000 AFY of highly treated water derived from non-conventional resources such as stormwater, brackish groundwater and municipal waste water, thereby increasing the total range of recharge to between approximately 13,131 AFY to 13,722 AFY. In addition, the City is engaging ECI to conduct a supplemental TINS analysis of the additional mountain front area that is thought to be contributing to recharge from outside the SMB. Results from this analysis are expected to increase the estimated range of potential recharge from this area.

Long-term the City is exploring new conservation programs to reduce demand and innovative projects for the expanded treatment and reuse of non-conventional water resources such as brackish/saline groundwater. When integrated with the recently completed Clean Beaches

Initiative Project (CBI) and the City’s SWIP, these programs and projects will result in a cohesive and comprehensive strategy for adaptive management of the City’s water resources.

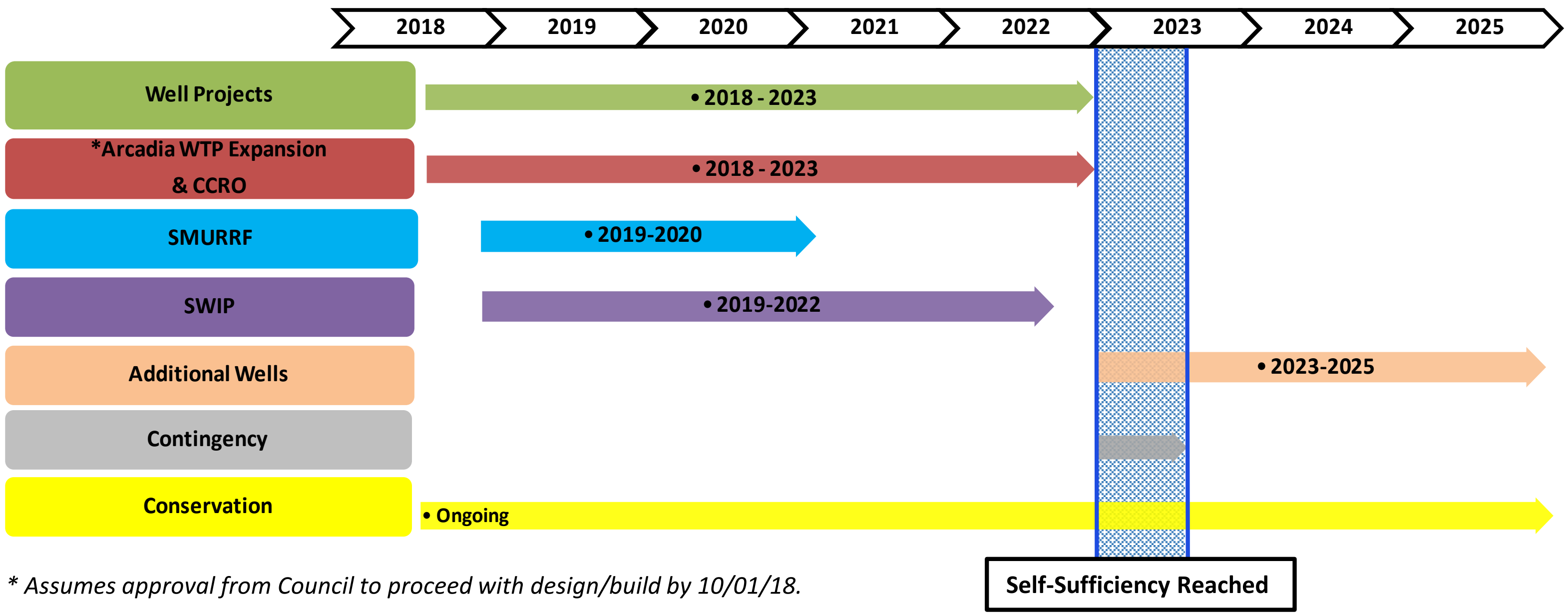
Lastly, it should be noted that this recharge estimate does not account for underflow to or from adjacent groundwater basins (other than the noted potential underflow from the Hollywood Basin into the Santa Monica Basin), nor does it consider the effects of groundwater extraction from pumping wells. However, it provides a valuable preliminary estimate of potential recharge in the SMB that is useful for the evaluation and estimation of sustainable yield. We understand that the City intends to revisit and update its recharge and sustainable yield estimates utilizing a water balance method that is consistent with hydrogeologic modeling concepts every two years going forward. This practice will help ensure the City meets and maintains its objectives of water resiliency and self-sufficiency.

APPENDIX B

Appendix B
Sustainable Water Master Plan
Water Treatment Enhancement Projects

PROJECT	DESCRIPTION	PRELIMINARY ESTIMATE	SCHEDULED COMPLETION
Closed Circuit Reverse Osmosis (CCRO)	New reverse osmosis technologies are available to recover more potable water from the treatment process. A pilot test of the CCRO technology will be conducted. If successful, this project would install a 3-MGD CCRO at the Arcadia Water Treatment Plant.	$17.6M	2023
Arcadia Water Treatment Plant Expansion	Focused modifications at the Arcadia Water Treatment Plant could provide increased treatment capacity to approximately 12 MGD. If feasible and effective, the treatment system modifications would be completed by 2023. This project goes hand in hand with the CCRO project above.	$12.4M	2023
Ultraviolet (UV), Advanced Oxidation, and Granular Activated Carbon	Additional Olympic Wellfield contamination treatment upgrades due to increased pumping and new state regulatory requirements.	$15.5M	2023
	Total:	**$45.5M**	

Water Self-Sufficiency Project Schedule



** Assumes approval from Council to proceed with design/build by 10/01/18.*

ATTACHMENT B

City Council Staff Report – Sustainable Water Master Plan Update and Pathway to Water Self-Sufficiency

(Water Resources Division, November 2018)

City of Santa Monica

City Council Report

City Council Meeting: November 27, 2018
Agenda Item: 8.C

To: Mayor and City Council

From: Susan Cline, Director, Public Works, Water Resources

Subject: Sustainable Water Master Plan Update and Pathway to Water Self-Sufficiency

Recommended Action

Staff recommends that the City Council:

1. Provide staff with direction to proceed with water self-sufficiency components.
2. Provide staff with direction regarding funding recommendations to achieve water self-sufficiency.
3. Authorize budget changes as outlined in the Financial Impacts and Budget Actions section of this report.
4. Direct staff to return for a public hearing on January 8, 2019, to consider implementation of 9% water rate increase previously approved by Council on February 24, 2015 to go into effect on March 1, 2019.

Executive Summary

The City of Santa Monica (City) has historically provided water service to residential and business customers allowing for bold efforts in securing resiliency and self-sufficiency for the community. Given the statewide challenges surrounding a safe and reliable water supply in recent years, Council directed staff to develop a water self-sufficiency plan with the goal of meeting 100% of Santa Monica's water demand using local water sources by 2020. On October 28, 2014, Council adopted the Sustainable Water Master Plan (SWMP), which outlines a strategy to achieve the City's water self-sufficiency goal (Attachment A). Staff initiated a comprehensive update of the SWMP in 2017 to incorporate new information regarding local groundwater resources and to integrate new water conservation programs and alternative water supply opportunities. On January 9, 2018, staff reported to Council that further analysis was needed to assess whether the City could meet its water self-sufficiency goal by 2020 (Attachment B). The further analyses have been completed and confirm that achieving water self-sufficiency that can be maintained into the future is practical and cost effective, but the projected date of reaching that goal would be 2023. The delay from the original date is due to new state drinking water requirements implemented in 2018, permitting requirements for alternative water supply projects, and results of recently completed feasibility studies which resulted in longer timelines for project completion relative to previous estimates.

The benefits of becoming water self-sufficient when compared to the alternative of continuing to meet a portion of local water demand using imported water include: long-term cost benefits for water ratepayers, establishment of a diverse, sustainable and drought resilient local water supply, and reduction of the City's water supply energy footprint. It should be noted that in the updated plan proposed by staff, water self-sufficiency equates to approximately 99% locally sourced water, with 1% of the City's water supply still being purchased from the Metropolitan Water District of Southern California (MWD) to maintain the imported water connection for emergency purposes.

The updated proposal to meet water self-sufficiency presented in this staff report includes an optimized water conservation program together with local water supply projects, an updated implementation timeline, and recommended funding toward achieving water self-sufficiency for the City. Following Council direction and approval, the final components will be included in an updated SWMP that will guide City efforts toward achieving the goal through 2023. To achieve self-sufficiency by 2023, staff is proposing to replace imported water purchases with a comprehensive plan consisting of:

- Component 1 - continuing and increasing water conservation efforts to permanently reduce water demand,
- Component 2 - developing sustainable and drought resilient alternative water supplies, and
- Component 3 - expanding local groundwater production within sustainable yield limits.

The anticipated cost to implement the components required to meet the self-sufficiency goal is approximately $38 million to increase local water supplies, which includes capacity expansion of the Arcadia Water Treatment Plant (WTP), implementation of production efficiency enhancements, as well as acquiring an additional groundwater well to enhance resiliency. The $38 million would be funded primarily through the issuance of a water revenue bond and a contribution from the Wastewater Fund ($3.25 million) to the Water Fund to fund the various projects outlined in this staff report, with the debt service on the bonds incorporated into water rates in an upcoming rate study. An additional $64 million from existing water-contamination settlement funds would be used for restoring the Olympic Sub-basin, which would allow additional water production from that sub-basin to support achievement of water self-sufficiency. The proposed water self-sufficiency plan and staff recommendations are based on recently completed studies (e.g., confirmation of sustainable yield analysis, evaluation of new drinking water regulations on the Olympic Sub-basin restoration, and feasibility studies to assess new technologies that increase production efficiency at the Arcadia WTP) in which multiple scenarios were evaluated for cost, benefits and effectiveness.

Lastly, staff will return to Council on January 8, 2019, for a public hearing and to recommend a full implementation of the 9% water rate adjustment (within the previously adopted Council authorization) for calendar year 2019 and effective on water bills issued on or about March 1, 2019. The recommended water rate adjustment would ensure a fiscally sustainable comprehensive program for safe, clean, reliable water supply to our community. It would also help offset increased construction costs to keep up with the City's 100-year water main replacement program and fund preliminary design efforts on the various components required to achieve water self-sufficiency as contemplated in the 2014 rate study.

Background

On January 25, 2011, City Council directed staff to develop a water self-sufficiency plan with the goal of meeting 100% of Santa Monica's water demand using local water sources by 2020. On October 28, 2014, Council adopted the SWMP which outlines a comprehensive plan to achieve water self-sufficiency. The SWMP involves a combination of water demand reduction strategies through various water conservation and efficiency programs designed to permanently reduce residential and commercial water use, along with increased water supply from 1) alternative water sources such as captured rainwater and treated wastewater; 2) increased efficiency of the City's water treatment systems; and 3) additional pumping from existing groundwater wells and new wells in the local groundwater basin. Implementation of the SWMP has been proceeding since 2014, with updates provided during Council's annual consideration of water rate adjustments. The most recent update was provided on January 9, 2018.

Between 2014 and 2018, other elements of the SWMP progressed, including completion of a preliminary Sustainable Yield Analysis (SYA) of the Santa Monica groundwater basin and finalizing plans for the Sustainable Water Infrastructure Project (SWIP) to support further analysis and refinement of alternatives to reduce reliance on imported water supply and meet the City's self-sufficiency goal. Staff initiated a comprehensive update of the SWMP in 2017 to incorporate new information regarding local groundwater resources, regulatory updates, and to integrate new water conservation programs and alternate water supply opportunities.

On January 9, 2018, staff reported to Council that further analysis was needed to assess whether the City could meet its water self-sufficiency goal by 2020. Additional work completed since January 2018 included analysis to validate preliminary SYA estimates of the local groundwater basin, drilling of exploratory water wells in the Coastal sub-basin to evaluate potential new local water production, technical studies to evaluate the cost and viability of increasing the production efficiency of the City's Arcadia WTP, evaluating the impact of new drinking water regulations (e.g., maximum contaminant level [MCL] for 1,2,3 TCP) on groundwater extraction from the Olympic Sub-basin, and evaluating the cost and viability of additional water conservation programs as requested by the Task Force on the Environment. A timeline summarizing key events related to the development of the SWMP from 2011 is provided in Figure 1. Staff currently anticipates that the City would achieve water self-sufficiency in 2023 based on the plan outlined in this report. In addition to the proposed plan to achieve water self-sufficiency, a Five-Year Rate Study (2020-2024) is also currently underway and will consider potential rate impacts of water self-sufficiency projects. Results of the Five Year Rate Study will be presented to Council in the first half of 2019.

Figure 1: Self-Sufficiency Timeline

Discussion

Goals and Benefits of Water Self-Sufficiency

The proposed plan to meet the City's self-sufficiency goal involves a combination of demand reduction through various water conservation and efficiency programs and the addition of local water supplies which will also provide the following benefits:

- Long-term cost benefits to ratepayers by maximizing local water resources
- Provide a more sustainable and drought-resilient water supply through a diversified water supply portfolio
- Reduce the City's water supply energy footprint through conservation and locally sourced water supplies

With imported water purchase costs from MWD expected to increase annually from 3 to 7 percent over the next 10 years, the primary focus of the updated SWMP was to develop water self-sufficiency scenarios that are both sustainable and economical compared to the continued purchase of imported water from MWD. Development of cost-effective local, sustainable, and drought resilient water supplies will provide Santa Monica water ratepayers with cost benefits over the long-term and provide the City with greater cost certainty on water rates compared to the continued purchase of imported water from MWD.

Providing a sustainable and drought-resilient water supply through a diversified water supply portfolio eliminates the City's reliance on the purchase of imported water from MWD and maintains reliable production during routine maintenance and unforeseen downtimes of treatment equipment.

Lastly, maximizing local water resources instead of purchasing imported water from MWD also has long-term environmental benefits for the community in terms of reduced energy use and the associated reduction in greenhouse gas emissions, which support Council's goal to achieve carbon neutrality by 2050 or sooner. The addition of alternative water supplies, expansion of local groundwater supplies, and increased conservation will result in a 25-30% reduction of total energy footprint from the City's water supply compared to continued purchase of imported water from MWD.

Marching Toward Water Self-Sufficiency

The City's water supply portfolio has progressively transformed since 2011, with the community making significant strides toward water self-sufficiency and reduced reliance on the purchase of imported water to supplement local water resources as indicated in Figure 2. In 2011, after completion of the Charnock Wellfield Restoration Project, the City was able to meet approximately 51 percent (~6,700 acre-feet per year [AFY]) of its water supply demand through local groundwater resources and reduce the purchase of water from MWD, which is imported from Northern California and the Colorado River, to approximately 48% (~6,400 AFY).

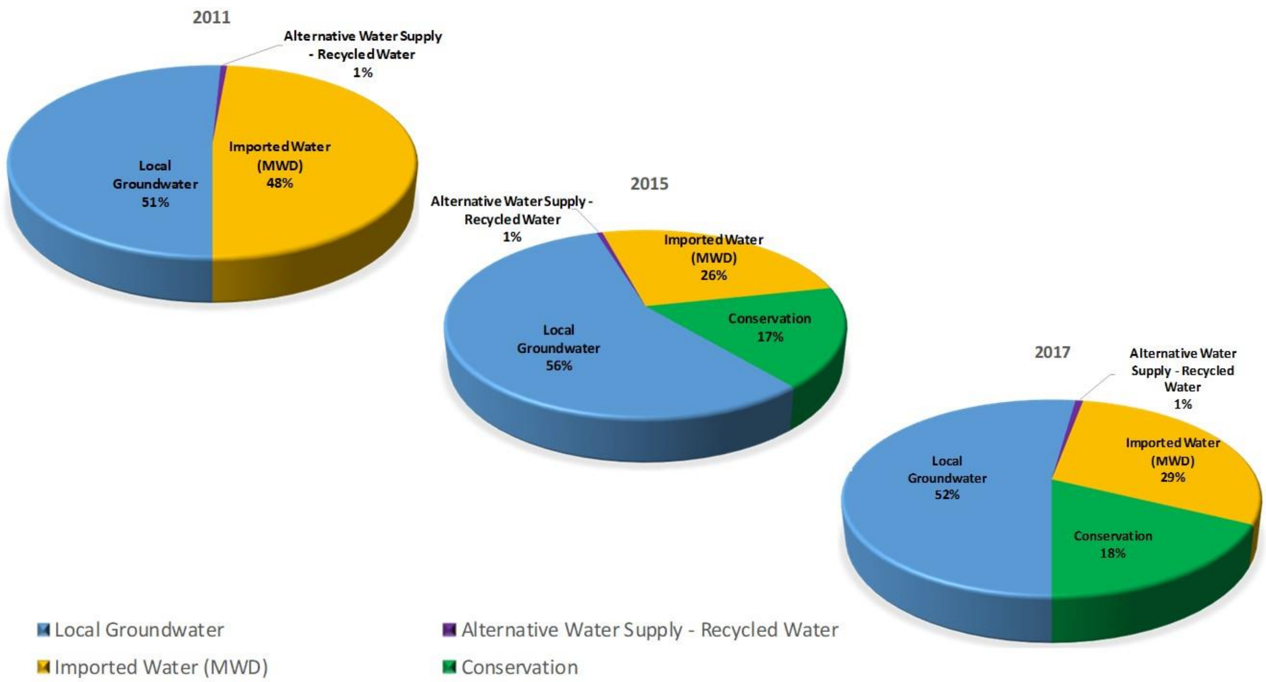


Figure 2: Overview of City's Water Supply Portfolio from 2011 through 2017

In 2015, the City and its residents responded to severe drought conditions throughout California with conservation efforts that resulted in a decrease in the City's total water demand of 14,300 AFY in 2014 by about 17% (-2,500 AFY) to approximately 11,800 AFY by 2017. Santa Monica's population grew by about 1.6% from 92,321 to 93,834 over the same period. Conservation efforts resulted in a decrease in average annual water consumption, measured in gallons per capita per day (GPCD), from 140 GPCD to approximately 110 GPCD as indicated in Figure 3 and continues today even after the governor declared an end to the drought.

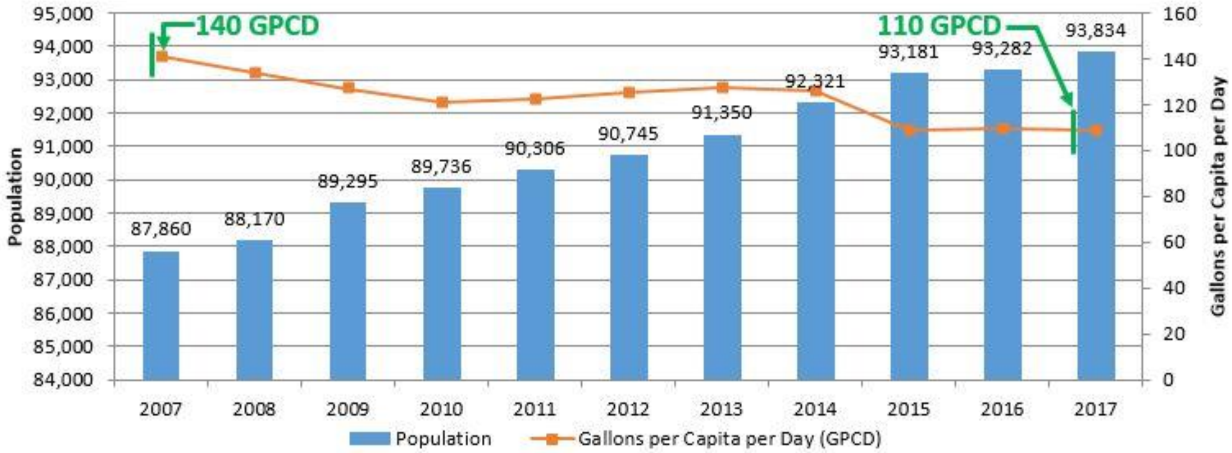


Figure 3: Historical Population Growth versus Per Capita Water Consumption

From 2015 through 2017, the City was meeting approximately 50-56% of its water supply demand through local water sources (7,400-8,200 AFY) and 26-29% through water conservation (approximately 2,500 AFY), with the amount of imported water purchased from MWD dropping to approximately 26-29% (3,700-4,100 AFY). In 2017, local groundwater supply temporarily decreased due to an extended shutdown (approximately six months) of one well in the Charnock sub-basin for maintenance and repair. The loss of a single well from the Charnock Sub-basin over the six-month period and loss of approximately 800 AFY of groundwater production highlighted the need to increase resiliency of the local water supply to maintain reliable production as the City continues its march toward water self-sufficiency.

Refined SWMP Pathway to Achieve Water Self-Sufficiency

Additional analyses of various elements of the SWMP, as outlined at the January 9, 2018 City Council meeting, have been completed, and based on those analyses staff now estimates that water self-sufficiency can be achieved by 2023. To achieve self-sufficiency by 2023, staff is proposing to replace the purchase of imported water from MWD (approximately 50% of the total water supply demand when self-sufficiency efforts were initiated in 2011) with a comprehensive plan consisting of: 1) Component 1 - continuing and increasing water conservation efforts to permanently reduce water demand, 2) Component 2 - developing sustainable and drought resilient alternative water supplies, and 3) Component 3 - expanding local groundwater production within sustainable yield limits.

The delay in achieving the City's self-sufficiency goal from 2020 to 2023 is due to several factors, including new regulations established by the State Water Resources Control Board's Division of Drinking Water (DDW) that required further analysis to determine the level of treatment required for the Olympic Sub-basin, the project timeline and permitting schedule for the SWIP project to recharge local groundwater aquifers with purified water, and the need to confirm and refine preliminary SYA estimates with additional data to establish an accurate estimate of the sustainable yield for the Santa Monica Groundwater Basin.

The remainder of this staff report is organized as follows to provide detailed descriptions of each component of the updated SWMP and its contribution/benefits toward the City's self-sufficiency goal:

- Proposed Plan to Achieve Water Self-Sufficiency
- SWMP Project Cost and Implementation Schedule
- Funding Recommendations

Proposed Plan to Achieve Water Self-Sufficiency

A comprehensive plan was developed through the SWMP and comprises three components that provide a path for the City to achieve water self-sufficiency by 2023. The contribution of each proposed component to eliminate reliance on imported water supply by 2023 is summarized in Figure 4 along with the percent contribution toward replacing imported water purchases. In total, the three components: 1) conservation, 2) alternative water supplies - production efficiency, recycled water, and purified water for recharge, and 3) new local groundwater will contribute approximately 8,057 AFY toward the City's total water supply and reduce imported water purchase to only 170 AFY. A brief description of each of the recommended components is provided below.

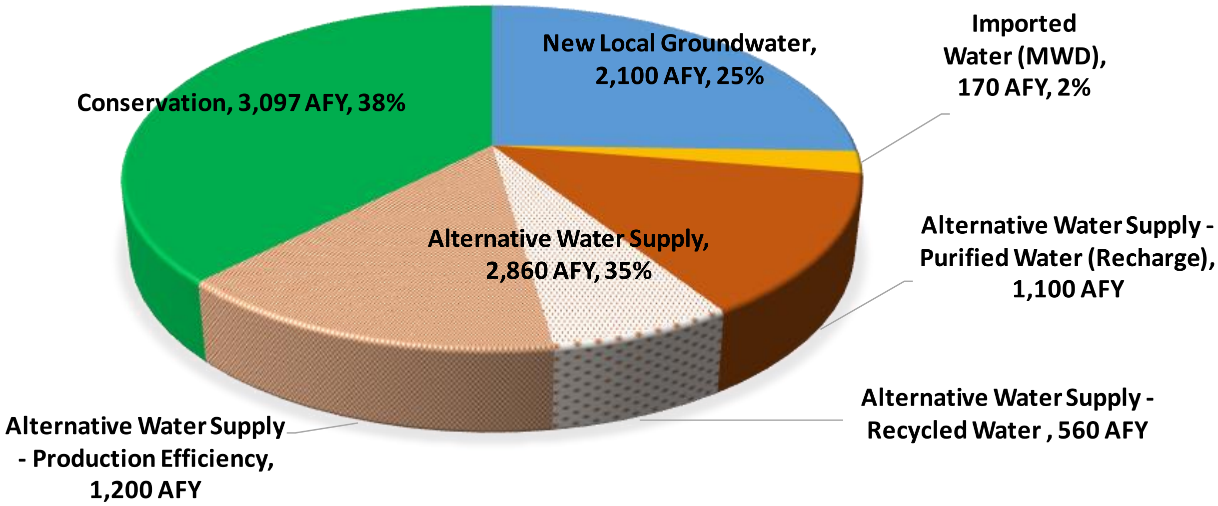


Figure 4: Summary of Proposed Components to Replace Imported Water Supply by 2023

Component 1 - Conservation (38% Reduction in Imported Water Purchases)

In 2014, Council authorized the significant expansion of staffing and funding to augment the City's water conservation efforts to address the state-wide drought and help the City meet its self-sufficiency goal. This contributed to a water demand reduction of approximately 20% over the past three years (2015-2017), which equates to saving approximately 2,500 AFY. Continued implementation of the existing conservation programs with the addition of supplemental conservation efforts is expected to continue this trend of water demand reduction through 2040, with the staff recommended *Optimal* conservation plan which is described below. Continuation of existing, and implementation of proposed, conservation programs are essential for the City to eliminate reliance on imported water from MWD. ***The recommended Optimal conservation plan will contribute approximately 3,100 AFY to the City's water supply portfolio in 2023 and reduce imported water purchases by roughly 38%.***

Staff modeled three conservation plans (Optimal, Enhanced, and 90 GPCD), which are presented in gallons per capita per day by 2025 and abbreviated as GPCD. The Optimal Conservation Plan can be completed using existing budgeted resources and would reduce the City's total water demand by approximately 20%, even after factoring in demand increases associated with expected population growth through 2025.

Increasing conservation efforts from the Optimal to the Enhanced Plan would cost an additional $7.2 million in total program cost, on top of the budget already allocated for the Optimal Conservation Plan, but with a marginal increase in water conserved (approximately 2% additional reduction in GPCD with the Enhanced Plan). The enhanced conservation plan would still require approximately 3,500 to 3,700 AFY of water that would need to be met through the purchase of imported water or from the development of additional local water resources. With marginal gains from increased conservation efforts compared to the additional implementation cost required, staff is recommending continuing with the *optimal* conservation plan, which costs approximately $708/AF of water saved.

A third, aggressive conservation plan was also studied following a request by the Task Force on the Environment to evaluate the cost and feasibility of reducing city-wide water demand to 90 GPCD by 2025. The assessment of the 90 GPCD Plan conducted by staff concluded that reducing overall water demand to 90 GPCD would be extremely costly and may not be feasible for implementation. The overall cost to implement this plan would exceed $56.6 million, with $40 million of the cost incurred over the first five years. In addition to the significant cost premium, this scenario would likely require additional staffing and would be very challenging to achieve by 2025.

Staff met with industry experts to review and receive input on the City staff modeling of proposed conservation programs. A panel of outside experts supported both the optimal and enhanced conservation plans and the proposed programs that comprise them. A summary of the conservation scenarios evaluated is provided in Table 1.

Table 1: Summary of Conservation Scenarios Considered

Description[1]	**Conclusion**	**Cost**
Optimal, 108 GPCD	• Best Conservation option • Does not achieve self-sufficiency goal by itself but supports demand reduction.	Within current operating budget $708/AF (over 30 years) [2]
Enhanced, 106 GPCD	• Feasible but expensive compared to Optimal Plan. Requires 1.5 new staff for 10 years	$7.2 million increase in program costs compared to Optimal (2018-2023)

	• Does not achieve self-sufficiency goal • Not worth the incremental cost for a 2GPCD reduction.	137% increase in budgeted costs (2018-2013) $1,078/AF (over 30 years) [2]
Aggressive, 90 GPCD	• Potentially feasible but very expensive, requires 2.5+ new staff for 10 years • Does not achieve self-sufficiency goal	$40.8M over the first five years; $58.6 M 2019-2040, 800% increase in costs (2018-2023) compared to Optimal Scenario ~$1,280/AF (over 30 years)[2]
[1]GPCD based on water conservation efforts achieved as of 2025 [2]Excluding ongoing conservation staffing cost.		

Due to conservation efforts since 2015, the City's current water demand measured in gallons per capita per day (GPCD) is approximately 110 GPCD. Staff also conducted a theoretical exercise to determine what would be required for the City to become water self-sufficient solely through conservation efforts (assuming no imported water and no additional local water production). Results of that exercise indicated that the total per capita water demand would need to be reduced to 64 GPCD. Staff consulted water conservation experts, analyzed conservation efforts in other cities and evaluated various local conservation scenarios and determined that attempting to achieve the self-sufficiency goal through conservation alone (i.e. achieving 64 GPCD in Santa Monica) is neither financially feasible nor realistic within the time horizon.

However, the community should be commended on the conservation efforts already taken to reduce water demand and decrease imported water purchased from MWD. Santa Monica is - and can be - a model for a new ethic of resource self-sufficiency and environmental sustainability. The Council's recent adoption of the 100% renewable default rate for community electric supply represents this ethos of "living within our means." Conservation will continue to play a critical role in the City's march toward water self-sufficiency by continuing to reduce overall water demand in the face of continued population growth from new housing and demand from the commercial and institutional sectors of our local economy.

Based on the modeling described above, staff recommends pursuing the *Optimal* conservation plan, which continues the successful conservation programs initiated over the past three years and increases water conservation in untapped areas such as:

- Funding of retrofits in Santa Monica-Malibu Unified School District facilities and landscapes
- Commercial sector fixture retrofits and enhanced rebates
- Coin-operated laundry machine retrofits
- Increase in Water Neutrality offsets and direct installs
- Rebates for new technologies including gray and black water systems
- Enhanced water conservation education and enforcement
- Additional sustainable landscape conversions
- Outreach to assist customers on how to properly adjust their irrigation timers
- New marketing and outreach campaign focusing on instilling permanent conservation behaviors consistent with the state's forthcoming framework for "Making Water Conservation a California Way of Life"
- Incorporating limited-term employees as part of the permanent water conservation team to ensure new state requirements and regulations are met, as well as maintaining programs at an effective level

In developing the water conservation plan to reach and maintain self-sufficiency, the City evaluated the potential for further water efficiency and conservation in all customer sectors. This included an assessment of the current level of water fixtures in the city, as well as identifying where the greatest opportunity for reducing water consumption existed. Based on this analysis, a program plan was developed to reach the City's long-term objectives via existing and new conservation programs.

Table 2 shows the projects planned over the next five years including the number of activities for each program such as number of rebates, consultations and direct installation of water efficient fixtures to replace inefficient fixtures in existing buildings throughout the city. The projected number of activities is based on historical participation, available market of opportunity, and strategic community engagement campaigns to increase programs over multi-year periods. The table also includes the estimated water savings and total costs from 2018 through 2023 when water self-sufficiency is expected to be reached.

Table 2: Summary of Optimal Water Conservation Programs and Results

Measure	Customer Class	Total Activities 2018-2023	Total Water Savings (AF) 2018-2023
Rebates, Single Family (i.e. clothes washers, landscape, soil sensors, toilets, irrigation)	Single Family	4,660	286
Water Use Consultations, Single Family	Single Family	720	58
Graywater System Incentive	Single Family	60	1
Direct Installs, Single Family (i.e. 0.80 gpf toilets, water neutrality)	Single Family	0	0
Direct Installs, Multi-Family (0.80 gpf and 1.06 or less gpf toilets)	Multi-Family	3,750	124
Rebates, Multi-Family (i.e. high-efficiency clothes washers, landscape, toilets)	Multi-Family	1,475	94
Water Use Consultations, Multi-Family	Multi-Family	750	90
School Education Program	Institutional	2,090	14
Direct Installs, Santa Monica Malibu Unified School District (i.e. 0.80 gpf and 0.125 gpf toilets and urinals, water neutrality)	Institutional	537	9
Santa Monica Malibu Unified School District Weather Based Irrigation Controller Incentive	Institutional	22	21
Santa Monica Malibu Unified School District Landscape Incentive	Institutional	9	8
Rebates, Commercial & Institutional (i.e. ice machines, toilets, urinals, toilets, irrigation)	Commercial & Institutional	1,792	260
Direct Installs, Commercial & Institutional (i.e. toilets and urinals)	Commercial & Institutional	3,280	517
Water Use Consultations, Commercial & Institutional	Commercial & Institutional	300	45
Performance Pays	Commercial & Institutional	4	9
Soil Moisture Sensor Rebates	Multi-Family, Commercial & Institutional	75	7
Water Saving Devices - Faucet Aerators	All	9,240	328
Water Saving Devices - Showerheads	All	4,200	160
Community Outreach & Education	All	16	1
Pilot Projects	All	2	2
Total		**32,982**	**2,034**

The financial summary of the Optimal Conservation Plan is provided in Table 3.

Table 3: Financial Summary of Optimal Water Conservation Plan

Average Water Savings (AFY)
610
Cost of Savings per Unit Volume ($/AF)

$708

Modeling of the water conservation plan was purposefully conservative and only includes expected water demand reductions directly related to City efforts. Therefore, the projected demand reductions do not include the potential savings from efficiency improvements in California State Plumbing Codes known as “passive conservation.” Passive water conservation is achievable through non-City sponsored programs, such as maximizing current plumbing code enforcement, landscape ordinances, natural fixture replacement rates, as well as future local and state regulations and codes. This includes the impact and enforcement of the legislation, California SB 407, requiring noncompliant plumbing fixtures in any single-family residential and multi-family residential, and commercial properties to be replaced by the property owner with water-conserving plumbing fixtures.

Through the currently established programs, proposed new programs, and passive conservation, it is estimated that the City can reach 99 GPCD by 2025 and 96 GPCD by 2030. These efforts would result in an estimated additional annual savings between 680 acre-feet (AF) per year by 2025 and as much as 1,000 AF per year in 2030. The City allocates funding for conservation within the water fund annual operating budget; no additional funding would be required to implement the Optimal Conservation Plan. Staff will return during the Five-Year Rate Study to present long-term staffing options for the recommended *Optimal* Conservation Program.

Component 2 - Alternative Water Supplies (35% Reduction in Imported Water Purchases)

To further diversify the City’s water supply portfolio and increase overall resilience***, three alternative water supply projects are proposed and collectively offset imported water purchases from MWD by 35 percent*** (see Figure 4). These projects include:

- Increase recycled water production through the Sustainable Water Infrastructure Project (SWIP), upgrading the existing Santa Monica Urban Runoff Recycling

Facility (SMURRF) and constructing a new Advanced Water Purification Facility (AWPF) that provides a drought resilient, local water supply. The increase in recycled water production from SMURRF would offset imported water purchases from MWD by approximately 4% (approximately 560 AFY).

- Recharge local groundwater aquifers in the Olympic Sub-basin to maintain sustainable yield pumping levels with purified water from the SWIP's AWPF. The purified water from the AWPF would offset imported water purchases from MWD by approximately 7% (approximately 1,100 AFY).
- Upgrade the City's Arcadia Water Treatment Plant (WTP) with new technology to increase overall production. Closed Circuit Reverse Osmosis (CCRO) would be added to the Arcadia WTP to treat the Reverse Osmosis concentrate waste stream, which is currently discharged to the sewer system, and increase the overall treatment efficiency at the Arcadia WTP to approximately 90 percent, or greater. The addition of CCRO at the Arcadia WTP would offset imported water purchases from MWD by approximately 8% (approximately 1,200 AFY).

The SWIP project is a major component of the alternative water supply for the City as it will provide a sustainable and drought resilient water supply by providing purified water to recharge local groundwater aquifers. In return, the aquifer recharge that will be provided by the SWIP will allow the City to maximize groundwater pumping, within sustainable yield limits, from the Olympic Sub-basin.

Component 3 - New Local Groundwater Production (25% Reduction in Imported Water Purchases)

To offset the remaining imported water purchased from MWD, ***local groundwater production would need to be increased to reduce imported water purchases from MWD by 25%*** and resiliency measures implemented to maintain reliable production. Staff developed and analyzed seven scenarios to expand the City's groundwater production and carefully vetted each scenario internally and with outside industry experts. The seven scenarios were compared based on project feasibility, capital, and operation cost, and are summarized in Attachment C. All scenarios evaluated assume that the *Optimal* Conservation Plan is implemented. Of the seven scenarios evaluated, Scenario 1 - Expansion of Arcadia WTP with Closed Circuit Reverse Osmosis (CCRO) combined with a Separate Olympic Sub-basin Pipeline and Treatment at the Arcadia WTP site is recommended. Scenario 1 combined with the Optimal Conservation Plan is the most cost-effective solution to achieve self-sufficiency and maximize local water resources. Scenario 1 includes the following elements:

- Expansion of the Arcadia WTP, including CCRO technology (as discussed under component 2 - alternative water supplies), to increase treatment capacity and accommodate future 2040 water demands.
- Acquisition of a new groundwater well to enhance resiliency.
- Olympic Sub-basin Restoration:
  - A new pipeline separating Olympic Sub-basin water, conveying it independently to the Arcadia WTP, thus requiring a smaller treatment facility at the Arcadia WTP to remove contaminants in the Olympic Sub-basin.
  - Separate contamination treatment facility at the Arcadia WTP for the Olympic basin.

Expansion at Arcadia WTP

To support development of alternative water supplies and restoration of the Olympic Sub-basin, treatment capacity expansion and plant upgrades are required at the Arcadia WTP to support an overall increase in water production and enhance resiliency to achieve water self-sufficiency. The Arcadia WTP is currently capable of treating up to approximately 11,300 AFY (10 million gallons per day [mgd]) and produce 9,900 AFY (8.9 mgd) of treated water (approximately 82% recovery or efficiency). The proposed expansion and addition of new technologies to increase production efficiency at the Arcadia WTP will increase its treatment capacity to approximately 14,700 AFY (13 mgd) and produce 13,400 AFY (12 mgd) of treated water (approximately 92% recovery or efficiency). The proposed improvements for expanding production capacity at the Arcadia WTP and enhancing water supply resiliency include:

- Acquire an additional groundwater well to enhance resiliency and maintain production during routine maintenance or unforeseen downtimes of groundwater wells, while aggressively pumping within the sustainable yield.
- Install new CCRO to increase overall plant efficiency to 90 percent or greater (as discussed previously under component 2 - alternative water supplies).
- Expand capacity (e.g., pumps, blowers, cartridge filters, etc.) of the Arcadia WTP to accommodate increased groundwater production and new technologies (e.g., CCRO described in Component 2).

Olympic Sub-basin Restoration

The Olympic Sub-basin plays a key role in achieving the City's water self-sufficiency goal as it could provide up to 3,200 AFY of groundwater and is also the location where purified water from the SWIP will be recharged to sustain this pumping rate. However, the Olympic Sub-basin contains several contaminants that would require additional treatment to meet drinking water standards. The key contaminants in the Olympic Sub-basin include: 1,2,3-Trichloropropane (1,2,3-TCP), 1,4-Dioxane, trichloroethylene (TCE), and tetrachloroethylene (PCE). Drinking water regulations, or maximum contaminant levels (MCL), have been in place for TCE and PCE prior to January 2018, and regulations for 1,2,3- TCP were established after January 2018 which required further treatment analysis. 1,4-Dioxane is currently on the State of California's drinking water Notification Level (NL) list, which is a health-based advisory level and not an MCL. It is anticipated that the NL of 1 microgram per liter (μg/L) or part per billion (ppb) for 1,4-Dioxane will likely become an MCL in the near future (within next 5 years).

Further analysis of treatment options for the Olympic Sub-basin was required due to a recently established drinking water regulation that established a MCL for 1,2,3 TCP at 5 parts per trillion (ppt), and additional data on 1,4 Dioxane was available to refine the treatment analysis to determine if the current 1 ppb NL (anticipated future MCL) could be met once full production of the Olympic Sub-basin is restored. The Olympic Sub-basin treatment analysis was performed by an outside consultant, Black & Veatch. Key findings of the treatment analysis are listed below:

- 1,2,3-TCP was only detected at one well, SM-4, and the MCL of 5 ppt could be met through blending with other wells at full production capacity.
- 1,4-Dioxane is present in all three wells (two existing and one future) and could limit groundwater production from the Olympic Sub-basin to 845 AFY or approximately 25% of the basin's total sustainable yield.
- Other contaminants, TCE and PCE, do not impact groundwater production from the Olympic Sub-basin as they would be removed through existing treatment processes at the Arcadia WTP.

To maximize groundwater production from the Olympic Sub-basin and comply with regulation on the key contaminants of concern, the following improvements are recommended:

- Increase groundwater pumping from existing wells (SM-3 and SM-4), complete equipping and permitting of one recently installed new well (SM-8) and install a replacement well (SM-9) to increase local production from this sub-basin to ~3,200 AFY within sustainable yield levels. Please note that purified water from the SWIP will be used to recharge the Olympic Sub-basin that helps maintain the sustainable yield levels by supplementing naturally available groundwater within the sub-basin. Design and procurement efforts are currently underway, and the well projects were previously approved by Council in the FY 19-20 Capital Improvement Budget.
- Construct a new pipeline to separate Olympic Sub-basin groundwater from Charnock wellfield groundwater for separate treatment at the Arcadia WTP, primarily to target removal of 1,4 Dioxane. This reduces the amount of water needing treatment since only the Olympic Sub-basin flows (3,200 AFY) contain 1,4 Dioxane. If the flows are not separated, 14,700 AFY (Olympic + Charnock) would need to be treated.
- Construct a new contamination treatment facility for only the Olympic Sub-basin flows to remove 1,4 Dioxane, 1,2,3-TCP, TCE, and PCE at the Arcadia WTP site. The proposed treatment train consists of the ultraviolet light advanced oxidation

process and granular activated carbon. With the new contamination treatment facility and increased production efficiency (90-92% recovery) at the Arcadia WTP, approximately 2,900 AFY of treated water will be produced from the 3,200 AFY extracted from the Olympic Sub-basin. The new contamination treatment facility will provide high-quality drinking water that meets current and future regulatory standards.

Sustainable Yield Update

The sustainable yield from the Santa Monica Groundwater Basin is a critical component to ensure overall groundwater production is within sustainable limits of the basin and could support the proposed projects described above on an ongoing basis. A preliminary Sustainable Yield Analysis, (SYA), prepared by Richard C. Slade & Associates (Slade) in 2017, was presented to Council in January 2018. Since then, additional work was performed to refine and update the SYA. Additional work included the Coastal Sub-basin Exploratory Boring Program and a digital elevation mapping study that analyzed the potential recharge from the nearby mountain front. The updated report contains findings from this recently completed work as well as 2017 data regarding rainfall, geology, static water levels in key wells, and groundwater withdrawals from active City wells and other known private well owners (Attachment D). The updated SYA estimate from Slade's analysis for the Santa Monica Basin is between 11,800 and 14,725 AFY.

To substantiate the assessment conducted by Slade, City staff contracted with consultants from ICF to perform a separate estimate of the sustainable yield using a water-balance approach. This method compares the amount of water that recharges into a basin (inflow) from a wide range of sources (natural and anthropogenic), with the amount of water leaving the basin (outflow) from losses caused by pumping, evapotranspiration, basin outflow, etc. ICF's assessment also considered findings from both the digital elevation mapping and Differential Interferometric Synthetic Aperture Radar Study (DInSAR) studies, presented to Council in January 2018. Based on ICF's water-balance approach, average sustainable yield was estimated to be between

11,416 AFY to 13,722 AFY. The similarity of the sustainable yield estimates developed by Slade and ICF using different modeling methods provide a strong level of confidence that the City can use local groundwater resources in an ongoing manner into the future without negatively impacting the basin or creating overdraft conditions.

It should be noted that the estimates developed by Slade and ICF are conservative and do not include a sustainable yield estimate for the Crestal Sub-basin. In addition, all estimates of sustainable yield are transitory due to myriad associated climatic and hydrogeologic factors that are constantly in flux. The State legislature enacted the Sustainable Groundwater Management Act (Water Code sections 10720 *et seq*.)("SGMA"), which became effective on January 1, 2015. A portion of the 50-square mile Santa Monica Basin that underlies Santa Monica has been designated by the Department of Water Resources as a "medium-priority" groundwater basin. Any groundwater basin designated as medium-priority must be managed under a groundwater sustainability plan ("GSP") adopted by a local groundwater sustainability agency and approved by the Department, by January 31, 2022. In light of SGMA, further analysis will be required to determine if future demand will exceed what could be sustainably pumped from the basin. If it is determined that the City's plans to extract more groundwater is not supported in the approved draft of the GSP, then the City may be precluded from withdrawing groundwater in excess of the then-projected sustainable yield and the City would need to continue purchasing imported water from MWD to meet its potable water demand. The potential limitations on future groundwater withdrawals from the City's active sub-basins indicate that the City's approach of pursuing nonconventional resources, indirect potable reuse via aquifer recharge, additional water supply wells in the Coastal sub-basin, replacement of underperforming wells, increasing treatment efficiency at the Arcadia Water Treatment Plant, and continuing conservation efforts are necessary for the City to achieve and sustain its long-term objective of independence from imported water. Future updates of the SYA and numerical models will further refine the sustainable yield for the basin. Going forward, the City is planning to update the SYA approximately every two to three years. Future updates will include additional findings from work being conducted jointly with the US Geological Survey (USGS) and an ongoing climate stress test evaluation by the Rand Corporation. The

City plans to produce groundwater within the upper limit of the estimated sustainable yield, while taking into consideration two irrigation pumpers in the Arcadia Sub-basin and one in the Crestal in addition to one diminutive residential irrigation well.

Summary of Proposed Plan to Achieve Water Self-Sufficiency

The three components proposed in the SWMP will help the City achieve water self-sufficiency by 2023 and eliminate the City's reliance on imported water purchases from the MWD. The projected makeup of the City's water supply portfolio is summarized in Figure 5, and contribution from each component to the City's total water supply is provided in Table 4. The location for each of the three components is provided in Figure 6, and the synergy and inter-relationship between each component is illustrated in Figure 7. Achieving water self-sufficiency through a diversified water supply portfolio also provides the City with greater cost control over water rates as compared to the continued purchase of imported water from the MWD. As noted previously, approximately 1 percent of the water supply would continue to be made up of imported water purchased from the MWD as periodic circulation is required to maintain the supply line as an emergency backup for the City.

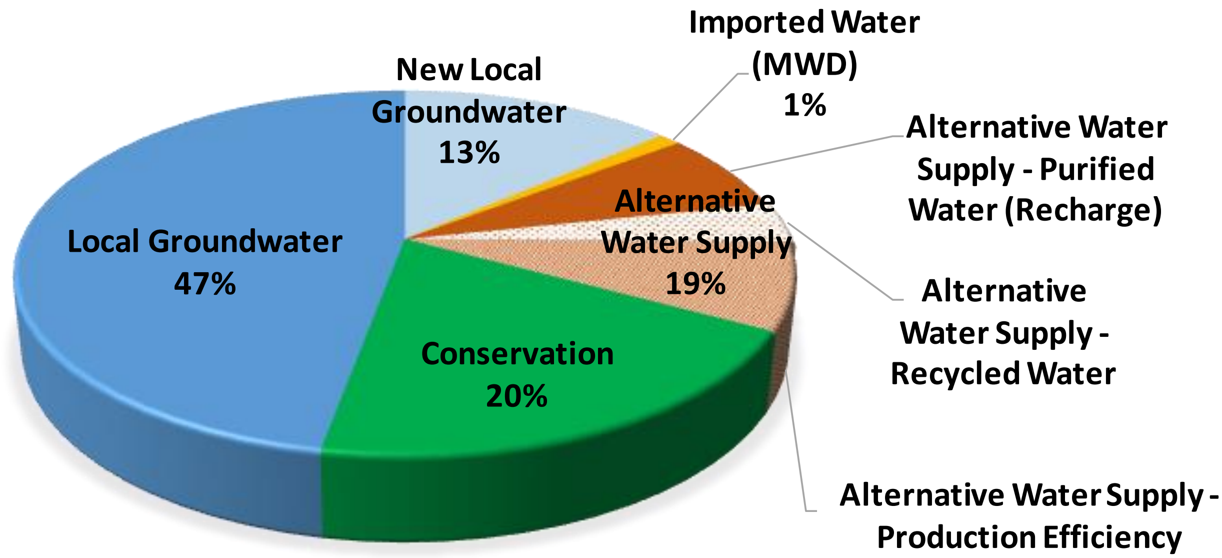


Figure 5: A Sustainable and Drought Resilient Water Supply Portfolio Achieved through Self Sufficiency

Table 4: Summary of Water Supply Contribution from Each Self-Sufficiency Component

Water Self Sufficiency Component	Estimated Water Supply Contribution by 2023 (AFY)	% Reduction in Imported Water	Estimated $/AFY
Component 1 - Conservation			
Optimal Conservation Plan	3,100	38%	$708
Component 2 – Alternative Water Supplies			
Recycled Water from SMURRF	560	7%	$420[1]
Purified Water from SWIP to Recharge Olympic Sub-basin	1,100	13%	$1,017[1]
Increase Production Efficiency at Arcadia WTP	1,200	15%	$1,071[1]
Component 3 – New Local Groundwater Production			
Arcadia WTP Expansion and Resiliency Enhancement[2]	N/A	N/A	$705[1]
Olympic Sub-basin Restoration	2,100	26%	N/A[3]
Subtotal	**8,060**	**99%**	
Existing Water Resources			
Existing Local Groundwater (2023 projected costs)	7,330		$1,100
Imported Water from MWD (to maintain for emergency use, 2023 projected costs)	170		$1,248
Subtotal	**7,500**		
TOTAL WATER RESOURCES (2023)	**15,560**		

[1]Estimated year 1 cost when project is complete and includes savings from avoided imported water purchase cost

[2]Aracadia WTP upgrades to accommodate increase in production efficiency and Olympic Sub-basin Restoration

[3]Olympic Sub-basin Restoration will be paid for through settlement funds

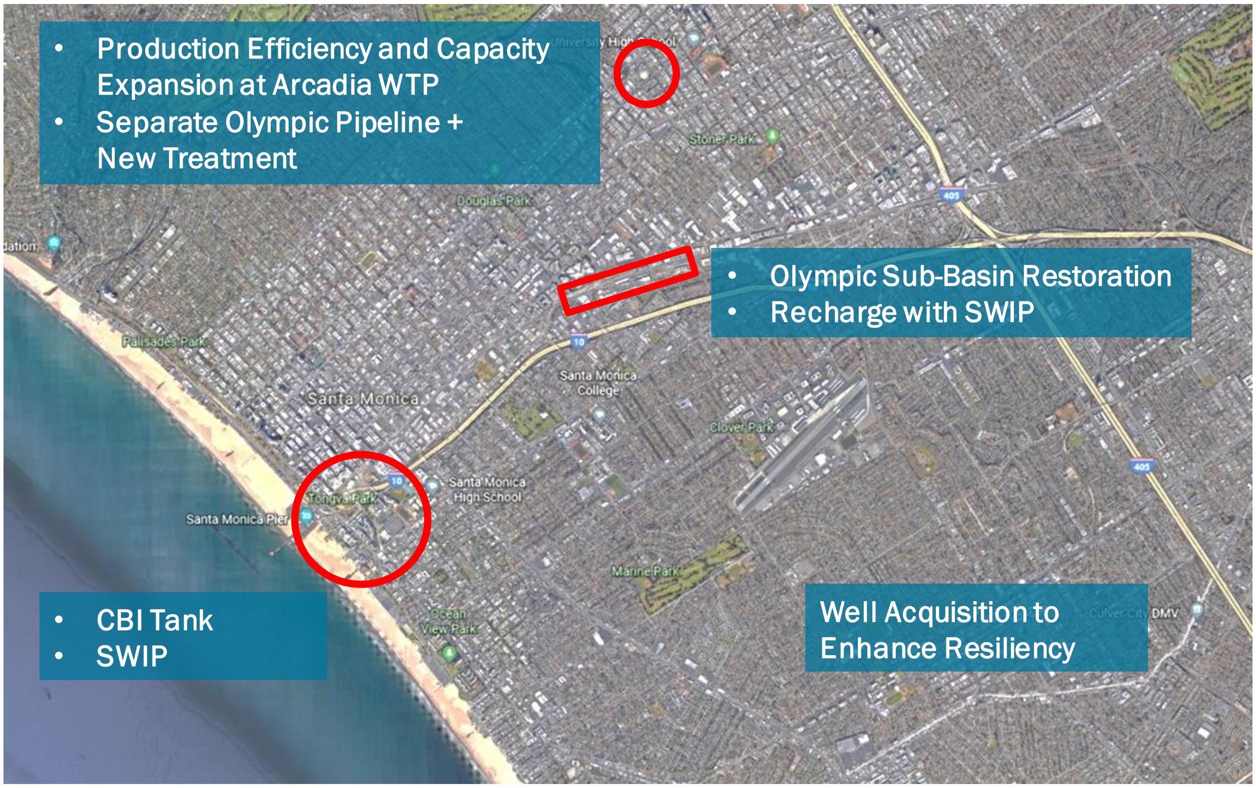


Figure 6: Project Locations of Proposed SWMP Component Toward Self-Sufficiency

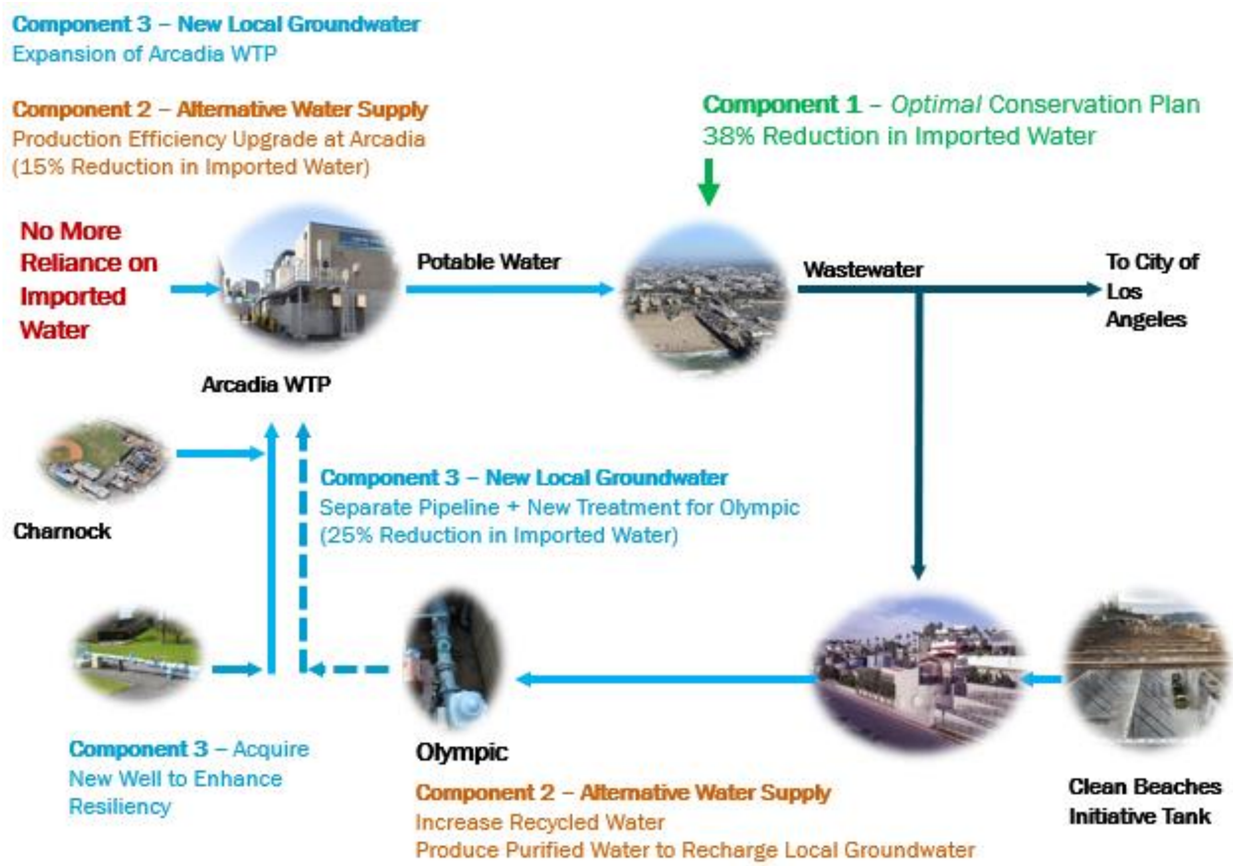


Figure 7: Synergy between Proposed Water Supply Components to Achieve Self-Sufficiency

SWMP Cost Summary and Implementation Schedule

A cost summary for the proposed SWMP components to achieve self-sufficiency by 2023 is provided in Table 5. The funding required to complete the capital projects increasing local water supplies and enhance water supply resiliency is $38 million. A Five-Year Rate Study (2020-2024) is currently underway and will present funding solutions to cover these costs. It is projected that the components of the proposed SWMP may be funded primarily through the issuance of water revenue bonds (approximately $34.75 million), with the debt service on the bonds incorporated into water rates, and from a contribution from the Wastewater Fund (approximately $3.25 million). Staff will return to Council in spring 2019 for a rate study session. An additional $64 million from existing water-contamination settlement funds would be used for restoring the Olympic Sub-basin, which would allow additional water production from that sub-basin to support water self-sufficiency. The Olympic Sub-basin restoration cost includes an approximate, one-time $20 million capital expenditure for treatment systems and 30 years of ongoing operation and maintenance for an additional $20 million. Based on current modeling projections by ICF, over 80% of the Olympic Sub-basin will be remediated within the first 30 years; however, the Sub-basin may not be completely restored. Thus, the remaining balance in the settlement fund ($24 million) should be reserved to address any contamination that may still be present after 30 years or any new regulations that may impact use of the Olympic Sub-basin. A more detailed discussion on recommended budget appropriations is provided below.

Table 5: SWMP Cost Summary for Proposed Components to Achieve Self-Sufficiency

Unfunded Projects	Additional Cost
Arcadia WTP: Expand Capacity and Production Efficiency Enhancement	$30M
Additional Well and Improvements: Increase Resiliency and Ground Water Production	$8M
Olympic Sub-basin Restoration, Capital Improvements and 30 years of Operations and Maintenance	$40M
Olympic Sub-basin Restoration Reliability Reserve	$24M
Total:	$102M

Implementing the SWMP and reaching water self-sufficiency by 2023 entails numerous capital projects that are interrelated. An overview of the proposed implementation schedule is provided in Figure 8. Several well projects (SM-8, SM-9 and injection well) were approved by Council on July 11, 2017 and on June 12, 2018 and are on track to be completed by 2021 (Attachments E and F, respectively). A portion of the projects are in the City of Los Angeles and require installation of pipelines. Construction and permitting of pipelines in the City of Los Angeles will take time and was considered in the schedule. The design, construction, and permitting of improvements at the Arcadia WTP, including efficiency upgrades, are expected to be completed in 2023 if procurement starts in December 2018. A schedule contingency of approximately six months has been included to account for unforeseen conditions or new regulations that could impact the plan implementation.

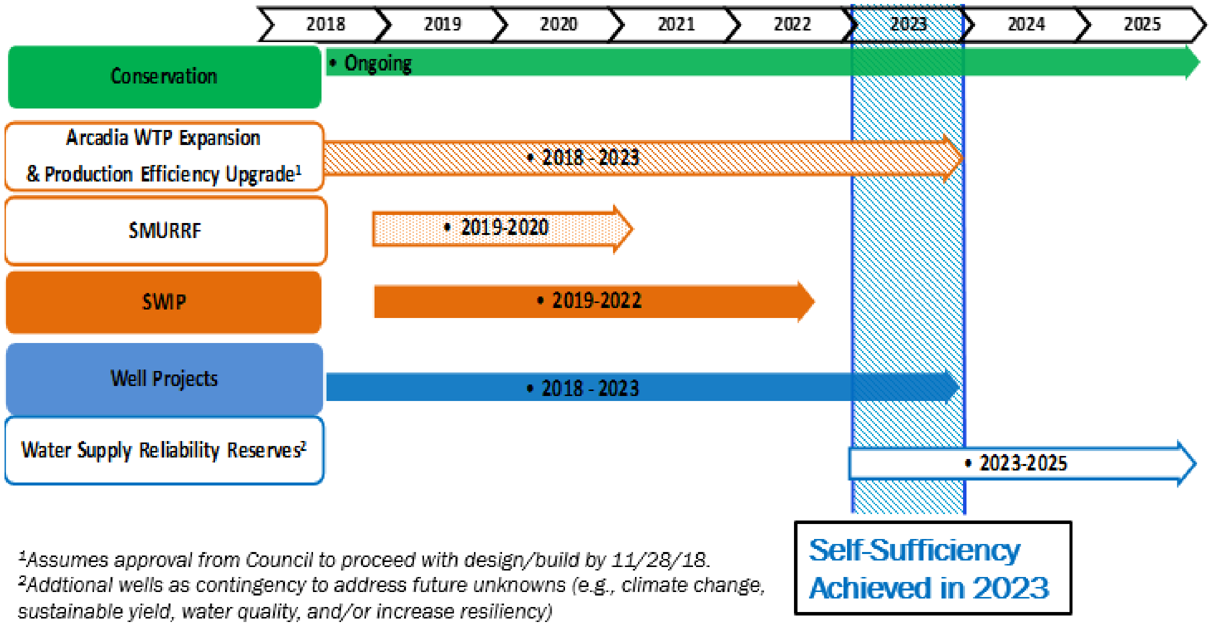


Figure 8: Proposed Implementation Schedule to Achieve Self-Sufficiency by 2023

Alternatives to Water Self-Sufficiency

The proposed SWMP components summarized above are a considerable investment towards the City's future resiliency and achieving water self-sufficiency by 2023. In consideration of the capital investment and impacts to water rates, staff has also evaluated potential alternatives to reduce capital expenditures to potentially provide relief to potential water rate increases (to be confirmed in the Five-Year Rate Study for 2020-2024). A summary of potential alternatives that may reduce upfront capital investment compared to the proposed water self-sufficiency plan is provided in Table 6. The capital cost summarized in Table 6 for each alternative is the capital cost that needs to be funded and does not include the $64 million in settlement funds that will be used for the Olympic Sub-basin restoration. For all alternatives, it is assumed that the Olympic Sub-basin restoration will be implemented. A brief description on which component is implemented and its associated capital cost to be funded is provided. Staff also considered delaying self-sufficiency goal to beyond 2023 and delaying capital expenditures to ease rate increase over the next five years. However, delaying implementation may result in increasing overall project cost due to inflation and negate any potential up front capital savings. The alternatives summarized in Table 6 only consider reduction in upfront capital cost and do not include projected increase of imported water purchase from MWD (estimated to be at 5% annual increase), which will ultimately be more expensive than locally produced water.

Table 6: Summary of Alternatives Considered for Self-Sufficiency

Alt. No.	Alternatives Description	Capital Cost[3]	Locally Sourced Water + Conservation	Imported Water Purchase from MWD
Staff Recommended Plan	***99% water self-sufficiency[1]*** Component 1 - Conservation Component 2 - Alternative Water Supplies Component 3 - New Local Groundwater	$38M	11,730 AFY (Existing Arcadia WTP + Olympic) 3,100 AFY (Conservation) 560 AFY (Recycled Water)[2]	170 AFY
1	***87% water self-sufficiency[1]*** Implement only SWIP and Olympic Sub-Basin Restoration. Acquire new well to enhance resiliency at Arcadia WTP. No expansion and production efficiency enhancements at Arcadia WTP	$8M	9,900 AFY (Existing Arcadia WTP + Olympic) 3,100 AFY (Conservation) 560 AFY (Recycled Water)[2]	2,000 AFY
2	***90% water self-sufficiency[1]*** Implement SWIP, Olympic restoration, and expansion at Arcadia WTP. No production efficiency enhancements at Arcadia WTP. Results in loss and negative impact to treatment resiliency.	$21M	10,500 AFY (Existing Arcadia WTP + Olympic) 3,100 AFY (Conservation) 560 AFY (Recycled Water)[2]	1,400 AFY
3	***94% water self-sufficiency[1]*** Implement SWIP, Olympic Restoration, expansion	$30M	10,900 AFY (Arcadia WTP + Olympic) 3,100 AFY	1,000 AFY

	and production efficiency upgrades at Arcadia WTP. Do not acquire a new well to enhance resiliency.		(Conservation) 560 AFY (Recycled Water)[2]	
[1]Percentages are based on year 2023 projected demand. [2]560AFY of recycled water to be available in 2023, but actual usage of full capacity may not be until 2040. [3]Excluding Olympic Sub-Basin restoration cost, which is funded through settlement funds and SWIP capital costs as it is already funded through a low interest loan from the State of California.				

The alternatives evaluated by staff are simply presented as scenarios to reduce capital expenditures over the next five years but does not provide a complete solution to achieve the City's water self-sufficiency goal.

Funding Recommendations to Achieve Water Self-Sufficiency

A financial analysis for the plan outlined in this report to achieve water self-sufficiency was conducted by staff. The financial analysis includes comparing the future cost of imported water to the projected cost of locally produced water over a 30-year period. This analysis excluded the Olympic Sub-basin restoration costs, as the recommended funding source would be from groundwater settlement funds received by the City from outside sources to cover the costs for remediating the contaminants in that sub-basin. In summary, locally produced water from the recommended SWMP components outlined in this report is projected to cost between $400/AFY to $1,100/AFY, which is less than the expected cost to purchase imported water from the MWD at $1248/AFY in 2023. Please refer to Table 5, presented previously, for a detailed breakdown on the cost per acre-foot for each local water supply component. A comparison of the projected cost differential between the purchase of imported water from the MWD and production of locally produced water is provided in Table 7. With locally produced water cheaper than imported water costs, the components outlined in the SWMP to achieve water self-sufficiency by 2023 are a positive investment toward the future of the City. Ratepayers will benefit from the implementation of these projects, thus keeping local water costs low compared to the ongoing cost increases for imported water. Not only does the proposed SWMP provide a sustainable and drought resilient water supply for the City, it would also benefit the ratepayers with greater control over future water rates compared with imported water rates that are projected to increase at a higher rate and are outside the City's control.

Table 7: Future Estimated Imported Water Cost (increased at 5%) Compared to Projected Locally Produced Water Cost. Assuming Efficiency (CCRO) technology is installed and 2,800AFY is produced.

Why Production Efficiency and Expansion at Arcadia Water Treatment Plant?

To avoid paying a higher imported water cost on 2,800 acre-feet (AF) every year.

CITY IMPORTS WATER	CITY LOCALLY PRODUCES WATER
ESTIMATED 2023 MWD COST ($/AF) $1,248	ESTIMATED 2023 COST ($/AF) $705-1,071
ESTIMATED 2050 MWD COST($/AF)[1] $5,137	ESTIMATED 2050 ($/AF)[2] +$1,695
CITY'S TOTAL COST BY 2050 ≈$205,000,000	CITY'S TOTAL COST BY 2050 ≈+$16,000,000
	$221M in Cost Savings over 28 Years

[1]Assumes an average 5% yearly rate increase.

[2]Assumes a 2.4% Arcadia WTP O&M yearly increase, 2.4% CCRO O&M yearly increase, 5% MWD Rate increase, avoided imported water savings, and includes CCRO & Arcadia Expansion capital costs.

As noted previously, staff recommends a combination of bonding and use of settlement funds to fund the capital projects supporting water self-sufficiency and the Olympic Sub-basin restoration.

Water Revenue Bond: A rate study is currently being conducted through October 2019 to set water and wastewater rates for calendar years 2020 to 2024. The rate study will address options to support the costs of this plan. A possible funding solution, to be confirmed in the rate study, is the issuing of a 30-year water revenue bond totaling approximately $34.75 million to increase local water supplies and enhance resiliency as outlined in the SWMP. The remaining $3.25 million would be contributed from the Wastewater Fund due to joint property use. The $34.75 million in bonds would cover new well acquisition, treatment capacity expansion and implementation of new technologies to enhance production efficiency at the Arcadia WTP, and other supporting infrastructure upgrades. The Water Fund would need to cover an annual payment of approximately $2.2 million over the next 30 years to fund the projects outlined in the SWMP. Assuming a bond is issued, Figure 9 illustrates projected annual savings from avoiding imported water purchases and estimated annual bond repayments. In year 2036, where the two lines cross, the City will start saving money for rate payers on an annual basis. This analysis assumes imported water cost from MWD will increase at an annual rate of 5%. The total money borrowed is estimated to be offset by cumulative savings in the year 2048.

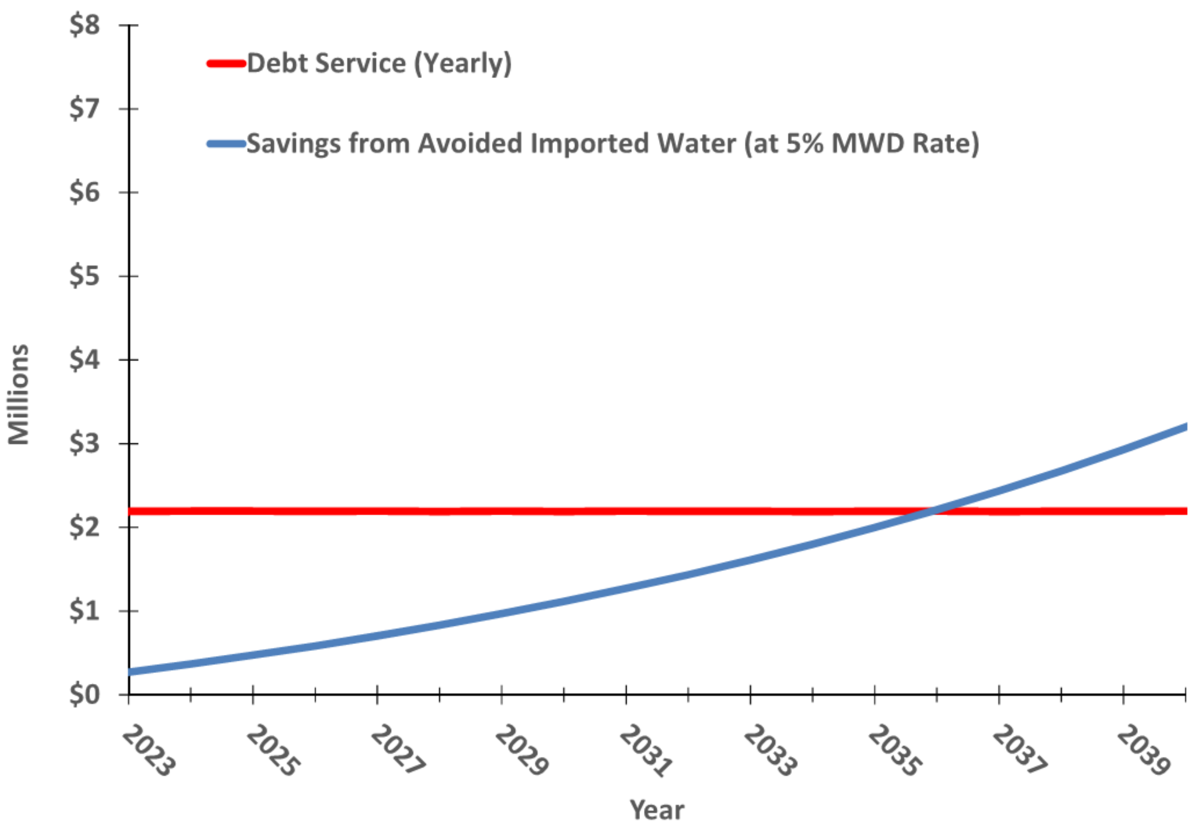


Figure 9: City's Projected Annual Savings due to Local Water Production in lieu of Import Water Purchases, compared to the Payments (debt service) for a 30 Year Bond.

Settlement Funds Usage - The current balance of Gillette/Boeing funds available to program is $64.1 million. This balance includes $11.1 million transferred and currently available in the Water Fund as authorized by Council on January 9, 2018 and $53.0 million in the General Fund. Staff recommends transferring $53.0 million from the General Fund to the Water Fund to be used to restore the Olympic Sub-basin. Additionally, to satisfy the settlement agreement, Boeing still owes the City three payments totaling $11.0 million. Staff recommends depositing these funds directly into the Water Fund.

Approximately $20 million would be used to construct a new treatment facility to remove the contaminants currently present in the sub-basin and $20 million would be reserved for operation and maintenance costs of the treatment facility related to restoration of the Olympic Sub-basin over a 30-year period. Due to uncertainty with the Olympic Sub-basin restoration after 30 years, staff recommends setting aside the remaining $24 million of Gillette/Boeing funds as a reliability reserve. The remaining $11.0 million that has been previously transferred to the Water Fund, is currently being used for groundwater modeling, monitoring, and reporting in support of Olympic Sub-basin remediation.

With the proposed injection of advanced purified water from the SWIP into the Olympic Sub-basin, staff will revisit this timeframe and report back to Council in the future once recharge operation begins.

Grants - Staff will identify and apply for state and/or federal grants to help offset the $38 million capital investment and return to Council in early 2019 with resolutions required for grant applications if available for the proposed projects. Staff has engaged a grant consultant to assist in the process. Grants being considered are:

- MWD, Local Resources Program
- California Department of Water Resources, Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1).

<u>Previously Authorized Water Rate Increase</u>

On February 24, 2015, the City Council adopted Resolution Number 10867 (CCS) to authorize water rate increases over a five-year period, beginning March 1, 2015.

The five-year water increase schedule was adopted after Council's consideration of a rate study conducted by Kennedy Jenks Consultants. Resolution Number 10867 (CCS) also contained a provision, giving Council flexibility to approve a suspension of each annual increase, in whole or part, beginning with the 9% scheduled increase for January 1, 2016. This resolution was adopted without a majority protest, following a noticed public hearing in accordance with Proposition 218. Since adoption of this resolution, Council has partially suspended the full increases authorized for 2016-2018, and instead approved 5% increases for each of those years due to:

- Actual water sales revenues exceeded expectations during 2015 to 2017.
- Actual operating and capital expenditures lower than expected. Resulting savings were applied to conservation programs, water main replacements and partially suspending planned 9% annual rate increases to more modest 5% increases.

State of the Water Fund and Forthcoming 2019 Rate Adjustment Justification

Staff will return to Council on January 8, 2019 for a public hearing and to obtain authorization for the full 9% water rate increase previously approved by Council on February 24, 2015 for calendar year 2019. If approved this would result in a monthly increase of $4.33 to average single-family customer. This is the final year of a five-year rate adjustment cycle approved via resolution as mentioned above.

A summary of rate increases from 2015 is provided in Table 8.

Table 8: Rate Increase History

Calendar Year	2015	2016	2017	2018	2019
Effective Date	March 1, 2015	January 1, 2016	January 1, 2017	January 1, 2018	January 1, 2019
Maximum Authorized Increase	9%	9%	9%	9%	9%

Actual Increase*	9%	5%	5%	5%	9%**
Date Actual Increase Authorized	February 24, 2015	February 23, 2016	November 22, 2016	January 9, 2018	**public hearing on January 8, 2019

The full implementation of the 9% previously authorized adjustment would be sufficient to allow the City to:

A) Deliver potable water to Santa Monica customers reliably, safely and sustainably in compliance with federal and state regulations.

B) Fund operating and capital budgets that are necessary to implement the City's self-sufficiency goals to encourage water conservation and sustainability, as contemplated in the City's 2014 water rate analysis.

C) Continue to implement infrastructure improvements associated with replacing aging existing infrastructure facilities comprised of water mainlines that are approaching the end of their useful lives.

The 9% rate increase would provide sufficient funding to complete the following capital projects as contemplated in the City's 2014 water rate analysis and to continue progress toward the City’s water self-sufficiency goal:

1. Additional capacity improvements, which include Preliminary Design for the Arcadia Treatment Capacity Expansion and Enhancement Project - $3.18 million in FY 2018-19. As noted in the prior section, the design would upgrade pumps, blowers, cartridge filters, and other equipment at the treatment plant to accommodate increased groundwater production and new technologies. The design would also incorporate a new process (CCRO) to increase overall plant efficiency to 90% or greater (as discussed previously under component 2 - alternative water supplies.
2. New Groundwater Resiliency Well - $6,825,000 in FY 2018-19 for acquisition of a new groundwater well to enhance resiliency. Also limit future exposure to imported water.
3. Water Main Replacement Cost Escalation - an increase of $2,000,000 starting in FY 19-20. The rate increase is necessary to fund the sharp increase observed in

water main replacement construction costs. Water main contract awards in 2017 and 2018 have returned bids of $600 to $700 per linear foot in the current high-cost construction environment. These costs have increased from a prior $400 per linear foot estimate. The budget was established at $4 million per year. However, staff is now estimating a need of $6 million per year to implement the recommended 100-year water main replacement cycle (2 miles replaced per year for the City's 205-mile water main system. Maintaining a $4 million per year budget would only yield replacement of 1.1 to 1.25 miles of pipeline per year, thus increasing the replacement cycle from 100 years to approximately 160 to 190 years. Staff recommends staying on a 100-year replacement cycle to maintain operational reliably.

- Council approval of the full 9% rate increase would also help fund the following ongoing operational expenditures:
    1) Metropolitan Water District (MWD) of Southern California - $5 million per year from FY 2020-21 to FY 2022-23 (additional $8.7 million) to ensure sufficient funding for imported water deliveries prior to achieving water self-sufficiency.
    2) City Yards Master Plan - Required contribution from the Water Fund for upgrades to City Yards - $4 million modeled, actual costs to be determined.

As noted above, staff will return to Council on January 8, 2019 with a recommendation that Council adopt the full 9% rate increase for calendar year 2019 as previously authorized in 2015. The staff report will include a detailed justification for the 9% rate increase as well as a 10-year fund forecast, cost comparison with other water agencies and an analysis of impacts to ratepayers.

Funding Summary

Table 9 provides a summary of funding recommendations to implement the SWMP. As noted above, staff also recommends that Council approve funding for three Capital Improvement Program (CIP) projects, which would commence in FY 2018-19:

- Arcadia Capacity Expansion and Enhancement Project, Preliminary Design ($3,180,000)
- New Groundwater Resiliency Well ($6,825,000)
- Olympic Wellfield Restoration Design ($1,800,000).

Table 9: Funding Summary

Settlement Funds Available for current remediation and O&M for next 30 years	Settlement Funds Available for Future Reserve (Olympic sub-basin Restoration)	Water Bond Amount (pending ongoing rate study)	Est. Annual Bond Payment (30 yrs):
$40 million	$24 million	$34.75 million	$2.2 million

Task Force on the Environment and Water Advisory Committee Actions

Findings of the Sustainable Yield Analysis, Sustainable Water Master Plan Update and proposed projects, cost and schedules were presented to the Task Force on the Environment on March 19, June 18, and October 15 and to the Task Force on the Environment Water Subcommittee on November 19, 2018. Similar updates were presented to the Water Advisory Committee on March 5, May 7, June 4, September 5 and November 5, 2018.

Rate Adjustment recommendations were presented to the Water Advisory Committee on November 5, 2018 and at a Task Force on the Environment Water Subcommittee on November 19, 2018. The Water Subcommittee strongly supports the Sustainable Water Master Plan Update and staff’s recommendations.

Financial Impacts and Budget Actions

Approval of the recommended action requires the following:

1. Appropriations to the FY 2018-19 Capital Improvement Program in the Water Fund:

Account Number	Amount
C5007740.689000 - Arcadia Capacity Expansion and Enhancement Project, Preliminary Design	$3,180,000
C5007750.689000 - Olympic Wellfield Restoration Design	$1,800,000
C5007760.689000 - New Groundwater Resiliency Well	$3,575,000
Total	$8,555,000

2. An appropriation to the FY 2018-19 Capital Improvement Program in the Wastewater Fund

C5107760.689000 - New Groundwater Resiliency Well, Property Joint Use.	$3,250,000
Total	$3,250,000

3. $53 million cash transfer of Gillette/Boeing settlement funds from the General Fund to the Water Fund and the corresponding release of the remaining fund balance in General Fund account 1.380237. The cash will be recorded in an interest earning restricted cash account in the Water Fund, Olympic Wellfield Remediation account 50.102442.

4. Transfer of two remediation capital projects, appropriated in previous fiscal years and funded with Gillette/Boeing funds, from the General Fund to the Water Fund to consolidate all budgeted Olympic restoration projects in the Water Fund.

General Fund Account Number	Proposed Water Fund Account	Amount
C019045.589000 Olympic Sub-basin Remediation	C5005880.689000	$1,909,732
C019067.589000 Olympic Sub-basin Well Hydrology	C5006050.689000	$1,946,407

5. The following budget items related to Gillette/Boeing water mediation settlement funds were previously taken by Council:

- On January 9, 2018, Council authorized staff to make an $11,100,000 transfer of Gillette/Boeing settlement funds from the General Fund to the Water Fund for ongoing and future remediation costs associated with polluted groundwater in the Olympic Wellfield (Attachment B). Staff transferred these funds to account 25695.570080 in FY 2017-18.
- On June 12, 2018, Council approved a FY 2018-19 transfer of $2,300,000 of Gillette/Boeing water mediation settlement funds from the General Fund to the Water Fund (Attachment F). This transfer was to fund the projects for the Olympic Wellfield remediation appropriated in the FY 2018-19 Capital Improvement Program.

Account Number	Amount
C5007460.689410 City / USGS Monitoring Well & Numerical Flow Model	$1,800,000
C5007260.689410 Redrill Santa Monica Well #3	$500,000
Total	$2,300,000

6. Future Gillette/Boeing settlement funds are to be deposited in the Water Fund, and a corresponding receivable shall be established. The liability associated with current and future pollution remediation utilizing Gillette/Boeing funds will be recorded in the Water Fund.

Prepared By: Alex Nazarchuk, Interim Water Resources Manager

Approved		**Forwarded to Council**	
Susan Cline, Director	11/17/2018	Rick Cole, City Manager	11/19/2018

Attachments:

A. October 28, 2014 Staff Report (Web Link)
B. January 9, 2018 Staff Report
C. Summary of Water Self-Sufficiency Scenarios to Expand Groundwater Production

D. Updated Preliminary Sustainable Yield Analysis
E. July 11, 2017 Staff Report (Web Link)
F. June 12, 2018 Staff Report (Web Link)