

UCLA

Recent Work

Title

LA Sustainable Water Project: Los Angeles River Watershed

Permalink

<https://escholarship.org/uc/item/42m433ps>

Authors

Mika, Katie
Gallo, Elizabeth
Read, Laura
[et al.](#)

Publication Date

2017-09-19

Copyright Information

This work is made available under the terms of a Creative Commons Attribution-NonCommercial License, available at <https://creativecommons.org/licenses/by-nc/4.0/>



LA SUSTAINABLE WATER PROJECT: LOS ANGELES RIVER WATERSHED

UCLA Grand Challenges

Sustainable LA



UCLA Institute of the Environment and Sustainability



This report is a product of the UCLA Institute of the Environment and Sustainability, UCLA Sustainable LA Grand Challenge, and Colorado School of Mines.

AUTHORS

Katie Mika, Elizabeth Gallo, Laura Read, Ryan Edgley, Kim Truong, Terri Hogue, Stephanie Pincetl, Mark Gold

September 2017

ACKNOWLEDGEMENTS

This research was supported by the City of Los Angeles Bureau of Sanitation (LASAN). Many thanks to LASAN for providing ideas and direction, facilitating meetings and data requests, as well as sharing the many previous and current research efforts that provided us with invaluable information on which to build. Further, LASAN and LADWP provided data and edits that helped to deepen and improve this report. Any findings, opinions, or conclusions are those of the authors and do not necessarily reflect those of LASAN.

We would like to acknowledge the many organizations which facilitated this research through providing data, conversations, reviews, and insights into the integrated water management world in the Los Angeles region: LADWP, LACDPW, LARWQCB, LACFCD, WRD, WBMWD, MWD, SCCWRP, the Mayor's Office of Sustainability, and many others.

**UCLA Grand Challenges, Sustainable LA
2248 Murphy Hall
Los Angeles, CA 90005-1405**

**UCLA Institute of the Environment and Sustainability
La Kretz Hall, Suite 300
Box 951496
Los Angeles, CA 90095-1496**

**Colorado School of Mines
1500 Illinois Street
Golden, CO 80401**



Contents

Executive Summary	5
Background	11
I. Introduction	12
A. Los Angeles River Watershed Study Area	12
B. Hydrology of the Los Angeles River Watershed.....	13
C. Donald C. Tillman, LA Glendale, & Burbank Water Reclamation Plants.....	13
D. Upper LAR Area groundwater basins	15
II. Stormwater Quality Modeling.....	17
A. Introduction	17
B. Policy Background	17
a. Upper LAR MS4 Programs	17
b. Total Maximum Daily Loads.....	19
C. Stormwater Modeling for Metal TMDLs	21
a. Metals TMDL Background.....	21
b. Site-Specific Objectives for Copper and Lead.....	21
c. Modeling Selection and Comparison.....	24
d. SUSTAIN Model Setup, Calibration, Validation	24
e. BMP Technologies in SUSTAIN.....	32
f. Cost Background.....	34
g. BMP Optimization	35
h. Modeling Results	36
D. Policy Analysis	42
a. Dry Weather Load-Based TMDL	42
b. Nutrient TMDL.....	48
c. LID Redevelopment Rate Impacts.....	50
d. Stream Buffer Ordinances.....	53
e. Discussion	56
III. Historical Flow Analysis in Mainstem and Selected Tributaries	59
A. Introduction	59
B. Flows in LAR and selected tributaries	61
a. Runoff Ratio.....	61

b.	Historic Flow Percentiles	63
c.	Historic Seasonal Flows.....	64
d.	Low Flow 7Q Analysis	66
e.	Impacts of BMPs on Streamflow	69
f.	Impacts of WRPs on Streamflow.....	74
g.	Historical Flow Discussion	76
C.	Establishing minimum flows to protect and enhance beneficial uses on the LAR	78
a.	LAR Background	78
b.	Recent Work	81
c.	Complexities around Removing River Flows.....	84
d.	Assessing Minimum Flows.....	85
IV.	Groundwater	88
A.	Introduction	88
B.	Upper LAR Area Groundwater Basins.....	91
a.	San Fernando Groundwater Basin	91
b.	Sylmar Groundwater Basin.....	95
c.	Verdugo Groundwater Basin	96
d.	Eagle Rock Groundwater Basin.....	97
e.	Groundwater Storage	97
f.	Salt and Nutrient Management Plan	99
C.	Remediation Efforts.....	100
a.	Current Projects, Plans, and Partnerships	100
b.	Future Remediation Efforts.....	106
D.	Increasing Stormwater Recharge.....	108
a.	Current and Planned Projects.....	108
b.	Increasing Stormwater Capture.....	112
E.	On Groundwater Recharge and Extraction.....	117
a.	Remediation	117
b.	Recharge	118
c.	Explore Additional ULARA Opportunities	119
V.	Wastewater and Recycled Water.....	122
A.	Introduction	122
B.	Water Reclamation Plants Background.....	122
C.	Groundwater Recharge.....	125

a.	Recycled Water Production	125
b.	Recycled Water Recharge (Spreading Grounds)	128
D.	NPR and Other Uses.....	130
VI.	Conclusions and Research Needs	133
VII.	Appendices	134
	Appendix A. LAR Reaches.....	134
	Appendix B. BMP Types and Quantity	135
	Appendix C. 7Q Flow Figures	138
	Appendix D. Sepulveda Dam Basin	139

This page intentionally left blank.

Executive Summary

The Los Angeles River (LAR) has been a focus for re-imagining since the days of the Olmsted brothers' 1930 vision of the Los Angeles region including the river. In 1985, Lewis MacAdams founded the group, Friends of the Los Angeles River, to focus on transforming a largely concrete lined, flood control channel into a city feature that resembled the river that gave birth to Los Angeles. The 1990s brought a focus on increasing the flood control capacity of the lower LAR through raising the walls without any ecological improvements: a contentious action to protect life and property that was opposed by the environmental community. More recently, the City of LA and the Army Corps of Engineers partnered on the LAR Revitalization Plan. They are moving forward on the most ambitious proposal for the largely unpaved 11 mile stretch of river: alternative 20. And in the last two years, world renowned architect, Frank Gehry, has led a team to re-envision the entire 51 mile river from the western San Fernando Valley to Long Beach.

In order to determine the future of the LAR, we need to better understand the current highly urbanized watershed and its impact on the river system. Flows in the LAR have increased over the last 50 plus years, as has the percent impermeable area in the watershed. Also, from a regulatory perspective, stormwater regulations and Total Maximum Daily Loads (TMDLs) are requiring the river and its tributaries to become clean enough for aquatic life and recreation within the next two decades. In addition, there is a concerted focus on local, sustainable water supplies from wastewater treatment (water reclamation) plants, remediated groundwater basins, and captured stormwater that could greatly modify the hydrology of the river system. The City's increased emphasis on a conservation ethic adds to those impacts by reducing dry season flows to the river. These shifts offer opportunities to design cost-effective projects at all scales that offer multiple benefits, but also highlight challenges that result from trying to plan for integrated water management within a system that evolved with siloed missions (e.g. flood control, water supply, wastewater treatment).

To better understand the impacts of these changes on the landscape of urban water management in the Los Angeles area, we looked at the potential to improve water quality and increase local water supply potential for the City of Los Angeles (the City) through implementing integrated water management practices in the LAR watershed. The highly urbanized LAR watershed covers approximately 825 square miles. In this watershed, the Donald C Tillman Water Reclamation Plant (DCTWRP), LA Glendale Water Reclamation Plant (LAGWRP), and Burbank Water Reclamation Plant (BWRP) provide wastewater treatment and potential water supply through treating wastewater to meet Title 22 California Code of Regulations requirements for recycled water. The adjudicated Upper Los Angeles River Area (ULARA) groundwater basins that underlie this watershed offer a place to store captured stormwater, recycled water, and imported water to extract for later use.

Stormwater – Water quality and beneficial uses in the LAR have been impaired by pollutants from urban runoff including metals, fecal indicator bacteria, trash, and nutrients. Both dry and wet weather runoff carry pollutants to many water bodies in Los Angeles County; implementing suites of Best Management Practices (BMPs) is one mechanism to capture and infiltrate or treat and release this runoff before it reaches downstream water bodies. In this study, a modified version of the US EPA's System for Urban Stormwater Treatment and Analysis (SUSTAIN) model was used to model the water quality impacts of implementing various suites of BMPs including vegetated

swales, bioretention, dry ponds, infiltration trenches, and porous pavement) in the LAR watershed. Six modeled scenarios that included combinations of treat-and-release BMPs and/or infiltration BMPs (installed on 'public land' uses) were designed to capture the 85th percentile storm (approximately $\frac{3}{4}$ of an inch of rain in a 24 hour period).

While multiple modeled BMP scenarios were able to manage the 85th percentile storm, tradeoffs were present among the scenarios – some were cheaper, some were more effective at reducing water quality exceedances or peak flows, and others provided greater water supply benefits. For example, scenarios that included porous pavement were capable of infiltrating the highest volumes of water and thus reducing peak flows by the greatest amount, but were also among the most expensive. Modeling BMP scenarios with a greater emphasis on treat-and-release BMPs, such as vegetated swales and dry ponds, resulted in fewer exceedances of the metals TMDLs as more treated “clean” flows were returned to the channel. However, this emphasis on treat-and-release approaches provided less potential recharge than those BMP scenarios with a greater emphasis on infiltration BMPs. A combination of treat and release BMPs and infiltration BMPs (vegetated swales and infiltration trenches) was low cost, provided groundwater recharge benefits, and greatly improved water quality for metals.

None of the modeled scenarios capturing the 85th percentile storm resulted in the elimination of load-based metals exceedances, even with the copper WERs and lead SSOs that the LARWQCB approved in 2015 included in the modeling analyses. The number of exceedances, however, was greatly reduced. For example, dry weather load-based copper exceedances per year dropped from 307 to 62-75 (range based on differing results across the 6 modeled scenarios), zinc exceedances dropped from 214 to 15-19, and lead exceedances dropped from 127 to 47-57. Wet weather exceedances were eliminated for lead (from 2 to zero in all scenarios), and reduced for copper (from 6 to 0-2) and zinc (from 14 to 3-6). However, the Regional Board has approved for Permittees to demonstrate compliance with concentration-based water quality-based effluent limitations during dry weather rather than through calculating and meeting load requirements. It is important to note that the baseline concentration-based exceedances are much lower. For example, the annual copper exceedances in the baseline scenario drop from 307 (load-based) to 13 (concentration-based) and baseline lead exceedances drop from 127 (load) to 0 (concentration).

This type of modeling analysis provides invaluable information on the potential tradeoffs among various BMP programs that all improve water quality. With this information, decision-makers can tailor programs, either through design of their own projects or programs to incentivize the construction of certain BMP types on private lands, to create desired outcomes in each part of the watershed. For example, infiltration-type BMPs could be preferentially selected where the connection of recharged stormwater to a groundwater basin used for water supply is readily quantifiable. Elsewhere, treat-and-release BMPs could be preferentially selected where the link to groundwater is not readily available or the released stormwater could be diverted to a local treatment plant or spreading basin downstream.

It is important to note that these modeling analyses only included the water quality impacts (for metals) of watershed-scale BMP installation by stormwater permittees such as the City of LA. Watershed-scale BMP programs provide valuable water quality (and potential water supply) benefits that complement the many additional programs and plans happening concurrently in the LAR watershed. For example, permittees are also implementing minimum control measures (MCM).

MCMs can include industrial and commercial stormwater pollution prevention programs, illicit discharge elimination programs, public information and participation programs, and new development / re-development programs. The City's Low Impact Development (LID) ordinance reducing runoff from new and redevelopment on privately owned land is an example of an MCM that is currently in place. Therefore, in a post-modeling analysis, we assessed the water quality and volume impacts of this LID ordinance as if it applied to the entire LAR watershed, instead of just the city of Los Angeles.

The LID ordinance in LA applies to parcels that create, add, or replace 500 ft.² or more of impervious area. For the presented analysis, we assumed a constant rate of redevelopment (ranging from 15% to 34% for different land uses as in other City of LA reports). With these assumptions, redevelopment under the LID ordinance will reduce the required volume of storm water (100% of the 85th percentile storm) that has to be captured by LA City, LA County, and other cities in the watershed by 21% by 2028. This would also result in a reduction in annual average loads of zinc and copper by 10% and 7%, respectively. Although required LID implementation will not result in water quality compliance on its own, the ordinance will result in the construction of thousands of BMPs on private property; this green infrastructure will improve water quality at minimal cost to the City as it will not be implemented by the City, but by private parties.

These benefits could be greatly magnified by extending the reach of an LID ordinance. For example, a LID retrofit upon sale ordinance that requires stormwater capture or infiltration for all parcels should be developed. The proliferation of LID projects can also be accelerated through the use of non-governmental organizations and other partners working with the City. Non-governmental organizations in particular can help on community engagement, implementing LID projects on private property, schools, parks, alleys, and in parkways, and LID BMP maintenance. The combination of watershed-scale BMP programs in concert with multiple efforts to reduce sources to the watershed and ramp up BMP implementation on private properties will result in greatly improved water quality as well as provide additional local water supply potential.

Flows – Observed annual average flows in the LAR at Wardlow gage (including the forested area) are approximately 274,000 AFY (2003-2014). Implementing watershed scale water quality-focused BMP programs to manage the 85th percentile storm, particularly those with a greater focus on the infiltration-based BMPs that increase the volumes of stormwater recharged into the groundwater basins, could impact the volumes of water flowing through the LAR. The increased focus on increasing recycled water use (approximately 30 million gallons per day is currently being discharged into the LAR from DCTWRP, LAGWRP, and BWRP) could also have a significant impact on flows in the LAR. To better understand this landscape, we examined the current and historical flows in the LAR and the potential impacts of implementing the modeled BMP scenarios while also increasing the use of recycled water from the WRPs on LAR flows.

The historical hydrology of the LAR can be investigated in a variety of ways, including changes in the runoff ratio over time as well as changes in actual flows over time. First, the runoff ratio for the entire LAR watershed was calculated for the years between 1956 and 2013; generally, the runoff ratio (which is an indicator of more water running off the surface, likely due to the increasing urbanization and impermeability of the LAR watershed) has greatly increased over time since the 1950s. We also looked at the impact of the modeled BMP scenarios on the runoff ratios – all BMP scenarios returned the runoff ratio to approximately the levels seen in the 1950s. Thus,

the BMP scenarios all resulted in less water running over the surface and lower runoff ratios than are currently observed, but they did not reduce the runoff ratio below historical 1950s levels.

Current low flows at the Wardlow Gage near the LAR's outlet are higher than they have been for much of the LAR's recent history, due in large part to the discharge of treated effluent from DCTWRP, BWRP, and LAGWRP. Effluent discharge into the LAR increased in-channel flows every time a new WRP came online. Analyzing annual 7-day flows provides insight on historical flows through determining the expected return periods (e.g., 7Q10 – expected 10 year return periods) for a range of low flows. 7Q10 flows at the Wardlow Gage increased from 42 cubic feet per second (cfs) for the time period between 1956 and 1985 to 157 cfs for the time period between 1986 (when DCTWRP came online) and 2014. In the Arroyo Seco, at a gage above the urbanized area, no such change in 7Q10 flows (approximately 2 cfs from 1917-2014) was observed. Thus, the Arroyo Seco appears to have been relatively unchanged over the last 100 years.

As wet and dry weather runoff is an additional source of flow to the LAR, we also assessed the impacts of the various modeled BMP scenarios on flows. Modeled average annual flows at Wardlow Gage dropped from 237,000 AF to between 63,000 and 111,000 AF (a reduction of 53 to 71%) with the implementation of various BMP scenarios. We also observed a reduction in modeled baseline flows in all seasons. Baseline seasonal flows ranged between 97,000 to 136,000 AFY, which dropped to between 63,000 and 72,000 AFY after BMP implementation.

Finally, we assessed the potential combined impacts of both watershed-scale BMP implementation and increased reuse of the treated effluent discharged into the LAR on annual minimum flows. At Wardlow Gage, for example, baseline annual minimum flows were 82-118 cfs, with flows dropping to 45-60 cfs after BMP implementation. Adding the reuse of 50% of the discharged effluent resulted in the annual minimum flows dropping to 22-32 cfs; with the assumption of 100% reuse of the discharged effluent flows, annual minimum flows were zero at the Wardlow Gage. It is important to note this is a first look at potential impacts of drastic changes in recycled water use on annual minimum flows; more detailed studies should be conducted to better characterize the in-channel flow impacts throughout the watershed of implementing individual water recycling projects under various flow conditions.

These analyses show that different watershed management approaches will result in different flows available to support the various needs and uses along the LAR. With this in mind, it is critical to accurately define the minimum required flows in the LAR. With the current volumes of effluent discharged into the LAR, we found recent low flows in the LAR to be approximately 100 cfs (2003 to 2014 data) at Wardlow Gage (based on analysis of daily average flows). Historical low flows (1956-2013), however, were noted to be an order of magnitude lower, approximately 10 cfs (~10th percentile). The ramifications to aquatic life and public recreation from these changed flows are substantial. A wide variety of research efforts have been and are occurring in the region to better understand the current state of the LAR (existing habitats, flows, etc.) and identify opportunities to redevelop and revitalize this important, regional, natural resource. A comprehensive study on the flows needed to create and maintain a healthy riparian ecosystem (and to define what that healthy ecosystem looks like in the highly urbanized LAR), while still supporting the river's recreational beneficial uses and augmenting our local water supplies, is the critical next step in designing a future vision for the LAR.

Water Supplies – Groundwater recharge of both recycled water and captured stormwater can increase the volumes of groundwater in storage in local groundwater basins. The ULARA groundwater basins include the San Fernando Basin, Sylmar Basin, Verdugo Basin, and Eagle Rock Basin; the City holds water rights only in San Fernando, Sylmar, and Eagle Rock Basins. The majority of the City’s groundwater comes from San Fernando Basin. To more fully utilize these groundwater basins, the City has extensive plans to increase groundwater recharge into and remediate historical contamination in the San Fernando Basin.

As described above, recycled water is currently being discharged from WRPs into the LAR; some of this flow also goes to support existing habitat and recreational features such as Balboa Lake and the Japanese Gardens before being discharged into the LAR. Non-potable reuses such as irrigation and industrial uses also currently provide local demand for treated effluent from these WRPs. In addition, the City is planning a large groundwater recharge project that will result in approximately 30,000 AFY of advanced treated recycled water from DCTWRP being recharged into the San Fernando Basin through the Hansen and Pacoima Spreading Grounds.

Plans to increase stormwater recharge include both large-scale centralized and smaller-scale distributed projects. Various regional efforts have identified multiple projects that will increase surface water recharge through enhancing the capability of centralized infiltration sites such as the Tujunga Spreading Grounds, the Lopez Spreading Grounds, the Big Tujunga Dam, Pacoima Dam, and the Pacoima Spreading Grounds to store and/or infiltrate greater volumes of water. Smaller-scale projects to capture stormwater across a wide variety of land use types will also increase the recharge of stormwater to groundwater basins. There is a lot of potential to increase the volumes of stormwater recharged in this area. For example, LADWP’s Stormwater Capture Master Plan identified goals to capture between 132,000 and 178,000 AFY of stormwater by 2035. Additional research to explore the potential to more fully utilize the capacity of SFB west of Interstate 405 could provide additional capacity for recharge and extraction.

Remediation is another important component to increasing the use of these groundwater basins. Remediation efforts are currently occurring in the North Hollywood, Burbank, and Glendale operating units, which pump and treat groundwater for use in local water supply. Additional treatment facilities are expected to be located in North Hollywood, Rinaldi-Toluca, and Tujunga well-fields to remediate additional groundwater in the San Fernando basins. Together, these facilities are expected to treat approximately 112 MGD (123,000 AFY) when they become operational in 2021. Design and construction costs are estimated to be around \$600 million dollars.

Conclusion - The research undertaken in this project demonstrates the complex interrelationships within urban water management. Projects that are geared towards managing stormwater to improve water quality can also increase local water supply potential. Groundwater basins provide an opportunity to store water, whether that water comes from advanced treated recycled water, captured stormwater, or imported water in times of excess. Additional research, however, is required to quantify the water supply benefits of recharged stormwater on local groundwater basins. For example, if 1 AF of stormwater is recharged, how much becomes available for extraction and use as water supply?

The regulatory and political environment surrounding water in general and the LAR in particular provides both opportunities and challenges to implementing integrated water management

programs that can truly address the multiple needs of urban water landscapes. Water quality BMPs should be considered within the context of other urban water management needs such as flood control, water supply, recreation, and habitat to identify multi-benefit and cost-effective projects. As more projects are designed with multiple goals in mind, partnerships will become established, methods of quantifying stormwater through the lens of water supply will become better defined, and regulations and policies can be adapted to reflect the equally important goals of cleaning up our surface water and increasing our local water supply resiliency in a semiarid region.

Managing the LAR effectively could maintain, increase, or create multiple benefits such as habitat, recreation, and flood control, while also maximizing the potential to augment our local water supplies. To do this, the entire 51-mile LAR and its watershed must be considered in all planning decisions – not just the water flowing between the two banks. Impacts of any large scale integrated water management plan on surface water, groundwater, land uses, or communities must be fully assessed to identify all possible benefits and any potential harms. Creating a future vision for the LAR that incorporates all of these factors, and then builds projects and partnerships to achieve this vision, may finally succeed in completing the re-imagining process that began in the 1930s with the Olmsted brothers.

Background

The City of Los Angeles (City) has worked closely with local communities and stakeholders to develop an integrated approach to managing water for over 15 years. The City understood that siloed approaches to wastewater, water supply, stormwater, and flood control management were inefficient and that integration of its water management programs would result in improved water quality, increased local water supplies, and better flood protection. The City developed an integrated water approach with a series of plans including the Integrated Resources Plan, the Water Quality Compliance Master Plan for Urban Runoff (WQCMPUR) and associated watershed compliance plans [Total Maximum Daily Load (TMDL) Implementation Plans, Enhanced Watershed Management Programs (EWMPs), Coordinated Integrated Monitoring Programs (CIMPs), and a Water Supply Plan]. The City is currently developing a One Water LA Plan, which aims to develop an integrated framework for managing the City's water resources, watersheds, and water facilities in an environmentally, economically, and socially beneficial manner.

For integrated water management to be effective, quantitative assessments identifying the feasibility of citywide implementation are necessary. Quantitative assessments will provide the City of Los Angeles Bureau of Sanitation (LASAN) with additional information to facilitate developing integrated water infrastructure priorities and management frameworks and garnering broader support for implementation and funding initiatives. The first report in this series was released in November 2015 with a focus on implementing integrated water management in the Ballona Creek Watershed.¹ The second report, released in July 2017, examined the opportunities and challenges to implementing integrated water management that are present in the DC and ML Watersheds.² This third report on the Los Angeles River watershed examines the same questions, and a fourth report looking at the integrated water management landscape in the City is forthcoming.

¹ Sustainable LA Water Project: Ballona Creek Watershed Report. UCLA and Colorado School of Mines. (2015) Available at: <http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/>

² Sustainable LA Water Project: Dominguez Channel and Machado Lake Report, UCLA and Colorado School of Mines. July 2017. Available at: <https://grandchallenges.ucla.edu/happenings/2017/08/03/new-ucla-report-looks-at-improving-water-quality-and-supply-in-l-a-s-dominguez-channel-and-machado-lake-watersheds/>

I. Introduction

A. Los Angeles River Watershed Study Area

The Los Angeles River (LAR) watershed begins at the confluence of Bell Creek and Arroyo Calabasas in the southwest corner of the San Fernando Valley. From its confluence, the LAR flows almost exclusively through soft and hard bottomed concrete channels until its discharge point, 51 miles downstream at the Port of Long Beach. The concrete lined channels within the basin serve as a means for flood protection by providing a quick and reliable way to expedite stormwater removal during high flows. Between its confluence and discharge, the LAR is segmented into six reaches³ (Figure 1.1, Appendix A).

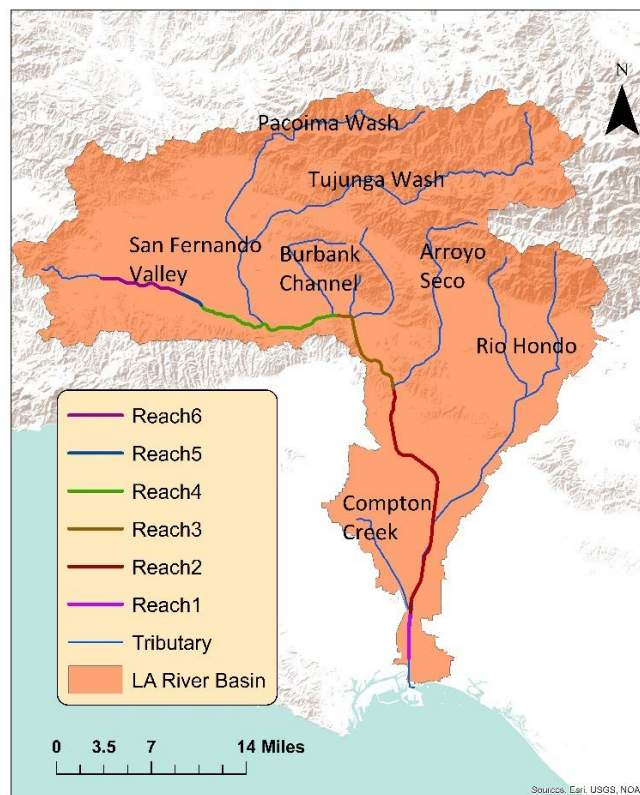


Figure 1.1. Overview map of LAR watershed and its tributaries and reach delineations

³ Following the LA Regional Water Quality Control Board delineation

B. Hydrology of the Los Angeles River Watershed

On average, the coastal portions of the LAR watershed receive around 13 inches of precipitation annually while the higher elevation areas in the San Gabriel Mountains receive approximately 27 inches. Yearly storm totals, however, can vary significantly from season to season.⁴ This variability in annual rainfall and rainfall intensity poses risks of floods during wet years and a lack of reliable water supply during dry years. Officials in the early and mid-20th century recognized the vulnerability to large floods and sought to minimize the damages by creating a set of structural flood control measures.⁵ These measures included channelizing the LAR and its major tributaries in concrete to encase and expedite stormwater flow, as well as constructing dams to regulate timing and height of peak flow.

C. Donald C. Tillman, LA Glendale, & Burbank Water Reclamation Plants

Three water reclamation plants (WRPs) in the LAR watershed (Table 1.1) consistently contribute daily effluent flow (Figure 1.2). Effluent from Donald C. Tillman WRP (DCTWRP), Burbank WRP (BWRP), and Los Angeles Glendale WRP (LAGWRP) is discharged into the LAR. The combined design capacity from all three WRPs is 115 MGD (128,800 AFY, Table 1.1); data suggests that the WRPs operate well under their design limit. Average daily flows were 31.9 MGD from DCTWRP and 18.2 MGD from LAGWRP over the modeling period (2004-2013).⁶ Due to data limitations, effluent from BWRP was estimated from a six month data record from WY 2011, averaged, and assumed consistent at that value (7 MGD) for the duration of the simulation period.⁷

Name	Operation Commencement	Design Flow (MGD)
DCTWRP	1985	80
BWRP	1966	15
LAGWRP	1976	20

Table 1.1. Water Reclamation Plant specifications

⁴ Hydrologic Report 2013-2014 County of Los Angeles Department of Public Works. Water Resources Division available at <http://ladpw.org/wrd/report/> Accessed on 1/1/2016

⁵ Orsi, J., 2004, *Hazardous metropolis: flooding and urban ecology in Los Angeles*. University of California Press: Berkeley.

⁶ eSMR Analytical Report obtained for Donald Tillman, LA-Glendale, LA-Burbank WRP's at <https://ciwqs.waterboards.ca.gov/ciwqs/readOnly/CiwqsReportServlet?inCommand=reset&reportName=esmrAnalytical> Accessed on 1/1/16.

⁷ As of early 2017, flow estimates can now be seen through the 1211 petition in the Burbank section. http://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/petitions/2017.shtml Effluent flows in 2015/2016 to Burbank Western Channel were 5,376 AF http://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/petitions/2017/ww0091_att.pdf

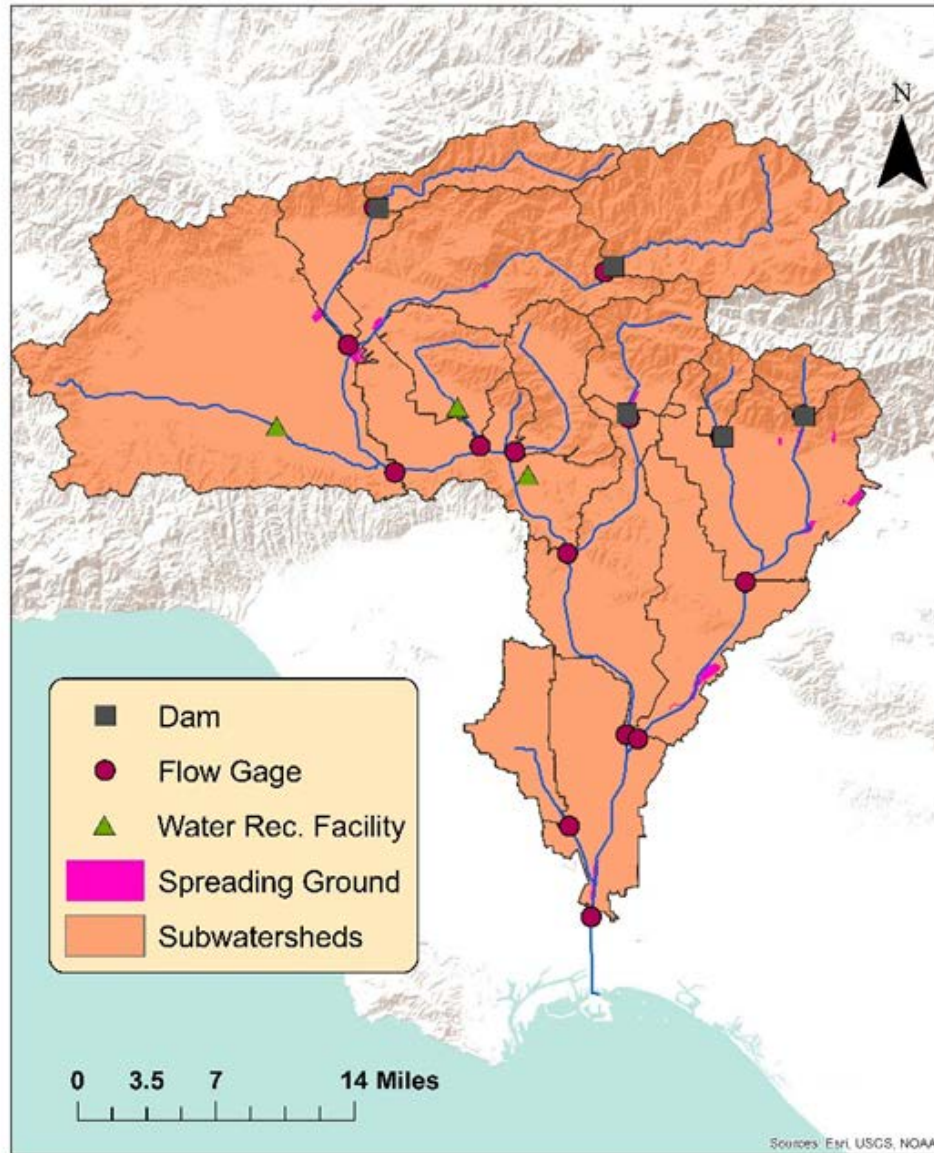


Figure 1.2 Map of hydrologic (subwatersheds) and engineering features (WRPs, flow gages, dams) of the LAR watershed

In the Upper Los Angeles River, recycled water is currently used for non-potable reuses (NPR) such as landscape irrigation, lake replenishment, golf course irrigation, in-plant use at the WRPs, power plant cooling, and other industrial uses. The City plans to increase the reuse of recycled water from DCTWRP through the Groundwater Replenishment (GWR) Project, which is planned to result in up to 30,000 AFY of recycled water being recharged into the San Fernando Basin to increase groundwater resources.⁸ Recycled water from DCTWRP will recharge into two major water conservation facilities that are operated by Los Angeles County Flood Control District

⁸ LADWP GWR DEIR p. ES-4

(LACFCD) in the SFB: the Hansen Spreading Grounds (HSG) and Pacoima Spreading Grounds (PSG). In addition to the GWR Project, the City plans to increase recycled water production at WRPs, expand distribution pipelines, and enhance spreading grounds to achieve the goals set out in their Urban Water Management Plan (UWMP).

D. Upper LAR Area groundwater basins

The Upper Los Angeles River Area (ULARA) overlies four unique groundwater basins and includes the entire watershed of the Upper Los Angeles River (Figure 1.3). From largest to smallest, the basins are: San Fernando Basin (SFB), Sylmar Basin (SB), Verdugo Basin (VB), and Eagle Rock Basin (ERB). The City only holds water rights in SFB, SB, and ERB. The City has rights to approximately 47,230 AFY of native safe yield in SFB and SB; the City has rights to as much as 91,070 AFY in SFB, SB, and ERB when including imported water return.⁹ ULARA is a critical source of groundwater for the City, comprising 89% (59,621 AFY) of its local groundwater supply on average from FY11 to FY15.¹⁰ SFB is the largest source of groundwater for the City; 58,741 AFY of the total were extracted from SFB and the remaining 880 AFY were extracted from SB.¹¹



Figure 1.3 The Upper Los Angeles River Area groundwater basins¹²

LADWP has been unable to extract their full pumping rights of groundwater, in particular from SFB, due to the presence of contamination from historic uses of the overlying lands. To remediate

⁹ LADWP UWMP 2015 p. 6-2

¹⁰ LADWP UWMP 2015 p. 6-4, Exhibit 6B

¹¹ http://www.water.ca.gov/waterconditions/docs/California_Significant_Droughts_2015_small.pdf; LADWP UWMP 2015 p. 6-4, Exhibit 6B

¹² Sources: Basemap (c) Bing Maps, Groundwater basin shape files from the ULARA Watermaster.

ULARA basins and fully utilize their pumping rights, LADWP has conducted multiple studies and begun implementing projects and exploring partnerships such as: the Groundwater System Improvement Study (GSIS), the Mission Wellfield Improvement Project, and the groundwater interconnection project with Burbank Water and Power. Thus, multiple efforts are ongoing in the region to remediate contaminated groundwater and increase groundwater recharge to more fully utilize the ULARA basins to maximize their local groundwater supply potential.

II. Stormwater Quality Modeling

A. Introduction

In the Los Angeles (LA) region, both dry weather runoff and wet weather storm runoff contribute significantly to water quality impairment in numerous receiving water bodies as runoff carries pollutants. However, there are multiple benefits to capturing and reusing as much of the system's runoff as possible, especially in times of water scarcity during California's periodic drought cycles (such as California's recent severe drought).¹³ In addition to improving receiving water quality, capturing stormwater runoff represents a source of local fresh water that could potentially supplement or replace imported water supplies. Further, stormwater volumes are projected to be roughly the same through the end of the 21st century in LA (although the timing and intensity of precipitation may change).¹⁴ Thus, building on the foundation of ongoing efforts, stormwater can potentially play an increasing role in local water supply.

Stormwater management may also provide flood protection benefits, habitat, and recreational open space benefits. Capturing runoff offers a source of local water that may be more reliable than imported water supplies, which can be affected by disasters, climate change, decreasing snowpack, increasing demands, upstream environmental needs, or rapid increases in the price of imported water. In this section, we delineate opportunities to achieve water quality compliance and maximize stormwater capture in the LAR watershed through a discussion of the current regulatory and policy-based requirements. We also present results from detailed modeling of various scenarios to improve water quality for metals as required under the LAR metals TMDL.

B. Policy Background

a. Upper LAR MS4 Programs

The LA County (LAC) Municipal Separate Storm Sewer Systems (MS4) Permit (Order No. R4-2012-0175, National Pollutant Discharge Elimination System (NPDES) Permit No. CAS004001) regulates storm & non-stormwater discharges from the MS4s in LA County (except for the City of Long Beach MS4). The current MS4 permit was adopted by the Los Angeles Regional Water Quality Control Board (LARWQCB) on November 8, 2012. The MS4 discharges regulated by the LAC MS4 permit are as follows: the LAC Flood Control District, LAC, and 84 municipal permittees. The current permit allows permittees to create watershed management programs (WMPs) or EWMPs to meet Water Quality Based Effluent Limits (WQBELs) individually or as a group. This MS4 permit offers an alternate compliance pathway to WQBELs, which is to

¹³ Griffin, D., & Anchukaitis, K. J. (2014). How unusual is the 2012–2014 California drought?. *Geophysical Research Letters*, 41(24), 9017-9023.; California's Most Significant Droughts: Comparing Historical and Recent Conditions, CA Department of Water Resources (2015); available at: http://www.water.ca.gov/waterconditions/docs/California_Significant_Droughts_2015_small.pdf

¹⁴ Berg, N., Hall, A., Sun, F., Capps, S., Walton, D., Langenbrunner, B., & Neelin, D. (2015). Twenty-First-Century Precipitation Changes over the Los Angeles Region*. *Journal of Climate*, 28(2), 401-421.

develop and implement WMPs / EWMPs (which require adaptive modeling and Best Management Practices (BMPs) implementation to achieve retention of the 85th percentile storm across the watershed) as the functional equivalence of complying with the receiving water limitations. The MS4 also requires the development of CIMPs that will provide a more complete dataset on which to base the models over the permit period.

Final versions of the EWMP and CIMP for the Upper Los Angeles River (ULAR) Watershed were approved in 2016 and 2015, respectively, and serve as guiding documents for achieving TMDL compliance goals set forth for ULAR.¹⁵ The EWMP and CIMP address stormwater challenges from the 19 MS4 permittees within the ULAR area, including jurisdictions from the cities of Alhambra, Burbank, Calabasas, South El Monte, Glendale, Hidden Hills, La Canada Flintridge, Los Angeles, Montebello, Monterey Park, Pasadena, Rosemead, San Fernando, San Gabriel, San Marino, South Pasadena, Temple City, Unincorporated County of Los Angeles, and the LA Flood Control District.¹⁶ The ULAR EWMP in which the City of LA is participating only covers a portion of the LAR watershed; the remainder of the LAR watershed will be covered by other MS4 permittees through either EWMPs, WMPs, or individual programs.¹⁷

The EWMP provides a framework for meeting stormwater regulations through implementation of low-impact development (LID), green streets, regional stormwater control projects, and institutional control measures.¹⁸ The EWMP serves as a reference document for the schedule of TMDL compliance for each reach of ULAR as well as proposed site-specific projects to meet stormwater compliance regulations. The EWMP outlines the TMDL compliance schedule for the watershed: 100% compliance by 2028 for copper, zinc, and lead in dry weather, and 100% compliance for fecal indicator bacteria (FIB) by 2037.¹⁹ Almost 700 watershed control measures, ranked as very high, high, and medium in priority, are proposed in the EWMP to reach compliance. Of these

¹⁵ (ULAR) Upper Los Angeles River Watershed Management Group, Approval of Enhanced Watershed Management Program, Available at: http://www.waterboards.ca.gov/losangeles/water_issues/programs/stormwater/municipal/watershed_management/los_angeles/upper_losangeles/20160127/UpperLARiver_main-body_revEWMP_Jan2016.pdf; http://www.waterboards.ca.gov/losangeles/water_issues/programs/stormwater/municipal/watershed_management/los_angeles/upper_losangeles/index.shtml

¹⁶ (ULAR) Upper Los Angeles River Watershed Management Group (2015), Coordinated Integrated Monitoring Program for the Upper Los Angeles River Watershed, Available at: http://www.waterboards.ca.gov/rwqcb4/water_issues/programs/stormwater/municipal/watershed_management/los_angeles/upper_losangeles/UpperLARiverFinalCIMP.pdf

¹⁷ CA SWRCB Watershed Management Programs. http://www.swrcb.ca.gov/losangeles/water_issues/programs/stormwater/municipal/watershed_management/index.shtml

¹⁸ (ULAR) Upper Los Angeles River Watershed Management Group (2015), Enhanced Watershed Management Program for the Upper Los Angeles River Watershed *DRAFT*, Available at: http://www.waterboards.ca.gov/rwqcb4/water_issues/programs/stormwater/municipal/watershed_management/los_angeles/upper_losangeles/UpperLARiver_DraftEWMP.pdf

¹⁹ Interim milestones for metals in the LA River include a 31% compliance goal by 2017 and 50% compliance goal by 2024.

measures, 26% are regional BMPs on “public land”, 31% are regional BMPs on “private land”, 14% are LID, and 30% are green streets. Results in the ULAR EWMP indicate that the total structural BMP capacity required for the City of Los Angeles by 2037 is 3,065 acre feet, with 2,115 acre-feet for regional BMPs, 607 acre-feet for green streets, and 344 acre-feet for LID.²⁰ In the ULAR EWMP, achieving compliance with all LAR TMDLs in the upper watershed was estimated to cost \$6.1 billion dollars in capital costs with about \$211 million in operation and maintenance costs per year.¹⁸

The CIMP is an MS4 permittee-led effort for a mandatory comprehensive watershed Monitoring and Reporting Program, and contains details for how the City plans to monitor a range of water quality pollutants.¹⁶ Section 13 of the CIMP details the implementation schedule for monitoring pollutants, which includes four phases that began in October 2015 and will end with the complete installation of auto-samplers by October 2018.¹⁶ Monitoring for compliance of the LAR metals TMDL is to occur monthly at all 13 locations in dry weather and during storm events at five of the 13 locations during wet weather. The CIMP specifies the annual frequency as four times per year for dry weather and three times during wet weather events.²¹ Parameters to be assessed during these sampling events include total and dissolved copper, lead, and zinc, total hardness, cadmium (reach 1, wet weather only), and total selenium (reach 6, dry weather only).¹⁶ Every two years, adaptive management processes will occur based on a variety of inputs including modeling, a RAA, input from the public and the LARWQCB, progress toward compliance goals, and new data as it becomes available.²²

b. Total Maximum Daily Loads

In highly urbanized and engineered systems such as the LAR watershed, pollutants build up on impervious surfaces, wash off during rain events, and accumulate in receiving waterbodies. As a result of this pollutant loading, seven tributaries to and all six reaches of the LAR have been designated as impaired water bodies under section 303(d) of the Clean Water Act (CWA).²³ Six NPDES dischargers are identified as ‘Major’ in the LAR watershed by the California State Water Resources Control Board (SWRCB), three of which are WRPs²⁴ whose combined design flows

²⁰ see Figure 7-1 in the ULAR EWMP for volumes and section 7 of the ULAR EWMP generally for description of how these volumes contribute to meeting compliance targets.

²¹ ULAR CIMP (Table 5)

²² ULAR EWMP, sections 6-8.

²³ Los Angeles River Watershed Impaired Waters List. Los Angeles Regional Water Quality Control Board. Accessed on 12/15/2015 from http://www.swrcb.ca.gov/losangeles/water_issues/programs/regional_program/Water_Quality_and_Watersheds/los_angeles_river_watershed/303.shtml. Accessed on 1/1/2016

²⁴ Los Angeles River Basin Non-Stormwater Permits. Los Angeles Regional Water Quality Control Board. Obtained at http://www.swrcb.ca.gov/losangeles/water_issues/programs/regional_program/Water_Quality_and_Watersheds/los_angeles_river_watershed/permits.shtml Accessed on 1/1/2016

sum to over 100 million gallons per day²⁵ (MGD) and account for 70% to 100% of monthly average flow into the river during the dry season.²⁶ In response, the LARWQCB has developed TMDLs and an implementation plan to comply with pollutant load regulations.²⁷

TMDLs have been established in the LAR for trash (latest amendment effective 2016), metals (latest amendment effective 2016), nitrogen-based nutrients (2014 – amended), and bacteria (2012).²⁸ The trash TMDL in LAR as described in the EWMP states that all waterbodies should meet an annual percent reduction from 2012 – 2016 to achieve compliance. ULAR WMAG members are attaining compliance through some combination of the installation of one of the following full capture devices, or partial capture device and / or institutional controls.²⁹ The LAR bacteria TMDL is for *E. coli* in wet and dry weather; bacteria is considered a limiting pollutant in dry weather. The TMDL compliance strategy for bacteria follows a Load Reduction Strategy (LRS), where priority and outlier outfalls are identified and actions are developed accordingly.³⁰ The LRS approach divides the river into five segments that each contain specific “control measures” on which to base scheduling and compliance.³¹

The nutrient TMDL limits ammonia, nitrate, nitrite, and total nitrogen (nitrate as N + nitrite as N). The metals TMDL applies to copper, lead, and zinc for both dry and wet weather, establishing different criteria for each, and to cadmium in wet weather. The presented work serves to further inform water quality scenarios by investigating the effects of BMP implementation at the watershed scale as a means to reduce metal loads and concentrations. Nutrients and metals TMDLs are discussed in greater detail in the following stormwater modeling section; only metals were modeled in the presented analyses.

²⁵ Waste Discharge Requirements for the City of Los Angeles, Donald C. Tillman Water Reclamation Plant. Order# 98-046. NPDES# CA0056227. California Regional Water Quality Control Board Los Angeles Region; Waste Discharge Requirements for the City of Los Angeles Los Angeles-Glendale Water Reclamation Plant (NPDES# CA0053953, Order# R4-2011-0197). California Regional Water Quality Control Board Los Angeles Region; Waste Discharge Requirements for the City of Burbank, Burbank Water Reclamation Plant (NPDES# CA0055531, CI# 4424). California Regional Water Quality Control Board Los Angeles Region

²⁶ Total maximum daily loads for metals Los Angeles river and tributaries. U.S. Environmental Protection Agency Region 9 California Regional Water Quality Control Board Los Angeles Region June 2, 2005

²⁷ Draft Los Angeles River Metals TMDL Implementation Plan. 2010. Prepared for City of Los Angeles Bureau of Sanitation Watershed Protection Division

²⁸ A summary of all approved TMDLs for the ULAR are listed in Table 2 of the CIMP.; TMDL list here: http://www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/tmdl_list.shtml

²⁹ see Section 6 of the CIMP for more details, p. 51

³⁰ http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/80_New/LARiverFinal/Staff%20Report%20LAR%20Bact%2015Jul10%20final.pdf

³¹ see Table 7-2 in the EWMP

C. Stormwater Modeling for Metal TMDLs

a. Metals TMDL Background

The permissible load for metals is formulated based on concentrations established by the EPA in the California Toxics Rule (CTR).³² The CTR specifies numeric criteria for a pollutant (e.g., metals) concentration to ensure human health and to protect the environment specific to each reach. To convert from the metal concentrations listed in the CTR to a TMDL load target for each metal, a ‘critical flow’ from each tributary and the entire LAR is calculated.

Critical flows are defined separately for dry and wet weather days. A dry weather TMDL applies when the majority of water present in the stream originates from WRPs and the storm-drain network, and a wet weather TMDL is defined for days when a rain event adds substantial volume of water (and carries pollutant load) to the river or its tributaries. The threshold between dry and wet weather days is defined by the flow at the lowest gage on the LAR, F-319 (“Wardlow” Gage). A dry-weather day is defined as when the maximum daily flow observed at Wardlow Gage is less than 500 cubic feet per second (cfs); a wet weather day is defined as a day with flow above 500 cfs. This heightened daily load limit is based on the flow rate present in the receiving water body and a conversion factor for each metal (Table 2.1). The Regional Board has approved for Permittees to demonstrate compliance with concentration-based water quality-based effluent limitations during dry weather rather than through calculating and meeting load requirements.³³

b. Site-Specific Objectives for Copper and Lead

There are a variety of mechanisms by which water quality standards compliance can be attained, including reducing pollutant loads or concentrations, implementing source control measures, or developing and applying site-specific water quality criteria. Site-specific objectives (SSOs) allow for changes to the water quality standards based on the characteristics of the water at the site, such as hardness, which can affect the potential impacts of the pollutant on aquatic life and habitat. Generally, studies must be performed at the site to assess the local water chemistry and site characteristics, impacts on sensitive species, and any other potential effects of changing the allowable metals concentrations in the assessed water body.³⁴ In 2015, the SWRCB approved

³² Environmental Protection Agency, Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California. Federal Register. 66(30), 9960-9962. EPA-823-00-008.

³³ MS4 Attachment O – TMDLs in the Los Angeles River WMA, p O-4.

³⁴ Revision of the Total Maximum Daily Load for Metals for the Los Angeles River and Its Tributaries-Second Revision staff report. Draft January 30, 2014. http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/bpa_113_R15-004_td.shtml (accessed November 22, 2016)

a Basin Plan amendment that would adjust the LAR Metals TMDL for both lead and copper based on water-effect ratios (WERS) for copper and recalculated criteria for lead.³⁵

WERS are defined as “a criteria adjustment factor accounting for the effect of site-specific water characteristics on pollutant bioavailability and toxicity to aquatic life.”³⁶ WERS facilitate accounting for the bioavailability of a contaminant, or how the toxicity of a pollutant, and thus its impacts on aquatic life, can change in different in-stream conditions and locations. A WER greater than 1 indicates the characteristics of the on-site water reduce the toxic effects of the pollutant being tested.³⁷

The LAR Metals TMDL includes options to conduct special studies to evaluate uncertainties and assumptions that were present during the TMDL development (such as WERS). Then, when new studies or information are available, the LARWQCB may reconsider the TMDL to assess the impacts of this new information on the TMDL.³⁸ For example, in 2010, copper targets for LAR Reaches 1 through 4 and the Burbank Western Channel as well as the copper Waste Load Allocations (WLAs) for DCTWRP, LAGWRP, and BWRP were revised by resolution number R10-003 to reflect the results of a WER special study conducted by the cities of Los Angeles and Burbank.³⁹

Results from a second copper WER study that applied not only to LAR Reaches 1 through 4 and the Burbank Western Channel but also to the tributaries Compton Creek, Rio Hondo, Arroyo Seco, Verdugo Wash, and Tujunga Wash, were submitted to the LARWQCB in 2014. Based on these studies, the LARWQCB approved copper dry-weather WERS that ranged from 1.3 to 9.7 for the LAR watershed in 2015 (Table 2.1).⁴⁰ These WERS mean that, based on site-specific aquatic

³⁵ LA River Basin Plan amendment. http://www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/tmdl_list.shtml, http://63.199.216.6/bpa/docs/R15-004_SB_RSL.pdf

³⁶Interim Guidance on Determination and Use of Water-Effect Ratios for Metals (EPA-823-B-94-001 1994) cited in Streamlined Water-Effect Ratio Procedure for Discharges of Copper, EPA-822-R-01-005, March 2001 <https://www.epa.gov/sites/production/files/2015-01/documents/streamlined-copper.pdf> (accessed July 27, 2016).

³⁷ Revision of the Total Maximum Daily Load for Metals for the Los Angeles River and Its Tributaries-Second Revision staff report. Draft January 30, 2014. http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/bpa_113_R15-004_td.shtml (accessed November 22, 2016) p. 4

³⁸ Revision of the Total Maximum Daily Load for Metals for the Los Angeles River and Its Tributaries-Second Revision staff report. Draft January 30, 2014. http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/bpa_113_R15-004_td.shtml (accessed November 22, 2016)

³⁹ Revision of the Total Maximum Daily Load for Metals for the Los Angeles River and Its Tributaries-Second Revision staff report. Draft January 30, 2014. http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/bpa_113_R15-004_td.shtml (accessed November 22, 2016) p. 3

⁴⁰ Larry Walker Associates, 2015, Implementation of Results of the Los Angeles River Copper Water-Effect Ratio and Lead Recalculation Studies. Accessible at: http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/105_new/Attachment%20C_FINAL-%20LA%20River%20SSO%20Imp%20Report%20-%20January%202015.pdf

and human health toxicity of copper in the LAR reaches, existing water quality standards are multiplied by 1.3 to 9.7 to obtain the adjusted copper target (as opposed to the previously used default WER of 1). A wet weather copper WER of 3.97 was also approved (Table 2.1).

		Critical Flow (cfs)	Cadmium	Copper	Lead	Zinc
Dry Weather	LAR Reach 5 ⁷	8.74	-	0.65 x WER ¹	3.6 x WER ¹	-
	LAR Reach 4	129.13	-	8.1 x WER ²	26 x WER ¹	-
	LAR Reach 3	39.14	-	2.5 x WER ²	9.6 x WER ¹	-
	Tujunga Wash	0.15	-	0.007 x WER ³	0.029 x WER ¹	-
	Burbank Channel	17.3	-	0.80 x WER ⁴	3.2 x WER ¹	-
	LAR Reach 2	4.44	-	0.24 x WER ²	1.02 x WER ¹	-
	LAR Reach 1	2.58	-	0.14 x WER ²	0.64 x WER ¹	-
	Compton Creek	0.90	-	0.041 x WER ⁶	0.16 x WER ¹	-
	Rio Hondo Reach 1	0.50	-	0.015 x WER ⁵	0.045 x WER ¹	0.16 x WER ¹
Wet Weather	Conversion factor (µg/L) ⁸		3.1 x WER ¹	17 x WER ²	62 x WER ¹	159 x WER ¹

¹Default WER of 1.0
²Approved WER of 3.97
³Approved WER of 8.28
⁴Approved WER of 4.75
⁵Approved WER of 9.69
⁶Approved WER of 3.36
⁷Reach 5 critical flow includes flows from Reach 6 and Bell Creek
⁸Conversion factor to account for change in wet weather loading capacity. Multiply daily storm volume (L) and conversion factor (µg/L) to arrive at wet weather TMDL (kg/day)

Table 2.1. Reach-specific TMDLs for wet and dry weather (kg/day)

Results from the recalculation of lead criteria based on the USEPA’s Recalculation Procedure were also submitted to the LARWQCB in 2014. The EPA’s method can be applied to account for differences between species used at a national level and a local level or to account for revisions or updates to the national dataset. Using a draft USEPA dataset, wet and dry weather numeric targets for lead were recalculated. The wet weather target was set to 94 µg/L and the dry weather targets ranged between 37 and 170 µg/L in the various LAR reaches and tributaries.⁴¹ The lead recalculation resulted in higher lead targets in wet and dry weather for all reaches and tributaries assessed.

⁴¹ Revision of the Total Maximum Daily Load for Metals for the Los Angeles River and Its Tributaries-Second Revision staff report. Draft January 30, 2014. http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/bpa_113_R15-004_td.shtml (accessed November 22, 2016) p. 8, 9

c. Modeling Selection and Comparison

To simulate metal loads and flows in the LAR, as well as the effect of BMP implementation, this study utilized the EPA's System for Urban Stormwater Treatment and Analysis IntegratiON (SUSTAIN) Model. SUSTAIN contains multi-objective optimization algorithms and the ability to vary BMP dimensions and performance. In addition, SUSTAIN generates cost curves from output; taken in concert these features allow the user to identify optimal BMP suites and ultimately generate BMP scenarios.⁴² In addition to meeting water quality targets, integrating BMPs into the watershed may provide other benefits such as increased flood protection, increased open-space recreational areas and habitat, and increased local water supply through groundwater recharge. SUSTAIN was selected over other stormwater management models due to its ability to model metal load reductions with cost, its optimization package, interface with ArcGIS, and congruence with work in the Ballona Creek Watershed.⁴³

d. SUSTAIN Model Setup, Calibration, Validation

The reaches and tributaries with established TMDLs were assessed in the modeling of flow, pollutant loading, and BMPs. Each impaired waterbody was contained within a watershed, delineated from topography and the storm drain network, which allowed assessment of the contributing flow and pollutant loads at each waterbody's terminus before and after BMP simulation. Further, the 85th percentile storm volume was assessed to determine the water quality impacts of implementing the current MS4 approach of managing the 85th percentile storm in the LAR watershed.

For modeling purposes, the 825 mi² (528,000 acre) LAR watershed was divided into 15 sub-basins ranging from 24 mi² (15,360 acre) to 268 mi² (171,520 acre, Table 2.2), delineated such that LA County stream gages utilized in the water quantity modeling were at the terminus of each subwatershed (Table 2.2). Subwatersheds were delineated from USGS 7 ½ minute, 1:24,000 scale topo quad sheets by the Hydraulic Water Conservation Division⁴⁴ obtained from the LAC Geographic Information System (GIS) data portal. To ensure that the resulting subwatersheds were hydrologically distinct, the storm-drain network was used to reshape the subwatersheds so all rain-water falling on a subwatershed exits only through the downstream gage.⁴⁵

⁴² Shoemaker, L.; Riverson, J.; Alvi, K.; Zhen, J.; Paul, S.; Rafi, T. (2009) SUSTAIN - A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality. User's Manual, United States Environmental Protection Agency.

⁴³ Los Angeles Sustainable Water Project: Ballona Creek Watershed Report

⁴⁴ Los Angeles County Subwatershed Delineation Data. Accessible at: <http://egis3.lacounty.gov/dataportal/2011/01/11/los-angeles-county-sub-watersheds/>

⁴⁵ Los Angeles County Storm Drain System Data. Accessible at: <http://egis3.lacounty.gov/dataportal/2013/08/08/los-angeles-county-storm-drain-system/>

Subwatershed Name	LAC Gage at Terminus	Area (mi ²)	Slope	Stream Length (m)
Glendale	F57	53.2	0.006	32,338
Compton Creek	F37	23.6	0.003	17,960
San Fernando	F300	268.3	0.032	45,891
Upper Pacoima	F118	28.3	0.040	33,394
Lower Pacoima	F305	25.3	0.063	14,100
Arroyo Seco	F277	30.6	0.060	23,224
Chavez Ravine	F34	62.1	0.013	37,742
Verdugo Wash	F252	29.8	0.056	19,184
Big Tujunga	F168	82.2	0.037	29,566
Burbank	E285	27.1	0.036	20,437
Wardlow	F319	49.4	0.001	25,878
Lower Hondo	F45	50.2	0.008	31,335
Upper Hondo	E326	75.4	0.054	23,145
Santa Anita	F119	10.8	0.143	8,600
Eaton Wash	F271	9.3	0.112	11,739

Table 2.2. Hydrologically distinct subwatersheds and attributes

Land cover type was identified from the 2005 two-acre resolution Southern California Association of Governments (SCAG) land cover raster.⁴⁶ A higher resolution (4 m²) land cover raster was used for the sections within the LA City boundary (~35% of the total basin area).⁴⁷ Percent imperviousness was calculated for each of twelve broad land cover categories and used in SUSTAIN to estimate runoff volumes.

Aggregated BMP placement was based on the amount of total land plausible for BMP construction. To determine land availability, the twelve SCAG land uses were grouped into “forested” (335 mi²), which consists of forest and vacant land, “urban private” (425 mi²), which consists of agriculture, commercial, industrial, multi-family residential, and single-family residential lands, “urban public” (59.3 mi²), which consists of education, recreation, and transportation lands, and “water” (11 mi²). Figure 2.1 illustrates the locations of these land use groupings throughout LAR. Forested, “urban private,” and within-water bodies land use categories were not considered for BMP placement due to the unsuitability of the forest for BMPs, the relative difficulty of buying-back land from private landowners, and the difficulty of placing a BMP in a waterbody. Although not included in these modeling analyses, “urban private” land uses will play a role in managing stormwater in the watershed through, for example, the City’s LID ordinance. The impacts of the

⁴⁶ Southern California Association of Governments Land Use Data. Available at <http://gis-data.scag.ca.gov/Pages/GIS-Library.aspx>

⁴⁷ McPherson, E.; Simpson, J.; Xiao, Q., Wu, C. Los Angeles 1-million tree canopy 585 cover assessment, 2008. Gen. Tech. Rep. PSW-GTR-207, Albany, CA: U.S. Department of 586 Agriculture, Forest Service, Pacific Southwest Research Station, 52

implementation of a similar LID ordinance across the entire watershed are explored in a post-modeling analysis (Section II.D.c below).

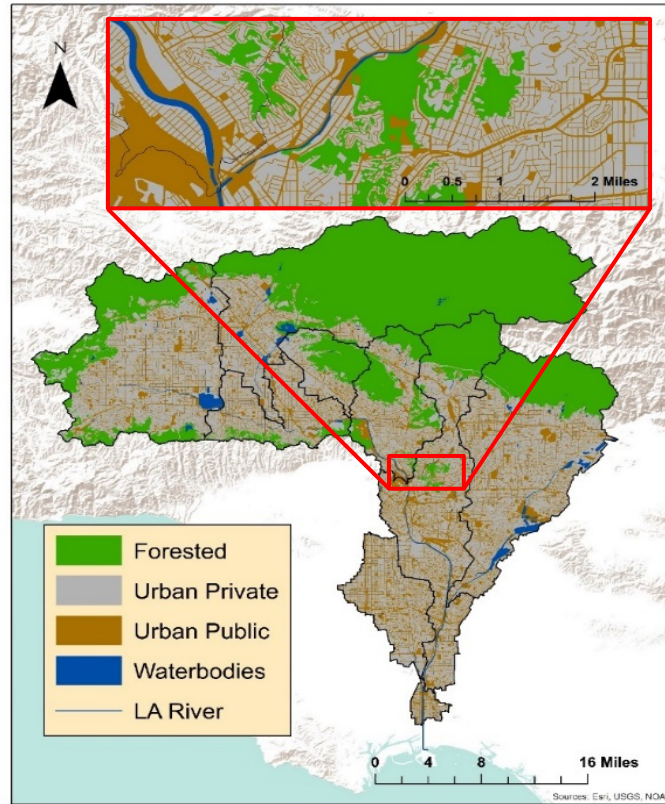


Figure 2.1. Land uses grouped to reflect BMP placement feasibility

We used “urban public” land (as locations to place BMPs) to model load reduction and water quality exceedances, and considered “urban private” land for a post-modeling scenario that examines the impact of potential re-development of urban lands in the watershed (discussed below). Within the “urban public” category, education, recreation, and transportation land-uses are well-distributed throughout the urban area, which is ideal in terms of constructing BMPs throughout the watershed. Please refer to Appendix B for additional details on BMP types and number of units placed in each subwatershed by land use grouping for this analysis. The final area calculations for modeling stormwater BMPs ranged between 4.87 and 14.12 mi² for the various types of “urban public” lands within LAR (Table 2.3).

Land use classification	Land Cover Type	BMP Appropriate Area (mi ²)	Total BMP Appropriate Area (mi ²)
Urban Public	Transportation	7.52	34.49
	Education	4.87	
	Parks and Recreation	14.12	
	Parking lots	7.99	

Table 2.3. “Urban Public” area available for BMP construction

Hourly precipitation inputs for SUSTAIN were derived from LA County rain gages using an Inverse Distance Weighted interpolation method to produce a precipitation value for each subwatershed. Climatological data, evapotranspiration (ET), min and max temperature, and wind speed were input as a daily time series and gathered from California Irrigation Management Information System (CIMIS) weather stations operated by the California Department of Water Resources (DWR). Precipitation and climatological data were also interpolated to calculate a single value per time step for the centroid of each subwatershed using inverse-distance weighting. Dams and spreading grounds were included in the SUSTAIN model, with input data on an hourly time step obtained from LA County Department of Public Works (LACDPW) water conservation reports.⁴⁸

Briefly, there are eighteen spreading grounds in the basin, seven of which infiltrate rainwater exclusively. The other eleven divert stormwater in addition to imported and recycled water. Branford, Buena Vista, Eaton Wash, Hansen, Lopez, Peck, Santa Anita, and Saw Pit spreading grounds were utilized in these modeling efforts (Table 2.4). The volume of water each spreading ground diverts per month was obtained from water conservation reports available on the LACDPW website.⁴⁹ The monthly volumes were disaggregated to an hourly timeseries to be consistent with observed stream flow gage timeseries used in calibration and validation. Over the ten-year simulation period, the average yearly volume of water diverted to these spreading grounds was 33,491 AFY. Additional non-modeled spreading grounds, such as Tujunga, Pacoima, and Dominguez Gap, are discussed in greater detail in the recycled water and groundwater sections of this report.

Spreading Basin	Estimated Infiltration Rate (cfs)	Storage (AF)
Branford	1	137
Buena Vista	6	177
Eaton Wash	14	525
Hansen	150	1409
Lopez	15	24
Peck	25	3347
Santa Anita	5	25
Saw Pit	12	13

Table 2.4. Spreading grounds utilized in modeling and their physical characteristics⁵⁰

⁴⁸ Los Angeles County Department of Public Works. Water Conserved website, Accessible at: <http://dpw.lacounty.gov/wrd/spreadingground/watercon/>

⁴⁹ Los Angeles County Department of Public Works. Water Conserved Information, Accessible at: <http://dpw.lacounty.gov/wrd/spreadingground/watercon/>

⁵⁰ Los Angeles County Department of Public Works. Spreading Ground Information, Accessible at: <http://dpw.lacounty.gov/wrd/spreadingground/>

Eight subwatersheds were selected for calibration and validation using discharge data from established Los Angeles County gages at the terminus of each subwatershed (Figure 2.2); see Edgley (2016)⁵¹ for details of the flow record and gage information.

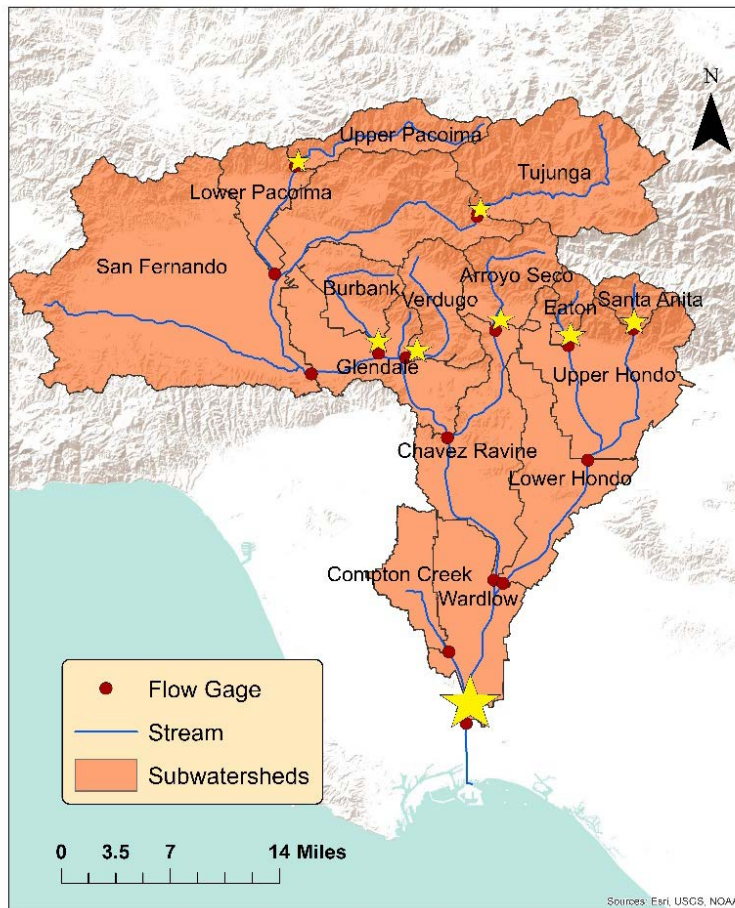


Figure 2.2. Flow and calibration gages (starred) in LAR subwatersheds. Yellow stars represent the eight locations where available discharge data was used to calibrate the SUSTAIN model.

SUSTAIN outputs hourly flow and pollutant loads for each contaminant over the simulation period. The period of analysis begins in WY 2004 and ends in WY 2013 but precipitation and other climatological data input to SUSTAIN begins in WY 2000 to allow sufficient antecedent conditions to develop the model. The first five-year period (WY 2004 – 2008) is utilized as the calibration period, in which parameters in SUSTAIN were varied and optimized to match flow. The validation period (WY 2009 – 2013) was used to evaluate the accuracy of those same parameters from the calibration period and evaluate their ability to forecast flow and loads for a different climatological period. Figure 2.3 illustrates the calibration (left) and validation (right) performance between observed and modeled flow.

⁵¹ Edgley, R., Hogue, T., & Colorado School of Mines. Hydrologic Sciences and Engineering Graduate Program. (2016). *Assessing the efficacy of BMPs to reduce metal loads in the Los Angeles River Basin at the watershed scale*

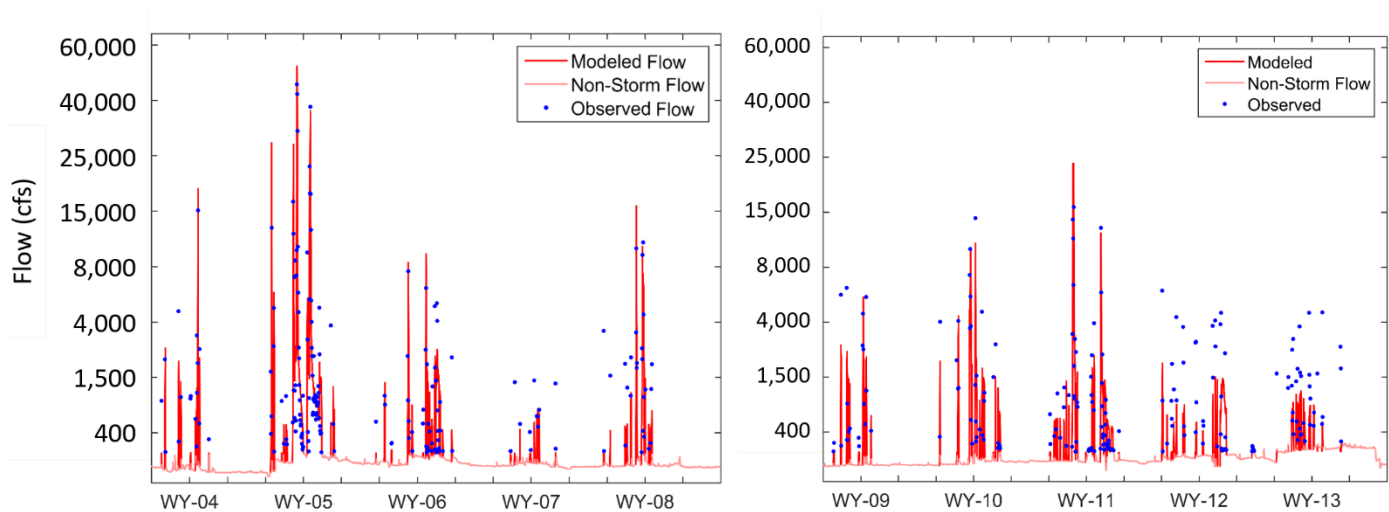


Figure 2.3. Calibration (left) and validation (right) of observed flow (dots) and SUSTAIN modeled flow (bright red lines) for the LAR at the Wardlow gage (F-319).

The percent bias, Nash Sutcliffe Efficiency, and R^2 were 5.2%, 0.85, and 0.84, respectively, for the calibration period and -3.5%, 0.51, and 0.61, respectively, for the validation period. The difference in performance between calibration and validation is likely due to the extreme variation in precipitation during the simulation period. For example, WY 2005 was one of the wettest years on record for several of the precipitation gages in the region – model calibration during this period resulted in parameters that better capture wetter periods as experienced in the winter of 2005-2006. Independent validation during the 2009 to 2013 period (without a change in parameter values) resulted in slightly worse model performance as WYs 2012 and 2013 were among the driest years. Although percent bias was still reasonable (<5%), NSE and correlation were slightly worse and highlight that SUSTAIN performance was slightly poorer during these dry years.

For simulating pollutant buildup and wash-off during storm events (wet-weather flow) in SUSTAIN, we utilize the Event Mean Concentration (EMC) approach, where EMC data is compiled by taking water quality samples at the discharge for specific land-use types. EMC data for LAR was taken from the LACDPW stormwater monitoring program and supplemented with data from the Southern California Coastal Water Research Project (SCCWRP).⁵²

Median values from EMC sampling data are traditionally used. However, using the median value during calibration led to significant and consistent under-prediction of pollutant loads when compared to observed values. Subsequently, various percentile values were tested in the calibration process to determine the EMC value that best matched observed water quality values. The selected

⁵² Watershed and Land Use Storm Water Pollutant Loading Data for the Greater LA Area, California, USA, 2007. for Agriculture & Recreation land-uses. Data provided courtesy of Southern California Coastal Water Research Project Accessible at: <http://www.sccwrp.org/Data/SearchAndMapData/DataCatalog/2007StormWaterLoading.aspx>.

percentiles for cadmium, lead, zinc, and copper were 75th, 95th, 95th, and 96th, respectively. Observed EMC data shows that values also differed based on the type of land use from which stormwater originated. For example, EMC data for copper for all land-uses for observed and modeled loading at Wardlow gage (the most downstream gage and considered the primary design point for this study) indicates that transportation (a large source due in part to the presence of copper in brake pads) contributes the highest median EMC (40 ug/L) of copper while the other land use EMCs vary from 7.3 to 32.27 ug/L (Table 2.5, Figure 2.4).

Pollutant		Landuse EMC Data (ug/L)								
		AG	COMM	EDU	IND	MFR	SFR	REC	TRAN	VAC
Copper	Min	10.8	6.5	7.0	7.0	6.1	5.9	29.2	13.0	2.0
	Max	79.4	320.0	232.0	990.0	230.0	69.0	37.0	292.0	270.0
	Median	22.3	24.0	16.0	22.1	13.4	13.9	32.3	40.0	7.3
	Mean	34.9	35.4	25.2	51.0	39.9	20.0	32.8	55.1	22.4
	N	6	45	42	53	41	38	3	69	30
Lead	Min	2.5	3	5.3	3.9	0.1	5.1	11.1	4	2
	Max	41	248	30	178	53.5	90	13.7	87	113
	Median	5.8	12	8.6	13	10.3	14.8	12.9	10	6.5
	Mean	11.5	23.6	10.8	27.9	14.3	23.7	12.6	16.8	24.2
	N	6	26	12	31	16	21	3	37	7
Zinc	Min	86.8	80	50	50	58	50	120	70	13
	Max	503.8	874	1610	5970	1020	253	125.2	1810	489
	Median	188.3	196	109	367	104	79	121.7	233.5	63
	Mean	261.2	241.9	150.5	575.2	176.8	105.6	122.3	308	98
	N	6	45	42	53	33	27	3	68	14

Table 2.5. EMC data for copper, lead and zinc across land-uses

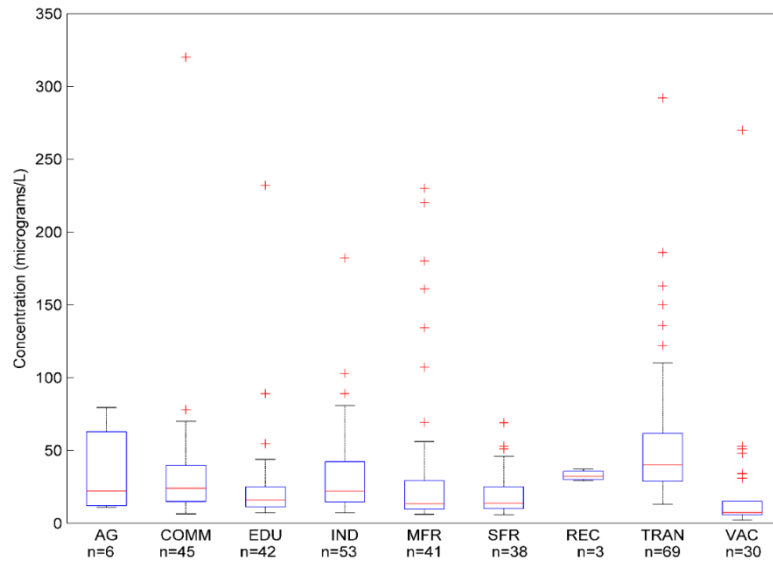


Figure 2.4. Boxplot of EMC data for copper across all land-uses

For the purposes of defining wet and dry weather days, non-storm flow (< 203 cfs) was determined by combining outdoor residential water use data with effluent from WRPs in LAR following the same procedure as in computing TMDLs. Observed daily discharge data from DCTWRP and LAGWRP was combined with monthly averages for six months in WY 2011 for BWRP (due to data limitations), and assumed consistent over the modeling time period. Runoff from outdoor residential use was back-calculated using observed data from WRPs and the downstream gage. This non-storm flow (203 cfs) was used to help calibrate the model. Then, the dry-weather and wet-weather flows were combined into a single time-series for SUSTAIN to determine pollutant loading and water quality exceedances over the modeling time period (Figure 2.5). For these modeling analyses, the applicable water quality standards were set according to wet and dry flow days as defined in the TMDL (the division between wet and dry days at 500 cfs).

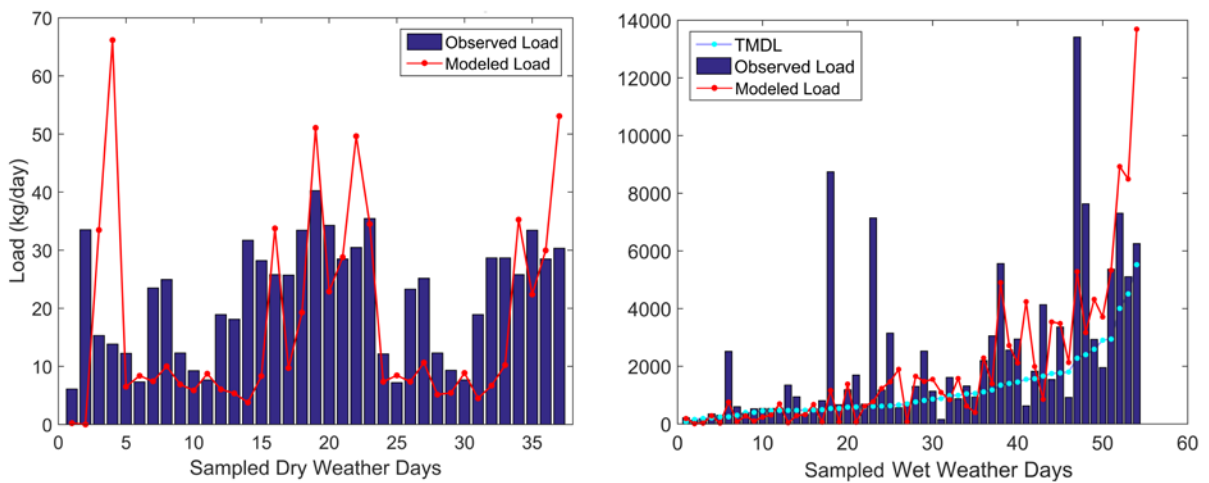


Figure 2.5. Observed and modeled loading for (a) dry-weather zinc and (b) wet-weather copper

BMP modeling scenarios also included the wet and dry weather copper WERs (Table 2.1) and the lead SSOs approved by the LARWQCB in 2015. More specifically, the reach-specific dry

weather copper WERs were used to set the copper targets in the model for days where flow at Wardlow was < 500 cfs. The wet weather copper WER of 3.97 was applied to Reach 1 for days with flow > 500 cfs. Thus, all modeling had either the wet or dry weather copper WER embedded in the BMP analyses. The WER significantly impacts the number of copper baseline exceedances in LAR. For example, measured at the terminus of the watershed, load-based copper exceedances occur in approximately 96% of sampled wet weather days without the WER and in 24% of sampled wet weather days with the WER (Figure 2.6).

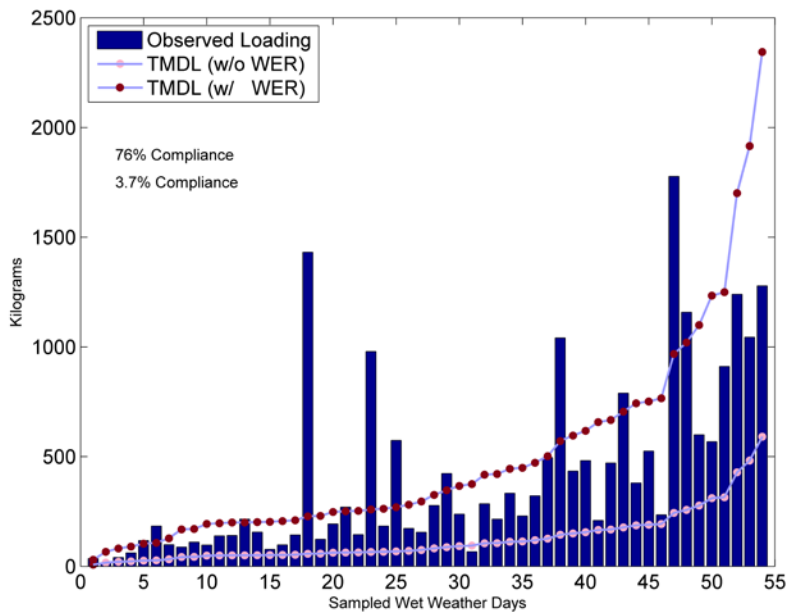


Figure 2.6. Copper loading from observed wet weather days, indicating the TMDL exceedances with and without the WER

e. BMP Technologies in SUSTAIN

BMP dimensions and types for LAR were based on previous BMP investigations in Southern California and the Ballona Creek Watershed.⁵³ The five BMPs (porous pavement, vegetated swales, bioretention, dry ponds, and infiltration trenches) were selected for this research based on robust performance as reported by the International Stormwater BMP (ISBMP) database and are also the same systems utilized in the Ballona Creek study.⁵⁴ These BMPs provide a wide variety of advantages and can be combined in various BMP portfolios to offer a range of benefits and

⁵³ Sustainable LA Water Project, Ballona Creek Watershed Report (2015).

⁵⁴ Sustainable LA Water Project, Ballona Creek Watershed Report (2015).

options for city officials weighing the various needs of the City to consider. Potential benefits across modeling scenarios include increasing groundwater recharge, reducing pollutant load, lowering peak flows, and reducing cost. Infiltration-based BMPs, for example, will allow for greater potential recharge than treat-and-release BMPs. Porous pavement, which contains a sufficient volume of pores to allow runoff to percolate while also maintaining sufficient strength to support vehicles, can be installed over impervious areas while maintaining the same function.⁵⁵ All BMPs require maintenance, which should also be considered during planning efforts. For example, porous pavement can clog up and be maintenance intensive; the City has developed standard plans for permeable pavement (e.g., utilizing interlocking pavers).⁵⁶

Modeling runs included both infiltration-based BMPs and treat-and-release BMPs. Vegetated swales are narrow, densely-vegetated depressions on the surface that act as channels for stormwater flow and reduce stormwater velocity, thus entrapping pollutants such as suspended solids and trace metals. Bioretention cells tend to be richly vegetated with various drought tolerant plants and shrubs and also have a layer of mulch and soil media that is responsible for filtering stormwater as it percolates. Stormwater in bioretention areas can pond to a depth of 6 inches. Thus, bioretention areas can infiltrate water slowly over the course of several days.⁵⁷ Dry ponds and infiltration trenches are considered regional (larger-scale) BMPs, designed to treat large volumes of stormwater through retaining water and settling pollutants (dry ponds) or filtering water through coarse gravel and/or soil media and allowing infiltration (infiltration trenches).⁵⁸ See Table 2.6 for dimensions of BMPs modeled in SUSTAIN and the Ballona Creek report for further details on utilized BMPs.⁵⁹ Infiltration trench BMPs, however, could also be distributed rather than regional if they serve the same function but have smaller dimensions. For example, a French Drain or dry well could be considered a smaller, distributed infiltration trench.

	Vegetated Swale	Bioretention	Porous Pavement	Dry Pond	Infiltration Trench
Length	250	46	62	45	90
Width	10	23	20	15	45
Depth	0.5	1.5	1	5	5

Table 2.6. Dimensions of simulated BMPs

⁵⁵ Environmental Protection Agency, 1999, Stormwater Technology Fact Sheet, Porous Pavement, EPA Office of Water Washington D.C. Accessible at: <https://nepis.epa.gov/>

⁵⁶ The City has developed standard plans on permeable pavement, including S-485, S-486, and S-480 (5.E, 5.I, 6.F, and 9.K). these are available at: <http://eng2.lacity.org/techdocs/stdplans/s-400.htm>

⁵⁷ Environmental Protection Agency, 1999, Stormwater Technology Fact Sheet, Bioretention, 832-F-99-012 EPA Office of Water Washington D.C.

⁵⁸ Environmental Protection Agency, 1999, Stormwater Technology Fact Sheet, Infiltration Trench, 832-F-99-019 EPA Office of Water Washington D.C.

⁵⁹ Sustainable LA Water Project, Ballona Creek Watershed Report (2015).

To effectively simulate BMPs in SUSTAIN, influent and effluent performances were calibrated to match those reported in the ISBMP database. BMP calibration was completed in previous Master's thesis research.⁶⁰ The resulting decay efficiencies (k) are shown below for each BMP and constituent (Table 2.7).

	Vegetated Swale	Bioretention	Porous Pavement	Dry Pond	Infiltration Trench
Cadmium	0.01	0.01	0.01	0.01	0.01
Copper	1.7	0.55	0.01	0.6	0.6

Table 2.7. Summary of reported BMP metal efficiencies⁶¹

f. Cost Background

The unit cost scheme developed in the previous BC Watershed report was utilized (Table 2.8) rather than the default built-in BMP cost database in SUSTAIN. This was both for consistency across watershed analyses associated with this project and because the BC Watershed approach customized costs to Southern California. Note that all costs are for initial construction only (capital costs), which is typical in a SUSTAIN simulation. It is also important to note that the number of samples for each BMP type is relatively small (n=4 to 14), with a relatively large cost range.⁶²

	Vegetated Swale	Bioretention	Porous Pavement	Dry Pond	Infiltration Trench
# of Samples	4	5	8	5	14
25% Quartile	5.37	12.30	10.57	4.40	3.33
Median	10.07	14.60	15.69	5.88	6.03
75% Quartile	18.53	16.24	16.17	15.71	16.63
Unit	\$/ft ³	\$/ft ³	\$/ft ³	\$/ft ³	\$/ft ³

Table 2.8. BMP construction costs (\$) per unit treatment volume of water

Since construction costs represent only a portion of the complete cost to implement and maintain BMPs, a simple life-cycle cost analysis was conducted to estimate operation and maintenance with capital costs for BMP implementation over a 20-year period. The life-cycle costs per BMP were assessed using the construction costs (Table 2.8) and O&M costs were from a stormwater

⁶⁰ Beck, D. Scenario Modeling of Best Management Practices (BMPs) in a Southern California Watershed using the EPA's SUSTAIN Model. Master's Thesis. Colorado School of Mines, Golden, CO. 2014

⁶¹ Radavich, K., 2015, Assessing the Effect of Best Management Practices on Water Quality and Flow Regime in an Urban Watershed Under Climate Change Disturbance. Master's Thesis. Colorado School of Mines, Golden, CO.

⁶² Sustainable LA Water Project Ballona Creek Report, page 48.

BMP report by the EPA and the LADWP Stormwater Capture Master Plan (SCMP).⁶³ According to the sample data available for this simple cost analysis, the median cost per cubic foot of dry ponds and infiltration trenches are the lowest. However, the 75th percentile cost is similar to the other BMPs that have higher median costs. Considering O&M costs in addition to capital costs is important to accurately assess overall costs (Figure 2.7). For example, the median construction cost of bioretention is comparable to that of other BMPs, but has a much higher life-cycle cost per cubic foot than other BMPs (Figure 2.7).

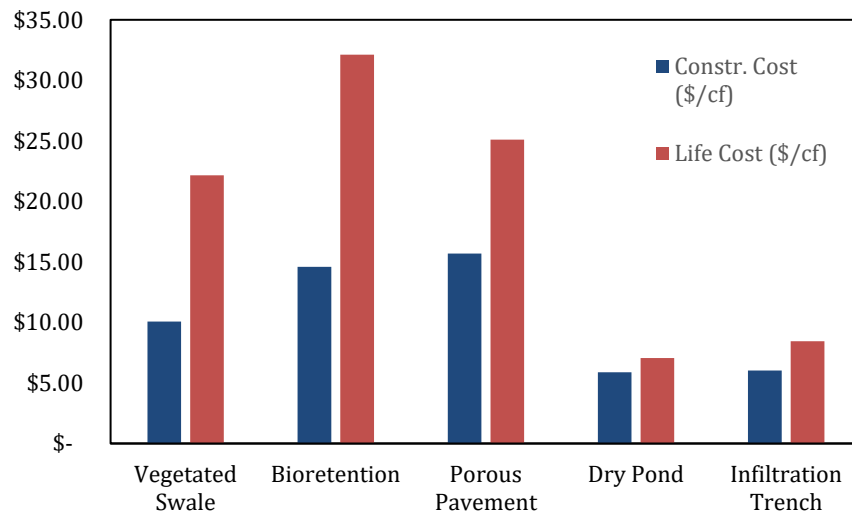


Figure 2.7. Comparison of median life cycle and construction costs for BMPs in this analysis

g. BMP Optimization

We explored six BMP scenarios to provide management options to place BMPs considering both cost and pollutant reduction. Prior to developing the BMP scenarios that combine BMP types, we conducted a sensitivity analysis on the optimization for each BMP type and each metal under study. In this “leave one out” analysis, we explored how including (or excluding) each BMP type affects pollutant removal and cost. Optimizations were run using SUSTAIN’s NSGAII algorithm and the top 100 solutions were chosen for comparison. In all optimization runs, each BMP type captured the same volume (i.e. they each capture 20% of the specified volume) of stormwater such that no BMP type is prioritized.

All optimization runs were bounded by a minimum and maximum number of BMPs. The minimum bound is sufficient storage to capture $\frac{3}{4}$ of the 85th percentile storm volume, while the maximum was sufficient storage to capture 1.5 times the 85th percentile storm volume in each

⁶³ Geosyntec, prepared for LADWP, 2015, Stormwater Capture Master Plan: Task 3 – Develop Stormwater Capture Alternatives; Environmental Protection Agency, 2005, Management Measure 11: Operation and Maintenance, from National Management Measures to Control Nonpoint Source Pollution from Urban Areas. Accessible at: https://www.epa.gov/sites/production/files/2015-09/documents/urban_ch11.pdf

subwatershed. The bounds are chosen such that SUSTAIN is optimizing within a fairly narrow range of volume near the actual volume of stormwater necessary to capture the 85th percentile storm and comply with the region's MS4 permit.

h. Modeling Results

This section overviews results from the six SUSTAIN optimizations described above for the LAR watershed (with a terminus at Wardlow gage). The objective of the optimization was to minimize both cost and pollutant loading. As the amount of copper in the stormwater system is expected to decrease significantly due to new CA regulations⁶⁴ on eliminating copper from brake pads, and the development of reach specific WERs has greatly increased the WLAs for copper sources, we focused our preliminary analysis on zinc. Zinc was also considered a limiting pollutant for modeling analyses conducted in the ULAR EWMP.⁶⁵ The leave-one BMP out sensitivity analysis for zinc highlights the tradeoff between reduction of zinc loading and cost for each BMP type, as well as the BMP footprint required (Figure 2.8).

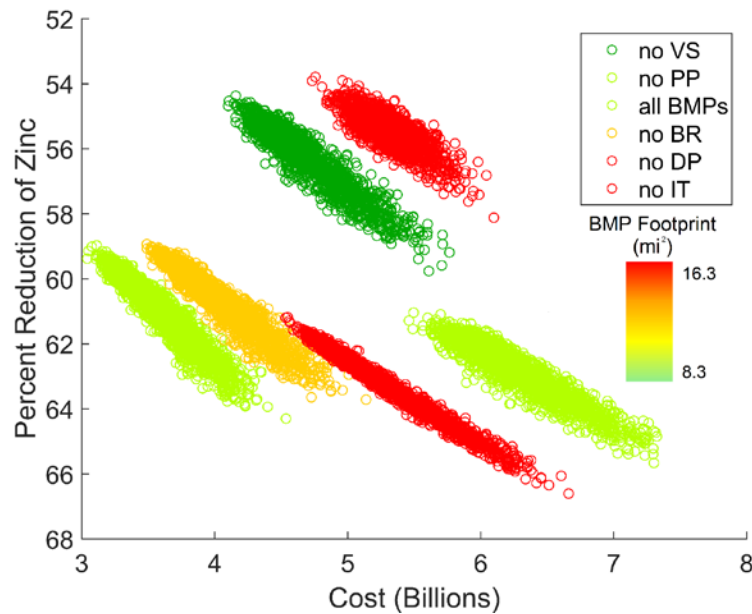


Figure 2.8. Leave-one BMP-out optimization of cost and percent reduction for zinc. Each BMP is represented by circles; colors are scaled to the land footprint required, green (low) to red (high)

⁶⁴ CA State Bill 346, Kehoe

⁶⁵ ULAR EWMP, Appendix 3

Leave-one-out analysis

BMP approaches without porous pavement (“no PP”) have the lowest cost and relatively lowest land footprint, while also providing a zinc load reduction of 60-64% for the LAR watershed (Figure 2.8). Including all five BMPs (“all BMPs”) results in a load reduction of 62-66% for a higher cost than the “no PP” analysis, with about the same land footprint. This visualization enables managers to weigh the three criteria when deciding which BMP configuration is optimal for reducing zinc for a given land area and capital cost. However, available cost data was very limited and additional studies should be performed to build a more robust database of BMP capital and O&M costs to inform this type of analysis for future studies.⁶⁶

Scenario analysis

Following the leave-one-out analysis, a set of scenarios were developed to explore the water quality impacts of various BMP combinations. The decision matrix in Table 2.9 provides a comparison between developed BMP scenarios (columns) for a range of criteria (rows). The baseline scenario “0” represents the condition with no BMPs and the remaining six scenarios correspond to a variety of BMP combinations. Scenarios “a” are without porous pavement, for each BMP type, (1a) bioretention (BR), (2a) vegetated swale (VS) and dry ponds (DP), (3a) VS and infiltration trench (IT); scenarios “b” also include porous pavement. The number of exceedances per year (rows), split by dry/wet weather and by metal represent the number of exceedances over the entire LAR watershed in one year. This value takes into account that each tributary of the LAR is capable of exceeding its TMDL once per day. Thus, as copper and zinc have TMDLs for all nine tributaries, the total possible number of potential exceedances (violations) is $9 \times 365 = 3,285$ per year. The total number of possible exceedances for zinc, however, is 365 as Rio Hondo is the only tributary with a zinc TMDL. Exceedances per year are provided in Table 2.9 in terms of both the concentration based TMDL and the load based TMDL.

⁶⁶ Our cost database was compiled in 2014 for the Ballona Creek Report and not updated for subsequent reports to maintain consistency and comparability across all watershed analyses

	Los Angeles River Scenarios		Baseline	1a	1b	2a	2b	3a	3b
	BMPs		No BMPs	BR	PP + BR	VS + DP	PP + VS + DP	VS + IT	PP + VS + IT
	Volume Capture	0	10,396	10,396	10,396	10,396	10,396	10,396	10,396
	Storm Capture %	0	85th %	85th %	85th %	85th %	85th %	85th %	85th %
Ancillary Criteria	Cost (Billions)	-	6.60	6.80	3.80	5.20	3.80	5.20	
	BMP area (mi ²)	-	10.8	5.8	14.4	9.6	14.4	9.6	
	Infiltration (% of Precip)	-	20.8%	22.0%	16.4%	20.4%	22.6%	22.9%	
	Infiltration (Million AFY)	-	0.16	0.17	0.13	0.16	0.17	0.17	
	Peak Flow Reduction	-	47.0%	53.0%	29.0%	46.0%	55.0%	57.0%	
		Dry Weather Days/yr	333	358	360	350	358	361	361
Water Quality Criteria		DW Total Possible Exceedances/yr (Cu, Pb)	2997	3222	3240	3150	3222	3249	3249
		DW Total Possible Exceedances/yr (Zn)	333	358	360	350	358	361	361
	Dry Weather Exceedances/yr	Concentration Based TMDL (Cu)	13	47	49	35	39	43	44
		Concentration Based TMDL (Pb)	0	12	13	7	10	16	14
		Concentration Based TMDL (Zn)	3	8	8	3	7	9	9
		Load Based TMDL (Cu)	307	68	71	62	69	75	75
		Load Based TMDL (Pb)	127	51	53	47	52	57	57
		Load Based TMDL (Zn)	214	18	18	15	18	19	19
		Wet Weather Days/yr	32	7	5	15	7	4	4
		WW Total Possible Exceedances/yr (Cu, Pb, Zn)	32	7	5	15	7	4	4
	Wet Weather Exceedances/yr	Concentration Based TMDL (Cu)	5	1	2	1	1	0	2
		Concentration Based TMDL (Pb)	2	0	0	0	0	0	0
		Concentration Based TMDL (Zn)	14	5	5	2	5	2	4
		Load Based TMDL (Cu)	6	1	2	0	1	0	2
		Load Based TMDL (Pb)	2	0	0	0	0	0	0
		Load Based TMDL (Zn)	14	6	5	3	6	2	4
		Cu Average Annual Load % Reduction	-	71.0%	60.8%	58.6%	55.6%	77.2%	61.2%
		Pb Average Annual Load % Reduction	-	83.1%	62.9%	59.7%	53.9%	79.4%	59.7%
	Zn Average Annual Load % Reduction	-	83.6%	63.1%	62.4%	59.4%	80.1%	59.9%	

Table 2.9. Decision matrix for evaluating tradeoffs between BMP scenarios,⁶⁷

While multiple modeled BMP scenarios were able to manage the 85th percentile storm, tradeoffs were present among the scenarios – some were cheaper, some were more effective at reducing water quality exceedances or peak flows, and others provided greater water supply benefits. For example, scenarios that included porous pavement were capable of infiltrating the highest volumes of water and thus reducing peak flows by the greatest amount, but were also among the most expensive. Modeling BMP scenarios with a greater emphasis on treat-and-release BMPs, such as vegetated swales and dry ponds, resulted in fewer exceedances of the metals TMDLs as more treated “clean” flows were returned to the channel. However, this emphasis on treat-and-release approaches provided less potential recharge than those BMP scenarios with a greater emphasis on infiltration BMPs. A combination of treat and release BMPs and infiltration BMPs (vegetated swales and infiltration trenches) was low cost, provided groundwater recharge benefits, and greatly improved water quality.

For all BMP scenarios, the dry weather exceedances per year in terms of the concentration based TMDL are lower than in terms of the load based TMDL. However, it is important to notice that the number of dry weather exceedances per year is drastically different between the concentration and load based TMDL for the baseline (no BMPs). For example, copper has 307 dry weather exceedances per year for the baseline using the load based TMDL while the concentration based TMDL only results in 13 exceedances per year. Similarly, lead exceedances drop from 127

⁶⁷ BR = bioretention, PP = porous pavement, VS = vegetated swale, DP = dry pond, and IT = infiltration trench. Relative performance color-coded using Conditional Formatting tool in Microsoft Excel, where the “worst” value for a given criterion in each row is white and the “best” value is dark green, with the gradient greens in the mid-range.

to 0 and zinc exceedances drop from 214 to 3 (Table 2.9). While the concentration based TMDL has fewer exceedances per year for scenarios 1a-3b than the load based TMDL, the number of exceedances actually increases from the baseline when using the concentration based TMDL and decreases when using the load based TMDL.

Based on TMDL load exceedances, the Rio Hondo tributary makes up the majority of metals exceedances per year for copper and lead (and all exceedances for zinc as it is the only compliance location) when compared to the other tributaries and reaches. So while 214 zinc exceedances per year in terms of the load-based TMDL appears high for the baseline, it is important to note that 95 of 307 and 75 of the 214 baseline exceedances, for copper and lead respectively, are located at Rio Hondo.

The increase in exceedances per year from the baseline to the BMP scenarios for the concentration based TMDL is due to the shift in wet weather days per year. For example, there are 32 wet weather days per year without BMPs. However, when BMPs are implemented throughout the watershed, the number of wet weather days decreases due to the capture and infiltration of stormwater (and thus lower in-channel flows). Scenario 3a (VS + IT) results in only 4 wet weather days per year (versus 32 in the baseline). This means that there are now 28 more days that are considered dry weather and thus 252 more possible exceedances per year total when taking into account the 9 tributary compliance locations for copper and lead. It is these dry weather days that would have been wet weather days without BMPs that cause the number of exceedances to increase. For example, Scenario 3a (VS +IT), would actually see a decrease in zinc dry weather exceedances per from 3 to 1 (Table 2.10) if those 28 wet weather days had not become dry. However, the 28 wet weather days that became dry weather days post-BMP implementation resulted in an additional 8 exceedances per year. Thus, a total of 9 exceedances per year was observed in Scenario 3a under the concentration based TMDL.

Zinc Dry Weather Concentration Based Exceedances			
BMP Scenario	Description of Value	Days/ 1 yr	Total Exceedance/yr
No BMPs	Total Exceedances	3	3
VS IT	Previous DW that are no longer exceeding	2	9
	Previous DW that are still exceeding	1	
	Previous WW days that are now DW and exceed the DW TMDL *	8	
VS IT	* Total WW days that became DW	28	

Table 2.10. Breakdown of zinc concentration based exceedances for the baseline scenario (no BMPs) and Scenario 3a (VS + IT).

Each scenario captures the 85th percentile volume of stormwater (10,396 AF) and thus all equally meet the 85th percentile stipulation in the MS4 permit. As previously mentioned, each

scenario also routes 90% of the runoff from the entire watershed to BMPs that are sited on “urban public” land. Thus, runoff from both “urban private” and “urban public” land uses is being treated in all modeling scenarios presented in Table 2.9. However, the various scenarios have significant differences in costs and in benefits such as water quality, potential infiltration, and flood control. This analysis enables a decision maker to prioritize their criteria for implementation. For example, if ancillary benefits (infiltration, BMP footprint, peak flow reduction) are valued higher than exceedances, then scenarios 3a and 3b might be optimal. If, however, the opposite were true, option 2a may be more appropriate. It is important to emphasize, however, that this is a relative ranking between the modeled scenarios and thus the magnitude of the differences among scenarios should also be considered when prioritizing. For example, the range of dry weather exceedances per year for copper only ranges between 0-2.

Making decisions on the best BMP(s) to implement in an integrated water management framework requires the consideration of multiple criteria. Considering the impacts of the implementation of porous pavement throughout the LAR watershed provides a good example of this complexity. In general, water quality for scenarios including porous pavement as a BMP is poorer (i.e. more exceedances, Table 2.9). Although water quality is relatively worse in these “b” scenarios, the volume of water infiltrated is higher and the BMP spatial footprint is lower. Both of these are important ancillary benefits to consider in a semi-arid region that is highly developed and dependent on imported water. However, the “b” scenarios that contain porous pavement are also much more expensive, and so may not be a feasible option for municipalities that are budget-limited in their decisions to satisfy water quality, cost, BMP footprint, and infiltration criteria. However, porous pavement is also an opportunity to decrease imperviousness of a developed surface and continue to use the land (e.g. parking lot) as is, rather than needing to transform the area both structurally and for use. All BMP scenarios aid in reducing the peak flow from the 10 simulated water years, with values ranging from 29% reduction (VS+DP) to up to 57% (PP+VS+IT) reduction; the highest flow reduction resulted from a scenario which included porous pavement.

The highest performing options in terms of volume of stormwater infiltrated are 3a and 3b (VS+IT and VS+IT+PP, respectively). These scenarios were expected to do well in this regard because infiltration trenches have a large capacity to infiltrate stormwater, as do porous pavement BMPs. However, the relative difference in volume infiltrated between 3a and 3b is small and the cost difference is \$1.4 billion (Table 2.9). Therefore, 3a offers a more cost-effective means to infiltrate relatively large volumes of stormwater. It should be noted that the volume of infiltrated stormwater does not necessarily equate to the volume of water that will actually reach groundwater aquifers or become available for local supply, a topic that needs further research in the LA region.

Average annual loading of copper, lead, and zinc were all reduced by more than half in wet weather in the majority of modeled scenarios (Table 2.11). The only exception is zinc, which was only reduced by 36% and 39% in Scenarios 1a and 1b, respectively. Scenario 3a (VS + IT) generally results in the highest reduction, between 74% and 80%, for all three metals (Table 2.11).

	1a	1b	2a	2b	3a	3b
Copper Reduction	65%	53%	56%	52%	74%	57%
Lead Reduction	80%	57%	58%	52%	77%	58%
Zinc Reduction	36%	39%	65%	55%	80%	59%

Table 2.11 Percent reduction of contaminants in wet weather

Additional scenario analyses to improve pollutant load reduction

Despite the reduction in the presence of metals, however, wet weather exceedances still occur even when the approach of managing the 85th percentile storm (through infiltration and / or treat-and-release BMPs) from the entire LAR watershed has been achieved through Scenarios 1a-3b. Hence, four additional scenarios, 4 through 7, were designed to assess their performance reducing exceedances under the load-based TMDL. These scenarios included managing a larger storm volume, increasing BMP decay rates, and reducing “private land” runoff EMCs. Scenario 2a (VS + DP) was chosen as the baseline scenario as it produced the best results in terms of wet and dry weather exceedances (Table 2.9).

In Scenario 4, the number of BMPs simulated was increased to evaluate the capture of a storm volume around the 95th percentile.⁶⁸ Even though the increased number of BMPs results in the capture of a larger volume of water, there is little effect on wet weather zinc exceedances and the number of dry weather load-based exceedances actually increases for copper, lead, and zinc (Table 2.12). This increase in exceedances stems from the implementation of additional BMPs in this scenario; a greater number of BMPs resulted in flow reduction, which in turn resulted in more dry weather days and thus in more opportunities to exceed the dry weather TMDL (as the distinction between wet and dry TMDLs is defined by in-channel flow volumes).

Scenario	2a	4	5	6	7
Description	VS DP	More BMPs	Higher Decay Rate	Private Land Use EMCs to half	Private Land Use EMCs to 0
DW Exceedances/yr (Cu)	62	63	60	60	59
DW Exceedances/yr (Pb)	47	49	46	46	45
DW Exceedances/yr (Zn)	15	16	15	15	15
WW Exceedances/yr (Cu)	0	0	0	0	0
WW Exceedances/yr (Pb)	0	0	0	0	0
WW Exceedances/yr (Zn)	3	2	2	1	0

Table 2.12. Load-based exceedances for copper, lead, and zinc in additional BMP scenarios

In Scenario 5, the impact of increasing the decay rates of the two modeled BMPs, VS and DP, was evaluated. Treatment efficiency was tested by increasing the 1st order decay rates for each BMP in the SUSTAIN simulations (i.e. improved pollutant removal). Each BMP type takes into

⁶⁸ Stronger storms can be more expensive to build for, e.g., section 6.1.1 Capture Curves in the SCMP Appendices. SCMP technical memo 3, p. 212 of pdf. Available at www.ladwp.com/scmp.

account inflow time series, concentration time series for each pollutant, and the 1st order decay factor/rate (1/hr) for each pollutant to predict the outflow and concentration time series for each pollutant.⁶⁹ The decay factor simulates an exponential decay over time. The goal was to determine the theoretical decay rates needed for zero days of wet weather exceedances. However, the percent pollutant reduction reached a maximum, even when simulating decay rates that were 100 times greater than the original rates. This is most likely due to factors relating to both the BMP design and external factors such as the volume of water routed to the BMPs. Pollutant decay rates modeled were those at which pollutant reduction reached its maximum.

Finally, the impacts of reducing the EMCs on “private land uses” on attaining compliance with water quality standards were analyzed. In Scenario 6, all “private land use” EMCs were set to half of their original calibrated value. In Scenario 7, all “private land use” EMCs were set to 0 mg/L. Wet weather exceedances for all metals are eliminated in Scenario 7 as zinc exceedances go to zero; copper and lead exceedances were zero in each of Scenarios 4-7. A further post-modeling analysis was conducted on both the flows and loads from “private lands” to assess the impact of the LID ordinance (Section II.D.c).

Dry weather exceedances show little to no improvement in all additional modeled scenarios, which is due to the fact that the EMCs implemented into SUSTAIN generate wet weather loadings only for storm events. Interstorm data or non-storm driven flow, including runoff from anthropogenic activity such as irrigation, is input into the model as background flow and contains loadings that are not generated by the EMCs. Also, some dry weather days do occur on days with storm events, for example, when the precipitation is low enough that the channel flow does not exceed the 500 cfs wet weather day cut off. However, the majority of the dry weather days are interstorm. Thus, changing the EMCs in the model does not have an effect on the majority of the dry weather days and little to no change is seen for the dry weather exceedances.

D. Policy Analysis

a. Dry Weather Load-Based TMDL

The dry weather exceedances remaining after the above modeling scenarios were further investigated to identify any patterns. Dry weather exceedances per reach for copper and lead were simulated from water year 2004 to 2013. Zinc was not included in this analysis since the only TMDL for zinc is at the Rio Hondo tributary. Baseline (no BMPs) and Scenario 2a (VS+DP, the most effective at reducing exceedances) were included in this analysis (Figure 2.9, 2.10).

⁶⁹ Lai, Dennis, T. Dai, J. Zhen, J. Riverson, K. Alvi, AND L. Shoemaker. SUSTAIN - An EPA BMP Process and Placement Tool for Urban Watersheds. In Proceedings, WEF 2007 TMDL Specialty Conference, Bellevue, WA, June 24 - 27, 2007. Water Environment Federation, Alexandria, VA, (2007).

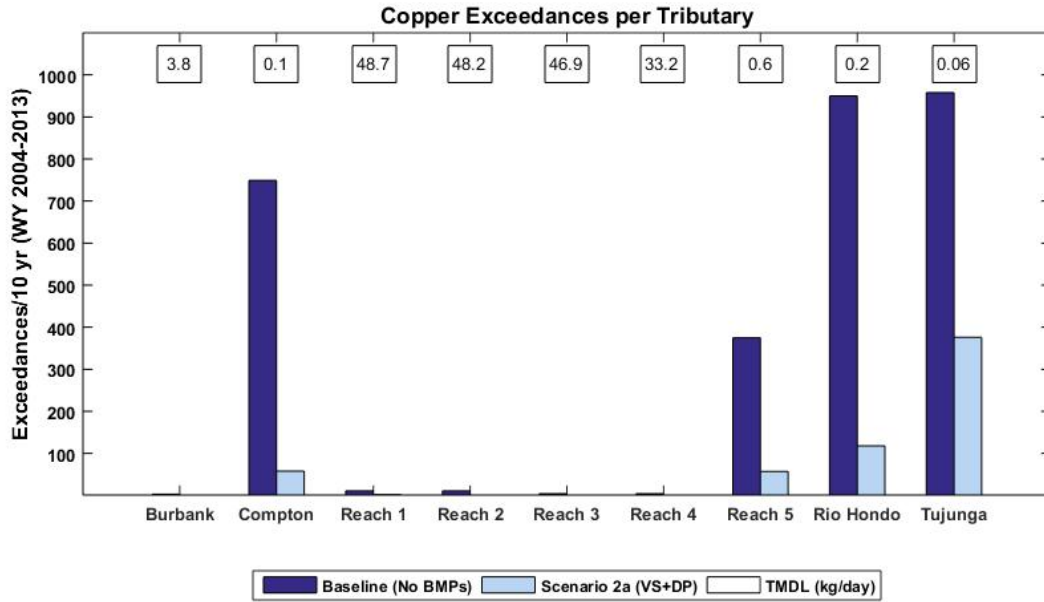


Figure 2.9. Total number of copper dry weather load-based exceedances for the modeled period from WY 2004 to 2013. Exceedances are broken up by tributary and show both pre-BMP (Baseline) and post-BMP (Scenario 2a, VS + DP). The TMDL (kg/day, with WERs) is on the top x-axis. The maximum possible number of exceedances per tributary over this time period is 3,650.

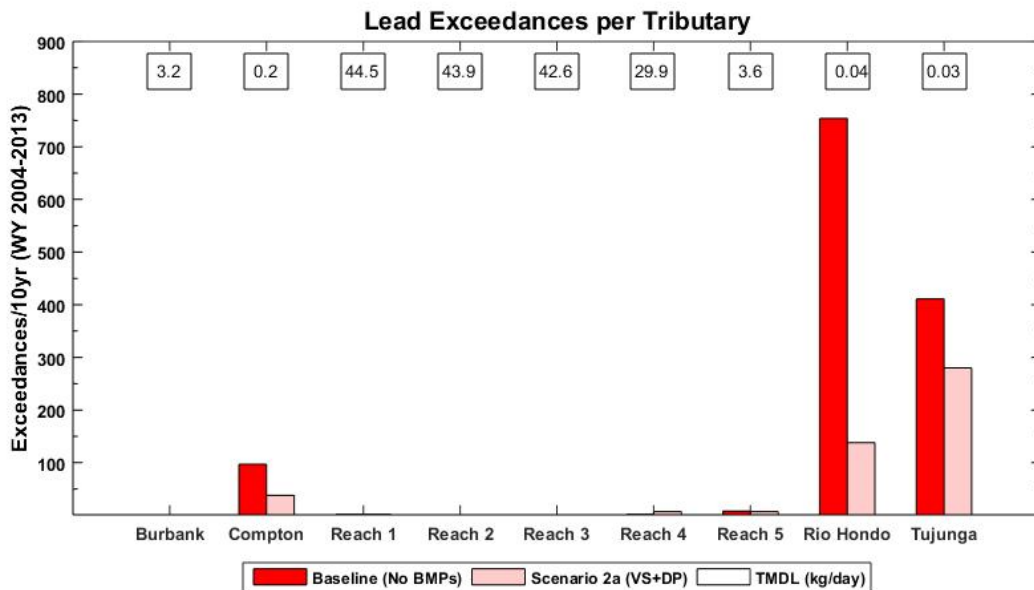


Figure 2.10. Total number of lead dry weather load-based exceedances for the modeled period from WY 2004 to 2013; the maximum possible number of exceedances per tributary is 3,650. Exceedances are broken up by tributary and show both pre-BMP (Baseline) as well as post-BMP (Scenario 2a, VS + DP). The TMDL (kg/day) is on the top x-axis.

Four tributaries (Compton, Reach 5, Rio Hondo, and Tujunga) make up the majority of the load-based copper exceedances in both the baseline scenario (no BMPs) and Scenario 2a (VS+DP, Figure 2.9). These tributaries also have the lowest load-based copper TMDLs, with values of 0.1, 0.6, 0.2, and 0.06 kg/day, in Compton, Reach 5, Rio Hondo, and Tujunga, respectively. Burbank, Reach 1, Reach 2, Reach 3, and Reach 4 all have higher TMDLs; none of these tributaries had greater than 11 exceedances over the whole ten-year period. Three of those tributaries, Compton, Rio Hondo, and Tujunga, also make up the majority of the lead total exceedances. Lead TMDLs in these channels are also the strictest, with lead TMDLs of 0.9 kg/day (Compton), 0.5 kg/day (Rio Hondo), and 0.2 kg/day (Tujunga, Figure 2.10). The remaining LAR tributaries had seven or fewer lead exceedances over the entire modeled ten-year span (Table 2.13).

Impaired Watershed	No BMPs	1a	1b	2a	2b	3a	3b
Burbank	0 (0)	0 (1)	0 (1)	0 (0)	0 (0)	0 (1)	0 (1)
Compton	10 (0)	2 (1)	2 (1)	4 (0)	1 (1)	3 (1)	2 (1)
Reach 1	0 (0)	1 (2)	1 (3)	0 (2)	0 (2)	1 (4)	1 (3)
Reach 2	0 (0)	1 (2)	1 (2)	0 (2)	0 (2)	1 (2)	1 (2)
Reach 3	0 (0)	0 (1)	1 (2)	0 (1)	0 (1)	1 (2)	1 (2)
Reach 4	0 (<1)	0 (1)	0 (1)	0 (1)	0 (1)	0 (1)	1 (1)
Reach 5	1 (0)	1 (0)	1 (0)	1 (0)	2 (0)	1 (0)	1 (0)
Rio Hondo	75 (<1)	16 (4)	16 (4)	14 (1)	16 (3)	18 (5)	17 (4)
Tujunga	41 (0)	31 (0)	32 (0)	28 (0)	32 (0)	33 (1)	33 (0)
Total	127 (4)	52 (12)	54 (13)	47 (7)	51 (10)	58 (16)	57 (15)

Table 2.13 Load- and concentration-based exceedances per year for lead in dry weather. Any difference in totals in this table compared to Table 2.9 stem from rounding. Concentration based exceedances are listed in parentheses.

As described above, the reaches with the most exceedances also had the lowest allowable TMDL loads. These dry-weather TMDL loading capacities (Table 2.1) are determined by multiplying specific numeric targets (ug/L)⁷⁰ by the critical flow (cfs) and thus, the quantitative load of metals allocated to each pollutant is also based on the critical flow of the river channel. As previously noted, the Regional Board allows concentrations to be used rather than loads, so these analyses are intended for discussion purposes on the impacts flows have on developing load-based water quality standards only.

We examined the impacts of these critical flows on TMDL load-based exceedances for the LAR as a whole and in each tributary. First, critical flows in the TMDL are represented by the

⁷⁰ California Water Board, 2015, Revised Basin Plan Amendment – Chapter 7, Accessible at: http://63.199.216.6/bpa/docs/R15-004_BPA_CH_7.pdf

median flow taken from the long-term flow record from 1988-2000.⁷¹ We assessed the impact on the number of exceedances using flows from the modeled BMP scenarios, which were calibrated and simulated from WY 2004 to 2013. Baseline modeled median flows from the four tributaries with the highest exceedances were determined to compare to the median flows from 1988 – 2000.⁷² Median flows from 2004-2013 are significantly higher than those from 1988-2000 (Table 2.14).

	Median Flow (1988-2000)	Median Flow (Modeled Flow 2004-2013)	TMDL (kg) (1988 - 2000)	TMDL (kg) (Modeled Flow 2004 - 2013)
Reach 5	8.74	17.7	0.64	1.30
Compton	0.9	7.0	0.14	1.09
Rio Hondo	0.5	7.7	0.15	2.37
Tujunga	0.15	2.1	0.06	0.86

Table 2.14. Comparison of median flows used to determine the critical flows for each tributary and calculate the final loading capacity TMDL. Currently set critical flows are based on median flows from 1988-2000.

Due to the relationship between flows and loads, these higher flows also resulted in a higher TMDL load for each reach. Using these new TMDL loads (based on the modeled critical flows from 2004-2013), both the baseline and Scenario 2a exceedances per year dramatically decrease for all pollutants (Table 2.15). For example, copper exceedances in the baseline scenario drop from 307 (1988-2000 flows) to 42 (2004-2013 flows) and from 62 (1988-2000 flows) to 16 (2004-2013 flows) in Scenario 2a. Thus, the flow volumes used to determine the acceptable pollutant loads have a significant impact on determining the TMDL loads.

	Baseline (1988-2000)	Baseline (2004-2013)	Scenario 2a (1988-2000)	Scenario 2a (2004-2013)
DW Exceedances/yr (Cu)	307	42	62	16
DW Exceedances/yr (Pb)	127	12	47	14
DW Exceedances/yr (Zn)	214	34	15	8

Table 2.15. Comparison of median flows used to determine the critical flows for each tributary and calculate the final loading capacity TMDL. Currently set critical flows are based on median flows from 1988-2000.

To further pull apart the cause for the exceedances in each tributary, total dry weather copper and lead load-based exceedances from Scenario 2a (VS +DP) were considered in the context of the TMDL (including copper WERs) and the critical flow (cfs) to determine the loading capacities

⁷¹ http://www.waterboards.ca.gov/water_issues/programs/tmdl/records/region_4/2006/ref108.pdf

⁷² California Water Board, 2015, Revised Basin Plan Amendment – Chapter 7, Accessible at: http://63.199.216.6/bpa/docs/R15-004_BPA_CH_7.pdf

(Table 2.16). Compton, Rio Hondo, and Tujunga have critical flows of less than 1 cfs per day for both copper and lead, which results in a lower load-based TMDL. In reaches with upstream tributaries contributing flow, the critical flow volume at the downstream tributary is the sum of its own critical flow and the upstream tributaries. For example, while the critical flow for Reach 1 is only 2.58 cfs⁷³, when taking into account the flow from all upstream tributaries the final additive critical flow at Reach 1 is 202.9 cfs (Table 2.16). Thus, how critical flows are defined impact TMDL loads at each reach as well as for the entire TMDL.

Scenario 2a (VS+DP)	Copper				Lead			
	WER	Critical Flow (cfs)	TMDL (kg / day)	DW Exceedances	WER	Critical Flow (cfs)	TMDL (kg / day)	DW Exceedances
Burbank	4.75	17.3	3.8	0	1	17.3	3.2	0
Compton	3.36	0.9	0.1	58	1	0.9	0.2	38
Reach 1	3.97	202.9	48.7	2	1	202.9	44.5	2
Reach 2	3.97	200.3	48.2	2	1	200.3	43.9	2
Reach 3	3.97	194.5	46.9	1	1	194.5	42.6	0
Reach 4	3.97	138.0	33.2	1	1	138.0	29.9	1
Reach 5	1	8.7	0.6	57	1	8.7	3.6	7
Rio Hondo	9.69	0.5	0.2	118	1	0.5	0.04	138
Tujunga	8.28	0.2	0.06	376	1	0.2	0.03	280
Total WY '04-'13				615				468
Per Year				62				47

Table 2.16. TMDLs as a dry weather loading capacity, associated critical flow, and resulting dry weather exceedances for scenario 2a (VS + DP). The number of exceedances per tributary represent the total number over the modeled time period from WY 2004 to 2013.

Lower critical flows result in lower allowable TMDL loads; Reach 1, which has a critical flow of 202.9 cfs, has far fewer TMDL exceedances than Rio Hondo, which has a critical flow of 0.5 cfs (Figure 2.11). As described above, concentrations also play a role in determining TMDL loads, so dry weather exceedances at Rio Hondo and Reach 1 were also examined using TMDL limits and modeled water quality concentrations (Figure 2.12). The number of exceedances based on allowable concentrations was much lower (1 per year) at Rio Hondo than when using the TMDL loading approach (95 per year). The opposite was seen in Reach 1, which also has far fewer exceedances in general. There were two copper exceedances per year based on the allowable concentrations and one per year using the TMDL loading approach. This may be due in part to the

⁷³ Revision of the Total Maximum Daily Load for Metals for the Los Angeles River and Its Tributaries-Second Revision staff report. Draft January 30, 2014. http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/bpa_113_R15-004_td.shtml Table pg 18 (accessed November 22, 2016)

fact that, as the critical flow at Reach 1 was higher, the difference between the number of concentration and load-based exceedances was smaller.

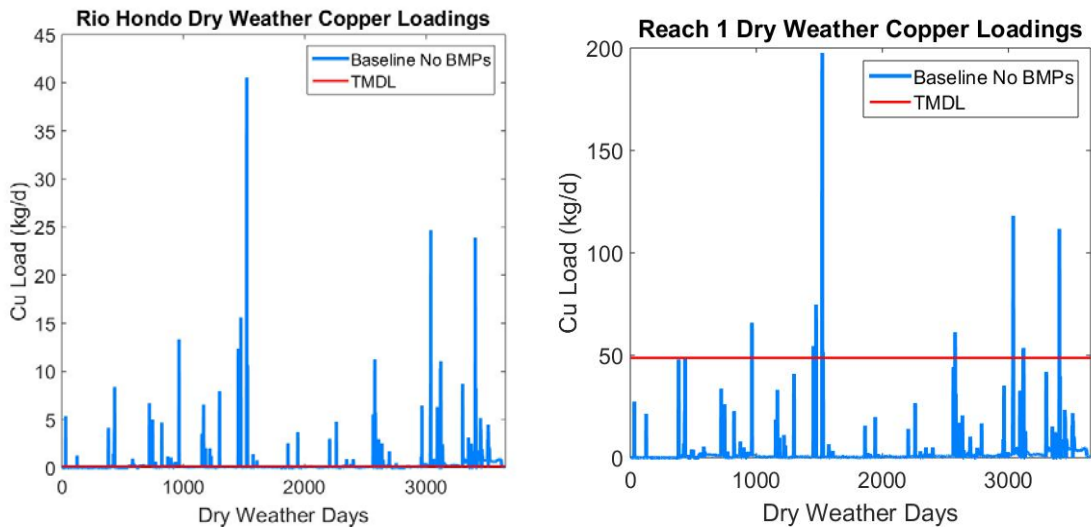


Figure 2.11. Copper dry weather exceedances based on TMDL loadings.

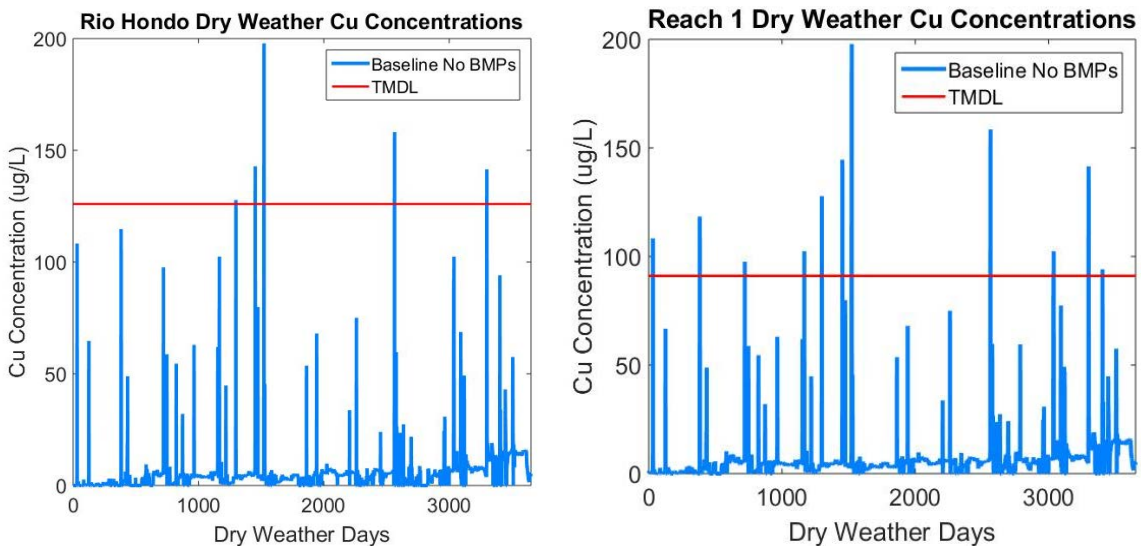


Figure 2.12. Copper dry weather exceedances based on TMDL concentrations.

Based on modeled water quality data, the tributaries that are contributing the majority of the concentration-based TMDL exceedances are slightly different from those based on TMDL load exceedances. Reach 5 and Compton represent the majority of LAR copper exceedances; Rio Hondo is no longer a major source of exceedances based on copper concentrations. Rio Hondo represents the only major source of the LAR lead exceedances. Additionally, Tujunga is no longer a source of dry weather exceedances for copper or lead with the concentration-based TMDLs.

This reach by reach analysis points to the importance of critical flow values for each reach in calculating TMDL loads. For example, based on the number of load-based exceedances, the Rio

Hondo reach would be a high priority for increased source reduction for copper. However, based on the concentrations and the overall loadings contribution to the watershed, Rio Hondo would be a low priority for source reduction efforts. Focusing on water quality exceedance issues in reaches with very low flows and very few concentration exceedances should be a lower priority compared to reaches with higher flows, higher concentrations, and aquatic life habitat. Also, it is important to note that watershed-wide BMP implementation programs will significantly change the flows in the reaches, and the critical flow values used to calculate loads as defined in the TMDL should change appropriately as well.

b. Nutrient TMDL

Reaches 1-5 of the LAR channel as well as Burbank West, Verdugo Wash (Reaches 1 and 2) and Arroyo Seco (Reaches 1 and 2) have also been listed as impaired for nutrients on the 303(d) list. The SWRCB, working with the EPA and the LARWQCB, established nutrient TMDLs in 2003 for the specified reaches. Numeric TMDL targets for total ammonia as nitrogen were established for receiving waters based on one hour averages and thirty-day averages for each reach upstream of the three WRPs. The one-hour averages are: 4.7 mg/L from Reach 5 and Reach 4 to DCTWRP, 8.7 mg/L from Reach 3 to LAGWRP, and 10.1 mg/L at BWRP. The thirty-day average numeric target is derived from a formula that is calculated based on temperature.⁷⁴

The TMDL also specifies that the highest four-day average within the 30 days should not exceed 2.5 times the 30-day numeric target for nitrate-nitrogen and nitrite-nitrogen as 8 mg/L and 1 mg/L, respectively. At major point sources, the TMDL specifies 30-day averages based on temperature and 30-day WLAs for nitrogen compounds as one-hour averages: DCTWRP, 4.2 mg/L; LAGWRP, 7.8 mg/L; and BWRP, 9.1 mg/L. Thirty-day WLAs were established for nitrate (NO₃N) – 7.2 mg/L, nitrite (NO₂N) – 0.9 mg/L, and Total N (NO₃N+NO₂N) = 7.2 mg/L. Ammonia WLAs were set for minor point sources as well.⁷⁵ Non-point source interim limits for ammonia were set as daily maximum/monthly averages: DCTWRP, 21.7/21 mg/L; LAGWRP, 19.4/16.5 mg/L; and BWRP, 24.1/22.7 mg/L.

Observed nutrient data provided by LACDPW were compiled to assess the current state of nutrients in the LAR. Figures 2.13-2.15 illustrate the observed sample data for Nitrate, Nitrite, and Ammonia, respectively, indicating that exceedances have dropped off dramatically in the last 5 to 10 years for all constituents. The LARWQCB considers the nutrient issue in LAR to be “improving” for both dry and wet weather conditions according to a review in 2013.⁷⁶ Assuming conditions continue to improve (or remain steady) for nitrogen-based compounds in the LAR main channel, the EPA and the SWRCB may revisit the 303(d) classification.

⁷⁴ California Water Board, 2013, Attachment A to Resolution No. R12-010 Los Angeles River Nitrogen Compounds and Related Effects TMDL, Accessible at: http://63.199.216.6/bpa/docs/R12-010_RB_BPA.pdf

⁷⁵ California Water Board, 2013, Attachment A to Resolution No. R12-010 Los Angeles River Nitrogen Compounds and Related Effects TMDL, Accessible at: http://63.199.216.6/bpa/docs/R12-010_RB_BPA.pdf

⁷⁶ TMDL Progress report. http://www.waterboards.ca.gov/about_us/performance_report_1516/plan_less/docs/fy1314/11112_r4_lariver_nitrogen.pdf

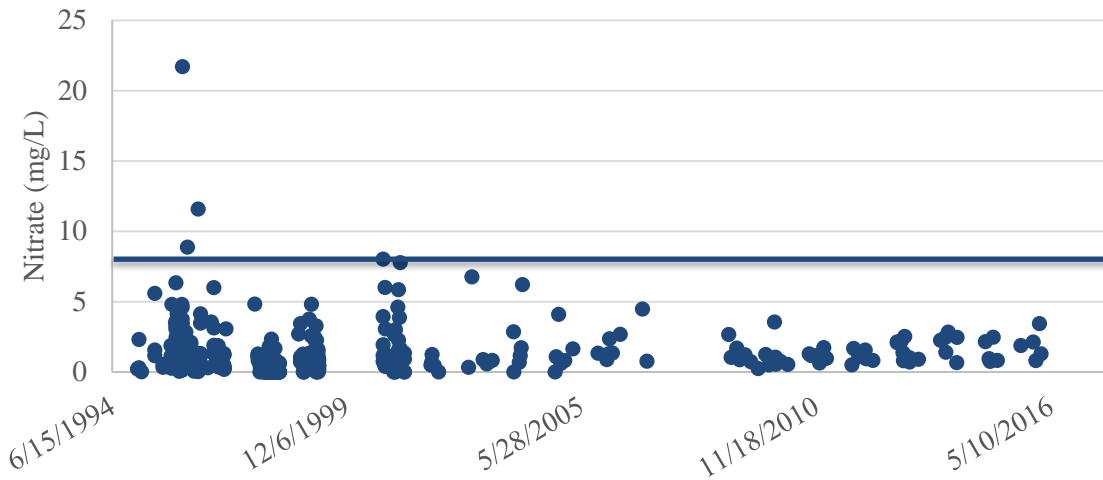


Figure 2.13. Nitrate samples collected throughout the LAR reaches from water years 1995-2015; line denotes approximate location of the current TMDL limits for Nitrate, 7.2 mg/L for major point sources and 8 mg/L for minor sources.

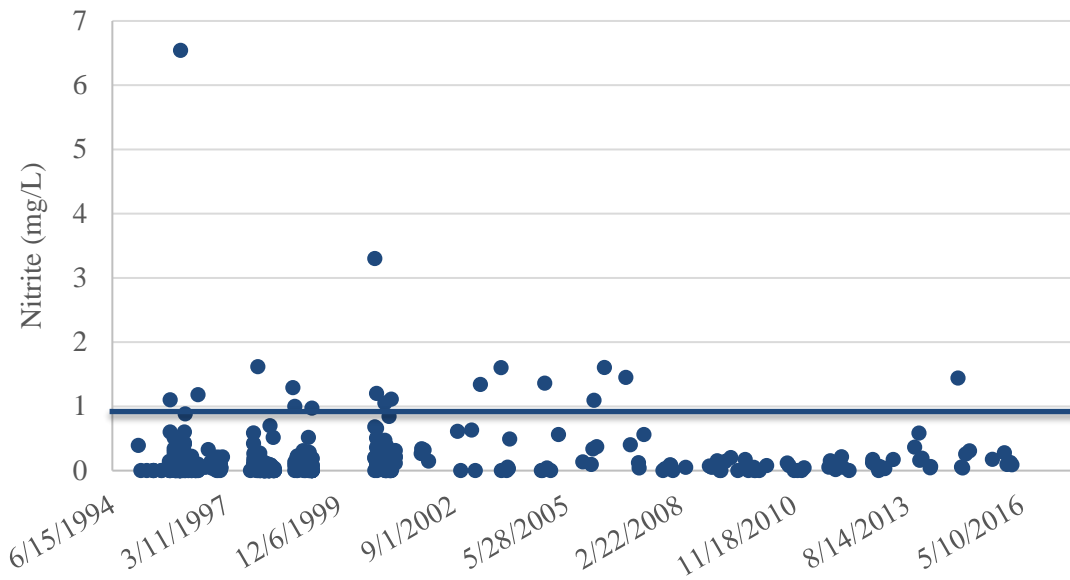


Figure 2.14. Nitrite sample data collected from 1995-2015 throughout LAR reaches; line denotes approximate location of current TMDL limits for Nitrite, 0.9 mg/L for major point sources and 1 mg/L for minor sources

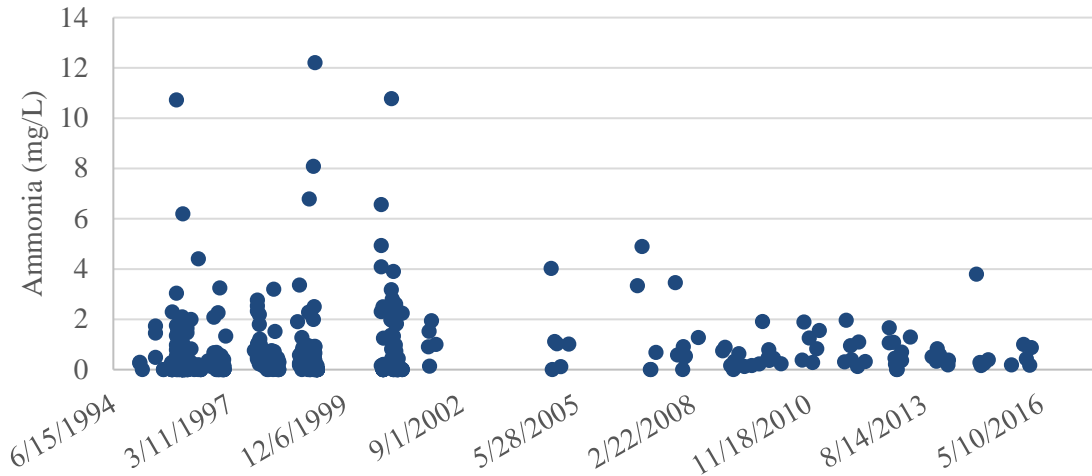


Figure 2.15. Ammonia sample data collected throughout LAR reaches from 1995-2015

c. LID Redevelopment Rate Impacts

The City has established future redevelopment rates through 2035 for residential, commercial, industrial, and educational land use classifications.⁷⁷ The City of LA LID Ordinance, which became effective in 2012, requires all development and redevelopment projects that create, add, or replace 500 ft² or more of impervious area to capture the three-quarter inch rain event for infiltration or reuse on site. We calculated estimates of the redeveloped land areas, required volume capture, and revised costs for each BMP scenario in a post-modeling analysis (Table 2.17) if this ordinance were applied across the entire LAR watershed. Our analysis assumed all redevelopment is greater than 500 ft² and the projected redevelopment rate is maintained through 2028; redevelopment rates used by the City in earlier research efforts were used (ranging from 15% to 34% for different land uses).⁷⁸

⁷⁷ Redevelopment rates - LADWP SCMP on page 67 and LASAN EWMPs

⁷⁸ Redevelopment rates - LADWP SCMP on page 67 and LASAN EWMPs

Land use	% Redeveloped (2028)	Redeveloped Area (mi ²)	Volume Captured (AF)
Residential	12%	35.9	1,436
Commercial	10%	5.31	235
Industrial	22%	8.92	357
Educational	10%	1.14	46

85 th Percentile Storm Required Capture (AF)	Pre - redevelopment	Post - redevelopment (2028)	% Reduction
	10,396	8,345	19.72%

Scenario	Current Cost (billions)	New Cost (billions)	Savings (billions)
1a	6.6	5.22	1.38
1b	6.8	5.38	1.42
2a	3.8	3.00	0.80
2b	5.2	4.11	1.09
3a	3.8	3.00	0.80
3b	5.2	4.11	1.09

Table 2.17. Impact of watershed-wide redevelopment on captured volume and BMP costs⁷⁹

The implementation of an LID ordinance will result in substantial volume captured from “private land” uses (more than 2,000 AF, Table 2.17). LID ordinance implementation on residential land uses throughout the LAR watershed, for example, was estimated to capture approximately 1,400 AF in our post-modeling analysis (Table 2.17). This volume reduction would in turn reduce the number of BMPs that would be required to capture the 85th percentile storm, and thus the associated costs as well. Our analysis shows that the total reduction in required volume capture across the watershed is about 21%, resulting in capital cost savings of \$800 million to \$1.4 billion, depending on the BMP scenario selected. The impacts within the City of LA are smaller but still significant – by 2035, 1,610 AF could be managed through LID on private properties, which would result in an approximately 15% reduction in the volume of water the City would need to manage.

The corresponding annual average loads of zinc and copper would also decrease as the volume of stormwater decreases. Thus, redevelopment across the watershed could result in a 10% reduction in the zinc load and a 7% reduction in the copper load (Table 2.18). While this analysis relies on future knowledge of redevelopment (which is uncertain), these estimates provide a glimpse into how policy changes that affect development practices across the watershed can influence water quality and compliance. Within the City’s boundaries, zinc and copper loads would be reduced by 5.7% and 6%, respectively, by 2035.

⁷⁹ Redevelopment rates - LADWP SCMP on page 67 and LASAN EWMPs

WY 2004-2013	LAR (2012 levels)	LAR after Redevelopment	% Reduction
Zn (annual avg. load)	206,170	185,290	10.13%
Cu (annual avg. load)	33,826	31,405	7.16%
Total Flow (billion-ft ³)	124	107	9.04%

Table 2.18. Reduction in volume and metal loading post-redevelopment from 2012-2028

WY 2004-2013	LAR (2012 levels)	LAR after Redevelopment	% Reduction
Zn (annual avg. load)	206,170	139,695	32.24%
Cu (annual avg. load)	33,826	24,185	28.50%
Total Flow (billion-ft ³)	124	0.86	30.64%

Table 2.19. Reduction in volume and metal loading post-redevelopment from 2012-2028 when redevelopment rates for all private land uses were set to 50% by 2035.

As mentioned above, managing the 85th percentile storm on residential land throughout the LAR watershed could result in managing 1,400 AF of stormwater. However, the potential on private land uses could be much higher. For example, voluntary programs to increase LID practices can create far larger benefits by expanding implementation beyond those properties mandated to participate by an LID ordinance. Goals outlined in the EWMP include annually enrolling 1% of residential parcels in an LID program and the SCMP's conservative annual implementation rate for on-site capture on SFR parcels is 1.4%.⁸⁰ Partnerships with non-governmental organizations and others can facilitate developing effective programs that include community engagement as well as the potential to prepare standard plans to further broaden the program's reach.

For example, 'urban acupuncture' demonstration projects under Water LA by the River Project have included rain tanks, rain grading, and pervious surfaces to prevent runoff from leaving the parcel and parkway basins that intercept and infiltrate street runoff.⁸¹ In Panorama City, 24 properties were outfitted with tailored urban acupuncture strategies and are collectively infiltrating approximately 3.8 AFY; approximately 0.25 AFY is being infiltrated per parcel at the subset of homes that chose to maximize their rainwater capture potential. In addition, post-program water usage at these properties has generally dropped to under 55 gpcd.⁸² A second phase of Water LA, which is estimated to infiltrate 170 AFY of stormwater into the ground and conserve 35 AFY of potable water, includes plans to retrofit 100 properties and 1,000 parkway basins.⁸³

Thus, these benefits could be greatly magnified by extending the reach of an LID ordinance and increasing the voluntary implementation of these practices. For example, a LID retrofit upon sale ordinance that requires stormwater capture or infiltration for all parcels should be developed. The proliferation of LID projects can also be accelerated through the use of non-governmental

⁸⁰ ULAR EWMP Sxn 5.4.2 p 5-10; LADWP SCMP p. 68

⁸¹ ULAR EWMP Sxn 5.4.2 p 5-10, <http://www.riverproject.org/projects/water-la>

⁸² Personal communication, Melanie Winter, Water LA, the River Project

⁸³ USBR/LACFCD LA Basin Study Task 5 section 4.4.7 p 126

organizations and other partners working with the City. Non-governmental organizations in particular can help on community engagement, implementing LID projects on private property, schools, parks, alleys, and in parkways, and LID BMP maintenance. The combination of watershed-scale BMP programs in concert with multiple efforts to reduce sources to the watershed and ramp up BMP implementation on private properties will result in greatly improved water quality as well as provide additional local water supply potential.

d. Stream Buffer Ordinances

One potential option for reducing pollutant loads, protecting existing riparian habitat, and restoring sections of the LAR, is to add a vegetated buffer alongside the river and its tributaries. This vegetated buffer zone could potentially offer an invaluable asset for water quality protection as it can be utilized to capture or treat runoff before it enters the LAR or its tributaries and channels. Earlier City efforts resulted in the development of a draft stream protection ordinance that specified different buffer zones to protect water quality in the City's urban rivers.⁸⁴ The previously proposed ordinance included a 30-foot setback from a stream's top of bank and a 100 foot setback for natural streams.⁸⁵ This proposed ordinance further included a request to investigate a stream management fee of \$50 / sq ft of impervious area, which could not exceed \$15,000 / year, for all new and redevelopment adjacent to the river and its tributaries. 30% of the funding generated through this fee was intended to go to water quality improvement BMPs and 70% was to go to incentive grants that would assist streamside owners in doing a river-friendly remodel.

While it is not yet clear whether the City will reinitiate efforts to move forward on the development and approval of a stream buffer ordinance, we explored implementing a stream protection ordinance from a land acquisition and redevelopment perspective in the presented work. The stream buffer analysis presented here approaches the concept of a buffer from a slightly different angle that protects the unlined (more habitat-rich) sections of the LAR to a greater degree than the lined sections. We undertook a simple assessment of the impact of adding a 30 ft. buffer to each side of the lined portions and a 100 ft. buffer to unlined portions of the LAR watershed for the area represented in Figure 2.16.⁸⁶

⁸⁴ Department of Public Works, March 23, 2007. Withdrawn 'Adopt the Proposed Stream Protection Ordinance Requirements Attached Herein for all City and Privately Sponsored Construction Projects'

⁸⁵ LA's Proposed Ordinance for Stream Protection. March 2007

⁸⁶ The forest and smaller tributaries shown in the northern section of the watershed (without channel lines drawn) were excluded from this analysis, although these streams were potentially protected under the earlier draft ordinance.

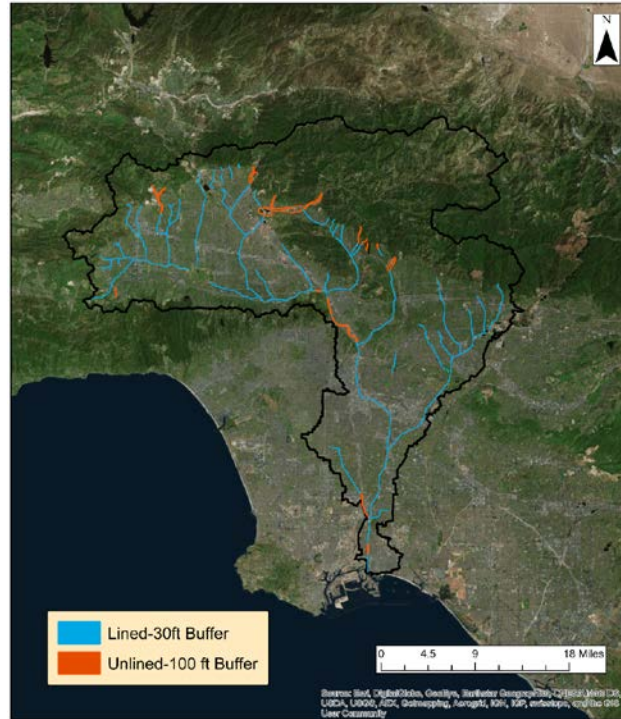


Figure 2.16. Map of the lined and unlined sections of the LAR watershed used for land use stream buffer analysis

Land use types were then quantified for regions within the unlined (~37 miles) and lined (~233 miles) sections as shown in Figures 2.17 and 2.18, respectively. Unlined channel sections were defined as a soft-bottom channel, according to the definition of an unlined channel identified by the LARWQCB through a feasibility study.⁸⁷ Using this definition, flowlines from the National Hydrography Dataset were used as a basis for the length of the channel; the undeveloped headwaters were removed and the incomplete streamlines were connected using ArcMap through aerial images to obtain the sections shown in Figure 2.16. The major land uses in the 100 ft. buffer surrounding the unlined segments of the river are vacant land (~52%), parks and recreation (14%), and single-family homes (~13%, Figure 2.17). The land uses in the 30 ft. buffer around the lined sections of the channel are predominantly single-family homes (~45%), followed by commercial (10%), and industrial (10%, Figure 2.18).

⁸⁷Los Angeles Regional Water Quality Control Board, 2010, Los Angeles Feasibility Study Workplan Attachment, Table 1, pg. 6; for a complete list of the soft-bottom reaches, refer to page 6 of this attachment: http://www.swrcb.ca.gov/losangeles/water_issues/programs/401_water_quality_certification/Flood%20Control%20Website%20Docs/6.%20Los%20Angeles%20Feasibility%20Study%20Workplan%20Attachment%20July%202010.pdf

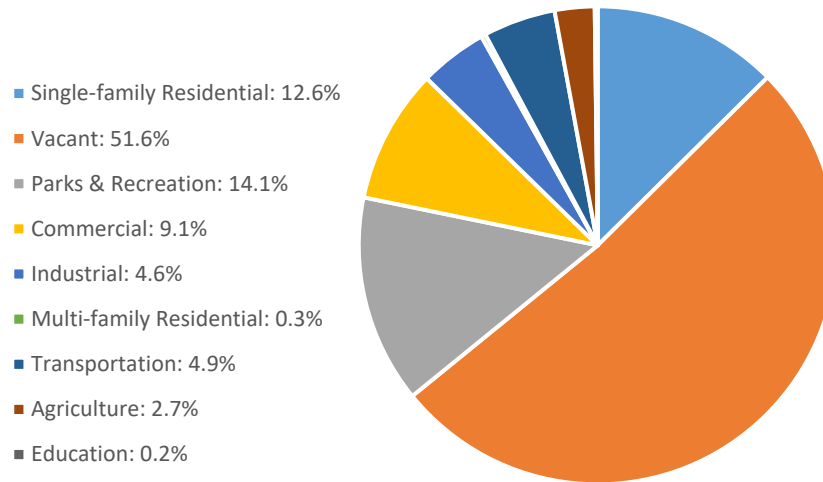


Figure 2.17. Land use classifications for the 100 ft. buffers adjacent to 37 miles of unlined section in LAR watershed

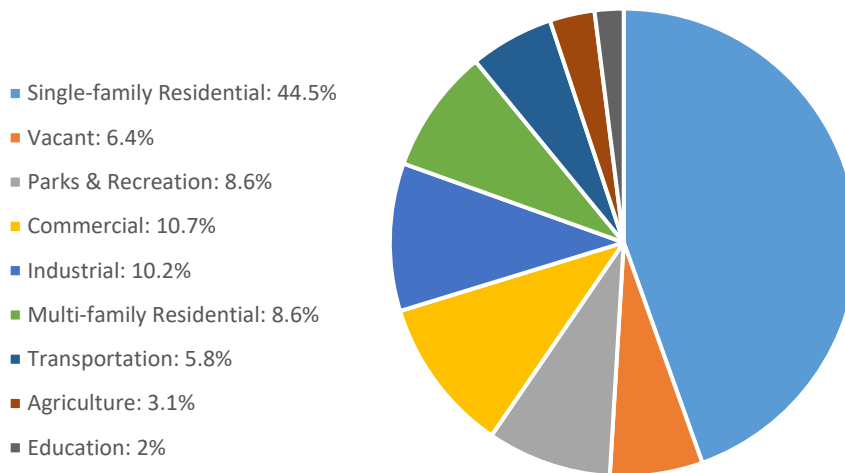


Figure 2.18. Land use classifications for the 30 ft. buffers adjacent to 233 miles of lined section in LAR watershed

Our analysis illustrates the opportunities and challenges associated with creating a riparian zone in a heavily urbanized basin. For example, due to a higher percentage of available vacant land, the unlined sections may be more easily converted to larger scale BMPs if the land is available for purchase and, importantly, if sufficient funding exists. Although the proposed draft stream protection ordinance could effectively reduce the further destruction of riparian habitat, the creation of protective buffer zones based on new and redevelopment adjacent to the river and its tributaries will not result in large, contiguous protected stream sections any time soon. In the lined sections in the lower basin however, single family homes comprise the largest land use type (at 45%) adjacent to these channels.

This points to the importance of implementing a broad range of programs that are targeted at specific areas and land use types to most efficiently capture runoff and improve water quality throughout the LAR watershed. In addition to the potential improvement in water quality, implementing a stream management fee along with these programs as was proposed in the 2007 ordinance could provide a sustainable funding mechanism to continue implementing BMPs adjacent to riparian habitat throughout the watershed. Further, this fee could facilitate the purchase of available vacant land for larger-scale BMP installation.

e. Discussion

None of the modeled scenarios capturing the 85th percentile storm resulted in the elimination of load-based metals exceedances, even with the copper WERs and lead SSOs that the LARWQCB approved in 2015 included in the modeling analyses. The number of exceedances, however, was greatly reduced. For example, dry weather load-based copper exceedances per year dropped from 307 to 62-75, zinc exceedances dropped from 214 to 15-19, and lead exceedances dropped from 127 to 47-57 depending on the modeled scenario. Wet weather exceedances were eliminated for lead (from 2 to zero in all scenarios), and reduced for copper (from 6 to 0-2) and zinc (from 14 to 3-6). It is important to note that concentrations can be used to attain compliance in lieu of load-based standards and concentration-based exceedances were far lower than in the baseline scenario. For example, the copper exceedances in the baseline scenario drop from 307 (load-based) to 13 (concentration-based). Similarly, lead exceedances drop from 127 to 0 and zinc exceedances drop from 214 to 3.

Thus, capturing and/or treating the 85th percentile storm volume may not necessarily result in the elimination of water quality standards exceedances. However, it is important to note that the quantitative modeling component presented here only considered the implementation of watershed-scale BMPs, not any of the additional measures that will be or are being implemented such as management control measures, source control, or BMP implementation on private land. In addition, this analysis only included metals impacts and the best scenarios for metals may not be the best scenarios for addressing other pollutants in the watershed such as trash or bacteria. The implementation of this type of watershed-scale BMP program does provide significant water quality benefits as well as offer the potential to augment local water supply and is thus a critical component of eliminating water quality exceedances. Robust modeling such as that outlined here provides the information necessary to address these trade-offs in planning efforts. The concurrent implementation of a wide variety of BMP programs of variable sizes on multiple land uses, as well as ongoing and planned source reduction mechanisms, will also help attain compliance with water quality standards in the LAR watershed. These BMP programs offer far greater water quality and ancillary benefit potential than, for example, a WER.

The copper WERs and lead SSOs that have been approved in the LAR watershed resulted in increased allowable concentrations and, thus, could effectively reduce the number of BMPs required to meet water quality standards. While this reduction in the required numbers of BMPs could potentially result in millions of dollars in cost savings, WERs do not provide any of the potential ancillary benefits (e.g., flood control, water supply, habitat, and recreation) that implementing BMP programs can. In addition, neither of these metals-focused changes eliminated any other water quality standards compliance requirements in the LAR. Thus, BMP programs will still

be required to address other pollutants such as fecal indicator bacteria as well as the metals exceedances that remain even after taking the WER into consideration.

Source reduction is an additional mechanism that will assist in achieving compliance with copper water quality standards in LAR. For example, California state legislation (SB 346) requires copper to be reduced to less than 0.5 percent copper by weight in new brake pads in cars by 2025 (currently, brake pads contain up to 20% copper with an average of 8% by weight).⁸⁸ This brake pad replacement is expected to greatly reduce copper concentrations in urban and stormwater runoff as it takes effect; a recent study found potential reductions in copper in urban runoff of as much as 61% if brake pads in essentially all on-road vehicles are at less than 0.5% copper.⁸⁹

Further, metals concentrations may also be reduced through additional requirements in the 2015 Industrial General NPDES Permit (IGP) to develop TMDL-specific permit requirements for those watersheds which include WLAs for dischargers that fall under the purview of the 2015 IGP.⁹⁰ For the LAR Toxic Pollutants Draft TMDL-IGP, responsible dischargers are IGP 2015 permittees “that discharge storm water associated with industrial activities and/or non-storm water to the impaired waterbody either directly or via a MS4 or an upstream [reach] or tributary.”⁹¹ If regional board and third party compliance assurance efforts are effective, then efforts by industrial dischargers to implement plans to reduce runoff pollutant concentrations and loads through program implementation should result in reduced industrial pollutant contributions to the LAR.

In addition, implementing BMPs throughout the watershed through programs such as an LID ordinance or voluntary / incentive programs will provide significant water quality and potential supply benefits. The multiple modeled BMP scenarios that were capable of capturing the 85th percentile storm volume in the LAR all required significant amounts of land for BMP implementation, some of which could also be offset by increasing LID implementation on private land uses. While our modeling analyses only placed BMPs on public lands, BMPs on private land also offer the potential to reduce loadings to the LAR channels through, for example, the City’s LID redevelopment ordinance. A post-modeling analysis looking at a similar LID ordinance implemented across the watershed found that a 10% reduction in zinc load and a 7% reduction in copper load was expected to stem from redevelopment on residential, commercial, industrial, and educational land uses by the end of 2028. This redevelopment will further result in a 21% reduction of volume

⁸⁸ Senators Kehoe and Simitian. February 25, 2009, amended on June 21, 2010. CA State Bill Number 346. http://www.leginfo.ca.gov/pub/09-10/bill/sen/sb_0301-0350/sb_346_bill_20100621_amended_asm_v92.html; https://calpsc.org/mobius/cpsc-content/uploads/2015/01/casqa_SB-346_brake_pad_Fact_Sheet.pdf;

⁸⁹ Estimated Urban Runoff Copper Reductions Resulting from Brake Pad Copper Use Restrictions https://www.casqa.org/sites/default/files/library/technical-reports/estimated_urban_runoff_copper_reductions_resulting_from_brake_pad_copper_use_restrictions_casqa_4-13.pdf

⁹⁰ 2015 IGP p.6

⁹¹ Proposed Addition to Attachment E (of IGP 2015), List of TMDLs Applicable to Industrial Stormwater Dischargers March 2016 for Machado Lake Pesticides and PCBs TMDL p. 1 and for DC/LAR Toxic Pollutants p.1

that must be captured to capture the 85th percentile storm. The volume captured through redevelopment could result in capital cost savings of \$800 million to \$1.4 billion due to the reduction in the number of BMPs required to comply with the MS4.

These benefits could be greatly magnified by extending the reach of an LID ordinance. For example, a LID retrofit upon sale ordinance that requires stormwater capture or infiltration for all parcels should be developed. The proliferation of LID projects can also be accelerated through the use of non-governmental organizations and other partners working with the City. Non-governmental organizations in particular can help on community engagement, implementing LID projects on private property, schools, parks, alleys, and in parkways, and LID BMP maintenance. The combination of watershed-scale BMP programs in concert with multiple efforts to reduce sources to the watershed and ramp up BMP implementation on private properties will result in greatly improved water quality as well as provide additional local water supply potential.

This type of modeling analysis provides invaluable information on the potential tradeoffs among various BMP programs that all improve water quality as well as provides insight into how and where the other efforts described above can best complement these BMP programs. With this information, decision-makers can tailor programs, either through design of their own projects or programs to incentivize the construction of certain BMP types on private lands, to create desired outcomes in each part of the watershed. For example, infiltration BMPs could be preferentially selected where the connection of recharged stormwater to a groundwater basin used for water supply is readily quantifiable. Elsewhere, treat-and-release BMPs could be preferentially selected where the link to groundwater is not readily available or the released stormwater could be diverted to a local treatment plant or spreading basin downstream.

III. Historical Flow Analysis in Mainstem and Selected Tributaries

A. Introduction

The LAR is entering another transformative era in its history, perhaps as great as the one which resulted in its channelization several decades ago. At a national level, the LAR watershed was selected for a nation-wide pilot effort under the Urban Waters Federal Partnership; one of the stated goals for the LAR watershed is to restore ecosystem functions.⁹² Although the LAR has always been protected by the CWA, in 2010 the entirety of the LAR was designated as a Traditionally Navigable Water. Subsequently, the State of California codified the LAR as a navigable water of the state as well.⁹³

The City and the US Army Corps of Engineers (USACE) have approved Alternative 20 (the locally preferred plan) to revitalize the LAR; the implementation of this alternative is planned to result in more than 700 acres of restoration features such as daylighted streams, widened channels, restored freshwater marshes, and restored confluences.⁹⁴ The total estimated cost to implement these projects is \$1.31 billion dollars.⁹⁵ The Water Infrastructure Improvements for the Nation Act (S. 612, WIIN Act), which was enacted in December 2016, authorized the US Army Corps of Engineers' Los Angeles River Ecosystem Project of the Los Angeles River Ecosystem Restoration Feasibility Study (also known as the "ARBOR" Study, which refers to its 11-mile Area with Restoration Benefits and Opportunities for Revitalization).⁹⁶ The City of Los Angeles is the project's non-federal sponsor. WIIN authorized the federal share of the project, which equals \$373.4 million to the Army Corps' Civil Works program. That program has a backlog of more than \$60 billion in authorized projects. The non-federal share is more than \$1 billion. Local funding actions will trigger federal appropriation actions. The process is expected to take many years unless creative, cross-sector financing, such as co-implementation with transportation infrastructure or funding utilizing State and/or private resources, is employed.

Several projects to improve the LAR watershed have already been funded through Proposition O, which Los Angeles citizens voted for in 2004, to fund up to \$500 million in projects related to improving water quality in the City. As a result, the City has directed funding toward 42 regional and distributed stormwater capture and treatment projects. City-wide Proposition O efforts as of

⁹² USACE LAR Ecosystem Restoration Draft Integrated Feasibility Report, Executive Summary, 2013, p. xx.

⁹³ USACE LAR Ecosystem Restoration Draft Integrated Feasibility Report, Executive Summary, 2013, p. xx.

⁹⁴ City of LA Los Angeles River Ecosystem Restoration Project Reader Guide, p.12; <http://lariver.org/blog/la-river-ecosystem-restoration-feasibility-study>; <http://www.spl.usace.army.mil/Missions/Civil-Works/Projects-Studies/Los-Angeles-River-Ecosystem-Restoration/>

⁹⁵ City of LA Los Angeles River Ecosystem Restoration Project Reader Guide, p.12; <http://lariver.org/blog/la-river-ecosystem-restoration-feasibility-study> p. 13

⁹⁶ <https://www.govtrack.us/congress/bills/114/s612>; <https://www.govtrack.us/congress/bills/114/s612/text>

July 2016 have resulted in: 26 completed projects, five projects in post construction phase, five projects in construction phase, and four projects in design.⁹⁷ Implemented projects range from stormwater capture to wetlands reconstruction.⁹⁸ All projects were designed to help meet TMDL water quality standards for trash, bacteria, and/or metals, with specific objectives to protect waterways; reduce flooding and pollutant loading in neighborhoods; and capture, clean, and reuse stormwater. In the LAR watershed specifically, Proposition O projects include Echo Park Lake, Hansen Dam treatment wetland, thousands of catch basin screens and inserts, the LA Zoo LID parking lot, Albion Dairy, Oros and Broadway green streets, South LA Wetlands Park, and Elmer Ave.

Further, multiple groups are exploring the potential in the LAR and its watershed on a variety of topics including water quality, water supply, recreation, habitat, and community access to resources such as parks, among other topics. In addition to the work presented here, multiple efforts in the Los Angeles area have recently assessed the conditions of the LAR; some also identified and examined a variety of potential future flow scenarios as part of this process. The Nature Conservancy⁹⁹, River LA¹⁰⁰, the US Army Corps of Engineers (USACE)¹⁰¹, and the City¹⁰² have been investigating the LAR to assess current conditions, potential and desired uses, and opportunities to enhance uses such as recreation, water supply, and habitat. Earlier studies such as the LAR Revitalization Master Plan, which aimed to develop a 20 year blueprint the City could implement for the development and management of the LAR, also provide valuable information.¹⁰³

These research and planning efforts are currently being undertaken to understand how we can change the face of the LAR to satisfy many potential functions such as flood control while also considering the potential for benefits such as recreation and habitat. There are multiple beneficial uses for water in the LAR, including habitat and recreational uses such as kayaking or hiking. The LAR can also play a role in potential local water supply. In this section, we will examine current and historical flows in the LAR and discuss a potential study design to identify the optimal flow values in the LAR.

⁹⁷ http://lacitypropo.org/uploads/docs/monthlyReports/2016/2016-07_PropositionOMonthlyReport.pdf

⁹⁸ See list of completed Prop O projects here: <http://www.lastormwater.org/green-la/proposition-o/about-proposition-o/>

⁹⁹ http://e360.yale.edu/feature/restoring_the_los_angeles_river/3015/

¹⁰⁰ <http://riverlareports.riverla.org/about/>

¹⁰¹ <http://lariver.org/blog/la-river-ecosystem-restoration-feasibility-study>

¹⁰² City One Water LA efforts – low flow study

¹⁰³ LA River Revitalization Master Plan archives and links to various other LA River research efforts: <http://lariver.org/master-plan>, Accessed July 2017.

B. Flows in LAR and selected tributaries

a. Runoff Ratio

As impervious surfaces replace undeveloped, more pervious surfaces, stormwater has less opportunity to infiltrate or evapotranspire. Instead, stormwater washes off surfaces and can lead to increased flood risk to life and property. The Los Angeles region recognized this risk in the early 20th century after a series of devastating floods.¹⁰⁴ With federal aid, the region built hundreds of flood control structural measures to ensure stormwater could be directed as quickly and efficiently as possible downstream to mitigate flood risk.¹⁰⁵

To investigate the historical hydrology of the LAR, we first evaluate the runoff ratio. Here we define an annual runoff ratio as: total depth of surface runoff (all water draining to a point) / depth of precipitation, over the annual water year. In this case, for the LAR, surface runoff includes WRP discharge and any imported water indirectly added to the system through irrigation and runoff. Our goal was to assess historical and future impacts on the LAR as a hydrologic system during all seasons rather than focusing only on stormwater runoff (precipitation-driven events). This value provides a metric for the amount of water leaving the watershed relative to incoming precipitation over an annual cycle.

The same precipitation gages and discharge observations (Wardlow, F319) used in the hydrologic modeling were used to calculate the long-term runoff ratio for the entire LAR watershed from 1956 to 2013 (Figure 3.1).¹⁰⁶ The calculated runoff ratio illustrates a violation of the natural theoretical limit, with values greater than one indicating a system that has higher runoff (output) than precipitation (natural input), due to imported water and outdoor irrigation. In addition to an increase in the runoff ratio since 1940, we note an increase in variability in the last decade, with 2002, 2007, and 2013 having markedly higher ratios than the surrounding years (Figure 3.1), due to reduced rainfall and higher irrigation and/or WRP additions to streamflow (higher numerator and lower denominator results in the higher runoff ratio).

¹⁰⁴ Department of Public Works Los Angeles County, History of the Los Angeles River, Accessible at: <http://ladpw.org/wmd/watershed/LA/history.cfm>

¹⁰⁵ Department of Public Works Los Angeles County, History of the Los Angeles River, Accessible at: <http://ladpw.org/wmd/watershed/LA/history.cfm>

¹⁰⁶ <http://wwwcimis.water.ca.gov/Default.aspx>

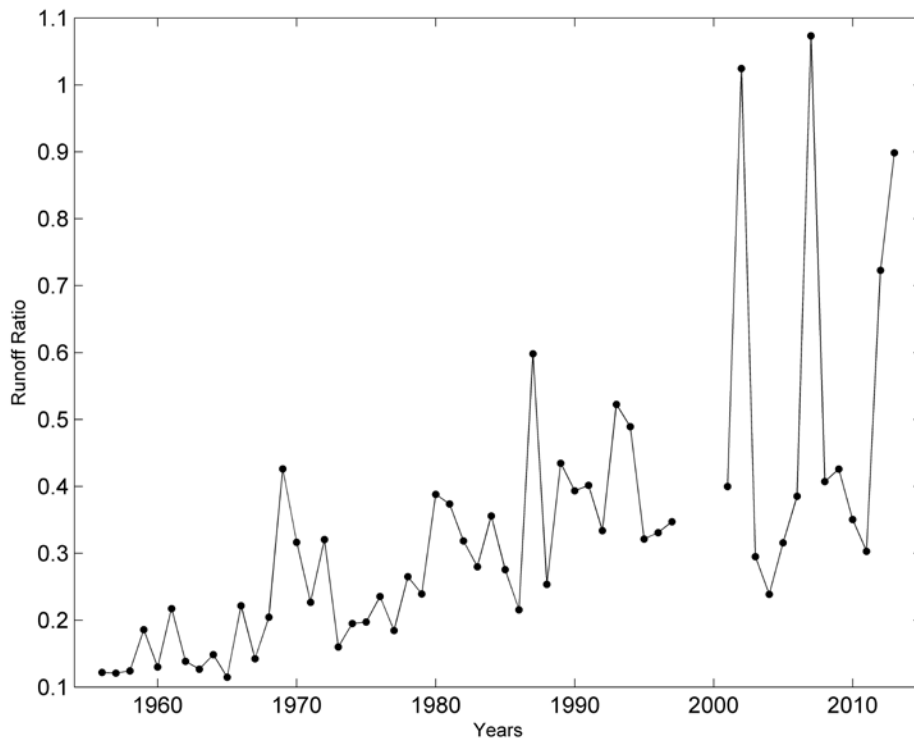


Figure 3.1. Historic runoff ratio for Los Angeles River

Decadal averages for the historic runoff ratio along with the effect of each BMP scenario over the 10-year simulation period were also examined (Figure 3.2). The most recent decade has a runoff ratio of around 0.58, whereas the mid-century (1950s) runoff ratio was just over 0.10. As the WRP facilities came online, flows through the basin increased relative to precipitation. The runoff ratio increased from 1990-2000, likely due to the wet 1997-1998 El Niño as well as high residential irrigation during the dry years. Results from the modeling show a dramatic decrease in flow during this time at the outlet across all BMP scenarios, with most values comparable to the 1950 value. In general, the increasing trend in historic runoff ratio can be explained by the impact of urbanization, which has led to more imported water, urban irrigation, and thus to a notable change in the hydrologic regime in LAR. Scenario 2a (VS + DP) has the highest runoff ratio because dry ponds treat-and-release stormwater back to the channel so more water is returned to the channel than in scenarios with more infiltration BMPs. Also, all of the “b” scenarios, which contain porous pavement, have a reduced runoff ratio as compared with “a” scenarios; this demonstrates that porous pavement provides additional capacity to infiltrate stormwater (see Table 2.9 for potential volumes of infiltrated stormwater under various BMP scenarios).

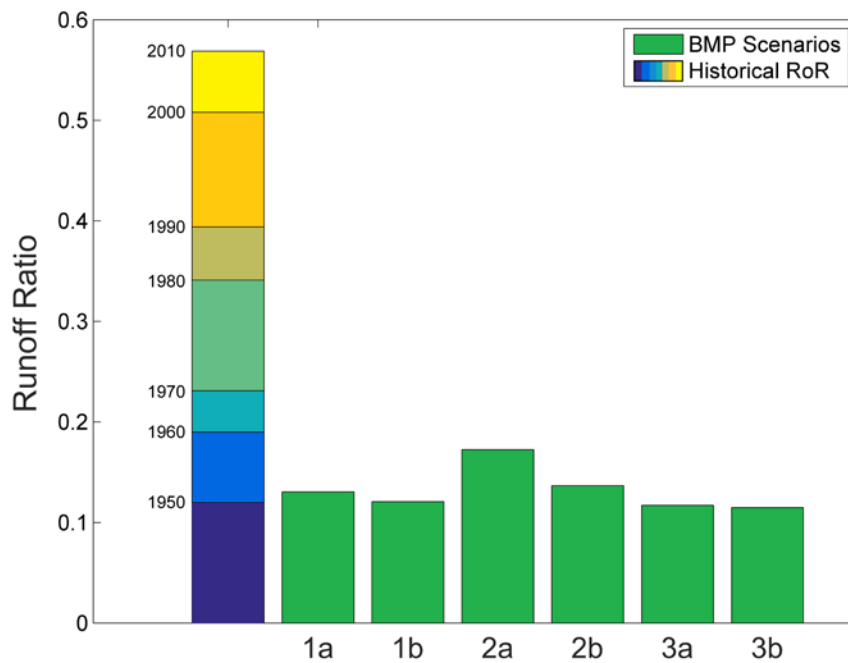


Figure 3.2. Comparison of historical (1940-2010) and BMP runoff ratios (2004-2013)

b. Historic Flow Percentiles

While the annual runoff ratio provides an indicator of general flow properties of a system, a flow duration analysis [represented by a cumulative distribution function (CDF)], represents the likelihood of a given flow volume occurring a certain percentage of the time. Figure 3.3 shows the CDF for the LAR, based on historic observed flow at the outlet from 1956-2013 (baseline, historical), and observed and modeled flow (2004-2013) without BMPs (baseline, observed and modeled) and with BMPs (scenarios 1a-3b). Daily average flows were used for this analysis. Note that WRP flow is included in the flow values for all cases. Results indicate a clear difference in observed low-flow percentiles between the complete historic and model periods, indicating a shift in the flow regime where there now is more flow in the river.

The implementation of BMPs reduces this shift in the baseline flow by about 20-30 cfs (13-19 MGD), though there is almost no difference between the post-BMP flow regimes themselves until the 80th percentile, where those scenarios with infiltration BMPs reduce peak flow more than the treat-and-release configurations. In general, this flat CDF shows an increasingly highly urbanized system, where the low and medium flows are nearly indistinguishable, and only the peak flows differentiate. With the current volumes of effluent discharged into the LAR, we found recent low flows in the LAR to be approximately 100 cfs (2003 to 2014 data) at Wardlow Gage (based on analysis of daily average flows). Historical low flows (1956-2013), however, were noted to be an order of magnitude lower, approximately 10 cfs (~10th percentile).

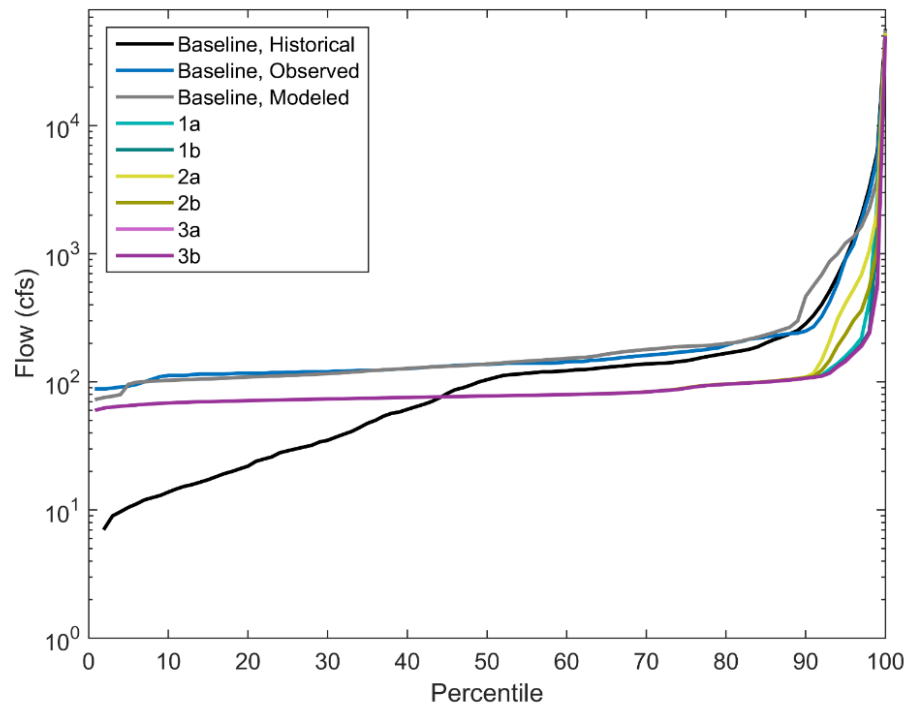


Figure 3.3. Flow duration analysis (or CDF) for LAR for different periods: baseline, historical (1956-2013); baseline, observed and modeled (2004-2013); BMP scenarios 1a-3b (2004-2013)

c. Historic Seasonal Flows

The variability of seasonal flows in LAR is also an essential piece of information, since the patterns of flow for winter and summer months are extremely different both in terms of the source (winter precipitation) and use (summer irrigation). In this study, winter is defined as December through February and summer is defined as June through August. Understanding the flow regime on a seasonal basis can enable planners to determine when reuse and alternative water savings technologies may be appropriate versus when infiltration and storage or diversion are possible. Figures 3.4 and 3.5 show observed seasonal minimum and maximum flows, respectively, at the outlet (Wardlow gage) for the period of record (note the data gap in 1999 due to inoperable gage). The vertical blue lines in Figure 3.4 (minimum) represent the three WRPs coming online; each new WRP gradually increases the baseline seasonal flow. As expected, the minimum and maximum flows are higher in the winter, though the difference in minimum flows between seasons is negligible aside from several peak years when flows were higher. The maximum flows in the

summer are lowest, indicating that this is not the optimal time of year for building up storage, though it is a peak time for outdoor irrigation use.¹⁰⁷

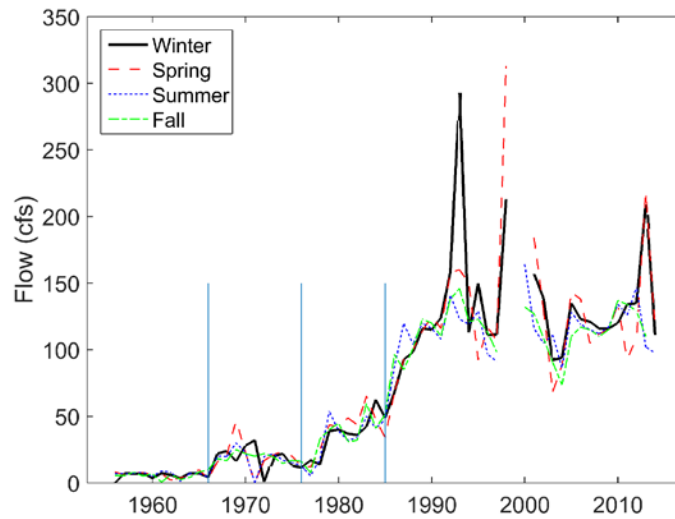


Figure 3.4. Historic seasonal annual minimum flows (daily average) in the LAR, measured at the Wardlow gage; blue vertical lines represent WRPs coming online

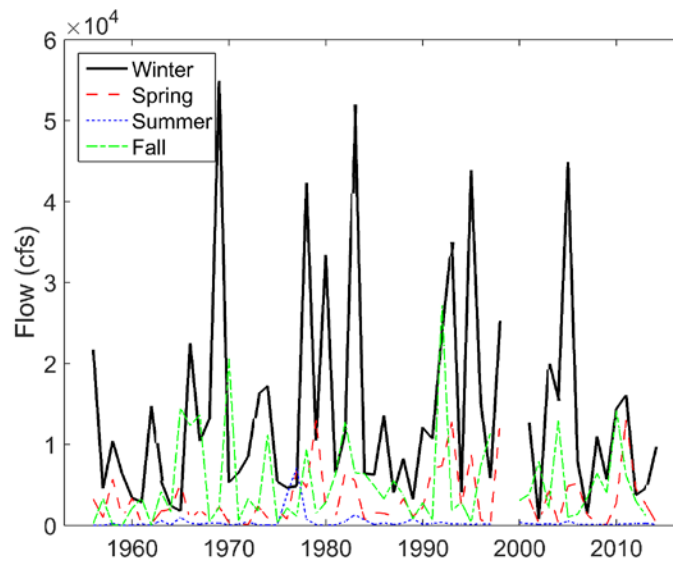


Figure 3.5. Historic seasonal annual maximum flows (daily average) in the LAR, measured at the Wardlow gage

¹⁰⁷ Manago, K. and T.S. Hogue, 2017: Urban streamflow response to imported water and water conservation policies in Los Angeles, California, JAWRA.

The intra-variability between BMP scenarios and inter-variability between locations regarding seasonal flows was examined for modeled flows from 2003-2014 for the Tujunga subbasin (no WRPs upstream of the gage site) and for the LAR at Wardlow gage (Table 3.1). The median values at Tujunga are lower by about 50% than those at Wardlow. Note that while the median seasonal flows for each BMP scenario (1a-3b) are approximately the same, all BMP scenarios are different than the baseline (modeled with no BMPs), which indicates the absolute impact that BMPs would have on seasonal median flows at each location.

Season	Tujunga	Flow (cfs)	Wardlow	Flow (cfs)
Fall	Baseline	65.01	Baseline	133.59
	1a	47.52	1a	91.00
	1b	47.53	1b	91.00
	2a	47.52	2a	91.00
	2b	47.53	2b	91.00
	3a	47.52	3a	91.00
	3b	47.52	3b	91.00
Spring	Baseline	71.44	Baseline	178.49
	1a	46.82	1a	89.37
	1b	46.96	1b	89.36
	2a	46.82	2a	89.37
	2b	46.93	2b	89.37
	3a	46.82	3a	89.36
	3b	46.82	3b	89.36
Summer	Baseline	61.54	Baseline	142.03
	1a	46.68	1a	87.08
	1b	46.68	1b	87.08
	2a	46.68	2a	87.08
	2b	46.68	2b	87.08
	3a	46.68	3a	87.08
	3b	46.68	3b	87.08
Winter	Baseline	79.57	Baseline	187.57
	1a	56.62	1a	99.72
	1b	59.13	1b	99.36
	2a	56.62	2a	100.11
	2b	58.44	2b	99.72
	3a	56.62	3a	99.27
	3b	56.62	3b	99.36

Table 3.1. Median seasonal flows summary: Tujunga basin and Wardlow gage for BMP scenarios

d. Low Flow 7Q Analysis

In an effort to understand the evolution of low flows for establishing ecological and recreational minimum flow policies, a 7-day (7Q) low flow analysis was conducted on annual minimum flows at several gages in the LAR watershed. Annual 7-day (7Q) low flow analyses were conducted at the Wardlow, Arroyo Seco, and Tujunga gages and constructed by averaging the flow every seven days of the year and taking the minimum value (Figure 3.6). A change point analysis, conducted to identify whether a shift in the mean and/or variance in the 7Q flows had occurred, and in what year, revealed that 7Q flows at Wardlow and Tujunga shifted in 1986. The Wardlow

and Tujunga gages both show an increase in 1986, at which point a higher baseline 7Q minimum flow is established. Note that the Arroyo Seco flows, however, which represent a more natural “unengineered” tributary (the measurement occurs at the outlet of the national forest), did not experience a change point and remain relatively constant over time.

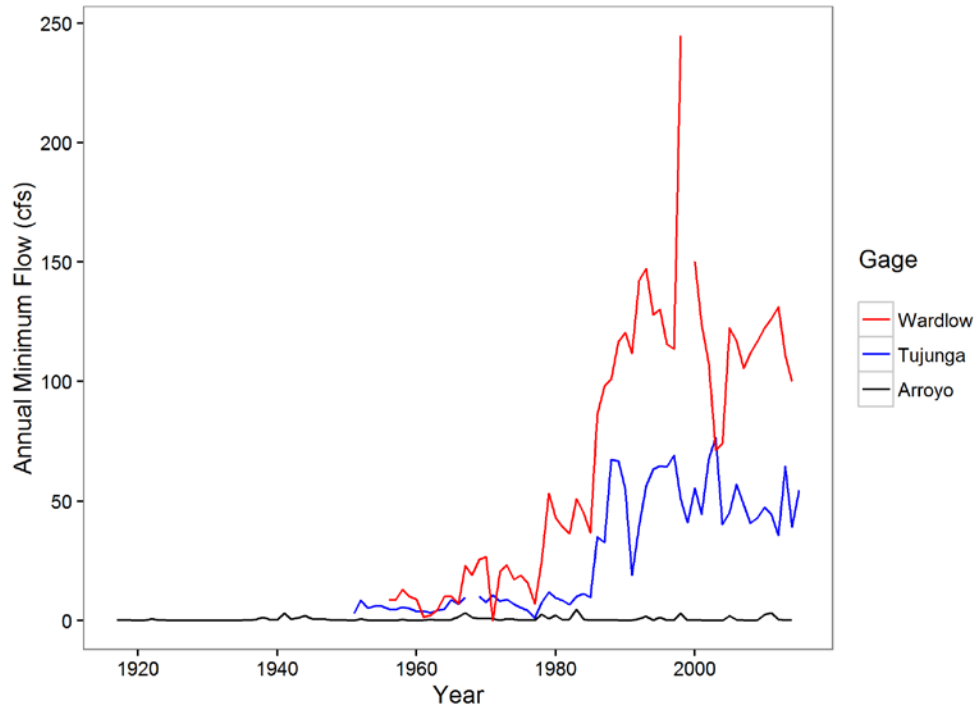


Figure 3.6. Annual 7-day low flows for LAR measured at three gages (Wardlow, Tujunga, and Arroyo Seco, gages located on tributaries) over historical records

According to standard practices put forth by the U.S. Interagency Advisory Committee on Water Data, the annual 7-day flows are fit to a Log-Pearson III to determine the expected return periods (e.g. 7Q2 – 2 year, 7Q10 – 10 year) for a range of flows (Figure 3.7).¹⁰⁸ Note that the 7Q analysis was split into two time periods (1957 – 1985; 1986 – 2015) due to the change point in 1986. An analysis found that the Gamma distribution was a better fit for the flows from 1957-1985 as measured by the confidence intervals, while the latter time period flows follow the Log Pearson III distribution. This analysis was also completed for Tujunga and Arroyo Seco, with 7Q figures shown in Appendix C; 7Q2 and 7Q10 flows were analyzed for the observed period of records across all three gages (Table 3.2). The shift in 7Q flows seen at Wardlow is attributed to the increased flow from the DCTWRP plant, which began discharging in 1986.

¹⁰⁸ U.S. Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency, Bulletin 17-B of the Hydrology Subcommittee: Reston, Virginia, U.S. Geological Survey, Office of Water Data Coordination, [183 p.]. [Available from National Technical Information Service, Springfield VA 22161, as report no. PB 86 15 7278.]

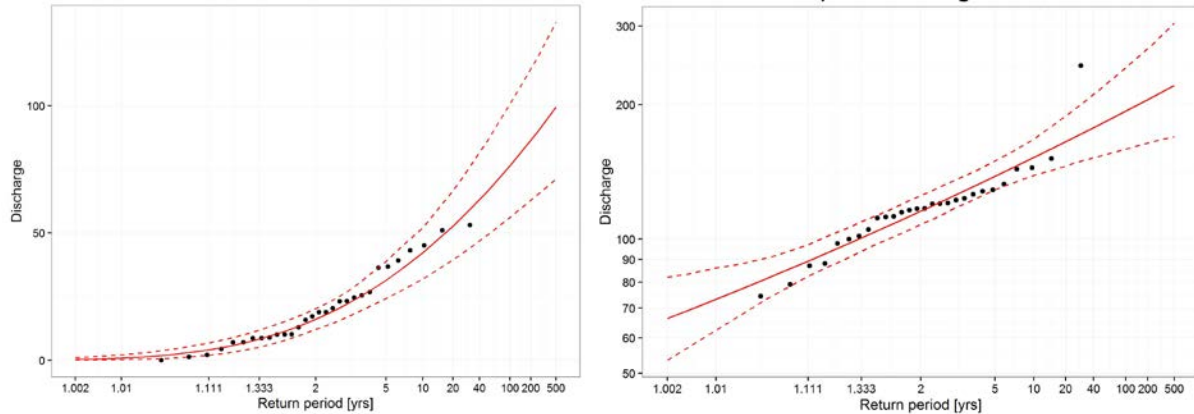


Figure 3.7. Annual 7Q low flows and expected return periods for LAR measured at Wardlow gage for (a) 1956-1985 and (b) 1986-2014; the red dashed lines indicate the 90% confidence interval for the distribution of flows – Gamma for (a) and Log Pearson III for (b). All discharge units are in cfs.

Gage	Time Period	Years	7Q2 (cfs)	7Q10 (cfs)
Wardlow	1956-1985	30	16.1	42.2
Wardlow	1986-2014	29	112	157
Tujunga	1951-1985	35	6.8	10.6
Tujunga	1986-2015	30	51	68.9
Arroyo Seco	1917-2014	98	0.3	1.73

Table 3.2. Summary of 7Q statistics for gages in LAR watershed

This analysis shows that 7Q10 and 7Q2 analyses are a valuable tool for assessing whether there have been changes in flows throughout the history of a waterbody and from there, identifying the potential causes of this change. This approach could inform decisions on appropriate flows in the LAR watershed and subwatersheds. At both Tujunga and Wardlow, an increase in flows occurs in 1986 (Table 3.2). The shift in flows at Wardlow from 42 cfs to 157 cfs can be attributed to a combination of the increased flows coming into LAR from Tujunga and to the discharge of effluent from DCTWRP into LAR; the reason for the shift in Tujunga flows during this time period is less clear. If one wanted to achieve flows that mimic historic flows, then choosing a flow regime with similar 7Q2s and 7Q10s for Wardlow and Tujunga pre-1986 would be one potential approach.

By way of contrast, flows in the Arroyo Seco (measured at the outlet of the national forest, above the urban area), which represents a more natural “unengineered” tributary, did not experience a change point. Thus, the Arroyo Seco appears to have been relatively unchanged by any external factors over the last hundred years (1917-2014). Identifying 7Q flows is a potential mechanism by which impacts on a river can be evaluated and monitored from policy or regulatory

standpoints. Defining changes in 7Q10 flows has been used in Vermont; there, a reduction in 7Q10 flows by more than 5% was established as a negative impact on natural river flow regimes.¹⁰⁹

e. Impacts of BMPs on Streamflow

Implementing BMPs to meet water quality compliance standards can also impact flow regimes in the basin; it is important to understand these flow impacts to ensure adequate year-round low flows in the LAR to support its designated uses. Since the LAR covers such a large area, three comparison points were selected based on available observational data and modeled sub-basins to examine seasonal flow distributions: Tujunga (no WRP flow contribution), Wardlow, and Glendale Narrows. The seasonal flow distribution for Tujunga is shown in Figure 3.8, with the six BMP scenarios (BR, BR+PP, VS+DP, VS+DP+PP, VS+IT, VS+IT+PP) compared against Wardlow Gage (in red) over the modeled time period (2004-2013). The boxplot in figure 3.8 displays the lower (Q1) and upper (Q3) quartiles of the given data (upper and lower bounds of the box). The horizontal line within the box is the median value (Q2) while the vertical lines above and below the box represent the maximum and minimum values of the data, excluding outliers. Outliers are defined as data values that are at least 1.5 times the size of the Q1 and Q3 bounds. In addition to this information, Figures 3.9 and 3.10 also display the mean value (blue dot).

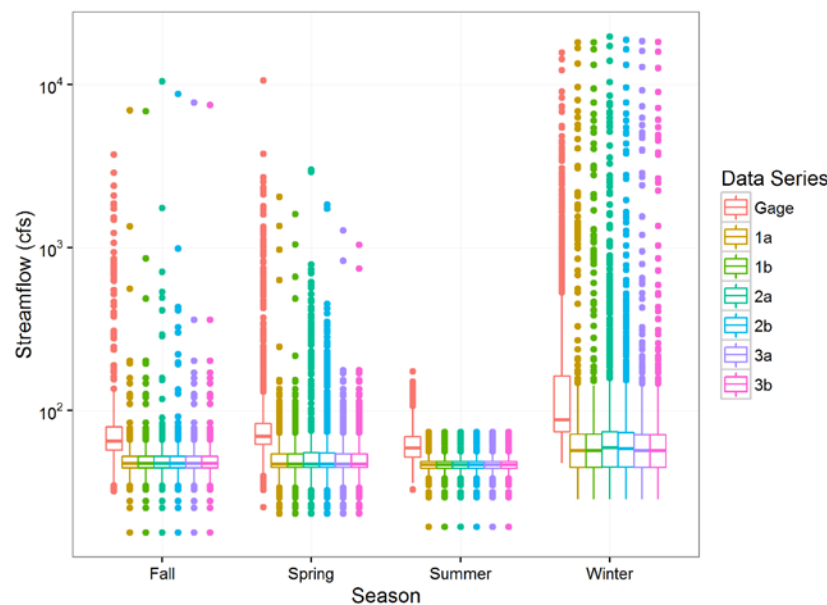


Figure 3.8. Comparison of seasonal flow distribution for Tujunga sub-basin for modeled time period (2004-2013) for gage (red) and six BMP scenarios

¹⁰⁹ Novak, R.; Kennen, JG; Abele, RW; Baschon, CF; Carlisle, DM; Dlugolecki, L; Flotermersch, JE; Ford, P, Fowler, J; Galer, R; Gordon, LP; Hansen, SN; HHerbold, B; Johnson, TE; Johnston, JM; Konrad, CP; Leamond, B; Seelbach, PW; (2015) Draft: EPA-USGS Technical Report: Protecting Aquatic Life from Effects of Hydrologic Alteration: USGS Scientific Investigations Report 2015-5160, USEPA EPA report 822-P-15-002, XX. <https://www.epa.gov/wqc/draft-epausgs-technical-report-protecting-aquatic-life-effects-hydrologic-alteration-documents> p. 44 (EPA USGS Hydrologic Alteration Report 2015)

In general, winter months are skewed toward higher flows with presumably most of the precipitation events occurring outside the interquartile range. Significant variability is observed in BMP scenarios in the fall and spring periods, when rainfall events are also more variable. The fall season has a few large outliers across the scenarios, but most of the modeled flows cluster on the lower end of the range for most BMPs (Figure 3.8). However, the spring season shows more flows clustered in the mid-range for BMP scenarios 2a and 2b, when vegetation swales and dry ponds are implemented. Summer flows are lowest overall with the least variability after BMP implementation across all tested scenarios. The similarity of the six BMP scenarios designed to capture the 85th percentile storm indicates that in terms of seasonal flow distribution, there will not be a significant difference between selecting one over another. For Glendale Narrows and Wardlow, the impact of BMP scenario implementation is represented by one single scenario for the purposes of brevity. As flow impacts are similar across scenarios, planners could select scenarios with the most infiltration without placing too much additional pressure on in-channel flow levels.

Comparison of seasonal flow distribution at the Wardlow and Glendale gages is a more complex story since the contribution of WRP flow has significantly impacted in-channel base flow. However, Tujunga receives no flow from WRPs. Figures 3.9 and 3.10 illustrate the seasonal flow distributions over distinct time periods for Glendale Narrows and Wardlow, respectively, to understand how the flow distribution pre- and post-BMP implementation compares with earlier time periods (pre- and post- WRP flows). The periods are divided according to WRP implementation, represented by Pre LA-B (BWRP), Pre LA-G (LAGWRP), and Pre- and Post DCT (DCTWRP), compared with the modeled baseline flow – no BMPs – (2004-2013) and post-BMP flows (2004-2013) (Figures 3.9, 3.10).

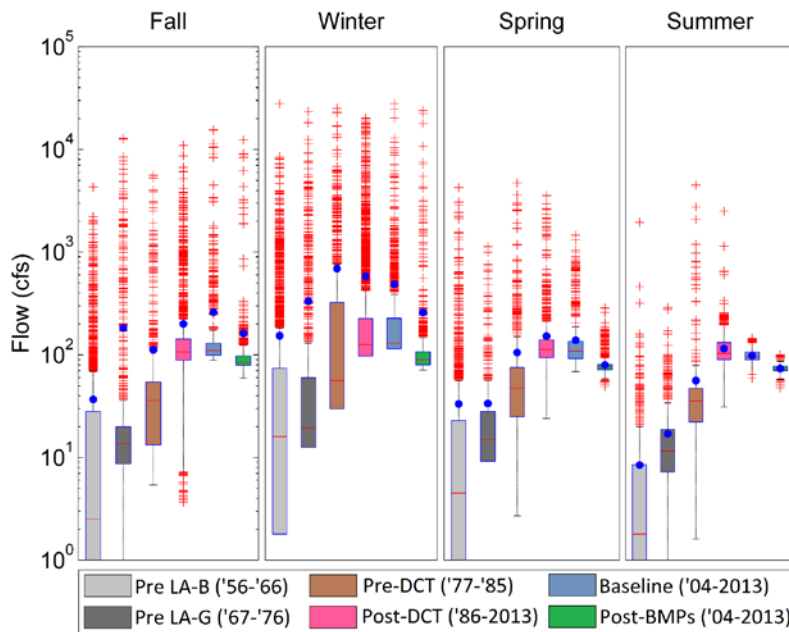


Figure 3.9. Comparison of selected historic seasonal flow distribution periods at Glendale Narrows F57 gage (observations) with modeled time period (2004-2013) showing baseline (blue) and post-BMP (green)

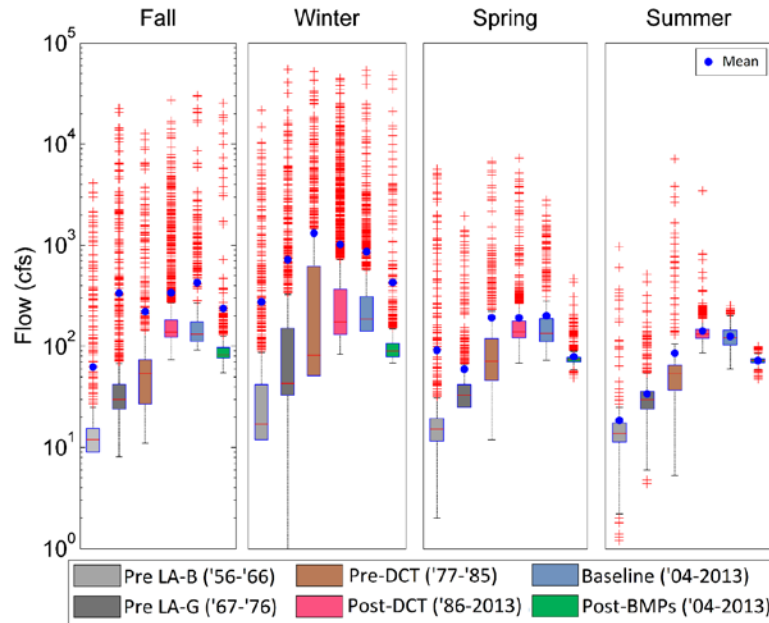


Figure 3.10. Comparison of selected historic seasonal flow distribution periods at Wardlow F319 gage (observations) with modeled time period (2004-2013); baseline (blue) and post-BMP (green)

At Glendale Narrows, the seasonal median flow post-BMP returns to a level between pre- and post-DCT, with a much tighter interquartile range across all seasons than historically observed. Note the tightening of seasonal flows since pre LA-B through post-DCT, indicating that the engineered infrastructure has altered the seasonal variation in flows over time. At Wardlow (Figure 3.10), the post-BMP seasonal flow median returns to a level similar to pre-DCT and shows the same pattern as Glendale. While the post-DCT median flows are similar between the baseline and post-BMP cases, note how the flow distribution tightens from the post-DCT to baseline and post-BMP implementation periods.

An additional question facing planners and water managers is whether or not flows in the LAR could approach zero if current WRP discharges are greatly reduced or eliminated and comprehensive BMP implementation occurs in the LAR watershed, and, if so, under what conditions. With regards to seasonal flow distribution, the impact of BMPs is expected to shift the median flow lower in all seasons compared with the baseline (no BMPs) over the same period at Tujunga, Glendale Narrows, and Wardlow as shown in Figures 3.8-3.10. Glendale Narrows and Wardlow were selected as points based on data availability, and observed flow was compared with modeled flow from scenario 3a (VS+IT) to assess impacts on flow due to BMP implementation. While implementing suites of BMPs to capture the 85th percentile does reduce annual in-channel flows, flows do not approach zero at Wardlow Gage or at Glendale Narrows due to the WRP discharge flows in the LAR. For example, modeled average annual flows at Wardlow Gage dropped by approximately 53 to 71%, from 237,000 AF to between 63,000 and 111,000 AF with the implementation of various BMP scenarios. Similarly, flows dropped 50 to 77% at Glendale Narrows from 94,000 AF to between 21,000 and 47,000 AF (Table 3.3).

Scenario	Wardlow Gage (AF)	Glendale Narrows (AF)
Baseline ¹¹⁰	237,000	94,000
BR	78,300	27,000
BR PP	68,400	24,500
VS DP	111,000	47,000
VS DP PP	78,200	32,300
VS IT	64,000	21,800
VS IT PP	63,500	35,100

Table 3.3. Average annual flow volumes at Wardlow Gage and Glendale Narrows.

One option for increasing supply is to build storage facilities and reclaim the water currently discharging from WRPs and the LAR channel out into the Pacific Ocean. Observed annual average flows in the LAR at Wardlow gage (including the forested area) are approximately 274,000 AFY (2003-2014).¹¹¹ Figure 3.11 shows the amount of water that has historically flowed through the Wardlow gage by season at the terminus of the LAR channel into the Pacific, thus representing the volume available for diversion or storage. Storage of flows during the winter months would provide the most water according to historical patterns, ranging from 10,000 to one million AF over the three-month period. Summer months are consistently lowest in terms of volume available, ranging from 2,000 to 10,000 AF.

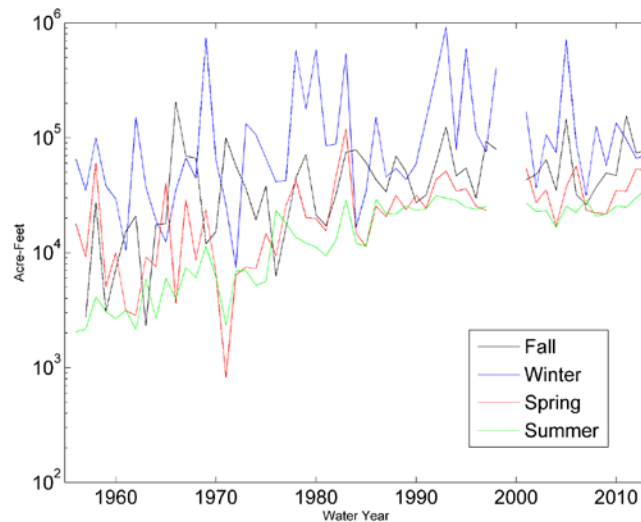


Figure 3.11. Seasonal volumes of water flowing through the Wardlow gage over the historical period (1956-2015)

¹¹⁰ LACDPW data

¹¹¹ LACDPW data

The annual volumes available for capture and supply after BMP implementation are shown in Figure 3.12, where the observed and modeled baseline flows are also illustrated for reference. During the particularly wet 2005, up to 800,000 AF were available for recapture without BMPs (600,000 AF with BMPs). However, during the more recent drier years, this volume was more likely to range between 100,000 to 200,000 AF with BMPs and 200,000 to 400,000 AF without BMPs. However, capturing and storing or infiltrating a large portion of these flows will require considerable investments in both regional and distributed green infrastructure projects.

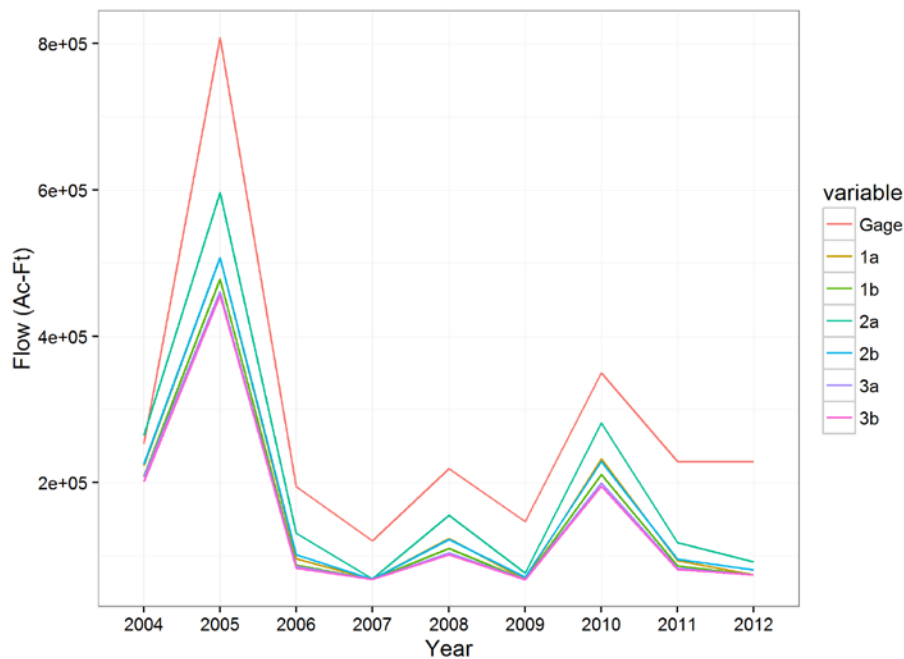


Figure 3.12. Annual flow volumes at Wardlow gage for the modeled time period (2004-2012) without BMPs compared to post-BMP implementation

Figure 3.13 illustrates the CDF (flow duration analysis as in Figure 3.3) at the Wardlow gage for pre-BMP (baseline, historical from 1956-2014; modeled and observed from 2003 – 2014) and post-BMP (BMP scenarios 1a-3b). Daily average flows were used in this analysis. WRP flows were not included in the flow values for all cases for comparison to daily average flows including WRPs (Figure 3.3). After BMPs are added to the system in scenarios 1a to 3b (and in the absence of WRP flows), there is no flow at Wardlow until the 80th percentile flow, which only results after a moderate to large rainfall event (Figure 3.13). Note that the difference between the historic flow profile (1956-2014) and recent period (2003-2014) shows a shift in the low flows (~ 0-50% percentiles), likely another result from the addition of WRP flows.

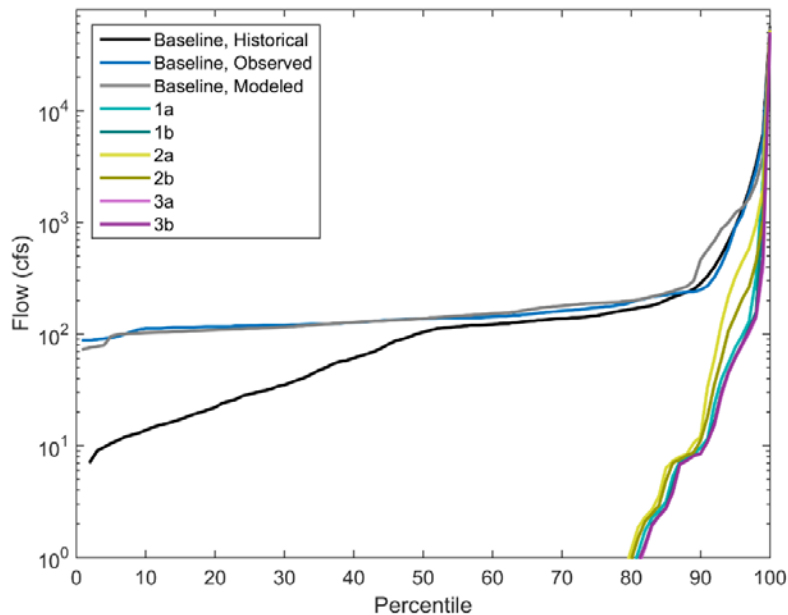


Figure 3.13. Flow duration analysis (or CDF) at the Wardlow gage (not including WRP flows), showing distribution of the historic flows (1956-2014; black), and BMP scenarios (1a-3b), baseline modeled with no BMPs (2003-2014; grey) and baseline observed (2003 to 2014; blue).

f. Impacts of WRPs on Streamflow

Flows in these channels, however, would also be affected if effluent being discharged into the channel is reduced as the volume of recycled water from these WRPs that is reused increases. To explore this, three ranges of annual WRP flow (2004-2013) contribution reductions (0%, 50%, 100%) were calculated to understand how flow would respond if some portion (or all) of WRP flow was stored or diverted for supply at Wardlow Gage and Glendale Narrows. For both locations, removal of all WRP flows after BMP implementation leads to the annual minimum flow approaching zero for all modeled years (Figure 3.14 and 3.15). Therefore, benefits from diverting WRP flow for supply will need to be considered alongside the potential adverse impacts of reducing LAR flows on aquatic or ecologic life and habitat as well as recreational activities.

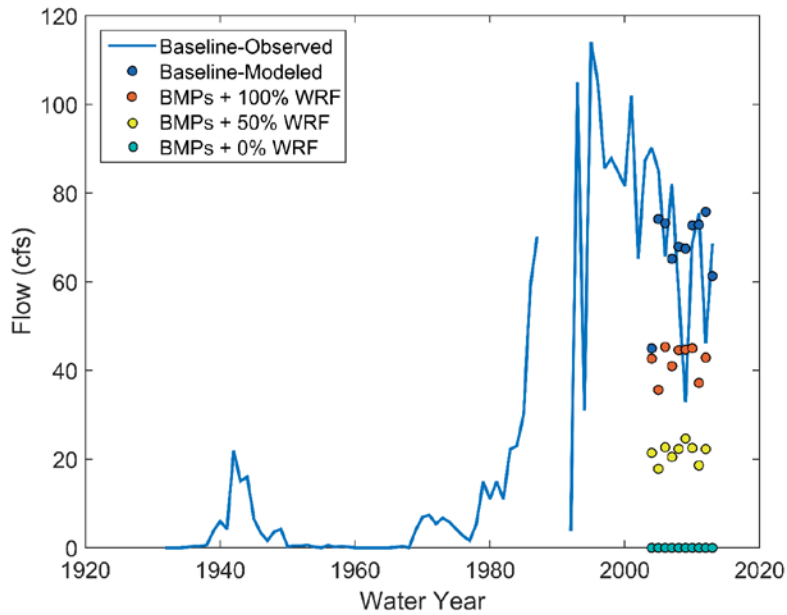


Figure 3.14. Annual minimum flows at Glendale Narrows (blue line) compared with modeled baseline (blue points), and post-BMP flows with varying amounts of WRP flow (0% - aqua, 50% - yellow, 100% - orange points)

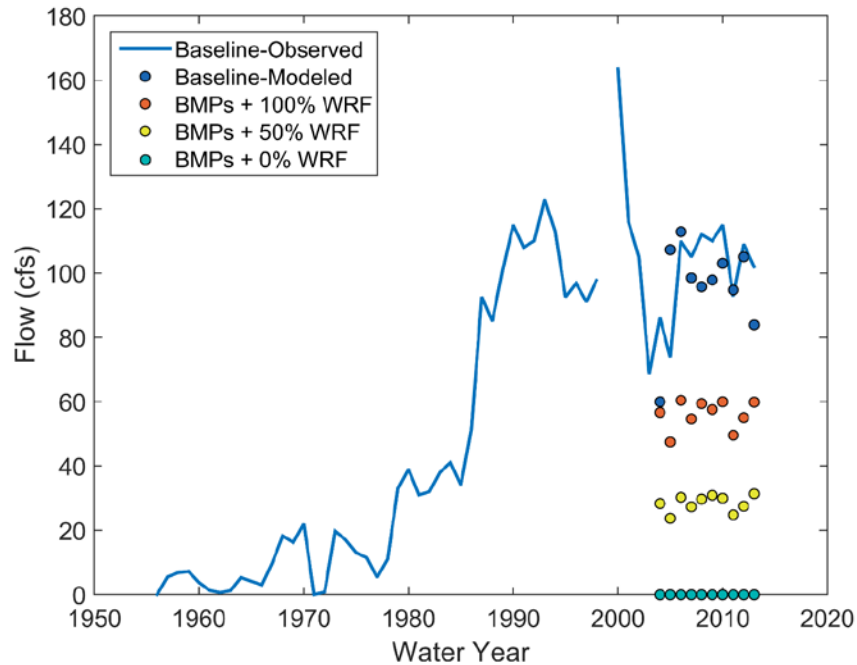


Figure 3.15. Annual minimum flows at the Wardlow gage (blue line) compared with modeled baseline (blue points), and post-BMP flows with varying amounts of WRP flow (0% - aqua, 50% - yellow, 100% - orange points)

g. Historical Flow Discussion

Flows in the LAR have changed greatly over time, and have been influenced by the discharge of effluent from three WRPs, wet and dry weather runoff from its urbanized watershed, and upwelling of groundwater. Effluent discharge into the LAR increased in-channel flows every time a new WRP came online. For example, 7Q10 flows in the LAR (using annual minimum flows) increased from 42 cfs for the period of record from 1956 to 1985 to 157 cfs for the time period between 1986 (when DCTWRP came online) and 2014 (Table 3.2). WRP effluent is now the largest component of the current volumes; flows in WY 2012-2013 from DCTWRP, LAGWRP, and BWRP combined were approximately 53 MGD, over twice the volume of the 7Q10 flows prior to 1986. Historical records indicate rising groundwater has contributed 1 to 7 MGD in flows since 1928 and was approximately 1.6 MGD in 2012-2013 (Table 3.4).¹¹² The final flow component is dry weather runoff and other urban sources, which has ranged between 1 to 11 MGD and was estimated to be approximately 10 MGD in WY 2012-2013.¹¹³

Source	Date	Flow ¹¹⁴		
		CFS	MGD	AFY
WRPs	WY 2012-2013	82	53	56,300
Urban Runoff Etc.	WY 2012-2013	15	10	11,000
Rising Groundwater	WY 2012-2013	2.3	1.6	1,700

Table 3.4. Snapshot of flows into LAR from water year 2012-2013

Multiple drivers, however, are changing or have the potential to change these patterns of flow in the LAR. Complying with water quality requirements will result in watershed scale implementation of BMPs to manage stormwater. These BMPs will likely include a combination of infiltration-based and treat and release systems, which will impact the runoff volumes that flow into the LAR channel. Modeled average annual flows at Wardlow Gage dropped from 237,000 AF to between 63,000 and 111,000 AF (a reduction of 53 to 71%) with the implementation of various BMP scenarios. We also observed a reduction in modeled seasonal flows, from 97,000 to 136,000 AFY (baseline) to between 63,000 and 72,000 AFY (with BMPs, Table 3.5). Implementing these BMPs will also impact the runoff ratio as less water runs off the watershed as a result. For example, the runoff ratio of modeled scenarios in our analysis was roughly equivalent to the runoff ratio in the 1950s and 60s (Figure 3.2) when far less of the watershed was paved.

¹¹² TNC LA River Study 2016 p. 3-30

¹¹³ TNC LA River Study 2016 p. 3-30

¹¹⁴ TNC LA River Study 2016 p. 3-30, 3-31

Season	Baseline			With BMPs		
	CFS	MGD	AFY	CFS	MGD	AFY
Fall	134	87	97,000	91	59	66,000
Winter	188	122	136,000	100	65	72,000
Spring	178	115	129,000	89	58	64,000
Summer	142	92	103,000	87	56	63,000

Table 3.5. Modeled median seasonal flows for Wardlow Gage with and without BMPs.

In addition, the recent focus on increasing local water supplies makes it likely that a higher percentage of the effluent that is currently being discharged to the LAR will be diverted to reuse. The annual minimum flows at Wardlow Gage and the Glendale Narrows did go to zero in our modeled analysis when effluent flows were fully diverted to reuse (no effluent was discharged to the LAR) and stormwater BMPs were implemented across the watershed to capture the 85th percentile storm volume (Table 3.6). Therefore, there is the theoretical potential for flows in the LAR to go to zero through implementing these programs. Additional research is needed to better characterize the potential impacts on low flows (a potential study approach is described below). The City has committed to maintaining the Sepulveda Basin lakes, which flow through to the LAR. In 2015, an annual average of 27 MGD (30,000 AFY) was discharged from the DCTWRP.

Annual Minimum Flows	Glendale Narrows			Wardlow Gage		
	CFS	MGD	AFY	CFS	MGD	AFY
Baseline Flows	60-80	38-52	43,000-58,000	82-118	53-76	59,000-85,000
BMPs + 100% WRP	38-43	25-28	28,000-31,000	45-60	29-39	33,000-43,000
BMPs + 50% WRP	18-23	12-15	13,000-17,000	20-30	13-19	16,000-23,000
BMPs + 0% WRP	0	0	0	0		0

Table 3.6. Annual minimum flows at Glendale Narrows and Wardlow Gage with increased reuse of effluent.

Additional work should be done to assess whether continuing to discharge an annual average of 27 MGD (30,000 AFY) of effluent is necessary or desirable to support the desired uses and needs of the LAR year-round. With the current volumes of effluent discharge into the LAR, we found low flows in the LAR to be approximately 100 cfs (2003 to 2014 data) at Wardlow Gage. These flow levels, however, are far higher than what was occurring at Wardlow Gage in the early to mid-20th century. Historical low flows (1956-2013) were noted to be an order of magnitude lower, approximately 10 cfs (~10th percentile). Elsewhere in the LAR, TNC's LAR study found contemporary dry weather flows to be approximately 107 cfs (median) at Station F57C in the LAR

(above Arroyo Seco).¹¹⁵ In addition, TNC's study found median historical flows to be less than 13 cfs (pre-1966, median, above the Arroyo Seco).¹¹⁶

TNC's LAR study also describes a variety of environmental benefits that could result from lower, slower flows. Examples of benefits identified by TNC include: this flow is more consistent with historical ecological conditions such as ephemeral surface flows and intermittent sedimentation; lower flows may foster increased diversity in in-channel vegetation as slower moving waters could increase the variety of available habitats; and this habitat diversity may in turn favor native animals while also allowing urban tolerant generalists to persist.¹¹⁷ Lower flow requirements in the LAR could also free up additional volumes of wastewater for advanced treatment and reuse in the watershed. However, lower flows during the summer would also greatly impact recreational uses in the LAR, especially kayaking and wading/bathing. Therefore, the impact of sustaining lower flows (e.g., in the 10-13 cfs range) in the LAR that more closely reflect historical on water supply and habitat in the LAR system needs to be assessed.

C. Establishing minimum flows to protect and enhance beneficial uses on the LAR

a. LAR Background

The relationship between those who settled in the LAR watershed and its flows has been variable and complex throughout their shared history. In the early days, the LAR water provided the lifeblood that allowed civilizations to survive in the dry summer months. First Native Americans and then the founders of Spanish missions and eventually of the City of LA settled near the LAR to take advantage of the LAR reaches and nearby streams with perennial flows and artesian wells as a reliable source of water supply.¹¹⁸ For example, the Arroyo Seco and its environs contained numerous historical springs. Flows in the LAR River were perennial throughout much of the area that is now downtown LA and high groundwater tables also led to many locations with upwelling water. By the early 1900s, however, groundwater extraction had already lowered the LAR water table to the degree that historically perennial reaches began to dry up.¹¹⁹

Thus, our reshaping of the LA River began with the need for more and more water to be distributed to the surrounding developed area and was then continued with the need for flood control. The LAR was the sole source of water supply for the City of LA from the mid-1800s until 1903.

¹¹⁵ TNC LA River report, Figure 3-26, p.3-30

¹¹⁶ TNC LA River Study 2016 p.4-46

¹¹⁷ TNC LA River Study 2016 p. 5-23

¹¹⁸ Brick, Tim; Appendix E: Water Resources Technical Report. The Arroyo Seco Watershed Restoration Feasibility Study. (Arroyo Seco study),

¹¹⁹ Arroyo Seco study

Although other supplies, such as the LA Aqueduct, became more significant water sources for LA in later years, the LAR (both surface and subsurface flows) remained an important part of the City's water supply until the 1940's brought in supply from the Colorado River Aqueduct. The last remaining surface diversion from the LAR was not shut down until 1971.¹²⁰

During wet years or heavy storms, the LAR rampaged across its floodplain, sometimes carving new channels for itself but always leaving wetlands, sediments, and rich habitat behind. In earlier times, homes were placed on higher elevations outside of the usual flood pathways. As the region grew more developed, however, these floods led to the potential for greater and greater damage to the settled areas. As a result, the region attempted various strategies to control floods during the early 1900's that culminated in the channelization of the LAR into concretized trapezoidal or rectangular channels in the late 1930s and 1940s.¹²¹ Three areas of the LAR, the Sepulveda Basin, the Glendale Narrows, and the intertidal estuary below Willow Street, were left in semi-natural or soft-bottom condition due to the presence of, for example, groundwater upwelling that precluded the use of concrete.¹²²

In the latter half of the 20th Century, however, a shift again occurred in the LAR as urbanization continued in the region, leading to increased runoff entering the LAR via surface runoff or the storm drain system. In addition, WRPs have been discharging effluent into the LAR and tributaries, which has created a relatively constant level of flow in the LAR below those discharges. As a result, flows in parts of the LAR are higher than they have been historically. As described above, with the current volumes of effluent discharged into the LAR, we found recent low flows in the LAR to be approximately 100 cfs (2003 to 2014 data) at Wardlow Gage (based on analysis of daily average flows). Historical low flows (1956-2013), however, were noted to be an order of magnitude lower, approximately 10 cfs (~10th percentile). Elsewhere on the LAR, TNC's recent study found historical flows (pre-1966) to be approximately 13 cfs on the LAR (median, above the Arroyo Seco) and more recent low flows (post-1966) to be approximately 107 cfs (median, above the Arroyo Seco).¹²³

The LAR in its current state can generally be divided into three hydrologically distinct subregions plus the intertidal estuary at the river mouth. The upper LAR watersheds are generally dominated by natural flows, the LAR mainstem (plus Burbank Western Channel) is generally dominated by WRP effluent, and the tributaries in the middle and lower watershed are generally dominated by urban runoff.¹²⁴ The percentage of flow comprised by WRP discharge varies considerably in the LAR depending on the season and year; for example, WRP discharge can range between

¹²⁰ Blake Gumprecht, *The Los Angeles River: Its Life, Death, and Possible Rebirth*. p125, 98,118. (Gumprecht)

¹²¹ The Council for Watershed Health's *LA River State of the Watershed* report (2012)

¹²² Gumprecht, *The Council for Watershed Health's LA River State of the Watershed* report (2012)

¹²³ TNC *LA River Study* 2016 p.4-46

¹²⁴ The Council for Watershed Health's *LA River State of the Watershed* report (2012) p. 2

19% of the LAR flow during wet weather and 92% during dry weather. Some flow is also contributed by natural springs in the upper watersheds such as Tujunga and Pacoima Wash, and by rising groundwater in the Glendale Narrows.¹²⁵

The current LAR flows are supporting in-channel recreational uses such as kayaking and multiple aquatic life and habitat uses. In one example, water sheeting over the concrete bottom of the lower portion of the LAR channel has also led to algal populations that provide a food source to local bird populations.¹²⁶ This is also an important food source for migratory birds; during the peak south-bound bird migration period from early July through late September, observing more than 10,000 shorebirds per day is not uncommon. Supporting this migratory shorebird habitat in the Lower LAR is especially important as it has become a “*de facto*” replacement for the estuarine wetlands that were present at the LAR river mouth prior to the port construction.¹²⁷ These uses may suffer or disappear if flows through the LAR vanish for some parts of the year.

We are now entering a time, however, in which it is likely that the current sources of flow to the LAR will be reduced. Watershed-scale programs such as the EWMPs, enhanced outdoor water conservation efforts, and other programs to incentivize the implementation of BMPs on private properties, will result in lower volumes of urban runoff entering the LAR and its associated storm drain system. The increased focus on local water supply in the region is also leading to an increased desire to reuse more of the treated wastewater that is currently being discharged into the LAR. Further, rising groundwater is currently a source of flow to the LAR; as groundwater rights are fully utilized and pumping patterns change to maximize local water supply potential, this source of flow may also decrease. As a result, we are at a critical juncture in determining the future of the LAR that demands a thorough understanding of what the flows on the LAR have been historically, are currently, and will be in the future. This is fundamental to determining the tradeoffs among the various needs and uses as well as how much water will be available to satisfy these needs and uses.

The type of robust data analysis and modeling work presented here is necessary to adequately compare these sorts of watershed management approaches in regards to beneficial use attainment and providing additional benefits such as increasing potential local supply. Our analysis demonstrates that different watershed management approaches will result in different flow volumes. For example, maximizing water recycling enhances water supply resilience and reduces reliance on imported water. However, it also results in much lower flow for much of the river in reaches downstream of the WRPs, reaches that also include the Glendale Narrows with soft-bottomed riparian habitat. Zero flow along this stretch, and watershed wide implementation of infiltration BMPs, would likely result in non-attainment for both aquatic life and recreational water contact (summer kayaking occurs in Glendale Narrows). Also, since the LAR consists in large part of

¹²⁵The Council for Watershed Health’s LA River State of the Watershed report) p.14

¹²⁶ http://e360.yale.edu/features/restoring_the_los_angeles_river

¹²⁷ The Nature Conservancy’s Urban Conservation Program, (December 2016) Water Supply and Habitat Resiliency for a Future Los Angeles River: Site-Specific Natural Enhancement Opportunities Informed by River Flow and Watershed-Wide Action Los Feliz to Taylor Yard. p. 5-13 (TNC LA River Study 2016)

effluent for most of the year, especially during dry weather, 100% water recycling in conjunction with watershed wide BMP implementation would lead to flows that are too low for most recreational water contact, and likely too low to support a healthy riparian aquatic community.

Understanding the potential impacts of providing seasonal flow variability on sustaining native wildlife while also possibly supporting recreational uses such as kayaking in certain stretches is also important. Kayaking outfits are open from Memorial Day to Labor Day. Kayaking season, however, also corresponds with the season of lowest flows and highest demand for the Title 22 effluent that comprises the majority of the dry weather flows in the channel. To support recreational benefits from May through September, potential opportunities to re-capture and store this water for use downstream should be explored.

A rigorous study to understand what flows are needed on the LAR to support potential uses and needs is required to appropriately plan the future of the LAR. Thus, a critical piece of information needed to guide revitalization efforts in the LAR is the definition of the minimum flow regime necessary to support the river's multiple needs and varied beneficial uses. First, we must thoroughly understand the elements that comprise a healthy, multi-benefit LAR. A diverse group of regulatory and wildlife protection agencies, watershed cities, the county, technical experts, and community leaders should convene to develop consensus on the attributes of a healthy LA River watershed. This effort may result in reach-specific parameters that should be optimized. A critical piece of designing appropriate minimum flows to support a healthy habitat in the LAR is defining what a healthy habitat looks like in such an urbanized and managed riparian environment. For example, a goal of restoring macroinvertebrate populations of sensitive species such as stoneflies may not be an appropriate or even realistic goal for reach 1 in the LAR, but a detailed ecological study must be performed to determine the appropriate benchmarks for each reach and tributary.

Here we outline a potential approach to defining what a healthy LAR, capable of sustaining multiple beneficial uses and municipal needs, could look like. The most important part will be designing and implementing a study to assess the volume of minimum flows required to support and protect habitat and aquatic life in and along the LAR. A strong grounding in the current realities of the LAR, as well as a clear vision for the future of the LAR, is a necessary part of the planning process to determine what the future of the LAR could or should look like.

b. Recent Work

Efforts to better characterize past and present flows, habitats, and biodiversity along the LAR are beginning; One Water LA is preparing a LA River flow study that describes existing flow conditions as part of the development of their One Water LA Plan.¹²⁸ The Nature Conservancy (TNC) also recently explored habitat enhancement opportunities along a 2.5 mile stretch of the LAR in the Elysian Valley between Los Feliz and Taylor Yard, a location where a diverse suite of plants and animals was known to occur.¹²⁹ The purpose of this study was to generate an ecological

¹²⁸ One Water LA Progress Report, Slide 30. <https://www.lacitysan.org/san/sandocview?docname=cnt019673>

¹²⁹ Prepared by the Land IQ Team for The Nature Conservancy, Los Angeles River Habitat Enhancement Study and Opportunities Assessment: Elysian Valley Los Feliz to Taylor Yard. Executive Summary P. ES-1, 2016

baseline by collecting fine-scale information about existing conditions. The assessment includes information about the historical ecology of this LAR section, as uncovered through an investigation of historical documents such as maps, journals, and natural history collections. To describe the current ecological conditions, a suite of expert biological surveys was conducted over the course of a calendar year. These included field survey efforts designed to document the presence and condition of vegetation, insects, reptiles, amphibians, birds, and mammals (fish surveys in this area were previously conducted by Friends of the LAR).¹³⁰

TNC's study also included a thorough investigation into the hydrology of this stretch of the LAR and laid out four potential scenarios for how the hydrology of the watershed may be altered in the future to maximize particular goals. Given that LAR hydrology is crucial to determining which biological communities will thrive, this assessment also presents several opportunities for supporting and enhancing native biodiversity along this section of the LAR, and how each of these opportunities would need to be modified given the possible hydrological scenarios.

Further, there are multiple ongoing monitoring efforts in the LAR watershed that can be used to inform quantitative efforts to define the health of the LAR. For example, the Los Angeles River Watershed Monitoring Program (LARWMP) is an ongoing monitoring effort that is part of the WRP permit conditions for the cities of LA and Burbank. This monitoring program is managed by the Council for Watershed Health (CWH) and helped inform and generate a State of the Watershed Report in 2012.¹³¹ Heal the Bay has also recently released an LAR bacteria report card with water quality information.¹³² CIMPs will also generate significant additional data on water quality in the LAR watershed that could inform this effort.

There are a wide variety of tools that can offer guidance on developing an LAR study or offer techniques to quantify various facets of the LAR. Methods exist to analyze the health of urban rivers, including wetland functional assessments using the California Rapid Assessment for Wetlands (CRAM) and bioassessments using benthic macro invertebrate samples to determine scores through the California Stream Condition Index (CSCI). An analysis of stream health in LA County using both CRAM and CSCI was conducted by SCCWRP. The results of this effort informed the Ecosystem Health section of the 2015 UCLA IoES "LA County Environmental Report Card."¹³³ Data for the wetland functional and bioassessments were collected through monitoring between 2009 and 2013 by the Stormwater Monitoring Coalition; these monitoring efforts only included

¹³⁰ FoLAR 2016 fish study available at: <http://clients.codebloo.com/folar/education/folar-studies/>

¹³¹ Available at: <https://www.watershedhealth.org/resources>

¹³² <https://healthebay.org/heal-bay-launches-river-report-card/>

¹³³ Available at: <https://www.ioes.ucla.edu/project/2015-environmental-report-card-for-los-angeles-county/>

perennial, wadeable streams. Additional monitoring will include revisits to previously sampled sites as well as at locations that encompass a wider range of stream types.¹³⁴

Generally speaking, scores using both CRAM and CSCI demonstrate that urban streams throughout LA County exhibit poor biological and functional conditions; these scores indicate that conditions are already highly altered from reference locations. Channelization and loss of floodplain connectivity in LA are potential factors that can impact CRAM scores; changed hydrologic regimes, loss of instream habitat, and water quality impairments are additional potential factors that can impact CSCI.¹³⁵ This highlights the importance of conducting a study on the LAR with a focus on characterizing the appropriate suite of indicators that will be able to assess and protect not only the health of an urbanized water body, but also required uses such as flood control. It is critical that monitoring efforts characterize all reaches in the LAR watershed under a variety of seasonal and flow conditions. For example, water quality samples should be taken and habitats and biodiversity assessed in streams under all conditions and seasons (e.g., when water is present and when water is absent in the streambed) to characterize all potential habitats.

However, the LAR must not only support healthy habitats and potential recreational uses, but also critical municipal needs, which include existing flood control. An engineering approach to the flows question that explores the potential for the LAR water and channel to support multiple uses under conditions with storm flows (but not so much flow that flood control would be compromised by supporting other uses concurrently) was recently developed. RiverLA, working with Gehry Partners, OLIN Landscapes, and others, used an approach which establishes a functional flow rate in various reaches of the LAR that would define the difference between multi-use and single-use conditions.¹³⁶ Please refer to the LAR Index website for the full details on their approach (briefly summarized here).¹³⁷

On average, water is present in only the low flow channel of the LAR for 330 to 345 days per year; on the remaining days there is a greater volume of water present in the LAR. After lighter rain events, which occur approximately 17 to 32 days per year, the channel has less than two to four feet of water which spans the width of the channel. Channel flows only exceed four feet of water when heavy rains occur, which is on average less than three days per year. The RiverLA approach ascribes the potential for the lower flow days to serve multiple benefits, including retention and recharge, recreation, water quality, and other uses, while the highest flow days are reserved exclusively for flood control.¹³⁸

¹³⁴ UCLA IoES report card 2015 P. 59

¹³⁵ UCLA IoES report card 2015 P. 60

¹³⁶ <http://riverlareports.riverla.org/flood-risk-management/>

¹³⁷ <http://riverlareports.riverla.org/about/>

¹³⁸ <http://riverlareports.riverla.org/flood-risk-management/>

Thirteen design reaches were identified along the LAR based on where channel characteristics are geometrically and hydraulically similar for the length of the design reach and then a variety of flow rates were determined for these reaches.¹³⁹ A range of potential functional flow rate conditions were identified in each reach; determining the best functional flow rate in each reach would be impacted both by cost-benefit analyses of recovering multiple uses at different flows and how often the rate is exceeded (as under those conditions the channel would revert to serving the single purpose of flood control).¹⁴⁰ In addition, flood protection levels vary along the length of LAR: the lower reaches generally have greater than 100-year level protection, upper reaches generally have greater than 50-year level protection, and the ARBOR reach generally has less than 50-year protection.¹⁴¹ This engineering approach to identifying flow levels at which additional benefits such as water supply could be served along with flood control provides one piece of information. These flow levels could potentially help identify conditions under which the LAR could provide additional benefits without increasing the risk of flooding along the channel.

c. Complexities around Removing River Flows

There are many nuances to removing flows from a river channel due to, for example, potential impacts on wildlife or habitat. There are legal examples of minimum flows being set and upheld to protect a variety of resources including designated uses as well as habitat preservation. In ‘Public Utility District No. 1 of Jefferson County v. Washington Department of Ecology,’ the Supreme Court found that reduced flows can be considered a water quality impairment as water quantity and quality are tightly linked and that thus, the State of Washington had the authority to impose minimum flow conditions under Section 401 of the CWA to protect designated uses and comply with anti-degradation.¹⁴² Similarly, a CWA Section 401 certification requiring minimum flows to protect designated fishing and recreational uses of a water body in Maine was upheld.¹⁴³ Thus, care must be taken in designating flows for the LAR which meet all beneficial uses from the onset for a wide variety of reasons, including legal precedent.

Removing flows from the LAR comes under additional requirements (CA Water Code Sections 1210-1212) if the removed flows consist of the treated effluent currently being discharged by the WRPs into LAR because removing this water could affect the availability of water for uses downstream of the discharge point. Under Water Code Section 1211, the treatment plant owners must get approval from the SWRCB Division of Water Rights before making any changes to this flow of effluent; if a proposed project will result in decreasing the flow in a water body, then a

¹³⁹ <http://riverlareports.riverla.org/tools-2/river-reaches/>

¹⁴⁰ <http://riverlareports.riverla.org/tools-2/functional-flow-rate-ffr/functional-flow-rate-data/>

¹⁴¹ <http://riverlareports.riverla.org/flood-risk-management/current-information/>

¹⁴² EPA USGS Hydrologic Alteration Report 2015 p.135

¹⁴³ EPA USGS Hydrologic Alteration Report 2015 p.136

Petition for Change must be filed to obtain approval to implement the project.¹⁴⁴ The Cities of Burbank and Glendale each filed Petitions for Change in early 2017 with requests to increase the volumes of recycled water that they use and to reduce their discharges to the LA River.¹⁴⁵

An additional aspect that must be considered is any potential impacts of removing flows from LAR on groundwater and any impacts on flows in the LAR from increasing the use of groundwater. Although California's Sustainable Groundwater Management Act (SGMA) does not specifically apply to ULARA (as it has already been adjudicated), SGMA points to the importance of considering impacts of groundwater management on surface water flows. SGMA defines "sustainable groundwater management" in Water Code Sec. 10721 as "management and use of groundwater in a manner that can be maintained ... without causing undesirable results." One of these undesirable results is a reduction in surface water flow that is significant enough to have an adverse impact on beneficial uses in surface water that is hydrologically connected to a groundwater basin.¹⁴⁶ These potential impacts should also be considered where relevant along the LAR (e.g., soft-bottom stretches with groundwater upwelling).

d. Assessing Minimum Flows

Additional guidance on the importance of identifying appropriate flows and approaches to supporting minimum flow requirements can be found in a recent technical report from the USGS and USEPA.¹⁴⁷ Several states have established water quality standard descriptions that include limiting flow alterations so that flow changes may not impair waters for a variety of categories including diverse aquatic communities, existing and designated uses, and fish and aquatic life criteria.¹⁴⁸ In addition, as described above, defining changes in 7Q10 flows has been used in Vermont as a policy or regulatory tool to quantify and frame a negative impact on flows in that river. However,

¹⁴⁴ State Water Resources Control Board Order WQ 2014-0090-DWQ-corrected. General Waste Discharge Requirements for Recycled Water Use. Adoption Date June 3 2014. P. 10 Available at: http://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2014/wqo2014_0090_dwq_revised.pdf; http://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/waterrightsrequirements.shtml

¹⁴⁵ SWRCB Notices of Petitions 2017; http://www.waterboards.ca.gov/waterrights/water_issues/programs/applications/petitions/2017.shtml

¹⁴⁶ <http://www.water.ca.gov/groundwater/sgm/definitions.cfm>

¹⁴⁷ Novak, R.; Kennen, JG; Abele, RW; Baschon, CF; Carlisle, DM; Dlugolecki, L; Flotermersch, JE; Ford, P, Fowler, J; Galer, R; Gordon, LP; Hansen, SN; Herbold, B; Johnson, TE; Johnston, JM; Konrad, CP; Leamond, B; Seelbach, PW;. (2015) Draft: EPA-USGS Technical Report: Protecting Aquatic Life from Effects of Hydrologic Alteration: USGS Scientific Investigations Report 2015-5160, USEPA EPA report 822-P-15-002, XX. <https://www.epa.gov/wqc/draft-epausgs-technical-report-protecting-aquatic-life-effects-hydrologic-alteration-documents> (EPA USGS Hydrologic Alteration Report 2015)

¹⁴⁸ EPA USGS Hydrologic Alteration Report 2015 p. 44-45

although the EPA recommends the use of minimum flow statistics such as 7Q10 flows as a mechanism to determine pollutant limits for NPDES permitting, they are not intended or derived to identify the flows required to support healthy aquatic ecosystems.

Therefore, while 7Q flows can provide valuable guidance on historical flows, changes in flows over time, and a mechanism to set boundaries on acceptable flow changes in a system, they are not in themselves sufficient to set flows needed for sustaining aquatic life beneficial uses. A separate study must be conducted to identify the habitat and ecosystem requirements in the LAR as well. Further, minimum flow criteria are not sufficient to maintain the extremes such as floods and drought that are often present within natural flow regimes.¹⁴⁹ This flow variability may be necessary for native wildlife, vegetation, and habitat and must also be included in future LAR plans.

There is also a local example of a required in-channel flow level at the Tapia Water Reclamation Facility (TWRP), which is required to cease discharge from April 15th until November 15th with a few exceptions. One of the exceptions is the need to maintain a minimum flow volume in Malibu Creek (as measured at LA County Gauging Station F-130-R). The TWRP is required to discharge volumes adequate to augment flows in Malibu Creek to 2.5 cfs; this flow level was determined by resource agencies as needed to maintain adequate habitat for the endangered southern steelhead downstream of the discharge and Rindge Dam.¹⁵⁰

One potential approach to assessing a river with multiple beneficial uses was taken by the city of Fort Collins, Colorado, which developed a River Health Assessment Framework (RHAF) in 2015 to assess the health of their Poudre River, assess the multiple demands on the river, and identify indicators which could provide information on progress towards meeting goals for all potential uses.¹⁵¹ The approach taken in Fort Collins contains elements that would be highly applicable for the LAR, including indicators which represent physical, chemical, and biological elements of the ecosystem as well as beneficial and functional uses such as water supply, water quality, recreation, and stormwater management.¹⁵²

Crucially, these indicators, and any embedded metrics, are quantifiable and acceptable ranges are identified for all elements which allows progress to be tracked. Further, similar to efforts in the LA region such as Heal the Bay's Beach Report Card and UCLA's Environmental Report Card for LA County, the Fort Collins RHAF uses an academic grading scale to translate the quantitative results into an easily understandable format for tracking progress. Finally, the Fort Collins RHAF

¹⁴⁹ EPA USGS Hydrologic Alteration Report 2015 p.48-49

¹⁵⁰ http://www.waterboards.ca.gov/losangeles/board_decisions/tentative_orders/individual/npdes/tapia/2010_722/Revised%20Tentative3%20%20Tapia%2007-06-10.pdf p 9, 21, 22

¹⁵¹ River Health Assessment Framework (RHAF 2015), City of Fort Collins Natural Areas Department and Utilities Service Area, P. 3. Available at : <http://www.fcgov.com/naturalareas/riverhealth.php>

¹⁵² RHAF 2015 p.3

lays the framework for long-term monitoring efforts that will result in the State of the River Assessment and Reports every 3 to 5 years; long-term and comprehensive monitoring programs are critical to generating additional data to fill any gaps as well as to track progress towards goals.¹⁵³

To fully assess minimum flows within the context of the multiple beneficial and functional uses that must all be supported, a study on the LAR should incorporate methods and results from all of the above efforts. It is critical to identify the parameters that may impact all current and potential LAR functions to develop a study to accurately assess all impacts simultaneously as well as provide a framework for future monitoring efforts to track progress towards LAR goals.

¹⁵³ RHAF 2015 p. 44

IV. Groundwater

A. Introduction

Groundwater throughout California is a critical resource that provides water supply resiliency for the state's variable climate. While the first legislation regulating groundwater in the state, SGMA, was passed in late 2014, many of the groundwater basins in the Los Angeles region previously finalized adjudications to govern total extractions from the basins as well as oversee individual pumpers' rights to pump, store, or transfer water from the basins. For all basins in the state, there is an urgent need to evaluate (or reevaluate) sustainable yields and aquifer overdraft status, especially given changes in hydrology, climate change, and changing trends in the management and use of groundwater for water supply. This has been proposed statewide through the DWR's Bulletin 118 update.¹⁵⁴

Groundwater basins in Los Angeles provide opportunities to store advanced treated recycled water and capture stormwater for local use. However, contamination by legacy pollutants and complex political, legal, and regulatory environments present challenges that can constrict managers' ability to fully utilize this local water supply opportunity. Further, many of the Los Angeles adjudicated groundwater basins rely on imported Metropolitan Water District (MWD) water to maintain "safe yield," and ensure groundwater rights holders can use the groundwater.

As briefly described earlier, ULARA overlies four unique groundwater basins, as identified by the Superior Court of Los Angeles, and includes the entire ULAR watershed. These groundwater basins, in order from largest to smallest, are as follows: San Fernando Groundwater Basin (SFB), Sylmar Groundwater Basin (SB), Verdugo Groundwater Basin (VB), and Eagle Rock Groundwater Basin (ERB, Figure 4.1). The watershed has an area of approximately 328,500 acres, with a landscape is comprised of hill and mountain areas with four intervening valley fill areas.¹⁵⁵ The fundamental watershed boundaries are marked by the Santa Susana Mountains in the north and northwest, the San Gabriel Mountains in the north and northeast, the San Rafael Hills in the east, the Santa Monica Mountains in the south, and the Simi and Chatsworth Hills in the west.¹⁵⁶

¹⁵⁴ From CA water action plan: California Statewide Groundwater Elevation Monitoring Program

¹⁵⁵ Introduction to the ULARA Groundwater Basins Technical Memorandum No. 1 Draft for the Salt and Nutrient Management Plan by Watermaster, Upper Los Angeles River Area February 2016 p. 12

¹⁵⁶ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 13



Figure 4.1 The Upper Los Angeles River Area groundwater basins¹⁵⁷

Water rights in ULARA were originally established by the Los Angeles County Superior Court by Judge Edmund M. Moor in March 1968.¹⁵⁸ For all four groundwater basins in ULARA, the original Trial Court adjudication limited all groundwater extractions to a total maximum safe yield of approximately 104,040 AFY effective October 1, 1968.¹⁵⁹ This restriction translated to a reduction of approximately 50,000 AF from the average amount extracted by all parties in the six years prior to adjudication.¹⁶⁰ This 1968 judgment was reversed by the California Supreme Court and in January 1979 Judge Hupp of the Superior Court of Los Angeles County signed the Final Judgment for the four groundwater basins. The Final ULARA Judgment included provisions and stipulations regarding water rights, such as native safe yield and permitted extraction rates, storage of water, stored water credits, and arrangements for physical solution water for certain parties in the watershed.¹⁶¹

In the vicinity of ULARA, the City holds water rights in SFB, SB, and ERB. In SFB and SB, the City has rights to approximately 47,510 AFY (43,660 in SFB and 3,850 in SB) of native safe

¹⁵⁷ Sources: Basemap (c) Bing Maps, Groundwater basin shape files from the ULARA Watermaster.

¹⁵⁸ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 14

¹⁵⁹ Upper Los Angeles River Area Watermaster Annual Report 2014 p. 2-15; (ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-15)

¹⁶⁰ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 2-15 (ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-15)

¹⁶¹ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 15

yield.¹⁶² Including imported water return, the City's combined water rights are approximately 91,070 AFY in SFB, SB, and ERB.¹⁶³ ERB does not have a safe yield. Instead, the safe yield is equal to the water imported by LADWP; ERB is incorporated into the 91,070 AF by contributing 500 AF. On average from FY11 to FY15, ULARA supplied the City with 89% (59,621 AFY) of its local groundwater, extracting 58,741 AFY from SFB and 880 AFY from SB (Table 4.1).¹⁶⁴

Ground water Basin	FY2010-11	FY2011-12	FY2012-13	FY2013-14	FY2014-15	Average	Percentage
San Fernando	44,029	50,244	50,550	68,784	80,097	58,741	88
Sylmar	225	1,330	1,952	891	0	880	1
Total	44,254	51,574	52,502	69,675	80,097	59,621	89

Table 4.1. LADWP Groundwater Basin Production in ULARA (AF)^{165,166}

During WY 2013-14, groundwater extraction from all four groundwater basins totaled approximately 35 billion gallons (BG) (107,580 AF).¹⁶⁷ This included: 32.5 BG (99,702 AF) from SFB; 1.3 BG (4,020 AF) from SB; 1.2 BG (3,649 AF) in VB; and 68 MG (209 AF) in ERB.¹⁶⁸ The total amount pumped in WY 2012-13 was less than the long-term (1968-2013) average of 88.7 MGD (99,334 AFY) but a 1.3 BG (4,105 AF) increase from WY 2011-12.¹⁶⁹ During WY 2013-14, total extractions were 7.9 BG (24,161 AF) higher than in WY 2012-13.¹⁷⁰ Of the total amount pumped in WY 2013-14, approximately 392 MG (1,204 AF) were for non-consumptive use and 429 MG (1,317 AF) were pumped for physical solutions, groundwater cleanup, water well development and testing, and dewatering activities by other parties.¹⁷¹ The average annual spreading to groundwater basins in ULARA from 1968 to 2013 was 28.2 MGD (31,608 AFY); in WY 2012-13 a total of 3.5 BG (10,782 AF) of water was spread in ULARA and in WY 2013-2014 3.4 BG (10,433

¹⁶² 1979 Judgement, p. 11, available at http://ularawatermaster.com/public_resources/City-of-LA-vs-City-of-San-Fernando-et-al-JUDGMENT.pdf

¹⁶³ LADWP UWMP 2015 p. 6-2

¹⁶⁴ LADWP UWMP 2015 p. 6-4, Exhibit 6B

¹⁶⁵ Sources: Basemap (c) Bing Maps, Groundwater basin shape files from the ULARA Watermaster.

¹⁶⁶ LADWP UWMP 2015 p. 6-4, Exhibit 6B

¹⁶⁷ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-32

¹⁶⁸ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-32

¹⁶⁹ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-33

¹⁷⁰ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-33

¹⁷¹ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-15

AF) was spread.¹⁷² Of this total, 2.2 BG (6,703 AF) and 2.3 BG (7,000 AF) was imported into ULARA in WY 2012-13 and WY 2013-14, respectively.¹⁷³

LADWP has made and continues to make efforts to remediate and restore pumping in the groundwater basins to maximize and develop the use, storage, and augmentation of local groundwater supplies. LADWP's proposed Groundwater Development and Augmentation Plan (GDAP) will result in a program that prioritizes LADWP capital improvement projects in development with regional partners, as well as improvement studies, the construction of remediation plants, and partnerships with other local agencies.¹⁷⁴

B. Upper LAR Area Groundwater Basins

a. San Fernando Groundwater Basin

Current Pumping Rights and Practices

The cities of LA, Burbank, and Glendale hold extraction rights in the SFB. The City holds exclusive rights, or the Pueblo Water Right, to extract and utilize the total native safe yield water in the SFB as determined by the Final ULARA judgment of 1979. The native safe yield was determined to be approximately 39 MGD (43,660 AFY) and, at the time of the adjudication in 1979, managed safe yield was defined as 81 MGD (90,680 AFY).¹⁷⁵ In addition to the native safe yield, the City is permitted to extract 20.8 percent of imported water (including recycled water) delivered only to the valley fill land of SFB (not water delivered to hill and mountain areas).¹⁷⁶ In WY 2014-15, the City had a total allowed groundwater extraction volume of 67 BG (206,827 AF) (Table 4.2). This number is greater than that pumped in WY 2013-2014 as it includes 14 BG (43,660 AF) of native safe yield, 13 BG (40,736 AF) of import return credit, and 40 BG (122,431 AF) of available stored water credit (Table 4.2).¹⁷⁷

¹⁷² ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-33; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-32

¹⁷³ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-33; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-32

¹⁷⁴ LADWP UWMP 2015 p. 6-5

¹⁷⁵ Intro to the ULARA Groundwater Basins TM1 Draft for the SNMP 2016 p16; ULARA adjudication 1979 p11

¹⁷⁶ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 17

¹⁷⁷ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-36, Table 1-4

City of LA	San Fernando Basin	Sylmar Basin	Verdugo Basin	Eagle Rock Basin
Water Rights	43,660 AFY (native safe yield)	3,570 AFY (half of safe yield)	0 AFY	500 AFY ¹⁷⁸
Additional Water Rights	20.8% of imported water delivered to valley fill land (average: 43,000 AFY), and available stored water credit	----	----	
Current Allowed Extraction	261,628 AFY ¹⁷⁹	12,584 AFY ¹⁸⁰	----	
Currently Extracted Volumes (AFY)	80,097 AFY ¹⁸¹	0 (no active wells)	----	

Table 4.2. LADWP Water Rights and Extraction Rates in ULARA

The cities of Burbank and Glendale also have a right to extract approximately 20 percent of the imported return water, which includes recycled water that is delivered to the valley fill land and all tributary hill and mountain areas of SFB.¹⁸² Each of the three cities has the right to recharge groundwater into the basin and extract the equivalent amount.¹⁸³ The parties can also choose to reduce their pumping and store, or “carry over,” any unused water rights into future years.¹⁸⁴

LADWP owns 10 major wellfields in SFB that include 115 water supply wells. Of LADWP’s 115 original water supply wells, there are currently only 37 active wells in SFB; more than 80 have been removed from service due to contamination.¹⁸⁵ The following wellfields are currently active: Aeration Wellfield in the North Hollywood Operable Unit (NHOU) with 3 wells; North Hollywood Wellfield with 13 wells; Pollock Wellfield with 3 wells; Rinaldi-Toluca Wellfield with 8

¹⁷⁸ UWMP 2015 p. 6-2

¹⁷⁹ WY 2014-15, includes native safe yield (43,660 AFY), import return credit (40,736 AFY), and available stored water credit (122,431 AFY); ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-36, Table 1-4

¹⁸⁰ WY 2014-15, includes safe yield and available stored water credits; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-36, Table 1-4

¹⁸¹ FY2014-15 LADWP UWMP p. 6-4, Exhibit 6B

¹⁸² Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 17

¹⁸³ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 17

¹⁸⁴ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-32

¹⁸⁵ LADWP UWMP 2015 p. 6-1

wells; and Tujunga Wellfield with 10 wells.¹⁸⁶ LADWP's main and largest wellfields are the Tujunga, Rinaldi-Toluca, and North Hollywood wellfields, which have a combined capacity of 268 cfs (Table 4.3).¹⁸⁷ Erwin, Verdugo, and Whitnall wellfields have a combined capacity of 29 cfs; Pollock and NHOU have capacities of 6 cfs and 2 cfs, respectively.¹⁸⁸ Crystal Springs and Headworks Wellfield are currently out of service but have historically provided 65 cfs.¹⁸⁹ If all 115 wells in the 10 wellfields were fully operational, the maximum pumping capacity would be 540 cfs.¹⁹⁰

	Tujunga and Rinaldi-Toluca	North Hollywood	Erwin, Verdugo, & Whitnall	Pollock	North Hollywood Operable Unit	Total
Pumping Capacity (cfs)	213	55	29	6	2	305
Percent	69	18	10	2	1	100

Table 4.3. San Fernando Basin Wellfields and Pumping Capacities

The City's average groundwater production from SFB between FY 2010-11 and FY 2014-15 was 52.5 MGD (58,741 AFY).¹⁹¹ In FY 2010-11 (FY11) the City extracted 14.3 BG (44,029 AF); in FY12, FY13, FY14, and FY15, LADWP extracted 16.4 BG (50,244 AF), 16.5 BG (50,550 AF), 22.4 BG (68,784 AF), and 26.1 BG (80,097 AF), respectively.¹⁹² Water production from the SFB represented 88% of LADWP's 5-year average groundwater supply.¹⁹³

Burbank currently pumps from 8 wells in the Burbank Operable Unit (BOU), which operates as a subsection in a USEPA superfund area where contaminated groundwater is extracted and treated to remove volatile organic compounds (VOCs).¹⁹⁴ Phase II of the remedy plan, which increased the extraction capacity of the facility to 9,000 gpm (13 MGD or 14,300 AFY), began at

¹⁸⁶ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 36

¹⁸⁷ LADWP UWMP 2015 p. 6-5

¹⁸⁸ LADWP UWMP 2015 p. 6-5

¹⁸⁹ LADWP UWMP 2015 p. 6-5

¹⁹⁰ LADWP UWMP 2015 p. 6-5

¹⁹¹ LADWP UWMP 2015 p. 6-4, Exhibit 6B

¹⁹² LADWP UWMP 2015 p. 6-4, Exhibit 6B

¹⁹³ LADWP UWMP 2015 p. 6-4, Exhibit 6B

¹⁹⁴ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 35, ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-14

BOU in 1998; currently the treatment system operates at flows less than this rate.¹⁹⁵ During WY 2013-14, 3.3 BG (10,148 AF) of groundwater were pumped and treated from BOU, a 403 MG (1,239 AF) increase from the previous water year.¹⁹⁶

In WY 2013-14, Burbank had a total allowable groundwater extraction right of 2.3 BG (7,017 AF), which included a 1.4 BG (4,288 AF) import return credit and 0.9 BG (2,729 AF) of available stored credit.¹⁹⁷ Before delivering water to customers, Burbank reduces the concentrations of nitrate in its blending facility per the requirement of the Consent Decree.¹⁹⁸ In addition to the BOU, Burbank Water and Power (BWP) owns 7 inactive wells for a total of 15 wells owned by the City of Burbank in the SFB.¹⁹⁹

Glendale actively pumps from 8 wells in the Glendale Operable Unit (GOU), an area that also operates within an EPA superfund area and removes VOCs from groundwater.²⁰⁰ The GOU is comprised of two wellfields: the Glendale North Wellfield and the Glendale South Wellfield, each with 4 wells. Together, the two wellfields have the capacity to treat up to approximately 5,000 gpm, or 7.1 MGD (7,920 AFY).²⁰¹ In WY 2013-14, 2.3 BG (7,231 AF) of water was pumped and treated from the GOU.²⁰² In WY 2014-15, Glendale had an allowable pumping right of 4.6 BG (14,297 AF), which included 1.6 BG (4,827 AF) of imported return credit and 3.1 BG (9,470 AF) of available stored water credit.²⁰³

As in the BOU, the treated pumped groundwater from the GOU is blended with imported MWD supplied water to decrease nitrate and hexavalent chromium concentrations.²⁰⁴ As a measure to control hexavalent chromium levels in local groundwater, the USEPA has permitted the GOU to operate under a modified pumping plan. This plan allows Glendale to reduce pumping from certain wells with high concentrations of chromium and increase pumping in ones with lower levels. Because the wells are in their 13th year of operation, one of the main challenges for Glendale is maintaining the capacities of the wells. Re-development operations have been initiated in

¹⁹⁵ United States Environmental Protection Agency, Pacific Southwest, Region 9: Superfund, San Fernando Valley (Area 1 North Hollywood and Burbank) <https://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/ViewByE-PAID/CAD980894893>; accessed 6/15/2016

¹⁹⁶ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-14

¹⁹⁷ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-36, Table 1-4

¹⁹⁸ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-14

¹⁹⁹ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 35

²⁰⁰ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 35

²⁰¹ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-15

²⁰² ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-15

²⁰³ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-36, Table 1-4

²⁰⁴ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-15

some of these wells in response to observed declining production.²⁰⁵ In addition to the GOU, Glendale owns two other wells for a total of 10 wells in SFB.²⁰⁶

b. Sylmar Groundwater Basin

The safe yield of SB was stated in the 1984 Stipulation to be 5.6 MGD (6,210 AFY).²⁰⁷ Since then this yield has been re-evaluated and re-assigned twice by the original Watermaster (Mr. Melvin L. Blevins) in 1996 and then by the new Watermaster (Mr. Mark G. Mackowski) in 2006.²⁰⁸ The current safe yield is 6.4 MGD (7,140 AFY), which the City shares evenly with the city of San Fernando.²⁰⁹ Another private party with overlying rights, Santiago Estates, is present in SB. Santiago Estates has not extracted from SB since 1998-99; if, however, the party chose to extract their water, then the cities of LA and San Fernando would equally share the remainder of the safe yield value.²¹⁰ In WY 2014-15 the City and San Fernando had 4.1 BG (12,584 AF) and 1.3 BG (3,974 AF) of groundwater extraction rights respectively; these volumes were a sum of the native safe yield and available stored water credit.²¹¹

The City and San Fernando each have one wellfield in SB. Originally, LADWP's Mission Wellfield had a total of 7 active wells. However, many of these wells have been taken out of service (in part due to groundwater contamination).²¹² LADWP is pursuing the Mission Wellfield Rehabilitation project, which will be discussed further in the following section, to facilitate greater extraction from this wellfield.²¹³ The City of San Fernando wellfield consists of two wells.²¹⁴

The average volume of groundwater extracted by LADWP from SB between FY11 and FY15 was 880 AFY.²¹⁵ In FY11, FY12, FY13, and FY14, LADWP extracted 225 AF, 1,300 AF, 1,952 AF, and 891 AF, respectively. In FY15, LADWP did not pump any groundwater from SB.²¹⁶

²⁰⁵ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-15

²⁰⁶ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 35

²⁰⁷ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 17

²⁰⁸ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 17

²⁰⁹ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 18

²¹⁰ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 18

²¹¹ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-36, Table 1-4

²¹² LADWP UWMP 2015 p. 6-12; ULARA Watermaster Annual Report WY 2012-13 (2014) p. 36; SNMP TM-1

²¹³ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 36

²¹⁴ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 36

²¹⁵ LADWP UWMP 2015 p. 6-4, Exhibit 6B

²¹⁶ LADWP UWMP 2015 p. 6-4, Exhibit 6B

Over the ten-year period from WY 2001-2002 to WY 2011-2012, LADWP pumped on average only 65% (2,240 AFY) of its annual water rights in SB due to the presence of TCE.²¹⁷

c. Verdugo Groundwater Basin

The City does not have rights to native water in Verdugo Basin (VB), but it may have a right to recapture the water it imports into the basin upon application to the Watermaster and on subsequent order after a hearing by the court.²¹⁸ The City of Glendale and the Crescenta Valley Water District (CVWD) hold appropriative and prescriptive²¹⁹ rights to extract 3.5 MGD (3,856 AFY) and 3 MGD (3,294 AFY) from VB, respectively; together these rates represent the 6.4 MGD (7,150 AFY) safe yield of the basin.²²⁰

Glendale has 5 active wells in VB, including Glorietta Wells (3), Foothill Well (1), and most recently Rockhaven Well (1); CVWD operates 12 active wells.²²¹ Glendale's Foothill Well was recently rehabilitated in 2010 and pumps water out of VB at a rate of 130 gpm.²²² Rockhaven Well construction was completed in 2011, but this well is not currently active as nitrate concentrations exceed the Primary MCL (45 mg/L).²²³ CVWD and Glendale are exploring options to address the nitrate contamination issue. Glendale has not yet extracted its full water right of 3.4 MGD (3,856 AFY).²²⁴ Glendale has been drilling pilot boreholes to find ideal well locations, but has yet to find an area with adequate flow rates and nitrate concentrations.

In addition to these wells, CVWD obtains a fraction of its water supply from the Pickens Tunnel, which is bored 600 ft into the mountain where water that has accumulated in the fissure of the rock drips into the tunnel. CVWD will begin pumping from the City of Glendale's Rockhaven Well per a recent land lease agreement.

²¹⁷ LADWP Groundwater Monitoring Wells Installation Project SB Attachment 5 – Work Plan 2012 p. 1

²¹⁸ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 18

²¹⁹ Appropriative water rights are issued to users who take water for use on non-riparian land or to use water that would not be there under natural conditions. Prescriptive rights refer to rights that have been acquired through adverse possession of someone else's water right and can only be granted by a court. State Water Resources Control Board, Water Rights Frequently Asked Questions http://www.swrcb.ca.gov/water-rights/board_info/faqs.shtml#toc178761089

²²⁰ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 18

²²¹ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 36 and 37

²²² ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-18

²²³ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-18

²²⁴ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-18

d. Eagle Rock Groundwater Basin

A measurable native safe yield does not exist for ERB as the allowed extraction is derived from imported water delivered to the overlying land by the City.²²⁵ DS Waters, the only other party that can extract water from ERB, has a physical solution right to extract groundwater from ERB but an exact extraction volume is not stated. A physical solution right requires that DS Waters compensates the City for the amount of groundwater it extracts from ERB.²²⁶ DS Waters produces groundwater for its commercial bottled water plant operations.

e. Groundwater Storage

The ability to store water in the ground for later use in dry times is a critical facet of creating and maintaining a sustainable local water supply. The storage conditions and the ability of rightsholders to store water varies among SFB, SB, VB, and ERB. Groundwater storage capacity has been estimated to be 310,000 AF in SB and 160,000 AF in VB.²²⁷ Changes in stored groundwater volumes in the ULARA basins can be tracked through the ULARA Watermaster Annual Reports. For example, groundwater in storage in SB increased by 935 MG (2,870 AF) in WY 2013-14 as compared to WY 2012-13.²²⁸ VB experienced a 1.1 BG (3,457 AF) increase in groundwater in storage during WY 2013-14; ERB is expected to experience an estimated 38 MG (115 AF) decrease in groundwater in storage.²²⁹ Storage rights do not exist for any parties in either VB or ERB. The current state of groundwater storage in SFB is more complex than in SB, VB, or ERB, and is thus the focus of the remainder of this section.

The Superior Court of Los Angeles implemented a regulatory requirement for groundwater storage in the SFB called the Safe Yield Operation. The Safe Yield Operation, which took into consideration normal wet-dry cycles, operational flexibility, and annual pumping based on the calculated safe yield, established a 117 BG (360,000 AF) requirement for groundwater in storage in the SFB.²³⁰ The regulation also established an upper and lower regulatory storage limit 68 BG (210,000 AF) above and 48 BG (150,000 AF) below the 1954 storage volume.²³¹ It was determined that the amount of groundwater stored in SFB should be maintained between these upper (to prevent excess rising groundwater from exiting the basin) and lower (to help provide additional

²²⁵ ULARA adjudication

²²⁶ Introduction to the ULARA Groundwater Basins TM-1 Draft for the SNMP 2016 p. 37

²²⁷ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-37

²²⁸ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-33

²²⁹ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-33

²³⁰ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-31

²³¹ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-31, Plate 13

storage space for groundwater in wet years) limits. SFB has rarely been operated within this regulatory storage range since extraction has been such that levels are below the lowest established storage volume.²³²

As a result of more water leaving the basin than is being recharged on a long-term average annual basis, groundwater in storage has been declining in SFB. Causes include excess pumping relative to long-term recharge rates, reduced natural recharge caused by increased runoff due to urbanization and development, groundwater underflow and rising groundwater leaving the basin, reductions in irrigation return-flow recharge due to water conservation efforts, and a decline in groundwater recharge as a result of restrictions at the spreading grounds in the northeast region of SFB.²³³ The problem deepens if the amount of Stored Water Credits each party has compiled and the deficit the groundwater basin would face if they were all extracted is considered. The Judgment provided the cities of Burbank, Glendale, and Los Angeles the right to reduce pumping and store any unused water rights as Stored Water Credits into future years.²³⁴ However, the Judgment does not limit the amount of Stored Water Credits or the time period over which those Stored Water Credits are allowed to accumulate.²³⁵ If the parties had pumped their full water rights every year since 1968, SFB would have been 148 BG (455,612 AF) below the 1968 court-determined Safe Yield Operation level by October 1, 2014.²³⁶

To address this issue, the cities of LA, Burbank, and Glendale entered into a 10-year stipulated agreement, the “Interim Agreement for the Preservation of the San Fernando Basin Water Supply” (Agreement) in 2007. The Agreement sought to restore balance in SFB while ensuring the three parties their pumping rights. The main provisions of the agreement were: the segregation and distinction of “available credits” and “reserved credits”; the support of the City of LA to work with LA County to restore and enhance the artificial recharge of stormwater within SFB; and the debit of estimated volume loss (approximately 1% of total Stored Water Credits) by rising groundwater and underflow from each party’s Stored Water Credits in SFB.²³⁷ This last provision helps the volume of stored water rights of each party more accurately reflect the SFB hydrology.

²³² ULARA Watermaster Annual Report 2014 Plate 13, Cumulative Change in Groundwater Storage, San Fernando Basin of the ULARA

²³³ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-31

²³⁴ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-32

²³⁵ Based on where groundwater levels would be had parties fully pumped their annual water rights each year since 1968, “the SFB cannot supply the total amounts of groundwater to which these Parties are entitled under the Judgment, and...there is significant shortfall between water rights and actual hydrologic conditions; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-32

²³⁶ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-32

²³⁷ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-33

It is estimated that there is approximately 520,740 AF of groundwater storage space available in SFB that “can be used to capture and store additional native water or imported water supplies during wet (above-average rainfall) years.”²³⁸ Groundwater in storage in SFB decreased by 4 BG (12,157 AF) during WY 2012-13, which was similar to the 3.4 BG (10,338 AF) decrease SFB experienced in WY 2011-12.²³⁹ These decreases are generally associated with the below-average rainfall and the corresponding decrease in stormwater spreading. Groundwater in storage decreased by much more, 59,010 AF, in WY 2013-14 as there was an increase in SFB groundwater extraction and this was another low rainfall year that limited stormwater spreading.²⁴⁰ By October 1, 2014, the amount of pumping rights that the three cities had accumulated totaled 186 BG (572,279 AF).²⁴¹ As of October 2013, the City accrued approximately 175 BG (537,453 AF) of stored water credits; 57 BG (175,806 AF) were made available for use while 118 BG (361,648 AF) were placed on reserve.²⁴²

f. Salt and Nutrient Management Plan

As described in more detail in the Ballona Creek and Dominguez Channel watershed reports, the California Recycled Water Policy requires the development of Salt and Nutrient Management Plans (SNMPs) for California groundwater basins. The SNMPs are intended to ensure that the quality of the water in the groundwater basins is maintained at acceptable levels and in accordance with anti-degradation requirements as more groundwater recharge with recycled water occurs. The ULARA SNMP is being developed under the lead of the Watermaster to assess the impacts on salt and nutrient conditions of increasing the recharge from all water sources into ULARA.²⁴³

As of this writing, multiple technical memos have been released as part of the ULARA SNMP process. For example, Technical Memo 1 provides background information on the ULARA basins while Technical Memo 3 describes the goals and objectives for the ULARA SNMP as well as provides an estimate of the amount of future recharge that will occur. Technical Memo 4 outlines the management measures and impacts on salt and nutrient concentrations over the approximately 10 year planning horizon of the SNMP, through 2025.²⁴⁴ Additional ULARA SNMP tech memos are due for release in 2017. The plans, projects, and management measures described in these draft and final Technical Memos have been cited and incorporated throughout this ULARA

²³⁸ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 2-34

²³⁹ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-34

²⁴⁰ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-34; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-33

²⁴¹ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 2-32

²⁴² LADWP UWMP 2015 p. 6-7

²⁴³ Current status and available tech memos can be downloaded here: <http://www.ularawatermaster.com/SNMP>

²⁴⁴ Current status and available tech memos can be downloaded here: <http://www.ularawatermaster.com/SNMP>

groundwater discussion. Generally, increased stormwater recharge into the ULARA groundwater basins is expected to increase the salt and nutrient (S/N) loading to these groundwater basins but decrease the overall concentration of S/N in the groundwater itself as S/N concentrations are lower in stormwater than in the basins.

C. Remediation Efforts

Generally, overall groundwater quality in ULARA has been reported to be within the recommended limits of the California Title 22 Drinking water standards.²⁴⁵ Certain regions of SFB, VB, and SB, however, have recorded elevated concentrations of contaminants. Parts of the eastern SFB have displayed high concentrations of trichloroethylene (TCE), perchloroethylene (PCE), hexavalent chromium, nitrate as NO₃ (NO₃-N), and 1,4-dioxane, while areas in the western part of SFB have seen high concentrations of TDS and naturally-occurring sulfate.²⁴⁶ In areas of VB, elevated concentrations of gasoline additive, methyl-tertiary-butyl-ether (MTBE) and NO₃-N have been found.²⁴⁷ Additionally, NO₃-N and certain volatile organic carbons (VOCs) have been found at elevated concentrations in SB. In areas where concentrations of contamination are excessive, either the impacted wells have been temporarily removed from service or the groundwater is pumped and treated or blended to meet State Drinking Water Standards.²⁴⁸

LADWP has made a number of efforts to develop a better understanding of the contamination issues in SFB and accelerate the remediation of the basin. These efforts are described in the following sections and include the Temporary Tujunga Wellfield Treatment Study Project, Groundwater System Improvement Study (GSIS), improvement at the North Hollywood Operable Unit (NHOU), Pollock Wells Treatment Plant, a Tujunga Wellfield Treatment Study Project, and a partnership with BWP. The majority of the long-term groundwater treatment in ULARA, and more specifically in SFB, is currently done through its USEPA operable units. There are four main operable units in ULARA where efforts are being made to remediate groundwater; NHOU, Burbank Operable Unit (BOU), Glendale North and South Operable Unit, referred to as a single unit GOU, and Glendale Chromium Operable Unit (GCOU).

a. Current Projects, Plans, and Partnerships

Temporary Tujunga Wellfield Treatment Study Project

LADWP, in partnership with MWD, implemented the Temporary Tujunga Wellfield Treatment Study Project in 2010 to restore 8,000 gpm (10.7 MGD; 12,000 AFY) of pumping capacity at two production wells in the Tujunga Wellfield that had been rendered unavailable due to high

²⁴⁵ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-3

²⁴⁶ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-3

²⁴⁷ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-3

²⁴⁸ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-3

levels of contamination.²⁴⁹ The two wellheads utilized a coconut-based media in GAC vessels that were designed to remove VOCs from groundwater to test the effectiveness of the new media. The project was designed to remove VOCs such as TCE, PCE, carbon tetrachloride, and 1,1 dichloroethene. In WY 2012-13, the project treated approximately 3.6 BG (11,000 AF) of groundwater and 12.5 BG (38,300 AF) was treated in WY 2013-2014.²⁵⁰ From this operation, coconut-based GAC technology has been proven to operate effectively. It is expected that this project will treat approximately 12,000 AFY moving forward (Table 4.4).²⁵¹

Agency	Current Remediation ULARA	Approx treatment volume (AFY) ²⁵²
LADWP/MWD	Tujunga Wellfield Treatment Study project	12,000
LADWP	North Hollywood Operable Unit	<1,300
Burbank	Burbank Operable Unit	10,000
LADWP/BWP	Burbank and LA Departments of Water & Power Inter-connection Project	500-3,000
Glendale	North and South Operating Units	7,200
Glendale	Verdugo Park Water Treatment	0
CVWD	Glenwood Nitrate Water Treatment Plant	400
LADWP	Pollock Wells Treatment Plant	2,580
Total		33,500

Table 4.4. Ongoing remediation efforts in the ULARA groundwater basins.

Groundwater System Improvement Study (GSIS)

The GSIS, a 6-year, \$11.5-million project, was completed by LADWP in February 2015.²⁵³ This project was developed to provide a basis and to fill data gaps for a comprehensive remediation and cleanup program in SFB. The project involved the installation of monitoring wells and the development of a sampling and analysis program. In addition to data from the new monitoring wells, water quality data was also collected from existing monitoring and production wells. The data from the new monitoring wells, in addition to historic water quality data, produced a list of 93 chemicals detected above a regulatory threshold in the groundwater since 1980.²⁵⁴ With the data and analysis of the resulting 93 identified chemicals, LADWP produced a Remedial Investi-

²⁴⁹ ULARA Final TM-4 for the SNMP 2016 p. 28

²⁵⁰ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-13; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-13

²⁵¹ ULARA Final TM-4 for the SNMP 2016 p. 28

²⁵² LADWP UWMP Chapter 6 p. 6-10 & 6-11; ULARA Watermaster Annual Report WY 2013-14 (2017) p 3-12.

²⁵³ LADWP UWMP 2015 p. 6-9

²⁵⁴ LADWP UWMP 2015 p. 6-108

gation Report that summarizes the results of the GSIS and offers a more current conceptual understanding of SFB in regards to the extent of contamination and physical basin characteristics.²⁵⁵ The Remedial Investigation Report allows LADWP to commence with the required environmental reviews, design, permitting, construction, and startup of groundwater remediation facilities to remove contaminants from SFB.

North Hollywood Operable Unit

Operations in the NHOU are run by LADWP under the direction of the USEPA as a Superfund site; this project was designed to have a treatment capacity of 2,000 gpm (3,230 AFY). Currently, five of the seven extraction wells in NHOU are in operation. In WY 2011-12, NHOU pumped and treated a total of 406 MG (1,248 AF) of groundwater (Table 4.4); 16,670 AF were treated by NHOU in WY 2013-2014.²⁵⁶ The NHOU's original objective was to contain and remediate highly concentrated VOC plumes but VOCs have been detected in other water-supply wells that were subsequently closed.²⁵⁷ New contaminants, such as hexavalent chromium and 1,4-dioxane, have also emerged in the NHOU that the existing air stripping treatment process is incapable of removing.²⁵⁸ The emerging presence of chromium was thought to be from a plume that has made its way from a former Honeywell site in North Hollywood. Honeywell received a Cleanup and Abatement Order by the LARWQCB in 2009 to contain the chromium plume that it was unable to carry out. This required the LARWQCB and other state and federal regulators to get involved to address the growing problem.

In 2009 the USEPA conducted a Focused Feasibility Study and issued its Record of Decision (ROD) for the NHOU Second Interim Remedy (NHOU2IR) to continue remediation in the basin. The new remedy included a plan to construct remediation facilities that could treat the VOCs and the newly present hexavalent chromium and 1,4-dioxane at a targeted treatment capacity of 4.4 MGD (4,923 AFY).²⁵⁹ The remedy included goals to improve hydraulic containment of the contaminant plumes by modifying certain existing OU extraction wells, adding new OU extraction wells, and constructing additional monitoring wells. Due to the persistent hexavalent chromium contamination exceeding 50 ppb, another pumping well was forced to close in 2012 requiring the attention of the LARWQCB.²⁶⁰

²⁵⁵ LADWP UWMP 2015 p. 6-10

²⁵⁶ ULARA Final TM-4 for the SNMP 2016 p. 28; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-9

²⁵⁷ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-9; ULARA Final TM-4 for the SNMP 2016 p. 27

²⁵⁸ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-10

²⁵⁹ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-10; LADWP UWMP 2015 p. 6-11

²⁶⁰ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-10

In 2014, the ROD was amended to allow for the option of reinjection of the treated water back into the local aquifer.²⁶¹ It is suggested that the new remedy should provide even higher flow rates to help ensure plume containment and allow permit extractions from deeper regions to reach the entire vertical range of the contaminant mass.²⁶² LADWP has proposed an alternative Cooperative Containment Concept, which would double the target treatment capacity to 10,500 AFY; negotiations are expected to conclude by early 2018.²⁶³

Burbank Operable Units

BOU uses air stripping and liquid-phase granular activated carbon (GAC) to remove VOCs from groundwater.²⁶⁴ However, the local groundwater also contains elevated concentrations of nitrate and hexavalent chromium, which the facility was not designed to treat. Therefore, to address the concern of hexavalent chromium and elevated nitrate levels, the City of Burbank blends all pumped groundwater with imported water from MWD.²⁶⁵ During WY 2011-12, BOU pumped and treated a total of 3.3 BG (9,993 AF) of groundwater (Table 4.4).²⁶⁶ Similarly, 10,148 AF was pumped at BOU in WY 2013-2014 and 11,387 AF in WY 2012-13.²⁶⁷

LADWP and BWP have partnered on a groundwater interconnection project to maximize the use of the BOU. Currently, low water demand during the cooler months causes the BOU to operate below design capacity. The proposed project would enable the BOU to operate at maximum capacity all year by conveying the excess treated groundwater through the new interconnection pipeline into LADWP's water distribution system. This expected remediation of as much as 2.7 MGD (3,000 AFY) of additional groundwater would result in the removal of an extra 1,500 pounds of contaminants a year (Table 4.4).²⁶⁸

The Burbank GAC Treatment Plant (Lake Street Wells) was forced to shut down in 2001 due to excessive concentrations of hexavalent chromium in the groundwater and remained out of service through WY 2007-08. In WY 2008-2009 the plant "saw limited use for NPR" and was used when necessary to obtain water quality goals between 2009 and 2013.²⁶⁹ The City of Burbank set

²⁶¹ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-10

²⁶² ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-11

²⁶³ LADWP UWMP 2015 p. 6-11; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-14

²⁶⁴ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-11

²⁶⁵ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-14

²⁶⁶ ULARA Final TM-4 for the SNMP 2016 p. 27

²⁶⁷ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-14

²⁶⁸ LADWP UWMP 2015 p. 6-12

²⁶⁹ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-13

a goal to reach a maximum concentration of 7 µg / L after blending for distribution. This plant could produce up to 9,000 gpm (13 MGD, 14,300 AFY), if returned to service (Table 4.5).²⁷⁰

Agency	Planned or potential remediation	Completion Goal	Potential Volume (AFY)
LADWP	Mission Wells Improvement	2017	3,000 to 4,000
GWP/CVWD	Connect Rockhaven well to Nitrate treatment plant	2018	500
LADWP	Pollock Wells Improvement	2020 ²⁷¹	4,700
LADWP	SFB Treatment Facilities	2021	123,000
CVWD	Well 2 reactivation	n/a	240
Burbank	Reactivation of Burbank GAC Treatment Plant	n/a	14,000
Total			145,440 to 146,440

Table 4.5. Planned or potential remediation in the ULARA basins.

Glendale Operable Units

The Glendale North and South Operable Units (GOU), which are operated by the City of Glendale, use an aeration treatment process and liquid-phase GAC to treat the VOC-contaminated groundwater before blending the treated water with MWD imported water. The two wellfields together have a treatment capacity of 7.2 MGD (8,065 AFY).²⁷² During WY 2011-12, GOU treated 2.6 BG (7,830 AF) of groundwater and in WY 2013-2014, 2.4 BG (7,231 AF) were treated. It is expected that the GOU will treat about 7 MGD (7,800 AFY) moving forward (Table 4.4).²⁷³

The Glendale Chromium Operable Unit (GCOU) was established in 2007 to determine the degree of chromium groundwater contamination and develop the necessary remedial action. In 2012, construction began on 30 new monitoring wells to aid in mapping out the location and range of the contaminated area; to date, at least 29 wells have been installed.²⁷⁴ The city of Glendale released the “Hexavalent Chromium Removal Research Project” Report to the CDPH in 2013, which identifies viable treatment technologies for the removal of hexavalent chromium. Well GS-3 in the Glendale South Wellfield is a Weak-Base Anion Exchange (WBA) Chromium Removal

²⁷⁰ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-13

²⁷¹ “San Fernando Groundwater Basin – Remediation Program Summary” on page 8. www.ladwp.com/remediation

²⁷² ULARA Final TM-4 for the SNMP 2016 p. 27

²⁷³ ULARA Final TM-4 for the SNMP 2016 p. 27; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-12

²⁷⁴ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-12; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-12

Demonstration facility and has been shown to effectively remove chromium to below concentrations below 5 micrograms per liter (1ppb).²⁷⁵

Additional Treatment

In addition to the treatment taking place at these four main operable units, there are three smaller treatment facilities in SFB that are currently responsible for remediation: Verdugo Park Water Treatment Plant, Pollock Wells Treatment Plant, and Glenwood Nitrate Water Treatment Plant. The Verdugo Park Water Treatment Plant is a filtration and disinfection facility with a capacity of 1 MGD (1,129 AFY), although it has been operating significantly below its capacity.²⁷⁶ In WY 2012-13, the Verdugo Park Water Treatment plant treated 103 MG (316 AF) of groundwater.²⁷⁷ However, no groundwater was treated in WY 2013-2014.²⁷⁸

The Pollock Wells Treatment Plant, which was built by LADWP, has the capacity to treat 3,000 gpm (4.3 MGD or 4,730 AFY, Table 4.5) of VOC-contaminated groundwater from two wells using four liquid phase GAC vessels.²⁷⁹ To address the growing presence of hexavalent chromium, LADWP plans to construct monitoring wells to determine the horizontal and vertical range of this and other contaminants. The Pollock Wells Treatment Plant treated 109 MG (333 AF) of groundwater in WY 2012-13 and (2,580 AF) in WY 2013-2014.²⁸⁰ These production wells also help reduce groundwater lost to the LAR by reducing rising groundwater to the channel in unlined reaches.²⁸¹

The Glenwood Nitrate Water Treatment Plant, operated by CVWD, uses an ion-exchange process for nitrate removal and treated 146 MG (448 AF) in WY 2011-12, 192 MG (589 AF) in WY 2012-13, and 49 MG (150 AF) in WY 2013-2014.²⁸² The operations at the treatment plant were temporarily suspended in 2011 to replace the ion exchange resin. The replacement of the resin with a nitrate-specific resin results in lower wastewater volumes and lower nitrate concentrations. This project decreases nitrate loading and concentration to the basin by treating groundwater with

²⁷⁵ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-16

²⁷⁶ ULARA Final TM-4 for the SNMP 2016 p. 27

²⁷⁷ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-12

²⁷⁸ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-17

²⁷⁹ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-12

²⁸⁰ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-12; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-13

²⁸¹ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-12

²⁸² ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-12; ULARA Final TM-4 for the SNMP 2016 p.27; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 3-12

an initial concentration of 44 mg/L to 20 mg/L.²⁸³ This plant is expected to treat groundwater at rate of 0.4 MGD (450 AFY) moving forward (Table 4.4).²⁸⁴

b. Future Remediation Efforts

The eastern part of SFB has experienced severe contamination since the 1940s that prevents LADWP from pumping its full adjudicated right of 78 MGD (87,000 AFY). Basin remediation is a key element of the City's plans to fully utilize their extraction rights. LADWP plans to use the findings and results from the GSIS to develop short and long term projects that include the construction of groundwater remediation facilities and improvement projects. Glendale Water and Power (GWP) and CVWD also have plans to remediate groundwater in ULARA to increase their benefit from the groundwater resources.

LADWP plans to address the issue of contamination through the construction of groundwater treatment facilities. Using sampling and monitoring data from GSIS, LADWP can more completely detail and track the extent of the contamination to best direct remediation efforts. The facilities are expected to be located in North Hollywood, Rinaldi-Toluca, and the Tujung Wellfields. These treatment facilities are anticipated to treat 110 MGD (123,000 AFY) of groundwater when operational but are currently pending completion of feasibility studies (Table 4.5).²⁸⁵

The North Hollywood central treatment facility would consist of aeration towers, liquid phase granular activated carbon (LPGAC), and vapor phase granular activated carbon (VPGAC) to treat VOCs.²⁸⁶ Tujung Wellfield wellhead and centralized treatment facilities would use aeration towers, LPGAC, VPGAC, and AOP (UV/H₂O₂) to treat VOCs and 1,4 dioxane.²⁸⁷ The design/build timeframe is currently from late 2017 to June 2021 for both facilities.

The North Hollywood West wellhead treatment facility has a proposed site west of CA-170, Hollywood Freeway, north of the Vanowen St.-Whitsett Ave intersection. The treatment facility would use AOP (UV/H₂O₂) and LPGAC to treat 1,4 dioxane.²⁸⁸ Construction is expected to take place between September 2017 and December 2019 by LADWP's Power Construction and

²⁸³ ULARA Final TM-4 for the SNMP 2016 p. 27

²⁸⁴ ULARA Final TM-4 for the SNMP 2016 p. 27

²⁸⁵ ULARA Groundwater Basins Technical Memorandum No. 4 Draft for the Salt and Nutrient Management Plan by Watermaster, Upper Los Angeles River Area March 2016 p. 41

²⁸⁶ LADWP "Groundwater Basin Remediation in the City of Los Angeles" Presentation given by Evelyn Cortez-Davis on September 28, 2016 at the Groundwater Resources Association Conference, slide 17

²⁸⁷ LADWP "Groundwater Basin Remediation in the City of Los Angeles" Presentation given by Evelyn Cortez-Davis on September 28, 2016 at the Groundwater Resources Association Conference, slide 18

²⁸⁸ LADWP "Groundwater Basin Remediation in the City of Los Angeles" Presentation given by Evelyn Cortez-Davis on September 28, 2016 at the Groundwater Resources Association Conference, slide 22

Maintenance Group.²⁸⁹ The treatment train would follow from the remediation wells, through san separators, bag filters, UV AOP, GAC, and then through to the North Hollywood Pump Station.

The Pollock wellhead treatment facility, which is proposed to be located at the intersection of Fletcher Dr. and the Route 2 Freeway West Bound off-ramp, would use AOP (UV/H₂O₂), LPGAC, and potential chromium treatment to treat 1,4 dioxane.²⁹⁰ Construction is expected to start September 2018 and continue until December 2020 by LADWP's Power Construction and Maintenance Group. The preliminary capital cost of this collection of facilities is \$635M, which is currently being revised.²⁹¹ The funding for these projects would be derived from water rates, responsible parties, Proposition 1, securitization, and other state/federal programs.²⁹²

The Mission Wellfield, which is located in the Sylmar community of the City, included two active groundwater supply wells, a groundwater storage tank, a booster pump station, and a chlorine disinfection facility in 2014.²⁹³ In FY 2015, LADWP did not extract any water from SB due to TCE contamination. The Mission Wells Improvement project in SB aims to reestablish pumping by LADWP to utilize its 3.2 MGD (3,570 AFY) of water rights and avoid losing approximately 3.9 BG (12,000 AF) of current stored water credits.²⁹⁴ Phase 1 included the replacement of water storage tanks and control systems. LADWP is now in the process of implementing Phase 2, which includes the construction of up to five monitoring wells and three new water-supply wells, as well as the destruction of two deteriorated wells. An ammonia station and onsite hypochlorite generating station will also be constructed to meet Stage 2 Disinfection Byproducts Rule.²⁹⁵ The overall cost is expected to be \$145/AF or \$17/AF for the Integrated Regional Water Management Plan

²⁸⁹ LADWP "Groundwater Basin Remediation in the City of Los Angeles" Presentation given by Evelyn Cortez-Davis on September 28, 2016 at the Groundwater Resources Association Conference, slide 22

²⁹⁰ LADWP "Groundwater Basin Remediation in the City of Los Angeles" Presentation given by Evelyn Cortez-Davis on September 28, 2016 at the Groundwater Resources Association Conference, slide 24

²⁹¹ LADWP "Groundwater Basin Remediation in the City of Los Angeles" Presentation given by Evelyn Cortez-Davis on September 28, 2016 at the Groundwater Resources Association Conference, slide 26

²⁹² LADWP "Groundwater Basin Remediation in the City of Los Angeles" Presentation given by Evelyn Cortez-Davis on September 28, 2016 at the Groundwater Resources Association Conference, slide 26

²⁹³ Los Angeles Department of Water and Power Groundwater Monitoring Wells Installation Project Sylmar Groundwater Basin Attachment 5 – Work Plan 2012 p. 1

²⁹⁴ ULARA TM-4 Draft for the SNMP 2016 p. 41

²⁹⁵ ULARA TM-4 Draft for the SNMP 2016 p. 41; ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-18

(IRWMP).²⁹⁶ For the first 15 years, 3.7 MGD (4,170 AFY) of contaminated groundwater will be treated, and 3.2 MGD (3,570 AFY) will be treated every year after for the life of the project.²⁹⁷

In VB, GWP currently has a pumping well that was deemed inoperable due to high nitrate concentrations. The Rockhaven Well project was developed to bring this well back into operation and increase groundwater production for both CVWD and GWP. The project consists of connecting the GWP extraction well to Glenwood Nitrate Water Treatment Plant, which is operated by the CVWD, and sharing the resulting 0.4 MGD (484 AFY) of treated groundwater.²⁹⁸ This will require the installation of a 450 gpm pump, on-site piping, an electrical system, a telemetry system, a drain line for waste, on-site improvements, and 1,200 feet of 8-inch diameter water main.²⁹⁹ This project was planned to begin in January 2016 and be completed by June 2018.

CVWD is also looking to increase their groundwater production in VB through reactivating its Well 2, which has a capacity to pump 150 gpm, or 0.22 MGD (240 AFY).³⁰⁰ This well was shut down in 1977 after excessive nitrate concentrations were found. To reactivate Well 2, CVWD proposes a project that installs a nitrate removal treatment facility, a new 150 gpm pump and motor, on-site piping, an electrical system, a telemetry system, a storm drain line to pump waste, and on-site improvements.³⁰¹

D. Increasing Stormwater Recharge

a. Current and Planned Projects

Approximately 31,000 AFY has been spread in ULARA on an annual average basis from 1968 to 2013; only 10,443 AF were spread in WY 2013-2014 (a low precipitation year).³⁰² Many projects to rehabilitate and/or enlarge existing spreading basins and increase the potential to spread water are ongoing in the eastern part of ULARA (where the best conditions for recharge exist). These projects consist of restoring spreading grounds to their full capacity, increasing the capacity of already existing infrastructure, updating intake structures, revitalizing recharge basins, remov-

²⁹⁶ Los Angeles Department of Water and Power Mission Wells Improvement Presentation by Nohemi Rangel 2014. <http://www.ladpw.org/wmd/irwmp/Docs/Prop84/round3/ULAR%20Subregion%20Projects.pdf>. Accessed 10/07/2016.

²⁹⁷ ULARA TM-4 Draft for the SNMP 2016 p. 41

²⁹⁸ ULARA TM-4 Draft for the SNMP 2016 p. 42

²⁹⁹ ULARA TM-4 Draft for the SNMP 2016 p. 42

³⁰⁰ ULARA TM-4 Draft for the SNMP 2016 p. 42

³⁰¹ ULARA TM-4 Draft for the SNMP 2016 p. 42

³⁰² ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-32

ing sediment behind dams, and constructing stormwater capture and treatment facilities. Enhancements made to increase groundwater recharge in these spreading basins can translate to a direct increase in groundwater extraction capacity.

Potential centralized stormwater capture projects that are expected to result in 64,000 AFY of annual recharge (including approximately 27,000 AFY of historical annual recharge and 35,000 AFY of increased annual recharge from identified projects) were identified in the LADWP UWMP.³⁰³ Improvements have already been made at many locations, such as the Big Tujunga Dam Seismic Rehabilitation and Spillway Modification, which was expected to result in about 4,500 AF of additional annual average stormwater capture at the dam, and the Hansen Spreading Grounds Basin Improvements, which increased storage capacity by over 400 percent to recharge an additional 1,200 AFY.³⁰⁴

Some of the major projects in the SFB with the highest expected captured volumes include the Tujunga Spreading Grounds (TSG) Enhancement Projects, Big Tujunga Dam (BTD) Sediment Removal, and the Pacoima Dam Sediment Removal Project, Pacoima Spreading Grounds (PSG) Enhancement Project, and Branford and Lopez Spreading Grounds upgrades. The Pacoima Sediment Removal Project will result in the removal of 2.4 to 5.2 million cubic yards of sediment and could result in 700 AFY of increased annual recharge.³⁰⁵ The Lopez Spreading Grounds upgrade includes upgrading and automating the intake and revitalizing the recharge basin, which could result in an increase of 480 AFY to 1,067 AFY.³⁰⁶ A pump will be installed at Branford spreading basin, a pipeline bridge across the Tujunga Wash channel, and a discharge outlet to TSG, which could result in an increased annual recharge of approximately 600 AFY to a total of 1,100 AFY.³⁰⁷ TSG Enhancement and BTD Sediment Removal are described in the following paragraphs and PSG Enhancement will be discussed in the following section on recycled water.

Tujunga Spreading Grounds Enhancement Projects

TSG, owned by LADWP and operated by LACFCD, occupies an area of 188 acres and is located at the confluence of the Tujunga Wash Channel and the Pacoima Wash Channel adjacent to the unlined Sheldon-Arleta Landfill. The enhancement project aims to increase stormwater recharge into the SFB through the relocation and automation of the current intake structure on Tujunga Wash, the installation of a second automated intake to receive flows from Pacoima Wash, and the reconfiguration of the existing spreading basins.³⁰⁸

³⁰³ LADWP UWMP Exhibit 7H p. 7-13

³⁰⁴ zevyaroslavsky.org/wp-content/uploads/LACFCD-WC-recent-history1.doc

³⁰⁵ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-24; LADWP UWMP Exhibit 7H p. 7-13

³⁰⁶ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-25; LADWP UWMP Exhibit 7H p. 7-13

³⁰⁷ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-25; LADWP UWMP Exhibit 7H p. 7-13

³⁰⁸ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-24

The enhancements will increase TSG storage capacity from 33 MG (100 AF) to 302 MG (927 AF) and increase its intake capacity from 250 cfs to 450 cfs.³⁰⁹ Additional open space improvements are being planned to construct or upgrade recreational walking trails, native habitat, and educational facilities. LADWP will provide \$27.2M to LACFCD for the project, which is expected to increase stormwater capture by approximately 8,000 AFY for a total of 16,000 AFY.^{310,311} This increase translates into approximately 5 billion gallons per year, a volume of water enough to sustain nearly 48,000 homes for a year.³¹²

Big Tujunga Dam (BTD) Sediment Removal

BTD has a 6,240 AF capacity reservoir that provides flood protection and water conservation for downstream communities. Stormwater captured at the dam can be released to Big Tujunga Wash where the water can flow through Hansen Dam Recreation Area to Tujunga Wash and be diverted to spreading grounds that recharge SFB.³¹³ Groundwater from the spreading grounds is later extracted by LADWP, treated, and delivered to residents. The BTD Sediment Removal Project will remove approximately 2.3 to 4.4 million cubic yards of sediment that has collected behind the dam as a result of the 2009 Station Fire in the Angeles National Forest.³¹⁴ LACFCD will lead the \$33M project through its anticipated end in 2021. The sediment removal will restore lost reservoir capacity by approximately 4 MGD (4,500 AFY).³¹⁵

³⁰⁹ LADWP Projects Website: Tujunga Spreading Grounds Enhancement Project.

https://www.ladwp.com/ladwp/faces/wcnav_externalId/a-w-p-o-tujunga-sprd-grnds?_afWindowId=null&_afLoop=1306061749707267&_afWindowMode=0&_adf.ctrl-state=xqkf254j4_64#%40%3F_afWindowId%3Dnull%26_afLoop%3D1306061749707267%26_afWindowMode%3D0%26_adf.ctrl-state%3D16712ntz68_17. Accessed 08/24/2016

³¹⁰ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-24; “Los Angeles’ Tujunga Spreading Grounds Enhancement Project to Conserve Billions of Gallons of Stormwater” August 22, 2016. <http://www.water-world.com/articles/2016/08/los-angeles-tujunga-spreading-grounds-enhancement-project-to-serve-billions-of-gallons-of-stormwater.html>. Accessed 10/20/2016

³¹¹ ULARA final TM-4 for the SNMP 2016 p. 20, Table 5-3 states that projected stormwater capture volumes at TSG are: 5,100 AFY from 2017 to 2019; 6,000 AFY from 2019 to 2024; 6,900 AFY from 2024 to 2029; 8,700 AFY from 2029 to 2034; and 11,850 AFY from 2034 onward.

³¹² LADWP Projects Website: Tujunga Spreading Grounds Enhancement Project.

https://www.ladwp.com/ladwp/faces/wcnav_externalId/a-w-p-o-tujunga-sprd-grnds?_afWindowId=null&_afLoop=1306061749707267&_afWindowMode=0&_adf.ctrl-state=xqkf254j4_64#%40%3F_afWindowId%3Dnull%26_afLoop%3D1306061749707267%26_afWindowMode%3D0%26_adf.ctrl-state%3D16712ntz68_17. Accessed 08/24/2016

³¹³ Los Angeles Department of Water and Power Big Tujunga Reservoir Sediment Removal Projects FAQs. <http://dpw.lacounty.gov/wrd/Projects/bigtujunga/FAQ.pdf>. Accessed on 09/27/2016

³¹⁴ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-26

³¹⁵ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-26

West Coast and Central Basins

Opportunities to recharge groundwater basins in the LAR watershed include not only the ULARA basins but also extend to WCBCB towards the LAR outlet. One example of a recharge opportunity is the Dominguez Gap Spreading Grounds (DGSG), which are located along the LAR near the southern boundaries of the CB and WCB, north of the 710 and 405 highway intersection. The DGSG is owned, operated, and maintained by the LACDPW. DGSG historically included basins on the west and east sides of the LAR that provided recharge for WCB and CB, respectively. Only the basin on the west side of the LAR, however, currently remains operable as a recharge facility; the use of the basin on the east side ceased in 2007 after the DeForest Treatment Wetlands Project was constructed to create an area for habitat and surface water quality improvement.³¹⁶

Two sources of recharge water at DGSG are controlled flows from the LAR low-flow channel and uncontrolled (not measured) flows from storm drains. Before the east basins were taken out of operation, it was assumed that WCB and CB each received 50% of the source water.³¹⁷ From WY 2000-01 to 2005-06, WCBCB total historical flow volumes from DGSG ranged from 135 AFY to 1,342 AFY, or 70 AFY to 670 AFY in WCB and CB.³¹⁸ From WY 2007-08 to WY 2009-10, WCB received all the recharge from DGSG; volumes ranged from 562 AFY to 2,085 AFY.³¹⁹ The baseline stormwater recharge flow to WCB from DGSG was calculated from the 10-year average historical conservation volumes obtained from the LACDPW for WY 2000-01 through 2009-10.³²⁰ The baseline recharge volume is reported as 760 AFY.³²¹

Potential projects are also being considered along the LAR for Central Basin. For example, the DGSG West Basin Percolation Enhancement Project is a stormwater recharge project that would increase percolation capacity. This project is expected to increase recharged water at DGSG by 1,000 AFY from 760 AFY to 1,760 AFY by WY 2017-18.³²² Another conceptual project is the LAR Aquifer Stormwater Recharge and Recovery Facility, which would result in capturing approximately 5,000 AFY of stormwater for Central Basin recharge. This project would include diverting stormwater to an infiltration basin for percolation into the shallow aquifer; that water

³¹⁶ SNMP for Central and West Coast Basin 2015 Appendix H p.11

³¹⁷ SNMP for Central and West Coast Basin 2015 Appendix H p. 11

³¹⁸ SNMP for Central and West Coast Basin 2015 Appendix H, Table H-4

³¹⁹ SNMP for Central and West Coast Basin 2015 Appendix H, Table H-4

³²⁰ SNMP for Central and West Coast Basin 2015 Appendix H p.11

³²¹ SNMP for Central and West Coast Basin 2015 Appendix H, Table H-4

³²² SNMP for Central and West Coast Basin 2015 p.25

would then be pumped out and injected into Central Basin as an additional source of replenishment supply.³²³

b. Increasing Stormwater Capture

Increasing both centralized and distributed stormwater capture can play an important role in improving water quality throughout the LAR watershed; proving links to increasing local water supply will require additional research and monitoring to determine whether the stormwater being infiltrated through this mechanism is actually reaching groundwater basins that are used for supply. Distributed systems such as rain barrels and cisterns can potentially provide additional local water supply through, for example, offsetting potable water use where stored rainwater is used for irrigation at a single family home. Many agencies and groups have looked into the potential to increase recharge at a variety of scales throughout the region. Distributed projects completed as of the 2013-2014 ULARA watermaster report (December 2015) were estimated to provide 250 AFY of additional recharge capacity into SFB with an additional approximately 450 AFY in the next 5 years.³²⁴ Many projects at a variety of scales have already been built or are in the process of being built; project recharge capacities range between 5 AFY and 118 AFY (Table 4.6).

Project Name	Expected or Existing Recharge Volume
Elmer Ave Neighborhood Retrofit	16 AFY
Garvanza Park Infiltration	16 AFY
LABT Stormwater (SW) Capture Project	6 AFY
Sun Valley Park Drain and Infiltration Project	30 AFY
North Hollywood Alley Retrofit	29 AFY
Woodman Ave SW Capture Project	55 AFY
Elmer Paseo SW Capture Project	6 AFY
Glenoaks – Sunland SW Capture Project	28 AFY
Glenoaks – Nettleton SW Capture Project	37 AFY
Laurel Canyon SW Capture Project	40 AFY
Whitnall Highway Power Line Easement	110 AFY
Valley Generating Station SW Capture	118 AFY
Rain Barrels and Rain Gardens Incentives	5 AFY

Table 4.6. Some existing or potential stormwater capture projects.

One example is the Water Augmentation Study by the Council for Watershed Health, which assessed the possibility of increasing stormwater recharge and included the completion of the Elmer Avenue Neighborhood Retrofit Project to demonstrate the potential of implementing BMPs

³²³ SNMP for Central and West Coast Basin 2015 Appendix J p.45

³²⁴ ULARA Watermaster Annual Report WY 2013-14 (2017) p. 1-27

at a neighborhood block-scale to reduce flooding and water pollution, increase groundwater recharge and green spaces, and enhance the community.³²⁵ The Arid Lands Institute modeled the potential to increase recharge in the San Fernando Valley including constraints such as groundwater contamination and underground storage tanks and found that approximately 92,000 AFY could be infiltrated or otherwise captured depending on site-specific constraints.³²⁶ The River Project's Tujunga / Pacoima watershed plan also identified multiple projects in the Tujunga and Pacoima washes in the upper LAR watershed.³²⁷

Community Conservation Solutions took a prioritized approach to selecting runoff capture projects based in part on proximity of public spaces to larger storm drains that identified opportunities to capture runoff from up to 20 square miles, create over 1,000 acres of parks, habitat, and open space, and improve water quality in 96 miles of the LAR and tributaries, San Pedro Bay, and coastal waters.³²⁸ 453 parcels were screened in Phase IV of the green solutions, which included the quantification of benefits such as available volumes of stormwater, volumes of water that could be reused onsite, area of native habitat that could be restored, associated GHG benefits from reducing water imports and sequestering carbon in new habitat, and socio-economic metrics.³²⁹

City and County agencies have also developed large scale studies with a multitude of partners to assess the potential to increase both distributed and centralized stormwater capture throughout the LADWP service area (the LADWP SCMP) and the LA Basin area (LACFCD and US Bureau of Reclamation study). The SCMP, developed with LADWP, Geosyntec, and TreePeople, quantified current and future stormwater capture potential; LADWP and partners currently actively capture and recharge approximately 29,000 AFY of stormwater along with another 35,000 AFY through incidental recharge.³³⁰ Over the next 20 years, baseline recharge and direct use could be expanded by an additional 68,000 to 114,000 AFY.³³¹ Under the aggressive scenario in the SCMP, volumes of stormwater infiltrated (mainly in the ULARA basins) through centralized recharge could increase by 51,000 AFY and through distributed recharge by 56,000 AFY.³³²

³²⁵ <http://lasgrwc2.org/programsandprojects/was.aspx>

³²⁶ Hadley and Peter Arnold, 2013, BOOM: The Journal of California, Vol. 3, Number 3, pps 95–101, ISSN 2153-8018, electronic ISSN 2153-764X., available at: <http://aridlands.org/project/where-it-lets-reuse-it>

³²⁷ <http://www.riverproject.org/projects/tujungapacoima-watershed-plan>

³²⁸ The Green Solution Project, Community Conservation Solutions, http://www.conservationsolutions.org/html/projects/greensolution/greensolution_ULAR3.html

³²⁹ Green solutions web tool: <http://gsp.conservationsolutions.org/>

³³⁰ LADWP SCMP 2015 p. ES-2

³³¹ LADWP SCMP 2015 p. ES-2

³³² LADWP SCMP 2015 p. ES-10

The LA Basin Study defined opportunities to increase stormwater capture through a variety of mechanisms and at multiple potential scales in the watersheds within the LA Basin area, including the LAR watershed.³³³ At the largest individual project scale, both the enhancement of 15 existing spreading grounds and the creation of 8 new spreading grounds were considered in the LA Basin study. Potential locations, mainly in the San Fernando Valley, for 8 new spreading grounds were identified; building these spreading grounds would require the acquisition of 682 acres (about 1 square mile) and could result in an additional 29,930 AFY of stormwater recharge. Increased maintenance at existing spreading grounds could result in another 13,380 AFY.³³⁴

An additional mechanism explored in the LA Basin study was building 7 new recharge ponds along the LAR in the LA Forebay region of Central Basin, which could potentially result in 5,587 AFY of conserved water. Retrofitting debris basins to store stormwater and then release it downstream later for infiltration through constructing a controlled outflow could result in 48 AFY.³³⁵ Converting some portions of the LAR stormwater conveyance system could result in stormwater conservation as well; for example, modifying 28,764 ft of the Arroyo Seco could result in the conservation of 932 AFY and modifying 34,988 ft along the Tujunga Wash could result in the conservation of 1,076 AFY.³³⁶ In addition to these larger scale projects, the implementation of distributed BMPs such as green infrastructure and LID throughout the watershed was assessed under current rates as well as under scenarios in which management solutions (such as incentives to property owners to implement BMPs on-site) have been implemented and have resulted in increased rates of BMP implementation (Table 4.7). The potential stormwater volumes that can be conserved through these distributed programs are not insignificant, ranging from approximately 16,000 AFY up to 84,000 AFY (Table 4.7).

Project Type	Area required (acres) ³³⁷	Stormwater conserved (AFY)
Green infrastructure	1,426	18,663
LID	48,063	40,112
Complete Streets	28,731	15,855
Stormwater management solutions	99,579	84,286
GI management solutions	63,052	52,570

Table 4.7. Potential implementation mechanisms and resulting potential volumes of stormwater conserved if LA Basin study programs are fully implemented in the LAR watershed.

³³³ LA Basin Study <http://www.usbr.gov/lc/socal/basinstudies/LABasin.html>

³³⁴ LA Basin Study, Task 5, Appendix B, <http://www.usbr.gov/lc/socal/basinstudies/LABasin.html>

³³⁵ LA Basin Study, Task 5, Appendix B, <http://www.usbr.gov/lc/socal/basinstudies/LABasin.html>

³³⁶ LA Basin Study, Task 5, Appendix B, <http://www.usbr.gov/lc/socal/basinstudies/LABasin.html>

³³⁷ LA Basin Study, Task 5, Appendix B, <http://www.usbr.gov/lc/socal/basinstudies/LABasin.html>

The potential to increase capture potential at LACFCD Dams through, for example, putting in pneumatic gates or slide gates at the dam spillways to facilitate stormwater capture above the spillway crest under certain conditions was also explored; the addition of these controls could potentially enable the increase of an additional 150,015 AFY (across the LA Basin Study area, not just LAR watershed).³³⁸

The potential to increase capture potential at LACFCD Dams through, for example, putting in pneumatic gates or slide gates at the dam spillways to facilitate stormwater capture above the spillway crest under certain conditions was also explored; the addition of these controls could potentially enable the increase of an additional 150,015 AFY (across the LA Basin Study area, not just the LAR watershed).³³⁹ General recommendations from the LA Basin study for USACE dams included conducting a feasibility study to increase water conservation at these dams, improving intake capacity at downstream spreading grounds, and developing a seasonal water conservation pool similar to Whittier Narrows Reservoir (in the context that flood control must be prioritized when doing these assessments as that is the USACE mandate).³⁴⁰ With some modifications at Hansen Dam, modeled results indicated there was approximately 8,000 AF of additional annual mean volume of storage that could be used for potential stormwater conservation.³⁴¹ An earlier feasibility study for Hansen Dam that was never finalized identified the potential to increase stormwater capture for recharge up to 3,400 AFY with minor changes to the outlet facility.³⁴² The potential to expand stormwater capture at dams (e.g., Hansen, Sepulveda, and Lopez) and reservoirs was also investigated in LADWP's SCMP.³⁴³

The USACE has also investigated other southern California facilities (including Hansen, Santa Fe, and Whittier Narrows) for their potential to increase stormwater capture. LACFCD and USACE discussed operating Hansen Dam, which also has ungated outlets, for water conservation purposes. The potential to raise the level of the existing water conservation pool by over 1,000 AF at Whittier Narrows, without impacting local habitat and endangered species, is currently being assessed. Potential impacts on roads and facilities that are located behind the dam and may be impacted by higher water levels must be considered in these efforts. The pairing between Hansen Dam and groundwater recharge basins along the Tujunga Wash may offer a potential example to follow to increase the water supply potential of Sepulveda Basin.

The Sepulveda Dam Basin is located 44 miles above the mouth of the LAR in the San Fernando Valley and managed and operated by the USACE. The dam has a substantial drainage area of 152

³³⁸ LA Basin Study, Task 5. Infrastructure and Operations Concepts. p. 90, 97

³³⁹ LA Basin Study, Task 5. Infrastructure and Operations Concepts. p. 90, 97

³⁴⁰ LA Basin Study, Task 5, p. 101 <http://www.usbr.gov/lc/socal/basinstudies/LABasin.html>

³⁴¹ LA Basin Study, Task 5, p. 102 <http://www.usbr.gov/lc/socal/basinstudies/LABasin.html>

³⁴² LADWP SCMP Task 1.3 Existing Stormwater Capture Facilities

³⁴³ LADWP SCMP Appendix, Task-1.3 existing stormwater capture facilities.

square miles and lies completely within the municipal limits of the City.³⁴⁴ The large drainage area provides intriguing potential to capture enormous volumes of stormwater for potential infiltration benefits or to increase recycled water volumes from DCTWRP. For example, the annual mean flow for the time period between 1943 and 2015 was 60.5 cfs (43,800 AFY) as measured at the ‘Los Angeles River at Sepulveda Dam’ gage (0.6 miles downstream from Sepulveda Dam, drainage area 158 mi²). The highest annual mean in that time frame was 292 cfs (211,400 AFY) in 2005 and the lowest annual mean was 7 cfs (5,000 AFY) in 1950.³⁴⁵ Currently, a small fraction of the stormwater from this drainage area is captured. Nearly all of it is discharged to the LAR. The dam stores flood runoff temporarily and releases the water at a rate that does not exceed the downstream channel capacity (17,000 cfs). Due to the highly urbanized nature of the watershed, the runoff response to rainfall is accelerated with high peak discharges of shorter duration.³⁴⁶

A study is needed to assess the water supply potential and storage requirements of the basin, both at current capacity if all the gates could be closed and under future potential scenarios (e.g., if more capacity was added to the basin, or some portion of space behind the dam could be created or reserved for water supply storage). For example, if the 8 existing dam gates were reconfigured to allow greater temporary storage, then flows could potentially be diverted to DCTWRP, which has approximately 30 to 40 MGD of excess capacity. These flows could be comingled with wastewater influent, treated, and then recycled through purple pipe. Or, these flows could be pumped to recharge basins in the eastern San Fernando Valley for groundwater infiltration. LADWP’s SCMP identified a pipeline between Sepulveda Basin and the HSG as a potential centralized project that could generate more than 3,000 AFY of recharge benefit.³⁴⁷

The potential to use water stored behind the dam for controlled releases to replace DCT effluent discharged to the LAR should also be considered, as this would free up additional recycled water for recharge at HSG. A study could be conducted to assess the feasibility of comingling runoff with the treated DCTWRP recycled water that is getting pumped to the HSG and whether there are other appropriate sites for spreading grounds for the captured stormwater. In addition, whether or not a dredging project could create storage capacity in the basin to be used to capture stormwater should be assessed. Finally, the possibility of prioritizing recycled water over stormwater for recharge at spreading basins should be considered.

In addition, the potential to add the opportunity to build flood control along the LAR through, for example, implementing BMPs, should be explored. There are binding constraints on flood control capacity behind the dam because of downstream flood risks. Wide-scale construction of regional and distributed infiltration BMPs, however, can potentially reduce flood risk downstream of the Dam as they would reduce the flows making it to the LAR. A wide variety of BMPs could

³⁴⁴ The boundaries of the drainage area are marked by the Santa Monica Mountains in the south, the Simi Hills in the west, the Santa Susana Mountains in the north, and a line extending north to south across the valley along the San Diego Freeway. It serves as one of six dams that provide flood risk management for the LA County Drainage Area.

³⁴⁵ [Water-Year Summary for Site USGS 11092450](#)

³⁴⁶ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-6

³⁴⁷ LADWP SCMP

be investigated for these purposes at distributed or regional scales. These BMPs do not need to be tied to the river or its reaches directly as benefits will be seen in reduced peak flows even from upstream BMPs or those in parts of the watershed that are further removed from the LAR. One option that could be explored includes putting cisterns alongside the LAR where tributary flows could fill in cisterns; this flow could potentially then be later used for irrigation or metered into the sewer system to increase WRP influent flows for recycling. Another option is adding regional infiltration BMPs that would reduce downstream peak flows. All could potentially serve to augment local water supplies where the local environment was conducive to groundwater recharge. Please see Appendix D for additional discussion of constraints and conditions at the basin.

It is important to note that there is overlap among the volumes identified in the various studies described above and in the presented work; the biggest take away from all of these efforts is multiple opportunities have already been identified to significantly increase the volumes of water being implemented on a scale ranging from putting in a dry well to creating a new spreading ground. Multiple partnership opportunities exist through which to implement these projects, including the EWMPs, the SCMP, the Greater LA Water Collaborative, the Greater LA County Integrated Regional Water Management Plan, the Greenways to Rivers Arterial Stormwater System,³⁴⁸ the LAR Ecosystem Restoration Feasibility Study, and the Water LA Program Collaborative. Sifting through and combining all of the potential projects to identify the lowest hanging fruits that can be implemented quickly as well as finding sustainable funding mechanisms are critical next steps to moving forward with increasing groundwater recharge, and thus potentially increasing locally stored groundwater, in ULARA.

E. On Groundwater Recharge and Extraction

a. Remediation

More than 30,000 AFY of remediation efforts are ongoing in ULARA basins to address historical contamination issues and facilitate the full extraction of rightsholders' groundwater volumes in ULARA. These ongoing remediation projects (Table 4.4) are managed by multiple agencies with water rights in the ULARA Basins, including LADWP, Glendale, BWP, and Crescenta Valley Water District (CVWD). Some projects, such as the interconnection project between BWP and LADWP, are joint efforts to increase the volumes of water that are treated to become part of the water supply of both participants.

In addition to the ongoing projects described above, there is an additional potential for almost 150,000 AFY of remediation to occur through pump and treat facilities in the ULARA basins through either currently planned projects or through reactivating facilities that are currently not

³⁴⁸ http://www.lastormwater.org/wp-content/files_mf/grasssummaryreport.pdf

operating or operating under their full capacity based on contamination (Table 4.5).³⁴⁹ For example, the Pollock Wells Treatment Plant has the capacity to treat approximately 4,700 AFY of VOC-contaminated groundwater but only pumped 333 AFY in WY2012-2013 due to a need to characterize the growing presence of hexavalent chromium.³⁵⁰ The vast majority of the planned remediation volume, 123,000 AFY, will stem from the groundwater treatment facilities LADWP is building in SFB based in part on their GSIS efforts.

b. Recharge

In addition to the remediation efforts described above, which will greatly increase the volumes of water that can be extracted from the basin, there are multiple opportunities to increase the volumes of water being recharged into the basins to increase the amount of groundwater in storage. Ongoing improvement projects at spreading grounds that overlie SFB such as Tujunga, Hansen, and Pacoima will greatly increase the volumes of recycled water and stormwater that can be recharged. The main City-led recycled water groundwater replenishment project that is already in progress will result in the recharge of up to 30,000 AFY of recycled water from DCTWRP to the Hansen and Pacoima spreading grounds when there is space available.

In addition to recharging recycled water, the City is planning to increase the recharge of stormwater into these basins to increase the groundwater levels and eventually be able to extract additional water in a sustainable way. The SCMP identifies conservative and aggressive goals by which the City can increase stormwater capture by 2035. These SCMP goals are 132,000 AFY (conservative) and 178,000 AFY (aggressive); both goals include 64,000 AFY of existing baseline stormwater capture. Stormwater capture potential identified in the SCMP for 2099 is even higher, at 258,000 AFY.³⁵¹ Regional efforts could also expand stormwater recharge into these basins; the LACFCD and USBR LA Basin Study considered both the enhancement of 15 existing spreading grounds (including those mentioned above) and the creation of 8 new spreading grounds. Potential locations, mainly in the San Fernando Valley, for 8 new spreading grounds were identified. Building these spreading grounds would require the acquisition of 682 acres (approximately 1 square mile) and could result in an additional 29,930 AFY of stormwater recharge.³⁵²

Enhancing or creating new spreading grounds is one opportunity to increase the capacity to store and recharge water into ULARA; working with the US Army Corps of Engineers (USACE) to identify if there are any opportunities to add storage capacity for water supply as well as flood control behind the Sepulveda Basin Dam is another. Both physical adjustments (e.g. 4 of the 8 gates are currently ungated) and political adjustments (e.g., an act of Congress to provide funding and allocate space for both water supply and flood control) would be required. Existing land uses and habitats must also be preserved. If all needs can be met, however, substantial flows pass

³⁴⁹ See Groundwater Remediation Efforts section for original data sources.

³⁵⁰ ULARA Watermaster Annual Report WY 2012-13 (2014) p. 3-12

³⁵¹ LADWP SCMP p. 19

³⁵² LA Basin Study, Task 5, Appendix B, <http://www.usbr.gov/lc/social/basin studies/LABasin.html>

through the Sepulveda Basin Dam. Even capturing some volume for storage could provide a substantial water supply benefit and merits further study.

c. Explore Additional ULARA Opportunities

The potential to increase the conjunctive use of the western portions of SFB (mainly located west of Interstate 405) could also be explored to identify any opportunities to increase additional use of these groundwater basins. However, there are many factors that must be considered in assessing potential in the western part of the basin. First, according to maps in the annual ULARA watermaster reports, almost all of the water supply wells are located in the eastern part of the basin; wells in the western part of the basin are mainly dewatering or clean-up wells (at sites such as Honeywell International, the Boeing Santa Susana Facility, Raytheon, and others).³⁵³ The presence of dewatering wells in this portion of the basin points to another important factor relevant to increasing the use of these basins, in particular SFB: groundwater levels in the western portion of SFB are significantly higher than those in the eastern portion. The depth to groundwater in SFB ranges between 24 and 400 feet; based on these contours the flows of groundwater are mainly from west to east then southward towards Central Basin. Looking at contour graphs of the 5 wells with hydrographs west of Interstate 405, groundwater levels in the west in recent years have been less than 20 feet below ground surface in the wells that are farthest to the west (1, 15) and between 200 and 250 feet below ground surface at the wells closer to Interstate 405 (2, 16, 17).³⁵⁴ Along with shallow groundwater levels, the western portion of SFB is subject to rising groundwater levels, high liquefaction potential, naturally occurring high TDS, and finer sediments.³⁵⁵ In FY2012-2013, the Reseda No. 6 Well in the western portion of the SFB had a TDS of 595 mg/L.³⁵⁶

As previously described, historical contamination in the eastern part of SFB (e.g., TCE, PCE, nitrates, and chromium) is significant and multiple efforts are in the works to pump and treat this water out of SFB. Any efforts to increase the use of groundwater in the western portion of SFB must not impact these remediation efforts; change the flows of groundwater into, through, or out of the basin; impact any other rightsholders; or contribute to any increases in already high groundwater levels in the western SFB. Although any increase in use of the western portion of SFB would be complex and may not currently be the most promising opportunity to expand on local water supply, the context is changing as the potential for drought, increasing demand for local water supplies, and persistent water quality issues in the region provide an impetus to manage water differently. Many planned remediation efforts and the implementation of large-scale stormwater management plans such as the EWMPs will further slowly change the face of SFB and how it is managed and recharged. In addition, more distributed BMPs are likely to go in at single family homes and smaller properties throughout the basin, which may impact groundwater levels as the region moves towards capturing more stormwater locally.

³⁵³ ULARA Watermaster Annual Report, FY2012-2013. Plate 3. ULARA Location of Individual Producers.

³⁵⁴ ULARA Watermaster Annual Report, FY2012-2013. P. 2-22 to 2-29

³⁵⁵ MWD 2007 groundwater basin assessment reports

³⁵⁶ ULARA Watermaster Annual Report, FY2012-2013 Appendix D. Representative Mineral Analyses of oWater.

An additional study to address opportunities to increase the use of the western portion of SFB is important to understand how to fully utilize the potential of this basin; questions of the impacts of increased distributed recharge on areas of shallower groundwater and how best to manage groundwater levels will need to be addressed in any case as the implementation of these types of projects becomes more frequent. The study should assess whether adding pump and treat capacity for brackish shallow groundwater in the half of the basin west of Interstate 405 could potentially increase the use of this water as well as create space in which to recharge water from additional stormwater capture projects. Regional examples of groundwater desalting such as the Calleguas MWD's Salinity Management Pipeline and associated treatment facilities and in the Inland Empire Utility Agency's (IEUA) Chino Desalter and Inland Empire Brine Line could inform whether pump-and-treat capacity is the most appropriate way to address salinity issues in the western half of SFB. In both the Calleguas and IEUA cases, brinelines allow for increased use of local brackish groundwater basins for local water supply and also remove salt from the watershed and basins by transporting the brine out of the area for discharge into the ocean.³⁵⁷

This study to examine the best opportunities to increase the conjunctive use of ULARA should also incorporate (where possible) the flows of groundwater that are already being dewatered and disposed of through the stormwater drainage system. For example, in a few areas of the SFB, the groundwater levels are close to the surface and pumping is required to artificially lower groundwater levels to maintain depths that are several feet below the bottom of the buildings or subterranean parking structures. In particular, this condition is present along Ventura Blvd on the south side of the SFB. Currently, building owners are required to meter the extracted groundwater, report the extractions to the ULARA watermaster, and enter into an agreement with an affected rights holder in the basin (such as the City) to pay for the extracted volumes.³⁵⁸ For example, in FY 2012-1013, the BFI Sunshine Canyon Landfill dewatered 79.03 AF, Glenborough Realty dewatered 10.62 AF, and MWD dewatered 138.20 AF; the total dewatered volume charged to the City's water rights was 310.61 AF.³⁵⁹ In most cases, this water is pumped out and sent to stormwater drains; the potential to channel the water either to on-site reuses or to the wastewater system for treatment and reuse should be explored further where feasible.

Other aspects that could be included in the study include the potential supply benefits of increased recharge to SFB through BMPs in the LAR channel that would not interfere with flood control purposes. In addition, identifying what portion of the recharged water is 'new' water is critical. SFB is a complex environment with multiple ongoing efforts to recharge, remediate, and manage the basin sustainably. Therefore, concerns such as the potential impacts on subsurface gradients of pumping more in the west should also be assessed to determine the potential to move the contaminant plumes west into the remaining operational supply wells and how these efforts might impact the planned 123,000 AF groundwater remediation facility. The City and other regional entities have conducted extensive research such as the SCMP, the GSIS, the SNMP, the LA

³⁵⁷ <http://www.calleguas.com/images/docs-documents-reports/crsmpbroc.pdf>; <https://www.ieua.org/facilities/chino-desalters/>

³⁵⁸ ULARA Annual Watermaster Report FY 2012-2013 p. 1-31

³⁵⁹ ULARA Annual Watermaster Report FY 2012-2013 Table 2-5: 2012-2013 Private Party Pumping – SFB

Basin Study, the RWMP, and many more that look at pieces of the puzzle. Findings from these studies should be put together to maximize the conjunctive use of the ULARA basin and its local water supply potential. Results from these studies should be assessed, combined, and interpreted to identify the many opportunities to push the use of these basins forward while also preserving and improving their water quality and maintaining the long-term sustainability of their supply.

V. Wastewater and Recycled Water

A. Introduction

There are two categories of planned wastewater reuse, non-potable reuse (NPR) and ground-water recharge (GWR), which is a form of indirect potable reuse (IPR). NPR is the use of recycled water for purposes such as irrigation, street sweeping, industrial cooling, dust control, and environmental benefits (e.g. maintaining lake levels). Direct potable reuse (DPR), which is the introduction of highly treated recycled water directly into potable raw water supplies, is another potential future opportunity to reuse wastewater. Regulation in California, however, does not currently permit the implementation of a DPR project. In ULARA, recycled water is currently used for NPR such as landscape irrigation, lake replenishment, golf course irrigation, in-plant use at the WRPs, power plant cooling, and other industrial uses. Regulations for the production and use of recycled water are known as Title 22 in the California Code of Regulations (CCR). Recycled water in ULARA meets the CCR's Title 22 standards and requires a dedicated recycled water pipeline to distribute. NPR reuse regulations are governed by the SWRCB, the LARWQCB, and the Los Angeles County Department of Public Health (LACDPH).

Three WRPs that produce recycled water are present in ULARA: DCTWRP, BWRP, and LAGWRP. In the 2010 UWMP, LADWP developed a goal to increase recycled water use to 53.6 MGD (59,000 AFY) by 2035. This goal was expanded to 64.5 MGD (72,200 AFY) in the 2015 UWMP.³⁶⁰ As much as 26.4 MGD (29,000 AFY) of this recycled water is expected to be used for NPR in the City. These three WRPs treated a total of 28.6 BG (87,877 AF) of wastewater in WY 2012-13.³⁶¹ DCTWRP and LAGWRP together are anticipated to provide 9.6 MGD (10,706 AFY) of the planned 25.9 MGD (29,000 AFY) of recycled water used by the City in the SFB by 2025.³⁶²

B. Water Reclamation Plants Background

Donald C. Tillman WRP

DCTWRP is a City of LA-owned treatment plant located in the city of Van Nuys. DCTWRP has a treatment capacity of 80 MGD (89,600 AFY) and treats domestic, commercial, and industrial wastewater in the San Fernando Valley Service Area. The treatment system includes nitrification and denitrification activated sludge biological treatment with fine pore aeration and tertiary treatment with disinfection. Chlorination is employed for disinfection of recycled water used for NPR,

³⁶⁰ LADWP and LASAN RWMP, UWMP. LADWP UWMP 2015 p. ES-19.

³⁶¹ ULARA Watermaster Report WY 2012-13 p. 2-21, Table 2-7

³⁶² ULARA TM-4 Draft for the SNMP 2016 p. 11

while recycled water that is used for in-plant processes, beneficial environmental uses, or discharged to the LAR is dechlorinated.³⁶³

DCTWRP currently operates under a NPDES permit for its discharge of tertiary treated wastewater to the LAR. Under this permit, DCTWRP must comply with specific water quality regulations that limit the concentrations of metals, nutrients, solids, biochemical oxygen demand, and bacteria. Effluent limitation on the concentration of Total N (Nitrate and Nitrite) is 7.2 mg/L; this concentration is the WLA under the Nitrogen Compounds TMDL.³⁶⁴ DCTWRP is currently without facilities for solids processing. Solids from DCTWRP, which consist of approximately 10 MGD of grit, primary and secondary sludge and skimmings, and filter backwash, are sent to HWRP for processing.³⁶⁵

DCTWRP treated 12.4 BG, or 34 MGD (38,000 AFY) of wastewater and supplied a total of 9.2 BG, or 25.2 MGD, (28,200 AF) of recycled water to the City in 2015.³⁶⁶ Of the 25.2 MGD (28,200 AFY), 2.4 MGD (2,647 AFY) of recycled water was delivered to customers in the Valley Service area.³⁶⁷ The majority of the recycled water was used for irrigation; dust control, cooling towers and equipment wash were the other uses. The remaining volume of recycled water demand from DCTWRP was delivered for environmental use, which increased slightly from WY 2012-13 by 309 AF. Environmental use totaled 8.6 BG (23.5 MGD, 26,317 AFY) in FY15 with 1.5 BG (4 MGD, 4,531 AF) for use in the Japanese Garden, 1.7 BG (4.6 MGD, 5,140 AFY) in Wildlife Lake, and 5.4 BG (14.9 MGD, 16,646 AFY) in Lake Balboa.³⁶⁸ In addition, approximately 6,400 AF of treated wastewater from DCTWRP was directly discharged to the LAR.³⁶⁹

Los Angeles-Glendale WRP

LAGWRP is jointly owned by the cities of Los Angeles and Glendale and is located in the city of Los Angeles. LAGWRP treats domestic, commercial, and industrial wastewater from the Metro Service area. LAGWRP has a wastewater treatment capacity of 20 MGD (22,400 AFY) and treats through tertiary levels and NdN processes.³⁷⁰ Tertiary-treated effluent that is not used for NPR

³⁶³ Donald C. Tillman Water Reclamation Plant Permit 2011 p. 6

³⁶⁴ Donald C. Tillman Water Reclamation Plant Permit 2011 p. 21, Table 6

³⁶⁵ California Regional Water Quality Control Board Los Angeles Region. Final Donald C. Tillman Water Reclamation Permit 2011 p. 6

³⁶⁶ LADWP UWMP 2015 p. 4-9, Exhibit 4C

³⁶⁷ Los Angeles Department of Water and power Recycled Water Annual Report 2015 p. 6

³⁶⁸ LADWP UWMP 2015 p. 4-20, Exhibit 4J

³⁶⁹ LADWP UWMP 2015 p. 4-9, Exhibit 4C

³⁷⁰ LADWP UWMP 2015 p. 4-10, Exhibit 4C

purposes is discharged into the LAR and regulated by a NPDES permit for effluent concentrations of metals, nutrients, solids, biochemical oxygen demand, and bacteria.

In WY 2012-13, LAGWRP treated 7 BG, or 19.1 MGD, (21,504 AFY) of influent.³⁷¹ In the same year, LAGWRP produced 16.1 MGD (18,068 AFY) of recycled water.³⁷² Of this 16.1 MGD (18,068 AFY) LAGWRP provided 11.5 MGD (12,898 AFY) to operational safety weirs in the LAR, 323 MG (990 AF) to in-plant operations, and 2.1 MGD (2,306 AFY) and 1.7 MGD (1,874 AFY) to LADWP and Glendale Water and Power (GWP) respectively for NPR.³⁷³ LADWP recharged 110 MG (338 AF) and GWP recharged 511 MG (1,571 AF) of recycled water into the SFB, while 83 MG (255 AF) were returned to VB in 2012-13.³⁷⁴

In FY 2014-15 LAGWRP treated 5.2 BG, or 14.2 MGD (16,000 AFY), of wastewater and served 815 MG, or 2.2 MGD (2,500 AFY), of recycled water to the City.³⁷⁵ NPR customers used the recycled water largely for irrigation and also dust control. The customer list includes Caltrans, greenways, Griffith Park, memorial parks, golf clubs, state parks, and the LA Zoo parking lot.³⁷⁶ Approximately 11,000 AF of treated wastewater from LAGWRP was discharged to the LAR.³⁷⁷

Burbank WRP

BWRP is located outside the City and owned and operated by the City of Burbank Department of Public Works; currently, BWRP does not supply any recycled water to the City. BWRP has the capacity to treat 10 MGD (11,200 AFY) of wastewater. In WY 2013-14, BWP treated 8,980 AF and 135 AF went through to HWRP. Of the treated water, 6,438 AF was discharged to the LAR and 2,407 AF was reused. Burbank reclaimed water users include cooling towers at the BWP steam power plant (approximately 50%), the Debell golf course, and the Burbank landfill.³⁷⁸

³⁷¹ ULARA Watermaster Report 2013 p. 2-21, Table 2-7

³⁷² ULARA TM-4 Draft for the SNMP 2016 p. 9, Table 4-1

³⁷³ ULARA TM-4 Draft for the SNMP 2016 p. 9, Table 4-1

³⁷⁴ ULARA TM-4 Draft for the SNMP 2016 p. 9, Table 4-1

³⁷⁵ LADWP UWMP 2015 p. 4-10, Exhibit 4C

³⁷⁶ LADWP Recycled Water Annual Report 2015 p.8

³⁷⁷ LADWP UWMP 2015 p. 4-10, Exhibit 4C

³⁷⁸ ULARA Watermaster Report 2013 p. 2-21, Table 2-7; ULARA TM-4 Draft for the SNMP 2016 p. 9, Table 4-1; <http://www.burbankca.gov/departments/public-works/water-reclamation-and-sewer/burbank-water-reclamation-plant>; ULARA Watermaster Annual Report WY 2013-14 (2017) p 2-21

C. Groundwater Recharge

a. Recycled Water Production

The GWR project was established in the 2012 RWMP with the objective to replenish SFB, via HSG and PSG, with 26.8 MGD (30,000 AFY) of advanced treated purified recycled water from proposed new Advanced Water Purification Facilities (AWPF) by 2024. The new AWPF would receive recycled water influent from DCTWRP. With DCTWRP operating at its full capacity of 80 MGD (89,600 AFY), the plant would produce approximately 73 MGD (81,760 AFY) of recycled water.³⁷⁹ Of the 73 MGD of recycled water produced, 2 MGD (2,240 AFY) would be used for in-plant functions, and up to 27 MGD (30,240 AFY) for flows to lakes and rivers; under these current plans, about 44 MGD (49,280 AFY) of recycled water would be routed for advanced treatment at the AWPF.³⁸⁰ After expected volume losses through the treatment processes, the AWPF would produce about 35 MGD (39,200 AFY) of purified recycled water.³⁸¹

In addition to these expected inherent process losses, the AWPF is also anticipated to be offline occasionally throughout the year due to routine maintenance, unforeseen interruptions, and during the wet season when HSG and PSG are unavailable for recycled water GWR due to stormwater capture.³⁸² Factoring in these days where the AWPF will be inoperable, average annual purified water production is expected to be 31.25 MGD (35,000 AFY).³⁸³ A potential way to increase purified water production is to build in above ground or subsurface storage capacity for high quality water to store the treated water until there is recharge capacity at HSG and PSG. 26.8 MGD (30,000 AFY) of this advanced treated water is expected to be applied over HSG and PSG through the implementation of the GWR project; the remaining 4.5 MGD (5,000 AFY) would be used to meet NPR demand.³⁸⁴

The volumes of recycled water produced, discharged to the LAR, and pumped to HSG or PSG could vary based on a number of factors. If an aquatic life/recreational beneficial use study on the LAR (as described above) demonstrates that lower flows are needed to support beneficial uses, then more recycled water can be utilized for water supply. The study may demonstrate that a flow similar to the current level (annual average 27 MGD, varied between 25.4 MGD and 26.1 MGD

³⁷⁹ LADWP GWR DEIR 2016 p. ES-11

³⁸⁰ LADWP GWR DEIR 2016 p. ES-11

³⁸¹ LADWP GWR DEIR 2016 p. ES-11; ULARA TM-4 Draft of the SNMP 2016 p. 10, Table 4-2 reports 3,000 AFY for in-plant use

³⁸² LADWP GWR DEIR 2016 p. ES-11

³⁸³ LADWP GWR DEIR 2016 p. ES-11

³⁸⁴ LADWP GWR DEIR 2016 p. ES-11

between May and September 2015³⁸⁵) is required for the kayak recreational use for the summer months, but lower flows are needed to support other recreational uses and aquatic life uses during the majority of the year. If so, then more DCTWRP water could be available for advanced treatment and use. Also, it is important to note that only tertiary treatment with NdN is required for discharges to the LAR or to the City's lakes, not advanced treatment.

This project was selected for implementation by LADWP and LASAN for multiple reasons. The primary consideration was the already existing and unutilized capacity of DCTWRP to treat up to 80 MGD (89,600 AFY) of wastewater.³⁸⁶ Wastewater that exceeds DCTWRP's current capacity bypasses DCTWRP and is instead conveyed to HWRP where it is treated to a secondary level and released into Santa Monica Bay. DCTWRP is expected to produce 73 MGD (81,760 AFY) of recycled water at full capacity, which is enough to meet existing and planned NPR and provide sufficient influent for the proposed AWPf.³⁸⁷ Further, a 10-mile pipeline, the East Valley Recycled Water Line (EVRWL) already exists between DCTWRP and HSG. The EVRWL would be used to move water produced at the AWPf to HSG. Currently the pipeline conveys recycled water from the Balboa Pump Station to the Hansen Storage Tank. The line has the capacity to convey an additional 30,000 AFY and could be extended to PSG as it is already within 2 miles of the spreading grounds.³⁸⁸

The GWR project includes the construction of a new AWPf, expansions to the system to provide storage capacity, ancillary facilities to support the AWPf, and a brine line connecting the AWPf to the Valley Outfall Relief Sewer (VORS) to be directed to HWRP.³⁸⁹ A new pipeline would need to be constructed to connect the EVRWL to PSG. Construction is scheduled to begin in the fourth quarter of 2018 and is expected to take 4 years until late 2022.³⁹⁰ The project is anticipated to cost approximately \$450 million with an annual operational and maintenance cost of \$22 million.³⁹¹

Advanced treatment processes for wastewater were chosen for GWR to maximize the volume of water that could be spread under the current groundwater recharge regulations, which involve,

³⁸⁵ GWR Project Draft EIR Page 2-13, Table 2-1. From May 2015 to September 2015, flows varied from 25.4 MGD to 26.1 MGD. (I.e. flows are considerably lower in the summer with current discharges.)

³⁸⁶ LADWP GWR DEIR 2016 p. ES-4

³⁸⁷ LADWP GWR DEIR 2016 p. ES-4

³⁸⁸ LADWP GWR DEIR 2016 p. ES-4

³⁸⁹ LADWP GWR DEIR 2016 p. ES-10

³⁹⁰ Los Angeles Department of Water and Power Groundwater Replenishment Project Draft Environmental Impact Report 2016 p. ES-12

³⁹¹ Los Angeles Department of Water and Power Groundwater Replenishment Project Fact Sheet 2016 https://www.ladwp.com/cs/idcplg?IdcService=GET_FILE&dDocName=OPLADWPCCB459610&RevisionSelectionMethod=LatestReleased. Accessed on 07/22/16

for example, blending and water quality requirements and log reduction credits. Advanced treatment processes could include ozonation, biologically activated carbon (BAC), or multiple-barrier filtration, [e.g. microfiltration (MF), reverse osmosis (RO), and advanced oxidation processes (AOP)].³⁹² In addition, this level of treatment could enable the recycled water to be DPR ready. A future possibility that should be explored is the option of pumping this purified water to the DWP drinking water treatment plant in Sylmar. There, the water would be comingled with Los Angeles Aqueduct and State Water Project water coming to the plant for filtration and disinfection. This approach could potentially provide the second barrier that will likely be required if the SWRCB approves regulations for DPR in the future (the blue ribbon task force report to the SWRCB included the need for a second barrier to go to DPR).

In 2015, the City began considering implementing an early phase of the proposed GWR project that uses recycled water that is not treated through advanced treatment processes. This idea was called the “near-term alternative” and stemmed from the need to increase GWR sooner and to create new water supplies due to ongoing drought conditions. The near-term alternative would make use of tertiary treated recycled water for groundwater replenishment before 2024 and also facilitate the investigation of alternative treatment processes that would optimize recycled water use. Reverse osmosis treatment wastes 15-20% of the treated water as brine concentrate, which then requires treatment and discharge to the ocean.³⁹³ However, RO does a much better job of removing pathogens and chemicals of emerging concern, such as pharmaceuticals, than tertiary treatment. This additional level of treatment provides critical public reassurance to customers that are concerned about the health risks of consuming recycled water. At the time of this writing, there hasn’t been a determination of whether or not this “near-term alternative,” non-AWT portion of the GWR will be implemented.

The allowable recycled water contribution (RWC) would be based on available diluent water and the degree of total organic carbon (TOC) removal, and recharge would begin at HSG. Per Title 22 criteria, the RWC at HSG would be 20% of total recharge water for the first year of operation, and reach a maximum of 45% RWC every year thereafter.³⁹⁴ Recharge at PSG would begin in 2024 when the new recycled water pipeline is to be completed and would increase in 2030 with increasing available diluent flows. It is assumed that the RWC at PSG would be set at 45% at the start of operations and maintained at this percent every year thereafter.³⁹⁵ By 2030, complete utilization of the available 26.8 MGD (30,000 AFY) of recycled water from DCTWRP is planned for replenishment at HSG and PSG.³⁹⁶ It is important to note that the RWC could be higher than

³⁹² LADWP GWR DEIR 2016 p. ES-2

³⁹³ ULARA TM-4 Draft for the SNMP 2016 p. 12

³⁹⁴ ULARA TM-4 Draft for the SNMP 2016 p. 13

³⁹⁵ ULARA TM-4 Draft for the SNMP 2016 p. 13

³⁹⁶ ULARA TM-4 Draft for the SNMP 2016 p. 15, Table 5-1

40% with advanced treated water. Thus, recycled water could potentially make up a larger percentage of the volume. For example, up to 100% advanced treated recycled water can be injected into the West Coast Basin Barrier Project.

b. Recycled Water Recharge (Spreading Grounds)

There are two major water conservation facilities (or spreading grounds) that are operated by the LACFCD through which recycled water may be recharged into the SFB, HSG and PSG. TSG is jointly operated by LACFCD and LADWP. HSG occupies an area of 156 gross acres and is comprised of six medium spreading basins, two small desilting basins, and one small distribution basin that together occupy 117 wetted acres.³⁹⁷ It receives controlled flows from Hansen Dam and Big Tujunga Dam and has an intake capacity of 380 MGD (425,600 AFY) with an average percolation rate of approximately 100 MGD (112,000 AFY), and an estimated maximum storage volume of 460 MG (1,412 AF).³⁹⁸ In WY 2012-13, LACDPW infiltrated a total of only 1,758 AF of native and imported water at HSG, with the majority of spreading occurring from December through March.³⁹⁹ LACDPW estimates that HSG will be unavailable for the GWR of recycled water approximately 70 days out of the year (during wet years) due to priority given at the spreading grounds to the capture and recharge of stormwater.⁴⁰⁰ The number of unavailable days will be lower during dry years.

PSG is located in the City near the intersection of Paxton and Arleta Streets on the west side of Pacoima Diversion Channel.⁴⁰¹ PSG occupies an area of 169 gross acres and is comprised of twelve large shallow spreading basins that occupy 107 wetted acres. PSG receives its replenishment water from four sources: controlled flows from Pacoima Dam, partially controlled flows from Lopez Flood Control Basin, and uncontrolled storm flows from East Canyon Channel and Pacoima Wash. Its intake capacity is 388 MGD (434,560 AFY) with an average percolation rate of 42 MGD (47,040 AFY) and an estimated maximum storage volume of 143 MG (439 AF).⁴⁰²

Over a 10-year period, PSG received a total average of 11,617 AFY; of that total, 7,420 AFY was stormwater and 4,197 AFY was imported water.⁴⁰³ During WY 2012-13, water spread at PSG

³⁹⁷ LADWP GWR FEIR 2016 p 2-2

³⁹⁸ LADWP GWR DEIR 2016 p. ES-7

³⁹⁹ ULARA Watermaster Report 2013 p. 2-13, Table 2-4

⁴⁰⁰ Los Angeles Department of Water and Power Groundwater Replenishment Master Planning Report 2012 p. 3-6, Table 3-4

⁴⁰¹ GLAC IRWM Implementation Grant Proposal 2013 Appendix 7-G: Pacoima Spreading Grounds Improvements Supporting Documents; Correspondence between Christopher Stone and Ken Zimmer Re: Pacoima Spreading Grounds Project Concept Report (2011)

⁴⁰² LADWP GWR DEIR 2016 p. ES-81 LADWP GWR FEIR 2016 p. 2-1

⁴⁰³ Upper Los Angeles River Area Salt and Nutrient Management Plan 2016 Final Tech Memo-4 p. 26

included 2.3 BG (7,015 AF) of native and imported water spread by LACDPW and 2.2 BG (6,703 AF) of imported MWD water spread by Burbank.⁴⁰⁴ The highest infiltration volumes during WY 2012-13 were in October (541 MG, 1,660 AF), November (788 MG, 2,420 AF), and December (684 MG, 2,100 AF), and infiltration occurred through to July (excluding June).⁴⁰⁵ LACDPW estimates that PSG will be unavailable approximately 30 days out of the year during wet years; during dry years the number of unavailable days will be less.⁴⁰⁶ The percolation rate is limited by low permeability due to clay-rich layers under the spreading grounds, an issue to be addressed by an enhancement project.

Pacoima Spreading Grounds (PSG) Basin Enhancement Project

Water conserved at PSG originates from storm flows and controlled releases from Pacoima Dam, partially controlled flow from Lopez Basin, and uncontrolled flows from East Canyon and Pacoima Wash. To completely utilize the full recharge potential of PSG, LACDPW plans to start on the PSG Basin Enhancement project in 2017 and anticipates its completion in 2019, before the start of the GWR project. The enhancement project addresses the limited percolation rate caused by the clay-rich layers that underlie the grounds by proposing the removal of these clay layers in the upper 12 to 24 feet of the subsurface of the grounds. The project will increase the storage capacity of the spreading grounds from 173 MG (530 AF) to 390 MG (1,200 AF) and the percolation rate from 42 MGD to 92 MGD.⁴⁰⁷

Additional proposed improvements include combining basins and constructing new interbasin structures, the replacement of the current radial gate with a rubber dam capable of operating during higher flows, and upgrading the intake canal to reinforced concrete pipes. The improved intake is expected to convey a flow rate of 600 cfs and eliminate flooding problems along Arleta Avenue. By increasing intake capacity and percolation rates, the whole enhancement project is estimated to conserve an additional 4.6 MGD (5,200 AFY) that might otherwise flow to the ocean.⁴⁰⁸

Projections of captured and recharged stormwater at PSG are: 5.9 MGD (6,564 AFY) between 2015 and 2019; 6.2 MGD (6,924 AFY) between 2019 and 2024 (due to improvements); 6.5 MGD

⁴⁰⁴ ULARA Watermaster Report 2013 p. 2-13, Table 2-4; ULARA Watermaster Annual Report WY 2012-13 (2014) p. 1-20

⁴⁰⁵ ULARA Watermaster Report 2013 p. 2-13, Table 2-4

⁴⁰⁶ LADWP GWR Master Planning Report 2012 p. 3-6, Table 3-4

⁴⁰⁷ LAGWR Draft EIR May 2016 p. 2-9 to 2-12

⁴⁰⁸ LADWP

(7,284 AFY) between 2024 and 2029 due to additional improvements; 8 MGD (9,004 AFY) between 2029 and 2034; and 8.4 MGD (9,264 AFY) from 2034 onward.⁴⁰⁹ Imported water is expected to average 6.6 MGD (7,425 AFY) over the next 34 years.⁴¹⁰ The enhancement project is expected to increase the loading of salts and nutrients to the groundwater basin but decrease the overall salt and nutrient concentration in the groundwater.

D. NPR and Other Uses

DCTWRP

In addition to the GWR project described above, a list of 9 potential NPR (irrigation) customers for DCTWRP's recycled water and each expected demand have been identified. Of these, Branford Park (approx. 25 AFY), Delano Park (approx. 5 AFY), and Woodley Park East (approx. 25 AFY) are online. Additional potential customers include Birmingham High School Complex (approximately 50 AFY), Fulton Middle School (approx. 5 AFY), LACMTA Orange line at Balboa (approx. 5 AFY), Mulholland Middle School (approx. 50 AFY), Sepulveda Basin Sports Complex (approx. 100 AFY), and Valley Alternative High School (approx. 5 AFY).⁴¹¹ This results in a total potential demand of 270 AFY for recycled water from DCTWRP.

Los Angeles-Glendale WRP

LAGWRP is expected to continue treating 20 MGD (22,400 AFY) of wastewater but increase its production of recycled water to 17 MGD (19,040 AFY) by 2025.⁴¹² NPR by LADWP and GWP is projected to be 5.4 MGD (6,000 AFY) and 1.5 MGD (1,662 AFY) respectively in 2025.⁴¹³ The Pasadena Water and Power Department is an anticipated new customer for LAGWRP that is expected to use 2.8 MGD (3,100 AFY) for NPR.⁴¹⁴ The remaining 7.4 MGD (8,278 AFY) will be discharged to the ocean through the LAR.⁴¹⁵ GWR to SFB is also planned to increase; 1.1 MGD (1,191 AFY) and 1.25 MGD (1,396 AFY) will be returned to the SFB through LADWP and GWP NPR respectively, and 0.2 MGD (255 AFY) is expected to recharge into VB.⁴¹⁶ The volume of recycled water returned to SFB from GWP [1.3 MGD (1,396 AFY)] was calculated to be 84% of recycled water used for NPR by GWP [1.5 MGD (1,662 AFY)].⁴¹⁷ However, some of LAG-

⁴⁰⁹ ULARA TM-4 Draft for the SNMP 2016 p. 20, Table 5-3

⁴¹⁰ ULARA TM-4 Draft for the SNMP 2016 p. 20, Table 5-3

⁴¹¹ LADWP Recycled Water Annual Report 2015 p. 6 and 7

⁴¹² ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2

⁴¹³ ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2

⁴¹⁴ ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2

⁴¹⁵ ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2

⁴¹⁶ ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2

⁴¹⁷ ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2, footnote 13

WRP's recycled water flows are conveyed to end uses overlying Central Basin; as this consideration was not included in the calculation, 1.3 MGD (1,396 AFY) may be an overestimate of the volume of water returned to SFB.⁴¹⁸

A list of potential customers for industrial, irrigation, and mixed use NPR from LAGWRP have been identified. The users with the highest expected demands are: Forest Lawn Expansion (approx. 250 AFY), Roosevelt Golf Course (approx. 250 AFY), Elysian Park (approx. 250 AFY), Cornfields Park (approx. 100 AFY), and Exposition Park (approx. 100 AFY).⁴¹⁹ In addition to expanded recycled water service from LADWP distribution pipelines, LADWP plans to construct connections to the City of Glendale's recycled water pipeline coming from the LAGWRP.⁴²⁰ This will help convert customer sites such as Atwater Park, Chevy Chase Park, and Los Feliz Golf Course to recycled water use.

Burbank WRP

Influent capacity at BWRP is expected to increase to 12.5 MGD (14,000 AFY) of wastewater and produce 9 MGD (10,080 AFY) of recycled water by 2025.⁴²¹ Ocean discharge of treated wastewater is expected to decrease to 4.4 MGD (4,920 AFY) and the remaining 4.6 MGD (5,160 AFY) will be used for NPR.⁴²² The return flow of recycled water to SFB is anticipated to increase to 5,160 AFY.⁴²³

LADWP is granting BWP groundwater storage credits in exchange for recycled water from the BWRP. This agreement involves the expansion of BWP's recycled water distribution system to the City of Los Angeles/Burbank boundary where LADWP will receive the recycled water for distribution to customers.⁴²⁴ After all infrastructure expansions are completed, BWP could deliver up to 2.95 MGD (3,300 AFY) of recycled water to LADWP.⁴²⁵

LVMWD Tapia WRP

Tapia WRP does not currently provide recycled water to ULARA, though projects are being planned to expand its recycled water distribution system. Tapia WRP is expected to be able to

⁴¹⁸ ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2, footnote 13

⁴¹⁹ LADWP Recycled Water Annual Report 2015 p.8

⁴²⁰ ULARA TM-4 Draft for the SNMP 2016 p. 11

⁴²¹ ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2

⁴²² ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2

⁴²³ ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2

⁴²⁴ ULARA TM-4 Draft for the SNMP 2016 p. 13

⁴²⁵ ULARA TM-4 Draft for the SNMP 2016 p. 14

produce 11 MGD (12,320 AFY) of recycled water, provide 7.2 MGD (8,081 AFY) to NPR purposes, and return approximately 0.9 MGD (1,040 AFY) to the SFB by 2025.⁴²⁶ There are three planned NPR pipeline extensions for LVWMD Tapia WRP. In the City of LA, the Woodland Hills Golf Course Extension would serve Woodland Hills Golf Course, Hidden Hills, and the Pierce College Extension. This extension would be able to deliver approximately 0.9 MGD (1,040 AFY) of recycled water for irrigation uses in the City of LA section of the SFB.

Fill Stations

LADWP has installed eleven fill stations throughout the City. Fill stations are access points built into recycled water pipelines that allow certified customer trucks to obtain recycled water for uses such as irrigation, construction activities, and street sweeping. These stations are located at Terminal Island, Playa Vista, Cypress Park, 425 N. San Fernando Rd., Griffith Park, Kester Ave., Delano Park, Woodley Lake Golf Course, Van Nuys Golf Course, Valley Presbyterian Hospital, Sun Valley/Pacoima.⁴²⁷ Fill stations are helpful for commercial customers who are not located near a recycled water pipeline and whose regular activities require trucking water. Existing customers include Gibson Ranch, Headworks Construction Site, and the Bureau of Street Services Street Sweepers.⁴²⁸ Potential additional fill station customers could include, for example, non-profit environmental groups and the Department of Recreation and Parks to water City trees and preserve natural resources. Additional potential uses could consist of dust control, pressure washing, and sewer cleaning.⁴²⁹

Considering New Options

In addition to exploring a regional partnership with Las Virgenes to serve Woodland Hills Country Club, LADWP is also working to determine if Encino Reservoir is a feasible option for seasonal storage for the Las Virgenes recycled water system. If carried out, the reservoir could potentially store up to 1.79 MGD (2,000 AFY) of recycled water available to the west San Fernando Valley.⁴³⁰ Further, other golf courses such as El Caballero, Woodland Hills, and Braemar could also be assessed to determine whether they could also be potential customers.

DPR is the introduction of highly treated recycled water directly into potable raw water supplies. As mentioned above, regulation in California does not currently permit the implementation of a DPR project. The challenge with DPR is replacing the environmental buffer, providing additional treatment and ensuring safety through multiple barriers. LADWP is exploring possible scenarios for implementing DPR in Los Angeles. They are currently participating in WateReuse Research Foundation projects, “Guidelines for Engineered Storage for Direct Potable Reuse” and “Synthesis of Findings from DPR Initiative Projects.”⁴³¹

⁴²⁶ ULARA TM-4 Draft for the SNMP 2016 p. 10, Table 4-2

⁴²⁷ LADWP Recycled Water Annual Report 2015 p. 15

⁴²⁸ LADWP Recycled Water Annual Report 2015 p. 14

⁴²⁹ LADWP Recycled Water Annual Report 2015 p. 14

⁴³⁰ LADWP Recycled Water Annual Report 2015 p. 18

⁴³¹ LADWP Recycled Water Annual Report 2015 p. 18

VI. Conclusions and Research Needs

- Implementing BMP suites to manage the 85th percentile storm volume across the LAR watershed will result in significant improvement in water quality for metals, but will not result in the elimination of all exceedances for metals.
- Implementing these BMP suites on a watershed-wide basis will not result in the eradication of flows from the LAR, but flows will be reduced to levels similar to those before DCTWRP was discharging effluent into the LAR.
- Current flows in the LAR are substantially higher than flows 60 years ago because of the construction of three WRPs that are discharging to the river. Also, flows increased because of expanding development in the watershed, which resulted in more impermeable area and an increase in the relative runoff ratio from just over 0.1 in 1950 to over 0.55 currently.
- Implementing an LID ordinance similar to that of the City of LA's across the LAR watershed would result in a nearly 20% reduction of required treatment volume and increased groundwater infiltration of more than 2,000 AF by 2028. This would also result in a reduction in the annual average loads of zinc and copper by 10% and 7%, respectively, by 2028.
- Annual minimum flows may approach zero during some dry weather periods in the LAR if the City reuses all treated wastewater effluent in the watershed.
- A LAR flow study is needed to determine the optimal flows to sustain and enhance beneficial uses in the river and its tributaries.
- A study is needed to determine the potential to divert some stormwater flows to DCTWRP for treatment and reuse.
- Studies are needed to determine the water supply and storage potential of the western SFB and the Sepulveda Dam Basin.
- The City is actively pursuing opportunities to remediate existing contamination, increase basin annual yields, and increase their recharge of water into the ULARA basins. The largest projects include the groundwater remediation project, which will result in approximately 120,000 AFY of water being pumped and treated, and the groundwater recharge project, which will result in up to 30,000 AFY of recycled water from DCTWRP being recharged into the ULARA basins through HSG and PSG.

VII. Appendices

Appendix A. LAR Reaches

Detailed description of LAR reaches

Reach 6 begins at the confluence of Bell Creek and Arroyo Calababas and extends to the Sepulveda Flood Control Basin in the San Fernando Valley. Tributaries flowing into this reach include Dry Canyon Creek and Arroyo Calababas in the Santa Monica Mountains to the South, Bull and McCoy Canyon Creek in the Simi Hills to the West and Aliso and Brown Canyon Wash, whose waters originate in the Santa Susana Mountains to the north.

Reach 5 of the LAR begins at the edge of the Sepulveda Flood Control Basin, a 2000-acre recreation area in the San Fernando Valley containing recreational spaces⁴³² and the DCTWRP, which contributes an average of 31.9 MGD of treated wastewater effluent to the river.⁴³³ Reach 5 extends for 2.4 miles across an earthen channel and ends at the gates of the Sepulveda Dam (operated by the US Army Corp of Engineers). Reach 4 begins at the discharge of Reach 5 and continues east for approximately 11 miles to Riverside Drive in Glendale, receiving water from the Tujunga Wash, the northernmost tributary on the watershed. Tujunga Wash itself has a drainage area of over 200 mi², most of which is in the Angeles National Forest to the north in the San Gabriel Mountains, and contains four large dams: The Pacoima and Big Tujunga, operated and maintained by the Los Angeles County Department of Public Works (LACDPW)⁴³⁴, and the Lopez and Hansen Dams operated by the Army Corps of Engineers.⁴³⁵

Reach 3 of the LAR begins at Riverside Drive in the city of Glendale where water flows southeast approximately 8 miles to the end of the reach at Figueroa Street in Los Angeles. This reach receives water from the Burbank Channel and the Verdugo Wash, both in the foothills of the San Gabriel Mountains to the North and also contains effluent from two water treatment facilities, the

⁴³² US Army Corps of Engineers Los Angeles District, 2011, Sepulveda Dam Basin Los Angeles County Los Angeles District, California Master Plan and Environmental Assessment.

⁴³³ California Regional Water Quality Control Board Los Angeles Region, Waste Discharge Requirements for the City of Los Angeles, Donald C. Tillman Water Reclamation Plant. Order# 98-046. NPDES# CA0056227..

⁴³⁴ County of Los Angeles Department of Public Works, 2014, Hydrologic Report 2013-2014. Water Resources Division, Accessible at: <http://ladpw.org/wrd/report/>; <https://dpw.lacounty.gov/wrd/Reservoir/>

⁴³⁵ US Army Corps of Engineers Los Angeles District, Dam Facts sheet. Dam Safety Program, Accessible at: <http://www.spl.usace.army.mil/Missions/CivilWorks/DamSafetyProgram.aspx>

LAGWRP and the Los Angeles-Burbank WRP, which can discharge up to 20 MGD⁴³⁶ and 12.5 MGD⁴³⁷, respectively. Reach 3 contains the Glendale Narrows, a six-mile length of the river where an upwelling of groundwater contributes flow to the river. This spring-action is a result of a periodic high water table whose volume of discharge varies with the height of groundwater. Although this contribution is not significant relative to effluent from WRPs⁴³⁸, it is sufficient to halt the laying of concrete on the floor of the channel (although the side walls are concrete-lined).

Reach 2 begins at Figueroa Street, just above the river's confluence with Arroyo Seco, and extends south nearly 19 miles to Carson Street in Long Beach. This Reach receives water from the Arroyo Seco, an approximately 45 mi² tributary that contains the Devils Gate Dam, a facility operated by LACDPW. The most significant tributary flowing into Reach 2 is the Rio Hondo, a nearly 150 mi² subwatershed that contains many significant spreading grounds and two large dams, the Santa Anita and Eaton Wash Dam, both operated by LACDPW. Reach 1 begins at Carson Street and flows south to the river's terminus at the Port of Long Beach approximately 3 miles downstream. This 2.6 mile-long reach receives water from Compton Creek, a small (23 mi²) and very developed subwatershed south of downtown Los Angeles. Just below this confluence is the Wardlow stream gage and Mass Emission Station (MES), operated by the LACDPW, which provides the final water quality and water quantity observations for the LAR⁴³⁹ and serves as the main calibration and validation point for the modeling in this work.

Appendix B. BMP Types and Quantity

Calculating a footprint for distributed BMPs assumed that for every length of road there is two feet of width available on both sides of the road for distributed BMPs. For example, a 10-foot length of road would have 20-square feet of vegetated swales on each side of the road. By using the total length of road in a subwatershed, the footprint and number of distributed BMPs that can occupy the sides of roads were calculated (Table B.1).

⁴³⁶ California Regional Water Quality Control Board Los Angeles Region, Waste Discharge Requirements for the City of Los Angeles Los Angeles-Glendale Water Reclamation Plant (NPDES# CA0053953, Order# R4-2011-0197).

⁴³⁷ California Regional Water Quality Control Board Los Angeles Region, Waste Discharge Requirements for the City of Burbank, Burbank Water Reclamation Plant (NPDES# CA0055531, CI# 4424).

⁴³⁸ City of Los Angeles Bureau of Sanitation, 2015, Integrated Resources Plan Draft Environmental Impact Report SCH No. 2004071091 SCAG No. I20040466. Section 3.11 Hydrology and Water quality. Accessible at: http://lacitysan.org/irp/draftersections/015_3.11-Hydrology&WQ.pdf

⁴³⁹ Los Angeles Department of Public Works, 1996, Los Angeles River Master Plan, Flood Management and Water Conservation. Accessible at: <http://www.ladpw.org/wmd/watershed/LA/Larmp/LARMP-07%20Flood%20Management%20and%20Water%20Conservation.pdf>

Subwatershed	Length of Road (mi)	Units of Vegetated Swale*	Units of Bioretention*
Burbank	277	2,343	1,845
Compton	970	8,195	6,454
Reach 1	143	1,204	948
Reach 2	1,949	16,465	12,969
Reach 3	779	6,581	5,184
Reach 4	817	6,902	5,436
Reach 5	1,772	14,970	11,791
Rio Hondo	2,086	17,623	13,880
Tujunga	1,133	9,572	7,539
*Unit quantities derived from BMP dimensions			

Table B.1. Summary of BMP Units per subwatershed

To determine the amount of land available for BMPs in the education land use category, the amount of pervious surface (29% for education) was multiplied by the total area. Table B.2 indicates the amount of area available and the number of distributed BMP units for each subwatershed. A similar analysis was conducted for the parks and recreation land use (85% pervious) to place regional BMPs (dry ponds and infiltration trenches) in these areas (Table B.3).

Subwatershed	Total Education area (mi ²)	Available Education area (mi ²)	Units of Vegetated Swale*	Units of Bioretention*
Burbank	0.24	0.07	776	1,834
Compton	2.20	0.64	7,115	16,812
Reach 1	0.20	0.06	647	1,528
Reach 2	3.20	0.93	10,349	24,454
Reach 3	0.92	0.27	2,975	7,031
Reach 4	0.92	0.27	2,975	7,031
Reach 5	3.80	1.10	12,290	29,039
Rio Hondo	3.70	1.07	11,966	28,275
Tujunga	1.60	0.46	5,175	12,227
*Unit numbers derived from BMP dimensions (Table)				

Table B.2. Summary of distributed BMPs for education by subwatershed

Subwatershed	Total Parks and Rec. Area (mi ²)	Available Parks and Rec. area (mi ²)	Units of Dry Pond*	Units of Infiltrated Trench*
Burbank	0.15	0.13	5,266	878
Compton	0.70	0.60	24,576	4,096
Reach 1	0.20	0.17	7,022	1,170
Reach 2	4.20	3.57	147,454	24,576
Reach 3	2.10	1.79	73,727	12,288
Reach 4	1.20	1.02	42,130	7,022
Reach 5	2.60	2.21	91,281	15,214
Rio Hondo	4.70	4.00	165,008	27,501
Tujunga	0.76	0.65	26,682	4,447
*Unit numbers derived from BMP dimensions (Table)				

Table B.3. Summary of regional BMPs for Parks and Recreation by subwatershed

Porous pavement is a unique BMP in that its location does not compete for space in Education, Recreation or Transportation land-uses like the other BMPs, rather it replaces traditional pavement. Because of its lack of normal strength, it is not currently strong enough to replace traditional pavement in high traffic, high volume transportation corridors, however it is plausible in low traffic parking lot locations.⁴⁴⁰ Porous pavement areas were estimated using the fact that the City of LA's Department of Building and Safety parking regulations require every 500 ft² of public facilities to provide one parking stall.⁴⁴¹ The dimensions of a parking stall are assumed the regions standard: 18-feet deep and 8-feet 4 inches wide. Summed across each watershed, the resulting area of parking spaces provide a conservative estimate of the footprint of porous pavement units (Table B.4).

Subwatershed	Identified Facilities (mi ²)	Identified Parking lot area (mi ²)	Units of Porous Pavement
Burbank	0.60	0.18	2,706
Compton	3.62	1.09	16,268
Reach 1	5.81	0.04	612
Reach 2	0.14	1.79	26,762
Reach 3	5.95	0.37	5,591
Reach 4	0.84	0.45	6,736
Reach 5	1.50	1.56	23,386
Rio Hondo	0.97	1.74	26,138
Tujunga	2.57	0.78	11,624

Table B.4. Summary of porous pavement area by subwatershed

⁴⁴⁰ Huang, B.; Wu, H.; Shu, X.; Burdette, E. Laboratory evaluation of permeability and strength of polymer-modified pervious concrete. *Construction and Building Materials* **2010** 24(5), 818–823

⁴⁴¹ City of Los Angeles Department of Building and Safety, Parking Design Information Bulletin/Public-Zoning Code: Reference #: L.A.M.C. 12.21A5, Document #: P/ZC 2002-001. Accessible at: <http://ladbs.org/docs/default-source/new-forms-publications/information-bulletins-guidelines/zoning-code/parking-lot-design-ib-p-zc2002-001.pdf>

Appendix C. 7Q Flow Figures

This section provides details on the 7Q low flow analysis for the Tujunga and Arroyo Seco gages, respectively.

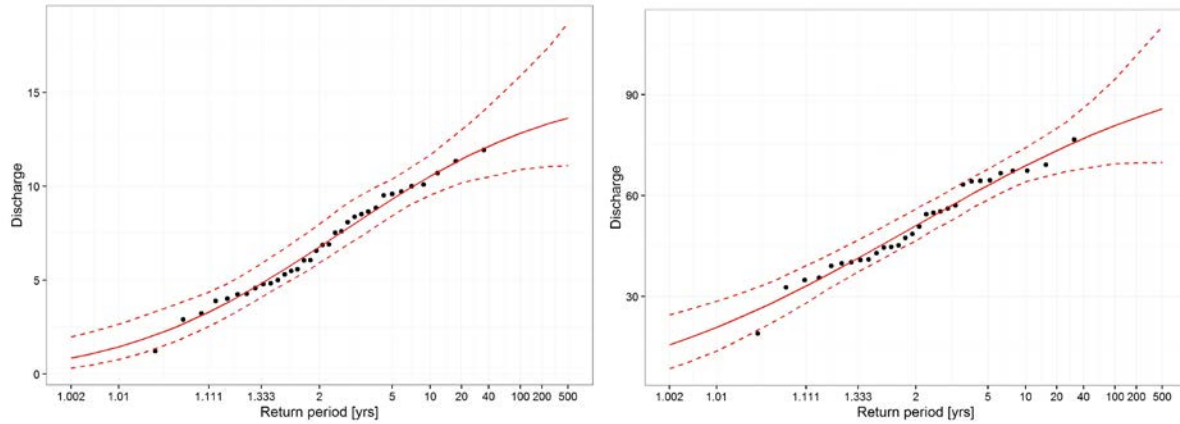


Figure C.1. Tujunga 7Q low flow analysis for (a) 1951-1985 and (b) 1986-2015; red dashed lines show the 90% confidence interval assuming the series follows a Log Pearson III distribution

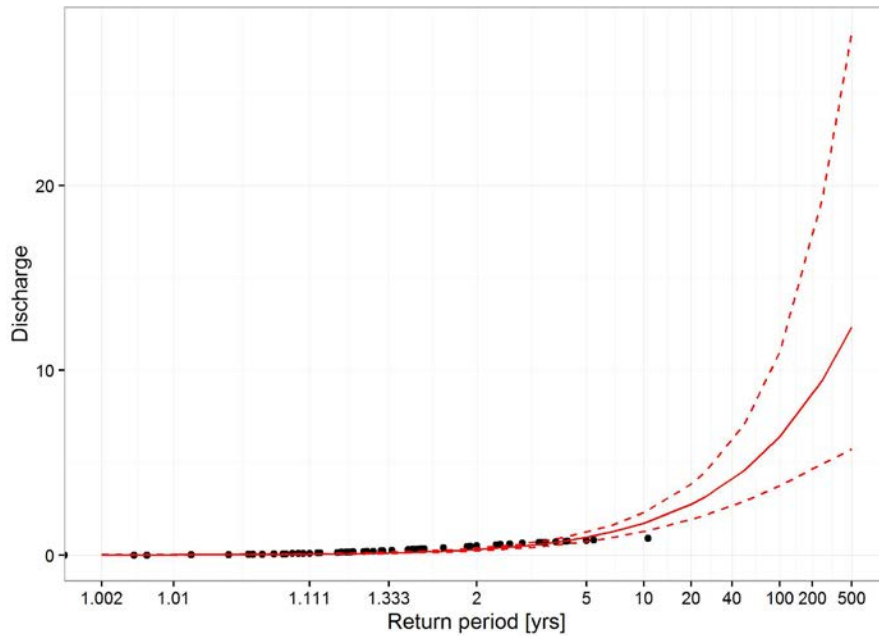


Figure C.2. Arroyo Seco 7Q low flow analysis for 1917-2014; red dashed lines denote the 90% confidence interval assuming the series follows a Log Pearson III distribution

Appendix D. Sepulveda Dam Basin

The Sepulveda Dam Basin has an earthfill embankment with concrete reinforced spillway and outlet works and a flood control pool area of 1,444 acres.⁴⁴² The crest length, including outlet works and spillway, is 15,444 feet (ft).⁴⁴³ The spillway crest normally remains at a down position height of 710 ft above the National Geodetic Vertical Datum, or NGVD. The NGVD was established in 1929 using a network of tidal gages to determine the true mean sea level datum.⁴⁴⁴ The outlets of the dam are at an elevation of 688 ft, and include four gated outlets, 6 ft wide by 9 ft high, and four ungated conduits, 6 ft wide by 6.5 ft high.⁴⁴⁵ The four ungated conduits cannot be closed and are always open to the channel to allow water to flow through.

These eight outlets can release water to the LAR at a combined maximum capacity of 16,500 cfs when the water is at height of 710 ft NGVD; the capacity of the downstream rectangular reinforced concrete channel is 17,000 cfs.⁴⁴⁶ When the water elevation in the reservoir reaches a height of 692.5 ft NGVD, the spillway gates automatically rise to a flood control pool elevation of 712 ft NGVD. When the flood pool reaches 712 ft NGVD the spillway gates begin to lower to increase the discharge capacity; the design discharge of the spillways is 99,540 cfs.⁴⁴⁷ The capacity of the flood control pool at an elevation of 710 ft NGVD is 18,129 AF, the flood control pool capacity is 20,920 AF, and the top of dam capacity is 46,764 AF.⁴⁴⁸

The historic maximum storage and flow occurred on February 16, 1980 when the surface elevation reached a height at 705.1 ft NGVD, the reservoir stored 11,470 AF, the mean hourly inflow was 58,970 cfs and the outflow was 15,320 cfs.⁴⁴⁹ The 100-year flood water surface elevation has been defined by the Corps as 712 ft NGVD and the Probable Maximum Flood (PMF) surface elevation

⁴⁴² USACE Sepulveda Dam Basin MP and EA 2011 p. 2-1 & 2-2, Table 2.1

⁴⁴³ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-1

⁴⁴⁴ Federal Emergency Management Agency. “NGVD→NAVD” 2007. p. 1 http://www.fema.gov/media-library-data/20130726-1755-25045-0634/ngvd_navd.pdf. Accessed 09/08/2016

⁴⁴⁵ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-1

⁴⁴⁶ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-2, Table 2.1; USACE Los Angeles River Ecosystem Restoration Feasibility Study Draft Appendix E Hydrology and Hydraulics 2013 p. 5

⁴⁴⁷ United States Army Corps of Engineers News Release. February 28, 2014. “Corps of Engineers Operates Sepulveda Dam During Storm”. <http://www.spl.usace.army.mil/Media/News-Releases/Article/477339/corps-of-engineers-operates-sepulveda-dam-during-storm/>. Accessed 08/25/2016.

⁴⁴⁸ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-2, Table 2.1

⁴⁴⁹ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-2, Table 2.1

is 716.7 ft NGVD.⁴⁵⁰ Due to the highly urbanized characteristic of the watershed, the runoff response to rainfall is accelerated with high peak discharges of shorter duration.⁴⁵¹

In addition to providing flood control, the basin area also provides recreational benefits through facilities such as golf courses, parks, wildlife areas, dog parks, skate parks, and playgrounds that are located within its boundaries. The City leases a significant portion of the basin, approximately 1,500 acres, from the USACE for recreational purposes.⁴⁵² Recreational uses developed by the City in the basin include three golf courses, the Anthony Beilenson Park, the Universally Accessible Playground, the Bull Creek Restoration Area, Balboa sports complex, Woodley Park and archery range, and the cricket fields.⁴⁵³ The Encino Franklin Field, Inc., a non-profit California corporation, also has a lease for 28 acres of land in the Basin.⁴⁵⁴ Other lease holders in Sepulveda Basin include: LASAN, which leases 96.59 acres for DCTWRP; the City of Los Angeles Department of Public Works, which leases 10.53 acres for a fire station; and the State of California, which leases 6 acres for a National Guard Armory.⁴⁵⁵

DCTWRP is also located within the basin and has an extended effluent outfall pipeline below the Dam spillway into the LAR. DCTWRP is protected by a surrounding concrete floodwall and earthen dike designed to prevent the plant from being inundated up to 712 ft NGVD, which is estimated to be the elevation of the one-percent chance exceedance event.⁴⁵⁶ The percent chance exceedance is based on statistical analysis of water surface elevations over the project's operational period of time. During an event that would result in a higher water elevation than 712 ft NGVD, DCTWRP would become inundated.⁴⁵⁷ Inundation of DCTWRP could cause the contamination of surface waters from untreated or partially treated wastewater, plant shut-down, and diversion of sewage to Hyperion Water Reclamation Plant (HWRP) for treatment and discharge.⁴⁵⁸ On-site stormwater is collected by storm drains and directed to DCTWRP for treatment where the treated effluent is either discharged to the LAR or recycled; the recycled water in excess of demand is discharged to the river 900 ft downstream of Sepulveda Dam.⁴⁵⁹

⁴⁵⁰ USACE Sepulveda Dam Basin DCTWRP Multi-Use Facility Project Draft EA 2012 p. 3-3

⁴⁵¹ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-6

⁴⁵² United States Army Corps of Engineers Sepulveda Dam Basin Master Plan and Environmental Assessment 2011 Executive Summary

⁴⁵³ Sepulveda MP and EA 2011 p. 4-6

⁴⁵⁴ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-6

⁴⁵⁵ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-7

⁴⁵⁶ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-6

⁴⁵⁷ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-6

⁴⁵⁸ USACE Sepulveda Dam Basin MP and EA 2011 p. 2-6

⁴⁵⁹ USACE Sepulveda Dam Basin DCTWRP Multi-Use Facility Project Draft EA 2012 p. 3-4

Currently, the Sepulveda Basin Dam's only approved function is flood control. Similar projects on the East Coast are considered reservoirs and have space allocated behind the dam to serve both storage for water supply and capacity for flood control purposes. By way of contrast, most of the Army Corps' West Coast projects are only considered dams; this classification means there is no allocated space behind the dam for water supply storage as it is all intended for flood control. Therefore, as there is no dedicated storage space behind the dam for supply storage, implementing any project to store additional water behind the dam for supply must involve demonstrating that water supply never conflicts with storage needs for flood control. In other words, more space must be made behind the dam to allow for storage to meet water supply needs or Congress must pass a bill allowing some of the storage space currently behind the dam to allow water supply storage. For example, Prado Dam in San Bernardino has the primary authorized purpose of flood risk management, but this is followed by an authorization for recreation and water conservation.⁴⁶⁰

One potential pathway to create more space behind the dam for water is to remove sediment from behind the dam. Precedent exists for removing sediment to mitigate the loss of flood storage capacity behind the Sepulveda Basin Dam. An expansion project is being proposed for DCTWRP that would construct a facility to increase conference room space, office space, and include a plaza and stage for public meetings, special events and educational activities. The construction of this new facility would remove 752 cubic yards, or 20,304 cubic feet of flood storage capacity within the Basin.⁴⁶¹ To mitigate the loss of flood storage capacity, 20,304 cubic feet of earth in the north-east area of DCTWRP outside of the dike will be removed.

Storing water behind the Sepulveda Dam poses additional logistical issues as the space behind the basin is fully utilized by the wide variety of uses described above. Thus, to store water behind the dam, real estate would need to be temporarily repurposed to allow for flooding in some areas during dry weather. For example, golf courses or other open spaces in the basin could potentially be redesigned to provide additional storage space behind the dam. Currently, the main roads through the basin are already closed a couple times a year during storm-caused flood events as gates are closed to keep flows in the channel below capacity and prevent flooding downstream.

All 8 of the outlets to the channel are currently open on a day to day basis at Sepulveda basin; of those, four have gates that can be closed as the water behind the dam rises to a point that flow leaving the basin needs to be slowed to prevent downstream flooding. Gate closures begin when the elevation behind the dam reaches 680 NGVD. Since it is impossible to completely cut off water leaving the basin under the current configuration and operation requirements, storage behind the dam during dry weather is not an option unless all outlets are gated.

The dam is mainly managed by a rule curve but the USACE is also looking at incorporating forecasts into its operation. There are approximately 70 gaging stations throughout the watershed, and

⁴⁶⁰ <http://www.spl.usace.army.mil/Missions/Asset-Management/Prado-Dam/>

⁴⁶¹ USACE Sepulveda Dam Basin DCTWRP Multi-Use Facility Project Draft EA 2012 p. 2-13

forecasting is much more accurate than in the era when the current management practices were established. It is important to note, however, that the runoff response to rainfall is rapid as a result of the highly urbanized watershed. Funding would need to be provided in order for the USACE to be able to do a study to evaluate how to safely manage the flood control capacity using forecasts and/or rainfall volumes. The USACE Hydrologic Engineering Center uses the Corps Water Management System (CWMS) to support water control management through real-time data inputs and modeling to determine multiple likely flow scenarios.⁴⁶² Potential factors that can be looked at in modeled alternative scenarios include future precipitation amounts, reservoir release rules, and hydrologic responses throughout the watershed. The LAR is currently modeled in CWMS; modeling efforts could be calibrated to assess water conservation potential at lower flows.

The pairing between Hansen Dam and groundwater recharge basins along the Tujunga Wash offers a potential example to follow to increase the water supply potential of Sepulveda Basin. Additional water is stored behind the dam at the end of a storm, and then that water is released at the rate that the downstream spreading grounds can capture as the initial stormwater pulse infiltrates and additional space becomes available in the spreading grounds. A bill should be created for approval by Congress that facilitates managing appropriate local reservoirs to perform water supply as well as flood control functions in Southern California. In this region, storms are less frequent and there is less risk of another storm occurring in rapid succession that would overwhelm basin capacity before the captured stormwater has been released and captured downstream. It is important to note that precipitation patterns vary widely across the United States and in some regions this approach would not be feasible. This bill should further include approval to gate all four currently ungated openings and funding for the USACE to continue evaluating forecast as a management tool as well as to allow both water supply and flood control purposes.

⁴⁶² <http://www.hec.usace.army.mil/cwms/cwms.aspx>