Los Angeles Sustainable Water Project: Ballona Creek Watershed

UCLA Grand Challenges
Sustainable LA

UCLA Institute of the Environment and Sustainability

School of Mines 1874 Colorado

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

Mark Gold, Terri Hogue, Stephanie Pincetl, Katie Mika, Katie Radavich

November 2015

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 provided edits which 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 Drew Beck for the initial development of the Ballona Creek Watershed model and Ryan Edgley for help and assistance on this project. We would further like to acknowledge the many organizations which facilitated this research through providing data, conversations, 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

Abstract

Implementing integrated water management systems (IWM) that incorporate all components of the urban water cycle, including imported water, local groundwater, captured stormwater, greywater, and treated wastewater is crucial to creating a sustainable water supply for the city of Los Angeles (City). Rapid and effective implementation of IWM is made even more necessary given the current drought conditions in California; this report explores opportunities and challenges to implementing IWM along the way to meeting water quality standards and maximizing use of potential local supplies such as captured stormwater and recycled wastewater in the Ballona Creek Watershed.

Multiple approaches to achieving compliance with receiving water quality standards for metals were examined through stormwater modeling scenarios that explored treatment through different BMP types over varied drainage areas. Scenarios designed to optimize the number of BMPs based on cost and drainage area routed to BMPs were analyzed. In additional scenarios, the number of BMPs was determined based on the volume needed to capture the runoff from the 85^{th} percentile, 24-hour storm over the watershed. Different BMP types were highlighted in multiple scenarios to determine the relative impact of utilizing regional treat and release BMPs, regional infiltration BMPs, or distributed LID BMPs.

Results from modeling efforts in this study show that, while it is possible to capture and treat stormwater volumes to achieve compliance along with other benefits of storm peak flow reduction and potential groundwater recharge in the Ballona Creek watershed, many challenges are present in locating the necessary BMPs. Challenges include a lack of available and appropriately located public land on which to install sufficient stormwater BMPs to manage this runoff, a lack of widespread requirements or incentives to require or encourage private land owners to install and properly maintain BMPs on their own properties, and cost.

Increasing stormwater capture has many benefits beyond improving water quality within an IWM framework, including the potential to increase available local water supply through infiltrating captured stormwater into local groundwater basins or irrigating landscapes on-site and thus reducing demand for potable water. Recycled water is another critical piece of IWM, particularly for the Ballona Creek Watershed, as it is located adjacent to the largest of the City's wastewater treatment plants: the Hyperion Treatment Plant (HTP). Almost 200 MGD (~220,000 AFY) of recycled water could be generated by HTP and the nearby WBMWD Edward C. Little WRF to potentially become local water supply based on the FY 2013 - 2014 HTP flow rate of 279 MGD and using MFRO treatment. Additional treatment to address TSS and an additional nitrogen removal step (nitrification-denitrification or a Membrane Bioreactor) is needed to ensure maximum HTP water recycling potential and maintain compliance with NPDES permit requirements and the California Ocean Plan.

Currently, ample storage space for both captured stormwater and recycled water is present in the two adjudicated groundwater basins underlying the Ballona Creek Watershed, West Coast and Central basins, but a lack of pumping infrastructure and the limitations imposed by the adjudications on storing and pumping water will require investments in both funding and in the pursuit of collaborative opportunities with other agencies and rightsholders in these basins to fully maximize and use the available basin storage. The 600,000 AF of space that is currently taken

up in West Coast Basin by legacy seawater intrusion contamination offers a regional opportunity to build desalting facilities; increasing basin withdrawals through this effort would both increase available storage space for clean water as the seawater plume is removed and provide an opportunity for increased infiltration of advanced treated recycled water. Studies to assess and quantify the maximum operational safe yield in the unadjudicated Santa Monica and Hollywood basins are necessary to utilize the potential opportunities in these basins to increase local groundwater supply through regional partnerships. These basins, as they do not have a pre-existing adjudication structure, do not have the same legal constraints that are present in West Coast and Central Basins.

In order to appropriately plan for the future, it is critical within an IWM system to consider both flows within the system and how each flow will impact others (e.g., in order to properly size and place new infrastructure for likely future flows rather than current flows). For example, increased indoor conservation or implementation of on-site greywater systems will result in lower flows going through wastewater treatment plants and therefore provide less flow available for reuse. Similarly, outdoor conservation will reduce dry weather runoff flows available for on-site use which leads to infiltration into groundwater basins, or flows for diversion through treatment plants for treatment and reuse. All of these factors are critical to accurately determining both the volume of potential local water supply and its potential distribution throughout the water system.

Potential local water supply exceeds demand in the Ballona Creek Watershed if the treatment capacity can be built and groundwater basin management can be shifted to allow the basins to be used more as a local water supply reservoir into which parties can routinely extract the water they recharge. In other words, Ballona Creek watershed has sufficient potential local water supply to meet demand. Approximately 220,000 AFY of advanced treated water could be generated using FY 2013-2014 flow volumes at HTP and the potential recharge volume estimated through the various water quality modeling scenarios is an additional 20,000 to 60,000 AFY (40% to 77% of the total runoff per year with 15 inches average rain depending on the BMP portfolio implemented) for a maximum potential of roughly 240,000 to 280,000 AFY. 2015 demand in the watershed is approximately 196,000 AFY (1.5 million people at 117 GPCD). It is important to note that the additional water supply contribution from recharge is lower than the potential recharge volume. These recharge numbers would be significantly reduced if fewer BMPs were implemented and less annual precipitation fell in the region.

Executive Summary

Background and Study Area

Implementing integrated water management systems (IWM) that incorporate all components of the urban water cycle, including imported water, local groundwater, captured stormwater, greywater, and treated wastewater is crucial to creating a sustainable water supply for the city of Los Angeles (City). The City has researched, written, and initiated implementation of recommendations from many reports critical to creating an IWM plan for the City as well as to defining the current capacity of the system. While work on this issue has been ongoing for many years, the extreme drought currently impacting water supplies throughout California has created a new urgency to increase the City's ability to provide a secure water supply through local sources. In April 2015, Governor Brown directed the first-ever statewide mandatory cut of 25% in urban water use due to the continuing drought conditions.

In addition to statewide efforts, many policies and plans have been created on a local level within the City that address urban water management, integrated resources planning, stormwater capture, and groundwater management. The Los Angeles Mayor's Office recently set strong goals to increase the sustainability of the City's water supply over the next several years. The goals included completing a comprehensive sustainability plan containing objectives for water supply and demand in the City, which was released in April 2015 (Sustainable City pLAn). In an emergency drought directive released in October 2014, the Mayor identified additional accelerated water goals including reducing per capita potable water use by 20% by 2017 (from 2014 baseline of 130 gallons per capita per day (GPCD) to 104 GPCD), reducing the City's reliance on MWD water by 50% by 2025, and converting 85% of public golf course acreage to recycled water by 2017.

Through building upon regional research and reports that have been generated on potential components of the local water supply portfolio (e.g., groundwater, recycled water, and stormwater), as well as gathering and analyzing current data on flows of water and wastewater throughout the City systems and environment, this project further identifies and refines opportunities to implement integrated water management throughout the City. As water quality regulation in the Los Angeles area currently drives much of the current water management practices, we examined greater water self-reliance through this lens. Therefore, the City has been divided by watershed to assess Total Maximum Daily Load (TMDL) compliance alongside integrated water management opportunities and challenges that exist and must be addressed in order to meet water quality compliance requirements and maximize local water supply. This first report focuses on the Ballona Creek Watershed and the Hyperion Service Area; following reports will focus on the Dominguez Channel and Los Angeles River watersheds.

Study Approach

Stormwater modeling was carried out using the EPA's System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN) model version 1.2 in ArcGIS 9.3. Model simulations focused on impairing metal pollutants copper, lead, and zinc because they are conservative pollutants for which sufficient water quality data was available. The model was calibrated and validated for the Ballona Creek watershed using observed flow data and historical precipitation data from various sources in the watershed (the LA County Department of Public Works' Stormwater Quality Monitoring program and the Southern California Coastal Water Research Project (SCCWRP)) as well as BMP performance data from the International BMP Database.

Multiple approaches to achieving compliance with metal WQS were examined in model scenarios that explored stormwater treatment through different BMP types over varied drainage areas. Infiltration basins and dry ponds were chosen to represent large-scale regional stormwater capture BMPs. Vegetative swales, porous pavement, and bioretention ponds were used to represent smaller, parcel-scale distributed BMPs and LID practices. In the initial scenarios, the number of BMPs was optimized for lowest cost and greatest pollutant load reduction at the outlet. These optimization scenarios tested treatment of runoff routed from 33%, 67% and 90% of the watershed's area through all BMP types. Capturing and treating runoff from 90% of the watershed area achieved the best pollutant removal and metals WQS compliance. These results informed the next set of scenarios in which the number of treatment BMPs were determined to capture the runoff volume during the 85th percentile, 24-hour storm (approximated with the ¾" rainfall event) over the watershed. Different BMP types were highlighted in multiple scenarios to determine the relative impact of utilizing regional treat and release BMPs, regional infiltration BMPs, or distributed LID BMPs.

From the continuous model outputs of hourly flow and metal pollutant load, TMDL compliance was calculated for metals. TMDL compliance is measured separately for wet and dry weather days, separated by the 64 cfs maximum daily flow threshold. Wet weather TMDLs are calculated with an acute exposure concentration limit for each metal multiplied by the total daily storm volume. Dry weather TMDLs are based on the chronic exposure concentration for each metal multiplied by the median daily flow for Ballona Creek (17 cfs) and are constant for all days considered dry weather.

<u>SUSTAIN Stormwater Modeling Results</u>

Results of simulated BMP implementation scenarios reveal that as long as a significant drainage area is routed to BMPs, dry weather exceedances can be nearly eliminated for copper, zinc, and lead, assuming pollutant contributions to dry weather runoff do not increase in future conditions. Wet weather exceedances were significantly reduced to around 11 or less per year for copper and zinc, with zero lead exceedances, even for multi-day storms with conservative pollutant loadings applied in the model. Benefits of peak flow reduction and potential groundwater recharge were also assessed for each BMP implementation scenario, and results varied based on the characteristics of the BMPs in each.

Out of the five generalized BMP types represented in the model, treat and release BMP types achieve the best wet weather compliance because they return treated, cleaner water to the channel to dilute remaining pollutants. They have lower relative construction cost due to economies of scale. However, these BMP types cannot reduce peak flows as effectively as infiltration-based BMPs, and do not remove as much pollutant load or provide as much recharge potential, only 40% of the total runoff (as little as 20,000 acre-feet per year (AFY) with an annual average of 15 inches of precipitation).

Infiltration based BMPs demonstrate the greatest potential groundwater recharge through infiltration, up to 77% of the total runoff (up to 60,000 AFY with 15 inches of annual precipitation), and achieve considerable peak flow reduction in large storms (up to 47% peak reduction for storms with less than 2” of rain). Though infiltration-based BMPs significantly reduce TMDL exceedances compared to no BMPs, they are not as good for reducing exceedances as treat and release BMPs because infiltration BMPs remove water from the channel, lowering the TMDL target at the point of compliance. However, infiltration BMPs remove more pollutant load than treat and release BMPs, so they improve the quality of the receiving waters as well as offer other potential IWM benefits such as groundwater recharge.

Distributed BMPs have high infiltration capabilities resulting in the second greatest infiltration capacity (up to 56% of total runoff, or 43,000 AFY with average annual precipitation of 15 inches). Infiltration along with vegetation in distributed BMPs increases evapotranspiration and flow attenuation, significantly reducing flood peaks as well. However, wet weather exceedances are greater when implementing distributed BMP systems than regional BMPs due to their shallow depth and smaller treatment capacity per BMP. Distributed systems also cost more because they lack the economy of scale of regional BMP projects, and many more BMPs are needed to achieve similar benefits. In general, all scenarios are more compliant at smaller storm sizes because there is more capacity to treat and/or infiltrate stormwater volumes. No scenario completely eliminates wet weather exceedances, especially for extreme storm events.

The land area needed for regional BMPs may not be available where it would be most effective – i.e. further downstream in the watershed where runoff from larger drainage areas can be captured and treated. Distributed BMPs achieve similar benefits but often require permission and cooperation from private land-owners to construct and maintain these technologies. Infiltration BMPs provide the most benefit, though because they narrow the window for TMDL compliance, they may be less appealing to implement. Creative alternatives to regional BMPs or distributed BMPs on private property are needed in an already highly urbanized watershed. One alternative is in-channel BMPs that would treat and infiltrate stormwater during all flow regimes, similar to distributed infiltration BMPs. These would be implemented in tributary confluences prior to flowing into the main channel. A variation of this is to place distributed BMPs next to the channel to capture diverted stormwater flow and return it back to the channel after treatment.

The range of stormwater volume estimated for potential groundwater recharge in the various BMP implementation scenarios is 20,000 to 60,000 AFY based on average annual precipitation of 15 inches. At the high end of this range are BMPs that infiltrate a large majority of stormwater runoff, which also achieve the greatest benefits in pollutant reduction and peak flow reduction. These types of BMPs also will reduce other pollutants such as bacteria and toxics. However, further research needs to be done on appropriate placement of these BMPs to ensure that runoff is not infiltrated in areas that will cause the mobilization of existing subsurface contaminant plumes. Also, it is important to consider that the volume of recharged stormwater water available to augment potable supply is less than the theoretical maximum infiltrated by BMPs. In order to get the complete picture of actual groundwater recharge due to BMP infiltration, the system should be analyzed using a more complex groundwater model, which is outside the scope of this study.

Groundwater Supply

Groundwater basins in Los Angeles provide significant opportunities to store advanced treated recycled water as well as captured stormwater that can be used later in times of need. However, contamination by legacy pollutants and complex political, legal, and regulatory environments present challenges that need to be addressed to take full advantage of this local water supply opportunity. This report examines these issues in detail, for the first time, pointing to delicate policy needs and tradeoffs. There are four groundwater basins that partially underlie the Ballona watershed: West Coast Basin, Central Basin, Santa Monica Basin, and Hollywood Basin. The City has water rights in both West Coast Basin and Central Basin, which are adjudicated basins. Santa Monica Basin and Hollywood Basin are both unadjudicated basins, with the city of Santa Monica and the city of Beverly Hills being the primary pumpers, respectively, in these basins.

There is space in groundwater basins underlying Ballona Creek Watershed to capture and store additional stormwater or advanced treated recycled water. In FY 2012-2013, approximately 20,000 acre-feet and 40,000 acre-feet, respectively, of total groundwater rights went unextracted in West Coast Basin and Central Basin. The City specifically did not use approximately 1,800 acre-feet of water rights in West Coast Basin (1,503 acre-feet adjudicated rights and 300 acre-feet carryover rights) and approximately 17,000 acre-feet in Central Basin (of approximately 23,000 acre-feet allowed City pumping allocation including 15,000 acre-feet of adjudicated rights and 8,000 acre-feet of carryover rights). Further, recent amendments to these adjudications identified 330,000 acre-feet of additional space in Central Basin and 120,000 acre-feet of additional space in West Coast Basin that is available to be used for storage and basin management purposes.

An additional opportunity to increase demand for groundwater recharge in West Coast Basin lies in creating a regional desalting project that incorporates many rights holders in the basin to address the legacy saltwater plume from seawater intrusion that currently occupies approximately 600,000 acre-feet of potential storage space. Creating a regional desalting project would provide dual benefits: remediating contaminated groundwater to increase the storage capacity for freshwater, and creating higher demand in West Coast Basin for groundwater recharge using either recycled water [from Hyperion Treatment Plant (HTP) or the West Basin Municipal Water District Ed C Little Water Recycling Facility (WRF)] or captured stormwater.

Challenges to utilizing this available space include working within the adjudications, a lack of infrastructure, legacy contamination, and potential seawater intrusion. However, the adjudications in West Coast and Central Basins cap the volume of additional water that rightsholders can store in the basins above their adjudicated rights and they also limit the volume of water that can be extracted annually above the adjudicated rights to a maximum of either 120% or 140% (West Coast Basin and Central Basin, respectively) although requests for excess storage and extraction can be presented to the Storage Board for approval. Additional infiltration of any water into these basins would need to be planned and monitored to address or at a minimum not spread legacy contamination or exacerbate seawater intrusion issues. In West Coast Basin, the City would need to install groundwater pumping wells in order to access any of the groundwater as they currently have no active wells there.

Recycled Water

Addressing these restrictions on the use of the groundwater basins will be critical in order to increase the reuse of wastewater generated in the Ballona Creek Watershed by the Hyperion Treatment Plant (HTP), located in Playa Del Rey. Currently, HTP does not have advanced water treatment facilities on-site. Secondary effluent from HTP is sent to the Ed C Little WRF for additional treatment and reuse to produce waters ranging in quality from disinfected tertiary effluent to advanced treated recycled water for a variety of uses, including a seawater intrusion barrier. Flows going through HTP in FY 2013-2014 averaged 279 MGD; 32 MGD of secondary treated effluent went to the Ed C Little WRF in 2013. As HTP and Ed C Little WRF are downstream from many customers, increasing the capacity for advanced water treatment through a process such as microfiltration - reverse osmosis (MFRO) at these facilities to generate flows of high-quality recycled water to recharge the groundwater basins provides a promising opportunity to increase the use of treated wastewater from HTP.

Brine disposal is among the most pressing difficulties in need of resolution in order to expand the advanced treatment of recycled water since the concentration of the constituents leaving through the HTP NPDES permitted discharge outfall increases as the volume of brine generated by a process such as MFRO increases. Effluent concentrations must remain in compliance with the NPDES effluent limits as well as with the limits to protect marine aquatic life in the California Ocean Plan. We used the FY 2013-2014 flow level of 279 MGD at HTP and assumed MFRO treatment to calculate the effect of increasing brine discharges on effluent quality at the HTP outfall. Under these conditions, maximum recycled water production at HTP is 198 MGD. We examined effects on the concentrations of effluent for several parameters (Ammonia as N, TSS, Turbidity, Cu, Zn, Pb, and Ni) to determine the effects of increasing concentrations going through the outfall from increasing volumes of brine discharge on water quality compliance. Concentrations of the majority of constituents remained in compliance at full capacity with the exception of Ammonia as N, which exceeded the California Ocean Plan standard at approximately 56 MGD of produced MFRO water, and TSS, which exceeded NPDES permit requirements at approximately 100 MGD of produced MFRO water. Based on this analysis, it is clear that additional treatment to address TSS and an additional nitrogen removal step (for example, nitrification-denitrification or a Membrane Bioreactor) is needed to ensure maximum HTP water recycling potential. The impacts of increasing volumes of brine from upstream plants in the HTP Service Area on HTP effluent quality would also need to be examined before implementation of these processes at upstream plants.

Non-potable reuse (NPR) is another opportunity to utilize our treated wastewater streams to satisfy and replace demands for potable water throughout the system. The 2012 LADWP & LASAN's recycled water master planning (RWMP) documents demonstrated that expanding and maintaining the NPR system would be cost-effective relative to the projected MWD costs of Tier 1 imported water. Multiple opportunities exist to expand the current and future demands for recycled water beyond those identified in the RWMP, such as exploring partnership opportunities with other agencies to provide recycled water to customers that are outside the service area. Increasing demands at current customers would both alleviate current water quality issues caused in part by low flows through the pipes and increase demands for NPR water overall. Finally, converting customers such as golf courses, residential developments, or country clubs which currently use groundwater for irrigation would both increase the demand for NPR water and preserve groundwater for potable use.

In addition to flows of brine and recycled water for non-potable reuses, it is critical to consider all flows within and among systems to assess all foreseeable challenges and opportunities. For example, HTP currently accepts dry weather urban runoff from 23 low flow diversion facilities (LFDs) in the Santa Monica Bay, including 8 City-owned LFDs. In addition to improving water quality, increasing diversion of the dry weather runoff as well as some portion of wet weather runoff to HTP and other WRPs in the City would increase the volume of water going through these facilities that could be treated to reusable standards. These runoff flows potentially could also dilute the increasing effluent concentrations caused by increasing discharge of brine from advanced treated water processes. However, it is likely that outdoor conservation will reduce available dry weather runoff while indoor conservation will further decrease flows going through the Water Reclamation Plants (WRPs). Increased implementation of on-site greywater technologies would reduce flow volumes going to WRPs as well as increase concentrations in wastewater effluent by removing one of the cleanest wastewater streams from the system, as well as most likely locking the use of that water into the potential use at that property. Careful consideration of the impacts of each of these flows, and the impacts of changes to these flows is necessary to determine the most appropriate method to ensure the streams of water currently leaving our system through treatment plants or runoff are put to the highest possible use in maximizing our local water supply potential.

<u>Local Water Supply Potential</u>

Conservation is another critical component of creating a sustainable water supply for California in general, and Los Angeles in particular, as stressors such as climate change and population growth continue to increase water demand. Executive Directive 5 from the City of Los Angeles Mayor sets an aggressive goal of 20% water conservation (to 104 GPCD) by January 2017, and the City and MWD have generously funded turf removal programs to reduce outdoor landscaping demand. Many additional opportunities to support conservation can be attained through instituting changes in the Building Code. Examples include setting an outdoor water budget, requiring new buildings to be greywater ready (separate piping for greywater and blackwater), requiring that 100% of water for uses such as industrial, water closets, and urinals comes from City-recycled water when it is available and non-potable water supply when it is not, installing water sub-meters to provide water use data on individual tenants within residential and commercial buildings, and dual metering in single family dwellings for indoor and outdoor water use. Greywater is a potential distributed component of a local water supply portfolio that may provide additional potable water use replacement. However, further research must be done into the long-term effects of greywater use on landscapes and the actual impact of installing onsite greywater systems at a parcel level on water use to determine the level to which this technology should be emphasized in a program to increase the City's local water supply by decreasing customer demand. Moreover, careful monitoring and analysis should be performed for each of these options and their potential unintended consequences.

If the treatment capacity can be built and groundwater basin management can be shifted to allow the basins to be used more as a local water supply reservoir into which parties can routinely extract the water they recharge, the available supply actually exceeds the demand in the Ballona Creek Watershed. Approximately 220,000 AFY of highly treated water could be generated through treating the current volume of HTP effluent with MFRO. Additional potential recharge capacity of 20,000 to 60,000 AFY of stormwater was estimated in the various modeling scenarios as discussed in the runoff section. This makes for a total local water supply in the Ballona Creek Watershed of roughly 240,000 to 280,000 AFY as compared to a 2015 demand of 196,000 AFY (1.5 million people at 117 GPCD) or a 2017 demand of approximately 175,000 AFY (1.5 million people at 104 GPCD, reflecting the Mayor's 20% conservation goal). However, it is important to note that the volume of stormwater that can be captured does not reflect the amount of actual local groundwater supply generated, because all water infiltrated by BMPs cannot make it to the groundwater supply aquifer due to impermeable layers in the subsurface. The volume of recharged stormwater water available to augment potable supply is less than the theoretical maximum infiltrated by BMPs. Further, potential recharge volume would be significantly reduced if fewer BMPs were implemented or less annual precipitation fell in the region.

Therefore, if the City continues to implement and accelerate the current goals, programs, and projects such as the EWMPs, SCMP, the Mayor's Executive Directive, and the Recycled Water Master Planning documents, there is a wide array of potential local water supply sources. However, the City also must work very closely with regional partners such as the watermasters and the Regional Water Quality Control Board to address the challenges and the restrictions that are currently in place to moving forward with maximizing the use of recycled wastewater and captured stormwater in the Ballona Creek Watershed and other watersheds to increase the sustainability of the City's water supplies.

Background

Over the last decade, the City of Los Angeles (City) has worked closely with local communities and stakeholders to develop an integrated approach to managing water. The City understood that a siloed approach to wastewater, water supply, stormwater, and flood control management was inefficient and that integration of its water management programs would result in improved water quality, increased local water supplies, and better flood control. The City developed an integrated water approach with a series of plans including the Integrated Resources Plan, the Water Quality Compliance Master Plan and associated watershed compliance plans [Total Maximum Daily Load (TMDL) Implementation Plans, Enhanced Watershed Management Workplans, Coordinated Integrated Water Monitoring Programs, and a Water Supply Plan].

However, there is still a need for quantitative assessment of the integrated water management approach identifying the feasibility of and opportunities for citywide implementation, including the benefits and costs of implementation. These quantitative assessments will provide the City of Los Angeles Sanitation (LASAN) with the information necessary for developing integrated water infrastructure priorities and management frameworks, and garnering broader support for implementation and funding initiatives. This report examines the opportunities and challenges to implementing integrated water management that are present in the Ballona Creek watershed.

I. Introduction

Implementing integrated water management systems that incorporate all components of the urban water cycle, including imported water, local groundwater, captured stormwater, greywater, and treated wastewater, as well as understanding its regulatory and management framework, is critical to creating a sustainable water supply for the City. The City has researched, written, and initiated implementation of recommendations from many reports critical to creating an integrated water management plan for the City as well as to defining the current capacity of the system. While the City has been working on this issue for many years, the extreme drought currently impacting water supplies throughout California has created a new urgency to increase water supply through local sources and to develop integrated water programs. A concerted transformation towards greater local water self-sufficiency is critical for climate adaptation as well as system resiliency in the face of emergencies.

Through building upon the regional research and reports that have been generated on potential components of the local water supply portfolio (e.g., groundwater, recycled water, and stormwater), as well as gathering and analyzing current data on flows of water and wastewater throughout the City systems and environment, this project further defines and refines opportunities to implement integrated water management throughout the City. Reflecting regulatory requirements, achieving water quality compliance in the Los Angeles area is the driving factor of this research. Thus, the City has been divided into watersheds for the sake of exploring site specific compliance. The focus of this report is on opportunities and challenges that exist in the Ballona Creek Watershed. Successive reports will focus on the Dominguez Channel and the Los Angeles River watersheds, regulatory and policy challenges throughout the study area, and economic and ancillary benefits associated with various integrated water management approaches.

Regulations and policies covering a broad range of topics, from protecting surface water quality for human and environmental uses to complying with water rights laws and ensuring the appropriate level of treatment of recycled water for different uses, come into play when undertaking integrated water management. While water quality standards attainment (permits, receiving water quality standards, TMDLs, etc.) were the driving objective for the alternatives assessed in the Ballona Creek watershed in this report, many other laws and regulations affect the implementation of an integrated water management system.

In addition to the strong regulatory background and recent changes strengthening, or in the case of groundwater, creating, regulations that encourage better management of water resources, the state of California has many policies that emphasize water quality as well as support Integrated Water Management (IWM). For example, the Governor's Water Action Plan (Five-Year Plan), the State Water Board's drought response package, the funding package in Proposition 1, and the California Water Plan all lay out programs, policies and goals. In the drought response package, the state mandated that all water districts pass a conservation ordinance that meets certain criteria after voluntary 20% conservation failed. Before that, the drought effort included reducing allocations to junior water rights holders (eliminating deliveries to almost all of them) as well as requiring every city to report their per capita water use on a monthly basis. Recently, Governor Brown required for all urban cities and counties to reduce water consumption by a mandatory 25% or risk significant penalties for non-compliance with conservation target requirements. IWM takes a lead role in the recently released CA Water Plan Update 2013 (Update 2013). As defined in Update 2013, IWM

> *"is a comprehensive and collaborative approach for managing water to concurrently achieve social, environmental, and economic objectives…[that] delivers higher value for investments by considering all interests, providing multiple benefits, and working across jurisdictional boundaries at the appropriate geographic scale. Examples of multiple benefits include improved water quality, better flood management, restored and enhanced ecosystems, and more reliable water supplies.[1]"*

This report provides a brief overview of regulatory and policy background to frame the specific opportunities and challenges that are present in the Ballona Creek Watershed. Further, we will describe the physical characteristics of the watershed, potential scenarios to achieve water quality compliance and potential opportunities to increase local water supply and resilience through implementing an integrated water management approach in the Ballona Creek Watershed.

---

[1] CA Water Plan Update 2013, Highlights, P.3.

A. Regulatory, Legal, and Policy Background

a. Regional

Many policies and plans have been created on a regional level that address urban water management, integrated resources planning, stormwater capture, and groundwater management.

Los Angeles Regional Water Quality Control Board (LARWQCB) Basin Plan. Regional boards are required by the Porter-Cologne Act to create basin plans (also called water quality control plans) for their respective regions. The basin plan for the Los Angeles region was adopted by the LARWQCB in 1994 and covers the coastal watersheds of Los Angeles and Ventura Counties.[2] Briefly, the basin plan designated beneficial uses for individual water bodies and segments, set water quality objectives that must be attained or maintained to protect those beneficial uses and comply with the state's antidegradation policy, describes implementation programs to protect water, and must incorporate all applicable water quality policies and regulations[3] such as NPDES permit requirements or California State policies. TMDLs and their requirements in the Ballona Creek Watershed are also incorporated into the LA Regional Basin Plan. Existing beneficial uses in the Ballona Creek watershed defined in the Basin Plan include recreation; navigation; commercial and sport fishing; estuarine habitat; marine habitat; wildlife habitat; rare, threatened, or endangered species; migration of aquatic organisms; spawning, reproduction and/or early development; shellfish harvesting; and wetland habitat. Additional existing potential uses in the watershed include municipal and domestic supply and warm freshwater habitat.[4]

Greater LA County Region Integrated Regional Water Management Plan (GLAC IRWMP). The GLAC IRWMP was originally published in 2006 by a variety of water stakeholders in the region including the city and county of Los Angeles, with a goal of improving collaboration and water resources. The GLAC IRWMP provides mechanisms to coordinate existing planning efforts within the region, identifies priorities for the region and watersheds, and enables the state to provide funding support for these plans and programs. An update to this plan was also published in 2014 to further define a path to sustainable water management in this region with a 20-year planning horizon.[5]

LA County (LAC) Municipal Separate Storm Sewer Systems (MS4) Permit. The current LAC MS4 permit (Order No. R4-2012-0175, NPDES Permit No. CAS004001) encompasses a drain-

---

[2] Water Quality Control Plan Los Angeles Region, LARWQCB, 1994 Cover Page.

[3] Water Quality Control Plan Los Angeles Region, LARWQCB, 1994, Introduction, p. 1

[4] Water Quality Control Plan Los Angeles Region, LARWQCB, 1994, Chapter 2 Beneficial Uses, Table 2-1 Beneficial Uses of Inland Surface Waters, p. 2-11

[5] http://www.ladpw.org/wmd/irwmp/index.cfm?fuseaction=update2013

age area greater than 3,000 sq mi. and multiple watersheds. The LAC MS4 regulates storm & non-stormwater discharges from the MS4s in LA County (except for the City of Long Beach MS4) and was adopted by the 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 plans (WMPs) to meet Water Quality Based Effluent Limits (WQBELs) individually or as a group within a watershed through an Enhanced Watershed Management Plan (EWMPs). This MS4 offers a novel alternate compliance pathway to WQBELs, which is to develop and implement WMPs / EWMPs (which require adaptive modeling and Best Management Practices (BMPs) implementation to achieve infiltration 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 Coordinated Integrated Monitoring Programs (CIMPs) that will provide a more complete dataset on which to base the models over the permit period. This permit was recently upheld by the SWRCB. WMP and EWMP workplans and CIMPs were provided to the LARWQCB in June 2014; the EWMPs themselves were submitted to LARWQCB in June 2015.

b. City of Los Angeles

Many policies and plans have been created on a local level that address urban water management, integrated resources planning, stormwater capture, and groundwater management. The Los Angeles Mayor's Office recently set strong goals to increase the sustainability of the City over the next several years that included goals for water supply and demand in the City. In an emergency drought directive released in October 2014, the Mayor identified additional accelerated water goals including reducing per capita potable water use by 20% by 2017 (from a 2014 baseline of 130 GPCD to 104 GPCD), reducing the City's reliance on Metropolitan Water District (MWD) water by 50% by 2025, reducing imported water use by 50% by 2035, and converting 85% of public golf course acreage to recycled water by 2017. In addition to explicit goals for water, opportunities to further the goals of increasing local water supply or provide further incentives to build the necessary infrastructure could be built into other City goals as well. For example, Mayor Garcetti set the goal of paving 2,400 lane miles of City streets in the Fiscal Year 2014-15 Budget.[6] A sub-goal could be created to replace some portion of this pavement with pervious pavement instead of standard pavement during the process.

Los Angeles Urban Water Management Plan (UWMP). The most recent UWMP was published in 2010 and a new version will be published in 2015 as required by the California Urban Water Management Planning Act. The UWMP forecasts future water demands and supplies, sets goals for achieving various water supply and quality targets, identifies conservation BMPs, and provides management strategies.[7] For example, goals in the 2010 UWMP included achiev-

---

[6] City of Los Angeles Fiscal Year 2014-15 Budget Summary as presented by Mayor Eric Garcetti- Changing the Conversation: from Short-Term Fixes to Long-Term Fiscal Sustainability. P. 3 of 32.

[7] Los Angeles Urban Water Management Plan, Executive Summary, p. 1

ing per capita daily water use of 138 gallons per capita per day (GPCD) by 2020 (already achieved), increasing recycled water use to 59,000 acre-feet per year (AFY) by 2035, and increasing stormwater capture to 25,000 AFY.[8] In order to meet the water quality and supply goals within the UWMP, the City has researched and written (or is in the process of writing) several planning documents. The Recycled Water Master Planning documents were completed in 2012, the Stormwater Capture Master Plan was released in mid-2015, and the Groundwater System Improvement Study as well as the Water Conservation Potential Study are still being drafted.

Recycled Water Master Planning (RWMP) Documents. The 2012 RWMP was divided into three reports, focusing on non-potable reuse opportunities, groundwater replenishment opportunities, and long-term opportunities to maximize recycled water reuse beyond 59,000 AFY and 2035. More specifically, the Non-Potable Reuse Master Planning Report (NPR Report) and the Groundwater Replenishment Master Planning Report (GWR Report) identify projects to meet the City's 2035 goals for recycled water reuse, and the Long-Term Concepts Report (LTCR Report) identifies opportunities to offset additional demand for imported water beyond 2035.

LA Stormwater Capture Master Plan (SCMP). The goal of the SCMP is to refine opportunities for the Los Angeles Department of Water and Power (LADWP) to implement stormwater management programs and projects that will also increase local water supply. Improving water quality will be a benefit of plan implementation, but projects were included mainly based on water supply. The report ranks groundwater basins by their quality, soil permeability, and the likelihood that captured stormwater would contribute to water supply (e.g. presence of active pumping wells owned by LADWP in the basin). Also, the plan identifies potential stormwater capture alternatives and projects that offer the most water supply benefits such as Old Pacoima Wash, the Rory M. Shaw Wetlands Park, and the Canterbury Power Line Easement (all with an estimated recharge benefit of 1,000-1,500AFY).[9] Further, the SCMP report brings together cost data for various BMPs, estimates the range of water supply benefits, and estimates some of the ancillary benefits that would be generated through implementing various alternatives such as water quality improvements, green space, and peak flow attenuation (for example, installation of certain BMPs types would provide no green space while other types would).[10] This report was released mid-2015.

Los Angeles Water Integrated Resources Plan (IRP) 2006. The IRP was adopted by the City in 2006 to create an implementable, regional watershed-based plan that integrated all aspects of water within the City (water supply, water conservation, water recycling, runoff management, and wastewater planning).[11] The IRP was reviewed and goals reassessed and updated in an IRP

---

[8] Los Angeles Urban Water Management Plan, Executive Summary, p. 12 ,5, 16

[9] Public Presentation on Stormwater Capture Master Plan Progress by Geosyntec & LADWP, 10/09/2014.

[10] Public Presentation on Stormwater Capture Master Plan Progress by Geosyntec & LADWP, 10/09/2014

[11] City of Los Angeles Integrated Resources Plan 5-year review, p. ES-1.

5-year review that was put together by LASAN and LADWP in 2012. The 2012 review identified areas where the plan was successfully implemented, areas where current conditions created a need for different goals or goals that could be postponed until necessary, and generally assessed progress towards integrated water management in the City. A few examples of results of the 2006 IRP are the Terminal Island Renewable Energy Project; completing the Recycled Water Master Planning documents; adopting the Water Conservation, Water Efficiency Requirements, and LID Ordinances; adopting the WQCMPUR described below; and constructing stormwater structural BMPs throughout the City.[12]

The *Water Quality Control Master Plan for Urban Runoff* (WQCMPUR) was developed by the LASAN Watershed Protection Division in collaboration with stakeholders as a watershed-based water quality master plan designed to reduce pollution from urban runoff in the City.[13] The WQCMPUR aimed to provide a compliance path to attain water quality standards in a manner that built upon other existing plans, projects, and efforts in the watershed to implement BMPs. The plan also established citywide approaches to achieving compliance, and created watershed protection interest at all levels of the community.[14]

Codes and Ordinances.

Standard Urban Stormwater Mitigation Plan (SUSMP) and Low Impact Development (LID) Requirements. LID is a site-specific stormwater strategy that aims to mitigate the impact of runoff by techniques such as capturing or infiltrating runoff on site or mimicking the site's pre-construction hydrologic patterns. The City enacted a comprehensive LID ordinance in 2012 which requires that all new and redevelopment projects mitigate runoff through implementation of LID BMPs. Numerous categories of development must capture and use, or infiltrate on-site, 100% of the 85th percentile storm. In the event that stormwater infiltration or capture isn't feasible on site, compliance can be achieved by implementing LID BMPs off-site that achieve 50% or more infiltration or capture them required on site. Most types of sites must prepare and implement a SUSMP on-site.[15]

---

[12] City of Los Angeles Integrated Resources Plan 5-year review, p. ES-2 to ES-6.

[13] Water Quality Control Master Plan Urban Runoff, Preface, P-1

[14] Water Quality Control Master Plan Urban Runoff, Executive Summary, ES-2

[15] http://www.lastormwater.org/green-la/low-impact-development/

B. Ballona Creek Watershed Study Area

a. Ballona Study Area and Geography

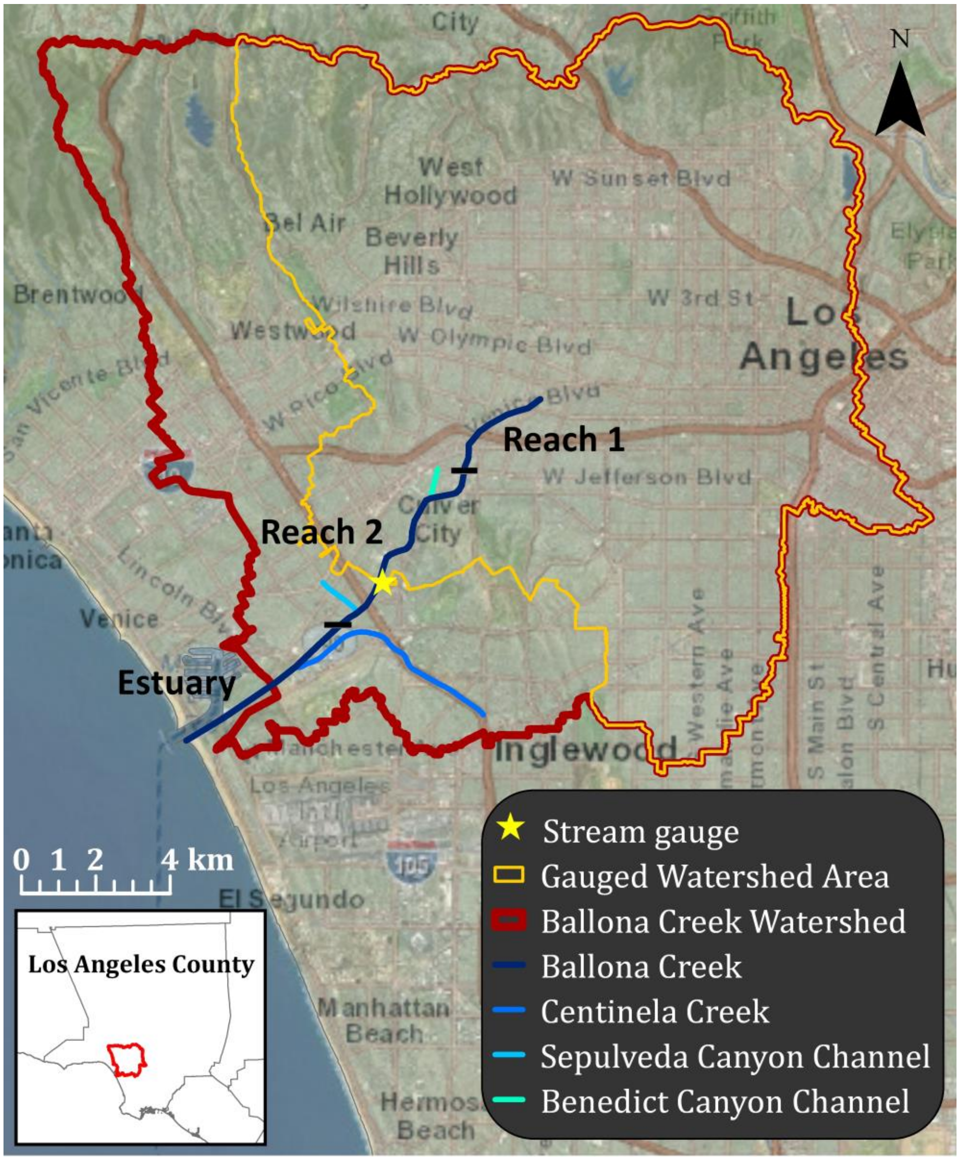


Figure 1: Reaches in the Ballona Creek Watershed. The star denotes the flow gauge at Sawtelle Blvd.

Together, the Cities of Beverly Hills and West Hollywood, portions of the cities of Culver City, Inglewood, Santa Monica, Los Angeles, and unincorporated areas of Los Angeles County comprise the 123 mi² Ballona Creek watershed.[16] In addition, the Los Angeles County Flood Control District owns and operates drainage infrastructure in this watershed. Ballona Creek is the largest watershed that drains into Santa Monica Bay. The Ballona Creek and Estuary are divided into three hydrological units as follows, (Figure 1): Ballona Creek Reach 1 is approximately 2 miles long, channelized with vertical concrete walls, and stretches between Cochran Avenue and National Boulevard. Reach 2 is mainly channelized as well, with trapezoidal walls, and stretches roughly four miles between National Boulevard and Centinela Avenue. Ballona Estuary begins at Centinela Avenue and ends at the Pacific Ocean. This portion of the channel is soft bottom, subject to tidal influx, and stretches approximately 3.5 miles. The main tributaries are Sepulveda Channel, which outlets into Reach 2, and Centinela Creek, which outlets into the Ballona Estuary. Del Rey Lagoon and the Ballona Wetlands are also included in this watershed.[17] Benedict Canyon Channel is a closed channel that daylights where it meets Ballona Creek and is not identified in the Basin Plan as a waterbody. Therefore, it is only considered a Ballona Creek tributary for the Bacteria TMDL in which it is identified as a tributary.

b. Hydrology of the Ballona Creek Watershed

The 123 square mile Ballona Creek Watershed is one of the most heavily urbanized in Southern California: 82% is developed and 61% of the watershed is impervious.[18] Ballona Creek was channelized starting in 1935, and by 1950 all lower tributaries were concrete lined.[19] This transition marked the shift towards significant hydrologic modification in the watershed. Land types changed from natural to residential, agricultural, and industrial, more areas became impervious, and flood potential increased. Groundwater was tapped for use and imported water became an integral part of the water budget after the turn of the 20th century.[20]

Ballona Creek has significant variability in seasonal flow rates. Peak flows of 36,000 cfs have been measured at the Sawtelle Blvd flow gauge station (Figure 1) during storm events; however dry weather flow is frequently in the single digits.[21] Ballona Creek is a naturally ephemeral stream, but after channelization and increased imported water use (outdoor irrigation),

---

[16] Ballona Creek EWMP workplan P. 1-3

[17] Ballona Creek EWMP workplan P. 1-3

[18] Ackerman, D., Stein, E., and Schiff, K., Modeled Wet Weather Trace Metal Loads to Ballona Creek, California, (2005), Proceedings of the Water Environment Federation, Vol (3), 1526–1541

[19] LA DPW. 2004. "Ballona Creek Watershed Management Plan." http://www.ladpw.org/wmd/watershed/bc/bcmp/masterplan.cfm.

[20] Liu, S. S., Hogue, T., Stein, E. D., and Barco, J., Contemporary and Historical Hydrologic Analysis of the Ballona Creek Watershed (2011). Technical Report, Santa Monica Bay Restoration Commission, p.1-2

[21] Ackerman, D., Stein, E., and Schiff, K., Modeled Wet Weather Trace Metal Loads to Ballona Creek, California, (2005), Proceedings of the Water Environment Federation, Vol (3), 1526–1541.

there is usually flow year round. Recently, dry weather flows have been constant and non-trivial due to anthropogenic inputs.[22]

The hydrologic impact of urbanization is clearly observed in the Ballona Creek Watershed. Though annual average precipitation inputs have not changed significantly over time, annual average outflow rates have increased significantly. Historical average annual precipitation (P) and runoff (Q) depths are 406 mm (16 in, approximately 105,000 AF of precipitation) and 198 mm (7.8 in, 51,000 AF of runoff) from 1932 – 2013, with a long term average annual runoff ratio (RR) of 0.51 (RR = runoff depth/precipitation depth). For the model simulation period in the current study, 1999 – 2008, average annual precipitation was 275 mm (11 in, ~74,000 AF) and runoff was 300 mm (12 in, 80,700 AF) per year, with an annual average RR of 1.1, greater than the theoretical maximum.[23]

In recent decades, there has been significantly more runoff than precipitation over the watershed, due to imported water and irrigation practices. Figure 2 shows historical precipitation and runoff ratios in the Ballona watershed.[24] The increasing trend in RR is clearly visible, with values above the theoretical maximum of 1 observed in the last decade up to 2008. However, it is difficult to discern how much of the additional runoff is due to increases in outdoor irrigation (imported water) or recent increases in impervious surface area. A change in the trend is seen in the last 6 years (2009-2014). The RR is back near the historical average of 0.5 in these most recent years. We hypothesize that this downward shift occurs after the City imposed mandatory water restrictions in Los Angeles, reducing outdoor water use (and corresponding runoff) considerably. [25]

---

[22] Liu, S. S., Hogue, T., Stein, E. D., and Barco, J., Contemporary and Historical Hydrologic Analysis of the Ballona Creek Watershed (2011). Technical Report, Santa Monica Bay Restoration Commission, p.10-11

[23] LADPW Stormwater Monitoring data

[24] Manago, Kim, and Hogue, Terri. (in prep). “Evaluating the Impact of Imported Water and Conservation Measures on Regional Water Budgets and Runoff in Los Angeles, CA”

[25] Mini, C., Hogue, T.S., Pincetl, S., *The effectiveness of water conservation measures on summer residential water use in Los Angeles, California* (2015). Resources, Conservation and Recycling

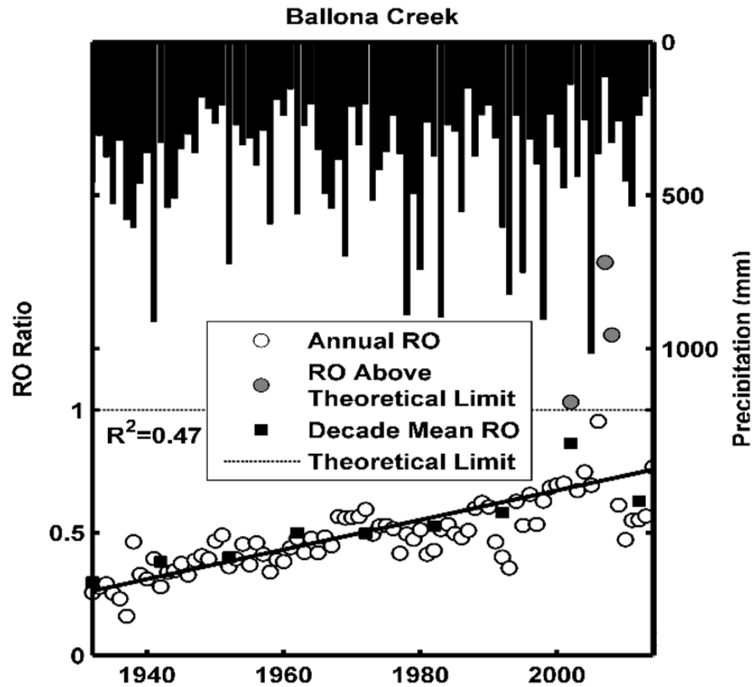


Figure 2: Annual Runoff Ratio (R/P) for WY1938-2014

This historic increased runoff regime is reflected in recent updates to TMDL regulations in Ballona Creek. Between 1987 and 2012, the average daily flow ranged from 1 cfs to 5230 cfs. The Ballona Creek Metals TMDL and Estuary Toxics TMDLs use this data to determine a cutoff between dry and wet weather flow (90th percentile average daily flow) and multiplies the dry weather flow rate (50th percentile average daily flow) by the numeric limit (chronic toxic concentration) to determine the allowable daily load. The runoff characteristics have changed so rapidly, that in 2013, 5 years after the original 2008 metals and toxics TMDL document was adopted, these values were adjusted by the Regional Board based on new data and shifted flow patterns. The 2008 TMDL was based on data from 1987 to 1998, when the 90th percentile average daily flow was 40 cfs. With 14 years of additional data (1987 – 2012) the 90th percentile value is now 64 cfs. The 50th percentile average daily flow for the dry weather TMDL calculation increased from 14 cfs to 17 cfs with the additional data.[26] This may need to be updated again to take into account the lower runoff volumes and conservation measures implemented during the current drought.

[26] LARWQCB Ballona Creek Metal and Toxics TMDL Reconsideration Staff Report (2013), p.7

c. Ballona Creek Watershed Policies, Plans, and Regulations

Due to the current reliance on imported water, growing populations, and changing wet and dry weather flow regimes, more efficient water management strategies need to be implemented in the watershed. Measures to reduce reliance on imported water include reducing water consumption, capturing stormwater, and recycling wastewater. Below are several management plans that have been developed for the Ballona Creek watershed to address these goals.

Ballona Creek Watershed Management Plan. A task force convened by the County of Los Angeles, the City, the Santa Monica Bay Restoration Commission, and Ballona Creek Renaissance developed a broad goal for the 2004 Ballona Creek Watershed Management Plan: to "set forth pollution control and habitat restoration actions to achieve ecological health."[27] The watershed planning area included the coastal interface zone and surface waters of Marina del Rey, the Oxford Flood Control Basin, the Venice Canals, Ballona Lagoon, and Del Ray Lagoon in addition to the Ballona Creek and Tributaries. More detailed goals in the areas of water (improve quality, maintain flood protection, restore hydrologic function, optimize water resources, and improve habitat), land (practice landscape stewardship, improve habitat quality, open space access, and pedestrian and bicycle access), and planning (create projects and plans across jurisdictions and with multiple benefits based on science, involve the public, utilize ongoing management, realize potential watershed restoration for sustainable economic development) laid the groundwork for many of the factors that are currently involved in integrated water management planning.

Ballona Creek Watershed TMDLs. Ballona Creek and Ballona Creek Estuary are on the Clean Water Act Section 303(d) list of impaired water bodies for many constituents, including metals such as cadmium, copper, zinc, and lead; toxics, such as DDT and PCBs; trash; and bacteria. Currently, TMDLs have been established for metals, trash, fecal indicator bacteria, and toxics in these water bodies. Point sources in Ballona Creek include 172 NPDES permits, including the Los Angeles County MS4 Permit and a statewide stormwater permit for the California Department of Transportation (Caltrans).

Ballona Creek Watershed Management Area EWMP and Coordinated Integrated Monitoring Program (CIMP). A preliminary draft of the Ballona Creek EWMP was released in April 2015 and submitted to the LARWQCB for review in June 2015. Jurisdictions that are involved in the Ballona Creek Watershed EWMP include Los Angeles (lead coordinating agency), Beverly Hills, West Hollywood, Culver City, Inglewood, Santa Monica, Los Angeles County, and the Los Angeles County Flood Control District.[28] The City comprises 83.2% of land area in this watershed management area. The waterbodies associated with the Ballona Creek Watershed Man-

---

[27] Ballona Creek Watershed Management Plan, Executive Summary page 4.

[28] Ballona Creek preliminary draft EWMP, April 2015, p.1-2. http://www.lastormwater.org/green-la/enhanced-watershed-management-program/

agement Area EWMP are, for the main-stem, Ballona Creek Reaches 1 and 2 and the Ballona Creek Estuary, as well as Sepulveda Channel, the Centinela Creek Channel, Del Rey Lagoon, Ballona Wetlands, and Santa Monica Bay.[29] Modeling results presented in the draft Ballona Creek Watershed EWMP identified a plan to achieve compliance with the MS4 permit as measured by the volume of stormwater managed by implemented control measures.[30] During wet weather, zinc and *E. coli* were identified as the limiting pollutants; during dry weather, only *E. coli* was the limiting pollutant. Zinc was considered the limiting pollutant rather than copper as it was assumed that the reduction in copper loading due to the phasing in of brake pads with lower copper levels required by AB346 will result in zinc becoming the limiting metal.[31]

The scheduling of the implementation of LID projects, green streets, and regional BMP projects was timed to achieve TMDL milestones of 50% for metals by 2016 and 100% (final compliance) for metals and bacteria by 2021.[32] An implementation strategy was laid out which included a set of BMPs with 13% LID projects, 17% green streets projects, 18% regional projects on public land, and 52% regional BMPs on private land due to limited public space for constructing BMPs.[33] The total structural BMP capacity required to capture the required volume of stormwater is 2,081 AF, of which 1,709 AF is within the City of LA.[34] The total estimated capital cost to implement the EWMP by 2021 is approximately $2.7 billion, with total operations and maintenance costs exceeding $77 million annually.[35] The total estimated cost for the City of Los Angeles is approximately $2.3 billion in capital costs and approximately $63 million in annual operations and maintenance.[36]

---

[29] Ballona EWMP workplan page 1-3.

[30] EWMP for the Ballona Creek Watershed. Executive Summary. June 2015 p. ES-6. http://www.waterboards.ca.gov/losangeles/water_issues/programs/stormwater/municipal/watershed_management/ballona_creek/index.shtml

[31] EWMP for the Ballona Creek Watershed. June 2015. P. 6-15

[32] EWMP for the Ballona Creek Watershed. Executive Summary. June 2015. p. ES-2.

[33] EWMP for the Ballona Creek Watershed. Executive Summary. June 2015. p. ES-7.

[34] EWMP for the Ballona Creek Watershed. Executive Summary. June 2015. p. ES-8. For total capacity, summed total capacity values of each jurisdiction in Figure ES-9. “BMP Capacity in Ballona Creek Watershed by Jurisdictions”

[35] EWMP for the Ballona Creek Watershed. Executive Summary. June 2015. p. ES-9.

[36] EWMP for the Ballona Creek Watershed. Executive Summary. June 2015. p. ES-10.

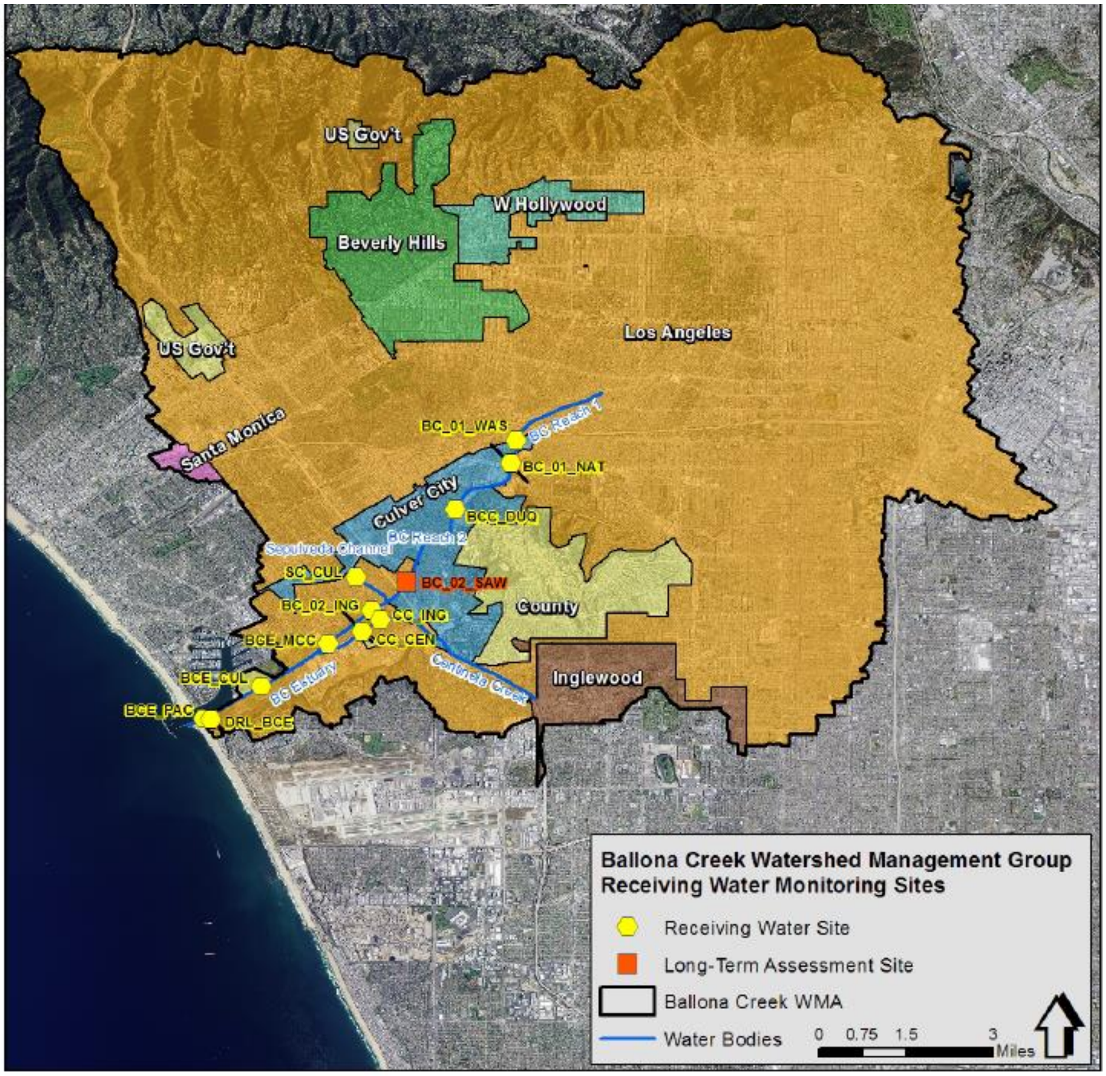


Figure 3: Overview of Receiving Water Monitoring Sites, from Ballona Creek Watershed CIMP (figure from CIMP)

In the CIMP, new monitoring locations have been added in order to gather more complete data regarding the water quality of both the receiving waterbodies and the discharges from the MS4 system. See Figure 3 for planned monitoring locations in the CIMP that will be used to implement the EWMP and provide new water quality data to inform management actions in the Ballona Creek Watershed going forward.

C. Hyperion Service Area and Groundwater Basins

The Hyperion Treatment Plant (HTP) is located just south of the LA World Airport and just east of El Segundo. HTP treats wastewater from the Hyperion Service Area (HSA) (Figure 4), which covers a tributary area of about 515 mi². Approximately 420 mi² are within the City.[37] Average daily flows going through HTP were 279 MGD for FY 2013-2014. HTP is also responsible for processing solids for the entire HSA, including the solids generated by the two inland Water Reclamation Plants (WRPs): the Donald C Tillman WRP (DCT) in Van Nuys and the Los Angeles-Glendale WRP (LAG) near Griffith Park. Both WRPs divert raw wastewater from the system for wastewater treatment and return solids back to the system for treatment at HTP.

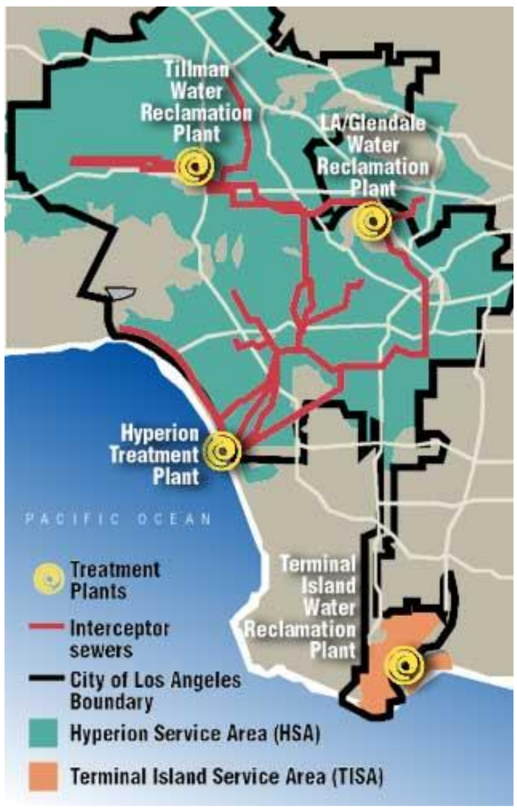


Figure 4. Image of Hyperion Service Area and 4 LA POTWs[38]

---

[37] Wastewater Treatment TM Admin Draft, LTCR appendix P.11

[38] LA Sewers website. http://lasewers.org/treatment_plants/about/index.htm

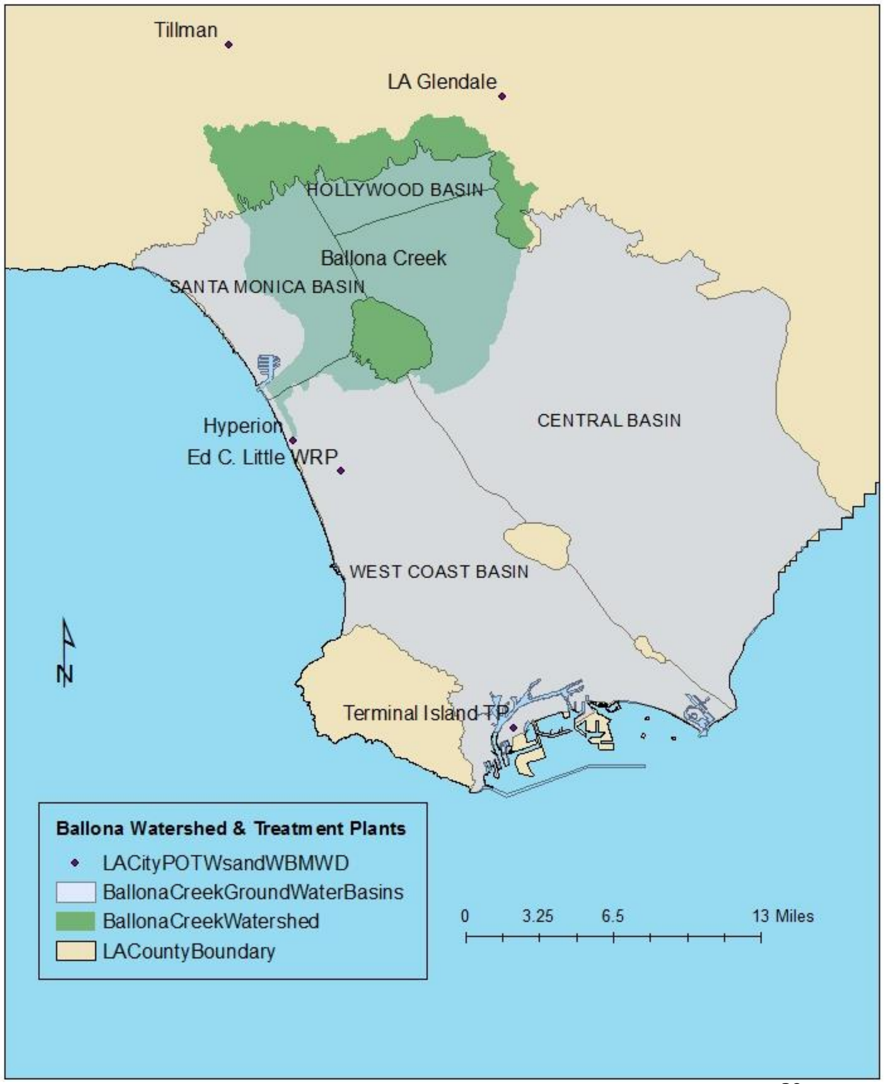


Figure 5: Groundwater Basins in Los Angeles County.[39]

In 2013, 32 MGD of secondary treated effluent from HTP went to West Basin Municipal Water District (WBMWD) for advanced treatment to produce waters ranging in quality from disinfected tertiary effluent to advanced treated recycled water for a variety of uses. HTP additionally provides an opportunity for further treatment and reuse of dry and some wet weather flows. Currently, HTP accepts dry weather urban runoff from 23 low flow diversion facilities (LFDs) throughout the city year-round, including 8 City-owned LFDs as well as LA County and City of

[39] Map created with data and layers from Los Angeles County Department of Public Works GIS database

Santa Monica LFDs. Runoff is diverted to HTP except during a storm event that generates greater than 0.1 inch of storm runoff and for the following three days after the storm.

The potential to increase recharge into and extraction from the four groundwater basins underlying the Ballona Creek Watershed also was analyzed in order to fully discuss the potential to increase local water supply within the Ballona Creek Watershed. These four basins are: West Coast Basin, Central Basin, Hollywood Basin, and Santa Monica Basin (Figure 5). Initial opportunities were identified in this report; further analyses of the challenges and opportunities to increasing local water supply through the adjudicated West Coast and Central Basins will be discussed in successive reports.

II. Dry Weather Urban Runoff and Stormwater Runoff

A. Introduction

In Los Angeles, both dry weather runoff and wet weather storm runoff contribute greatly to water quality impairments in regional water bodies. There are multiple benefits to capturing and reusing as much of this runoff as possible, especially during times of water scarcity such as those that California is currently experiencing. In addition to improving water quality, capturing this runoff represents a source of local fresh water that could replace imported water supplies. Also, stormwater capture and/or infiltration provides flood control benefits, and may additionally provide habitat and recreational open space benefits as well. Recent studies from UCLA have shown that while the timing and intensity of precipitation may change, the total amount of precipitation in Los Angeles is projected to be roughly the same through the end of the 21st century.[40] Capturing runoff offers a source of local water that is more reliable than imported water supplies, which are affected by disasters, climate change, upstream environmental needs, or rapid increases in the price of imported water. In this section, we delineated opportunities to achieve water quality compliance and maximize stormwater capture in the Ballona Creek Watershed through a discussion of the current regulatory and policy-based requirements, and conducted detailed modeling of various scenarios to achieve water quality standards compliance for metals as required under the Ballona Creek metals TMDL.

B. Water Quality Regulations

a. Metals TMDL Background

In the Ballona Creek Watershed, the Los Angeles County MS4 NPDES permit requires compliance with TMDLs in impaired water bodies in the watershed. The recently amended Ballona Creek Metals TMDL addresses Copper, Lead, and Zinc in Ballona Creek Reaches 1 and 2, and Sepulveda Canyon Channel (Selenium was also present in the previous version of the TMDL and was removed during a reconsideration of the TMDL based on limited exceedances).[41] While several interim goals to compliance are included in the TMDL, 100% compliance during dry weather must be achieved by January 2016; and the final wet weather compliance deadline is January 2021.[42] The metals TMDLs are applied based on wet or dry weather flow, determined by the instantaneous daily peak flow value (in cubic feet per second, cfs). If the daily peak flow is greater than 64 cfs, the day is considered a wet weather day. If the flow is less than 64 cfs, it is

---

[40] http://newsroom.ucla.edu/releases/ucla-researchers-project-southern-california-rainfall-levels-through-end-of-century

[41] Reconsideration of Certain Technical Matters of the Ballona Creek Estuary Toxics TMDL and Ballona Creek Metals TMDL Staff Report (2013), P. 12

[42] EWMP Workplan p 1-10.

considered a dry weather day, with no direct stormwater runoff contributing to flow.[43] In the case of a fully channelized river with no hydraulic connection to groundwater, contributions to inter-storm flow consist of urban runoff from irrigation, permitted discharges, and other outdoor water uses.

Both wet and dry weather metals TMDL targets are concentration based. The targets are based on EPA's California Toxic Rule (based on the National Toxics Rule). The RWQCB derived the targets and chose a maximum concentration specific to each metal pollutant not to exceed for the safety of wildlife and humans. The dry weather target is based on the chronic exposure level, while the wet weather target is based on the acute exposure level. The Waste Load Allocations (WLAs) (the actual TMDL limit on which the MS4 Permit is based) are calculated by multiplying this specified concentration by the daily flow in the water body (median daily flow rate for dry weather, total daily flow volume for wet weather). The end result is a pollutant load describing the total maximum daily load allowable at the point of compliance in the water body.

Increased hardness in the water can reduce the toxicity of the metals to aquatic life because metals are less biologically available at high hardness concentrations. The Water Effects Ratio (WER) reflects site-specific water quality conditions, including hardness, and is used to adjust the water quality criteria. If studies are conducted to develop environmentally conservative WERs that reflect site-specific water conditions, then the WER can be used as a multiplier for the numeric limits of each TMDL for the metal studied. While there have been no WERs developed in the Ballona Creek Watershed, an amendment to the Basin Plan to incorporate copper WERs for certain reaches and select tributaries of the LA River watershed was approved by the LARWQCB in April 2015. The WER is dependent on the average hardness and dissolved organic matter in the receiving water, which affects the toxicity of copper during the critical condition (for the LA River, the critical condition was found to be dry weather regardless of season)[44], and can be a factor greater than 1 if the toxicity reduction is significant. The WERs approved by the Regional Board based on the Los Angeles River Water-Effect Ratio Study, ranged between 1.3 and 9.7.[45] We tested various levels of WERs to assess the effects on compliance if similar WERs are found to apply in the Ballona Creek Watershed in the future.

The dry weather TMDL is calculated using the mean dry weather peak daily flow, determined to be 17 cfs in Ballona Creek. The wet weather TMDL varies from day to day and is based on the daily flow volume at that time. This results in a higher TMDL limit when there is more water in the channel, for example after a storm. This also means that the TMDL limit is

---

[43] Reconsideration of Certain Technical Matters of the Ballona Creek Estuary Toxics TMDL and Ballona Creek Metals TMDL Staff Report (2013), p.7

[44] Los Angeles River Los Angeles River Copper WER Final Report, April 2014, p. ES -3.

[45] Los Angeles River Los Angeles River Copper WER Final Report, April 2014, p. ES -4.

lower with less water in the channel, for example if water is diverted into a BMP and infiltrated to groundwater. Therefore, an infiltration approach to runoff can make compliance more difficult than a treat and release approach.

Under the MS4, meeting TMDLs is not the only way to achieve compliance with water quality regulations. The MS4 permit outlines an alternative approach, which states that if the municipality can demonstrate that they are capturing and infiltrating or treating runoff from the 85th percentile storm, they will be considered compliant with the regulations. This condition is the basis for several of the BMP scenarios we modeled to evaluate compliance with TMDLs in the Ballona Creek watershed.

b. Overview of Additional TMDLs

BACTERIA: The LARWQCB developed and adopted the Ballona Creek Watershed Bacteria TMDL in 2006. Waterbodies in the Ballona Creek Watershed are currently identified as impaired for bacteria. Water quality standards for Santa Monica Bay include four types of bacterial indicators: fecal coliform (FC), total coliform (TC), E. coli (EC), and enterococcus (ENT). A Bacteria TMDL was established with a compliance goal measured through the percent of the MS4 area that meets the WQBELs. The Ballona Creek Bacteria TMDL addresses TC, FC, and ENT in the Estuary during dry weather. This TMDL also addresses EC (freshwater criteria) in Reaches 1 & 2, Sepulveda Canyon, Centinela Creek, and Benedict Canyon during both dry and wet weather.

Compliance with the bacteria TMDL is measured at various monitoring locations and is defined as having no more days on which the TMDL is exceeded (exceedance days) than are allowed by the permit. Compliance standards are defined differently for three time periods within the year: summer dry weather from April through October, winter dry weather from November to March, and wet weather on days with greater than 0.1 inches of rain and the following three days.[46] Zero exceedance days are allowed during summer dry weather, three exceedance days are allowed during winter dry weather, and 17 exceedance days are allowed during wet weather per year. Dry weather compliance (100% of the watershed meeting WQBELs) was required in the Estuary by April 27, 2013.[47] The final compliance date for 100% of the MS4 and Santa Monica Bay meeting WQBELs during wet weather is July 15, 2021. Concentrations of indicator bacteria are measured to determine compliance; single sample maximums as well as a rolling 30-day geometric mean are used for different indicator bacteria. The numeric targets for specific indicator bacteria are dependent on designated beneficial use and type of water body and vary by beneficial use and stream reach.

---

[46] Ballona Bacteria TMDL, P. 25

[47] Ballona EWMP Workplan, Table 1-5.

A preferred strategy to achieve water quality compliance through a watershed-based and integrated solution was identified through the Ballona Creek Bacteria TMDL.[48] Some of the implementation strategies outlined in the Bacteria TMDL include institutional flow source control, bacteria and structural/physical source control strategies to reduce bacteria levels and decrease flows (e.g., on-site capture for infiltration for use or treatment), treatment and discharge/reuse, diversion to HTP, or in-stream solutions such as creek restoration.

TOXICS: The LARWQCB developed and adopted the Ballona Creek Estuary Toxics TMDL in 2006. The Ballona Creek Toxics TMDL applies to the Estuary. Constituents addressed in this TMDL are, for sediment, Copper (Cu), Lead (Pb), Zinc (Zn), Silver (Ag), DDT, Chlordane, and PCBs. Interim compliance goals are set by the % of the watershed that is meeting WQBELs. The final compliance date for the amended Ballona Creek Toxics TMDL, by which 100% of the watershed must meet WQBELs, is January 11, 2021.[49]

Pyrethroids are an important contributor to toxicity in the Ballona Creek Estuary. A follow-up study to the TMDL, which aimed to determine the causes of the toxicity collected and analyzed samples from 2007-2010, found that pyrethroids were a contributing source of the observed toxicity. Ballona Estuary sediments were found to be highly contaminated with pyrethroids.[50] Applications to impervious surfaces are the primary route of pyrethroids transport, often due to structural pesticide control activities. Structural pesticide control applicators are the key users of these pyrethroids in the watershed.[51] Regulations that will help diminish the frequency and concentration of pyrethroids in surfaces waters were approved by the CA Department of Pesticide Regulation (CDPR) in 2012. Application of this group of pesticides was restricted to certain application methods (such as spot treatment) and prohibited in situations where pesticides were likely to runoff to surface bodies (such as during precipitation, to surfaces with standing water, or to components of a constructed drainage system).

TRASH: The Regional Board has characterized the Ballona Creek Watershed as impaired for trash and a trash TMDL was established in Ballona Creek. The Ballona Creek Trash TMDL, which went into effect in August 2005, applies to all waterbodies in the watershed and the compliance goal is measured through a percent reduction in trash. Full compliance must be met during all weather conditions by September 30, 2015. The narrative water quality objectives in the Basin Plan state that waters cannot contain floating materials or solid, suspended, or settleable

[48] Ballona Bacteria TMDL, P. 32

[49] Ballona EWMP Workplan, Table 1-5.

[50] Bay, SM, Greenstein, DJ, Maruya, KA, & Lao, W. (2010). Toxicity Identification Evaluation of Sediment (Sediment TIE) in Ballona Creek Estuary Final Report. Costa Mesa, CA: Southern California Coastal Water Research Project.

[51] Kazue Chinen. UCLA report (in progress)

materials "in concentrations that cause nuisance or adversely affect beneficial uses."[52] Trash impairs many beneficial uses in Ballona Creek, especially those related to recreation, habitat, and harvesting fish, as debris throughout the river system can impede these practices and cause harm to wildlife through ingestion or entanglement. In addition to being a physical nuisance, some trash can itself be a source of bacterial (e.g., diapers) or chemical (e.g., plasticizers or other chemicals leaching out of plastic trash) contamination to the water body.[53] Zero (0) trash is the TMDL target for the amount of trash in the water.[54] Storm drains, wind action, and direct disposal are three of the main mechanisms by which litter is transported into the water bodies.[55] Compliance with the trash TMDL can be achieved through placing full capture devices, which trap all particles retained by a 5 mm mesh screen and have a design treatment capacity of at least the peak flow rate from a one-year, one-hour, storm in the subdrainage area,[56] at stormdrain inlets. Further, management control measures such as education must be implemented to further reduce trash levels flowing into the waterbodies. The City has installed over 20,000 catch basin screens and inserts as part of the Proposition O project implementation throughout their portion of the watershed.[57]

METALS: Metals TMDL discussed previously in the section above.

C. Stormwater Metals TMDL modeling

a. Modeling Selection and Comparison

BMPs, including LID practices, were explored as methods to improve stormwater quality and capture stormwater runoff for potential reuse and groundwater recharge. The US EPA's System for Urban Stormwater Treatment and Analysis model (SUSTAIN) version 1.2 in ArcGIS 9.3 was chosen to simulate stormwater runoff quantity and quality in the heavily urbanized Ballona Creek watershed. An initial stormwater model comparison was undertaken[58] and SUSTAIN was selected over other stormwater models because it represents structural BMPs using physical dimensions, soil infiltration properties, and pollutant decay factors. SUSTAIN also includes an

---

[52] Water Quality Control Plan ("Basin Plan"), p. 3-9 (floating) & 3-16 (solid)

[53] Ballona trash TMDL, p. 7

[54] Ballona Trash TMDL, p.11

[55] Ballona Trash TMDL, p.11

[56] Ballona Creek Trash TMDL-Proposed Amendments to the Water Quality Control Plan-LA Region. p. 5.

[57] Proposition O – Clean Water Bond Program, October 2014 Monthly Report.

[58] Beck, Drew J., Evaluating Best Management Practice Scenarios in Ballona Creek Watershed Using EPA's SUSTAIN Model (2014), Colorado School of Mines, Master's Thesis, section 3.4, p. 26-33.

optimization module to optimize costs and pollutant removal for multiple BMPs in a scenario.[59] The EPA's Storm Water Management Model (SWMM) was considered, but as SUSTAIN is based on SWMM for the hydrologic parameterization and routing, SUSTAIN was more optimal due to this additional optimization capability. Geosyntec's Structural BMP Prioritization and Analysis Tool (SBPAT) was also considered, but the model is considered more optimal for BMP siting and high resolution modeling, rather than large sewer-shed scale compliance modeling and scenario testing.[60] In addition, our research seeks to tailor the BMP parameterization of the physical dimensions, soil characteristics, and pollutant removal to Southern California, more specifically than BMP parameters based on data from the International BMP Database (IBMPD).[61] SUSTAIN was chosen for its capability to customize physical BMP parameters.

With the TMDLs emphasizing trash, bacteria, toxics and metals as pollutants to reduce, efforts were made to determine if each of these constituents could be modeled in this study. It was determined that due to the broad, watershed scale of this study, only conservative pollutants with well documented water quality and BMP performance data available (a significant sample size with standardized units) would be feasible to model. Hence, only Copper (Cu), Lead (Pb), and Zinc (Zn), were modeled.

b. SUSTAIN Model Setup, Calibration, Validation

The goal of this modeling effort is to assess how various BMP types with varied performance mechanisms affect flow regimes and water quality at the watershed scale. The goal is not to recommend specific parcel-scale locations for BMPs, but to look at the number and cost of BMPs of each type needed across the watershed as a whole to achieve compliance and ancillary benefits.

To calibrate and validate the model, the Ballona Creek watershed was separated into 8 sub-basins (between 2,000 and 16,000 acres each) above the flow gauge at Sawtelle Blvd (Figure 6)[62], totaling 89.5 square miles, or 70% of the full watershed. This allowed good representation of the heterogeneity of the watershed's land uses, land cover, soil characteristics, and precipitation patterns. Runoff only could be calibrated and validated above the gauge where flow and quality data had been measured. These sub-watersheds have been used by the City and County

[59] Shoemaker, L., Riverson, J., Alvi, K., Zhen, J. X., Paul, S., and Rafi, T. (2009). SUSTAIN - A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality. User's Manual, Environmental Protection Agency, 1–202.

[60] Geosyntec Consultants. (2008). A User's Guide for the Structural BMP Prioritization and Analysis Tool (SBPAT v1.0). User's Manual, City of Los Angeles and County of Los Angeles, 1–65.

[61] Beck, Drew J., Evaluating Best Management Practice Scenarios in Ballona Creek Watershed Using EPA's SUSTAIN Model (2014), Colorado School of Mines, Master's Thesis, section 3.4, pp.26-33

[62] Beck, Drew J., Evaluating Best Management Practice Scenarios in Ballona Creek Watershed Using EPA's SUSTAIN Model (2014), Colorado School of Mines, Master's Thesis, section 3.4, pp.26-33

and other studies[63] and are consistent with topography and storm drain networks. In general, they represent major storm drain or stream junctions within Ballona Creek. Also, the sub-basin downstream of the gauge (24,000 acres), making up the remaining area of the watershed, was added to the SUSTAIN model after calibration and validation was completed at the gauge. BMP scenarios were implemented and optimized over the full 128 square mile watershed.

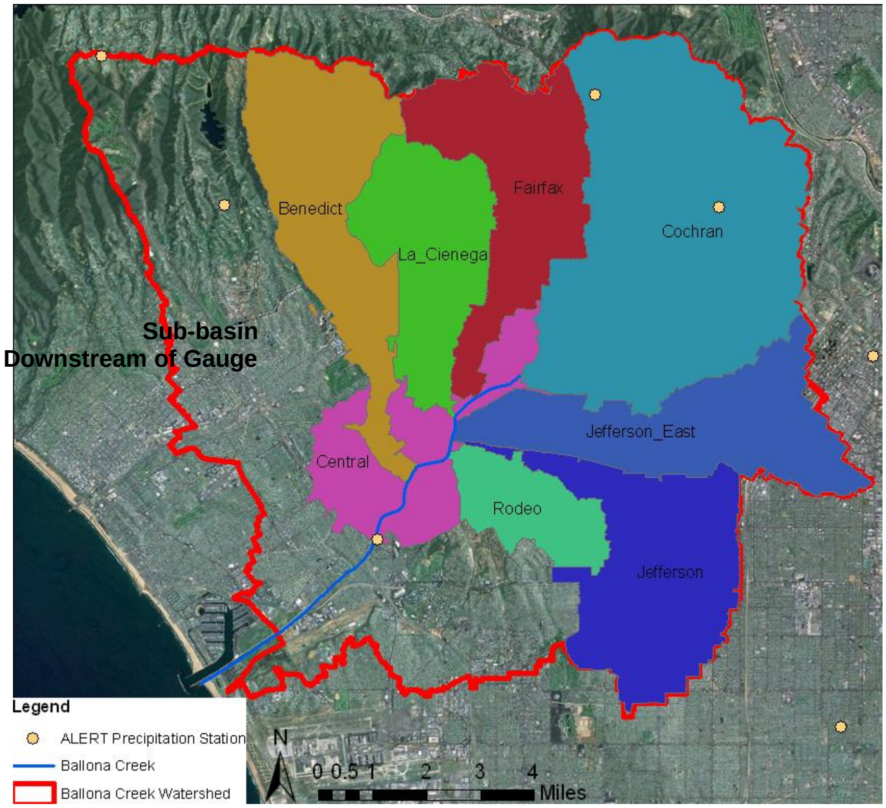


Figure 6: Ballona Creek Watershed sub-basin delineations for model simulations

Water quantity and quality were calibrated and validated in SUSTAIN based on historical flow gauge data and water quality sample data that had been collected as part of the LA County Department of Public Works' Stormwater Quality Monitoring program[64] and the Southern California Coastal Water Research Project (SCCWRP)[65] in the Ballona Creek watershed. Data from the SCCWRP study provided mass emission station data collected by the County from various

---

[63] Liu, S. S., Hogue, T., Stein, E. D., and Barco, J., *Contemporary and Historical Hydrologic Analysis of the Ballona Creek Watershed* (2011). Technical Report, Santa Monica Bay Restoration Commission, p.11

[64] LA County DPW Annual Stormwater Monitoring reports, (1998-2014), available at http://dpw.lacounty.gov/wmd/NPDES/report_directory.cfm

[65] Liu, S. S., Hogue, T., Stein, E. D., and Barco, J., *Contemporary and Historical Hydrologic Analysis of the Ballona Creek Watershed* (2011) Technical Report, Santa Monica Bay Restoration Commission.

land-use types provided Event Mean Concentration (EMC) pollutant data for water quality validation in SUSTAIN. Although build-up and wash-off pollutant data would have provided a better estimate of first-flush characteristics in the channel, sufficient data on build-up, wash-off, and antecedent conditions were not available for this study.

Water quantity was calibrated and validated using water years (WYs) 2004-2008 and WY 1999-2003, respectively. The data period was chosen based on available receiving water quality sampling as well as storm occurrence and variability. The model scenarios (in Section II.C.d.) are based on the calibration period of WY 2004-2008 because it is the most recent period that best represents the historical average hydrology in the watershed, at an average of 11 in of precipitation per year (see Ballona Creek watershed historical hydrology, Section I.B.b). The calibration process focused on matching individual storm volumes and annual flow volumes because the EMC method used for water quality is directly related to runoff volume. Peak timing was not the main focus of the calibration process because it does not impact the pollutant loads associated with individual storms or annual loads. Furthermore, the secondary flood control benefits provided by the BMPs were reported on a relative, rather than a discrete, basis.

Seven storms of varying volume and intensity were selected for calibration from WYs 2004-2008 (Table 1). Calibration was conducted by manually adjusting the percent impervious, overland flow width, Manning's N for impervious areas, depression storage for impervious areas and the percentage of impervious area with zero depression storage. These parameters were the main focus of calibration process as they had been determined to be most sensitive in initial model sensitivity analysis.[66]

Table 1: SUSTAIN Water Quantity Calibration: Storm Outputs. (Dur = Storm duration, RO ratio = runoff ratio (storm runoff depth/precipitation depth), ante = antecedent, Q_{pk} = Storm peak flow)

Event	Dur (hrs)	RO ratio	ante period (days)	Total Precip (in)	Avg Storm Intensity (in/hr)	Total Runoff (in)	Q_{pk} (cfs)	Peak Rainfall Intensity (in/hr)	+/- vol dif	+/- Q_{pk}
Storm 1	14	0.50	2.5	3.34	0.24	1.67	14,771	0.43	7.9%	-7.7%
Storm 2	12	0.46	3.5	0.79	0.07	0.37	5,755	0.18	4.7%	-26.0%
Storm 3	12	0.57	2	1.09	0.09	0.62	11,115	0.31	3.5%	-18.1%
Storm 4	10	0.47	3	1.38	0.14	0.65	10,274	0.40	7.1%	-8.3%
Storm 5	8	0.55	5	0.87	0.11	0.48	8,646	0.30	0.8%	-19.2%
Storm 6	12	0.60	11	0.55	0.05	0.34	3,676	0.18	0.5%	12.9%
Storm 7	9	0.65	1	0.62	0.07	0.40	4,730	0.13	-1.8%	-11.7%

[66] Beck, Drew J., Evaluating Best Management Practice Scenarios in Ballona Creek Watershed Using EPA's SUSTAIN Model (2014), Colorado School of Mines, Master's Thesis, section 3.4, pp. 44-47

Overall the runoff flow and volume calibration process was successful for smaller storms (< 1” precipitation) and less successful for larger storms (>1” precipitation) (Table 1). Greater emphasis was placed on volume accuracy versus peak accuracy because water quality depends more on flow volume. This resulted in in all six storms having less than 10% volume difference between modeled and observed volumes. Duration and antecedent days were similar for all of the calibration storms, with the exception of eleven antecedent days for storm 6. Storm intensity affected the success of the calibration process with intense storms (> 0.12 in/hr) containing larger relative errors compared to less intense storms. Peak values were generally under predicted, with the exception of storm 6 for which the model over-predicted peak flow. This can be attributed to the fact that the total precipitation and storm peak for this storm is the smallest of all of the storms analyzed. The parameter values from each calibrated storm were then averaged and applied to the validation period.

Table 2: Statistical analysis of Hydrologic Validation period WY 1999 – 2003

	Number of Storms (n)	Avg Precip (in)	Avg Vol Bias	Avg Peak Bias	Avg Vol NSE	Avg Peak NSE
Top Quartile	20	1.16	8.8%	-16.2%	0.97	0.92
Mid 2 Quartiles	38	0.28	-3.5%	-25.0%	0.93	0.81
Lower Quartile	20	0.06	-44.1%	-58.5%	0.68	0.42

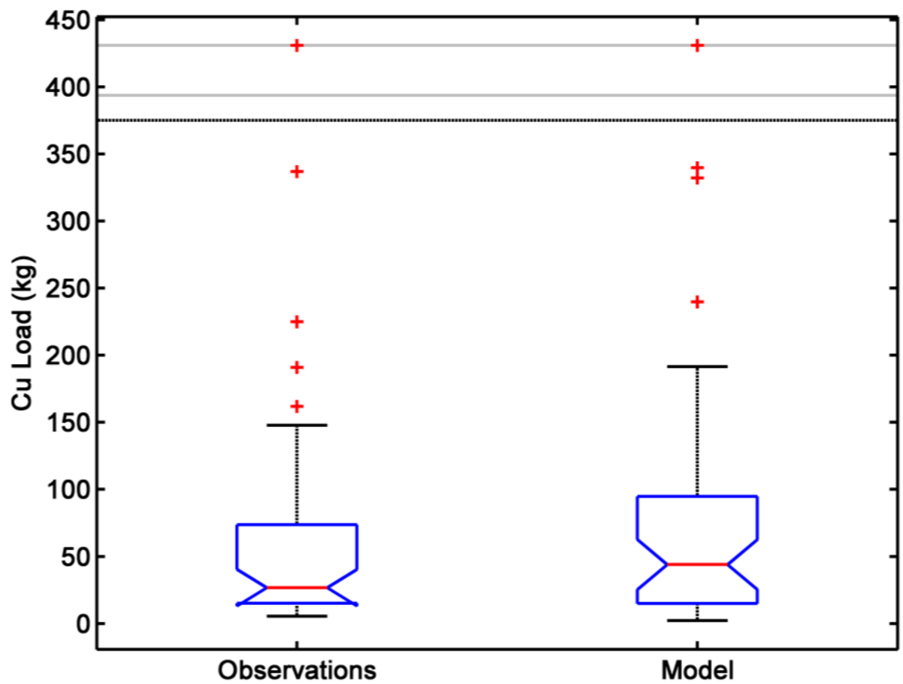


Figure 7: Box plots for validation storms for Copper pollutant load simulations. The median is depicted by the red center line and notches in the box. The lower and upper quartiles are captured in the main blue box. The crosses indicate outliers.

For validation, the model was run over a separate validation time period (WY99-03). Individual storms as well as annual discharge values were analyzed to determine success of the calibration. The modeled validation period had favorable bias and NSE statistics for larger storm events (top quartile of all storms) (Table 2). A slight positive bias of 8.8% for large storm volumes and -3.5% for medium storm volumes were noted; however all had Nash Sutcliffe Efficiency (NSE) values >0.90. The model has poorer performance for the bottom quartile of storms with average bias and NSE values of -44% and 0.42, respectively. However, because BMPs are designed to capture medium size storms it is assumed that they could capture all of the runoff from trace storms, thus the fact that the model performs poorly for this lower quartile is less relevant. The water quality validation results overlap in the middle quartiles (large boxes in Figure 7), with the model slightly over-predicting pollutant loads, as seen by comparing the red median lines in Figure 7.[67]

c. BMP Technologies in SUSTAIN

Five BMP types were assessed in SUSTAIN with regards to their ability to improve water quality, decrease peak storm flows, and infiltrate water for groundwater recharge. The five types include infiltration trenches and dry ponds (regional BMPs), vegetated swales, bioretention basins, and porous pavement (distributed BMPs). These are each described in more detail below. Each BMP type was assumed to have a specific treatment volume determined by the physical dimensions specified in the model (Table 3), and all BMPs of one type were assumed to have the same dimensions. These five types and their average dimensions were chosen as a representative population of the most common BMP systems by reviewing multiple sources of BMP construction projects: Standard Urban Stormwater Mitigation Plans (SUSMP)[68], IBMPD[69], Proposition O[70] and other City project reports.

[67] Beck, Drew J., Evaluating Best Management Practice Scenarios in Ballona Creek Watershed Using EPA's SUSTAIN Model (2014), Colorado School of Mines, Master's Thesis, section 3.4, pp. 44-60

[68] Standard Urban Stormwater Mitigation Plans, *Information and Documentation found at* http://www.swrcb.ca.gov/losangeles/water_issues/programs/stormwater/susmp/susmp_details.shtml

[69] International BMP Database, *available at* http://www.bmpdatabase.org/

[70] LA City Bureau of Sanitation, Proposition O, http://lacitysan.org/wpd/Siteorg/LAPropo/index.htm

Table 3: Regional and Distributed BMP Types utilized in the Ballona Creek model

BMP	Type	L (ft)	W (ft)	D (ft)	Treatment Capacity (cf)
Infiltration Trench	Regional	90	45	5	20,250
Dry Pond	Regional	45	15	5	3400
Vegetated Swale	Distributed	250	10	0.5	1250
BioRetention Basin	Distributed	46	23	1.5	1600
Porous Pavement	Distributed	62	30	1	1860

Each BMP type utilizes slightly different pollutant and flow attenuation unit processes. In this study, we utilized infiltration trenches to represent larger regional trenches with dimensions of 45 ft wide by 90 ft long, similar to features that could be implemented next to larger transportation corridors or receive diverted overflow drainage from storm sewers. These systems are meant to represent small spreading basins (~half acre-foot of storage) but can also represent multiple smaller trenches as one unit. These regional infiltrating BMPs are assumed to be on top of soils with high hydraulic conductivity and remove about 70% of water annually on average through infiltration and percolation into the subsurface. Dry ponds are also regional BMPs due to their large size, and are depicted in the model to infiltrate about 40% of the inflowing water on an average annual basis. Dry pond basins are lined with a low-permeability layer and achieve a “treat and release” process that allows pollutants to settle out over a pre-set hydraulic retention time before releasing the water back to the channel. Dry ponds take better advantage of sedimentation to settle out pollutants while infiltration trenches mainly remove pollutants by infiltration, not settling. Both regional types limit open-water evaporation due to their depth.

Another type of large capacity infiltration BMP is the dry well, also called a French Drain, which is generally deeper (~30 ft) with a small areal footprint. This type was not available as a BMP type in SUSTAIN, so further work will be done to calibrate the optimal dimensions and pollutant removal rates to create a customized BMP type for dry wells in SUSTAIN. Information from recently installed dry wells will also be used in SUSTAIN to examine the efficacy of these infiltration BMPs for metals removal in the LA River Report. In addition, we will model the widespread use of distributed cisterns to determine the impact on storm flows, and pollutant concentrations and loads in the LA River.

Distributed BMPs including vegetated swales, porous pavement, and bioretention basins were utilized in the modeling effort and are referred to as distributed BMPs in this study. Distributed BMPs typically have smaller treatment capacity and therefore are more feasible to implement on private property or along transportation corridors than larger basin-type BMPs. Their small treatment area enables them to be applied almost anywhere. LID BMPs attempt to capture stormwater runoff very close to its point of origin and restore the natural ecosystem and hydrologic regime to the region.

Vegetated swales are mainly a flow-through BMP type (little retention time) and are relatively shallow (0.5 ft). Porous pavement is modeled with a unit depth of 1 ft, and no operation and maintenance is taken into account in its performance capability over time. Bioretention basins are modeled with a layer of biologically-active media that assists in removal of pollutants and an underdrain with additional settling capacity. These shallow, small, local BMPs increase infiltration, percolation, and evapotranspiration considerably, such that they evaporate 6–18% and infiltrate 50–74% of inflowing water (values simulated in the model after BMP calibration). These LID BMPs use filtration and biological uptake to reduce pollutant and sediment loads in stormwater runoff.[71] Utilizing LID practices recreates the natural, pre-urban hydrology, which has multiple benefits including increased wildlife habitat, reduced stormwater peak flows and volumes downstream, and enhanced natural groundwater recharge.

BMP performance, or pollutant removal efficiency, was calibrated in the model by comparing influent and effluent concentrations with BMP data reported in the IBMPD. A 1st order decay pollutant removal factor was calibrated for each pollutant individually based on the corresponding influent/effluent data. The performance of each BMP type remained static over time, as if operation and maintenance practices were applied to maintain initial BMP removal efficiency. Future work will involve updating this calibration with more recent BMP data from semi-arid climates, and better simulating the decline in pollutant removal efficiency over time. We note that this calibration can likely be improved upon with more field data, though effluent pollutant concentrations are hard to measure so useful data is sparse and was not available at the time of this model setup. After LASAN completes its assessment of the efficacy of Proposition O BMPs for reducing pollutant concentrations, we can incorporate these results in the LA River phase of the project.

d. BMP Scenarios for TMDL Compliance

Compliance with TMDLs was tested by implementing varying suites of BMPs to capture and treat runoff from different land-use types and drainage areas. Scenarios were designed based on permit requirements and recommendations for ways to meet compliance. The scenarios were compared by days in compliance with wet and dry weather TMDLs for each metal, average annual pollutant load reduction for each metal, storm peak flow reduction, and potential groundwater recharge volumes.

The five BMP types were integrated into the SUSTAIN model using an aggregate BMP approach. This varies from the typical discrete BMP modeling framework in which each BMP is placed at a discrete location and runoff from a specific drainage area is treated and routed to the downstream channel or water body. The aggregate BMP approach is more efficient for modeling at larger, watershed scales because a large number of BMPs are needed to affect water quality at this scale and it computationally intensive to model each BMP individually.

One "aggregate BMP" represents multiple BMPs of each type that have the same dimensions and pollutant removal decay rates. The number of each type of BMP can be optimized (scenario

---

[71] Zhen, J., Shoemaker, L., Riverson, J., and Cheng, M.-S., *BMP Analysis System for Watershed-Based Stormwater Management* (2006). Journal of Environmental Science and Health Part A, 41, 1391–1403.

1, Table 4) or specified exactly to capture a pre-determined amount of runoff (scenarios 2-4, Table 5). Within each sub-basin, portions of runoff from each land use type are routed to each BMP type in the aggregate BMP, and then to the outlet. Other portions of runoff can be set to bypass all BMPs (no treatment) and are routed directly to the outlet.[72]

Five scenarios involving different BMP schemes were simulated in the model. They are described below in detail, and their shorthand notation which is used to refer to them throughout the report is shown in Table 5. A BMP optimization study was designed by Beck[73] for the watershed area upstream of the gauge at Sawtelle Blvd (gauged watershed area), and then the optimal pollutant removal target was applied to the full watershed for this report in Scenario 1. Additional BMP implementation scenarios were designed to test WQS compliance recommendations from the MS4 permit, explored in Scenarios 2 through 5. These scenarios are described in more detail in a Master's thesis by Katie Radavich.[74]

Table 4: BMP Optimization Study (upstream of the flow gauge) routing runoff from various percentages of watershed area to be captured by BMPs and various Cu reduction targets for optimization. These scenarios were tested for the gauged portion of the watershed only, then the optimal constraints (highlighted in gray) were applied to optimize the full watershed in Scenario 1 below.

Scenario	**Cu Reduction Target %**	**Total BMP Treatment Volume (ac-ft)**
Runoff from 33% WS Area to BMPs	30-40	3600
Runoff from 33% WS Area to BMPs	40-50	*
Runoff from 33% WS Area to BMPs	50-60	*
Runoff from 67% WS Area to BMPs	30-40	2050
Runoff from 67% WS Area to BMPs	40-50	2000
Runoff from 67% WS Area to BMPs	50-60	12300
Runoff from 90% WS Area to BMPs	30-40	**2000**
Runoff from 90% WS Area to BMPs	40-50	**2600**
Runoff from 90% WS Area to BMPs	50-60	**5000**

[72] Shoemaker, L., Riverson, J., Alvi, K., Zhen, J. X., Paul, S., and Rafi, T., *SUSTAIN - A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality. User's Manual,* (2009). Environmental Protection Agency, 1–202.

[73] Beck, Drew J., Evaluating Best Management Practice Scenarios in Ballona Creek Watershed Using EPA's SUSTAIN Model (2014), Colorado School of Mines, Master's Thesis, Chapter 4, pp. 61-80

[74] Radavich, Katie A., Assessing the Effect of Best Management Practices on Water Quality and Flow Regime in an Urban Watershed under Climate Change Disturbance (2015), Colorado School of Mines, Master's Thesis, Section 3.3, pp. 36-41

*These scenarios were run, but did not yield convergent pareto results because when routing runoff from only 33% of the watershed area to BMPs, 40 – 60% Cu reduction could not be achieved.

The BMP optimization study by Beck[75] applied SUSTAIN's built-in optimization algorithm, the Non-dominant Scattering Genetic Algorithm Version II (NSGA-II), to optimize the number of BMPs needed to meet a user-specified pollutant removal target at the lowest cost. Ranges of pollutant removal targets and drainage areas routed to BMPs were tested over the gauged area of the watershed. Table 4 shows the annual average pollutant removal targets (Cu as the limiting pollutant) of 30-40%, 40-50%, and 50-60% that were tested in scenarios that routed runoff from 33%, 67%, and 90% of the gauged watershed area through all BMP types. These multiple pareto solutions are compared together in Figure 8. The similar color schemes indicate that those scenarios are in the same family of drainage areas routed to BMPs: light gray, medium, and dark gray colors represent runoff from 33%, 67%, or 90% routed to BMPs respectively. The points' shape indicates the Cu removal target for that scenario; square, diamond, and circle represent 30-40%, 40-50%, and 50-60% Cu removal targets respectively. The optimization results were compared by the total BMP treatment volume and resulting cost and pollutant removal. Cost inputs and BMP parameters in the model have been more recently updated, so the costs and BMP treatment volumes in Figure 8 are only relative values. When comparing these scenarios on a relative basis, the conclusion was that the greatest pollutant removal benefit was achieved by BMPs intercepting and treating runoff from 90% of the watershed area when 60% Cu removal was targeted. The main take-away is when runoff from larger areas is routed to BMPs, greater pollutant removal was achieved for lower cost.[76]

[75] Beck, Drew J., Evaluating Best Management Practice Scenarios in Ballona Creek Watershed Using EPA's SUSTAIN Model (2014), Colorado School of Mines, Master's Thesis, Chapter 4, pp. 61-80

[76] Beck, Drew J., Evaluating Best Management Practice Scenarios in Ballona Creek Watershed Using EPA's SUSTAIN Model (2014), Colorado School of Mines, Master's Thesis, Chapter 4, pp. 71

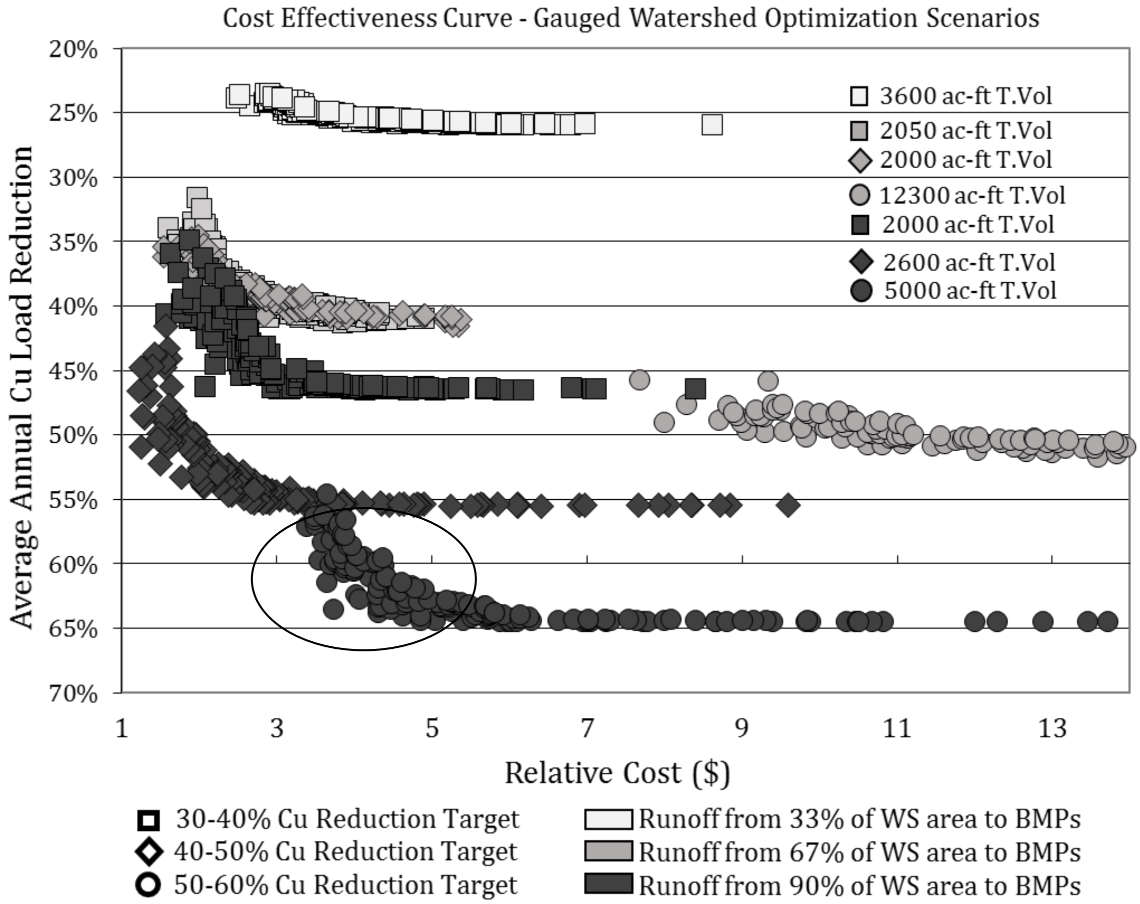


Figure 8: Cost-effectiveness pareto solutions for the BMP Optimization Study of Ballona Creek watershed above the flow gauge. Costs and BMP treatment volumes are relative values only as model inputs were updated after this initial study.

Scenario 1) applied the NSGA-II optimization algorithm to optimize the number of BMPs needed to achieve 60% pollutant reduction when runoff from 90% of the full watershed area was routed to all 5 BMP types. These optimal criteria were identified in the BMP Optimization Study from the gauged portion of the watershed (Table 4). They were applied to the full watershed with 60% load reduction targets for all three metals, Cu, Pb, and Zn in Scenario 1. This resulted in a pareto of optimized solutions from which the 100 best solutions were chosen. The number of BMPs in those 100 best solutions were averaged to determine the number of BMPs that would be implemented in the final modeled Scenario 1. Therefore, there is a set number of each BMP type in Scenario 1, similar to the other Scenarios 2 through 5 below.

Scenarios 2 through 5 were designed based on capture of the historical 85th percentile storm event (approximated by the ¾" precipitation event[77] in the MS4 permit). The number of BMPs implemented in each scenario was determined by the runoff volume that is generated during a ¾" precipitation storm event over the specified land-use categories in each scenario (Table 6). The land-use categories and BMP types vary between each scenario. The current condition in the watershed is taken to be the baseline and is compared to the resulting pollutant load at the outlet after BMP implementation in each scenario.

Scenario 2) routes runoff from all urban land cover (85% of the total watershed area) to infiltration trenches, regional BMPs in which infiltration into the subsurface dominates.

Scenario 3) routes runoff from all urban land cover to dry ponds, also regional BMPs which capture, treat, and then release the majority of water in the treatment volume ("treat and release" BMP type).

Scenarios 4 and 5 implement three distributed LID BMP types to capture runoff (vegetated swales, bioretention basins, and porous pavement, Table 3). Similar to scenarios two and three, the number of BMPs in scenarios four and five is determined by the volume of ¾" storm runoff over the specified land-use categories (Table 6).

Scenario 4) implements LID BMPs to capture runoff from private land-use categories including single family residential, multi-family residential, commercial, and industrial (~77% of the total watershed area) (Table 6).

Scenario 5) implements LID BMPs to capture runoff from the public property land-use categories of education, parks and recreation, transportation, vacant, and agriculture. These land cover types comprise 23% of the total watershed area and include all remaining land-use categories not analyzed in Scenario 4 (Table 6). This means that any runoff from private property is not routed to these BMPs for treatment.

[77] LA County DPW, *Analysis of 85th Percentile 24-hour Rainfall Depth Analysis Within the County of Los Angeles* (2004) p.1

Table 5: The five BMP implementation scenarios investigated for TMDL compliance with abbreviated notation (shown in later tables)

	Full Scenario Description	Abbreviated Notation
1)	NSGA-II Optimization for cost and Cu Removal using all 5 BMP types	1) BMP Optimization
2)	¾" Precipitation (Ppt) Storm Capture of Runoff from Urban Land-uses using Regional Infiltration BMPs (Infiltration Trenches)	2) Urban Runoff Infiltrated
3)	¾" Precipitation (Ppt) Storm Capture of Runoff from Urban Land-uses using Regional Treat and Release BMPs (Dry Ponds)	3) Urban Runoff Treat and Release
4)	¾" Precipitation (Ppt) Storm Capture of Runoff from Private Properties using all distributed BMP types	4) Private Property Runoff to LID
5)	¾" Precipitation (Ppt) Storm Capture of Runoff from Public Right of Ways (ROW) using all distributed BMP types	5) Public Property Runoff to LID

Table 6: Explanation of the land-use types that contribute runoff to BMPs in each scenario

Scenario	**Land-uses contributing Runoff to BMPs**	**Runoff from % of Watershed Area to BMPs**
1) BMP Optimization	All	90 %
2) ¾" Ppt Urban Runoff Infiltrated	SFR, MFR, COMM, IND, EDU, PARKS, TRANS, AG (VAC excluded)	85 %
3) ¾" Ppt Urban Runoff Treat and Release	SFR, MFR, COMM, IND, EDU, PARKS, TRANS, AG (VAC excluded)	85 %
4) LID ¾" Ppt Private Land	SFR, MFR, COMM, IND	77 %
5) LID ¾" Ppt Public ROW	EDU, PARKS, TRANS, VAC, AG	23 %

Table 7: Land-use explanations and actual area in the Ballona Creek watershed (BWS) of each land type

Abbreviation	**Land-use Category**	**BWS area (acres)**
SFR	Single Family Residential	30260
MFR	Multi-Family Residential	17550
COMM	Commercial	11440
VAC	Vacant/OS	10730
IND	Industrial	3200
PARKS	Parks and Recreation	2470
ED	Education	2400
TRANS	Transportation	1680
Other	Other/water	1030
AG	Agriculture	40
	Total Ballona Watershed Area	***80800 acres***

Table 7 describes relevant land-use category abbreviations used in Table 6 and also shows the total area of each category in the watershed. General comparisons can be made between the available land and the amount of land needed to implement each BMP scenario. The implementation of distributed BMP types on private property in scenario 4 requires 2,770 acres. Private property types including SFR, MFR, and COMM all have more than enough area on which these BMPs could be implemented (Table 7). However, the available area on public property types including EDU, TRANS, and PARKS is smaller and might not be sufficient to support 2,770 acres of LID BMPs needed to capture the 85^{th} percentile storm runoff volume from private properties.

Regional BMP scenarios (2 and 3) require 500 acres, and would likely only be implemented on vacant or open space that is not protected area, or in existing parks. The vacant and parks categories include protected and non-protected land for a total of 13,200 acres, and the protected area within that is 11,300 acres. This leaves roughly 2,000 non-protected acres to potentially implement large regional BMPs. This may be sufficient area, but logistically this land is not ideal because it is largely at the top of the watershed. The most polluted stormwater runoff requires capture and treatment near the bottom of the watershed below more intense urban development. For this reason, it will be difficult to fully achieve compliance by implementing regional BMPs alone. A combination approach that emphasizes distributed BMPs is likely most practical to achieve water quality compliance.

Each scenario includes implementation of a set suite of BMPs into the model. The model simulates the runoff time-series which is then routed into the BMPs. Table 8 shows the various types and total number of BMPs implemented in each scenario. The total footprint area and total volume of water treated by all BMPs in each scenario was calculated. Treatment volume can be directly compared between scenarios, while the treatment area and total number of BMPs shows the variability in area needed to implement distributed vs. regional BMP types. Distributed types are much smaller and shallower, hence the area and number of BMPs needed is much greater than that needed for the regional BMPs. Scenario 4 has lower total treatment volume than scenarios 2 and 3, but much larger treatment area. Scenario 1 needs greater area and number of BMPs than scenarios 2 and 3 because scenario 1 includes both distributed and regional BMPs. These metrics are useful to compare treatment capacity between scenarios as well as to assess the area available to implement each scenario in the actual watershed.

Table 8 shows the details for each scenario including % of watershed area routed to BMP treatment, type and number of BMPs, summed footprint area for all BMPs in the scenario, and summed stormwater capacity for all BMPs in the scenario.

Table 8: BMP types, total numbers, and treatment capacity per scenario.
*Median depth of distributed BMPs is less than 1 ft (larger footprint area than volume).

Scenarios	% of Water-shed Area to BMPs	BMP Type used	Treatment Volume per BMP (cf)	Number of BMP units used	Total Treatment Volume Needed (ac-ft)	Total Treat ment Area (acres)
1) BMP Optimization	90 %	All types	1250-20,250	21,100	1102	872
2) Urban Runoff Infiltrated	85 %	Inf Trench	20,250	5400	2510	500
3) Urban Runoff Treat and Release	85 %	Dry Pond	3400	32,400	2510	500
4) Private Property Runoff to LID	77 %	Veg Swale, BioRet, PP	1250-1860	64,570	2270	2770*
5) Public Property Runoff to LID	23 %	Veg Swale, BioRet, PP	1250-1860	7280	255	312*

e. Cost Background

The effectiveness of the developed BMP scenarios cannot be fully assessed without estimation of the associated cost, which help provide guidance to the City when deciding which stormwater control measures to implement. BMP construction costs per unit volume of water treated for each BMP type were estimated from a number of available sources (Table 9). Operation and maintenance costs were not taken into account in these estimations. Unit cost values were adjusted to 2014 dollars using the Bureau of Labor Statistics Inflation Calculation Method.[78] The developed costs were applied to each BMP implementation scenario to generate a total construction cost per scenario (Figure 10). BMP resources with adequate cost information included project bids from the City, County, consulting firms, transportation projects, and CA Stormwater Quality Association (CASQA) BMP handbooks.[79]

Construction costs are easier to quantify because they are measured in dollars expended, much like the costs of any infrastructure project such as sewage treatment plants or freeway interchanges. Benefits are more subtle and are indirect. In this section we only show costs, while potential benefits will be discussed in later reports. It is important to keep in mind that dollar expenditures result in important benefits including pollution reduction that can result in human and environmental health improvements, green jobs, potential additional water resource availa-

[78] Bureau of Labor Statistics, *available at* http://www.bls.gov/cpi/cpifact8.htm

[79] CASQA, *California Stormwater BMP Handbook* (2003). Technical Report, California Stormwater Quality Association.

bility, greenhouse gas emissions reductions, and potential increase in habitat for fauna and flora. Along with these benefits, streets programs integrated with distributed BMPs improve quality of life by providing access to walking and biking areas and also increasing property values, therefore achieving multiple benefits.

A range of sources were found with BMP costs reported in various formats. However, many of these BMP costs were considered incomplete for this study because not enough information about the complete construction costs and the volume of water treated in the final BMP system were reported. Although unit process costs were available in many sources (for example, cost per volume to excavate soil material), not enough information about the completed BMP system was available to use these line item costs to determine a cost per volume of water treated. This resulted in small sample sizes (N) (Table 9) used to determine the final cost values. Our sample sizes were low also because we purposely focused on projects mainly in Southern California and data was not readily available. Expanding the survey area to encompass BMPs in all semi-arid regions in the United States could improve our sample size, though this is outside the scope of this study. Also, in SUSTAIN, line item costs can be entered for activities that contribute to construction, planning, or O&M. This can be a valuable tool for modeling smaller scale projects in SUSTAIN, but is not feasible at the watershed scale in this analysis.

Table 9: BMP Construction Costs per unit treatment volume of water (or area for porous pavement)

BMP Type	N	25% Quartile	Median Cost	75% Quartile	Unit
Infiltration Trench	14	$ 3.33	$ 6.03	$ 16.63	$/cf
Dry Pond	5	$ 4.40	$ 5.88	$ 15.71	$/cf
Vegetated Swale	4	$ 5.37	$ 10.07	$ 18.53	$/cf
BioRetention Basin	5	$ 12.30	$ 14.60	$ 16.24	$/cf
Porous Pavement	8	$ 10.57	$ 15.69	$ 16.17	$/sf

f. Modeling Results

The BMP scenarios were updated with the most current cost information available. Performance metrics of cost, average annual pollutant load reduction percentages, TMDL compliance for wet weather and dry weather, storm peak reduction, and potential groundwater recharge for each scenario are reported in Figures 10 – 18 and Table 10.

Scenario 1 is evaluated utilizing the SUSTAIN optimization NSGA-II algorithm to find the best solutions. This produces multiple different combinations, or suites, of BMPs (2000 in our model) and the associated cost and pollutant removal efficiency for each solution is plotted as a cost-effectiveness curve, also called a Pareto Efficiency Curve (Figure 9). The best solutions are found where cost is minimized and load reduction is maximized, shown by the solid circles in Figure 9. Any solution in this region will achieve similar pollutant reduction for a similar cost.

The number of BMPs in the top 100 best solutions in the Pareto Efficiency Curve were averaged to determine the number of units of each BMP type that comprise the optimal solution. These BMPs were reinserted back into the model, and a simulation was run that routes stormwater runoff through those BMPs. The resulting hydrograph and pollutograph have reduced flow and pollutant load, indicative of the amount of water and pollutant removed by the BMPs. These flow and pollutant time-series' determined the performance metrics used for comparison with other scenarios: daily TMDL compliance, average annual flow and pollutant reduction, peak flow reduction, and recharge potential. Wet weather daily Cu loads and TMDL limits from this time-series for Scenario 1 is shown in Figure 11.

All three metals were optimized separately in Scenario 1. When the same pollutant load reduction target range is applied, the best solutions for each metal were very similar in load reduction, cost, treatment volume, and number of BMPs in each case. However, copper and zinc both have stricter water quality targets compared to lead, and in the baseline scenario (no BMPs), copper showed the most TMDL exceedances. Therefore, copper was chosen as the representative metal for all scenarios.

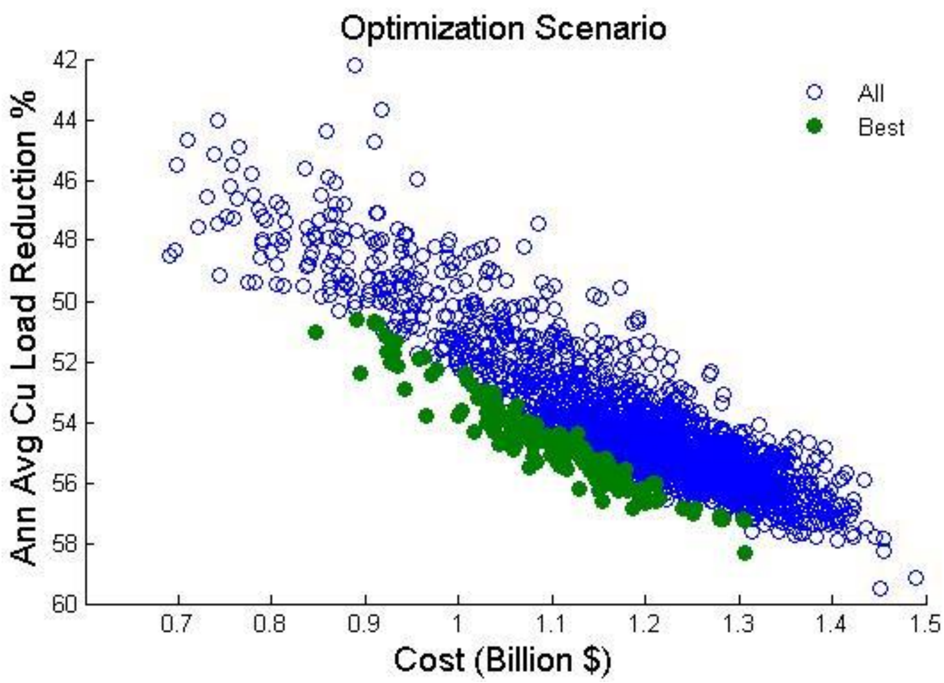


Figure 9: Optimization Cost-Benefit solutions for 50%-60% annual average Cu load removal target range in the full Ballona Creek watershed. The best 100 solutions are shown in green solid circles. The number of BMPs in those 100 best solutions were averaged to determine the number of BMPs that were implemented in the final modeled Scenario 1.

In scenarios 2–5 the number of BMPs were pre-determined based on the volume of runoff from the ¾" storm event. The exact number of BMPs was implemented in the model using the aggregate BMP framework, and a simulation was run to route stormwater through the respective BMPs. Daily TMDL compliance and other comparison performance metrics were determined from the resulting hydrograph and pollutograph.

Median and upper and lower quartile costs were determined and applied to the total BMP treatment volume in each scenario and are compared in Figure 10. The error bars show the lower and upper quartiles (25% and 75%) for costs in each scenario.

The lowest cost approach is scenario 5. However, this solution has the lowest percent pollutant removal for all metals (8-10%) because it only captures runoff from 23% of the watershed area (Table 6). For these reasons, scenario 5 is removed from the following discussions for purposes of comparison.

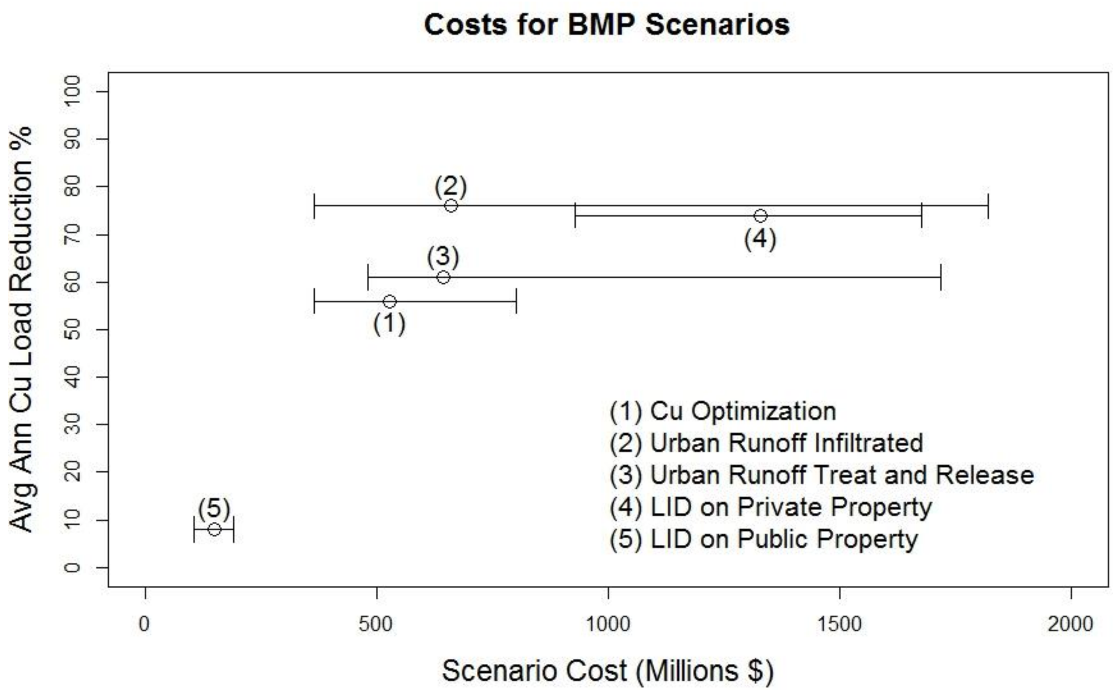


Figure 10: Percent Cu Reduction vs. Construction Costs per BMP implementation scenario. The circles represent the median cost and the bars indicate the lower and upper quartile cost values for each scenario.

Costs are simplified in SUSTAIN to a value per unit volume of water treated, so the total scenario cost is very sensitive to the individual BMPs in that scenario. For example, scenario 2 and 3 (infiltration trenches only / dry ponds only) are the least expensive because the cost per unit volume of water treated is the lowest for those two BMP types. They also have a larger cost range because the cost data for those BMP projects varied more than the other BMP types (Table 9).

Scenario 1 is also sensitive to the cost per unit volume treated. The optimization algorithm adds more regional BMPs to the optimal solution because they are less expensive. However, the optimization requires a minimum number of each type of BMP, so distributed BMPs are emphasized almost as much as regional BMPs. This constraint reduces the overall performance relative to scenarios that include only regional BMPs due to lower treatment capacity of distributed BMPs.

Scenario 2 (regional infiltration trenches) has the lowest cost and best pollutant removal, followed closely by scenario 4 (distributed LID BMPs). This illustrates the benefit of infiltration-dominated BMP types. Larger regional BMPs can infiltrate more water and consequently remove more pollutant load. The infiltration trenches in the model are 5 feet deep and have a large instantaneous capacity during a storm event. The smaller distributed BMPs (scenario 4) with average depth less than 1 foot fill up rapidly in a storm event, but the large surface area for treatment allows the volume of water to spread out, diffusing the storm intensity and allowing more infiltration. The larger surface area encourages higher evapotranspiration rates and plant uptake after the storm has passed.

Figures 11 through 15 depict the pre-BMP and post-BMP wet weather daily Cu load (bars) and corresponding daily TMDL (lines) in pounds of Cu per day for all wet weather days over a 5 water year period for each scenario. The wet weather days (x-axis) are sorted by their corresponding daily storm volume, so larger storms are associated with higher Cu loads. An exceedance is when the pre- (post-) Cu load bar is higher than the pre- (post-) TMDL line on each wet weather day. When the bar is lower than the line, the Cu loads are in compliance for that wet weather day. These figures mainly illustrate how implementing different BMP types in each scenario results in different wet weather TMDL limits due to the amount of water removed in each case. BMPs that infiltrate more water reduce the volume of water at the outlet of the channel, decreasing the TMDL limit. These figures also show different compliance behaviors during large and small storms.

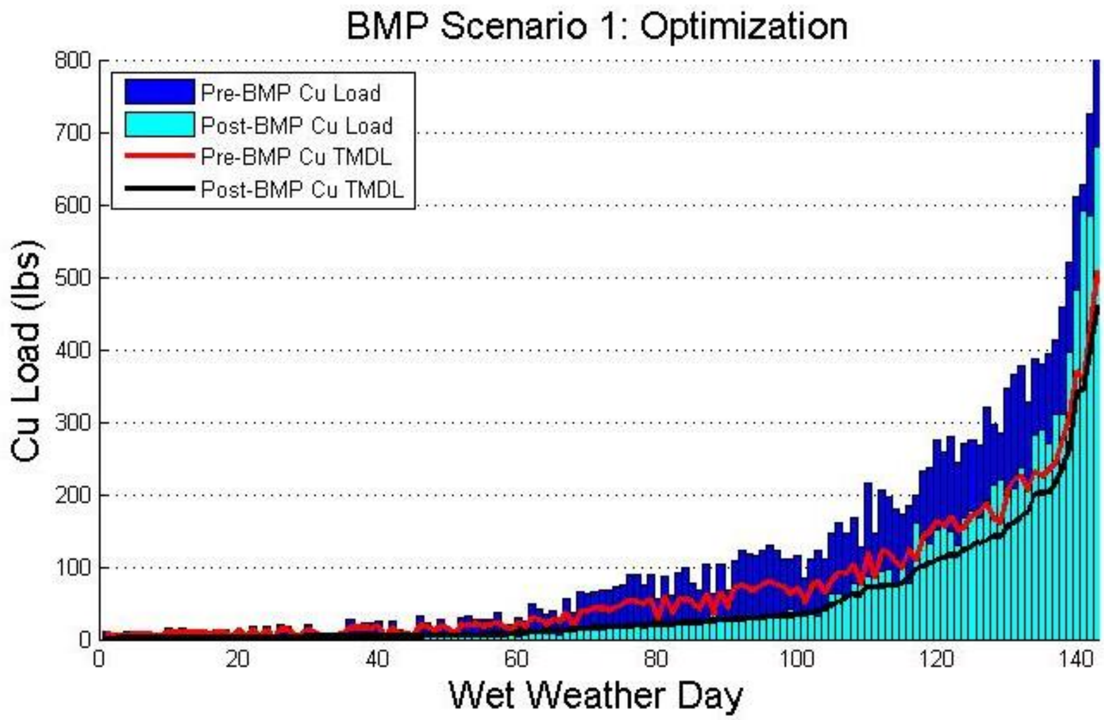


Figure 11a) Scenario 1: BMP Optimization of costs and Cu load removal, showing Cu load and TMDL limit (lbs Cu per day) for all wet weather days.

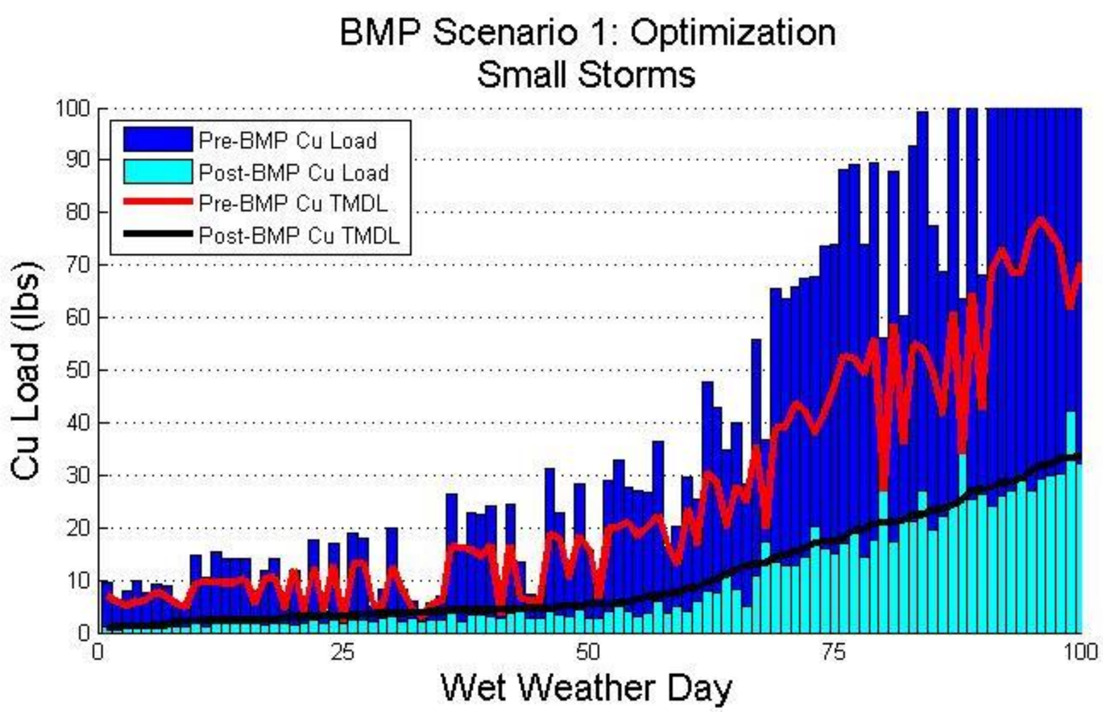


Figure 11b) Scenario 1 (Figure 11a) zoomed in to small storms.

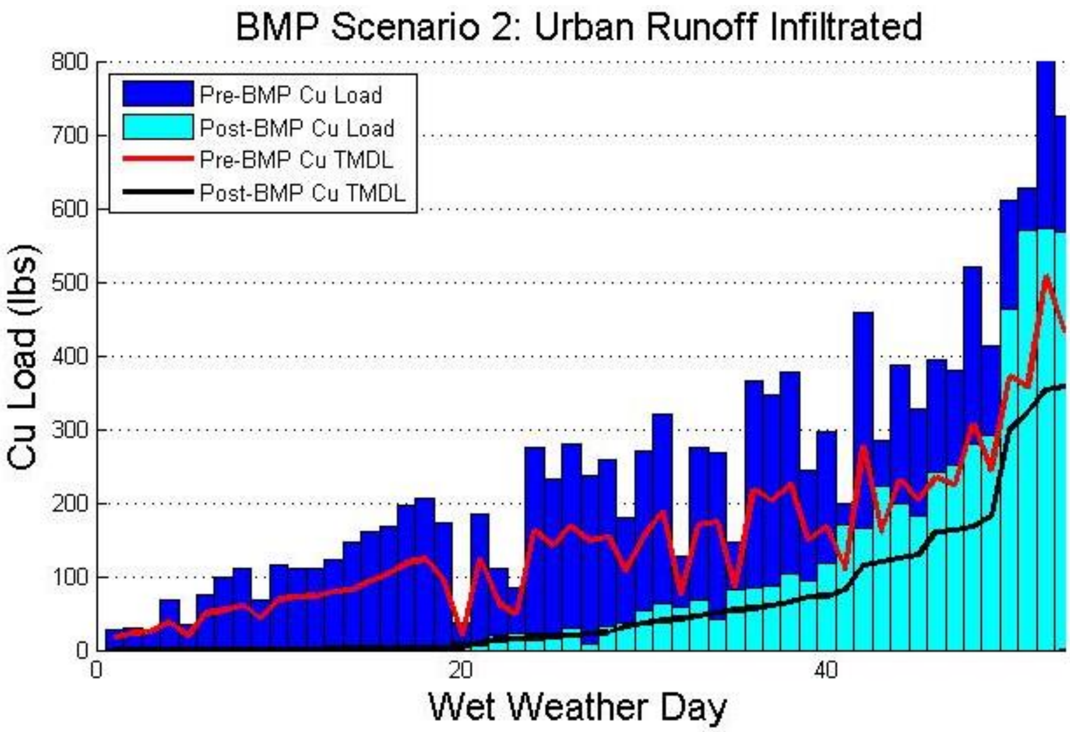


Figure 12a) Scenario 2: Infiltration BMPs capturing urban runoff, showing Cu load and TMDL limit (lbs Cu per day) for all wet weather days.

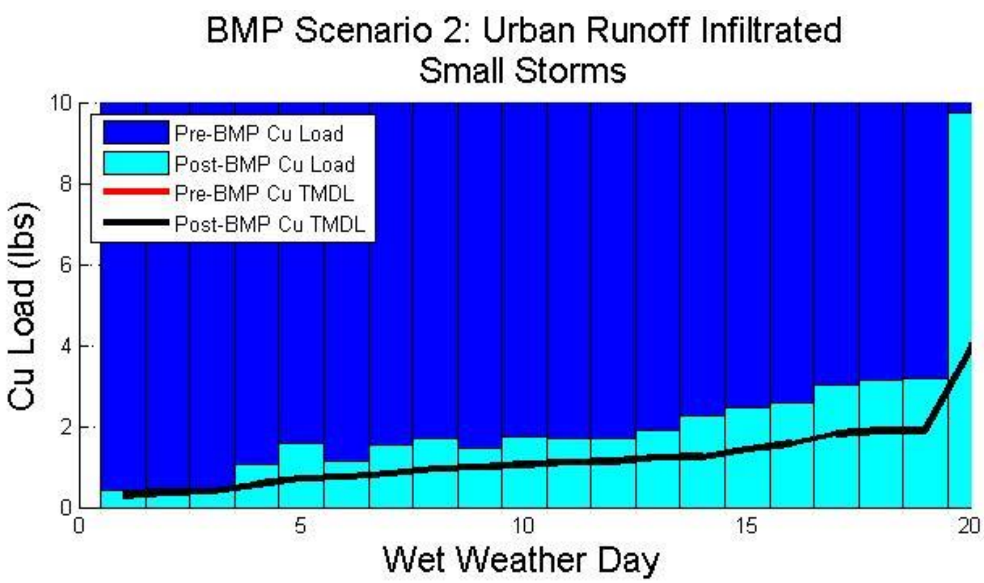


Figure 12b) Scenario 2 (Figure 12a) zoomed in to small storms.

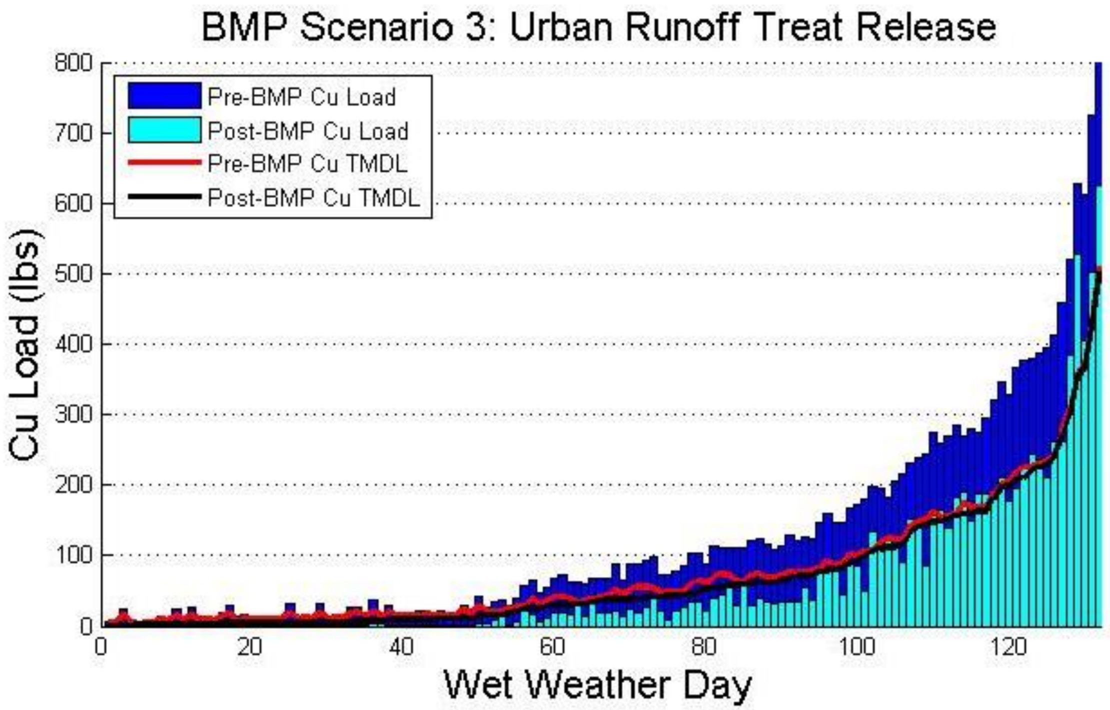


Figure 13a) Scenario 3: Treat and Release-type BMPs (Dry Ponds) capturing urban runoff, showing Cu load and TMDL limit (lbs Cu per day) for all wet weather days.

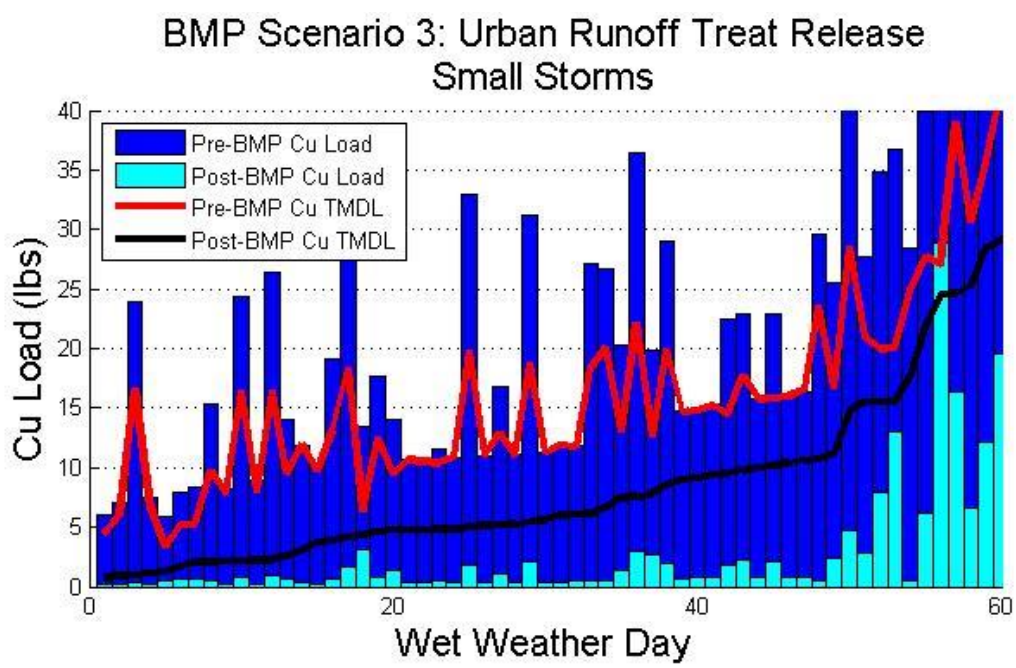


Figure 13b) Scenario 3 (Figure 13a) zoomed in to small storms.

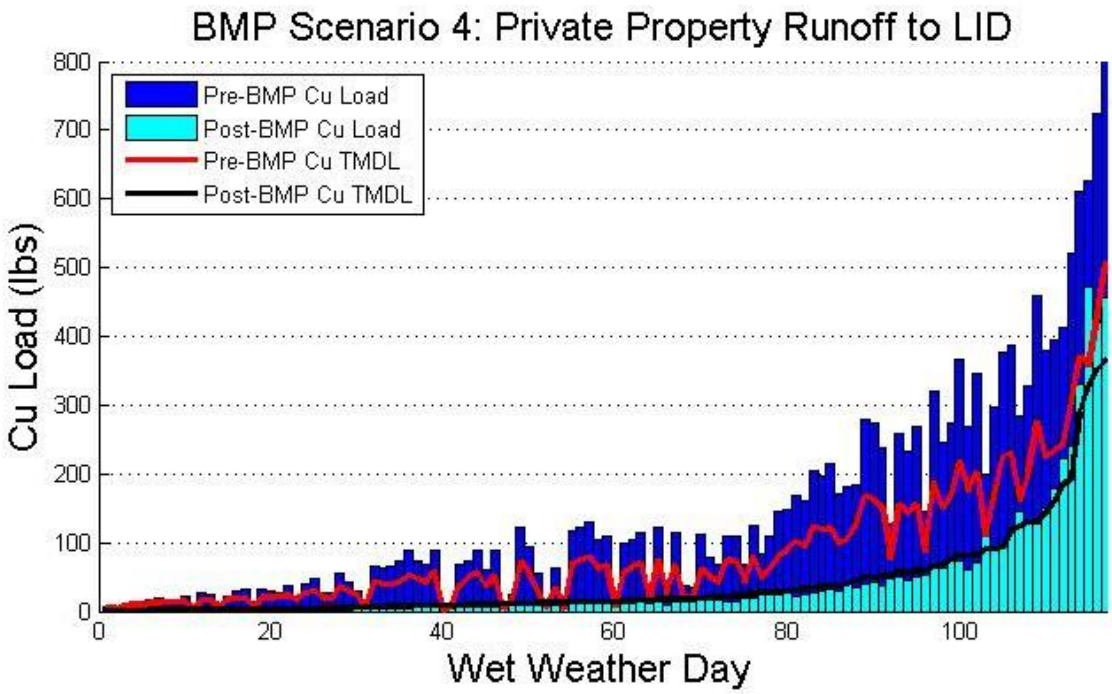


Figure 14a) Scenario 4: LID Retrofit using distributed BMP types (vegetated swale, bioretention, porous pavement) capturing runoff from private properties, showing Cu load and TMDL limit (lbs Cu per day) for all wet weather days.

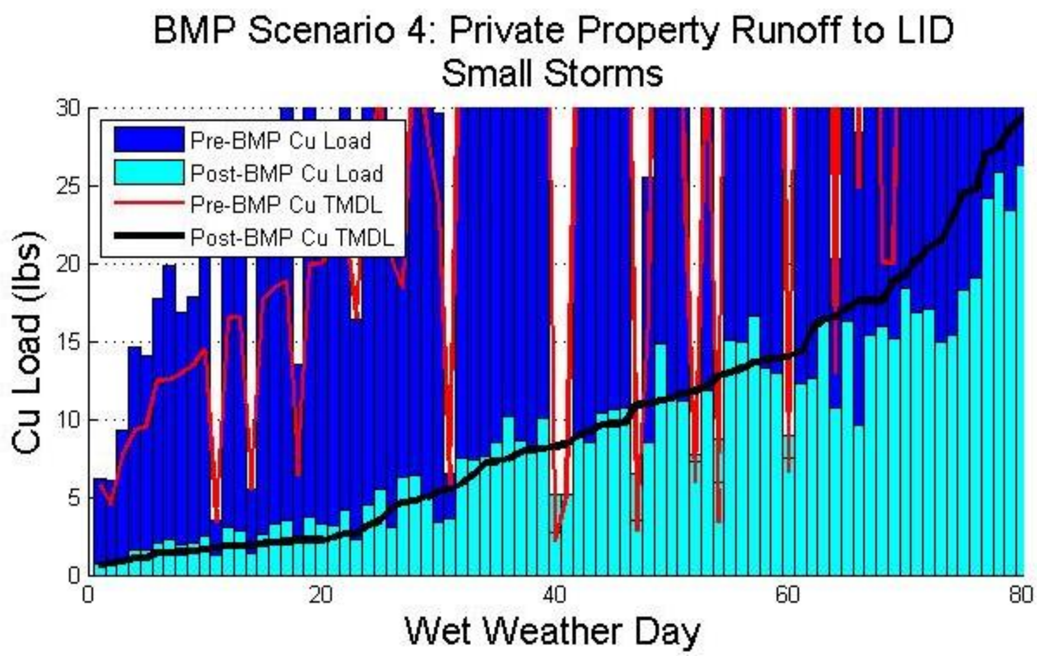


Figure 14b) Scenario 4 (Figure 14a) zoomed in to small storms.

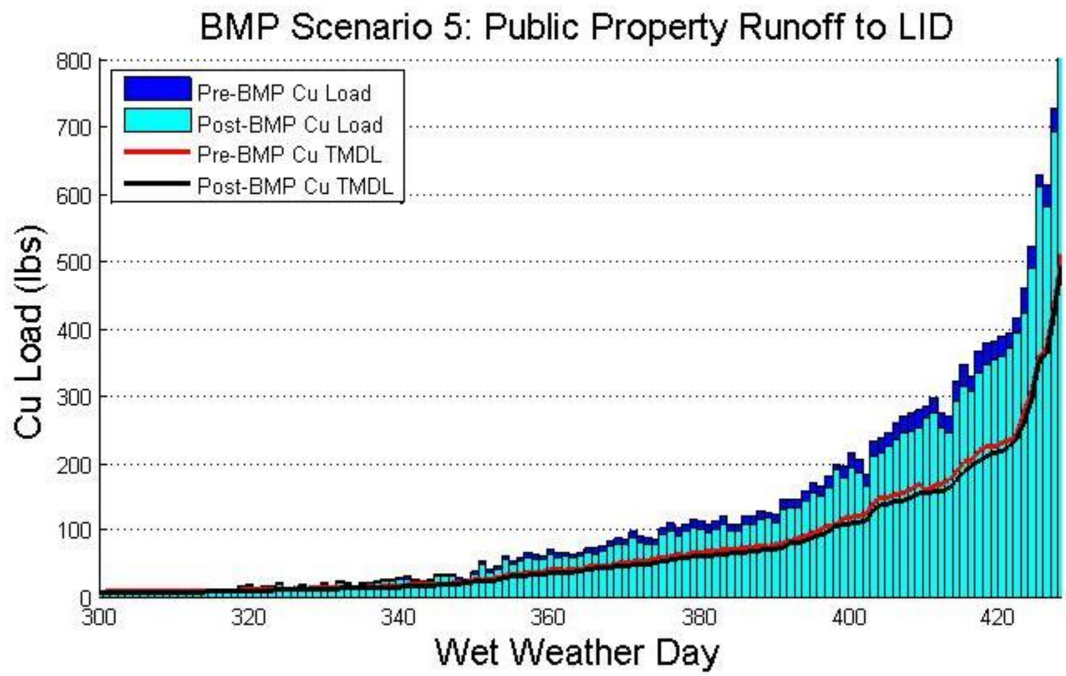


Figure 15) Scenario 5: LID retrofit of land in the public right of way, showing Cu load and TMDL limit (lbs Cu per day) for all wet weather days. The area treated is very small and so the post-BMP load and TMDL are not much different from the pre-BMP load and TMDL.

In the BMP optimization scenario 1 (Figure 11a and 11b) and scenario 3 with dry ponds (Figure 13a and 13b), the majority of TMDL exceedances occur during large storms. Scenario 2 with infiltration trenches (Figure 12a and 12b) and scenario 4 with distributed LID BMPs (Figure 14a and 14b) have many exceedances across the range of storm sizes. Both scenarios 2 and 4 emphasize treatment by infiltration. Scenario 3 with dry ponds demonstrates the best compliance over the range of storm sizes, with fewest exceedances for wet weather days. However, the daily load more closely approaches the TMDL in larger storms in scenario 3, meaning that those days are close to non-compliance. In general, larger storms are less compliant in all scenarios. Once the BMP capacity is reached in larger storms, additional pollutant removal is minimal.

Scenarios 1, 2, and 4 (more infiltration-type BMPs) show less compliance across the range of storm sizes compared to scenario 3 (treat and release BMPs), even though they achieve greater average annual load reduction (Figure 16). This points out an unintended consequence of instituting a concentration-based compliance limit to better protect aquatic life. If BMPs infiltrate and recharge more water, the TMDL remains just as strict, resulting in minimal reductions in WQS exceedances for those scenarios. The resulting metal load in the channel is similar at comparable storm sizes, but the smaller amount of water in the channel affects compliance. In effect, if the same amount of Cu load is removed by infiltration as is removed by treat and release, the infiltration scenario could still be out of compliance relatively frequently. This maintains the CTR requirement for protecting aquatic life but disincentivizes infiltration for compliance goals. This also means that utilizing treat and release BMPs will not enhance local water availability.

Figure 15 (scenario 5) illustrates that capturing runoff from the small area of public property types is not enough to appreciably decrease pollutant loads. This is also evident in the TMDL exceedances of scenario 5 in Table 10 below. The exceedances in scenario 5 are not very different from the baseline scenario. For this reason, scenario 5 is not rigorously compared with scenarios 1-4 in the following conclusions.

Table 10 outlines the TMDL exceedances per year as calculated from the daily model outputs over the 2004-2008 WY model time period. Wet and dry weather TMDL exceedances are shown for Cu, Pb, and Zn. Implementing the BMP scenarios also changes the flow regime, illustrated by the different number of wet weather days and dry weather days in each scenario (WW days plus DW days in each scenario sum to 365). These values change if the BMP scenario takes more water out of the system, for example scenario 2 with only 11 WW days per year on average compared to 106 WW days in the baseline scenario with no BMPs.

Table 10: TMDL Exceedances (Exc) per year and total days per year in the Wet Weather and Dry Weather flow regimes

	WET Weather			**DRY Weather**			**WET**	**DRY**
Scenario	Cu Exc per year	Pb Exc per year	Zn Exc per year	Cu Exc per year	Pb Exc per year	Zn Exc per year	Days per year	Days per year
Baseline – No BMPs	**105**	**0**	**19**	**86**	**0**	**0**	**106**	**259**
1) BMP Optimization	10	0	1	0	0	0	29	336
2) Urban Runoff Infiltrated	10	0	8	0	0	0	11	354
3) Urban Runoff Treat and Release	6	0	0	0	0	0	26	339
4) Private Property Runoff to LID	11	0	2	0	0	0	25	340
5) Public ROW Runoff to LID	84	0	18	73	0	0	87	278

Dry weather TMDL exceedances are generally eliminated in all scenarios that treat a majority of the runoff (scenarios 1-4). In addition, the TMDL for Pb is high enough that the baseline case does not have any exceedances during dry or wet weather. The only exceedances of concern are Cu and Zn during wet weather conditions (max daily flow > 64 cfs) and Cu during dry weather. The new regulation (SB 346) requiring Cu to be eliminated from new brake pads in cars by 2025[80] will considerably reduce Cu in stormwater runoff, and could reduce the Cu TMDL exceedances to a negligible amount. In addition, a Basin Plan Amendment to incorporate several Cu WERs for the LA River, which range from 1.3 to 9.7, was approved by the LARWQCB in April 2015. If similar Cu WERs are developed for reaches or tributaries in the Ballona Creek Watershed in the future, Zn would become the main metal constituent of concern going forward with TMDL compliance. A zinc WER analysis also may occur in the future.

Wet weather exceedances are similar in the distributed BMP scenario (4), the infiltration trench scenario (2), and the optimization scenario (1). Scenarios 1 and 4 feature distributed BMP types that allow more evaporation and high infiltration which reduces the amount of water that reaches the channel, thereby having negligible impact on pollutant concentrations in the remaining outflow volume. The end result is less of a water quality standards compliance benefit from the infiltration BMP approach.

Figure 16 shows the metal reduction achieved in each scenario. Scenario 2 has the highest percent reduction followed by scenario 4 (the baseline metal load is the same for all scenarios). The BMPs in both of these scenarios emphasize infiltration which increases the pollutant removal capability.

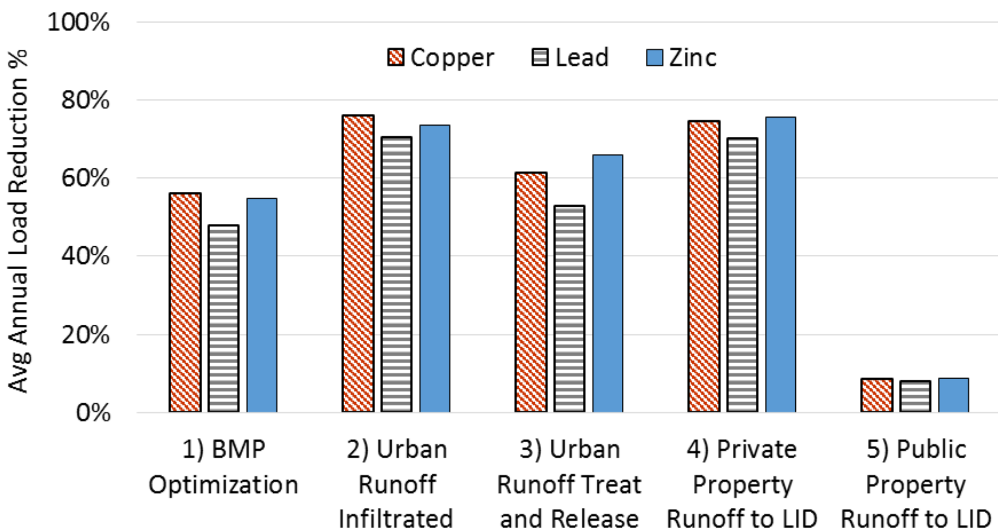


Figure 16: Average Annual Metal Load Reduction for each scenario

80 http://www.leginfo.ca.gov/pub/09-10/bill/sen/sb_0301-0350/sb_346_cfa_20090419_192501_sen_comm.html p.2 SB 346 text

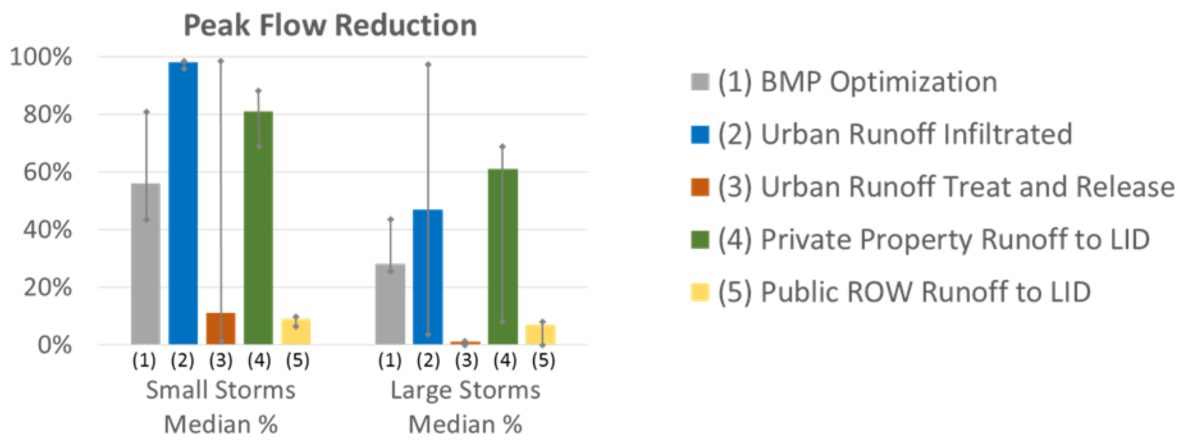


Figure 17: Median Flood Peak Reduction (%) achieved in each scenario. Small and large storm events were separated by the ¾" precipitation event, for storms up to 2" of rain. The vertical bars represent the upper and lower bounds (max and min) of the peak flow reduction percentage in each scenario.

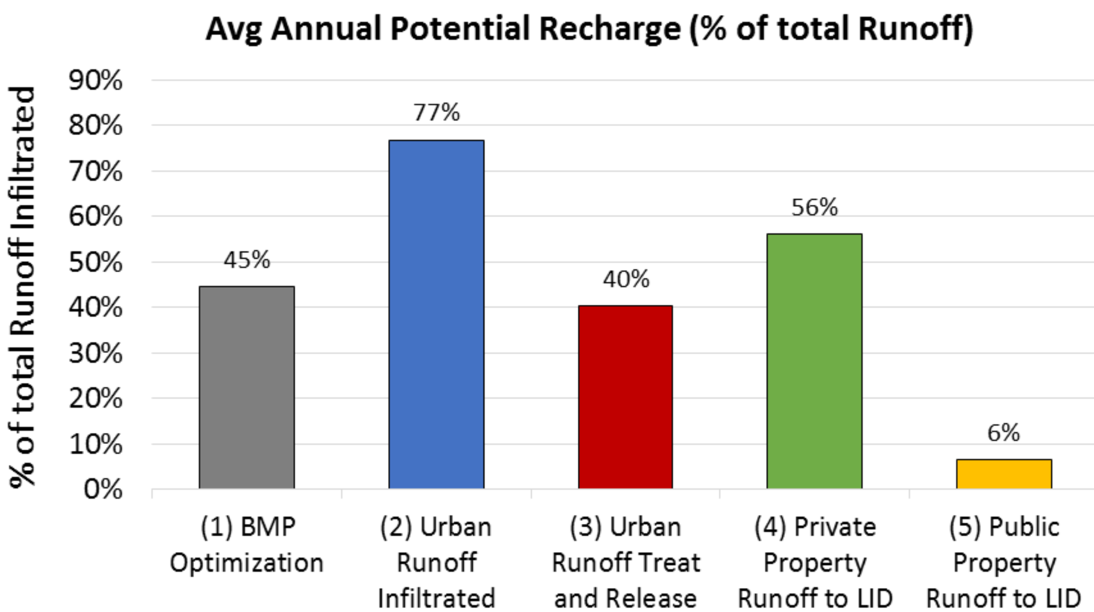


Figure 18: Average annual potential recharge as a percent of the total annual runoff volume in each scenario. For 15 inches of rain per year, this equates to a range of 20,000 to 60,000 AFY in scenarios 1 – 4.

Flood peak reductions in Figure 17 are determined by comparing the individual storm peaks in the modeled baseline to those in the BMP implementation scenario model output. Potential recharge values in Figure 18 are taken from the water budget of inflow minus outflow and evapotranspiration. Scenarios 2 and 4 also show the highest peak flow reductions (Figure 17) and potential groundwater recharge (Figure 18). Scenario 2 shows potential recharge of 77% of the total runoff (60,000 AFY with average annual 15 inches of precipitation) which is the highest water volume of all the BMP scenarios. This is due to the high infiltrative and storage capacity of the regional infiltration BMPs. This scenario also results in a peak flow reduction of 47% for large storms up to 2” of rain. Scenario 4 achieves potential recharge of 56% of the total runoff (43,000 AFY with average annual 15 inches of precipitation) and peak flow reductions of 61% for large storms up to 2” of rain. This is due to the distributed LID BMPs that infiltrate a large percentage of the runoff and encourage high evapotranspiration due to vegetation and large surface areas.

The “treat and release” BMP systems (dry ponds) infiltrate much less water, and hence, do not influence recharge, peak flow reduction, or metal load reduction capabilities as much as the BMPs with more infiltration capacity. They only capture 40% of the total runoff for potential recharge (as little as 20,000 acre-feet per year (AFY) with an annual average of 15 inches of precipitation). However, the wet weather TMDL is a load value based on a concentration and calculated with the total flow volume each day. This means that if a larger volume of treated water stays in or is returned to the channel at the compliance point, the TMDL WLA will be higher and easier to meet compliance requirements. This explains why BMPs that “treat” by retaining water allowing pollutants to settle, and “release” water back to the channel show better water quality compliance. This is best highlighted with smaller storms in which the BMP capacity can capture the majority of the storm volume. During larger storms, the dry pond BMP capacity is not large enough to capture the full runoff volume, and their effective storage volume is less because they do not infiltrate as much as the infiltration trench BMPs. This allows more polluted stormwater to overflow or bypass the dry pond BMPs as untreated water.

From this analysis, with an historical average of 15 inches of rain, the estimated potential recharge would be a range of 20,000 AFY to 60,000 AFY for scenarios 1 – 4. More in-depth modeling is required to simulate the surface water to groundwater interactions at the interface between the BMPs and the subsurface in order to determine how much of that water makes it through deep percolation into each of the four groundwater aquifers underlying the watershed. This subsurface behavior would then need to be compared to the location of groundwater aquifers available to accept the infiltrate, which could influence the management decisions of BMP type and placement. This research was outside the scope of this model and study at this time.

Higher evaporation and infiltration rates may also explain why the distributed scenario shows the greatest peak flow reduction capability, but infiltrates less volume of water compared to the regional infiltration trenches (scenario 2). The distributed systems infiltrate the majority of water during the rising limb of the storm before the peak, therefore reducing the peak flow by the greatest amount. However, these smaller BMPs are quickly filled to capacity and cannot infiltrate any more stormwater runoff after the first part of the storm. Regional BMPs, on the other hand, can continue to capture and infiltrate a larger volume of water because of their large storage capacity.

D. Additional Routes to Compliance

a. Water Effect Ratio Analysis

Even with conservative metal Event Mean Concentrations applied to the land-uses in the model, metals in stormwater runoff do not exceed the TMDL limits by large margins, unlike other impairing pollutants like Fecal Indicator Bacteria (FIB). Histograms with the number of exceedances and by what percent the TMDL is exceeded in each wet weather day are shown in Figures 19 and 20, depicted for scenario 4 as an example to show the relative exceedances pre- and post-BMP. A negative percent means that the metal load is in compliance with the TMDL for that wet weather day (non-exceedance). These figures show that the Cu and Zn TMDLs are exceeded by three times the TMDL limit or less (150% max exceedance for Cu, 110% max exceedance for Zn).

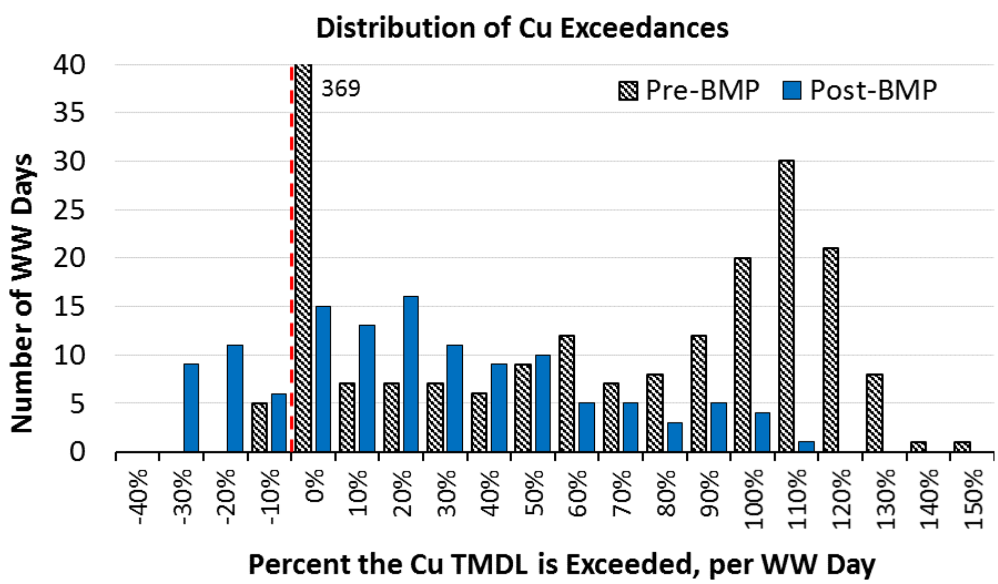


Figure 19: Distribution of Cu TMDL exceedances for Scenario 4: Urban runoff to private property LID retrofits for all WW days in the 5 year study period. The dashed line is 0% exceedance. Negative x values are non-exceedances.

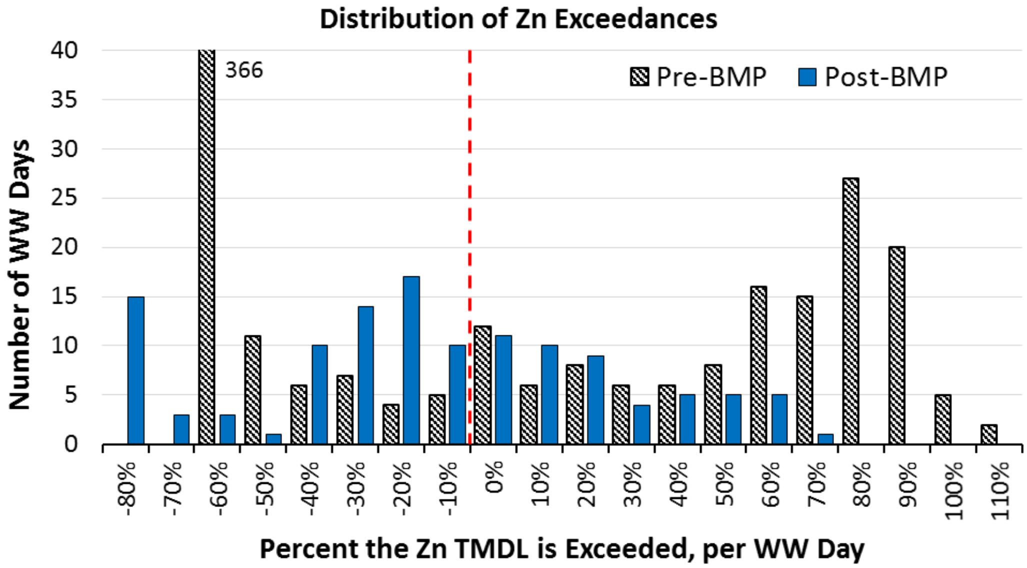


Figure 20: Distribution of Zn TMDL exceedances for Scenario 4: Urban runoff to private property LID retrofits for all WW days in the 5 year study period. The dashed line is 0% exceedance. Negative x values are non-exceedances.

A representative WER was applied to copper and each scenario was re-evaluated with the WER applied to the TMDL limits. A mid-range copper WER that was determined in the LA River WER Study is 3.98. The WER of 3.98 was multiplied by the numeric target for both wet and dry weather to yield a higher allowable copper load. Application of this WER to the Ballona Creek Watershed copper TMDL resulted in zero wet and dry weather TMDL exceedances for copper in all scenarios, including the baseline scenario with no BMPs. This outcome occurred even before considering the expected copper load reductions from brake pad changes required under SB 346.

A copper WER of 2 was also tested to identify the point at which TMDL compliance would reach 100 percent. In this case, there were zero dry weather exceedances with a WER of 2 even in the baseline scenario. The wet weather exceedances per year (Table 11) for Scenarios 1-4 are all 0 or 1. For the Ballona Creek Watershed, a Cu WER greater than 2 would result in zero wet weather Cu exceedances per year in the baseline scenario. At that point, zinc would become the remaining metal of concern for compliance.

Table 11: Results per WY (R13-010 numeric TMDL targets) for Cu WER of 2. Wet weather (WW) and dry weather (DW) exceedances per year are shown with the WER.

Scenarios	WW Cu Exc / Year +WER=2	WW Pb Exc /year	WW Zn Exc /year	DW Cu Exc / Year +WER=2	DW Pb Exc /year	DW Zn Exc /year
Baseline – No BMPs	**0**	**0**	**19**	**0**	**0**	**0**
1) BMP Optimization	0	0	1	0	0	0
2) Urban Runoff Infiltrated	1	0	8	0	0	0
3) Urban Runoff Treat/Release	0	0	0	0	0	0
4) Private Property Runoff to LID	0	0	2	0	0	0
5) Public Property Runoff to LID	0	0	18	0	0	0

b. Zinc Compliance Investigation

Without taking into account a theoretical Cu WER, implementing BMPs to capture the 85th percentile storm still resulted in significant TMDL exceedances per year in Ballona Creek: 6 – 11 Cu exceedances per year shown in Table 10. Zn also exceeds the TMDL in some of the scenarios, though not as often as Cu: 1-8 Zn exceedances per year (Table 10). This shows that the compliance condition in the MS4 permit of treating the 85th percentile storm with BMPs does not actually achieve full compliance with WQS. Supplementary model simulations were done in order to determine the level of treatment that would be necessary to minimize WQS exceedances for Cu and Zn.

Based on the results in Table 10, in some scenarios, more BMP treatment would be needed to remove enough Cu from stormwater to achieve full compliance, defined as less than one exceedance per year. After the Cu phase out brake pad legislation (Senate Bill 346) takes effect and Cu pollution is significantly reduced, Zn will become the limiting metal pollutant in the watershed. For example, if compliance with SB 346 leads to a 50% reduction in copper loads and receiving water concentrations in Ballona Creek, then that is equivalent to the compliance outcome achieved by a WER of 2, demonstrated in Table 11 with zero Cu wet weather exceedances per year with no BMPs implemented.

With Zn having fewer TMDL exceedances than Cu, Zn pollution could be mitigated with potentially fewer BMPs and lower cost. In this section, BMP treatment volume was adjusted in model scenarios 2 through 4 to determine if fewer exceedances for Cu and Zn could be achieved with more or less BMPs. The number of BMPs was increased and decreased incrementally to determine the limits of TMDL exceedances, with the goal of achieving full compliance (less than one exceedance per year). The number of BMPs was decreased if the exceedances were already less than one per year in the 85th percentile scenario results in Table 10.

Table 12 gives a summary of the results of this analysis. When adjusting the BMP treatment volume in each scenario, instead of the exceedances decreasing to zero in all scenarios, a minimum, and sometimes non-zero, number of exceedances was reached. The third column in Table 12 shows the change in BMP treatment volume compared to the original 85th percentile storm capture scenarios from Section II.C.d above. This illustrates the difference in BMP treatment volume between the original scenarios designed to capture the 85th percentile storm and the same scenarios when they are designed to minimize the WQS exceedances.

The dry pond Scenario 3 achieves the best compliance for Cu (1 exceedance/year) with 100% more BMP treatment volume. This is because implementing dry ponds allows treated water to flow to the outlet to dilute pollutants from the untreated runoff. An interesting conclusion in the LID scenario 4 is that slightly better compliance for Cu can be achieved (from 11 to 10 exceedances/year) by decreasing the treatment volume by 25%, with an estimated $300 million lower median cost. This small reduction in exceedances is achieved through lower BMP volume because LID BMPs have much higher plant uptake and evaporation compared to the other BMPs and can infiltrate a large percentage of the runoff captured. Again, this assumes that runoff from at least 77% of the watershed is routed to LID BMPs. Even though this is a small improvement, it still leaves 10 Cu exceedances per year.

Median costs were calculated for the scenarios adjusted to minimize exceedances (Table 12, column 7) and compared to the median cost of the original 85th percentile storm capture scenarios (Table 12, column 8). The scenarios requiring more BMP treatment volume also increased in cost. Most Cu scenarios required an increase in BMP treatment volume to become more compliant with WQS, and full compliance was still not attainable with the additional capacity. Almost full compliance can be achieved for Zn compared to Cu. Zn can be fully compliant using dry ponds only (Scenario 3) or LID only (Scenario 4) with 50% less treatment volume and cost than the original 85th percentile storm capture scenario.

Full compliance cannot be achieved for Cu while runoff from a portion of the watershed bypasses BMP treatment. To achieve full compliance even if it were possible to route 100% to BMPs, the BMPs would need to be large enough to capture and treat the largest storm event. However, as discussed above, the reduction in copper levels that will result from compliance with the brake pad legislation would facilitate compliance with Cu standards (as would a Cu WER if implemented in Ballona Creek Watershed). Full compliance can, however, be achieved for Zn under current conditions due to slightly lower Zn loading in the watershed. However, infiltration-type BMPs are not as effective at reducing TMDL exceedances for Zn or Cu because they reduce the volume of water in the channel which lowers the TMDL target at the monitoring location.

Table 12: Summary of BMP treatment volume adjustments needed to minimize WQS exceedances for each scenario 2 – 4. T.Vol (TV) and T.Area (TA) are the resulting BMP treatment volume and surface area from increasing or decreasing the number of BMPs in each scenario to minimize exceedances. The adjusted median cost of the new treatment volume is compared to the original 85th percentile scenario median cost. Gray boxes indicate a decrease in treatment volume and cost relative to the original scenarios.

Cu	**T.Vol (AF)**	**TV % change from original**	**T.Area (acres)**	**Fewest Cu exc/year**	**Adjusted Median Cost ($B)**	***Original Median Cost ($B)***
2 - Inf Trench	5020	+100%	1000	9	$1.3	*$0.7*
3 - Dry Pond	5020	+100%	1000	1	$1.3	*$0.6*
4 – LID	1700	-25%	2080	10	$1.0	*$1.3*
Zn	**T.Vol (AF)**	**TV % change from original**	**T.Area (acres)**	**Fewest Zn exc/year**	**Adjusted Median Cost ($B)**	***Original Median Cost ($B)***
2 - Inf Trench	2760	+10%	550	7	$0.7	*$0.7*
3 - Dry Pond	1260	-50%	250	0.2	$0.3	*$0.6*
4 - LID	1130	-50%	1380	1	$0.7	*$1.3*

c. Street Sweeping

For impervious land segments, SUSTAIN supports a street-sweeping algorithm adopted from the Stormwater Management Model.[81] A user can specify the number of days between sweeping, and the number of days since the last sweep at the start of a simulation. Additionally the user is able to input the fraction of accumulated sediment types (i.e. sand, silt, clay) available to be removed by sweeping as well as the fraction of sediment type that is removed by sweeping.[82]

Street-sweeping for our purposes focuses on the removal of metals like copper, nickel, lead and the fine sediments they can adhere to on city streets. Studies have shown that street sweep-

[81] Rossman, L.A. *Stormwater Management Model User's Manual*, *Version 5.0. EPA/600/R-05/040*, (2005). U.S. Environmental Protection Agency, Water Supply and Water Resources Division, National Risk Management Research Laboratory, Cincinnati, OH.

[82] Shoemaker, L., Riverson, J., Alvi, K., Zhen, J. X., Paul, S., and Rafi, T., SUSTAIN - *A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality. User's Manual*, (2009). Environmental Protection Agency, 1–202.

ers are capable of picking up as much as 8,000 lbs of material per curb mile annually, with trash, road debris and vegetation comprising the majority of the load.[83]

Unfortunately, the research investigating the capabilities of different street-sweeping technologies and their ability to pick up fine materials (i.e. sand, silt, clay), which are required inputs into the SUSTAIN simulation, are few and do not draw the same conclusions. For this reason the street-sweeping algorithm was not utilized in the aforementioned simulations in the Ballona Creek watershed. Two studies that offer some insight into the effectiveness of street-sweeping on water quality are detailed below and will be considered in future model simulations.

In Madison, Wisconsin the USGS performed a 5-year study examining the removal efficiencies of various street-sweeping technologies. The best performing street-sweeper was the regenerative air style sweeper which was able to remove up to 76% of street-dirt. Water quality from the resulting runoff was analyzed, but because of the extreme variability in stormwater quality loads, researchers were unable to determine whether street-sweeping or other factors affecting the movement and supply of debris in the watershed were responsible for changes in water quality.[84]

Another study completed by the city of Seattle in 2012 scrutinized the effectiveness of their urban street-sweeping program. Seattle set an ambitious 60% target removal load of the median available quarterly average street-dirt. This level of removal was chosen because it provides a similar level of treatment as structural BMPs for metals as described by the Ecology TAPE guidance performance standards.[85] In addition, the street-sweeping target metal-load removal efficiencies were based on the assumption that the city of Seattle's stormwater median dissolved metal fraction is approximately 0.35 for copper and 0.36 for zinc, based on 34 samples over three land uses.[86]

The Seattle 2012 study also found that regenerative air sweepers picked up significantly greater than the 60% target for fine sediments (<250 μm) as well as for all particle size classes combined (clay and silt, fine sand, coarse to medium sand, and gravel) for a sweeping frequency of every two weeks. These findings indicate regenerative air street-sweepers may be able to provide a similar level of treatment than a structural BMP offers for copper and zinc as well as other

---

83 Bannerman, R. T. *Sweeping Water Clean* (1999). American Sweeper Magazine. Huntsville, Al. 7(1)

84 Selbig,W. R., Bannerman, R. T. *Evaluation of Street Sweeping as a Stormwater-Quality-Management Tool in Three Residential Basins in Madison, Wisconsin* (2007). U.S. Geological Survey, Reston, Virginia. Scientific Investigations Report 2007–5156

85 *Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies.* Technology Assessment Protocol – Ecology (TAPE). August 2011 revision, Publication no. 11-10-061. *Available at* https://fortress.wa.gov/ecy/publications/publications/1110061.pdf

86 Seattle Public Utilities. *Program Effectiveness Report.* (2012)

metals. Currently, the city of Los Angeles utilizes brush street-sweepers, so there is potential for major load reductions from switching the fleet to regenerative air street-sweepers.

d. In-Channel BMPs

Given that so much acreage is required to capture the desired level of runoff for the MS4 Permit design storm (85^{th} percentile-24 hour), existing stormwater infrastructure offers a potential location for BMPs since both wet and dry runoff is already being routed through the stormdrain network and there is an extensive area available within the channel network. In order to place stormdrain BMPs in the existing channel network, which are not designated waterbodies under the Basin Plan, it would be necessary to work with USACE and LA County Flood Control to demonstrate that the presence of in-channel BMPs would not have an adverse effect on flood control and that the channel infrastructure would not be adversely affected by the placing and operation of in-channel BMPs. Another possible approach would be to utilize land adjacent to the channels to place BMPs that would then discharge "treated" water back into the channels.

A regional example of this is the Santa Ana River engineered El Prado wetlands, through which a portion of the Santa Ana River flow is routed for treatment by the wetlands and then discharged back into river channel. This is an example of a flexible stormwater policy that allowed a BMP (the wetland) to be implemented treating the flow from and then discharging the flow back into the Waters of the United States (WOUS) to remediate high nutrient levels impacting downstream flows.

Placing the stormwater BMPs into the channels that are designated waterbodies, such as Ballona Creek or Sepulveda Canyon Channel, would require working with the LARWQCB as well as with the LA County Flood Control District to obtain an exemption and the required permits to place in-channel BMPs. Under the Clean Water Act, BMPs cannot be placed into WOUS without an exemption, as receiving waters cannot be used to transfer waste through a BMP. NPDES permits may also be required at the outlet of the BMP. The proposed inflatable dam adjacent to the North Outfall Treatment Facility (NOTF) located near La Cienega Blvd. will be a treat and release BMP providing the City gets project approval from the pertinent agencies.

One possible scenario would be to go through a use attainability analysis and de-designate certain uses (recreation, various aquatic life uses, etc.) in the portions of the channel in which the BMPs would be installed. The argument can be made that there are many upstream opportunities in these watersheds for recharge or treatment in the channels to improve water quality and enhance groundwater recharge before the waters get to an area that harbors significant aquatic life resources. Further, using the upper areas of the watershed through implementing in-channel BMPs is a strategy that offers the opportunity to greatly reduce impact on the receiving waters through improving the water quality or decreasing the in-channel flows. In addition, maximizing infiltration along the soft bottom channel sections such as Tujunga Wash, associated gravel pits (e.g. Strathern Pit – Rory M. Shaw Wetland Park or other suitably clean gravel pits in the region), and spreading grounds will lower the flows, augment local water supply, and reduce the levels of contaminants impacting receiving waters at the outlets of the watersheds.

Precedent for removing portions of the flow from the LA River (designated a WOUS in 2010) and purchasing water rights to use this water has recently been set through the Metabolic

Studios water wheel project. Further, dry and wet-weather diversions which divert flow from receiving waters to HTP for treatment are already fairly wide-spread along the coast. A total of 23 LFDs, including eight City LFDs that divert runoff to HTP are already in place throughout Santa Monica Bay.[87] Minimum flow studies may need to be conducted in all City watersheds to determine how much flow needs to remain in the channels to support designated beneficial uses so that the remainder can be used to off-set potable water demands and decrease the City's reliance on imported water. Diverting flow to HTP achieves two benefits: 1) influent flow is increased which in turn provides the opportunity to produce more advanced treated water for reuse; and 2) diluting the concentration of nutrients, organics, and salts present in wastewater with runoff.

E. Water management implications

It is the intention that these modeling results provide insight for effective water management decisions. Recommendations are based on several conclusions reached through this modeling work.

Dry weather metals TMDL exceedances can be almost completely eliminated with the tested scenarios 1 through 4. Cu and Zn are the main concerns for exceedances in wet weather because Pb has much higher TMDL targets and zero exceedances in the baseline scenario without BMPs. If a Cu WER is developed for Ballona Creek Watershed, a WER above 2 would result in zero Cu exceedances per year even in the baseline scenario in which no additional BMPs are implemented. This would also be the case if 50% reductions in Cu from the brake pad legislation were achieved. The only metal out of compliance in that case would be Zn, and Zn would only be out of compliance in wet weather.

When looking at TMDL compliance for Zn as the limiting pollutant, full Zn compliance was achieved by increasing or decreasing the BMP treatment volume in each original 85th percentile scenario. Zn can be fully compliant with dry ponds only (Scenario 3) or LID BMPs only (Scenario 4) with 50% less treatment volume and 50% lower cost than the original 85th percentile storm capture scenarios.

Treat and release-dominated BMPs offer the best TMDL compliance due to the dilution effect at the outlet. While this is beneficial to wildlife by upholding the CTR limits in the short-term, more load can be passed through to the receiving waters, which may be detrimental to long-term accumulation in those water bodies. The treat and release scenario achieves about half the infiltration of the other scenarios, with very poor peak flow attenuation. The cost for scenarios 2-4 are all in similar ranges (~$0.5B – $1.5 Billion).

---

[87] http://www.lastormwater.org/blog/2015/06/outta-sight/, Water for LA Becoming a Green-Blue City, ASCE December 2014 article, List of Existing and Planned Diversions for Santa Monica Bay, LASAN.

Scenarios utilizing infiltration-based BMPs are beneficial for many reasons. Regional infiltration trenches (scenario 2) recharge the most water (77% of the average annual runoff) and achieve considerable peak flow reduction in large storms. They remove the largest pollutant load, on the same par with distributed BMPs (scenario 4). Distributed LID BMPs have high infiltration capability due to their large surface area resulting in recharge of the second greatest amount of runoff (56% of the average annual runoff). Infiltration along with vegetation in distributed LID BMPs increases evapotranspiration and flow attenuation, therefore reducing peak flows by the largest amount of all scenarios. However, wet weather exceedances are greater for infiltration-based BMPs than with treat and release BMPs because infiltration reduces stormwater volume in the channel and doesn't reduce metals concentrations in the stormwater discharged to the creek, resulting in a lower TMDL target at the monitoring location, even though more Cu load is removed. Distributed projects cost more because they lack the economy of scale of regional BMP projects.

Different opportunities and challenges exist to implementing BMPs in both the regional and distributed BMP scenarios. While sufficient acreage of vacant land exists in Ballona Creek watershed to implement the necessary regional BMPs, the vacant land is either protected, not available or unsuitable for BMPs, or located in the upper reaches of the watershed and thus not useful for capturing the polluted runoff discharging from the lower reaches. These factors combined hinder the ability to effectively site and implement the large regional infiltration BMPs. In the distributed BMP scenario, more distributed BMPs are needed to achieve the necessary treatment capacity because of their larger overall footprint. On the plus side, there is much more privately owned land area located nearer to the watershed outlet on which distributed BMPs could be effectively implemented. However, convincing property owners to retrofit their existing properties with stormwater capture BMPs offers its own set of challenges and may be difficult unless property owners are obligated to by regulation and/or receive compensation to do so. Possible approaches to increasing distributed infiltration BMPs are green street requirements for all street improvements over a certain cost and retrofit upon sale requirements for all buildings, including single family homes. Further, inspection programs or some other mechanism would need to be put in place to ensure that these BMPs were being appropriately maintained in order to continue providing the expected water quality benefits.

Overwhelmingly, BMPs which infiltrate a large majority of the water achieve the most benefits in pollutant reduction, potential recharge, and peak flow reduction. However, consideration for subsurface contaminant mobilization needs to be investigated more thoroughly. Treat and release BMPs are very effective at meeting water quality requirements over a wide range of storm sizes. Infiltration BMPs will also reduce other pollutants like bacteria and toxics, with additional help from dilution by treat and release BMPs. Overall, combining the attributes of all BMP types can achieve the desired results, though tradeoffs will need to be made to balance peak flow reduction, recharge, and load reduction with water quality compliance. The optimized BMP Scenario 1 is an example of this compromise, with middle-ranges of all benefits achieved. Additionally, in-channel BMP types may provide extra capability to infiltrate large volumes of water near the outlet of the subwatersheds, where the tributaries meet the main channel.

The City is already is in compliance with the Ballona Creek trash TMDL because of their watershed wide installation of over 20,000 catch basin screens and inserts, and numerous CDS units. Also, compliance with the metals TMDLs in the Ballona Creek watershed will become easier in the future due to the expected source reduction benefits of the legislation to reduce the amount of copper in brake pads. Going forward, compliance with the Ballona Creek bacteria TMDL is likely to be the most challenging to achieve as FIB concentrations frequently vary by orders of magnitude rather than the factor of 1 to 3 observed for metals in our study. Street sweeping would help with trash and other pollutant reduction, though more experimental data on the effect of street sweeping on receiving water quality is needed to adequately address this in the model. However, through reviewing published reports, the City should seriously consider switching all or part of the current fleet to regenerative air street sweepers in order to reduce sediment and metal loads before they are washed off in storm flows.

The infiltration scenarios highlighted above in scenarios 2 and 4 would be the most effective at reducing FIB loadings to Ballona Creek and Santa Monica Bay, but the treat and release scenario 3 provides some additional dilution benefits for FIB densities in receiving waters. (Scenario 1 has the combined characteristics of both infiltration and treat and release so therefore would provide both benefits). Unfortunately, the FIB density reduction data for structural BMPs is not very robust, does not demonstrate tremendous promise in reducing FIB densities, and BMP performance is far too variable to model without extremely large uncertainties. Since regional compliance with the FIB TMDLs for Ballona Creek and Santa Monica Bay Beaches continue to pose an enormous challenge, the value of infiltration BMPs and reducing FIB loadings must not be discounted.

At this point, we can only speculate on the most appropriate approach for reducing wet weather FIB densities in Ballona Creek and Santa Monica Bay, but dry weather compliance can be achieved with diversion of 100% of the dry weather flow to the sewer system (providing the approach is approved by the LARWQCB and Resource Management agencies including the California Department of Fish and Wildlife, NOAA, and the USFWS). Dry weather FIB compliance also could be attained with a combination of dry weather diversions and capture, treat, disinfect and release BMPs. Unfortunately, application of these approaches during wet weather may prove infeasible because large storm flows could exceed sewer capacities. However, the feasibility and water quality and supply benefits of first flush diversions to the HTP should be assessed.

III. 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 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 Department of Water Resources' Bulletin 118 update.[88] 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 MWD water to maintain "safe yield," and ensure groundwater rights holders can use the groundwater.

Available storage capacity in West Coast Basin (WCB) and Central Basin (CB) creates an opportunity to increase the infiltration of advanced treated recycled water from HTP into WCB and CB. However, caps and limits on both the storage and extraction of water from these adjudicated basins constrain these groundwater basins as ready sources for storing water supply locally. Further, as the third amended judgments for WCBCB have been finalized recently and are relevant to Dominguez Channel as well, additional details on the opportunities and necessary actions to increase recharge into and extraction out of the basins will be discussed further in the subsequent Dominguez Channel Report.

B. Groundwater Basins Underlying Ballona Creek Watershed

a. West Coast Basin

The WCB lies along the coast in Western Los Angeles County, and underlies a significant portion of the City (Figure 21).[89] The WCB contains many confined aquifers, including the Silverado aquifer, which is 100 to 500 feet in thickness and yields 80% to 90% of the groundwater

---

[88] From CA water action plan: California Statewide Groundwater Elevation Monitoring Program

[89] Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 14

extracted annually from the WCB. [90] Although many of the aquifers are confined, limited groundwater replenishment occurs through local runoff and infiltration and underflow from the CB to the east. Increasing the volume of water infiltrating into CB through spreading grounds has some potential to increase the amount of natural subsurface flow into WCB and thus WCB groundwater levels as well. Additional replenishment to WCB is provided through injection wells along the WCB Barrier Project (WCBBP) to prevent seawater intrusion[91]; there are no in-land injection sources, but this is an area that has potential for additional replenishment.[92]

Mean precipitation over the WCB in 2012-2013 was 5.91 inches, less than half of the long-term mean over the WCB of 12.64 inches.[93] The total volume of adjudicated rights in WCB is 64,468.25 AF. In FY 2012-2013, 43,307.37 AF of groundwater, including 1,239.19 AF of water extracted through non-consumptive water use permits, were extracted of the total adjudicated water rights in the WCB.[94] Among the rights which were not extracted were 1,503 AFY of rights belonging to the City (plus approximately 300 AF of carry-over rights). In-lieu replenishment, in which groundwater producers use supplemental water from sources outside the basin rather than their groundwater rights, is another avenue to reduce annual extractions from WCB. [95] Groundwater levels can vary greatly annually based on factors such as extraction, barrier recharge, subsurface flows, and precipitation; between spring 2012 and spring 2013, levels dropped as much as 11 feet (between Gardena and Compton) and rose as much as 29 feet (Gardena). [96] Generally, the ground surface elevation of the Silverado aquifer in WCB has been rising from a low of around -80 feet to current levels of around -60 feet (although there has been a decrease since 2005 from about -40 feet).[97] There are some water quality concerns in WCB due to high levels of dissolved solids and chlorides. Two groundwater desalter projects in the City of Torrance, the C. Marvin Brewer Desalter Treatment Facility (Brewer Desalter), constructed by

[90] Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 7

[91] Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 5

[92] Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 36.

[93] Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 5 (ranging from 5.32 inches to 6.45 inches at three gauges within WCB)

[94] Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 1

[95] Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 5

[96] Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 7

[97] Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 45

WBMWD in 1993, and the Robert W. Goldsworthy Desalter (Goldsworthy Desalter), which WRD began operating in 2001, are currently desalting groundwater in WCB.[98] The current capacity of the Brewer Desalter is 5 MGD (5,600 AFY). There are plans to double the capacity at the Goldsworthy Desalter to 5 MGD (5,600 AFY).[99]

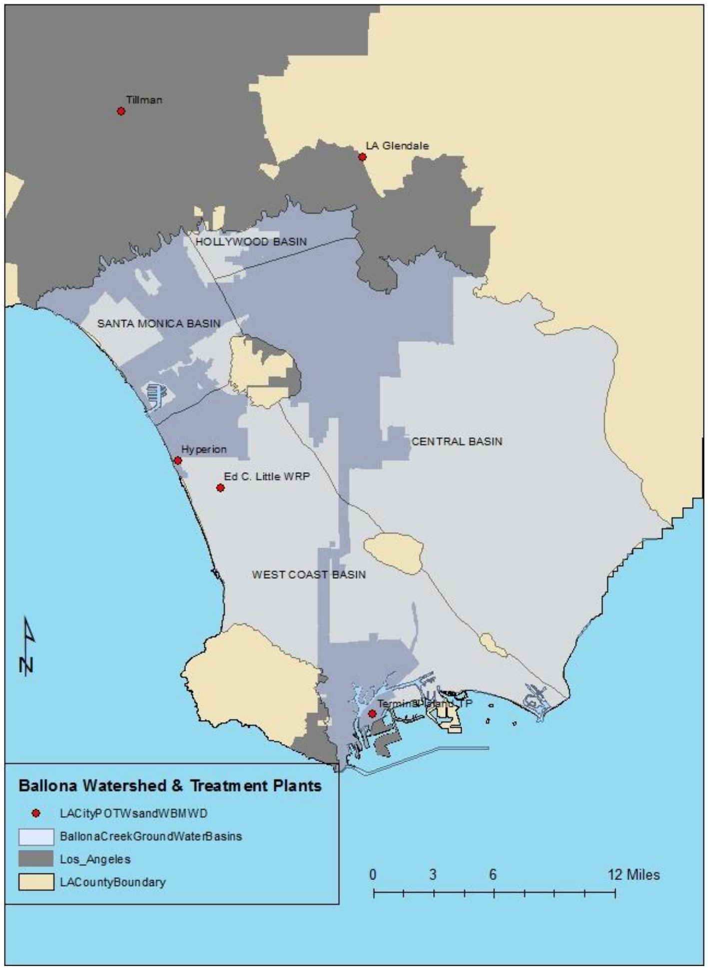


Figure 21: Map of Groundwater Basins underlying the City, data from LA County GIS Data Portal.

---

[98] Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 6

[99] Initial Study Robert W. Goldsworthy Desalter Expansion Project (pdf) CH2MHILL for WRD. 2013 http://www.wrd.org/Goldsworthy-IS.pdf

b. Central Basin

Groundwater recharge in the CB occurs both through natural processes, mainly through surface and underground flow from the San Gabriel Valley through Whittier Narrows, and managed processes, mainly infiltration through spreading grounds. Intentional replenishment is achieved in CB through spreading a mix of stormwater runoff, purchased imported water, and recycled water (from Whittier Narrows, San Jose Creek, and Pomona Water Reclamation Plants) at the Rio Hondo and the San Gabriel Spreading grounds located in the Montebello Forebay. In 2012-2013, the replenishment distribution was the following: 8,274 AFY from local runoff, 58,113 AFY[100] from recycled water (infiltrated into CB), and 2 AFY MWD untreated imported water (stemming from MWD maintenance operations).[101] In 2011, MWD stopped offering discounted water for groundwater replenishment, which is one of the reasons why so little MWD water was used to replenish CB in 2012-2013. Some additional replenishment to CB is generated from the Alamitos Barrier Project as well, which is a system of 4 extraction wells and 43 injection wells that is designed to prevent further seawater intrusion into CB. In 2012-2013, the mean precipitation over CB (measured at six precipitation stations throughout the basin) was 5.55 inches.[102] Little precipitation infiltrates into CB except for the spreading grounds due to the prevalence of impermeable surfaces.

The 132 parties to the CB judgment extracted a total of 196,262 AF of their 259,509 AF allowed pumping allocations (APA) in 2012-2013, and kept 38,072 AF as carryover.[103] In 2012-2013, the City only extracted 6,310 AF from CB of a potential 23,250 AF (includes adjudicated and carry-over rights). Twenty-three incorporated cities plus several unincorporated communities are present within the CB Watermaster Service Area, which overlies 227 square miles of the CB.[104] In the CB judgment, there are two provisions that allow parties to extract above their production rights to allow flexibility in the face of unexpected water demands or circumstances. First, each party can carry over up to 20% of its allowed pumping allocation (APA) or 20 AF, whichever is larger, and unused Exchange Pool water can be carried over into the following fis-

---

[100] An additional 14,318 AF of recycled water was used in the area overlying the basin.

[101] Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 28

[102] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. P. 6

[103] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. P. iii; Although ~63,000 AF of water was left in the ground, only ~38,000 AF of water was eligible to be carried over as there is a cap on carryover water for each rightsholder from one administrative year to the next: 20% of APA or 20 AF, whichever is greater. P.2

[104] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. P. 1

cal year.[105] This exchange pool provides additional water rights to parties whose predicted demand exceeds their supply, but parties must file a request for more water with the Watermaster before April 1 to be considered; if no parties apply, the exchange pool doesn't operate the following fiscal year.[106] Second, over-extractions of up to 20% of APA or 20 AF are allowable under certain conditions, including making up the over-extraction in the following year. Pending Watermaster approval, over-extraction of greater amounts also may be permitted.[107] APAs are also transferrable between parties through either lease or sale[108], which can provide another method for parties facing more demand than supply to increase their allowable pumping allocation. Interestingly, water rights do not always pass to the new land owner unless the water rights are explicitly included in the land sale.[109] Parties may petition the WRD for non-consumptive water use permits as part of projects to address groundwater contamination.[110]

Further opportunities for the City to increase the reuse of recycled water exist through supplying recycled water to rights holders in WB and CB to be used in-lieu of those rights holders pumping their allotted groundwater from the basin. The WRD may contract with any producer with access to supplemental water that could be used in CB to avoid groundwater extraction. While the in-lieu water counts as pumping extractions for the rights-holder in that year, it does not affect the quantity of water rights belonging to that rights-holder overall. However, while in-lieu exchanges could increase demand for advanced treated recycled water from the City, it may not provide additional water supply for the City to extract from CB since in-lieu water does count towards the parties APA for that year. The potential opportunity presented by in-lieu exchanges will be assessed further in the following report on Dominguez Channel along with other factors that could impact allowable extractions within the newly identified storage capacity.

c. Santa Monica Basin

The Santa Monica Basin also underlies a portion of the Ballona Creek watershed as well as the cities of Santa Monica, Culver City, Beverly Hills and the communities of Pacific Palisades,

---

[105] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. P. 2

[106] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. P. 4

[107] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. P. 3

[108] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. P. 4

[109] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. P. 4

[110] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. P. 3

Brentwood, Venice, Marina del Rey, West Los Angeles, Century City, and Mar Vista.[111] The five subbasins of the Santa Monica Basin (divided by faults) are Arcadia, Olympic, Coastal, Charnock, and Crestal. This groundwater basin is up to 550 feet deep and consists of the Ballona aquifer and the Silverado aquifer (alluvium, and the San Pedro formation, respectively) as well as the Lakewood formation. The total storage capacity of the basin is 1.1 million acre-feet[112]; the natural safe yield was estimated to be roughly 7,500 AFY.[113] Both the total amount of unused storage space and the portion of unused storage space that could be used for storage are unknown in this basin as it is an unadjudicated basin.[114] In general, groundwater quality in the Santa Monica Basin is fair to poor with total dissolved solids concentrations that are high enough (between 729 and 1,156 mg/L) to require blending or treatment of the water in order to meet drinking water standards.[115] However, the primary concern in this basin is the MTBE contamination. Treatment systems are now in place to treat water to potable quality at the Arcadia wells as well as to treat the MTBE contamination in Charnock. The basins also have TCE, PCE and 1,4 dioxane contamination in some areas.

Some groundwater production within this basin currently occurs through wells that tap into the Lakewood formation in the Arcadia and Olympic sub-basins and the majority of the potable production comes from the Silverado aquifer.[116] Groundwater recharge in this basin occurs mainly through percolation of precipitation and runoff from the Santa Monica Mountains and discharge occurs through surface runoff and subsurface outflow. Average precipitation over this basin between 1985 and 2004 was 13.7 inches. Currently, the City of Santa Monica is the primary producer in the Santa Monica Basins, with wells in the Arcadia Subbasin (Arcadia wellfield), the Charnock Subbasin (Charnock wellfield), and the Olympic Subbasin (Santa Monica wellfield).[117] EPA Region 9, the California Department of Health Services, and the LARWQCB have been involved in managing the cleanup of MTBE contamination in the Charnock and Arcadia

---

[111] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Santa Monica Basin. MWD. P. IV-5-1. September 2007.

[112] California Department of Water Resources (DWR). 1961. Planned Utilization of the Ground Water Basins of the Coastal Plain of Los Angeles County. Bulletin No. 104.

[113] United States Geological Survey (USGS). 2003. Water Resource Investigation Report 03-4065. Geohydrology, geochemistry, and ground-water simulation – Optimization of the Central and West Coast Basins, Los Angeles County, California.

[114] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Santa Monica Basin. MWD. P. IV-5-2. September 2007.

[115] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Santa Monica Basin. MWD. P. IV-5-6. September 2007

[116] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Santa Monica Basin. MWD. P. IV-5-3. September 2007.

[117] Feasibility Report for Development of Groundwater Resources in the Santa Monica and Hollywood Basins. Prepared by Kennedy / Jenks Consultants for LADWP. December 2011. P. 2-15

Wellfields.[118] Although the Santa Monica Basin is adjacent to the Hollywood Basin, the WCB, and the CB, water only moves from the Santa Monica Basin into the WCB (~1,000 AFY) as the Newport-Inglewood Uplift restricts flows to or from the other adjacent basins.[119] There are drinking or irrigation wells installed in every subbasin except for Coastal, and all production in this basin is designated for municipal use. One of the reasons groundwater production has not occurred in the Coastal sub-basin is that water levels in this area are currently near sea level and in the past have been as low as 100 feet below sea level.[120] During the 1980s, Santa Monica injected as much as 2,148 AFY of MWD water into Charnock but this injection ended in 1990.[121] Two elements that need to be taken into consideration for increasing injection or extraction from this basin are the ongoing need to continue remediating the MTBE and TCE contamination as well as the need to manage the potential for seawater intrusion through any new groundwater programs.

d. Hollywood Basin

The Hollywood Basin also underlies a portion of the Ballona Creek watershed as well as the cities of Beverly Hills, West Hollywood, and the City of Los Angeles.[122] The depth of this groundwater basin is up to 660 feet and consists of three aquifers: Alluvium, Lakewood Formation (Exposition and Gage aquifers), and San Pedro Formation (Jefferson, Lynwood, Silverado, and Sunnyside aquifers).[123] The Gage aquifer is the main water-bearing aquifer in this basin, but overlying aquifers are also important as they contribute some amount of water to the lower layers through percolation. Similar to the Santa Monica Basin, percolation of precipitation and streamflow in the Santa Monica Mountains are the main avenues of recharge to this basin. Total storage has been estimated to be 400,000 AF, but the amount of available storage is unknown. The natural safe yield of the basin was estimated as roughly 3,000 AFY.[124] The Hollywood Basin is adjacent to both the CB and the Santa Monica Basin, but the only inter-basin flow

[118] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Santa Monica Basin. MWD. P. IV-5-4. September 2007.; http://www.epa.gov/mtbe/water.htm

[119] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Santa Monica Basin. MWD. P. IV-5-4. September 2007.

[120] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Santa Monica Basin. MWD. P. IV-5-7. September 2007.

[121] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Santa Monica Basin. MWD. P. IV-5-6. September 2007.

[122] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Hollywood Basin. MWD. P. IV-6-1. September 2007.

[123] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Hollywood Basin. MWD. P. IV-6-2. September 2007.

[124] SA Associates, 2005. City of Beverly Hills 2005 Urban Water Management Plan.

is from the Hollywood Basin into the CB. This flow is estimated to be roughly 5,900 AFY (1971-2000), but no formal agreements pertain to this flow.[125]

Hollywood Basin is unadjudicated but managed by the city of Beverly Hills through municipal ordinances that regulate groundwater production and protect water quality, prohibit waste, and require dewatering to mitigate adverse impacts. Beverly Hills is the primary producer from the Hollywood Basin and has historically produced more than 7,000 AFY. Between 1976 and 2002, Beverly Hills did not produce any groundwater from the basin. Currently, they are producing water through four active production wells (combined capacity of 2,025 gallons per minute) and a reverse osmosis desalter facility. Between 2005 and 2009, the average production was roughly 1,200 AFY, with a range of 884 to 1,311 AFY, and it was used to meet local demand in Beverly Hills.[126]

The desalter facility treats up to three MGD of groundwater and includes a brine line to deliver waste to HTP. It is designed to produce 2,600 AFY of treated water and discharge 336 AFY to the brine line.[127] Water quality is generally fair in this basin but TDS concentrations ranging from 519 to 788 mg / L require the use of the desalting facility before use, as many samples exceed the secondary standard of 500 mg / L.[128] Currently no groundwater storage program exists in this basin, and shallow groundwater (less than 20 feet depth to groundwater in central and eastern portions of the basin) could limit the ability to store water in this basin.[129]

C. Possible approaches to increase local groundwater production

Challenges to increasing the use of groundwater storage underlying the Ballona Creek watershed include historical contamination of the groundwater basins that constrict storage capacity and pumping, risk of seawater intrusion from increased extractions, limits to extractions of infiltrated groundwater within the legal agreements of the WCB and CB adjudications, brackish

[125] United States Geological Survey (USGS). 2003. Water Resource Investigation Report 03-4065. Geohydrology, geochemistry, and ground-water simulation – Optimization of the Central and West Coast Basins, Los Angeles County, California. Cited in: Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Hollywood Basin. MWD. P. IV-6-4. September 2007.

[126] Beverly Hills UWMP, 2010, p 1-5

[127] Metropolitan Water District of Southern California (Metropolitan), 2006. Local Resource Program, Recycled Water and Groundwater Recovery Projects, Summary Report August 2006. Cited in: Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Hollywood Basin. MWD. P. IV-6-6. September 2007.

[128] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Hollywood Basin. MWD. P. IV-6-7. September 2007.

[129] Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Hollywood Basin. MWD. P. IV-6-8. September 2007.

groundwater, and brine disposal. Potential opportunities to address these challenges are discussed below and further in the Recycled Water Opportunities section.

a. Increasing Storage & Extraction in West & Central Basins

Recently, amendments to the adjudications in both WCB and CB have defined tens of thousands of acre-feet of additional available storage space. The CB amendment was finalized in December 2013, and identified 330,000 acre-feet of storage space available in the Basin. The WCB adjudication amendment was recently finalized, and identified 120,000 acre-feet of additional available storage space.

Prior City analyses have assessed the space available in these groundwater basins to store increased volumes of advanced treated recycled water. In particular, the 2012 RWMP assessed groundwater capacity, estimating that "the additional conjunctive use storage and recovery capacity of the WCB could be on the order of 50,000 AFY (45 MGD).[130] The historical maximum that was injected into WCB through the WCBBP was 44,390 AF (in 1965-66) as part of an effort to replenish the groundwater basin to remedy substantial overdraft.[131]" Currently, 17,000 AF (15 MGD) is injected into the WCB through the WCBBP so there is likely to be additional injection capacity at this site based on the historical maximum injected during the 1960s. The 2012 RWMP estimated this injection potential through the WCBBP may be as high as 27,390 AF (24 MGD) above the volume of water currently injected as a barrier to seawater intrusion.[132] We will further investigate and define the institutional structures within which the City of LA would need to work to increase storage in WCB and/or increase injection through the WCBBP.

LADWP has the opportunity to pump an additional 1,503 AFY from WCB to use all of their currently allocated rights plus the approximately 300 AFY of their accumulated carryover water rights. The City has not extracted any of its rights in WCB since 1980 due to localized contamination with high TDS & chlorides and well deterioration at Lomita Wellfield.[133] Constructing a pumping and treatment facility to extract the total volume of adjudicated rights would both increase the volume of groundwater being used for LA water supply and create additional space to recharge the basin with more advanced treated recycled water or captured stormwater. The City

---

[130] Their assumptions for this number: historical peak extraction 100,000AFY, today 40,000AFY so physically possible to extract 60,000AFY plus conversations with WRD staff. From Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 37.

[131] Water Replenishment District of Southern California Engineering Survey and Report, 2014, pg. A-2 http://www.wrd.org/May_2014_ESR.pdf

[132] Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 6, 11.

[133] UWMP – 1980; volumes from Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P. 10

also has some ability to transfer rights between WCB and CB, which we will examine further in the following report on Dominguez Channel.

Opportunities to increase storage capacity water in WCB and CB also could be obtained by increasing either water storage for later extractions under the new adjudication amendments or in-lieu water rights. These will be discussed in more detail in the following report on Dominguez Channel to more fully include the changes under the newly amended judgments, such as transitioning the watermaster from CA DWR to a watermaster comprised of the WRD, a Water Rights Panel, and a Storage Board (Figure 22).

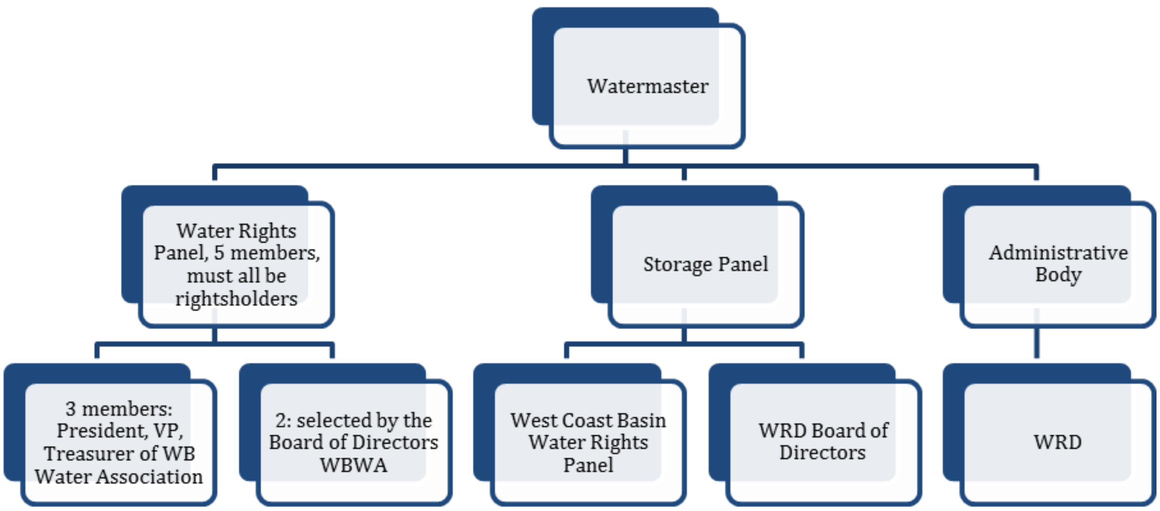


Figure 22: Structure of the watermaster under the recently amended WCB adjudication.

In addition to defining the volume of available storage space in WB, current amendments allow rights holders to store and extract water above their adjudicated rights. In WB, extractions are capped at 120% of rights annually and in CB, extractions are capped at 140% of rights, but in both basins you can petition the newly formed storage board to extract a greater volume of water. With the new amendments to WCB judgment, the City could store as much as 5,260.50 AF with special storage panel and watermaster approval (plus 300.60 AF carryover initially, but the carryover right would cease to exist once the City begins pumping its allotted rights from this basin) (Table 13). Before this judgment, the City had access to a total of 1,803.60 AF of rights (adjudicated + carryover). In CB, the City has 15,000 AF of adjudicated rights and 8,250 AF of carryover rights plus 5,000 AF of emergency extraction. These additional unused water rights in CB also offer opportunities to increase recharge and extraction of advanced treated recycled water from HTP. The City did not gain any additional storage rights in CB under the recently amended judgment although other basin rights holders will be able to store up to 200% of their adjudicated rights as in WCB. In 2012-2013, the City extracted only 6,310.08 AF from CB of the 23,250 AF they were allowed to extract, leaving almost 17,000 AF as unused balance (Table 14).[134] Opportunities to store water above this volume in CB will be explored further in the following Dominguez Channel Report. In addition, opportunities to store and extract water in 'No Man's Land' in CB, which is located immediately south of Hollywood Basin and roughly to the north of Martin Luther King, Jr. Blvd, will be investigated. 'No Man's Land' is located in the CA DWR-defined boundary but outside of WRD's jurisdiction.[135]

Table 13: City of LA water rights under the WCB and CB adjudications.

Basin	Adjudicated (AF)	Carryover (AF)	Additional storage (AF)	Emergency extraction (AF)	Total storage (AF)
WCB	1,503	300.60	3,757.50	n/a	5,561.10
CB	15,000	8,250	n/a	5,000	23,250

Total pumping by all rightsholders in both WCB and CB was approximately 20,000 AF below the total adjudicated rights / APA in FY 2012 – 2013 (Table 14).[136] Considering the unused balance, which is the allowable extraction (adjudicated rights + carryover + leases) minus the amount pumped and any in-lieu water, shows larger volumes of water left in the ground in FY 2012-2013. The balance of water left unused was approximately 35,000 AF and 60,000 AF in WCB and CB, respectively (Table 14).[137] These balances do not include the potential additional storage rights that are now possible under the third amended judgment for WCB and CB.

[134] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. October 2013. Table 1, P. 11

[135] Kennedy Jenks for LADWP, Feasibility Report for the Development of Groundwater Resources in the Santa Monica and Hollywood Basins (December 2011). p.3-3 http://www.m2resource.com/images/KJ_Feasibility_Studysmall.pdf

[136] Watermaster Service in the Central Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013.; Watermaster Service in the West Coast Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. P. 11

[137] Watermaster Service in the West Coast Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013

Table 14: Water rights (AF) left unused in FY 2012-2013 in WCB and CB

Basin	Party	Adjudicated Rights / APA	Allowable[138] Extraction	Amount Pumped	Unused Balance[139]
WCB	All parties	64,468.25	76,570.86	42,068.18	34,502
	City of LA	1,503	1,803.60	0	1,803
CB	All parties	217,367	259,508.82	196,261.73	61,067
	City of LA	15,000	23,250	6,310.08	16,939.92

Given the large volume of water rights that are currently not being extracted, there is the potential for rights holders within the basin to increase extractions and therefore increase demand for recharge water, which, for WCB and CB, could come from HTP or Ed C. Little WRF. The safe yield set by the adjudications, which determines the amount of water that can be extracted from the basin without producing an undesired effect such as groundwater depletion, land subsidence, or reduction of ecological base flows, is maintained based on injections or spreading of water of various sorts. This recharge water can come from MWD and/or other sources. In this scenario, the additional extraction volume would be coming from the injection of increased volumes of advanced treated wastewater from HTP and Ed C. Little WRF. At the same time, withdrawing more water requires the injection or spreading of more water to keep groundwater levels at sustainable levels and so could increase demand for advanced treated wastewater in WCB and CB.

Many large rights holders did not use all of their water rights within WCB and left a large balance of water in the ground in FY 2012-2013 (Table 15). These rights holders offer potential opportunities for the City to pursue increasing their ability to pump water from within WCB by leasing or buying rights from other rights holders. Consolidation of existing groundwater rights among larger users in adjudicated basins in Southern LA County is a fairly common occurrence. A recent study at UCLA found evidence of consolidation of rights among the 5 largest rights holders in all studied basins since the time of adjudication, which shows smaller parties may be able to sell and also possibly demonstrates an interest among larger parties in ensuring long-term

---

[138] Allowable extraction = adjudicated right + carryover + leases. Watermaster Service in the West Coast Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. P. 11

[139] Balance left unused in WCB and CB FY 2012-2013 (includes adjudicated rights, carryover, and leased rights). Balance = Allowable extraction – amount pumped – in lieu. Watermaster Service in the West Coast Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. P. 11

groundwater access or guaranteeing an increased ability to bank groundwater by increasing their rights.[140]

Another possibility to increase pumping may exist through offering in-lieu exchanges. For example, an opportunity to increase demand by roughly 10,000 AF in WCB is present because approximately that volume of water rights were not extracted by oil companies such as Tesoro, Mobil, and Phillips 66 in 2012-2013. The City may be able to do exchanges for this volume, or supply advanced treated water for the needs of the refinery in an in-lieu exchange for the 11,000 AF of water that these oil companies did extract in 2012-2013.[141]

Table 15: Selected water rights holders with relatively large volumes of adjudicated rights in West Coast Basin.142

Rightsholder	**Unused Balance (AF) FY2012-13**	**Adjudicated rights (AF)**
City of Torrance	2,436.76	5,638.86
CA Water Service Co	2,840.80	4,070
CA Water Service Co (Dominguez)	7,652.47	10,417.45
Golden State Water Co	2,878.26	7,502.24
City of Inglewood	3,175.39	4,449.89
City of Lomita Water System	1,370.61	1,352.00
Mobil Oil Corporation	2,018.87	2,596.40
Chevron	140	4,601.30
Phillips 66	2,478.92	6,170.00
Tesoro Refining / Marketing Co	5,688.42	8,741.00
Total	30,680.5	55,539.14

[140] Porse, Erik, Madelyn Glickfeld, Keith Mertan, Stephanie Pincetl (2015). "Pumping for the Masses: Evolution of Groundwater Management in Metropolitan Los Angeles" GeoJournal, pp 1-17.

[141] Watermaster Service in the West Coast Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. P. 11

[142] Watermaster Service in the West Coast Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013

As demonstrated in the two tables, and as laid out in the recent amendments, there is available storage space in WCB and CB to greatly increase the local storage of water in our groundwater basins. However, the ability of rights holders to store and extract water is highly dependent on both the written language in the basin adjudications and the interpretations and actions of the newly-structured basin Watermasters. In the following report on Dominguez Channel, we will explore these storage opportunities and restrictions in greater detail to determine the types of projects and volume of water that the city can access under the recently amended adjudications.

Over the long term, water augmentation projects such as adding mid-basin injection wells to increase potential recovery or working with other potable water users in the basin to develop new capacity are potential options to increase the reuse of recycled water.[143] Although it would not increase the reuse of recycled water, implementing more enhanced stormwater infiltration projects over WCB could also increase recharge into WCB. To date, there has not been a concerted focus to enhance stormwater recharge in the WCB. Opportunities also exist for indirect recharge to WCB through the injection of recycled water (from HTP effluent) into the CB through the creation of AWT facilities at HTP, expanded AWT at WBMWD or separate City of LA satellite treatment plants.[144] LADWP would also need to install pumping capacity in WCB as the closure of the Lomita wellfield in 1980 ended all LADWP withdrawals from WCB.[145]

In the following report on Dominguez Channel, we will continue to research this topic to identify the maximum capacity for storage and extraction of recycled water in WB and CB through existing adjudications and regional partnerships. We also will investigate the volume of water which can be sustainably injected and extracted into WB and CB as well as determine, where possible, which types of projects would allow the City of LA to retain or attain rights to "new" water it introduces into these basins. We will research to what degree increased extraction also would increase demands for recycled water at the WCBBP and where and what type of new wells should be installed. In addition, we will identify data gaps that are challenges to determining recommended approaches for these issues. Depending on the location of the wells, increased demand was estimated in the 2012 RWMP to be between 14,000 (12.5 MGD) and 18,000 AFY (16 MGD).[146] Opportunities to utilize in-lieu rights within and between basins also offer potential opportunities to increase the City's ability to extract water from each basin above their adjudicated rights. One example of a regional project to pump and treat the historic saltwater plume in WB is discussed further in the following sub-section. We also will delve further

---

[143] Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 11

[144] Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 12

[145] LADWP UWMP 2010, p. 132.

[146] Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 6, 11.

into the CB adjudication amendment to define additional potential storage capacity beyond the City's 15,000 AFY of adjudicated rights, if any.

b. Remediating Legacy Saltwater Plume in West Basin

Remediating the brackish water that is a result of historic seawater intrusion into WCB offers a huge opportunity for a regional project that would greatly increase the potential to inject more recycled water into WCB. Roughly 600,000 to 650,000 acre-feet of space in WCB is currently taken up by the saltwater plume.[147] This is around 10 times the annual adjudication rights in the basin and greater than the City of LA's annual water use and thus offers a very significant source of additional storage for fresh water as the plume is remediated. Desalters have been operating in the region since 1993. The Brewer Desalter currently produces 5,600 AF (5 MGD)[148] and there are plans to double the capacity at Goldsworthy from 2,800 AFY (2.5 MGD) to 5,600 AF (5 MGD).[149] Constructing numerous additional large regional pump and treat facilities among basin rights holders to address this plume would clean up this historical contamination, free up more space in the groundwater basin for freshwater, and greatly increase the demand for replenishment water (which could be advanced treated recycled water).

As discussed above, there are tens of thousands of AF of water rights that are currently going unextracted each year in WB and CB. In the following report on Dominguez Channel, we will investigate the opportunity to create a regional project among basin rights-holders that could also increase the City's ability to extract water from these basins. We will study how and when the City could exercise their pumping rights from WB in CB as well. A regional project to remediate the salt water plume could potentially also create a greater demand to replenish the basin through the WCBBP or elsewhere as brackish water is removed from the basin. In this scenario, the conjunctive use of the groundwater basin could be operated like a reservoir with constant flows of water going in and out of the basin. We also will assess the efficacy of aquifer storage and recovery (ASR) wells, which allow both injection and extraction through the same well. However, ASR wells could not be used with recycled water injection unless direct potable reuse (DPR) was legal or if the State Water Board offered a new regulatory pathway for use of ASR wells with advanced treated wastewater.

c. Exploring Opportunities in Santa Monica and Hollywood Basins

In addition to increasing the conjunctive use of West Coast and Central Basins, increasing the conjunctive use of the Hollywood and Santa Monica groundwater basins offers an additional

---

[147] WRD Memorandum, Report by the Groundwater Quality Committee: Saline Plume Update. Ted Johnson, September 24, 2009.

[148] http://www.westbasin.org/water-reliability-2020/groundwater/groundwater-recovery

[149] Initial Study Robert W. Goldsworthy Desalter Expansion Project (pdf) CH2MHILL for WRD. 2013 http://www.wrd.org/Goldsworthy-IS.pdf

opportunity to increase local water supply and potentially available groundwater storage space for the City of Los Angeles and other cities in the watershed. As discussed above, the city of Santa Monica is currently extracting groundwater from three of the five subbasins within the Santa Monica groundwater basin, Arcadia, Olympic, and Charnock, but is not extracting any groundwater from the remaining two subbasins, Coastal and Crestal. The city of Beverly Hills is currently extracting groundwater from the Hollywood Basin. In both basins, private pumpers also are withdrawing groundwater for irrigation and industrial uses.

The safe yield of the Santa Monica Basin (including only Charnock, Arcadia, and Olympic subbasins) has been estimated at between 7,500 AFY and 12,400 AFY[150] and the safe yield of the Hollywood Basin has been estimated at between 3,000 and 4,400 AFY.[151] Safe yields have not been identified for either the Coastal or Crestal subbasins individually. Opportunities to increase groundwater production were identified in a 2011 report looking at the potential development of groundwater resources in the Santa Monica and Hollywood Basins for LADWP (KJ report); results from the KJ report will be discussed briefly below. Please see full report for more detailed information on these scenarios.[152]

To assess the potential additional groundwater capacity in Santa Monica Basin, the KJ report assumed that the 12,400 AFY safe yield of Charnock, Arcadia, and Olympic subbasins would be fully utilized by Santa Monica once they have achieved their goal of 100% local water by 2020 and therefore no additional capacity was available in the subbasins. 2,000 AFY of additional potential groundwater extraction from either the Coastal or Crestal subbasins was assumed for planning purposes in the KJ report[153] and is discussed here (Table 16). However, conducting a groundwater study to determine the maximum operational safe yield in all five Santa Monica Basin subbasins, including quantifying both manmade and natural recharge potential, is critical to ensure they are utilized to their full potential. Water quality constraints also were assessed in the subbasins as part of the KJ report. In the Crestal subbasin, water quality parameter assumptions were based on adjacent basins; overall TDS was 900 mg/L, taste and odor compounds were present, and iron and manganese were present above secondary maximum contaminant levels and would require removal.[154] In the Coastal subbasin, the assumed water quality parameters were as

---

[150] Feasibility Report for Development of Groundwater Resources in the Santa Monica and Hollywood Basins, prepared for LADWP by Kennedy / Jenks Consultants. December 2011. (Kennedy / Jenks Report) *Available at*: http://www.m2resource.com/images/KJ_Feasibility_Studysmall.pdf P. 2-17

[151] Kennedy / Jenks Report P. 2-22

[152] Kennedy / Jenks Report (All)

[153] Kennedy / Jenks Report P. 2-29

[154] Kennedy / Jenks Report P.5-17

follows: overall TDS was 1,800 mg / L, no VOCs, and iron and manganese were present at treatable levels. [155]

The city of Beverly Hills pumped approximately 800 to 1,400 AFY of groundwater from the Hollywood Basin for their water supply, leaving 1,600 to 3,600 AFY of the estimated safe yield of the Hollywood Basin potentially available for additional extraction.[156] (Table 16) The most productive groundwater wells are in the northwest corner of the basin, going as deep as 600 to 800 feet with production rates between 700 and 1,200 gallons per minute (GPM) as compared to those in the southwestern and eastern portions of the basin in which wells average 200 to 400 feet deep with production rates less than 400 GPM.[157] It is important to note that approximately 5,900 AFY flows from the Hollywood Basin southward into the Central Basin and rigorous studies and careful coordination among partners in this basin would be critical to ensure that increasing groundwater production in the Hollywood Basin does not result in negative impacts to the Central Basin. The KJ report identified potential projects to extract either 2,500 AFY or 3,000 AFY over either six or 10 months per year to allow for seasonal demand.[158] A potential partnership opportunity was identified between the city of Beverly Hills and LADWP through which these projects could be implemented. As the existing Beverly Hills treatment plant could treat as much of two times the current flow, LADWP could fund new groundwater wells and then route the water through the existing treatment plant and into the existing LADWP system.[159] Water quality concerns were also assessed through this process (TDS, iron, manganese, arsenic, color, and odor for this potential project) and potential treatment trains identified to bring the water up to potable standards.[160]

---

[155] Kennedy / Jenks Report P. 5-16

[156] Kennedy / Jenks Report P. 2-30

[157] Kennedy / Jenks Report P. 2-19

[158] Kennedy / Jenks Report P. 2-30

[159] Kennedy / Jenks Report P. 3-3

[160] Kennedy / Jenks Report P. 5-18

Table 16. Estimated storage, safe yield range, pumpers, pumping volumes, and volumes potentially available for extraction as estimated in the KJ report.

Groundwater basin	Estimated storage in basin	Safe yield range (reviewed in KJ report)	Pumper	Volume	Potentially available for extraction
Hollywood	400,000 AF[161]	3,000 to 4,400 AFY	Beverly Hills	800 to 1,400 AFY	1,600 to 3,600 AFY
			Private	unknown[162]	
Santa Monica	1,100,000 AF	7,500 to 12,400 AFY	Santa Monica	12,400 AFY (in 2020)[163]	2,000 AFY[164]
			Private	unknown[165]	

Finally, the KJ report identified the cost per acre foot of the various groundwater projects identified In the Hollywood Basin and the Coastal and Crestal subbasins as well as qualitatively assessed non-economic factors such as uncertainty, aesthetics, access, community impacts, and environmental impacts to identify the best projects with which to move forward.[166] The cost per acre foot ranged between $433 and $1,348 across all identified projects. Although the cheapest identified project was the Pan Pacific Park project, with a cost range per acre foot between $433 and $614, the non-economic impacts were fairly negative (impacts of well construction, limited site access).[167] Therefore, moving forward with the next lowest cost project, the Venice Reser-

[161] United States Geological Survey (USGS). 2003. Water Resource Investigation Report 03-4065. Geohydrology, geochemistry, and ground-water simulation – Optimization of the Central and West Coast Basins, Los Angeles County, California. Cited in: Chapter IV-Groundwater Basin Reports. Los Angeles County Coastal Plain Basins-Hollywood Basin. MWD. P. IV-6-4. September 2007.

[162] Private wells for irrigation and industrial use are known to exist but no available records on usage. Kennedy / Jenks Report P. 2-16

[163] 12,400 AFY is estimated safe yield from Charnock (8,200 afy) and Arcadia / Olympic (4,200 afy) from 2010 PBS&J Water Supply Assessment. Cited in Kennedy / Jenks Report P. 2-17

[164] Coastal and Crestal subbasins only as Arcadia, Charnock, and Olympic were considered fully utilized by Santa Monica's projected groundwater use in 2020 in the Kennedy Jenks report for LADWP.

[165] Private wells for irrigation and industrial use are known to exist but no available records on usage. Kennedy / Jenks Report P. 2-16

[166] Kennedy / Jenks Report P.8-1, 8-2

[167] Two potential Pan Pacific Park projects were identified within the Hollywood Basin Pan Pacific Park site. Both projects include a minimum spacing of 450 feet, the treatment facility was sited in a lower use area at the south end of the park, and treatment consists of pressure filters for iron and manganese removal, GAC vessels, and a 2,600 square-foot chemical building. The first project, with a 10-month operational scenario, would consist of six wells with a 380 gpm capacity and a finished water capacity of 3,000 AFY. The second project, with a 6-month opera-

voir Park site at $889 to $1,015 / AF but with fewer non-economic impacts (impact on site aesthetics was only negative ranking)[168], may be the better choice. This illustrates the importance of including noneconomic factors in considering potential projects as it is one method of including externalities in the project cost as well.

Further study to characterize the current operational safe yield of these basins would likely yield opportunities to increase production beyond the estimates in the KJ report. Groundwater recharge estimates in both Santa Monica and Hollywood Basins from the KJ report were higher than those calculated in 2003 (Table 17). The KJ report approach included separate estimates for pipe leakage, direct rainfall, and irrigation return flow rather than the 2003 USGS approach, which had one estimate for uniform surficial recharge. While groundwater recharge does not directly relate to safe yield, the higher groundwater recharge numbers in the more recent research provides an indication that the safe yield of these basins may be higher than the currently used estimates. Further, these estimates do not include the potential manmade recharge that could result through additional stormwater capture and infiltration BMPs, Low Impact Development infiltration requirements for new and redevelopment, infiltrated grey water used for irrigation, or infiltration or injection of recycled water. Quantifying and including these volumes could result in a higher operational safe yield that would allow increased production from the groundwater basins without resulting overdraft. Accurately quantifying the volumes of groundwater being produced from the Hollywood and Santa Monica Basins by both public and private pumping entities is critical to accurately assessing a sustainable operational safe yield.

Table 17. Groundwater recharge estimates in a 2003 USGS study and in the KJ report.

Groundwater Basin	**Assessed GWR (USGS 2003)**	**Assessed GWR (KJ report)**
Hollywood	5,900 AFY	8,241 AFY
Santa Monica	13,100 AFY	21,564 AFY

The Santa Monica and Hollywood groundwater basins offer a unique opportunity to develop regional partnerships to maximize the conjunctive use of groundwater outside of the restrictions of a pre-existing adjudication. It is critical for all parties to work together to stay informed on all

tional scenario, would consist of nine wells with a 360 gpm capacity and a finished water capacity of 2,500 AFY. Kennedy / Jenks Report P. 7-4

[168] Two potential Venice Reservoir projects were identified within the Venice Reservoir site in the community of Mar Vista. Both projects include a minimum well spacing of 420 feet, a treatment facility in the southeast corner of the park, and treatment consisting of an RO system and 3,800 square-foot chemical building. The first project, with a 10-month operational scenario, would consist of four wells with a 450 gpm capacity and the second project, with a 6-month operational scenario, would consist of six wells with a 500 gpm capacity. Both projects have a production capacity of 2,000 AFY. Kennedy / Jenks Report P. 7-25.

current projects in the groundwater basin to identify the projects which provide the most benefits and which projects are best implemented through collaborations. For example, one of the constraints on groundwater production in the Coastal subbasin is the risk of seawater intrusion, which through groundwater flow patterns, could also impact Charnock subbasin.[169] There is a need for studies to assess whether the injection of advanced treated recycled water from HTP (or water from other potential sources) along the Coastal subbasin as a seawater intrusion barrier would enable the sustainable extraction of more groundwater from Santa Monica subbasins for use in local water supply.

In 2009, Beverly Hills commissioned a study exploring the possibility of developing shallow groundwater wells to increase the groundwater component of their water supply and increase the flow through their water treatment plant.[170] Current groundwater levels in Beverly Hills are high enough that active dewatering sumps, which collect groundwater, pump it to the surface, and then discharge it to a nearby storm drain (under a NPDES permit), are required at some properties. Data from two properties with sumps near the shallow groundwater well study site were collected; average flow volumes at one site between 2002 and 2007 were between 210,000 and 290,000 gallons per day and two days of initial monitoring data from the other site had average daily volume of 431,000 gallons per day and 443,000 gallons per day.[171] Further research into available information on flow volumes of groundwater currently being discharged to storm drains through dewatering could help identify opportunities to establish partnerships to capture and use this water rather than sending it through the storm drains and out to the ocean.

---

[169] Kennedy / Jenks Report P. 2-26

[170] Richard C Slade and Associates LLC, Hydrogeologic Feasibility Study and Preliminary Design Report for Development of Shallow Groundwater Near Water Treatment Plan. Prepared for the Public Works Department City of Beverly Hills. January 2009.

[171] Richard C Slade and Associates LLC, Hydrogeologic Feasibility Study and Preliminary Design Report for Development of Shallow Groundwater Near Water Treatment Plan. Prepared for the Public Works Department City of Beverly Hills. January 2009.

IV. Wastewater and Recycled Water

A. Introduction

Recycled water is a valuable resource that can be used to increase Los Angeles's independence from imported water. Potential uses of recycled water include irrigation, industrial uses, groundwater recharge and Indirect Potable Reuse, and environmental enhancement. The California SWRCB has set goals (Figure 23) through its recycled water policy to increase the use of recycled water by 869,000 AFY by 2020 and 1,169,000 AFY by 2030 (over 2002 levels).[172]

Year	Actual Surveys)	Goal (Strategic Plan/ Recycled Water Policy)	Mandate (Recycled Water Policy)
1970	175,220	-	-
1977	183,941	-	-
1987	266,559	-	-
2001	525,460	700,000	-
2009	669,157	-	-
2010	-	1,000,000	-
2015	-	1,250,000	-
2020	-	1,500,000	869,000
2030	-	2,525,000	1,169,000

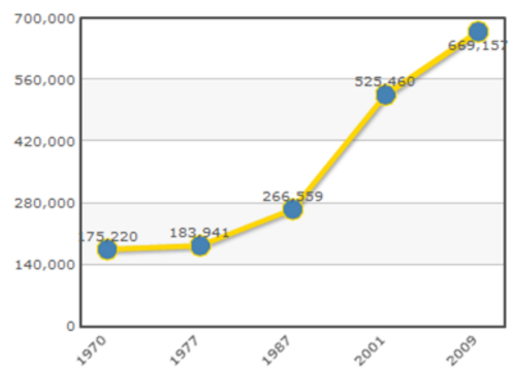


Figure 23. Showing actual amounts of recycled water used in CA between 1970 and 2009 and goals set by the Strategic Plan and Recycled Water Policy.[173]

Locally, the City has set several goals to increase the use of recycled water within its boundaries. The most recent goal and current target is to use at least 59,000 AFY of recycled water as part of its local water supply portfolio by 2035[174] through a combination of expanding the recycled water distribution system to supply non-potable reuses and the use of purified recycled water to replenish groundwater basins. Currently, NPR and barrier supplement in the Dominguez Gap Barrier consume about 8,000 AFY of recycled water and projects in development represent an additional 11,350 AFY of demand.[175] The focus through 2035 is on developing the additional 39,650 AFY required to meet plan goals through implementing projects that will result in 30,000 AFY from groundwater recharge (GWR) and 9,650 AFY from assorted NPR uses.[176] Beyond

[172] SWRCB FY 2012-2013. http://www.waterboards.ca.gov/about_us/performance_report_1011/plan_assess/12514_ww_reclamation.shtml

[173] SWRCB FY 2012-2013. http://www.waterboards.ca.gov/about_us/performance_report_1011/plan_assess/12514_ww_reclamation.shtml

[174] UWMP, Ch. 4, p.81, 2010

[175] Non-Potable Reuse Master Planning Report Executive Summary, p. ES-1, March 2012

[176] Non-Potable Reuse Master Planning Report Executive Summary, p. ES-1, March 2012

the 2035 goals, an additional goal described in the LTCR is offsetting imported water to the maximum extent possible by 2085 (up to 168,000 AFY based on MWD level used in the LCTR). In an executive directive issued in late 2014, Mayor Garcetti identified an additional goal for recycled water: converting 85% of public golf course acreage to recycled water by 2017.[177]

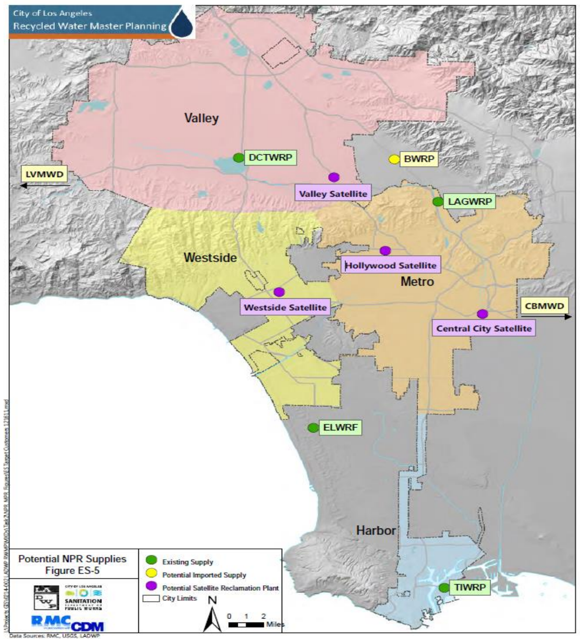


Figure 24. Map from 2012 RWMP depicting wastewater service areas for 4 City-owned WRPs

To further these goals, the City has conducted extensive research to identify potential projects and create plans to guide the process of increasing the use of recycled water in a manner that is both cost-effective and consistent with local, state, and federal environmental regulations. Some examples of recent reports with detailed goals for increasing the reuse of recycled water include the Urban Water Management Plan (UWMP), the Recycled Water Master Plan (RWMP), and the Water Integrated Resources Plan (IRP). The 2012 RWMP was divided into three reports, focusing on non-potable reuse (NPR) opportunities, groundwater replenishment (GWR) opportunities, and long-term opportunities to maximize recycled water reuse beyond 59,000 AFY and past 2035. More specifically, the Non-Potable Reuse Master Planning Report (NPR Report) and the Groundwater Replenishment Master Planning Report (GWR Report) identify projects to meet the City's 2035 goals for recycled water reuse, and the Long-Term Concepts Report (LTCR Report) identifies opportunities to offset additional demand for imported water beyond 2035.

---

[177] Mayor Eric Garcetti, Executive Directive #5, Issue Date: October 14, 2014. Page 2.

Only the NPR Report and the LTCR Report identify goals for HTP, which is the City-owned treatment plant within the Westside Service Area (Figure 24). The WBMWD Edward C. Little Water Recycling Facility (Ed C. Little WRF) is also within the Westside Service Area. The NPR Report further defined two subareas within the Westside service area, the Westside-Westside System and the Westside-Westwood System; all existing recycled water infrastructure is present in the Westside-Westside System.

B. Recycled Water Policies and Regulations

Many policies and regulations apply to the use and distribution of highly treated recycled water in California. Title 22 and Title 17 are codified in the California Code of Regulations (CCR), and refer to treatment and effluent quality requirements for recycled water reuse and criteria to protect the public drinking water supply from contamination by recycled water reuse, respectively. Title 22 also specifies criteria to ensure the protection of public health which is enforced by the SWRCB and the RWQCBs. Treatment and effluent requirements specified in Title 22 vary depending on the proposed reuse, with the degree of public access and proximity to drinking water wells and food crops being main factors in determining which requirements apply. At a minimum, wastewater must undergo secondary treatment to produce oxidized and stabilized wastewater for reuse and may then be used for purposes specified in Title 22, such as irrigation of non-food-bearing trees. After undergoing tertiary treatment and disinfection, the uses allowed by Title 22 expand greatly to include irrigating parks and schoolyards and non-restricted recreational impoundment. Title 22 also specifies reliability requirements, recycled water quality sampling and analyses requirements, engineering reports to demonstrate compliance with requirements, and use area requirements.

Recycled water jurisdiction is under the SWRCB, and other agencies such as the California Department of Water Resources are also involved in encouraging water reclamation. CDPH adopted uniform water recycling standards for indirect potable reuse (IPR) by mid-2013 as required by Senate Bill 918. Since the water division of the CDPH is now part of the SWRCB, compliance assurance with the final regulations for groundwater replenishment using recycled water is a SWRCB responsibility. Further, CDPH was required to develop and adopt uniform water recycling standards for surface water augmentation (if these standards are found to be protective of public health by a panel of experts) and to provide a final report on the feasibility of developing regulatory criteria for direct potable reuse (DPR) by the end of 2016.[178] This is now the responsibility of the SWRCB.

Currently, recycled water for IPR through groundwater recharge must meet the following standards: <10 mg / L total N, and a 7 day median < 2.2 Total Coliform / 100 mL.[179] There are

[178] Senate Bill No. 918. September 30, 2010. http://www.leginfo.ca.gov/pub/09-10/bill/sen/sb_0901-0950/sb_918_bill_20100831_enrolled.pdf

[179] Regulations Related to Recycled Water. June 18, 2014 (Revisions effective on 6/18/14) P. 15

additional virus log kill requirements that are dependent on the treatment and disinfection technology used for wastewater. Further, the SWRCB must provide recommendations on a case-by-case basis for groundwater recharge projects using recycled water. Title 17 sets requirements to protect the water system through specification of minimum backflow prevention where there is potential for contamination to the potable water supply from the reuse of recycled water.

Guidance on recycled water use is provided in part through resolution 2009-0011 "Recycled Water Policy," which was adopted by the SWRCB in 2009. The Recycled Water Policy created uniform standards to guide RWQCBs in interpreting and implementing the Anti-Degradation Policy (SWRCB resolution No. 68-16, 1968) that would allow consideration of providing the "maximum benefit to the people of the State" along with water quality changes when permitting recycled water projects. The Recycled Water Policy requires agencies producing recycled water that is not being reused to make that water available to water purveyors on good terms and conditions, which may include sharing the costs of the recycled water supply and facilities.

The SWRCB Recycled Water Policy addresses landscape irrigation projects and recycled water groundwater recharge projects. Incidental runoff may be regulated by WDRs; projects must have an O&M plan to detect and correct leaks quickly, appropriately designed sprinklers, no irrigation during rain events, and sufficient volume in recycled water impoundments to prevent overflow unless a 25-year or greater storm event occurs.

The recycled water policy further requires that salt and nutrient management plans (SNMPs) must be completed and submitted to the RWQCB within five years for each groundwater basin and sub-basin in California replenished by recycled water to address the need to achieve or maintain compliance with water quality objectives and maintain the protection of beneficial uses. SNMPs must be designed to address local water quality concerns, include stormwater recharge to balance the typically higher nutrients and salts in recycled water. These plans are intended to be used to manage salt and nutrient issues regionally, and to manage all nutrient and salt sources to the groundwater basin, rather than solely managing these issues through imposing requirements on individual recycled water projects as they are proposed.

SNMPs must include a monitoring network to determine compliance with water quality objectives; CEC monitoring; goals and objectives for water recycling and stormwater recharge; identification of salt and nutrient sources, basin assimilative capacity, and the fate and transport of salt and nutrients; implementation measures; and an antidegradation analysis to ensure projects within the plan will not impair water quality beyond acceptable limits. Landscape irrigation projects can be approved without an anti-degradation analysis if the project is consistent with the SNMP and qualifies for streamlined permitting or by demonstrating that the project will use less than 10% of the assimilative capacity of the basin or sub-basin for salts and / or nutrients.

SNMPs in the Los Angeles Region are currently in various stages of development. The final version of the WCB and CB SNMP which pertains to groundwater basins relevant to the Ballona Creek watershed was submitted to the LARWQCB. A tentative Basin Plan amendment to "incorporate stakeholder-proposed groundwater quality control measures for salts and nutrients in the Central and West Coast groundwater basins of Los Angeles County" was presented at the February 2015 LARWQCB meeting and subsequently approved.[180] The contents and implications of the WCB and CB SNMP will be discussed in greater detail in the Dominguez Channel Report.

In addition, the LARWQCB adopted the Non-Irrigation General Reuse Order to promote recycled water use, streamline the permitting process, and delegate the administration of water reuse programs to local agencies as much as possible (Order Number R4-2009-0049, 2009). This general order is a region-wide general permit that covers Title 22 recycled water uses that present a low risk to the beneficial use of groundwater. Uses include industrial boiler feed, nonstructural firefighting, mixing concrete, dust control on roads and streets, flushing sanitary sewers, and industrial and commercial cooling or air conditioning that does not create a mist.

C. Current conditions

Watersheds and wastewater service areas are strongly linked together through flows of wastewater influent and effluent, treatment and supply of recycled water, and relationships to allow exchanges and sales of these different flows. These interrelationships offer huge opportunities to fully utilize recycled water within City boundaries as the relationships span regions with differing supply and demand opportunities, but can also provide challenges in finding ways to work together and to overcome differences among chartered responsibilities, jurisdictions, agencies, and governances. Figure 25 below demonstrates the interlinkage that already exists between the Westside Service Area and the Harbor Service Area through various agreements and established flow patterns. The focus of this section will be on the opportunities and challenges that exist in the Westside Service Area; the Harbor Service Area will be discussed in the following report on Dominguez Channel.

[180] http://www.wrd.org/saltnutrient/docs.html; http://www.wrd.org/saltnutrient/index.html

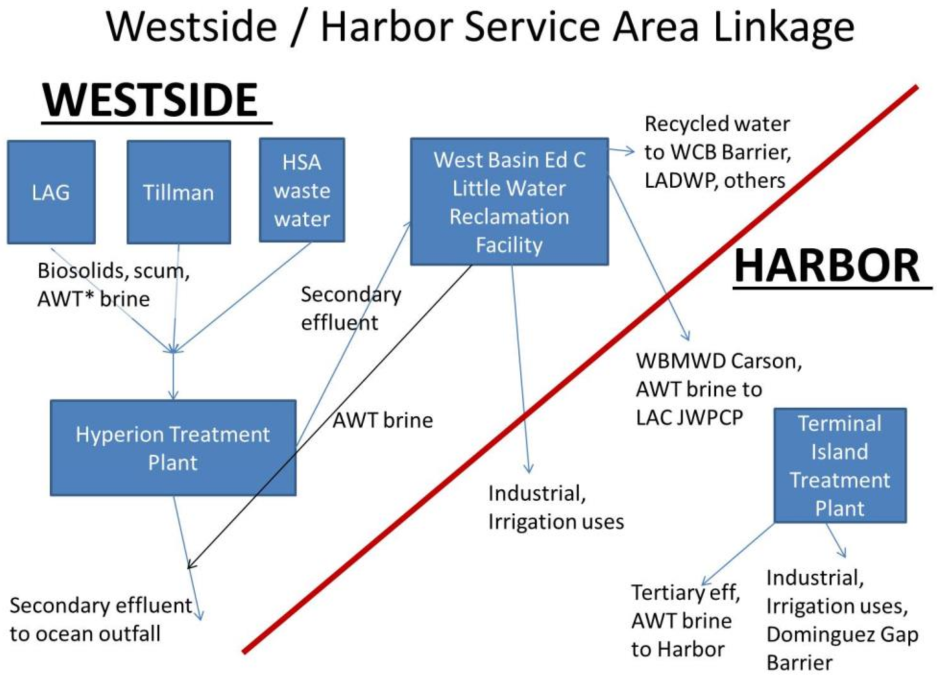


Figure 25: Linkages between Westside and Harbor Service Areas

HTP is located south of LA World Airport (LAWA) and west of El Segundo on a 144 acre site.[181] The Hyperion Service Area (HSA) treats wastewater from a tributary area of about 515 mi², with about 420 mi² within LA City.[182] All influent to HTP undergoes secondary treatment. HTP is also responsible for processing solids for the entire HSA, including the solids which are generated by the other two inland Water Reclamation Plants (WRP): the Donald C Tillman WRP (DCT) in Van Nuys and the Los Angeles-Glendale WRP (LAG) near Griffith Park (Figure 26). Both WRPs divert and treat raw wastewater from the system and return solids back to the system for treatment at HTP. In addition, sludge from the Burbank WRP is returned to the Burbank Sewer System to be treated at HTP,[183] but we will discuss this as part of the LA River watershed report. We will discuss the potential impacts on HTP effluent quality of treating additional brine generated through advanced water treatment at DCT and LAG in this report, but discuss the use of the recycled water produced at DCT and LAG in a future report looking at integrated water management in the Los Angeles River watershed where the produced recycled water is used. HTP further accepts dry weather urban runoff from 23 LFDs,[184] including 8 City LFDs, year-

[181] Wastewater Treatment TM Admin Draft, LTCR appendix P.11

[182] Wastewater Treatment TM Admin Draft, LTCR appendix P.11

[183] Hyperion NPDES 2010, p. 9

[184] http://www.lastormwater.org/blog/2015/06/outta-sight/

round except during a storm event that generates greater than 0.1 inch of storm runoff and the following three days as well as additional LA County and City of Santa Monica LFDs.

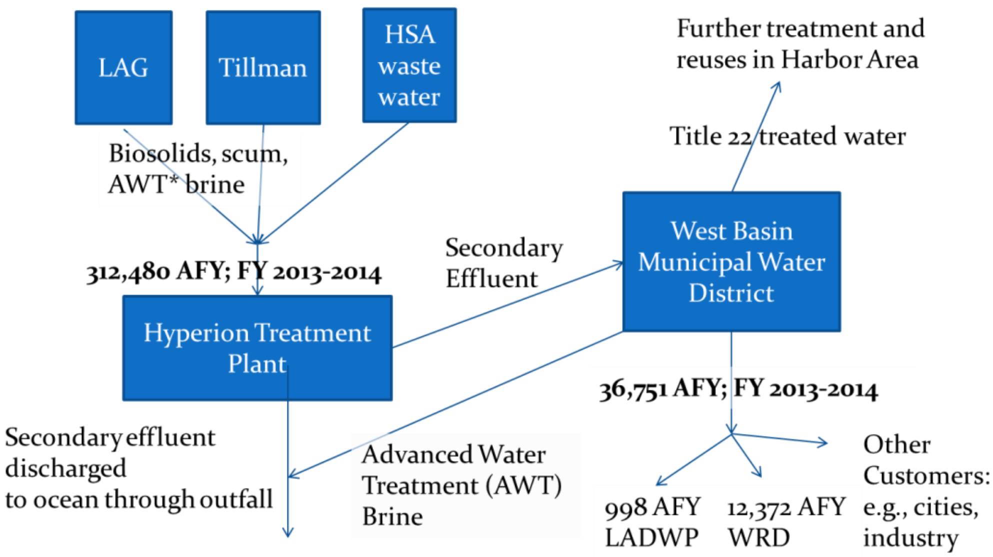


Figure 26: Hyperion Service Area and West Basin Municipal wastewater and recycled water flows.[185]

HTP is subject to both State waste discharge requirements and Federal NPDES permit requirements. Both the state and federal requirements are included in a single Order / Permit for HTP (RWQCB Order Number R4-2010-0200 and NPDES No. CA0109991), which specifies some secondary effluent goes to WBMWD for water reclamation.[186] WBMWD has both a WDR that serves as an NPDES permit and a Water Reclamation Requirements permit. Although HTP has a permitted average dry weather capacity of 450 million gallons a day (MGD) of influent, existing average flows in 2013 were 254 MGD[187] (279 MGD for FY 2013-2014). On an annual average basis as of 2009, approximately 90% of the HTP undisinfected secondary effluent is discharged through a 5 mile long, 12 feet diameter outfall pipe into the Pacific Ocean.[188] One hundred percent of the biosolids produced in the HSA are beneficially reused. In 2010, 91% of the biosolids were applied to agricultural land, 7.4% went to composting, and 1.6% was injected into

[185] HTP Recycled Water Table FY 2013-2014 279 MGD; WBMWD Water Use Report FY 2013 to 2014.

[186] Non Potable Reuse Regulatory and Practices TM, NPR Report Appendix B, March 2012, P. 18.

[187] Hyperion Annual Monitoring Report, 2013.

[188] Wastewater Treatment TM Admin Draft, LTCR appendix P.15

the earth to create biogas for energy through the Terminal Island Renewable Energy Project (TIRE).[189]

We assessed the current effluent concentrations of Ammonia as N, TSS, turbidity, and metals at HTP using monitoring data from January 2011 through September 2014.[190] These parameters were selected as they have the most significance for implementing integrated water management and impacting water quality. HTP is currently in compliance with permit effluent limits and is meeting designated performance goals. Currently, Pb levels have been non-detects (ND) or detectable but not quantifiable (DNQ). Annual average values for the 2013 calendar year are as follows for selected parameters: Ammonia as N, 40.88 mg / L; TSS 41,600 lbs / day or 19.58 mg / L; turbidity 8.4 NTU; Cu 10.75 µg / L; Zn 21 µg / L; Ni 4.93 µg / L; and Pb 0.16 µg / L (DNQ values only). Please see below charts for monthly averages of Ammonia as N (Figure 27), TSS (Figure 28), and turbidity (Figure 29) all; charts for all other parameters can be found in Appendix A.

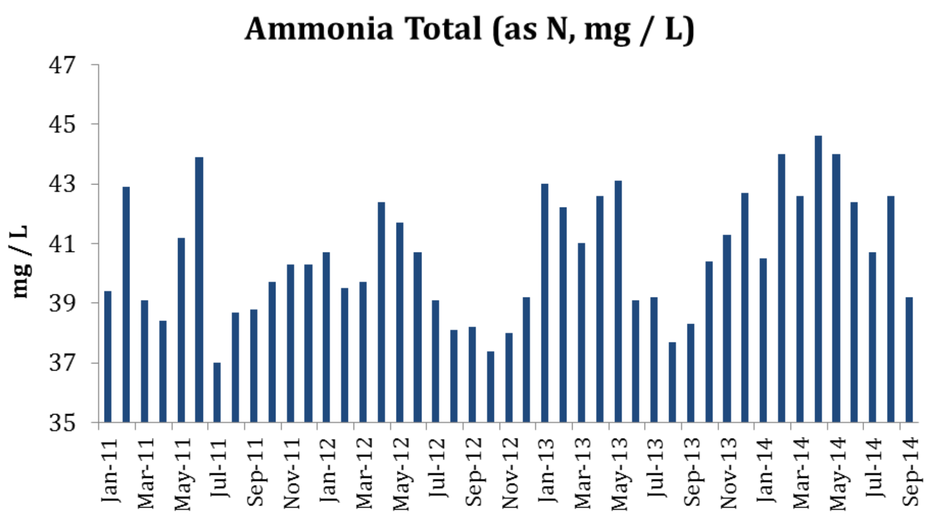


Figure 27: Monthly averages of Ammonia as N from January 2011 through September 2014. Performance goal in NPDES permit is 44. 1.

[189] GWR volume 3 of 3, RWMP, P. 28 of PDF

[190] https://ciwqs.waterboards.ca.gov/ciwqs/readOnly/CiwqsReportServlet?inCommand=reset&reportName=esmrAnalytical, Accessed November 2014.

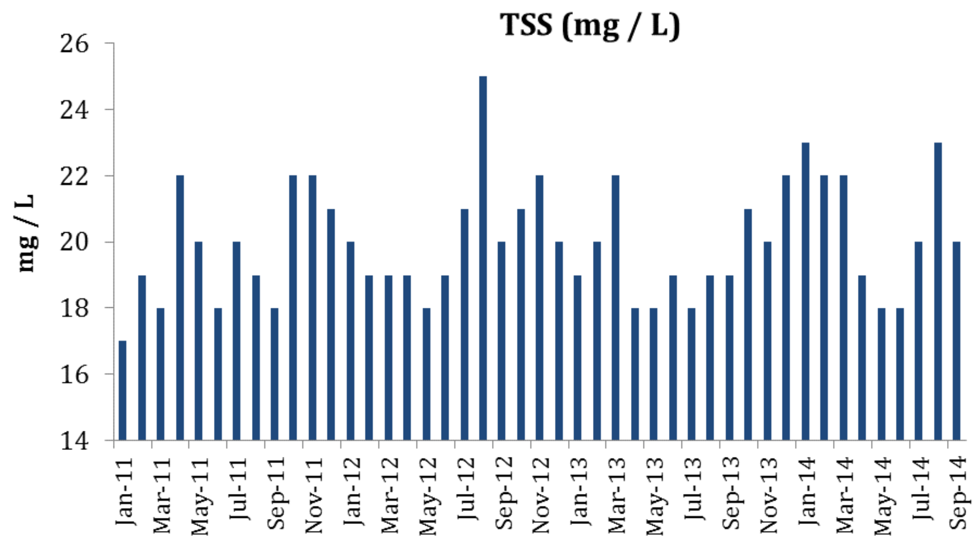


Figure 28. Monthly averages of TSS from January 2011 through September 2014. Effluent Limit in NPDES permit is 30.

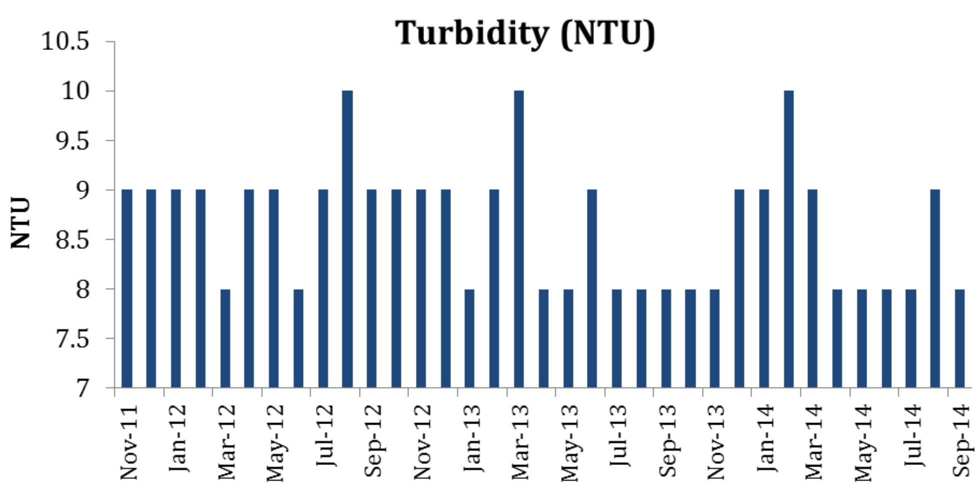


Figure 29. Monthly averages of Turbidity from January 2011 through September 2014. Effluent Limit in NPDES permit is 75.

HTP currently reuses roughly 12 MGD of treated wastewater on site (Figure 30), a portion of which goes to uses which would otherwise require potable water (for example, landscape irrigation). Further, HTP is planning to expand this onsite reuse as well as generate their own energy onsite through building a cogeneration plant that will use about 26 MGD of treated wastewater for cooling water.[191] This additional use will not be consumptive however, and those flows will remain available for further treatment and reuse as the capacity for advanced treatment increases on the West Side.

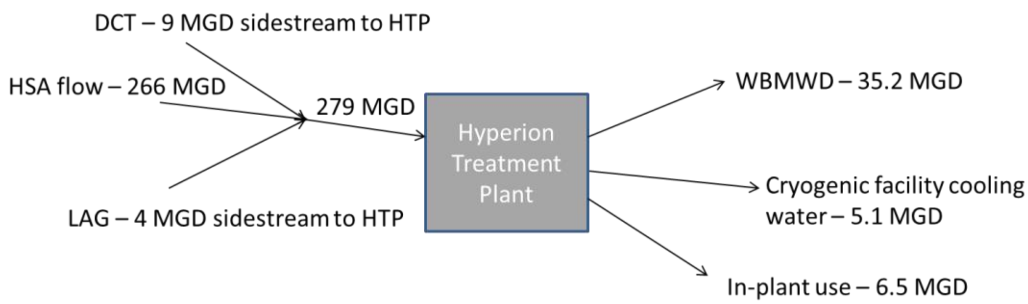


Figure 30. Conditions at HTP for FY 2013-2014.

Currently, HTP does not produce any advanced treated water on-site. WBMWD purchases HTP secondary effluent for further treatment to sell to other customers, including LADWP, who then sells that water back to customers in order to replace potable water use. WBMWD owns and operates two advanced water treatment facilities, the Ed C. Little WRF in El Segundo and the Carson Regional Water Recycling Treatment Facility (Carson Facility). Waste brine generated at the Ed C. Little WRF is discharged to the ocean off Palos Verdes via the HTP outfall and the brine generated at the Carson Plant is discharged to the ocean through the outfall at the Los Angeles County Sanitation District's Joint Water Pollution Control Plant.[192] In 2013, 32 MGD of secondary treated effluent from HTP went to WBMWD for advanced treatment and reuse to produce waters ranging in quality from disinfected tertiary effluent to advanced treated recycled water for a variety of uses. Advanced treated recycled water undergoes microfiltration (MF), reverse osmosis (RO) treatment, and ultraviolet disinfection/advanced oxidation with hydrogen peroxide. WBMWD supplies water to LADWP, cities, industrial customers, and to WRD for injection into seawater intrusion barriers.

Secondary effluent from HTP and further treated waters from the Ed C Little WRF are sold between LASAN, LADWP, and WBMWD as it goes through the process of being treated for reuse and then used. LADWP has a 25 year purchase agreement (expiring in 2016) with WBMWD for up to 25,000 AFY of tertiary-treated Title 22 recycled water for a cost that is no greater than the actual cost of treatment and distribution from WBMWD.[193] However, on aver-

[191] LASAN Recycled water fact sheet 2013-2014

[192] Non Potable Reuse Regulatory and Practices TM, NPR Report Appendix B, March 2012, P. 19

[193] *Agreement No. WR 10-1030 by, between and among, the LADWP, LADWP, BoS, and WBMWD for Recycled Water Service to the City of Los Angeles' Harbor Area*, page 2, http://www.westbasin.org/files/pdf/agendas/2011_01/Agenda%20No.%2024%20Exh%20D.pdf ; before the board Feb 1, 2011.

age, LADWP purchases less than 1,000 AFY from WBMWD. In the 10 year period between 2004 and 2014, sales of recycled water from WBMWD to LADWP have increased annually from 283 AFY for FY 2004-2005 to 998 AFY for FY 2013 to 2014.[194] Under this agreement, WBMWD pays $7.50 / AF to purchase secondary effluent from HTP.[195] WBMWD, LADWP, and DPW / LASAN also have an existing agreement in which DWP will purchase 9,300 AFY from WBMWD to supply the LA Harbor Area; any volume over that can be supplied from TIWRP or other sources, or through a new agreement with WBMWD.[196]

WBMWD also has an existing water purchase agreement (Agreement W1339) with the Water Replenishment District (WRD) that allows WRD to purchase up to 12,500 AFY for use at the WCBBP (~75% of the current demand). In 2009, WBMWD and WRD signed an amendment that allows WRD to purchase up to 17,000 AFY to fulfill 100% of the demand for infiltration at the WCBBP.[197] After the completion of the Phase V Expansion of Ed C Little WRF, "WRD will purchase the first 4,500 AFY at a rate based on actual cost to produce water that shall not exceed 95% of the WBMWD Tier 1 rate.[198]" The pricing structure from the original agreement, in which WRD pays a set price that increases by a set percentage annually ($20/AF increase for 2009 & 2010), will apply to the rest of the recycled water provided to the barrier up to a total of 12,500 AFY.[199] For fiscal year 2014-2015, pricing for the water up to 4,500 AF and the water provided above 4,500 AF is $1,112 / AF and $586 / AF, respectively.[200] In FY2012-2013, 7,761 AFY of recycled water was injected through the WCBBP.[201]

WBMWD began supplying recycled water to WRD to use for injection at the WCBBP in FY 1994-1995.[202] The initial permitting allowed the use of 5,600 AFY of recycled water for re-

---

Original agreement: "Agreement between the city of LA and WBMWD, for transporting secondary effluent from the Hyperion Wastewater Treatment Plant for Tertiary Treatment by WB and, thereafter, Beneficial Reuse of the Reclaimed Water" approved by LA board of water and power commissioners in Resolution No. 910344, C-83502.

194 WBMWD Water use report, FY 2013-2014. P. 42.

195 LTCR volume 3 of 3, RWMP, P. 151-152 of PDF

196 *Agreement No. WR 10-1030 by, between and among, the LADWP, LADWP, BoS, and WBMWD for Recycled Water Service to the City of Los Angeles' Harbor Area*, page 4

197 "Water Independence Now" projects ID'd by WRD – West Coast Barrier Seawater Intrusion to full recycled is one of them.

198 Joint Board WRD & WB Meeting Notes, Page 1, April 17, 2009.

199 Joint Board WRD & WB Meeting Notes, Page 1, April 17, 2009.

200 http://www.westbasin.org/files/finance/schedule-water-rates-fy-14-15-table.xlsx.pdf

201 Water Replenishment District of Southern California Engineering Survey and Report, 2012, pg. A-2, Table 1, p.44 (pdf)

202 Water Replenishment District of Southern California Engineering Survey and Report, 2014, pg. A-2 http://www.wrd.org/May_2014_ESR.pdf

charge[203], which was expanded to 8,400 AFY in 1997 (50% of total demand at that time).[204] In 2006, WDRs which authorized the expansion of the project up to 14,000 AFY (75% of total demand at that time) and included provisions for expansion to up to 19,600 AFY (120% of total demand at that time) if various requirements are met.[205] The completion of recent expansions at the Ed C Little water recycling facility will allow WRD to use 100% recycled water to prevent seawater intrusion at WCBBP, as long as there is an underground retention time of at least 12 months before extraction for drinking uses and a minimum horizontal separation of 2,000 feet between the injection wells and the nearest drinking well. Current WRD projections for FY 2014-2015 show 100% of the water demand (17,000 AFY) for the WCBBP being satisfied through recycled water and 0% through imported water. For FY 2012-2013, 7,761 AFY of WCBBP demand was satisfied through recycled water and 9,095 AFY through imported water (as compared to the FY2012-2013 projections of 13,500AF and 4,500AF, respectively).[206]

In the LADWP service area in 2012/2013, WBMWD sold only 968 AFY out of a total produced recycled water volume of 29,716 AFY.[207] This number represents an increase in demand from the 880 AFY of existing demand identified by LADWP and LASAN in the Westside service area in the NPR Report[208] but still represents only 3% of the recycled water sold through WBMWD (Figure 31). Although overall existing Westside Service Area demand has increased from that identified in the 2012 NPR Report, demand from some individual customers has decreased according to WBMWD recycled water sales numbers. Some existing customers which were counted as demand in the NPR Report were listed as zero demand, having less demand, or were not listed as an existing customer by WBMWD.[209]

---

[203] RWQCB Order No. 95-014, cited in Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 32.

[204] RWQCB Order No. 97-069, cited in Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 32.

[205] Order No. R4-2006-0009, cited in Long-Term Concepts Report, Appendix F, Regional Groundwater Assessment Technical Memo, November 25, 2009, P. 32-33.

[206] Water Replenishment District of Southern California Engineering Survey and Report, 2012, pg. A-2, Table 1, p.44 (pdf)

[207] West Basin Annual Report 2012/2013

[208] Non-Potable Reuse Master Planning Report, Appendix A, P. 47

[209] Existing demand listed in tables in: West Basin Municipal Water District Capital Implementation Plan, page 3-5, 2009 and Non-Potable Reuse Master Planning Report, Appendix A, P. 47

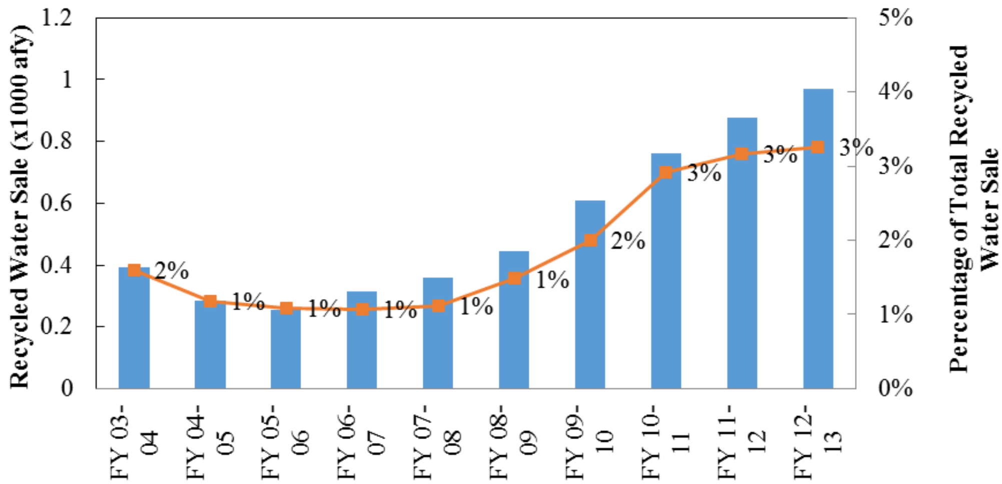


Figure 31: Volume and percentage of WBMWD total recycled water sold to LADWP.

The current recycled water system is served with tertiary-treated recycled water from Ed C. Little WRF, and provides an estimated annual demand of 884 AFY (Table 18).[210] There are 15 miles of existing recycled water pipeline in the Westside Service Area.[211] LADWP currently serves nine customers with recycled water in the Westside Service area, of which the majority (872 AFY) is currently used for landscape irrigation. HTP and Phase 1 of the Playa Vista Development also use recycled water in their dual plumbed systems for bathroom use. The four customers with the highest existing demand are the Westchester Golf Course (250 AFY), Playa Vista Development (200 AFY), Loyola Marymount University Phases 1 and 2 (125 AFY), and LAWA (160 AFY)[212] (Table 18).

[210] Non-Potable Reuse Master Planning Report (2012), Existing and Planned Recycled Water Systems, Appendix A, p. 47

[211] Non-Potable Reuse Master Planning Report (2012), Existing and Planned Recycled Water Systems, Appendix A, p. 51

[212] Non-Potable Reuse Master Planning Report (2012), Existing and Planned Recycled Water Systems, Appendix A, p. 47

Table 18. Existing LADWP Customers Recycled Water Demand

	Existing Demand-NPR (AFY)[213]	**Type**
Westchester Golf Course	250	Landscape
Playa Vista Development, Phase 1	189	Landscape
Playa Vista Development, Phase 1	11	Dual Plumbing
Los Angeles International Airport (LAX)	160	Landscape
Loyola Marymount University	125	Landscape
Hyperion Treatment Plant (HTP)	64	Landscape
Hyperion Treatment Plant (HTP)	1	Dual Plumbing
Westchester Park	30	Landscape
Central Regional Elementary School #22	25	Landscape
Carl Nielsen Youth Park	15	Landscape
Street Medians	5	Landscape
Scattergood Generating Station	5	Landscape
Coldwell Banker at Playa	3	Landscape
The Parking Spot	1	Landscape
Total	884	

Playa Vista is a 330-acre development in West Los Angeles that consists of residential properties, commercial office space, neighborhood retail shops, and community-serving uses located adjacent to the Ballona Wetlands and north of LAWA.[214] Using recycled water on the property at Playa Vista was a condition of development in the Environmental Impact Report, and estimated recycled water demand for Playa Vista Development Phase 1 is roughly 200 AFY.[215] The majority of this water is used for irrigation with a small amount being used for bathroom plumbing in commercial areas.

LAWA also receives recycled water from the Ed C Little WRF to use for irrigation. From 2004 to 2007, LAWA used between approximately 120 AF and 160 AF of recycled water each year to irrigate roughly 35% of its landscaped acres.[216] LAWA has also increased the presence of native and drought resistant vegetation in its landscaped areas by more than 50%.[217] Two ad-

[213] Non-Potable Reuse Master Planning Report (2012), appendix A, P. 47.

[214] Protecting the Ballona Wetlands in West Los Angeles: A Look Back at Three Decades of Urban Habitat Advocacy, Carlyle W. Hall Jr., Golden Gate University Environmental Law Journal, Volume 6, Issue 1, P. 21, 2012

[215] Non-Potable Reuse Master Planning Report (2012), appendix A, P. 47.

[216] Los Angeles World Airports Sustainability Report (2008), P. 7, 8

[217] Los Angeles World Airports Sustainability Report (2008), P. 9

ditional opportunities for future uses of reclaimed water are also currently present at LAX. One is the Sepulveda / Imperial Gateway Reclaimed Water Line, which WBMWD installed in 2010 to bring reclaimed water to the southern boundary of LAX. The other is the Antonio Villaraigosa Pavilion in the Tom Bradley International Terminal, which has piping for reclaimed water when it becomes available.[218] Westchester Golf Course is an 18 hole executive golf course located on LAWA property and operated by American Golf that has been using recycled water for irrigation since 2010. Water is delivered through a 24-inch recycled water pipeline under Manchester Boulevard.[219] Loyola Marymount University, Carl Nielsen Park, Westchester Park, Scattergood Generating Station, Coldwell Banker, The Parking Spot, and street medians all use recycled water for landscape irrigation purposes.

D. Possibilities

a. Increasing Advanced Water Treatment

Reuse of recycled water from HTP could be increased by increasing the production of advanced treated water through building treatment capacity at HTP or increasing the production capacity at WBMWD. FY 2013-2014 flows at HTP are at 279 MGD.[220] FY 2013-2014 recycled water sales from WBMWD are at 36,751 AFY(~33 MGD)[221]; plans at WBMWD describe scenarios to increase production to about 62 MGD (70,000 AFY) by 2020 with an ultimate described demand of approximately 73 MGD (82,300 AFY).[222] Currently, the West Basin NPDES permit only allows discharge of 4.5 MGD through Hyperion outfall so either this allowance would need to be increased or more brine disposed of through the JWPCP outfall or elsewhere to ramp up to treating larger than current volumes of secondary effluent at WBMWD.

It is important to keep in mind that the overall flow coming into the plant as well as decreasing flow rates can lead to decreased effluent quality and create the potential for operational issues during the treatment process. For example, if flow rates to HTP decrease below a certain level, the skimmers may not be able to contact the surface of the wastewater and would thus be unable to perform their function without additional maintenance or changes. Looking forward, flow rates may be impacted by increasing conservation, greywater systems, and even on-site wastewater treatment systems as codes and regulations are changed to allow or even require

---

[218] Los Angeles World Airports Sustainability Report (2011-2013) P. 15

[219] Los Angeles World Airports Sustainability Report (2010), P. 9

[220] LASAN Recycled Water Fact Sheet.

[221] WBMWD Water use report, FY 2013-2014. P. 42

[222] WBMWD. Capital Implementation Master Plan Chapter 8 Future Systems Analysis, p. 8-4, June 2009; http://www.westbasin.org/water-reliability-2020/recycled-water/master-plan

these systems to be built. Increasing flows at DCT from the current 44 MGD to full capacity of 80 MGD (Figures 32 and 33), if the flows are diverted from wastewater currently going to HTP, would result in a decrease of about 40 MGD at HTP from current levels. Increasing effluent flows to WBMWD for treatment would result in an additional reduction of water available for additional treatment at HTP to about 140 MGD (Figure 34). Future flow potentials should be considered to identify the appropriate locations and sizes of additional advanced water treatment capacity within the HSA.

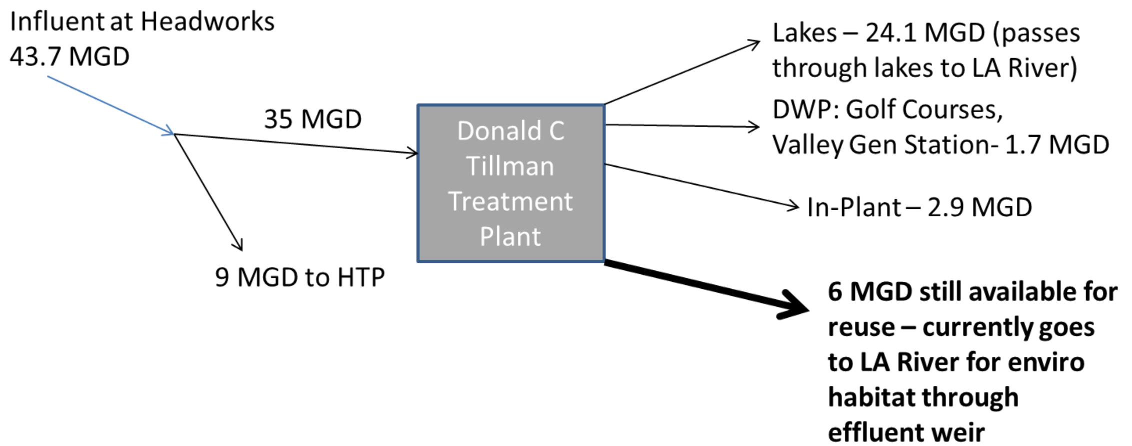


Figure 32: September 2014 flow balance at DCT

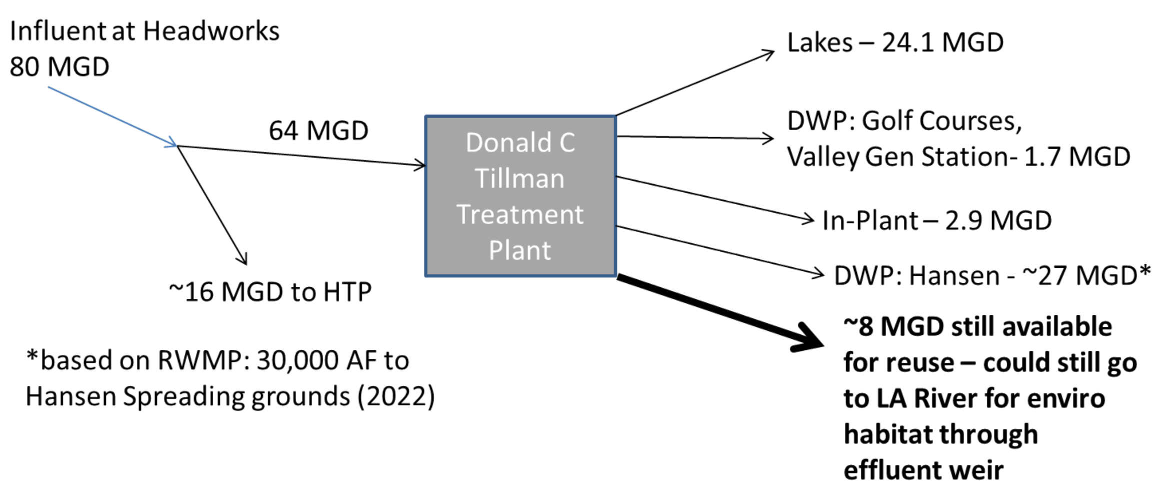


Figure 33: Future flow balance at DCT, from LASAN Fact Sheet 2014.

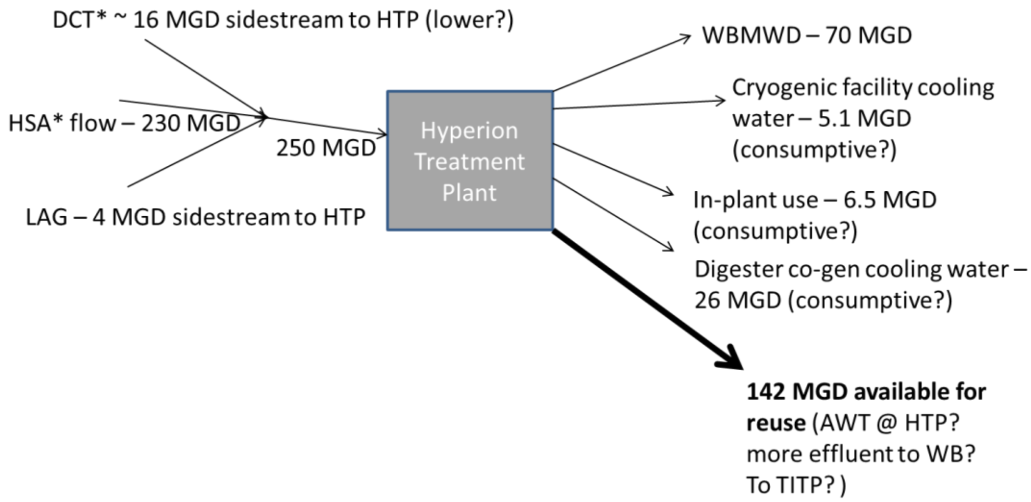


Figure 34: Future HTP flows.

At a minimum, nitrification-denitrification (NDN) capacity would need to be installed at HTP in order to obtain lower ammonia levels to maximize the potential for reuse at HTP, whether the treatment occurs on site or through WBMWD. The current levels of ammonia as N (40.88 mg / L 2013 calendar year annual average) in the secondary effluent from HTP are limiting the potential reuse of recycled water from HTP. Current customers have been experiencing water quality concerns due to the age of water in the pipes, and potential customers that are interested in using recycled water for cooling tower operations have expressed concern over ammonia concentrations.[223] Beyond that, there are alternative treatment pathways that could be installed at HTP depending on the existing demands that are the most practical to reach from HTP. One example would be to add membrane bioreactors (MBR) and disinfection treatment trains in order to get to Title 22 water quality (e.g., for non-potable reuse). Another option would be to install an advanced water treatment system in order to get to IPR water quality (e.g., for increased injection into groundwater through the WCBBP or elsewhere in the WCB or the CB).

An all- microfiltration - reverse osmosis (MFRO) scenario was chosen for future exploration both because that was the scenario explored in the RWMP and because demand for higher quality recycled water may be higher than demand for lower quality recycled water (e.g., Title 22). We will further examine this question in future reports as well as analyze potential costs and benefits of scenarios reusing different qualities of recycled water. The MFRO approach was also explored in the RWMP LTCR and these results are described below, followed by analyses conducted during this Ballona Creek Watershed work.

---

[223] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-256, I-279

Sufficient space was identified on-site at HTP to achieve 100% reuse (160 MGD) in the 2012 RWMP using MFRO with an assumed flow of 301 MGD. Available sites identified for the construction of facilities included 128 MGD of on-site production, 32 MGD of off-site production, and 30 MG of on-site equalization volume. Estimated total construction cost is $1.3 billion and estimated annual O&M cost is $84.2 million.[224] Assumptions in the RWMP included: average influent flows will not change very much by 2040 and so are projected remain around 301 MGD, 70 MGD of secondary effluent will go to WBMWD, the recycled water will be treated with MF and RO, worst-case recycled water recovery of 71% (89% for MF and 80% for RO), and flow of brine and MF residuals to HTP outfall at maximum recycled water production will be 65 MGD. RWMP calculations subtracted 6 MGD of in-plant consumptive uses and 70 MGD to WBMWD, leaving 225 MGD of secondary effluent available for advanced water treatment. Thus, using the 71% recovery rate, 160 MGD at HTP was established as a maximum recycled water production capacity. At this flow level, discharge from the outfall will remain high enough to avoid water intrusion into the outfall as long as brine streams are returned to the outfall and flow equalization is used. HTP outfall flow rates must remain higher than 20 MGD to avoid seawater intrusion into the plant.[225]

However, it is likely that the available effluent volumes leaving HTP will stay below the RWMP estimates using 301 MGD. HTP flows in 2013 were 254 MGD and flows for FY 2013-2014 were 279 MGD.[226] Flows through HTP could be reduced further if some of the increase of influent to DCT to the full 80 MGD capacity by 2035 assumed in the RWMP comes from diverting flows through DCT that are currently going straight to HTP. Increased flows through DCT are necessary in order to be able to meet both current needs (on-site uses, flows to the lakes and LA River) and the future need of sending influent to the advanced water purification facility when it comes online.[227] Additional existing wastewater reuse occurs currently at HTP through use as cooling water and, in the future, will also occur through a planned cogeneration plant.

Although space has been identified at HTP for increasing advanced water treatment, increasing the volume of brine generated by advanced water treatment plants in the HSA will increase the concentration of constituents in the discharge from the HTP coastal outfall. Advanced water treatment in the HSA will both increase the volume of brine and decrease the volume of secondary effluent available to dilute the brine through mixing in the outfall. As the production of advanced treated recycled water is increased, effluent concentrations must be monitored to ensure HTP remains in compliance with water quality requirements. These include effluent limits and

---

[224] LCTR RWMP, Volume 2 of 2, Appendix C, draft HTP opportunities TM with addendum (February 5, 2010), p. 42

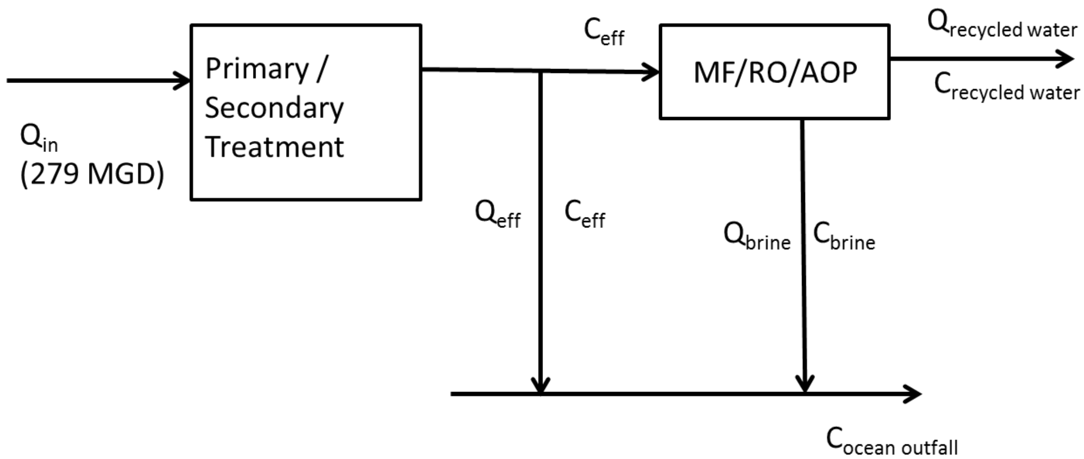
[225] LCTR RWMP, Volume 2 of 2, Appendix C, draft HTP opportunities TM with addendum (February 5, 2010), p. 36

[226] HTP Annual Monitoring Report

[227]GWR Executive Summary, RWMP Volume 1 of 3, P. ES-12

performance goals in the NPDES permit, anti-degradation requirements, and criteria to protect marine aquatic life in the California Ocean Plan. Whether brine is added to the system through discharge by upstream advanced water treatment plants or through the addition of advanced water treatment facilities at HTP, the additional brine will result in increasing concentrations of constituents that may require additional treatment processes to maintain the necessary effluent concentrations at the outfall.

In order to assess the levels of recycled water production at which concentrations of certain parameters in HTP effluent would exceed the limits and goals discussed above, we used the following assumptions in a mass / flow balance (Figure 35): average influent flows will remain around 279 MGD (FY 2013-2014 levels), the recycled water will be treated with MFRO, 97% of the constituents in the effluent end up in the brine volume based on the rejection rate of the membranes, and worst-case recycled water recovery of 71% (89% for MF and 80% for RO). We did not subtract the volume of effluent that is currently (32 MGD) or projected to be (73 MGD) going to WBMWD from the total available flow for HTP in these calculations. As some brine is currently discharged by WBMWD through the HTP outfall, we wanted to assess whether the total volume of brine that would be produced from treating the current flows through HTP could be discharged through the HTP ocean outfall, regardless of whether MFRO treatment occurred at WBMWD or HTP.



$Q_{rw}=0.71*(Q_{in}-Q_{eff})$

$Q_{brine}=0.29*(Q_{in}-Q_{eff})$

$C_{brine}=M_{brine}/Q_{brine}= (0.97*C_{eff}Q_{eff})/(0.29*Q_{eff})=(0.97*C_{eff})/0.29$

$C_{outfall}=(C_{eff}Q_{eff}+C_{brine}Q_{brine})/(Q_{eff}+Q_{brine})$

Figure 35: Flow diagram and equations used to determine brine flows and effluent quality as increasing volumes of MFRO produce water are generated.

Under these assumptions, maximum recycled water production using MFRO at HTP is 198 MGD. We examined effects on the concentrations of effluent for several parameters (Ammonia as N, TSS, Turbidity, Cu, Zn, Pb, and Ni) to determine the effects of increasing concentrations going through the outfall from increasing volumes of brine discharge on water quality compliance. Effluent concentrations (flows consisting only of brine at this stage as all flow undergoes MFRO) at the maximum production of advanced treated recycled water were as follows (Table 19): Ammonia as N 162 mg / L, TSS 65 mg / L, Turbidity 28 NTU, Cu 36 µg / L, Zn 70 µg / L, Pb: 0.5 µg / L, and Ni 16 µg / L (Table 19). TSS levels will exceed NPDES effluent limitations at the production of approximately 100 MGD of recycled water and Ammonia as N will exceed the California Ocean Plan standards at approximately 56 MGD of MFRO-treated produce water. Additional treatment processes or improving the efficiency of current treatment processes prior to any advanced treatment processes could remedy these exceedances and enable full production of MFRO water at HTP. Below graphs for TSS (Figure 36) and Ammonia as N (Figure 37) show the trends as the volume of brine is increased going through the HTP outfall, with current effluent limits / performance goals as a reference line.

Finally, concentrations of the above constituents in the combined discharge of effluent and brine were compared to limits in the California Ocean Plan after applying the dilution factor of 84 that the NPDES permit allows due to mixing with the ocean water at the outfall. With the dilution factor, the only parameter that exceeds an applicable California Ocean Plan limit is Ammonia as N and that happens at a production of approximately 56 MGD of advanced treated recycled water (Table 20). These high ammonia concentration results (up to approximately 160 mg/L), however, could be remedied by putting in an NdN process prior to any advanced treatment process. In general, total nitrogen levels in wastewater effluent drop to approximately 5 mg / L after an NdN process, and ammonia as N represents 10% of total N, leaving 0.5 mg / L of Ammonia as N in the effluent. Using a more conservative estimate of 10 mg / L of total nitrogen would give a value of 1 mg / L of Ammonia as N in the effluent. Using either 0.5 mg / L or 1 mg / L (Figure 38), Ammonia as N stays well below both the HTP NPDES performance goals and the California Ocean Plan Standards even at the max production of MFRO water from HTP.

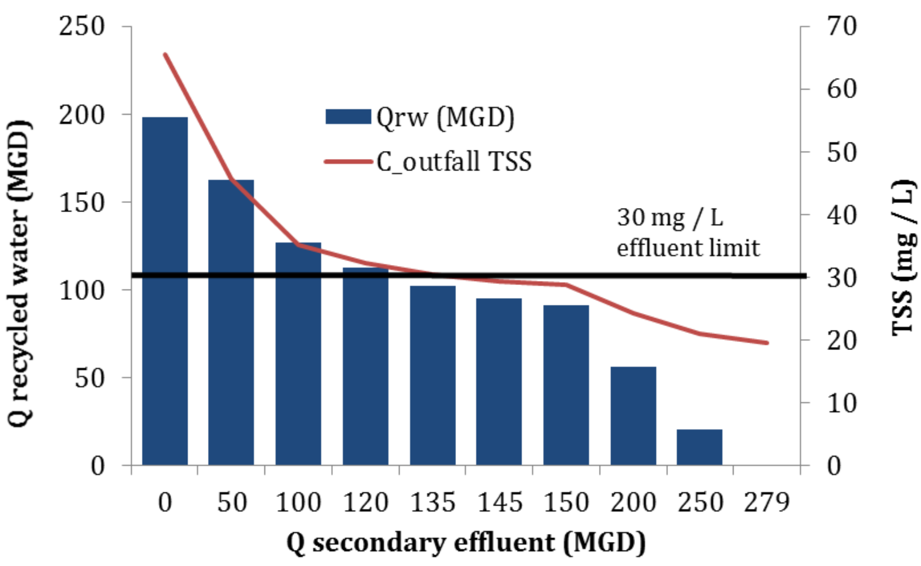


Figure 36: Levels of TSS in the effluent as recycled water production increases. TSS levels will exceed NPDES effluent limitations at the production of approximately 100 MGD of recycled water

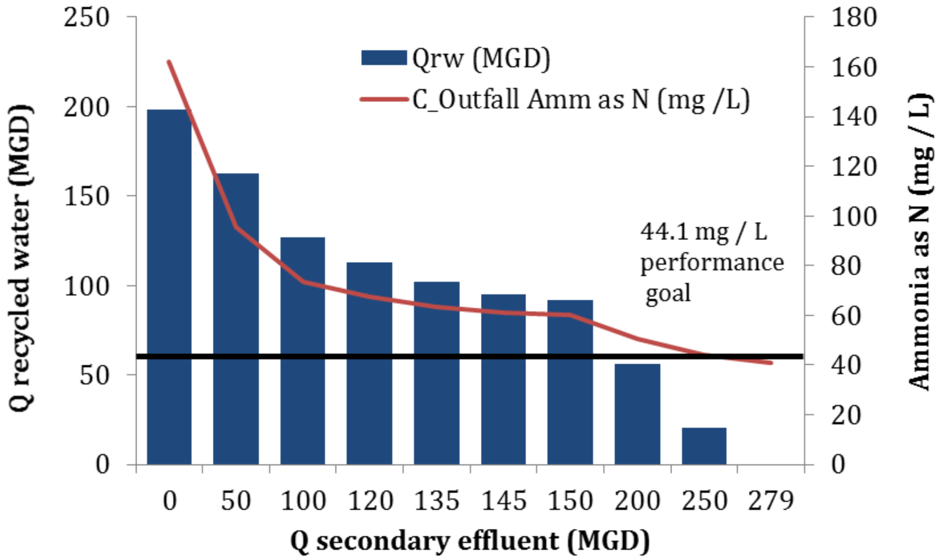


Figure 37: Levels of Ammonia as N in the effluent as recycled water production increases from current level of 40.88 mg / L. Performance goals for Ammonia as N are exceeded at approximately 56 MGD of MFRO-treated produce water.

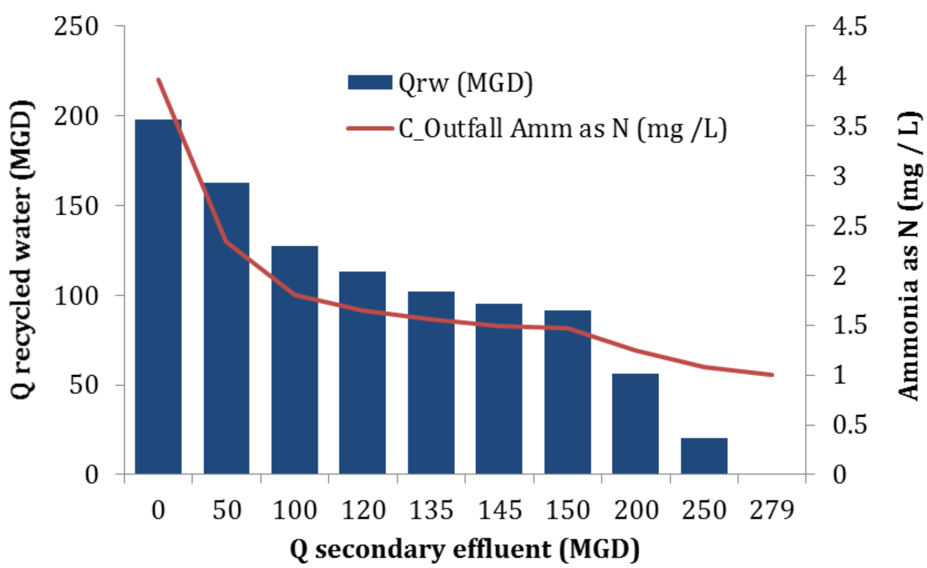


Figure 38: Levels of Ammonia as N in the effluent as recycled water production increases assuming NdN treatment brings Ammonia as N levels down to 1 mg / L. Performance goal for Ammonia as N is well below performance goal at 198 MGD, which is full production of MFRO-treated produce water.

Table 19: Parameters which exceed either the performance goals (PG) / effluent limits (EL) in the HTP NPDES permit or the concentrations to protect marine aquatic life in the California Ocean Plan based on current effluent concentrations. Red, bolded text denotes exceedances.

	NPDES limits	Effluent Concentration @ max MFRO water produced	CA Ocean Plan Limit (84 dilution factor.)	Ocean Concentration diluted 84x at max MFRO
Ammonia as N (40.88 mg/L) (2013)	44. 1 (PG)	162	0.6	**1.9**
Ammonia as N (1 mg/L) (with NdN)	44. 1 (PG)	3.96	0.6	0.05
Ammonia as N (0.5 mg/L) (with NdN	44. 1 (PG)	1.98	0.6	0.02
TSS (mg / L)	30 (EL)	**65**		
Turbidity (NTU)	75 (EL)	28		
Cu (µg / L)	25 (PG)	36	3	0.4
Zn (µg / L)	31 (PG)	70	20	0.8
Pb (µg / L)	10 (PG)	0.5	2	0.01
Ni (µg / L)	3 (PG)	16	5	0.2

Table 20: Red, bolded values exceed levels required to protect marine aquatic life in the California Ocean Plan (after applying HTP dilution factor at the outfall of 84). With addition of NdN treatment, California Ocean Plan requirements are never exceeded.

Secondary Effluent flow (MGD)	Flow MFRO produced water (MGD)	Concentration at Outfall of Ammonia as N (mg / L)	Dilution Factor	Concentration at Outfall of Ammonia as N (mg / L) after dilution factor	Ammonia concentrations with NdN treatment (1 mg / L Ammonia as N in effluent)
0	198	**162**	84	**1.9**	0.05
50	163	**96**	84	**1.1**	0.03
100	127	**74**	84	**0.9**	0.02
120	113	**67**	84	**0.8**	0.02
135	102	**64**	84	**0.8**	0.02
145	95	**61**	84	**0.7**	0.02
150	92	**60**	84	**0.7**	0.02
200	56	**51**	84	**0.6**	0.01
250	21	44	84	0.5	0.01
279	0	41	84	0.5	0.01

As can be seen from the above calculations, careful consideration of the effects on effluent quality of increasing volumes of brine resulting from advanced treatment on effluent quality is among the most pressing difficulties in need of resolution in order to expand the advanced treatment of recycled water. This is particularly the case for inland water treatment plants, and if brine from upstream plants in the HSA is also sent to HTP and discharged through the ocean outfall, the above scenarios will be exacerbated. Current disposal options for reverse osmosis brine include surface water discharge, deep well injection, evaporation ponds, and land application.[228] Brine disposal is site specific and requires consideration of brine quantity and quality, water quality goals, regulations, ecological situations, implementation costs[229], and many other factors.

As the flows of advanced treated recycled water increase from HTP or Ed C Little WRF increase, additional recycled water demand needs to be identified as well. As these plants are downstream from the majority of potential customers, it would be highly energy-intensive to pump advanced treated recycled water to individual customers upstream in the HSA. Promising opportunities to increase demand for this high-quality water include increasing groundwater recharge and extraction in the storage space in WCB and CB discussed above in the groundwater section through either the existing WCBBP or installing mid-basin wells. Another option, rather than adding advanced water treatment capacity at HTP, would be building satellite facilities upstream which would generate high-quality treated water near potential customers as discussed below.

b. Satellite Treatment Plants

The NPR report identified two regions of high demand for industrial and irrigation water in the Westside area, the Rancho Park Region (average demand 2.7 MGD) and the North Outfall Treatment Facility (NOTF) Region (average demand 0.6 MGD).[230] The Rancho Park facility would be fed by scalping raw wastewater flows from the sewer system, and the NOTF facility, which will be described further in subsection D, will be fed by Ballona Creek flows.[231] Treating an average demand of 2.7 MGD and the peak demand of approximately 5.4 MGD with an MBR / UV treatment trains requires a Rancho Park facility footprint of approximately 3.7 acres. Eight

---

[228] American Water Works Association (AWWA) Membrane Residuals Management Subcommittee, Committee Report: Current Perspectives on Residuals Management for Desalting Membranes, 2004.

[229] L. Malaeb, G.M. Ayoub, Reverse osmosis technology for water treatment: state of the art review, Desalination 267 (2011) 1–8.

[230] Non-Potable Reuse Master Planning Report (Feb 2010), Satellite Reuse Options TM, Appendix F, p. 39

[231] Non-Potable Reuse Master Planning Report (Feb 2010), Satellite Reuse Options TM, Appendix F, p. 40

potential sites have been identified as good candidates to house this facility.[232] The total annualized unit cost for treating water at this plant would be $1,070 / AF).[233]

Further, LASAN and LADWP have designed a plan to irrigate an additional 106 acres of turf with recycled water in order to meet the goal in the Mayor's Executive Directive of irrigating 85% of public golf course acreage to recycled water by 2017.[234] Currently 995 acres of turf on public golf course acreage are irrigated by recycled water (76%) of a total of 1,306 acres.

UCLA and the City have been looking into a possible satellite wastewater treatment plant on the UCLA campus that would divert some flow from the sewers for treatment and reuse on campus. The location under consideration would be at the corner of Strathmore Drive and Gayley Avenue. Sewage from the residence halls would be treated and the resulting water would be used as industrial water in the campus cogeneration plant. Which technology, what funding structure, and whether or not the City would partner at that site are still being considered. There has also been some discussion about the possibility of constructing California's first DPR facility at UCLA. Title 22-level water could be used for cogeneration plant cooling water, and advanced treated water with a buffer could potentially be used for DPR. Constraints to this approach include the lack of current DPR regulations, the lack of funding for the advanced treatment plant, and space constraints at UCLA. Sufficient external demand exists around UCLA satellite plant to place a larger plant than required to meet the demand at UCLA if sufficient available space can be identified to place treatment facilities. Among the potential customers near UCLA are the Hillcrest Country Club, LA Country Club, Bel Air Country Club, and the VA grounds and cemetery.

c. Expanding Non-Potable Reuse.

An extensive review of the existing potential for recycled water reuse was conducted as part of the LADWP and LADPW recycled water master planning process. In the Westside Service Area, potable demand is 24,000 AFY and non-potable demand is 12,000 AFY.[235] Customers with greater than 50 AFY of potential recycled water demand were identified as potential target customers that could anchor a WRP. On the Westside, 18 potential target customers were identified with the total estimated non-potable demand of 3,310 AFY (potable demand of these customers is 7,949 AFY). 12 customers with irrigation-only uses had an estimated demand of 2,255

---

[232] Non-Potable Reuse Master Planning Report (Feb 2010), Satellite Reuse Options TM, Appendix F, p. 45

[233] Non-Potable Reuse Master Planning Report (Feb 2010), Satellite Reuse Options TM, Appendix F, p. 45

[234] Mayor Eric Garcetti, Executive Directive #5, Issue Date: October 14, 2014. P. 2.

[235] Non-Potable Reuse Master Planning Report (2012), Market Assessment, Section 4, p. 4-10

AFY and six customers with potential mixed-use/industrial uses had an estimated demand of 1,055 AFY.[236]

The NPR report defines opportunities to increase demand by 608 AFY on the current Westside-Westside System, which is defined as WRPs that would build off the existing / planned system using water from Ed C. Little WRF.[237] The 608 AFY of additional demand is comprised of CalTrans at Playa Vista, Emerson Adult College, expanded use at LAWA, and expanded use at Phase 2 of the Playa Vista Development.[238] LAWA will expand its use to the cooling towers, with an estimated demand of 350 AFY and Playa Vista will use some of its estimated 200 AFY demand for dual plumbing. All other customers' estimated demand is for irrigation uses only. To complete this recycled water system expansion, 1.2 miles of additional recycled water pipelines need to be built to reach the LAWA cooling towers.[239]

In addition to identifying the existing and planned demand in the Westside system, the NPR report identified potential recycled water demands in the Westside-Westwood System, which is defined as WRPs that would serve large customers that are far from existing infrastructure in the northern half of the Westside Service Area.[240] Further development opportunities within the Westside service area in both the Westside system and the Westwood system were explored in the RWMP. Seven preliminary project opportunities were identified; the three WRPs with unit costs less than $2,000 / AF and the Penmar WRP were carried forward for further research. The WRPs that were not carried forward at this time were a WRP that would serve Bel-Air Country Club and Getty Museum (total demand 340 AFY, unit cost $2,200 / AF), a WRP that would serve Will Rogers State Park (total demand 85 AFY, unit cost $5,700 / AF), and a WRP that would have served Penmar Golf Course (total demand 125 AFY, unit cost $2,700 / AF). The WRPs that were carried forward were UCLA (total demand 2,650 AFY, unit cost $1,500 / AF). Kenneth Hahn (total demand 200 AFY, unit cost $1,700 / AF), and Laterals (total demand 125 AFY, unit cost $1,100)[241].

In the Westside system, two potential WRPs, Penmar and Laterals, were carried through. Nine potential customers representing 177 AFY of potential recycled water demand were identified around Penmar WRP, with the City-owned Penmar Golf Course as the potential anchor cus-

---

[236] Non-Potable Reuse Master Planning Report V 1 of 3 (2012), Market Assessment, Section 4, p. 4-11

[237] Non-Potable Reuse Master Planning Report (2012), Existing and Planned Recycled Water Systems, Appendix A, p. 50

[238] Non-Potable Reuse Master Planning Report (2012), Existing and Planned Recycled Water Systems, Appendix A, p. 50

[239] Non-Potable Reuse Master Planning Report (2012), Existing and Planned Recycled Water Systems, Appendix A, p. 51

[240] Non-Potable Reuse Master Planning Report Executive Summary, p. ES-23, March 2012

[241] RWMP, NPR report, Section 6: Systems Development, 2012, Page 6-25

tomer. Current potential customers at this site include high schools, recreation centers, and others. Estimated uses at this site are 172 AFY of irrigation demand and five AFY of next-use demand.[242] Penmar WRP was included despite the higher cost (total demand 150 AFY, unit cost $3,000 / AF), to be reanalyzed as an opportunity after LASAN's pending implementation of the Penmar Water Quality Improvement Project (WQIP) which will reuse dry and wet weather runoff for irrigation and reduce the potential demand for irrigation water at this site.[243] Penmar WQIP Phase I, the construction of a cistern, has been completed. Penmar WQIP Phase II, which includes the construction of an onsite stormwater treatment / disinfection system, is scheduled to be completed by December 2016.[244] For the Laterals WRP, 24 potential customers, which included hotels, schools, businesses, and parks, were identified within ½ mile of existing pipelines and representing an overall average annual demand of 390 AFY (unit cost $1,270 / AF).[245] A potential demand of 50 AFY for the cooling towers at Loyola Marymount University would serve as the anchor demand. Overall, customers at this location represent 92 AFY of industrial demand, 181 AFY of mixed-use demand, and 117 AFY of irrigation demand.[246]

Two potential WRPs were also identified in the RWMP for further study in the Westwood system, Kenneth Hahn State Recreation Area (Kenneth Hahn) and UCLA. It would be necessary to build a set of facilities, including pressure reducing valves, tanks, and pumps to provide sufficient pressure to service the intended customers at both Kenneth Hahn and UCLA WRPs.[247] Although both WRPs could potentially be supplied from the Inglewood connection, which is located at the Inglewood terminus and was initially designed to provide several thousand AFY to LADWP,[248] the UCLA scalping plant option described above is another viable option which is currently being explored. These systems would pass through other service areas and require construction of portions of the system outside of the City boundaries, which both offers the opportunity for cost-sharing if non-LADWP customers can be added to the system, and requires coordination with other local entities to move forward. Further, as WBMWD has potentially identified uses for its planned capacity to produce recycled water, available supplies (and pipeline capacity) through the existing system will need to be verified or opportunities to increase

---

[242] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-261

[243] RWMP, NPR report, Section 6: Systems Development, 2012, Page 6-26, Page 7-61

[244] Proposition O – Clean Water Bond Program, April 2015 Monthly Report, p. 29-30

[245] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-253

[246] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-255

[247] RWMP, NPR report, Section 7: Water Recycling Project Descriptions, 2012, Page 7-71

[248] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-275

recycled water supplies for installing advanced treatment at HTP will need to be identified in order to construct these WRPs. [249]

At the Kenneth Hahn WRP, seven customers, including three anchor customers, were identified that represent a total potential demand of 349 AFY.[250] Two of the anchor customers represent irrigation uses, Kenneth Hahn State Recreation Area (160 AFY) and Jim Gilliam Recreation Center (75 AFY); the final anchor customer, Plains Exploration and Production Company, represents industrial use (50 AFY). Estimated demand for irrigation is 299 AFY and for industrial use is 50 AFY. There is a potential opportunity to convert the existing oilfields into open space at such time as oil operations cease and that land becomes available for park acquisition.[251] If the "One Big Park" vision is implemented to create a two square-mile Park as described in the Baldwin Hills Park Master Plan, the resulting large recycled water demand for irrigation could help anchor this WRP. [252]

At the UCLA WRP, 40 potential customers, including 10 potential anchor customers, were identified with a total potential annual demand of 2,836 AFY (Table 21).[253] Of the 2,836 AFY identified demand, 335 AFY is for industrial uses, 1,371 AFY is for irrigation, and 1,130 AFY is for mixed-use.[254] The unit cost of the water would be $1,610 / AF.[255] Although the UCLA WRP has the highest potential demand of the WRPs identified in the NPR report, the closest anchor customers are more than 7 miles from the WBMWD Inglewood connection and the first 5 miles of the alignment is outside of the City so large capital investments and extensive coordination with other entities would be required to complete this WRP.[256] Also, as discussed above, LASAN is exploring the option of installing a satellite treatment plant at UCLA, which could affect the demand as identified in the NPR report.

---

[249] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-277

[250] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-265

[251] The Baldwin Hills Master Plan, executive summary. http://www.baldwinhillspark.info/plan.html

[252] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p. I-271

[253] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p. I-278

[254] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p. I-275

[255] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p. I-265

[256] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p. I-277

NPR demand at some of the golf courses and country clubs near the proposed UCLA WRP (Table 21) is lower than would be expected based on estimated demand at other local courses and the average use of golf courses (350 AFY)[257] due to the use of groundwater for irrigation. Brentwood Country Club was installing a groundwater well for irrigation use at the time of the RWMP site visit, Riviera Country Club was using groundwater for ½ of their irrigation demand but was interested in fulfilling the second half of the demand with recycled water, and the Los Angeles Country Club was using groundwater for 80% of their irrigation demand. They were interested in fulfilling the remaining 20% with recycled water.[258] Based on these use percentages, Riviera is currently extracting approximately 180 AFY (50% of overall demand is estimated to be 180 AFY recycled water in the RWMP) and the LA Country Club is currently extracting 560 AFY from the groundwater (20% of overall demand is estimated to be 140 AFY of recycled water in the RWMP). Working with these customers to transition completely from groundwater to recycled water could provide an opportunity to both increase demands for recycled water and preserve groundwater for potable uses. However, as groundwater use for irrigation is preferable to potable water use, exploring the potential to use groundwater for golf courses such as Hillcrest and Rancho Park could be an opportunity to reduce potable water demand by these golf courses and / or supplement the potential use of recycled water and captured stormwater at those sites.

Table 21. List of customers identified for a UCLA WRP. Annual demands over 50 AFY are potential anchor customers.

Potential Customers[259]	**Estimated Annual Demand (AFY)**	**Use Type**
UCLA	540	Mixed-use
Veterans Administration	430	Mixed-use
Rancho Park Golf Course	400	Irrigation
Brentwood Country Club	230	Irrigation
Riviera Country Club	180	Irrigation
Hillcrest Country Club	170	Irrigation
Los Angeles Country Club	140	Irrigation
Cheviot Hills Recreation Center	70	Irrigation
Trigen-LA	170	Industrial
Breitburn Energy	165	Industrial
Total Non-anchor customers (30)	341	Irrigation, Mixed-use
Total annual demand	2,836	Irrigation, Mixed-use, Industrial

[257] Frank Deford, Water-Thirsty Golf Courses Need to Go Green, NPR blog, June 11th, 2008. http://www.npr.org/templates/story/story.php?storyId=91363837

[258] NPR Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p. I-278

[259] LADWP & LASAN Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p. I-278

Overall, expanding and maintaining the NPR recycled water system is cost-effective relative to the projected MWD costs of Tier 1 imported water under current conditions. The cumulative cost for implementing a representative 9,650 AF NPR program is $3.34 billion, for implementing NPR using a pay-as-you-go model is $3.01 billion, and for MWD water is $4.2 billion.[260] Spread out over 50 years, the present value unit cost of the recycled water program is $1,140 / AF, which is less than the projected MWD Tier all 1 Imported Water Costs of $1,366 / AF.[261] LADWP expects to spend $510,402,000 on recycled water projects between 2009 and 2019.[262]

Further, expanding potential demand by identifying additional non-LADWP customers that have large demands for recycled water and are located close to existing purple pipe infrastructure could provide additional opportunities to use recycled water in the area. In addition, increasing flows through pipes, particularly at the end of the system, can help alleviate some of the water quality issues that result from the purple pipes being overbuilt for current flows.[263] HTP and Scattergood Generating Station have experienced water quality issues that likely result from stagnant water due to an oversized pipe.[264] Loyola Marymount University has also experienced water quality issues with their current recycled water supply irrigation use which they would like to see resolved before they expand their recycled water use to include their cooling towers.[265] Nearby schools are good candidates for this purpose as schools use 72% of their water on landscaping, which can be irrigated with recycled water instead.[266]

Cemeteries and parks in the Westside Service Area that are just outside LA city boundaries but close to existing pipelines provide additional opportunities. Specific examples of these types of land uses abound on the West Side. For example, potential demand near the Playa Vista development includes Hillside Memorial Park[267] / Mortuary, Holy Cross Catholic Cemetery, West-

---

[260] LADWP & LASAN, RWMP Non-Potable Reuse Master Planning Report (2012), Section 8: Implementation Plan, Page 8-4

[261] LADWP & LASAN, RWMP Non-Potable Reuse Master Planning Report (2012), Executive Summary, p. ES-26

[262] Water System Capital Improvements Program

[263] LADWP & LASAN, RWMP Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-249

[264] LADWP & LASAN, RWMP Non-Potable Reuse Master Planning Report (2012), Existing and Planned Recycled Water Systems, Appendix A, p. 48

[265] LADWP & LASAN, RWMP Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-255

[266] Peter Gleick, et al. Commercial Water Use and Potential Savings: Appendix E: Details of Commercial Water Use and Potential Savings, by Sector. http://pacinst.org/publication/waste-not-want-not/ p. 20 Pacific Institute. 2003.

[267] Hillside Memorial Park currently has 92.30 AF adjudicated rights in WCB. In FY 2012-2013 Hillside pumped 128.07 AF, which was over its allowable extraction of 98.89 and it's allowable over-extraction by 13.65. Hillside's

field Mall Culver City, Culver Park High School. Potential demand near Westchester Park includes St. Bernard High School, Westchester High School / Del Rey Continuation High School, and Paseo del Rey natural science magnet school (adjacent to Westchester High). Potential demand near Prairie/Manchester includes Centinela Hospital, Hollywood Park and Casino, Inglewood Park Cemetery, and The Forum. It is important to note, however, that supply needs to be confirmed with WBMWD or plans made to provide additional supply through implementing advanced treatment processes at HTP to meet these potential demands as WBWMD has potential plans to use all remaining treatment capacity.[268]

d. Increasing Volume of Runoff Flows to HTP for Treatment and Reuse.

Directing all of the Ballona Creek dry weather flow and at least part of the first flush through increased use of stormwater diversion systems to HTP for treatment and reuse would increase flows to this facility and therefore increase the volume of water available for advanced treatment and reuse at HTP or through the Ed C Little WRF. Using 15 cfs, which is the median (50th percentile) of summer flows,[269] approximately 9.7 MGD of dry weather runoff flows through Ballona Creek Watershed. Existing City LFDs that capture flows near the beaches channel approximately 5 cfs (3.2 MGD) of summer dry weather flow and 15 cfs (9.7 MGD) of winter dry weather flow to HTP; total volumes including County and City of Santa Monica LFDs are approximately 9 cfs (5.8 MGD) and 28 cfs (18 MGD), respectively.[270] Additionally, flows to HTP will increase as additional flows will be diverted to HTP when the Coastal Interceptor Relief Sewer is constructed.

Plans are currently underway to utilize the NOTF, a decommissioned sewer overflow containment facility, both as part of the TMDL Implementation Plan to improve water quality in Ballona Creek and to increase reuse of the runoff in Ballona Creek. The NOTF project is a Ballona Creek Water Quality Improvement and Beneficial Use Project to improve water quality in the channel. It is partially funded through the California Clean Beaches Initiative Grant program. The NOTF is located roughly five miles upstream from the mouth of Ballona Channel, and will capture flows from about 85 square miles of upstream urban watershed. This project would divert, treat, and possibly reuse the dry weather runoff and up to 2 AF of the first flush through capturing and treating the flow through Ballona Creek. Flows would be captured with a rubber dam and pumped up to the NOTF for treatment and disinfection. Current plans call for treated

total over-extraction was 29.18 AF. Watermaster Service in the West Coast Basin, Los Angeles County. July 1 2012 – June 30, 2013. September 2013. P.18.

[268] Non-Potable Reuse Master Planning Report (2012), Potential Water Recycling Project Descriptions, Appendix I, p.I-253

[269] 2013 TMDL update staff report

[270] List of Existing and Planned Diversions for Santa Monica Bay, 12-18-08, LASAN WPD.

flows to be discharged to Ballona Creek to assist in meeting TMDL concentration limits but the NOTF was also explored in the NPR report as an opportunity to satisfy NPR demand identified in the region.[271] As discussed above, an average NPR demand of 0.6 MGD and a peak NPR demand of 1.2 MGD is present near the NOTF. Dry weather flows in Ballona Creek were estimated to be 10 MGD, of which one option is to return at least 4.5 MGD to Ballona Creek and use the remaining 5.5 MGD for Title 22 reuse (Title 22 reuse would require the addition of treatment processes at the planned NOTF facility beyond those currently planned to treat Ballona water for metals and bacteria prior to discharge).[272] Treating just enough runoff to meet the identified peak NPR demand of approximately one MGD would require a facility with a footprint around 1.2 acres;[273] treating the estimated volume of runoff available (5.5 MGD) would require a treatment plant similar in size to that of the proposed Rancho Park Facility discussed above (3.7 acres).

An alternative option to treating the full runoff volume to Title 22 reuse standards on-site at the NOTF is to route some or all of this flow from the NOTF to HTP for treatment and reuse. Routing urban dry and wet weather runoff through HTP would both help increase flows going to the plants and also help dilute the effluent stream as brine from advanced water treatment becomes a larger percentage of the flows leaving HTP through the ocean outfall. 23 LFDs, including eight City LFDs, that divert runoff from Santa Monica Bay to HTP are already in place; collecting additional data on the volumes as well as the water quality of the runoff flows coming into HTP from these diversions is critical to determine the long-term potential of increasing these flows and to characterize the effect of increasing these flows through the system for treatment and reuse potential. An additional LFD in Santa Monica Canyon, which will have the potential to divert an additional 86,400 gallons of runoff to HTP, is also due to come online shortly.[274] The Central Intercept Relief Sewer, a 4,500 foot gravity relief sewer, is being built between Will Rogers Beach and the City of Santa Monica to handle the increased flows coming from the LFDs to HTP.[275]

Generally, increasing diversion of the dry weather runoff and some portion of wet weather runoff to WRPs in the City would increase the volume of water going through these facilities and potentially could dilute the increasing effluent concentrations caused by increasing discharge of brine from advanced treated water processes. Increased runoff diversions could also reduce the need for diverting additional flows from the sewers in HSA to DCT or LAG to maximize advanced water treatment capacity at those facilities. Using runoff rather than wastewater would

---

[271] Non-Potable Reuse Master Planning Report (Feb 2010), Satellite Reuse Options TM, Appendix F, p. 40

[272] Metals and Bacteria TMDL Implementation Plans as described in Non-Potable Reuse Master Planning Report (Feb 2010), Satellite Reuse Options TM, Appendix F, p. 43

[273] Non-Potable Reuse Master Planning Report (Feb 2010), Satellite Reuse Options TM, Appendix F, p. 45

[274] http://www.lastormwater.org/blog/2015/06/outta-sight/

[275] http://www.lapropo.org/sitefiles/CIRS/intro.htm Proposition O, Central Intercept Relief Sewer Introduction.

have the advantage of keeping flow levels going through HTP more constant and maintain the same level of advanced water treatment production capacity there.

e. Direct Potable Reuse.

Current policy does not allow direct potable reuse (DPR) but there is a possibility that DPR may be allowed in California in the not too distant future. The tremendous economic advantage of DPR is that purple pipe infrastructure does not need to be built. DPR water would be allowed to be discharged directly into the potable water system. The State Water Board is under a mandate from the California legislature to report on the feasibility of DPR by December 31, 2016. This makes long-term planning decisions difficult as installing purple pipe networks to increase the use of recycled water is an expensive endeavor that could become obsolete if DPR is allowed.

V. Conservation and On-Site Reuse as Local Water Supply

A. Introduction

In addition to opportunities to improve water quality and increase the local water supply through increasing stormwater capture, remediating contaminated groundwater, and maximizing the reuse of advanced treated recycled water, conservation and on-site reuse offer additional possible avenues to increase the long-term sustainability of the City's water system. Increasing indoor and outdoor conservation will reduce water demand and pressures on the City to import water. On-site treatment systems such as laundry to landscape greywater systems may offer a useful tool to raise awareness among homeowners about the water issues currently facing California but require further research to determine their utility in decreasing water demand. Currently, there are no data on the ratio of greywater that is recycled versus household water use. Conservation and on-site treatment and reuse can both have an effect on the volumes of water available for treatment and reuse at central wastewater treatment facilities and it is important to assess these impacts when planning infrastructure needs and defining local water supply portfolio goals. In this section, we discuss the above topics. These topics will additionally be discussed more fully in the final policy and economics reports as the impacts and challenges will apply across the entire City (for example, implementing steeply tiered water rates to incentivize further conservation).

B. Conservation

Conservation is another critical component of creating a sustainable water supply for California in general, and Los Angeles in particular, as stressors such as climate change, environmental needs, and population growth continue to increase water demand. Urban residential use, which accounts for the largest potable water use within the Municipal and Industrial Sectors, accounts for approximately 54% of the water consumption in the South Coast Hydrologic Region in which Los Angeles is located along with all of Orange County, most of San Diego and LA Counties, and parts of several other southern Californian counties.[276] The state has instituted many policies, recommendations, and laws encouraging or requiring conservation state wide, such as the emergency regulation for statewide water conservation.[277] The Water Conservation Act of 2009 (SBX7-7) requires a statewide 20 percent reduction in urban per capita water use by Dec. 31, 2020. UWMPs must also include conservation plans. LADWP's conservation plan in-

---

[276] CDWR CA Water Plan Update 2005; CA Groundwater Update Ch. 7, South Coast Hydrologic Region p. 148. 2003

[277] SWRCB. http://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2014/rs2014_0038_regs.pdf;

cludes drought response outlines, information on compliance requirements of the City's green building[278] and LID Ordinances, and how to assess water supply needs for new developments.[279]

Mayor Garcetti's Executive Directive 5, issued in October 2014, sets an aggressive goal of 20% water conservation by January 2017.[280] 131 gallons per capita per day (GPCD) was LADWP's annual average water use for the fiscal year 2013-14; LADWP GPCD for October 2014 was 129 GPCD. The Mayor's goal requires a reduction to 117 GPCD by July 2015, 111 GPCD by January 2016, and 104 GPCD by January 2017. Los Angeles has a long history of successfully increasing conservation within the city. Before 1990, Angelenos conserved less than 50,000 AFY. The City is now conserving slightly more than 100,000 AFY, and needs to conserve another approximately 112,000 AFY by 2017 to meet the Mayor's goals (4,000,000 people, GPCD reduction from 129 GPCD to 104 GPCD). However, the active conservation programs currently planned for implementation by January 2017 are not enough to reach the Mayor's GPCD Goals, which will require a total conservation effort of greater than 200,000 AFY. Thus, the City must identify areas in which they can expedite the implementation of plans that were intended for later years or identify new opportunities to increase conservation within the City.[281]

Both the City and regional agencies have run many successful conservation efforts through offering incentives and rebates to both commercial and residential customers to, for example, install water-saving appliances or remove residential turf and install alternate land covers which use less water. Until very recently, MWD had a turf replacement program offering rebates of $2 per square foot for turf replacement. MWD's board increased the conservation budget (which funds turf replacement as well as other water-saving devices) twice, from $40 million to $100 million in December 2014 and then again by $350 million in May 2015 but customer demand was so high that all of this additional turf-replacement funding was allocated by July 2015. MWD estimates that this turf removal program will result in the removal of over 170 million square feet of turf in southern California.[282] Currently, LADWP is offering residential customers rebates of $1.75 per square foot (up to 1,500 square feet) and commercial / multi-family customers rebates of $1.00 or $0.50, depending on project size, to replace turf grass with California Friendly plants, mulch, and permeable pathways.[283] Although approximately 3,300,000 square

---

[278] Green building info: http://ladbs.org/LADBSWeb/green-bldg.jsf

[279] http://clkrep.lacity.org/onlinedocs/2014/14-0078_rpt_dwp_01-31-14.pdf : p 5 – info on compliance with the city's green building and LID ordinances. Info on need for water supply assessment for new developments.

[280] Mayor Eric Garcetti, Executive Directive #5, Issue Date: October 14, 2014. Page 1.

[281] LADWP January 2015

[282] Southland Demand for Metropolitan Turf Rebate Program Exhausts Available Supplies (July 8, 2015) Metropolitan Water District of southern California News Release.

[283] LADWP Rebates and Programs webpage, accessed October 2015.

feet of residential turf have been removed so far and more is being removed every day, increasing this program alone will not provide sufficient reduction in potable use to meet the Mayor's GPCD Goals.[284] This program could be enhanced through offering loan programs that would offset the initial cost of doing the re-landscaping until the rebate is received or through offering a slightly higher rebate for customers who retrofit their property to capture the 85th percentile storm at the same time they replace their turf. In addition, incentives could be offered to change irrigation practices over to smart irrigators, drip systems, and other water-saving systems. Monitoring water use over time is critical to understand the ways the implementation of these systems and turf-replacement programs are impacting demand for potable water, whether customers are watering existing landscapes efficiently, and the types of stricter requirements on outdoor landscapes that need to be placed on properties.

Further, LADWP is running a pilot project with WaterSmart to send new bills, which contain information such as how your water use compares to your neighbor's water use, potential savings in the water volume used, and the cost of installing water conserving devices such as installing a faucet aerator or ultra-low flush toilets, to 20,000 customers.[285] Also, WaterSmart encourages water saving behavioral changes such as only running a full dishwasher, and it provides you with an overall WaterScore. Pilot results run by WaterSmart in different California cities and with different California water agencies have shown an additional 5% water conservation savings resulting from this program. The goal of this study is to educate single-family customers on their water use, quantify the effectiveness of the program, persuade users to increase water conservation efforts, and encourage them to participate in existing rebate and incentive programs. Other opportunities to increase conservation through influencing consumer behavior include more frequent billing (e.g., monthly vs. every two months) or more current usage information. Ideally, smart meters that could give residents information on their water use daily (or even more frequently) would be installed.

Many ordinances are already in effect in the City to help meet conservation goals, including some which encourage or require the installation of water-efficient appliances and fixtures. Among these are three plumbing ordinances, which successively expanded the requirements to install indoor water-conserving devices and were passed between 1988 and 2009. The first two, in 1988 and 1998, dealt with residential buildings; the first required property owners to install indoor water-conserving devices upon plumbing retrofits and the second expanded that requirement to property owners before closing escrow. The third extended the scope of the jurisdiction to include commercial and industrial properties as well as updated the characteristics of water efficient devices and fixtures.[286]

---

[284] LADWP January 2015

[285] http://www.latimes.com/local/california/la-me-0624-water-letters-20150626-story.html

[286] LADWP UWMP 2010.

Many additional opportunities to support conservation can be attained through instituting changes in the Building Code. Possible programs include setting an outdoor water budget, installing an efficient hot-water delivery system, exploring whether and how new buildings should be required to be greywater ready (separate piping for greywater and blackwater), requiring beneficial use of groundwater where it is being extracted above a certain volume per day (pursuant to approval by LARWQCB and LADWP), requiring that 100% of water for uses such as industrial, water closets, and urinals comes from City-recycled water when it is available and non-potable water supply when it is not, installing water sub-meters to give water use of individual tenants within residential and commercial buildings, installing dual meters for indoor and outdoor water use and differential pricing, requiring smart meters, and requiring swimming pool covers for residential properties.

Quantification of the future potential for water conservation within the LADWP service area is needed to strategically and effectively implement different conservation measures or institute new ordinances within the city boundaries. LADWP is currently drafting a Water Conservation Potential Study to assess this future potential. Determining the level of saturation that exists for specific water-conserving devices also offers one method for water districts to demonstrate that they have achieved the CUWCC requirements for specific BMPS. For example, since roughly 33% of households in Los Angeles have occupied their homes since before 1999, which is just after the retrofit upon resale plumbing ordinance passed,[287] there is still a need to continue replacing plumbing fixtures with high efficiency toilets. The efficiency of water saving devices can increase over time as technology improves. For instance, toilets have gotten steadily more efficient over time, going from 5 gallons (pre-1994) per flush, to 1.6 gallons, to the current value below 1.28 gallons. Another important factor to note is that diminishing returns often occur with technological improvements – 3.5 to 1.6 gallons resulted in a bigger flow reduction than the subsequent reduction from 1.6 gallons to less than 1.28 gallons. In general, the pre-1994 stock building stock will contain water efficient plumbing by 2020 through a combination of state requirements and saturation rates.[288] Therefore, the greatest conservation potential beyond 2020 will remain in outdoor water use reduction. We've seen tremendous improvements in indoor water conservation and these are best demonstrated by the over 33% decrease in sewage influent flows at city treatment plants over the last 25 years.

C. On-site Capture and Reuse (Distributed Systems)

Distributed projects that capture and reuse water on-site offer potential opportunities to reduce the demand for potable water (for example, capturing rain in a rain barrel or reusing greywater from the washing machine to use for outdoor irrigation in-lieu of potable water). However, there are many challenges to implementing distributed projects which will be examined in the

[287] US Census Bureau, table and analysis in Ch 3 LADWP of Hilda Blanco Water Supply paper p 56

[288] Blanco Chapter 8, the future potential for water conservation. Page 211.

following reports. For example, while the use of rain barrels may provide limited supply benefits at a substantial cost per AF, they can have tremendous educational value. Larger home cisterns in the 500 gallon range have a great deal more potential for providing significant water supply benefits but greater clarity from the LA County Department of Public Health on the requirements for the operation of these larger cisterns would prove beneficial for more widespread installation. We will explore the potential use of rain barrels and other distributed rainwater capture systems in following reports but begin in this report with greywater. Greywater is a potential distributed component of a local water supply portfolio that is more reliable than rainwater capture in regions such as Los Angeles where the annual rainfall is relatively low and can be unpredictable but also has many of its own challenges which are discussed below.

Domestic greywater is generated from a variety of sources within buildings, including bathrooms (tubs, sinks, and showers), kitchens (sinks and dishwashers), and laundry rooms (washing machines).[289] Between 127 and 151 L of greywater is generated daily per person in the United States[290], which can represent up to 70% by volume of indoor wastewater generation.[291] Further, greywater can provide a relatively clean water source as it contains only 23% of the mass of suspended solids in the wastewater leaving the house.[292]

Greywater can be defined in two different ways, heavy greywater and light greywater. Light greywater is wastewater from bathroom sinks, bathtubs, and showers as well as washing machines, while heavy greywater is wastewater from kitchen sinks and dishwashers.[293] The CA plumbing code does not allow the use of untreated heavy greywater at residences, but has streamlined the process for simple light greywater systems such as laundry to landscape. Greywater systems that do not require cuts to the existing plumbing pipe system, deal with the volume of water from a single laundry machine, serve two families or less, and are only used for subsurface irrigation for nonedible crops or landscaping are not required to get a permit by the CA plumbing code.[294] In CA, water quality criteria have been established for two types of onsite

[289] Zita L.T. Yu, Anditya Rahardianto, J.R. DeShazo, Michael K. Stenstrom, Yoram Cohen. Critical Review: Regulatory Incentives and Impediments for Onsite Graywater Reuse in the United States (2013). Water Environment Research, Volume 85, Number 7. P. 651

[290] Mayer, P.W., DeOreo,W. B. (1999) Residential End Uses ofWater; Report No. 1583210164; American Water Works Association: Denver, Colorado.

[291] Abu Ghunmi, L.; Zeeman, G.; Fayyad, M.; van Lier, J. B. (2011) Grey Water Treatment Systems: A Review. Crit. Rev. Environ. Sci. Technol, 41, 657–698. Friedler, E. (2004) Quality of Individual Domestic Greywater Streams and Its Implication for On-site Treatment and Reuse Possibilities. Environ. Technol., 25, 997–1008.

[292] Abu Ghunmi, L.; Zeeman, G.; Fayyad, M.; van Lier, J. B. (2011) Grey Water Treatment Systems: A Review. Crit. Rev. Environ. Sci. Technol, 41, 657–698. Friedler, E. (2004) Quality of Individual Domestic Greywater Streams and Its Implication for On-site Treatment and Reuse Possibilities. Environ. Technol., 25, 997–1008.

[293] http://www.environment.ucla.edu/reportcard/article4870.html Graywater - A Potential Source of Water

[294] Information on current greywater allowances and requirements. Greywater plumbing codes: http://ladbs.org/LADBSWeb/LADBS_Forms/InformationBulletins/IB-P-PC2011-012Graywater.pdf

greywater reuse. For subsurface irrigation, a primary treatment level is required which carries no specific, numeric water quality criteria. For aboveground non-potable reuse, disinfected tertiary (Title 22 Recycled Water Quality) criteria, which are 2 NTU (average) and 5 NTU (maximum) for turbidity and 2.2 MPN / 100 mL (average) and 23 / 100 mL (maximum) for total coliform, must be met.[295] Since tertiary treatment levels are difficult and expensive to meet at a typical residence, subsurface irrigation with minimal to no additional treatment has a great deal more potential for widespread use in the city.

In Los Angeles, approximately 68% of potable water goes to residential uses annually.[296] According to a recent case study on greywater potential in Los Angeles, the current volume of greywater in LA that is available for reuse (mainly in the non-potable uses of irrigation, toilet flushing, and laundry) represents an estimated 25% of its 2013 water supply.[297] The study estimated that onsite greywater recycling could displace approximately 50% of irrigation water and reduce potable water demand by 27% in single-family residences (SFR) and replace all irrigation water demand and reduce potable water demand by 38% at multifamily residences (MFR). The study used the following estimates: 627,000 SFR (using 1,320 L / day - assuming 3 residents) and 764,400 MFR (using 810 L / day) in the City of LA, and outdoor water use is 52% and 18% at SFR and MFR, respectively.[298] While the cited study provides an excellent starting point as well as first steps towards a cost-benefit analysis of greywater versus other water supply options, we will research the potential benefits and costs of greywater in our future reports, as well as perform a literature review to better understand some of the potential consequences of greywater which are discussed briefly below.

It is important to note that further research would need to be done in order to quantify the effects of greywater uses on the consumption of potable water to determine whether greywater use replaces the use of potable water. For example, if a property owner transitions to use greywater for landscape irrigation, but still needs to use potable water as well, does the property owner track water use closely enough to subtract the volume of greywater from the previous volume of water used and therefore use less potable water? Or does the property owner continue using as much, or even more, potable water along with the additional greywater? A recent case study looking at the effects of installing greywater systems by the City of Long Beach actually found that, on average, homes of greywater systems used more water than before the installation on a

---

[295] Zita L.T. Yu, Anditya Rahardianto, J.R. DeShazo, Michael K. Stenstrom, Yoram Cohen. Critical Review: Regulatory Incentives and Impediments for Onsite Graywater Reuse in the United States (2013). Water Environment Research, Volume 85, Number 7. p 655.

[296] For FY 2006-2007, LADWP City of LA Water Supply Action Plan, 2008, P. 3,

[297] Zita L.T. Yu, J.R. DeShazo, Michael K. Stenstrom and Yoram Cohen. Cost-Benefit Analysis of Onsite Residential Graywater Recycling – A Case Study: the City of Los Angeles (2014) p. 3

[298] Zita L.T. Yu, J.R. DeShazo, Michael K. Stenstrom and Yoram Cohen. Cost-Benefit Analysis of Onsite Residential Graywater Recycling – A Case Study: the City of Los Angeles (2014)

monthly basis.[299] However, other valuable benefits such as heightened awareness of water usage within the home and the diversion of reusable water from the sewer system, were cited by the Office of Sustainability staff as stemming from the studied Greywater Program and it is possible that over the long term potable water use will go down at the home as homeowners get used to the system.[300]

Another concern is the potential public health impacts of improperly installed, operated or maintained greywater systems. It is critical that the flows from greywater remain in the subsurface where there is no direct human contact. Homeowners will need training to maintain their systems, and it is unclear what the effect on resale value of the home will be. Monitoring over time will be needed to understand how well these systems are maintained as well as the potential rebound effect of homeowners using more water elsewhere since they are replacing some irrigation use with greywater. Further, wastewater generated by these greywater homes will have to be monitored over time as well.

Further investigation into the benefits as well as the risks of long-term use of greywater systems should be completed before implementing large-scale programs to encourage the installation of these systems broadly across the region as there is currently limited information on the potential impacts. Also, further studies on the potential risks of indoor use of greywater and the necessary level of regulations and treatment necessary for safe indoor use need to be performed before widespread use of indoor greywater occurs. Toilet flushing and laundry are the two main potential indoor non-potable uses of greywater.[301] It is also important to better understand the potential ramifications of long-term use of greywater irrigation on soil quality and potential impacts on groundwater quality through infiltration of the irrigation water. A recent study looked at the effects of greywater over more than five years and found that, while most landscape plants remained healthy with the exception of avocados, lemon trees, and Scotch pine, the concentration of sodium, surfactants, and antimicrobials did increase in the soils over time (sodium concentrations remained low enough not to raise concerns about soil quality). [302]

In addition to potential public health and water quality impacts, it is critical to consider the interrelationships between the various potential water supply sources. For example, increasing use of onsite treatment and disposal systems such as greywater will remove the cleanest residential water from the wastewater system as well as decrease the flow of wastewater that is available

---

[299] "Laundry to Landscape" Graywater Pilot Program Report executive summary. City of Long Beach Office of Sustainability. July 2013. P. 2

[300] Laundry to Landscape" Graywater Pilot Program Report executive summary. City of Long Beach Office of Sustainability. July 2013. P. 3

[301] Zita L.T. Yu, J.R. DeShazo, Michael K. Stenstrom and Yoram Cohen. Cost-Benefit Analysis of Onsite Residential Graywater Recycling – A Case Study: the City of Los Angeles (2014)p 3

[302] Sharvelle, S et al. Long-Term Study on Landscape Irrigation Using Household Graywater-Experimental Study. The Urban Water Ctr., Colorado State University, WERF, 2012. Abstract.

for treatment and reuse. Careful consideration of what the best use of water in the system is, and whether greywater is of more value remaining in the system for treatment and reuse at a centralized location where uses can evolve over time (e.g., water can be routed to IPR uses rather than irrigation as new treatment systems come online or new demands are identified) or of more value in distributed on-site systems with a more rigid use once installed (e.g., in on-site laundry to landscape systems).

D. Local Water Supply Conditions and Goals

Defining the local water supply in Los Angeles is a very complex process and greatly depends upon the metrics which are used to measure local supply. For example, although the water from the Los Angeles Aqueduct (LAA) comes from hundreds of miles away, it is under the jurisdiction and ownership of LADWP and thus can be considered as local under the metric of city management. Another potential definition of available local water supply includes only supplies from within or adjacent to city or county boundaries such as stormwater runoff, treatment and reuse of wastewater, and groundwater. Even this definition of local water supply contains nuances that stem from the fact that some groundwater recharge occurs using imported water, and imported water can also feed the water supply that is discharged to the wastewater recycling plants. Going forward, it is very important for the City to carefully define what "local water supply" means and then to create goals that reflect that definition. The recently released sustainable city plan for Los Angeles (the pLAn), includes a goal of sourcing 50% of water locally (not including LAA) by 2035, including 150,000 AFY of stormwater capture.[303] Local water should be defined by geographic location within LA County (including stormwater, recycled water, greywater, and groundwater) rather than by jurisdiction (including LAA water).

The water supply portfolio in the 2010 LADWP UWMP (an average of FY 2006 – 2010), is fairly representative of an average water supply year. The total water supply was 621,700 AFY (Figure 39). Approximately half of the water (52%) came from the Metropolitan Water District (MWD), 36% from the LAA, 11% from groundwater, and 1% from recycled water. The existing 100,000 AFY of existing conservation as of 2010 was not included as water supply, and there was no water coming from stormwater capture or water transfers.

[303] pLAn, Transforming Los Angeles, 2015. p. 20. http://plan.lamayor.org/

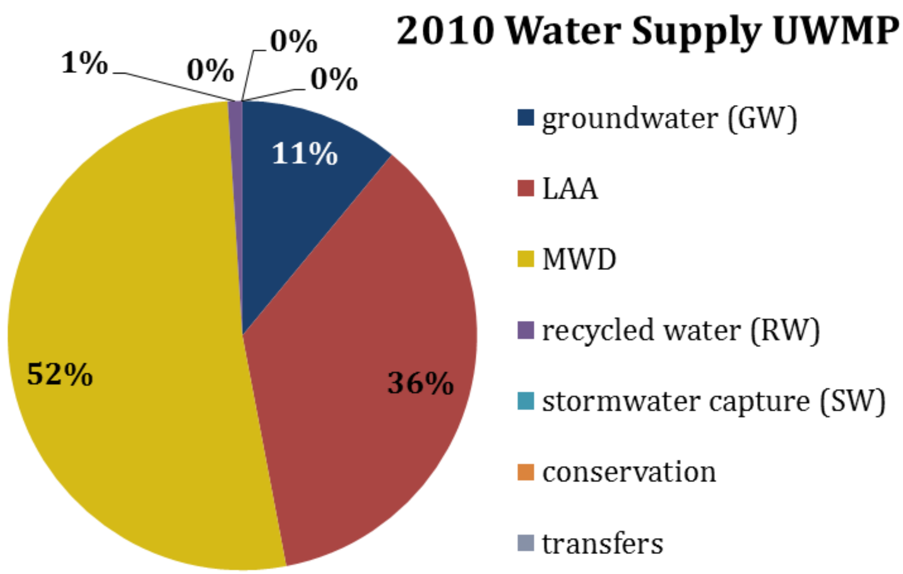


Figure 39: Water supply in the 2010 UWMP.

By way of comparison, the water supply portfolio in 2014 reflects the extreme drought conditions. 75% of the City's water (approximately 440,000 AFY) comes from MWD, 13% from groundwater, 10% from the LAA, and 2% from recycled water (Figure 40).[304] The total volume of water supplied in 2014 was 592,352 AFY.

[304] https://data.lacity.org/A-Livable-and-Sustainable-City/LADWP-Water-Supply-in-Acre-Feet/qyvz-diiw

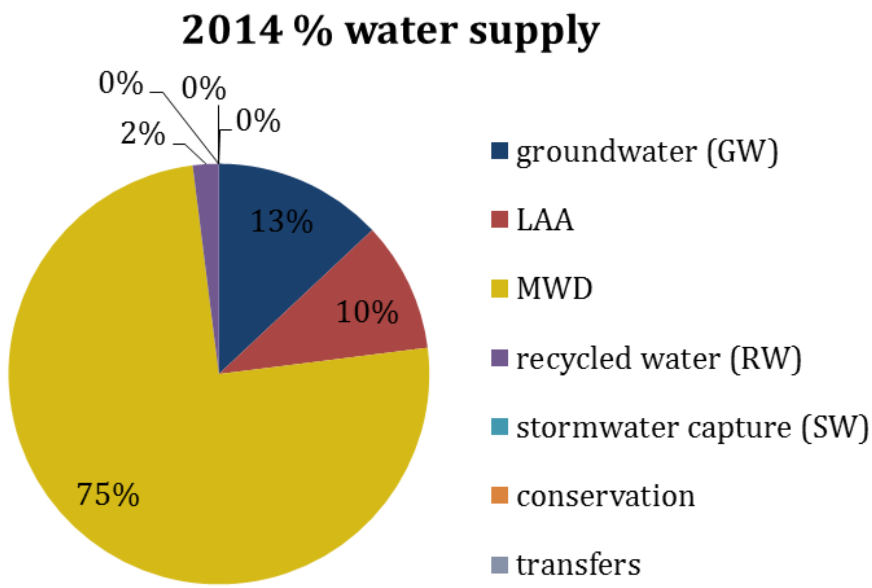


Figure 40: Water Supply Portfolio in 2014, data from https://data.lacity.org/A-Livable-and-Sustainable-City/LADWP-Water-Supply-in-Acre-Feet/qyvz-diiw

The goals defined for the water supply in FY 2034-2035 in the LADWP UWMP 2010 reflect both demand reduction through conservation and a more diversified water supply portfolio. The 2035 total water demand is projected to be 711,000 AFY in the UWMP. UWMP goals are for 24% of the water to come from MWD, 33% from the LAA, 16% from groundwater, 8% from recycled water, 4% from stormwater capture, 9% from new conservation, and 6% from water transfers. (Figure 41)

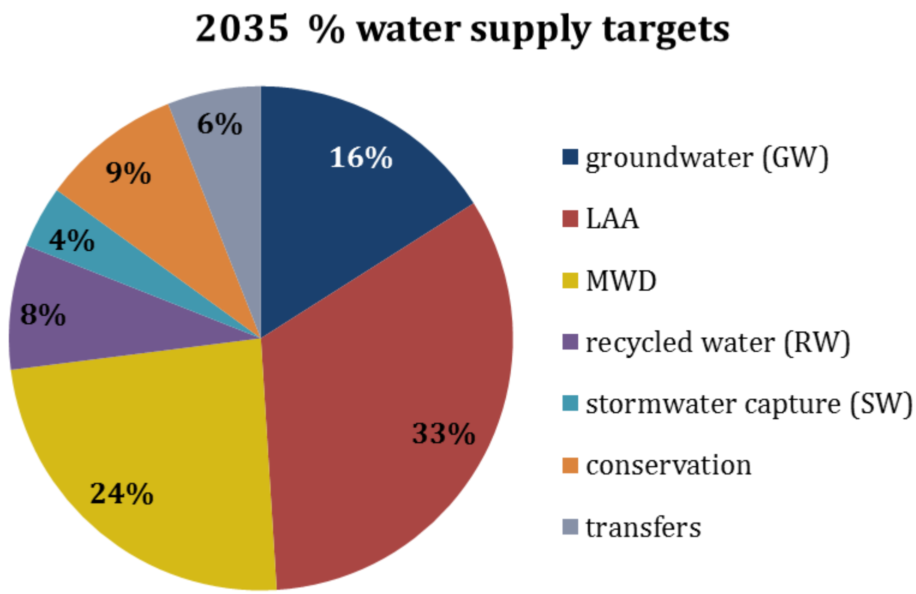


Figure 41: Water supply portfolio targets for 2035 as defined in the 2010 UWMP.

A second set of goals has been defined for the City's water supply through the targets in Mayor Garcetti's goals in Executive Directive 5.[305] First, an additional 20% conservation must be achieved by 2017 (from a 2014 baseline of 130 GPCD). Current consumption as of September 2015 is 109 GPCD.[306] Second, the volume of purchased imported water must be reduced by 50% by 2025. Defining the baseline year or set of years makes a difference in the volume of water that would still be being imported in 2024 after accomplishing the 50% reduction goal. Using FY 2006 to 2010 as a baseline, purchased imported water would need to be reduced from approximately 220,000 AFY to 110,000 AFY. Using 2014 as a baseline, purchased imported water would need to be reduced from approximately 440,000 AFY to 220,000 AFY. According to the goals in the 2010 UWMP for 2034-2035, MWD water needs to be at approximately 170,000 AFY. These goals need to be reconciled and clarified.

In addition, defining which beneficial reuses of wastewater count towards achieving recycled water goals is critical. When doing the accounting to determine the volumes of wastewater that are being beneficially reused in the area to compile a water supply portfolio, it is important to take into consideration which uses are replacing potable water demand, both within the City and outside its boundaries, and which uses are not replacing potable water demand. For example, of the HTP secondary effluent which is currently reused, only 0.8 MGD is counted by LADWP as

[305] Mayor Eric Garcetti, Executive Directive #5, Issue Date: October 14, 2014. Page 1.

[306] LADWP. In addition, average per capita water use is being posted on the pLAn website at: https://performance.lacity.org/en/stat/goals/yn4r-yz4i/jeid-b9sx/45iu-c9nj. Last accessed October 15, 2015.

supplied recycled water. This is the volume of recycled water that is sold back to LADWP to serve to its customers after further treatment at the Ed C Little WRF. However, additional uses also serve to replace potable water, such as the 34.4 MGD of water that is used by customers served by WBMWD and at least some portion of the 6.5 MGD of recycled water that goes to in-plant uses at HTP. The definition of beneficial use of wastewater should be related to the reduction of potable demand. For example, treated wastewater from DCT that is currently going to Balboa Lake should be counted as beneficial reuse as potable water would be going to Balboa Lake in the absence of DCT water.

Beyond identifying the appropriate baselines, definitions, and goals, it is important to quantify the actual amount of water supply that is available locally. For the Ballona Creek Watershed, the available supply actually exceeds the demand. Approximately 220,000 AFY of highly treated water could be generated through treating the FY 2013-2014 volume of HTP effluent with MFRO. An additional 20,000 to 60,000 AFY was estimated as potential recharge volume from the various stormwater modeling scenarios as discussed in the runoff section for a year of an average 15 inches of precipitation. This makes for a total local water supply in the Ballona Creek Watershed of roughly 240,000 to 280,000 AFY as compared to the demand in this watershed of approximately 196,000 AFY [1.5 million people (2010) at 117 GPCD (estimate for all of 2015)]. However, it is important to note that the volume of stormwater that can be captured does not reflect the amount of actual local water supply generated, as the stormwater model does not predict the amount of water infiltrated by BMPs that percolates into producing aquifers to become supply.

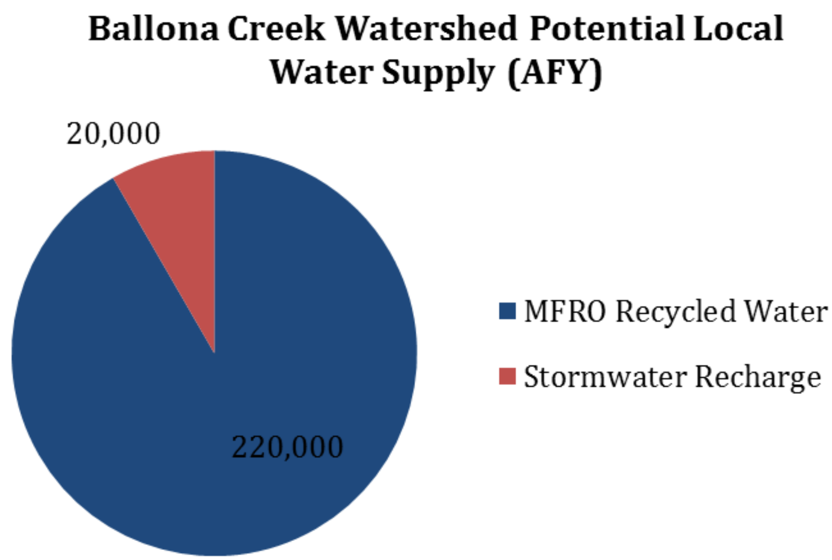


Figure 42: Potential local water supply in the Ballona Creek Watershed reflecting the lower range of potential recharge volume.

Expanding this analysis to the City as a whole, there is approximately 273,000 AFY of advanced treated recycled water that could be generated from the four POTWs run by the City based on FY 2013-2014 flows. Based on the results from the 2015 LADWP SCMP, the existing recharge baseline is 92,400 AFY through a combination of centralized facilities and incidental distributed capture.[307] Therefore, potentially available local water supply based on these numbers is approximately 365,400 AFY. The 2015 water demand in the City is 524,000 AFY (based on 4 million people at 117 GPCD). Based on 104 GPCD water use (reflects Mayor's 20% conservation goal), water demand in the City will be 466,000 AFY in 2017. Therefore, the potentially available local water supply represents approximately 70% of 2015 City water demand and 78% of the projected City water demand in 2017. Additional potential local water supply could be obtained through increasing stormwater capture throughout the City and increasing groundwater production from polluted supplies. For example, a total of 285,900 AFY of potential stormwater capture was identified in the SCMP under an aggressive scenario looking at implementation opportunities through 2099.

[307] Draft Stormwater Capture Master Plan Interim Report, P. 4, Geosyntec Consultants for LADWP, December 2014.

VI. Overall Conclusions

Dry and Wet Weather Runoff

- Routing runoff from a significant portion of the drainage area through BMPs eliminated dry weather copper and zinc exceedances and greatly reduced wet weather copper and zinc exceedances (11 or less exceedances per year for copper or zinc). Based on modeling outputs with available data in the watershed, lead contamination in stormwater was below the TMDL level without BMP implementation.
- Treat and release BMPs returned cleaner water to the channel and achieved the best compliance with metal WQS. Regional infiltration systems achieved multiple benefits including significant storm peak flow reduction and pollutant load removal. Distributed systems took advantage of evaporation and plant uptake for additional runoff volume and pollutant load reduction. Overall, an approach that emphasizes infiltration on both centralized regional scales and local distributed scales will have the most benefit.
- The amount of water estimated for potential groundwater recharge depends heavily on the amount of annual precipitation across the watershed. For average annual precipitation of 15 inches, the estimated potential recharge range is 20,000 AFY to 60,000 AFY for Scenarios 1 – 4. Scenarios emphasizing infiltration-based BMPs are on the high end of this range. It is important to note that the additional water supply contribution from recharge would be lower than the potential recharge volume. These recharge numbers would also be significantly reduced if fewer BMPs were implemented and less annual precipitation fell in the region.
- The degree of variability in copper exceedances in the Ballona Creek Watershed is such that a fairly low WER (greater than 2) would result in the watershed being in compliance for copper without the implementation of additional BMPs. Also, this compliance would be achieved through copper reduction of 50% or more via brake pad source control efforts. If a copper WER were established in the future for the Ballona Creek Watershed, or source reduction was very effective, zinc and fecal indicator bacteria would become the drivers of water quality compliance in the watershed.
- If zinc becomes the limiting metal pollutant as outlined above, the City can be compliant for zinc with similar treatment, and in some scenarios, less BMP treatment volume than copper. For example, zinc can be fully compliant with dry ponds only (Scenario 3) or LID only (Scenario 4) with 50% less BMP treatment volume and 50% lower cost than the original 85th percentile scenario.

Groundwater

- Additional groundwater storage space identified through the amendments to the most recent West Coast and Central Basin adjudications offers potential opportunities to infiltrate captured stormwater and advanced treated recycled water from HTP and/or the Ed C Little WRF, but further research to quantify the relationship between groundwater recharge and yield is required.

- Establishing regional partnerships and gathering data on the maximum potential safe operational yields (which include the potential recharge from both advanced treated recycled water and stormwater) to enable the conjunctive use of the unadjudicated Santa Monica and Hollywood groundwater basins is critical to moving forward with increasing the local water supply in the region.
- Approximately 600,000 acre-feet of legacy seawater contamination in the West Coast Basin offers an additional opportunity to establish regional partnerships to extract and treat this brackish water for use as water supply at the same time freeing up additional groundwater storage space for freshwater.

Recycled Water

- With the addition of additional treatment processes at HTP such as a membrane bioreactor, it is possible to put all of the current flow going through HTP through an advanced water treatment process that produces brine and remain in compliance with water quality permits at the outfall.
- Almost 200 MGD (~220,000 AFY) of recycled water could be generated by HTP and the nearby WBMWD Edward C. Little WRF to potentially become local water supply based on the current HTP flow rate of 279 MGD and using MFRO treatment.
- Increasing the recharge of advanced treated recycled water into the nearby groundwater basins is an additional potential beneficial reuse of HTP water that could greatly increase the sustainability of LA's water supply.
- Non-potable reuse is another pathway to beneficially reuse HTP water. Placing satellite treatment plants near areas of high demand could allow additional reuse of wastewater without requiring the construction of a purple pipe line to pump recycled water back uphill from HTP to potential customers. Areas surrounding UCLA and Rancho Park are possible locations for placing a satellite treatment plant.
- Careful consideration of the costs and benefits of all available wastewater treatment and reuse options, as well as of the tradeoffs that result from removing and treating flows upstream for reuse versus downstream at a centralized treatment plant, will be necessary to determine the best approach to increase reuse of wastewater. For example, placing satellite treatment plants upstream for localized treatment and reuse would result in flows that are both reduced in volume and more concentrated in pollutants to the downstream plant. This would both reduce opportunities for reuse at the plant and potentially result in requiring additional treatment processes to treat the more concentrated waste stream.

Local Water

- The Ballona Creek watershed has sufficient potential local water supply to meet demand. Approximately 220,000 AFY of advanced treated water could be generated using FY 2013-2014 flow volumes at HTP and the potential recharge volume identified through the various water quality modeling scenarios is an additional 20,000 to 60,000 AFY during a year with 15 inches of precipitation for a maximum potential of roughly 240,000 to 280,000 AFY. 2015 demand in the watershed is approximately 196,000 AFY (1.5 million people at 117 GPCD). It is important to note that the additional water supply contribution from recharge would be lower than the potential recharge volume estimated above. Further, these recharge numbers would be significantly reduced in years with less than 15” of precipitation or if fewer BMPs were implemented.

VII. Appendix A: Monthly HTP Effluent concentrations.

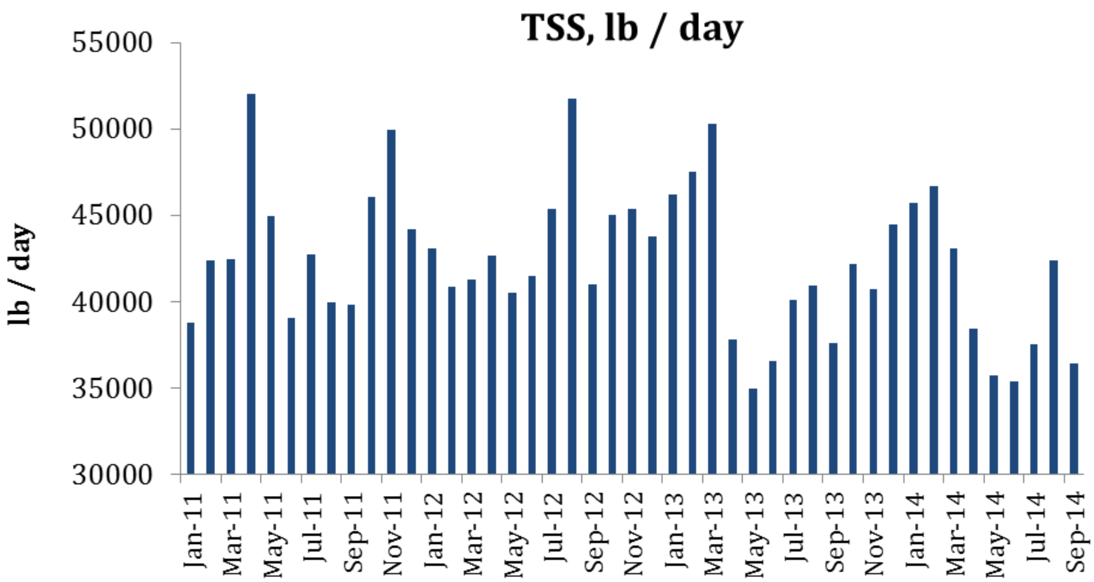


Figure A.1: Monthly TSS levels, January 2011 through July 2014

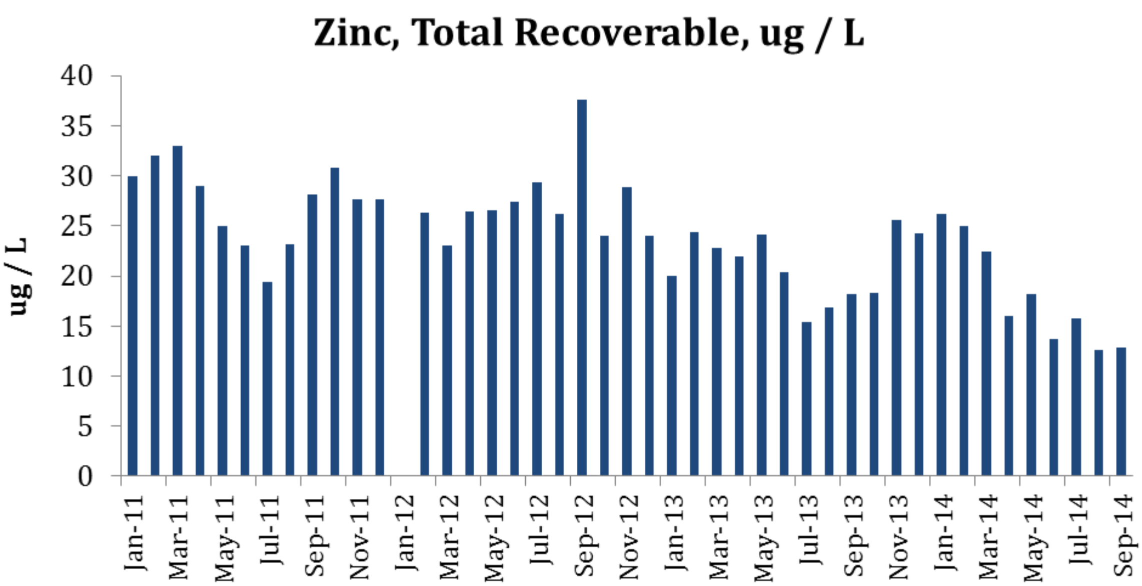


Figure A.2: Monthly zinc levels, January 2011 through September 2014

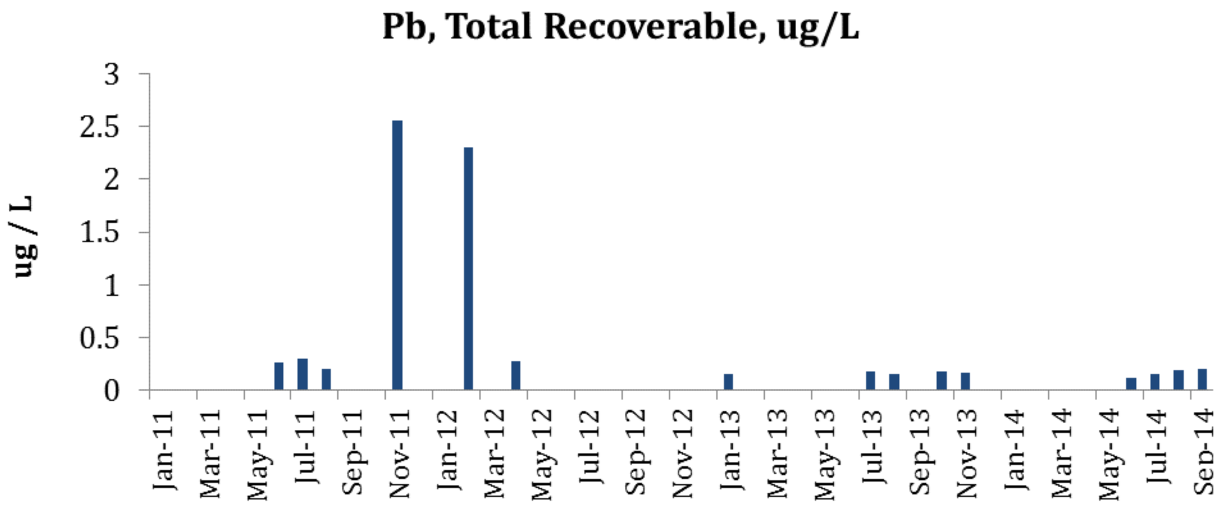


Figure A.3: Monthly Pb levels. All numbers in the Pb chart are for detectable but not quantifiable samples.

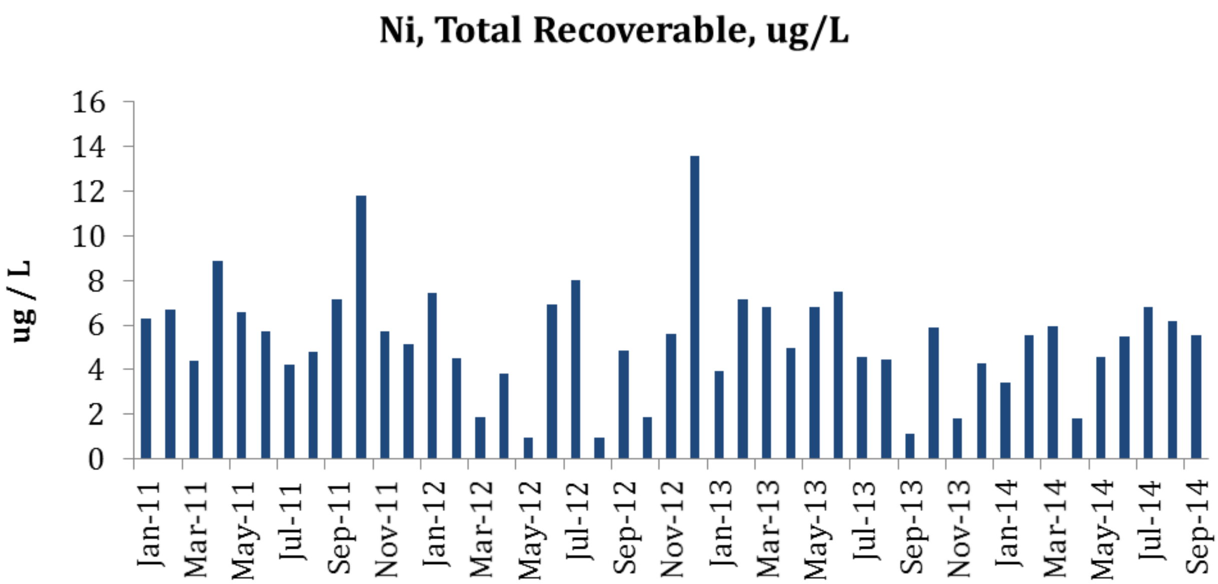


Figure A.4: Monthly Ni levels, January 2011 through September 2014

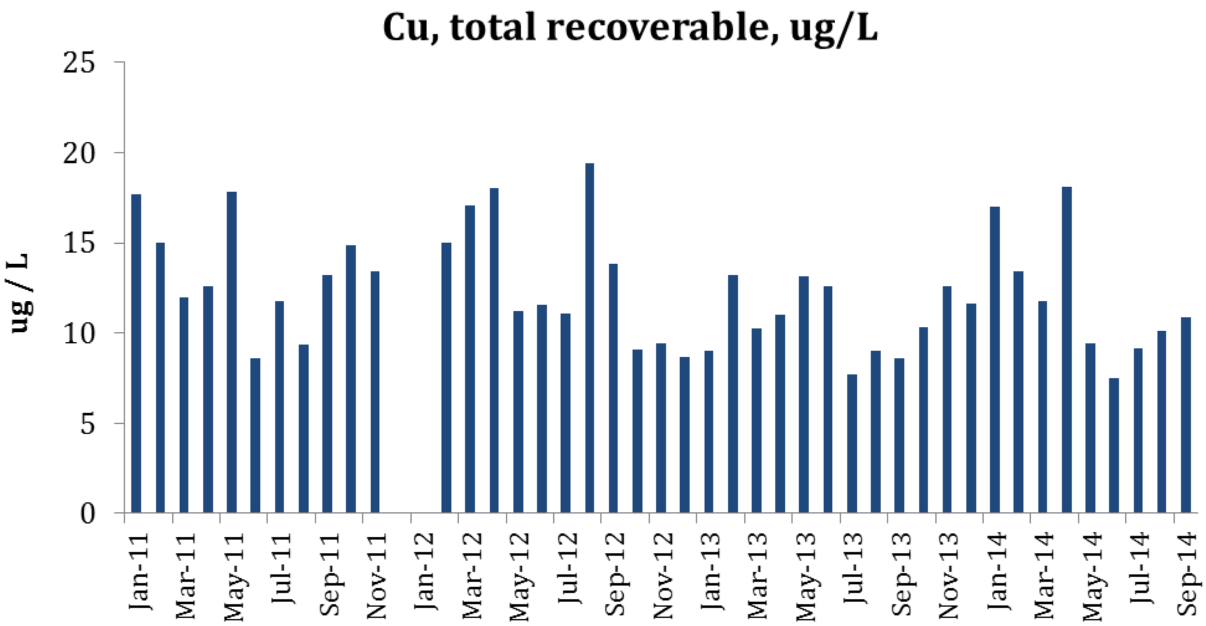


Figure A.5: Monthly Cu levels. January 2011 through September 2014.