Metropolitan Water District of Southern California

Potential Regional Recycled Water Supply Program:

Historical Review and 2015 Update

Version 1.8

WORKING DRAFT

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1 Introduction

1.1 Purpose

This document provides an historical review and 2015 update of a potential recycled water supply program (Program) that would be developed through a collaborative effort between the Metropolitan Water District of Southern California (Metropolitan) and the County Sanitation Districts of Los Angeles County (Sanitation Districts). The potential program would involve the development of a large-scale regional indirect potable or direct potable reuse program. This document was developed primarily by Metropolitan, with input and review by Sanitation Districts, and is for planning purposes only. As such, it provides a baseline of data, assessments and preliminary staff conclusions for use by staff for an upcoming demonstration project and detailed feasibility studies. It is intended as a historical reference and includes information that was available in 2015 serving as the basis for staff recommendations to Metropolitan's Board for approval of a demonstration project in November 2015.

Significant additional technical and environmental studies beyond the scope of this report will be required to determine the overall feasibility of the program. No outside agencies or institutions were contacted for this evaluation. Consequently, significant involvement with outside stakeholders will have to take place in the next phase of the work effort in order to confirm the assumptions upon which this document's conclusions are based. It is understood that the data and findings of this document are preliminary and subject to the interpretation and final conclusions that will result from subsequent studies.

As currently conceived, the program would utilize secondary treated effluent from the Sanitation District's Joint Water Pollution Control Plant (JWPCP) in Carson, California. The secondary treated water would undergo advanced treatment processes at a new advanced water treatment (AWT) facility located at the JWPCP, and be conveyed through a new regional distribution system to either local groundwater aquifers, a reservoir or treatment plants for reuse. If practical and feasible, implementation of such a regional program holds the potential to provide Metropolitan with a new and drought resistant source of reliable and high-quality water to supplement Metropolitan's current sources of imported water supplies. This new source could benefit the region by providing a buffer against annual variations in imported water supplies, improving the operational flexibility to distribute those imported supplies, and by increasing supplies on the coastal side of the major regional faults capable of interrupting imported supplies, which will enhance Metropolitan's seismic preparedness .

The objective of this 2015 Update was to document the initial assessment of the facility, regulatory, and treatment requirements, and to generate a range of potential costs for the potential Program. The document focused on the ability to maximize the use of available effluent from the JWPCP, which is currently a full-secondary wastewater treatment plant, permitted for ocean discharge purposes. Hence, significant effort was expended to assess the ability of state-of-the-art AWT processes to further treat the plant's effluent to the point that the water can be used for potable water purposes. Additional objectives of the document were to examine potential end uses for the advanced treated water, either as a supply for groundwater recharge, as a supplemental source of water to existing reservoirs, or to existing Metropolitan treatment plants. In addition, the document presents a 2015 evaluation of the availability of alternative program funding mechanisms, including grants funds and low interest loans in order to reduce overall program costs. Finally, the document utilized all of the information from the work identified above to develop concept-level cost estimates for the program, as well as unit price cost estimates for the water produced from the program under several financial scenarios.

The study is organized as follows:

Chapter 1: Introduction and history of potable reuse, background of Metropolitan and the Sanitation Districts, and overview of the program concept

Chapter 2: Summary of prior studies conducted between 2010 and 2012 to evaluate the feasibility of advanced water treatment processes on JWPCP secondary effluent to meet California Department of Public Health (CDPH, now the Division of Drinking Water, DDW) Draft Title 22 Groundwater Replenishment Regulations, and to assess potential implementation options

Chapter 3: Discussion of key developments that have occurred since the completion of prior studies, the relevance to the prior studies, and the impacts to the potential implementation of a large-scale regional program

Chapter 4: Overview of the JWPCP facility including source water control program, current treatment process, influent and effluent water quality, current and projected flows, and space available for advanced water treatment (AWT) facilities

Chapter 5: Overview of the current regulatory environment for planned potable reuse, including indirect potable reuse (IPR) through groundwater recharge and surface water augmentation, and direct potable reuse (DPR)

Chapter 6: Evaluation of AWT process requirements for groundwater recharge and surface water augmentation, DPR, and for an AWT demonstration project

Chapter 7: Evaluation of grant and loan funding opportunities

Chapter 8: Approach to California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) Compliance

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Chapter 11: Planned potable reuse project scenarios, including capital and operation and maintenance (O&M) cost estimates

Chapter 12: Summary of 2015 update and Next Steps

1.2 Background

1.2.1 History of Planned Potable Reuse

Planned IPR programs involve the strategic incorporation of recycled water into a raw water supply, such as a groundwater aquifer or untreated water supply reservoir. The recycled water is treated using either tertiary treatment or advanced treatment prior to discharge into an aquifer or an untreated water supply reservoir. In both cases, the aquifer and reservoir serve as an environmental buffer between the treatment of the recycled water and introduction to the potable system. This recycled water, which may be blended with raw water, is stored for a specified period of time to allow further water quality improvements by natural processes and to allow time to respond in case of treatment issues. Following a minimum specified retention time, the blended water may receive additional water treatment prior to distribution as a potable water supply.

DPR programs involve the incorporation of advanced treated water into a drinking water supply system without the use of an environmental buffer. Under this approach, the advanced treated water can be incorporated either upstream of a conventional treatment plant where it is blended with raw water supplies prior to conventional treatment, or directly into the treated water distribution system.

Planned potable reuse and its health effects have been studied for decades and implemented in a number of areas around the world. Specifically within Southern California, two large-scale planned IPR programs have been developed and are ongoing. The Water Replenishment District uses up to 55,000 acre-feet per year of tertiary treated water and the Orange County Water District uses up to 100,000 AFY of advanced treated water for groundwater recharge to supplement natural supplies. As demonstrated by these projects, water reuse can be a reliable source of water to supplement other supplies. The projects listed below are examples of planned potable reuse programs implemented both nationally and internationally.

Montebello Forebay Project (1962)—The Montebello Forebay Groundwater Recharge Project, located in Los Angeles County, California uses tertiary treated recycled water as a supplemental source for groundwater recharge. The project provides recycled water to the Central Basin. Recycled water is provided by the Sanitation Districts. Combination sampling and analysis from its three source water reclamation plants, and multiple monitoring wells located upstream, downstream, and within the spreading grounds has shown no indication of degradation of groundwater quality since the program's inception.

Upper Occoquan Project (1978)—The Millard H. Robbins Water Reclamation Plant, located in Centreville, Virginia, treats the wastewater of 275,000 nearby residents before discharging the effluent into Bull Run River, a tributary to the Occoquan Reservoir. The reservoir serves as a drinking water source for 1 million residents of Northern Virginia. The plant, which utilizes AWT technologies to treat the wastewater, has a capacity of 54 million gallons per day (MGD).

San Diego Water Purification Project (1994)—Located in San Diego, California, the project proposed the planned indirect potable reuse of approximately 20 MGD of wastewater using AWT methods. The advanced treated water would then be blended with an equal amount of raw water and stored in the San Vicente Reservoir before conveyance to a local water treatment plant. The proposal was dropped due to public opposition. The city of San Diego has revived the project under the PureWater San Diego Program, and recently completed a 1-MGD AWT demonstration project. The proposed PureWater program would supply an initial 15 MGD by 2021 with plans to produce 83 MGD by 2035.

NEWater Project (2003)—Located in Singapore, the NEWater project supplies advanced treated water (microfiltration, reverse osmosis and ultraviolet disinfection) for both non-potable and indirect potable reuse. Currently, NEWater meets up to 30% of Singapore's water needs with long term plans to increase up to 55%. Due to recent drought, up to 35 MGD of NEWater was injected into local reservoirs to maintain healthy reservoir levels.

Western Corridor Recycled Water (WCRW) Project (2007)—Based in Queensland, Australia, the WCRW Project was constructed to provide 61.3 MGD of advanced treated water for industrial, agricultural, and indirect potable reuse. A portion of the water was to be used as an influent source for the Wivenhoe Reservoir. The reservoir is a primary drinking water source for Brisbane and other adjacent regions. The option to augment the reservoir was dropped due to political and public adversity, and many of the constructed facilities have been decommissioned due to inadequate planning.

Groundwater Replenishment System (GWRS) (2008)—The GWRS, located in Orange County, California, is operated by the Orange County Water District (OCWD) and uses AWT (microfiltration, reverse osmosis, and ultraviolet and hydrogen peroxide disinfection) to further treat secondary treated wastewater supplied by the Orange County Sanitation District. The project was recently expanded from 72,000 AFY to 100,000 AFY to provide advanced treated water for recharge of the local groundwater basin and for a seawater intrusion barrier. The GWRS is viewed as a model for implementation of a potable reuse program due to the extensive public outreach and awareness program that was conducted as part of the development of the project.

Big Springs, Texas DPR Project (2013)—The Big Springs Texas DPR Project uses advanced treatment (microfiltration, reverse osmosis, and ultraviolet and hydrogen peroxide disinfection) to treat recycled wastewater to better than drinking water standards. The project produces 1.8 MGD of advanced treated water, which is conveyed to pipeline carrying raw water from the E.V. Spence Reservoir, and delivered to a conventional water treatment plant prior to distribution.

Wichita Falls, Texas DPR Project (2014)—In July 2014, the City of Wichita Falls began integrating water under an emergency permit from their 2.5 MGD AWT facility as a source for their potable water supply. The emergency permit was granted due to low lake levels from extended drought. Following advanced treatment (microfiltration and reverse osmosis), water is mixed at a 50:50 ratio with raw water from the city's supply reservoir and conveyed to a conventional treatment plant prior to entering the potable distribution network. Ultraviolet disinfection was added to the advance treatment process in February 2015 as a requirement to extend the emergency permit for the project. After heavy rain restored reservoir levels to near full, the city ended the DPR project with the intent of developing an IPR project in its place.

1.2.2 Metropolitan Water District of Southern California

The Metropolitan Water District of Southern California is a consortium of 26 cities and local water agencies that provides drinking water to 18 million people over a 5,200 square mile service area within Los Angeles, Orange, Ventura, Riverside, San Bernardino, and San Diego Counties (Figure 1-1). On average, Metropolitan delivers 1.7 billion gallons of water per day to its customers. Metropolitan owns, operates, and maintains five conventional water treatment plants, nine pumping plants, 16 hydroelectric plants, 33 dams and reservoirs, over 830 miles of large diameter pipelines and tunnels up to 20.5 feet in diameter, and the 242-mile Colorado River Aqueduct (CRA).

Metropolitan imports Colorado River water from the border of California and Arizona into coastal Southern California via the CRA. Metropolitan also imports water from Northern California under the State Water Project, which is conveyed through the California Department of Water Resources' (DWRs) California Aqueduct. In an average year, these two conveyance facilities supply 50% of the water used within Southern California.

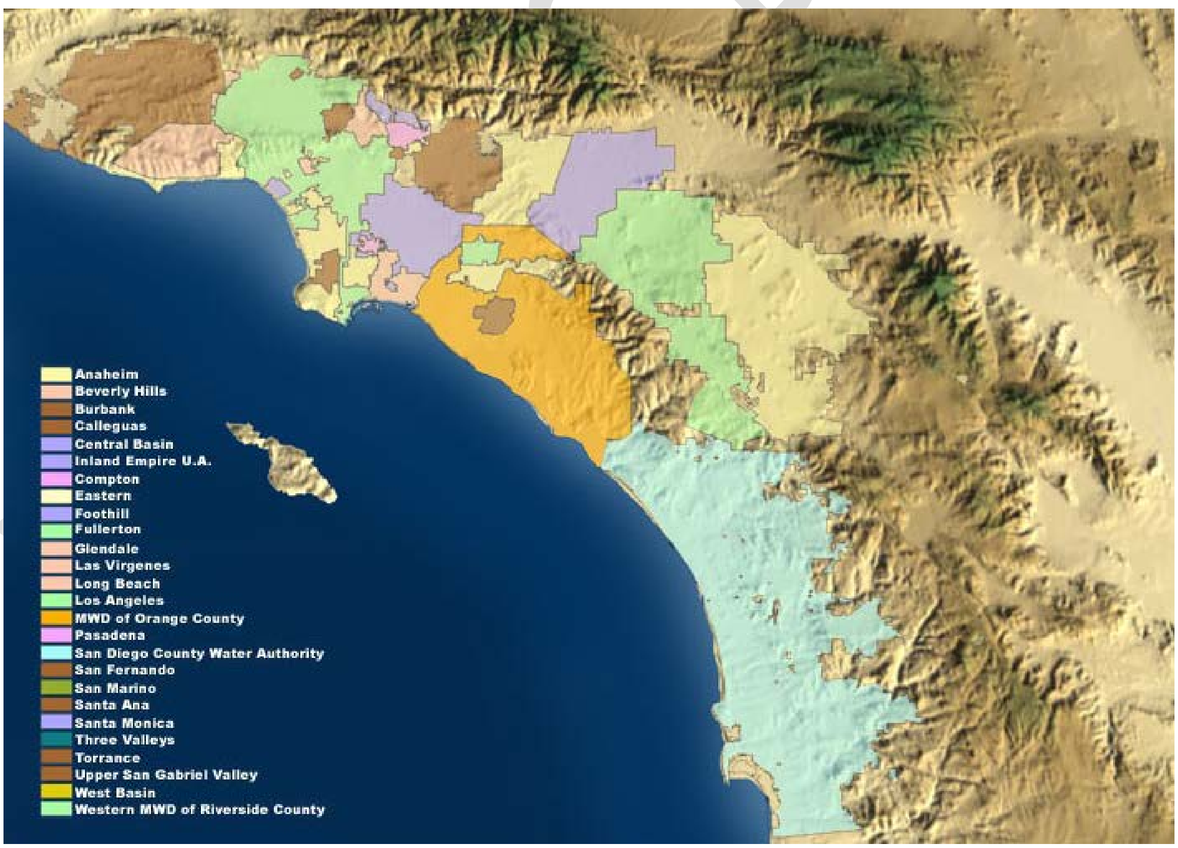

Figure 1-1: Metropolitan Service Area

In recent years Metropolitan has seen a reduction in available imported supplies of both State Water Project water and Colorado River water. These reductions are the result of consecutive years of drought and environmental restrictions limiting State Water Project flow from the Sacramento-San Joaquin Bay Delta area. As a result, Metropolitan is evaluating the feasibility of supplementing its imported water supplies with alternative local supplies.

1.2.3 County Sanitation Districts of Los Angeles County

The Sanitation Districts were formed in 1923 after the adoption of the Sanitation District Act by the State Legislature. It is a confederation of 24 independent special districts that serve the wastewater and solid waste management needs of approximately 5.5 million people in Los Angeles County (County). The Sanitation Districts' service area covers approximately 824 square miles and encompasses 78 cities and unincorporated territory within the County. Within the Sanitation Districts' service area, there are approximately 9,500 miles of sewers that are owned and operated by the cities and county that are tributary to the Sanitation Districts' wastewater collection system. The Sanitation Districts own, operate and maintain approximately 1,400 miles of sewers that convey approximately 510 MGD of wastewater to 11 wastewater treatment plants (Figure 1-2). The Sanitation Districts' service area includes sewer systems located within the Los Angeles County Basin, the Santa Clarita Valley, and the Antelope Valley.

Seventeen of the 24 districts, with a population of 4.9 million people, are served by the Joint Outfall System (JOS). The JOS is a system of interconnected facilities that provide wastewater collection, treatment, reuse, and effluent disposal for residential, commercial, and industrial users. It encompasses 73 cities and unincorporated territories including some areas within the City of Los Angeles.

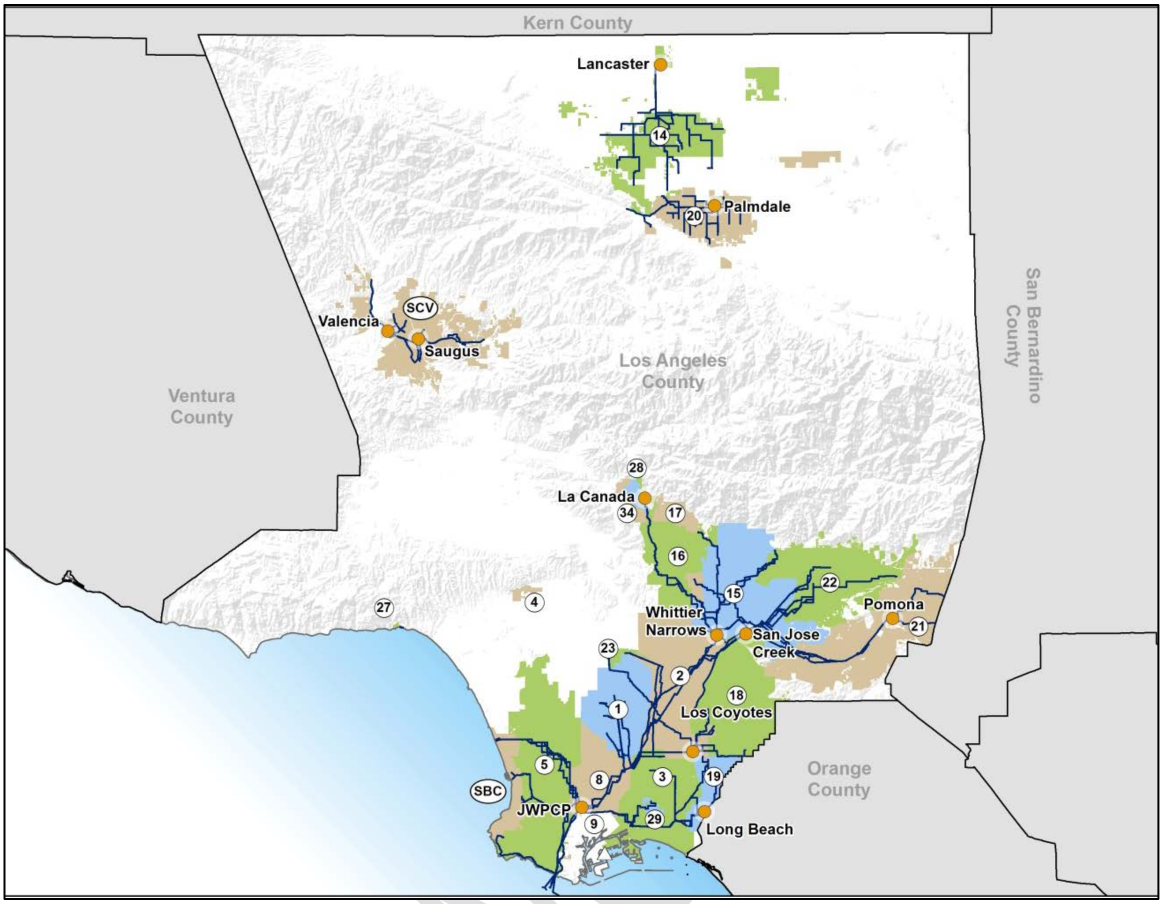

Figure 1-2: Sanitation Districts Service Area

1.3 Program Concept

The program concept is to develop a regional IPR or DPR program as a new source of water for Metropolitan to supplement its imported State Water Project and Colorado River water supplies. The source of water for the program would be the JWPCP, which currently provides secondary treatment to an average flow of approximately 265 MGD of wastewater before discharge into the Pacific Ocean. The Sanitation Districts project the output of the JWPCP to increase to approximately 400 MGD by 2050. Metropolitan proposes to use this water for a regional program.

To treat the water to meet regulatory requirements, JWPCP effluent would be diverted to new AWT facilities located on the JWPCP property. Prior to diversion, Metropolitan would rely on the Sanitation Districts' source control program, which has been effective in maintaining the quality of the wastewater going into the JWPCP. The AWT provided would likely model the process used by the OCWD GWRS and other similar IPR projects. The AWT would utilize a multiple barrier approach in order to increase the overall system reliability and ensure the quality of the advanced treated water. It is anticipated that the ultimate build-out of the AWT system would produce 150 MGD for potable reuse.

Following advanced treatment, the water would be conveyed through a new distribution system for one or more of three options:

- Groundwater Recharge – the advanced treated water would be either spread or injected into the local groundwater basins. Following the required retention period, the water would be extracted for use by local member agencies.
- Surface Water Augmentation – the advanced treated water would be blended with raw water in accordance with regional requirements and discharged into a suitable reservoir. Following the required retention period in the reservoir, the water would be considered part of Metropolitan's normal raw water supply and would be treated at one of Metropolitan's treatment plants.
- Conventional Treatment Plant Supply – the advanced treated water would be blended with a raw water source upstream of one of Metropolitan's treatment plants. The blended water would then undergo Metropolitan's conventional treatment prior to distribution.

2 Previous Recent Work on Recycled Water

In March 2010, Metropolitan and the Sanitation Districts entered into a Memorandum of Understanding to jointly study the potential for an IPR project utilizing secondary effluent from the JWPCP. The drivers of this initial partnership for Metropolitan were a multi-year drought, a state-wide water shortage, and low storage levels in basins and reservoirs. For the Sanitation Districts, their board had previously endorsed a plan to maximize reuse and pending legislation would have required at least 50% of wastewater annually discharged into the ocean to be recycled and put to beneficial use by the year 2030[1].

The Sanitation Districts indicated that up to 200 MGD of secondary treated wastewater was available from the JWPCP for a reuse program. The joint study included planning studies to assess the potential for utilizing the available effluent from the JWPCP and an AWT pilot plant to assess the potential for Metropolitan to meet the Draft Title 22 Groundwater Replenishment Regulations (DGRR) in effect at the time. The feasibility studies and the AWT pilot plant conducted for this effort are described in the following sections.

2.1 Prior Planning Studies (2010 – 2012)

Prior studies conducted from 2010 to 2012 assessed the potential for a regional indirect potable reuse program through either groundwater recharge or surface water augmentation. Direct potable reuse was not considered for the study. Specifically, the studies assessed water quality issues, institutional and regulatory issues, and the physical facilities that would be required for a regional program.

An update on the initial findings for the prior studies was provided to Metropolitan's Board in July 2011. The initial findings presented were as follows:

- Due to limitations in open reservoir storage, the lack of a clear regulatory pathway, and limited available sites, reservoir augmentation was likely not feasible at the time.
- Groundwater basins would be a key resource for a large scale program and there is potential for a traditional groundwater recharge program or a storage and export program.
- Groundwater basin adjudications in existence at the time would limit the potential program size for a traditional groundwater recharge program.

[1] Senate Bill 565 introduced by Senator Fran Pavley, February 27, 2009.

- A 150 MGD or greater project was technically feasible under a storage and export program, but that phased implementation would be required due to blend restrictions for recycled water.
- Stakeholder partnerships would be key for successful implementation of a project.

As reported at the Board update, there were a number of changed conditions that offset the original study drivers including above average rainfall, which filled reservoirs to or near capacity; the governor ending the drought declaration; projected lower long-term demands in Metropolitan's 2010 Integrated Resources Plan (IRP) Update; and the non-passage of SB 565 and the absence of any other passed or pending recycled water legislation. In addition, Metropolitan and the Sanitation Districts were unable to develop terms satisfactory to either organization for a full-scale program.

2.2 Pilot Study (2010 – 2012)

Between June 2010 and July 2012, a 17.5 gallon per minute (GPM) Pilot Study[2] was conducted jointly by Metropolitan and the Sanitation Districts at the JWPCP, to evaluate the feasibility of AWT processes on JWPCP secondary effluent to meet California Department of Public Health (CDPH, now the Division of Drinking Water, DDW) DGRR as of 2008. The main tasks of the Pilot Study included:

- Literature review of similar reuse projects
- Assessment of water quality performance of two AWT trains with respect to criteria specified in the 2008 DGRR
- Evaluation of operating conditions and performance of the two trains, and
- Evaluation of ultraviolet (UV) photolysis, with and without hydrogen peroxide, for treatment of compounds that are not removed by reverse osmosis (RO) membranes.

Other supporting tasks included evaluating the impact of biological nitrification in the membrane bioreactor (MBR) unit on overall train performance, and evaluating chemical additives to improve ultrafiltration (UF) and RO membrane performance (including chloramines, anti-scalants, acids).

Two treatment trains were considered as shown in Figure 2-1. One consisted of what is considered a standard AWT train, with UF, RO, and an advanced oxidation process (AOP) using UV oxidation with

[2] Sanitation Districts of Los Angeles County and Metropolitan Water District of Southern California; *Joint Water Purification Pilot Program: Pilot Study of Advanced Treatment Processes to Recycle JWPCP Secondary Effluent, Final Report*; September 28, 2012

hydrogen peroxide. The second train was the same as the first train except that an MBR was used in lieu of the UF membrane. Although AWT trains are often comprised of microfiltration (MF) membranes, UF membranes can be used as an alternate to MF membranes.

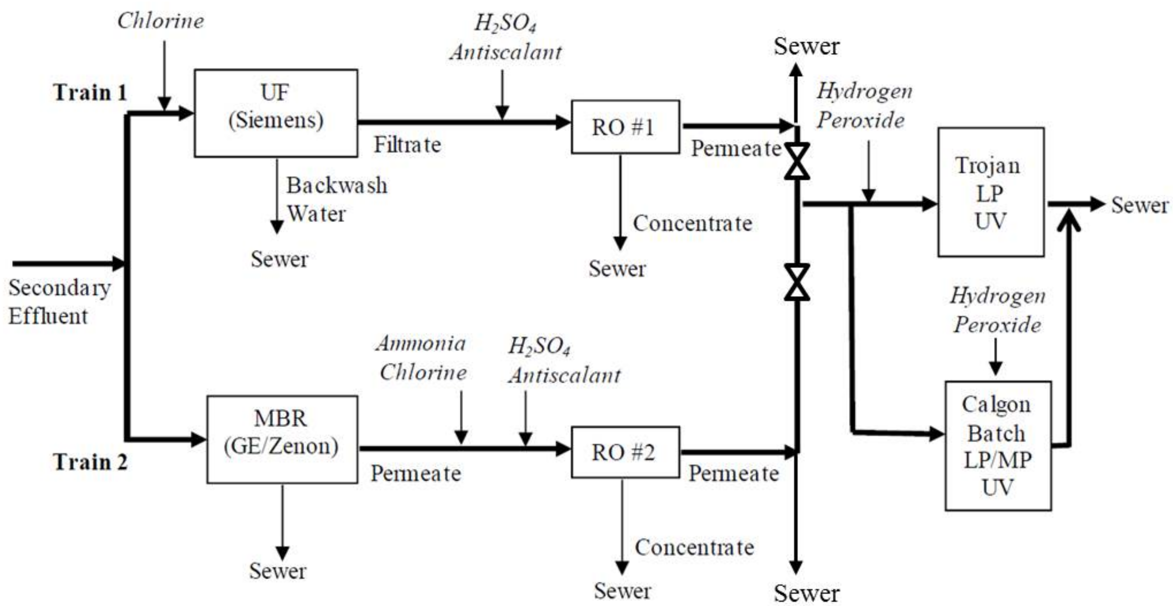

Figure 2-1: Schematic Diagram of Pilot Study Treatment Process Trains

2.2.1 System Description

The design criteria and operational information for each of the unit processes are included in Appendix B. The UF-RO-AOP train will be referred to as the "UF train", and the MBR-RO-AOP train will be referred to as the "MBR train". It should be noted that the UV system was not online for the full duration of the testing. Rather, all AOP experiments were conducted as shown in Appendix B to determine the required UV and hydrogen peroxide doses to meet nitrosamine NLs and 1,4-dioxane removal requirements per the DGRR, based on the maximum observed concentrations of these constituents in RO permeate.

2.2.2 Results

The key findings regarding the UF-RO-AOP versus the MBR-RO-AOP trains are summarized in Table 2-1, and the major findings of the Pilot Study are summarized below.

Table 2-1: Comparison of the UF and MBR Trains

	UF-RO-AOP	MBR-RO-AOP
Operation	Operations of UF negatively affected by the secondary effluent water quality; poor secondary effluent water quality increased fouling and cleaning requirements	Operation of MBR was less affected by secondary effluent water quality; tertiary MBR could be operated at a flux similar to the UF flux
Design	Required a smaller footprint	Required aeration tank(s) as well as membrane tank(s)
Chemical Use	Sulfuric acid dose to lower the pH of UF filtrate was higher	Sulfuric acid dose to lower the pH of MBR permeate was much lower because the MBR consumed 75% of the secondary effluent alkalinity during nitrification
Energy Use	Energy to operate the UF system was lower	MBR system required air scouring of the membranes, therefore using more energy; air used for membrane scouring was sufficient to fully nitrify the secondary effluent in this study
Effluent Water Quality	Median total nitrogen concentration was ~2 mg NH_3-N/L Total organic carbon (TOC) concentration was occasionally higher than the target of 0.5 mg/L	Median total nitrogen concentration was ~3 mg NO_3-N/L TOC concentration was consistently below the target of 0.5 mg/L AOP removal of nitrosamines and 1,4-dioxane was slightly better because of lower alkalinity and/or higher UVT in the RO permeate

2.2.2.1 Membrane Filtration

The UF membrane was irreversibly fouled by the end of the two year period, although it has an expected life of five years. The UF process recovered more quickly from process upsets due to the fact that the MBR required re-establishment of the mixed-liquor suspended solids (MLSS) concentration to the desired value after an upset. However, the MBR appeared to be less sensitive to changes in JWPCP effluent due to the biological activity within the MBR tank. The biological processes in the MBR tank likely attenuated and degraded some of the organic foulants in the secondary effluent. The nitrification processes occurring in the MBR tank which enabled the MBR to perform effectively over the 2 year study period is analogous to the nitrification/denitrification (NDN) upstream of the OCWD GWRS which enhanced overall MF performance. During the Pilot Study, secondary effluent ammonia levels ranged between 22 and 49 mg N/L with a median of 37 mg N/L, and UF filtrate levels remained high at a median of 36 mg N/L. In contrast, MBR effluent ammonia levels ranged between < 1.0 and 1.9 mg N/L, with a median of < 1.0 mg N/L. JWPCP staff recently indicated that ammonia levels have increased since the Pilot Study was conducted, averaging 41 mg N/L in 2014. RO permeate total nitrogen levels in the UF train were approximately 1.9 mg/L, mostly as NH_3-N, whereas total nitrogen levels in the MBR train were 2.8 mg/L, mostly as NO_3-N.

Although energy use in the MBR system was higher due to aeration requirements (in both the aeration tank and air scour), chemical usage was less in the MBR train due to lower alkalinity, which was consumed during the nitrification processes, thereby lowering the required sulfuric acid dose upstream of the RO membranes to achieve the low target pH at the RO influent between 6.5 and 6.8. In addition, the hydrogen peroxide dose used to achieve target removals for NDMA and 1,4-dioxane was 1 to 2 mg/L lower than that used in the UF train (0 to 6 mg/L). This is likely due to the fact that alkalinity was lower in the MBR train, since alkalinity is known to scavenge hydroxyl radicals.

2.2.2.2 Reverse Osmosis

A comparison of RO permeates in the two trains shows that biological processes in the MBR train lowered several constituents compared to the UF train, including bulk organic matter (total organic carbon [TOC], dissolved organic carbon [DOC]), trace organics (mainly through sorption), manganese, five nitrosamine compounds, several constituents which may be removed through biological oxidation (t-butyl alcohol, total trihalomethanes [THMs], and dichloromethane) and color, thereby increasing overall UV Transmittance (UVT). This again in turn likely lowered the required hydrogen peroxide dose for AOP targets.

Not considering nitrosamine and 1,4-dioxane compounds removal which was targeted by the AOP processes, the RO membranes were effective at removing most compounds except for those with low molecular weight, including formaldehyde, chlorate, volatile organic compounds (VOCs), and boron. Differences in RO membrane performance between the UF and MBR trains were due to the biodegradation of organic matter and nitrification processes that occurred in the MBR train, with higher nitrate levels but lower ammonia and alkalinity levels in the MBR-RO train than the UF-RO train. In addition, there were differences in the distribution of halogenated methanes between the MBR and UF trains, which were likely due to differences in organic precursors at the time of chlorine addition, which was upstream of the UF for the UF train, but downstream of the MBR for the MBR train.

2.2.2.3 UV Disinfection and Advanced Oxidation

AOP processes had similar impacts on water quality for both trains, with a decrease in alkalinity and increase in formaldehyde, which is consistent with literature. Slight increases in nitrate (approximately 0.1 mg N/L), chloride, and TDS observed were likely due to UV photolysis of chloramines and potentially the reaction of ammonia with hydroxyl radicals. Some differences were observed in the total THM concentrations since some THMs are known to be photolyzed by UV, such as bromoform and chlorodibromomethane, which were the dominant THM species in the MBR train; whereas some are not susceptible, such as chloroform, which was the predominant THM species in the UF train. Other differences were likely due to metals leaching from the UV reactors, increasing copper, lead, and hexavalent chromium concentrations in AOP effluent compared to influent. The UF train was only tested with the Trojan UV reactor, whereas the MBR train was tested with both the Trojan and Calgon UV reactors. Copper and lead leached more from the Trojan UV reactor than the Calgon UV reactor.

AOP experiments were conducted to observe reduction of 1,4-dioxane, NDMA, N-nitrosodi-n-Propylamine (NDPA), and N-nitrosodiethylamine (NDEA) to within target concentrations and/or removals. These three nitrosamines were selected from a subset of seven nitrosamine species because they were above detection levels in RO permeate. Coincidentally, these are the only three nitrosamines which currently have NLs that could be enforced under the new groundwater replenishment regulations using recycled water (effective as of June 18, 2014). With UV electrical energy doses (EED) of 2-6 kWh/kgal and hydrogen peroxide doses from 0-6 mg/L, all constituents were removed to within targets and/or achieved removal goals with the exception of NDEA (see Appendix B). It is likely that higher UV and/or peroxide doses would effectively reduce NDEA to within target concentrations, and this capability should be demonstrated. It is noted in the Pilot Study report that the recommended UV and hydrogen peroxide doses for the AOP process are reactor specific and should not be applied to another reactor. Lastly, NDEA concentrations increased across the UF and MBR membranes. More study and testing is recommended to understand this mechanism.

2.2.2.4 Other Water Quality Results

TOC levels of the MBR effluent always met the < 0.5 mg/L goal, whereas the UF membrane occasionally exceeded this target by 10%. It is likely that this would not be an issue, since once the RO membranes were replaced for both trains in Phase 3 of testing, both trains consistently met the goal.

Constituents that were not at or below target levels in the effluent of the UF and MBR trains included boron and pH. The current boron state NL is 1 mg/L, and the target level used during the Pilot Study was 0.5 mg/L. It should be noted that certain groundwater basins have a boron water quality objective of 0.5 mg/L. Final effluent from the UF and MBR trains had approximately 0.6 mg/L of boron as a median value. Alkalinity and pH levels are typically low after RO processes due to the low pH required for anti-scalants. In a full-scale system, alkalinity and pH adjustment could be carried out with lime slurry or a combination of caustic soda and calcium chloride to meet the target pH range of 6 to 9.

In addition to general parameters that were routinely sampled during the Pilot Study to evaluate the performance of the various pilot units, almost 300 constituents were sampled during six events to analyze the general parameters, nitrosamines, 1,4-dioxane, radiologicals, volatile and semi-volatile organic compounds, microbiological parameters, pesticides, herbicides, disinfection byproducts, hormones, endocrine disrupting compounds, and pharmaceutical and personal care products. Detectable levels of these constituents were found in JWPCP secondary effluent but all were subsequently reduced to below their laboratory reporting limits in both the UF and MBR trains except for several VOCs, chlorate, and formaldehyde. These constituents, however, were below the target levels set for the Pilot Study. Due to the biological activity in the MBR, several nitrosamines and biodegradable trace organic constituents achieved greater removal through the MBR versus the UF membrane.

2.3 Prior Studies Findings and Conclusions

Based upon the prior studies and the pilot plant results, an indirect potable reuse program appeared technically feasible. However, changed conditions which offset the original drivers of the study and the inability to develop terms for a full-scale program agreeable to both organizations resulted in a postponement of additional studies relating to the potential program.

Since the completion of the prior planning studies, a number of changes have occurred pertaining to regulation of potable reuse projects and the management of local groundwater basins. Consequently, many of the findings for these initial studies are potentially no longer valid, and constitute a need for reexamination of the previous findings. These changed conditions and their impacts on a potential new project are summarized in Section 3.

3 Drivers for 2015 Update

Following the completion of the prior planning studies described in Section 2, a number of events and changed conditions have occurred that warranted a reexamining of a partnership with the Sanitation Districts to begin new studies to reassess the potential for a regional recycled water supply program. These changes include: new developments in the regulatory environment for potable reuse projects, changes to the operations of local groundwater basins, continued long-term drought, and the expectation that satisfactory terms could be developed between Metropolitan and the Sanitation Districts. These events have improved the potential to successfully implement a regional reuse program in the near term.

3.1 Developments in the Regulatory Environment

3.1.1 Groundwater Replenishment Regulations

In June 2014, regulations for IPR through groundwater replenishment were finalized and incorporated into Title 22 of the California Code of regulations. Unlike the DGRR in effect during the initial 2010-2012 study, the current finalized groundwater replenishment regulations provide a clear path for regulatory approval of a project. A couple of changes in the finalized regulations also improve the potential to implement a large project: 1) the potential for an initial 100% Recycled Water Contribution (RWC) for projects that utilize reverse osmosis and advanced oxidation processes, and 2) a reduced minimum retention time to two months from six months. Consequently, the initial sizing of a project may not be limited by the blending requirement. A lack of blend water had been previously identified as a potential limitation for a large regional program. Also, the potentially shorter retention time would impact less existing production wells. A full discussion on the finalized groundwater replenishment regulations is provided in Section 5.

3.1.2 Surface Water Augmentation

Senate Bill 918, which was signed into law in September 2010, requires that the California Department of Public Health (now the State Water Resources Control Board, Division of Drinking Water) develop regulatory criteria for surface water augmentation by December 2016. While draft criteria have not yet been released, a number of presentations have been given, which highlight criteria under consideration. These criteria differ significantly from what was assumed for the initial study. For example, the regulations require that only reservoirs that have been in operation for sufficient time to have developed a baseline raw and treated water quality can be utilized for surface water augmentation. In addition, advanced treated water introduced into a reservoir may be considered ambient after 24 hours for the purpose of calculating dilution. Consequently, the previous assumptions regarding a potential surface water augmentation program are no longer valid, and a new review of the potential for utilizing Metropolitan's existing reservoirs was deemed prudent. A full discussion on the potential surface water augmentation regulations is provided in Section 5.

3.2 Developments in Groundwater Storage and Production Potential

The groundwater basin adjudications in existence at the time of the prior study would have limited the potential size and flexibility for a regional IPR groundwater recharge program. Following the completion of the prior planning studies, the judgments for the Main San Gabriel, West Coast and Central Basins were amended to allow for increased storage and extraction. Consequently, the potential for a regional groundwater recharge program has improved. Potential recharge amounts for each basin in consideration for this study are provided in Section 9.

3.3 Developments in Metropolitan and Local Supplies

One of the primary drivers of the prior studies was a four year drought which resulted in low storage levels in reservoirs and basins that supply the region. As stated previously, above average rainfall during the 2011/12 wet year allowed Metropolitan to fill its storage reserves, but local groundwater basins were not able to fully recover. Since this time, California has been in the midst of another long-term drought. In 2014, Metropolitan received a record low 5% allocation of its State Water Project Supplies, and the 2014/15 wet year resulted in record low snow pack in the Sierra Nevada Mountain Range, which supplies the State Water Project. The current drought has resulted in reservoirs and groundwater basins being near or at historic lows.

Despite the lower demand projections in the 2010 IRP Update, Metropolitan is approximately 150,000 acre-feet below its targets for water use efficiency and local supplies. In addition, local groundwater production is approximately 250,000 acre-feet below the 2010 IRP projections. Metropolitan is in the process of developing the 2015 Update of IRP. Goals identified as part of the update include a focus on improving the sustainable yield of local groundwater basins, and development of a diverse resource mix. The 2015 IRP Update sets a resource target to increase local resources development by an additional

200,000 acre-feet per year by 2040. A regional recycled water supply program would be a significant step toward meeting these goals.

3.4 Development of Terms between Metropolitan and the Sanitation Districts

Prior to reengaging in a partnership to study the potential for a regional recycled water supply program, Metropolitan and the Sanitation Districts determined that it would be prudent to work toward the development of satisfactory terms outlining the roles and responsibilities for each organization, and provide a framework to implement a regional program. These terms were presented to each organization's respective Boards in November 2015, and were subsequently approved. The terms bind Metropolitan and the Sanitation Districts to the design, construction and operation of an AWT demonstration facility at the JWPCP, and provide a framework for development a full-scale program should the respective Boards agree to move forward.

3.5 Conclusion

Since the completion of the initial studies in 2012, a number of significant events have occurred, which have increased the need for Metropolitan to diversify its supply portfolio, and improved the potential for implementation of a large-scale potable reuse project. These developments have also invalidated some of the assumptions and conclusions from the prior studies warranting a reassessment of a potential program. Lastly, Metropolitan and the Sanitation Districts have gone further to develop terms that provide a framework for a potential full-scale program so that the organizations going forward will have confidence in the roles and responsibilities of each party.

4 JWPCP Facility Overview

4.1 Background

The JWPCP is located at 24501 South Figueroa Street, Carson, California. The plant occupies approximately 420 acres to the east of the Harbor (110) Freeway. Approximately 200 of the 420 acres are used as buffer between the operational areas and residential neighbors. Buffer areas include the Wilmington Boys and Girls Club, a 17-acre fresh water marsh area, a commercial complex, nursery operations, and others. A site map of the operational and buffer areas is provided in Figure 4-1, and a location map for the site is presented in Figure 4-2. JWPCP is the largest facility within the JOS, and provides primary and secondary treatment to approximately 265 MGD of wastewater, with a design capacity of 400 MGD. Prior to discharge, the treated wastewater is disinfected with sodium hypochlorite and sent to the Pacific Ocean through a pair of tunnels and network of outfalls. These outfalls extend 1.5 miles off the Palos Verdes Peninsula to a depth of approximately 200 feet. The plant serves a population of approximately 3.5 million people throughout Los Angeles County. The Sanitation Districts project the output of the JWPCP to increase to approximately 400 MGD by 2050.

Figure 4-1: JWPCP Operational and Buffer Zones

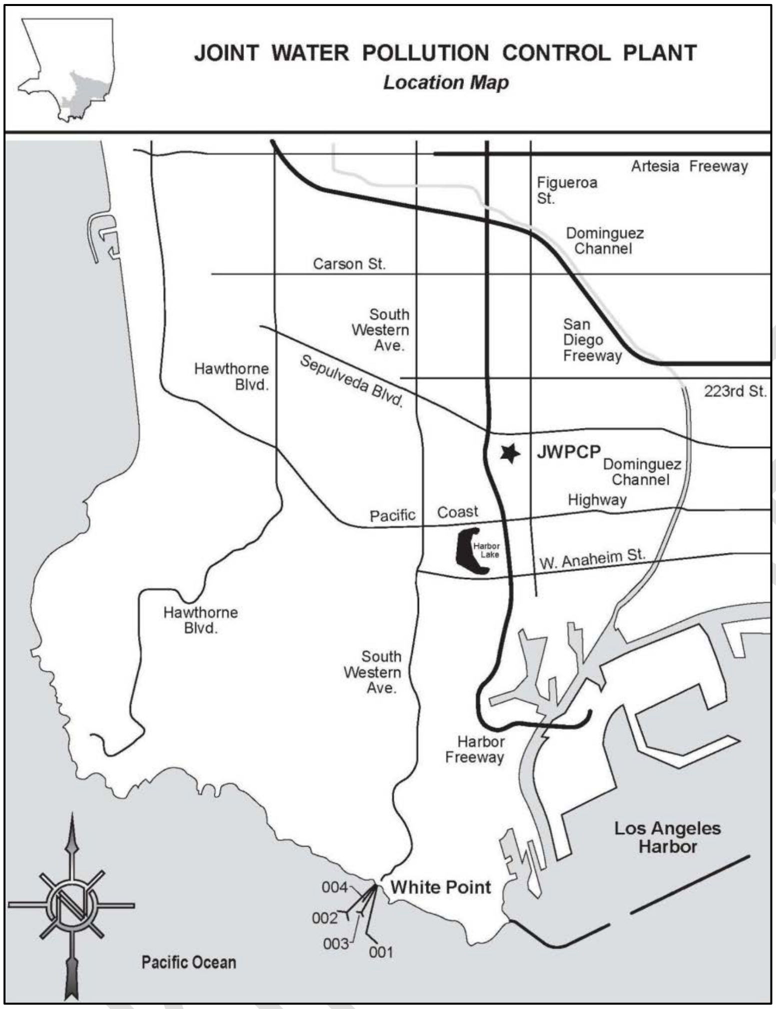

Figure 4-2: JWPCP Location Map

4.2 Source Water Characteristics

4.2.1 Sources of Influent to JWPCP

The JWPCP receives wastewater from approximately 3.5 million residents, numerous commercial businesses, and over 1,500 permitted industrial users. The JWPCP also provides centralized processing of treatment residuals from the other facilities in the JOS. These facilities include six tertiary Water Reclamation Plants (WRPs) located upstream of the JWPCP: La Canada WRP in La Canada Flintridge, Long Beach WRP in the City of Long Beach, Los Coyotes WRP in the City of Cerritos, Pomona WRP in the City of Pomona, San Jose Creek WRP near the City of Whittier, and Whittier Narrows WRP near the City of South El Monte. Together, these WRPs have a design flow of 193 MGD and treated an average of 117 MGD of flow in 2014. The residuals from the upstream WRPs consist of organic solids, or biosolids, which are the byproduct of the primary and secondary treatment trains at each of the WRPs. JWPCP also receives industrial wastewater flows from the Inland Empire Utilities Agency's Non-Reclaimable waste line.

Approximately 19% of the flow entering the JWPCP is from industrial sources. The largest dischargers are four major oil refineries: BP Carson Refinery, ExxonMobil, Tesoro, and Conoco Phillips. Other major types of discharge include food manufacturing, steel manufacturing, water treatment, textile manufacturing, and oil production fields. Due to source water quality concerns, the industrial wastewater dischargers are permitted by the Sanitation Districts. Discharges into the JOS from the permitted discharges are regulated and monitored by the Sanitation Districts to ensure satisfactory operation of the JWPCP treatment process and effluent requirements are achieved.

4.3 Source Monitoring and Control Program

The Sanitation Districts implement an extensive source control program to maintain and enhance its wastewater treatment systems and ensure they continue to protect public health and the environment. The program focuses on preserving downstream receiving waters as well as producing high quality recycled water. The source control program includes a comprehensive industrial pretreatment and source control program, public outreach and policy development, and a proactive source investigation and monitoring program that addresses evolving potable reuse requirements as described below.

4.3.1 Industrial Pretreatment and Source Control Programs

The Sanitation Districts operate a well-established industrial pretreatment and source control program, which is the focus of the agency's overall source control efforts. The program has the following objectives:

(1) to allow the Sanitation Districts' treatment plants to comply with effluent discharge requirements;

(2) to protect the public, the environment, Sanitation Districts' personnel, and Sanitation Districts' facilities from potentially harmful industrial wastes; and

(3) to ensure that industrial users (IUs) pay their fair share of treatment operations and maintenance costs.

While the industrial pretreatment program was formally approved by the United States Environmental Protection Agency (USEPA) in 1985, it started well before that. In 1972, the Wastewater Ordinance was adopted, which gave the Sanitation Districts the strict legal authority to fully control industrial dischargers. The ordinance allows the Sanitation Districts to regulate for a broad spectrum of pollutants and is regularly evaluated to make sure it aligns with program objectives. The ordinance includes categorical and industry limits, which are specific to certain industry types, as well as local limits which are applied to all industrial and commercial dischargers. Permit specific limits may also be imposed on an industry or group of industries to meet particular treatment plant limits or reuse objectives. A copy of the Wastewater Ordinance is provided in Appendix A.

The Sanitation Districts' program is one of the largest industrial waste programs in the country. It has an annual budget of over $12 million, employing 67 staff, including 24 engineers, 29 inspectors and 7 technicians. The Sanitation Districts permit over 2,100 industries from a variety of different industrial categories. Due to the large number of industrial users and the diversity of the industrial base, the Sanitation Districts' pretreatment program has been enhanced through the use of computer-automated permitting, inspection, and compliance programs that allow for tracking, assessment, notification, and enforcement of applicable regulations.

The Sanitation Districts' industrial users are required to obtain Industrial Wastewater Discharge Permits. Permit applications are reviewed by knowledgeable engineering staff, with specific technical expertise, to evaluate industrial wastewater sources and determine if the pretreatment equipment proposed is adequate to meet appropriate discharge limits. Permits can be modified at any time if necessary and all significant industrial permits are renewed at a minimum of every five years. The Sanitation Districts also identify new dischargers by routine canvassing of its service area by inspectors and through coordination with local agencies, such as those companies seeking building permits, construction permits, and plumbing permits.

The Sanitation Districts implement an extensive inspection program to ensure continued compliance by its industrial users. Rigorously-trained inspectors conduct over 10,000 site visits per year to assess industries, verify the Sanitation Districts' industrial waste regulatory program is observed and that adequate pollution prevention control practices are applied, identify industrial sources that may cause treatment plant upsets or incidents, and disseminate information on the pretreatment program. A night inspection crew further enhances the Sanitation Districts' capabilities to monitor industrial dischargers.

Standardized enforcement procedures have been developed to achieve timely and effective compliance, and 99% of all samples tested met discharge limits in 2014.

4.3.2 Public Outreach and Policy Development

The Sanitation Districts also lead public outreach and policy campaigns for the source control of pollutants that are primarily discharged by non-industrial sources such as residences and small businesses. These campaigns, focused on pollution prevention, raise awareness to help reduce or eliminate the pollutants of concern. The Sanitation Districts create messages, develop outreach materials, and implement other strategies to communicate issues of concern and effective behavior changes to the public. Furthermore, the agency leads efforts to make legislative changes and works with other regulatory agencies to control use of the pollutants in products.

Examples of current efforts include control of pharmaceuticals in wastewater through the No Drugs Down the Drain program, a public outreach and education campaign on proper disposal of medications; control of fats, oil and grease entering the sewerage system through an outreach program that targets restaurants and food service establishments; chloride reduction through removal of automatic water softeners as well as other methods; and bans and/or limited use of specific pesticides by working with the California Department of Pesticide Regulation and the USEPA to confirm that water quality impacts are adequately addressed during review of pesticide registrations.

In the past, the Sanitation Districts have worked with legislators and agencies to ban paradichlorobenzene-based urinal deodorizers, pharmaceutical use of lindane, and chlorinated solvents in a number of consumer products due to their impact on water quality. The Sanitation Districts also used source control measures to reduce n-Nitrosodimethylamine (NDMA) by characterizing incoming wastewater, researching potential sources, and then implementing a number of actions, including a ban on the usage of a root killing product high in NDMA. Not only were these programs effective in reducing pollutants, they also received numerous state, local, and national recognitions.

Furthermore, the Sanitation Districts oversee and promote household hazardous waste collection events throughout Los Angeles County, which allow for the proper disposal of unwanted household chemicals, keeping them out of the wastewater system. In 2014, over 50,000 households participated in the events and approximately 182,000 gallons of used paint, 22,000 gallons of used oil, and 141,000 gallons of miscellaneous hazardous waste were collected.

4.3.3 Monitoring of Source Water

To ensure effective source control, the Sanitation Districts routinely sample influent water at their 11 treatment plants to track various constituents and investigate any changes in concentrations. At the JWPCP, more than 150 parameters are monitored at least quarterly and many are monitored monthly. Among the parameters monitored are arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, zinc, cyanide, phenols, various organic compounds and ammonia. A complete list of monitoring results for 2014 wastewater influent at the JWPCP is included in Appendix A.

Currently, the concentrations of most compounds in the influent to JWPCP are below drinking water standards, on average for 125 out of the 126 priority pollutants, as identified by the USEPA. The influent does not meet the standards for benzene, which is contributed by the industrial wastewater from oil refineries and oil producing fields. Through a program paid for by these dischargers, the Sanitation Districts installed air scrubbers at the JWPCP that remove the benzene volatilized during treatment to reduce health risks as well as comply with regulatory requirements for benzene air emissions. As a result, the JWPCP effluent meets the drinking water standards for benzene and for all other priority pollutants.

The Sanitation Districts also regularly monitor for Constituents of Emerging Concern (CECs) at both the JWPCP and WRPs. Effluent at JWPCP has been tested for a number of CECs, including compounds that were recommended by State Water Resources Control Board (SWRCB) expert panels on CECs in recycled water and aquatic life, as well as compounds that were recommended in draft versions of the Division of Drinking Water's (DDW) groundwater replenishment regulations. The list of CECs monitored was developed in consultation with the Los Angeles Regional Water Quality Control Board (RWQCB) and in consultation with other laboratories. The effluent from JWPCP only exceeded two Monitoring Trigger Levels (MTLs) that were developed by the SWRCB expert panel on CECs in recycled water, for caffeine and 17-beta-estradiol. Although the concentrations were at levels that required no additional response, the Sanitation Districts will continue to regularly monitor for these compounds.

4.3.4 Source Control and Potable Reuse

Title 22, Articles 5.1 and 5.2 of the California Code of Regulations provide wastewater source control requirements for groundwater replenishment projects using recycled water. The Sanitation Districts comply with these source control requirements and will continue regular source monitoring and investigations that focus on chemicals and contaminants specified by DDW and the RWQCBs. Furthermore, the Sanitation Districts will continue to take a proactive approach, tracking new chemicals and contaminants resulting from new sources or changes to existing sources that may impact water quality. As meeting drinking water requirements is essential to these projects, the Sanitation Districts will also routinely conduct source monitoring for drinking water constituents, both regulated and unregulated.

In cases where parameters are measured at levels of concern and/or issues arise in operation of the AWT plant affecting the end use of the water, action may be taken. Increased monitoring, enhanced source identification, and source control may be implemented if it is practical and cost-effective to do so.

For source identification, the Sanitation Districts would first conduct an assessment to determine if the occurrence is:

- Localized, usually caused by a specific source;
- High in several areas, due to use by industries, applications in the commercial sector, and/or a result of limited use products; or
- System-wide, indicating it is the result of a consumer product.

Then source control strategies would be applied to address the contaminants and reduce their levels. These strategies, similar to those considered by Orange County Sanitation District (OCSD) for the GWRS, may include:

- Establishing best management practices for the industrial and commercial sectors, including modifying chemicals used in the manufacturing process, to reduce the contaminants;
- Adding local limits and/or making other changes to the Wastewater Ordinance to reduce the contaminant from a broad range of industries;
- Implementing permit specific limits;
- Leading development of policies and regulations that limit use of the contaminant such as product bans; and

- Employing educational efforts that inform residents and businesses of the contaminants and actions to take to limit their presence in the wastewater stream.

For example, during pilot testing completed at the JWPCP between 2010 and 2012 to characterize the fate of pollutants through advanced water treatment processes, it appeared that boron, NDMA, N-nitrosodi-n-Propylamine (NDPA), and N-nitrosodiethylamine (NDEA) were not adequately removed. The source identification methods described above may be used to determine where these constituents are coming from and if they can be cost effectively reduced through any of the source control strategies or if additional treatment may be necessary prior to recycling.

The Sanitation Districts are committed to producing high quality water from the JWPCP that is provided to Metropolitan and its member agencies for ultimate reuse. The Sanitation Districts will work with Metropolitan to address any contaminants in the wastewater stream that may impact Metropolitan's mission of providing a reliable, high quality drinking water supply. Specifically, source control methods may be used to help safeguard Metropolitan's AWT process and the end use of the water.

4.4 Influent Water Quality

Influent at the JWPCP is tested for a number of different water quality parameters. Testing for various parameters is conducted on a continuous, daily, weekly, monthly, quarterly, or semi-annual basis. A summary of influent water quality data for 2014, for all parameters that were sampled in the JWPCP influent is presented in Appendix A.

4.5 Existing Treatment Process Description

Wastewater treatment processes at JWPCP include screening, grit removal, primary sedimentation, pure oxygen activated sludge secondary treatment, secondary clarification, anaerobic sludge digestion, and sludge dewatering. These unit processes are designed and operated to ensure that the plant's effluent quality meets and exceeds the ocean discharge regulatory permit requirements. Effluent produced at the JWPCP is tested for a number of different water quality parameters. Testing for various parameters is conducted on a continuous, daily, weekly, monthly, quarterly, or semi-annual basis. A more detailed description of the JWPCP treatment process and its effluent water quality from is summarized in Appendix A.

Solids collected in primary treatment and secondary treatment are processed in anaerobic digestion tanks where bacteria break down organic material and produce methane gas. After digestion, the solids are dewatered and hauled off-site for use in composting and land application, or combined with municipal solid waste for co-disposal. Methane gas generated in the anaerobic digestion process is used to produce power and digester heating steam in a system that utilizes gas turbines and waste-heat recovery steam generators. The on-site power generation capability permits the JWPCP to produce most of its electricity.

4.6 Available Water for Reclamation

Currently, JWPCP produces an average of 265 MGD of high quality secondary effluent in compliance with its NPDES permit limits, performance goals, and mass emission benchmarks (MEBs). As shown in Figure 4-3, JWPCP effluent varies diurnally from a minimum of 150 MGD to a maximum of approximately 350 MGD. The high quality secondary effluent produced at JWPCP is discharged to the ocean. The Sanitation Districts estimate that, dependent on regulatory compliance issues associated with the brine discharge, and potential further reduced flows from conservation, all 265 MGD could be available for reclamation.

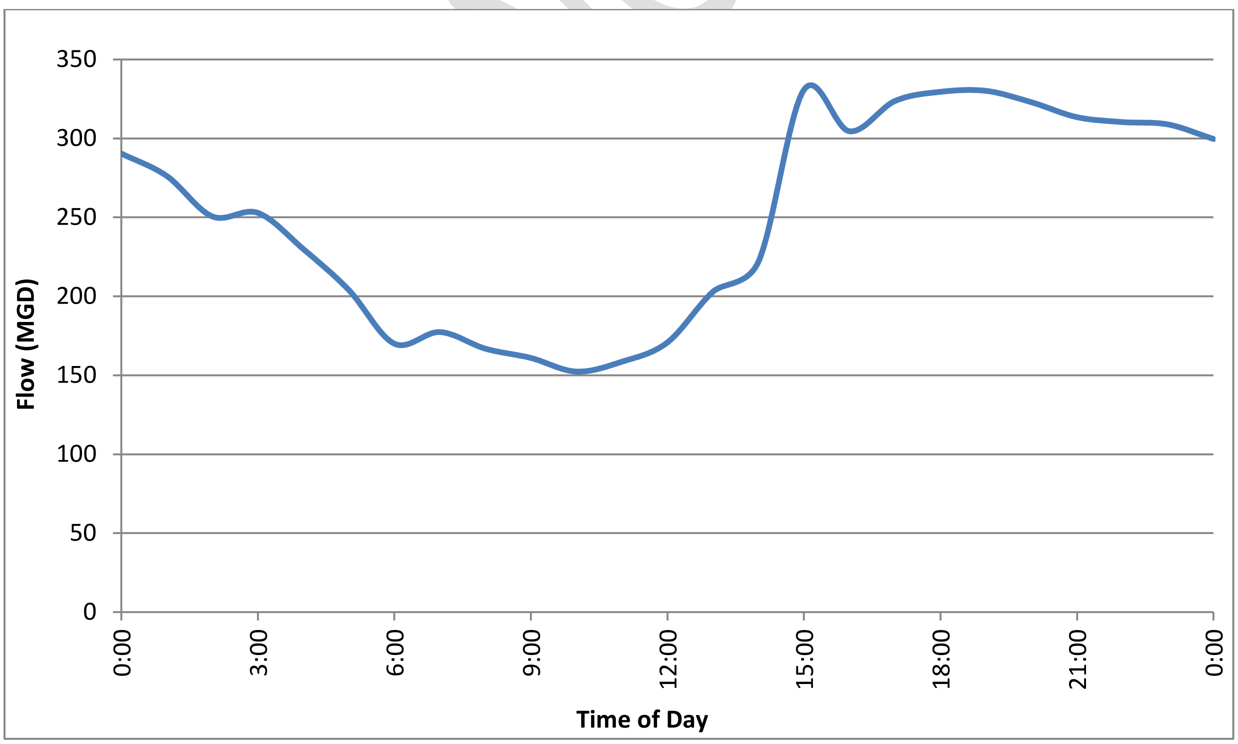

Figure 4-3: JWPCP Current Diurnal Flow Curve

The current and projected dry-weather influent flows to the JWPCP are shown in Table 4-1. These projected flows are based on the current per capita wastewater generation rate and the most recent Southern California Association of Governments (SCAG) population estimates as well as the anticipated changes in the amount of treatment and reclamation that occurs at the Sanitation Districts' upstream WRPs. Wet weather peak flows at the JWPCP that are generated by storm events were not considered as flows that are available for reclamation under this program due to the unpredictable nature of their occurrence and volume. The brine waste streams from the AWT process would be directed into the JWPCP effluent system for eventual ocean discharge, while other treatment waste streams from the AWT process would be directed to a suitable location at the head works of the plant for retreatment.

Table 4-1: Projected JWPCP Effluent Flows

	Current (2015)	Year 2050
Average Flow (MGD)	265	400
Minimum Flow (MGD)	150	200
Maximum Flow (MGD)	350	530

The sizing of a potential AWT facility at the JWPCP, and consequently the sizing of the Program, is dependent on the flow patterns at the JWPCP. Due to the uncertainty of future flow conditions related to ongoing conservation efforts, the AWT facility sizing exercise for the initial near-term phases of the Program was based on the current diurnal flow conditions at the JWPCP shown in Figure 4-3. The study assumed that approximately 85% of the secondary effluent treated at the AWT can be converted into highly purified water suitable for the Program. In other words, if the program is producing 100 mgd of advanced treated water, the AWT facility is processing approximately 118 mgd of secondary effluent. Therefore, under current diurnal flow conditions at the JWPCP, the AWT facility will be able to produce 130 mgd of highly purified product water without the need for flow equalization tanks. As the project is increased in size beyond 130 mgd, flow equalization will be required. However, if the future flow conditions materialize as projected in table 4-1, it is possible that sufficient secondary effluent will be available for the AWT facility to produce greater than 130 mgd of product water without the need for flow equalization. This issue of flow equalization will have to be examined in detail when the Program build-out expands beyond the low diurnal flows.

5 Regulatory Framework for Potable Reuse

The use of recycled water for IPR is regulated in California to ensure protection of public health and water quality. IPR refers to the augmentation of groundwater or surface water with highly treated recycled water. IPR through groundwater replenishment has been conducted for decades in California. Regulations were initially developed in the late 1970s and evolved over time as use of recycled water expanded. Current groundwater replenishment regulations were finalized and incorporated into Title 22 of the California Code of Regulations (CCR) in June 2014.

Although significant regulatory guidance has been developed for groundwater replenishment projects, to date limited guidance has been developed for augmenting surface waters. In September 2010, Senate Bill 918 (SB 918) was signed into law. This bill required the California Department of Public Health (now State Water Resources Control Board, Division of Drinking Water or DDW) to adopt uniform water recycling criteria for IPR for groundwater replenishment by December 2013. It also directed DDW to develop regulatory criteria for surface water augmentation by December 2016. SB 918 further requires DDW to investigate the feasibility of developing regulatory criteria for DPR and to provide a final report to the Legislature regarding that investigation by December 2016. The requirements of SB 918 were incorporated into the California Water Code (CWC) §13350, §13521, and Chapter 7.3. Once complete, this regulatory development will provide critical guidance to further expand water reuse in California.

This section provides an overview of applicable regulations, policies, and other guidance on IPR projects. As described above, the most established regulatory path for potable reuse is currently through groundwater replenishment. This section will therefore focus on groundwater replenishment which relates directly to the initial options being considered for treated effluent from the Sanitation Districts' JWPCP. Additional information is also presented on the current regulatory outlook for IPR through surface water augmentation and DPR. This section details the roles and requirements of the regulatory agencies that have oversight over water recycling, the process for permitting a groundwater replenishment project, and the approach that Metropolitan may take, in partnership with the Sanitation Districts and groundwater agencies, to work collaboratively with the regulating authorities to develop a potential Regional Recycled Water Supply (Program).

5.1 Regulatory Oversight of Water Reuse Projects

Regulatory oversight of recycled water projects is carried out by the State Water Resources Control Board (SWRCB) through DDW and the individual RWQCBs. The SWRCB is generally responsible for setting statewide water quality policy and providing direction to the nine RWQCBs. The SWRCB is organized into five divisions, including the Division of Water Quality. The Division of Water Quality is responsible for water quality planning and regulatory functions, including the regulation of activities associated with the Porter-Cologne Water Quality Control Act (Porter-Cologne Act). The Porter-Cologne Act establishes a comprehensive program for the protection of water quality and beneficial uses of surface water and groundwater, and applies to both point and non-point sources of pollution.

DDW has been statutorily directed to establish uniform statewide reclamation criteria for the various uses of recycled water which are currently set forth in CCR Title 22 §60301 to §60355. The RWQCBs have the exclusive authority to enforce water reclamation requirements through permit enforcement. The RWQCBs rely on the expertise of DDW for the establishment of permit conditions needed to protect public health. It should be noted that DDW was previously the California Department of Public Health (CDPH), and prior to that, California Department of Health Services (CDHS). In July 2014, the state's Drinking Water Program was transferred from CDPH to the SWRCB, and is now known as DDW.

5.1.1 Water Recycling Criteria

Water Recycling Criteria is codified in CCR Title 22, Division 4, Chapter 3, §60301 to §60355. These sections establish the statutory authorities over water recycling and include specified approved uses of recycled water, numerical limitations and requirements, treatment method requirements, reporting mechanisms, and performance standards. Use of recycled water is also regulated through the CWC and the California Health and Safety Code (CHSC). Recycled water is defined in CWC §13050 as *"water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource."* It should also be noted that the Water Recycling Criteria could be considered as primarily focusing on domestic waste, as indicated in CWC §60302 which states that "*the requirements in this chapter shall only apply to recycled water from sources that contain domestic waste, in whole or in part.*"

5.1.2 Memorandum of Agreement

Due to the potential for confusion and duplication of effort between DDW and the RWQCBs, the former CDHS and SWRCB signed a Memorandum of Agreement (MOA) in 1996[3]. The MOA delineates responsibilities of each agency in the review and approval of recycled water projects. DDW requirements for permit approval are to be incorporated into the RWQCB permit. DDW will meet with RWQCB staff and attend RWQCB hearings as necessary to explain any requirements or recommendations associated with the protection of public health. Following the public hearing(s), DDW issues *Findings of Fact and Conditions* for the project, which is then submitted to the RWQCB as the agency's formal recommendations for a project. RWQCBs must consult with and review recommendations from DDW on proposed projects, and permits issued by RWQCBs must be in conformance with the Title 22 Water Recycling Criteria.

The MOA includes reference to IPR as follows:

> *"Planned indirect potable reuse of reclaimed water is commonly practiced in California through artificial groundwater recharge with reclaimed water. Furthermore, indirect potable reuse is being proposed through the introduction of reclaimed water into a water supply reservoir that would serve as a raw water supply for a potable water system. The Department [DDW] has the responsibility to identify when and under what conditions a raw water supply is suitable for potable purposes."*

5.1.3 Water Reclamation Requirements/Permitting

The Water Recycling Criteria and DDW's recommendations for groundwater replenishment projects are implemented and enforced through water reclamation requirements (WRRs) and waste discharge requirements (WDRs) imposed by the RWQCBs. For any project involving surface water discharge, including surface water augmentation projects, a National Pollutant Discharge Elimination System (NPDES) permit is required as well. Maximum Contaminant Levels (MCLs) established in CCR Title 22 have been used as a basis for effluent limitations in water recycling permits to protect municipal and domestic supply beneficial uses. CWC §13260 requires that a Report of Waste Discharge (ROWD) be filed with the RWQCB for any project proposing to discharge waste that could affect the quality of waters of the State. The RWQCB would prescribe WRRs and/or WDRs that would reasonably protect all

[3] http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Recharge/MemorandumofAgreement.pdf

beneficial uses and implement any relevant water quality control plans and policies. Any entity proposing to recycle water is to file an Engineering Report with DDW and the RWQCB on the proposed use. Further details regarding the Engineering Report are provided in the following section. Following receipt of the Engineering Report, additional requests for information as necessary from the project sponsor, and consultation with the RWQCB; DDW holds a public hearing(s) along with the project sponsor. Following the public hearing(s), DDW submits its recommendations through the *Summary of Public Hearing* and *Findings of Fact and Conditions*, which the RWQCB then incorporates into WRRs and/or WDRs for the proposed use.

5.1.4 Title 22 Engineering Report

CCR Title 22 §60323 requires submission of an Engineering Report to DDW and the RWQCB before recycled water projects are implemented. The purpose of the Engineering Report is to describe how a project will comply with Title 22 Water Recycling Criteria (CWC §60301 through §60355). The Engineering Report must be prepared by a qualified registered engineer in California and experienced in the field of wastewater treatment. The report must describe the design of the water reclamation system and clearly indicate the means for regulatory compliance. It should also include a contingency plan to assure that no untreated or inadequately treated wastewater will be delivered to the area of use. In addition to Title 22 criteria, the Engineering Report must also address compliance with water quality standards and objectives in the affected region's Water Quality Control Plan (Basin Plan). The Engineering Report shall also include a comprehensive hydrogeological assessment of the proposed project setting.

DDW has developed *Guidelines for the Preparation of an Engineering Report for the Production, Distribution and Use of Recycled Water*[4]. These guidelines state that an Engineering Report "should contain sufficient information to assure regulatory agencies that the degree and reliability of treatment is commensurate with the requirement for the proposed use, and that the distribution and use of the recycled water will not create a health hazard or nuisance." The guidelines also describe the types of information that are typically presented in the Engineering Report. A typical Engineering Report for a groundwater recharge project would provide sufficient details to address the following information:

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[4] http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/recharge/ERGUIDE2001.pdf

- Project Description
- Project Participants and Regulations
- Groundwater Basin Description
- Water Supply Uses of the Basin
- Groundwater Flow Evaluations
- Source of Wastewater
- Treatment Process and Operating Criteria
- Advanced Treated Water Quality
- Conveyance Systems
- Recharge Areas and Operations
- Compliance with Recharge Site Criteria
- Monitoring and Reporting Program
- Operation Optimization Plan
- Contingency Plan
- Findings and Conclusions

Metropolitan would be required to complete an Engineering Report as part of the permitting process for the full-scale Program. The Engineering Report would follow the demonstration testing as described later in this section. The Engineering Report would be accomplished in partnership with groundwater basin managers for the targeted replenishment sites. Moving forward, Engineering Reports must be amended prior to any modification to the project. In addition, Metropolitan and partnering groundwater agencies would be required to update the reports every five years for submittal to DDW and the RWQCB for approval.

5.2 Groundwater Replenishment Regulations

DDW regulates groundwater recharge projects under Title 22 of the CCR. Final regulations for groundwater replenishment reuse projects utilizing surface application (i.e., spreading) and subsurface application (i.e., injection) went into effect in June 2014. Changes were made to CCR Title 22, Division 4, Chapter 3 to amend Article 1 (definitions), add Article 5.1 (Indirect Potable Reuse – Surface Application), add Article 5.2 (Indirect Potable Reuse – Subsurface Application), and amend Article 7 (Engineering Report and Operational Requirements). These Groundwater Replenishment Regulations address the protection of public health with respect to chemicals, microorganisms, and constituents of emerging concern. DDW requires that groundwater replenishment projects incorporate a multiple barrier strategy. This approach ensures protection of public health by incorporating safeguards into the process that ensure failure at any given treatment step will not compromise public health and ensure long-term protection of the groundwater aquifer as a source of drinking water supply.

Table 5-1 provides a summary of key requirements of the Groundwater Replenishment Regulations. Further information detailing Metropolitan’s compliance requirements under these regulations is provided in the text that follows.

Table 5-1: Groundwater Replenishment Regulations – Summary of Key Requirements

Constituent/Parameter	Type of Recharge	
	Surface Application	**Subsurface Application**
Pathogenic Microorganisms		
Filtration	≤ 2 NTU	
Disinfection	450 CT mg-min/L with 90 min. modal contact time or 5-log virus inactivation; and < 2.2 total coliform per 100 mL	
Pathogen Control	12-10-10 log removal for enteric virus, *Cryptosporidium*, *Giardia* reduction	
Response Retention time	≥ 2 months (depending on estimating method used)	
Regulated Constituents		
Drinking Water Standards	Meet all drinking water MCLs in recycled water (or recharge water, as applicable); quarterly for primary MCLs; annually for secondary MCLs	
Nitrogen Compounds	TN ≤ 10 mg/L in recycled or recharge water	
Unregulated Chemicals Control		
Total Organic Carbon	$TOC \leq \frac{0.5\frac{mg}{L}}{RWC}$ Compliance point is in recycled water or in recycled water after soil aquifer treatment not impacted by dilution (no blending)	$TOC \leq 0.5\frac{mg}{L}$
Recycled Water Contribution		
RWC Definition	$RWC = \frac{\text{Vol of Reycled Water}}{\text{Vol of Reycled Water} + \text{Diluent Water}}$	
RWC_{max} Initial	Up to 20% without RO/AOP[a] Up to 100% with RO/AOP	Up to 100% (RO/AOP required for entire waste stream)
Increased RWC_{max}	≥ 20% subject to add'l requirements	Up to 100% subject to add'l requirements

[a] RO/AOP represents treatment using reverse osmosis and an advanced oxidation process that meets requirements as outlined in the regulation

5.2.1 Source Control

The Sanitation Districts and other providers of recycled water to a groundwater replenishment project must administer a comprehensive source control program that includes (1) an assessment of the fate of DDW and RWQCB-specified contaminants through the wastewater and recycled water systems; (2) provisions for contaminant source investigations and contaminant monitoring that focus on these contaminants; (3) an outreach program to industrial, commercial, and residential communities; and (4) an up-to-date inventory of contaminants. It should be noted that some constituents of concern for IPR projects may not fall under the authority of federal statutes addressing wastewater source control. Source water for the JWPCP is currently comprised of approximately 19% industrial flow. The plant produces secondary treated wastewater effluent that has not previously been utilized for potable reuse. Therefore, it is envisioned that the Sanitation Districts and Metropolitan will work together to ensure effective source water strategies are in place to safeguard AWT processes and protect end uses of the recycled water. Details of the Sanitation Districts' source control program are described in Section 2.3.4.

5.2.2 Advanced Water Treatment

Advanced water treatment is required for any subsurface application of recycled water. AWT can be defined as the treatment of an oxidized wastewater using reverse osmosis (RO) and an advanced oxidation process (AOP) that meets the performance criteria established in Title 22 §60320.201. Metropolitan, in conjunction with the Sanitation Districts, may perform an occurrence study on the municipal wastewater to identify indicator compounds representative of various functional groups. Removal of indicator compounds must be demonstrated. As an alternative to conducting an occurrence study, Metropolitan must demonstrate at least a 0.5-log reduction of 1,4-dioxane through AOP. Challenge tests must also be conducted to confirm findings. Monitoring and reporting requirements have also been established in the regulations to demonstrate the efficacy of the AOP.

5.2.3 Pathogen Control

At a minimum, recycled water quality for a groundwater replenishment reuse project must meet Title 22 definitions for filtered wastewater (§60301.320) and disinfected tertiary recycled water (§60301.230). The treatment system must achieve a 12-log enteric virus reduction, a 10-log *Giardia* cyst reduction, and a 10-log *Cryptosporidium* oocyst reduction using at least three treatment barriers (also generally referred to as 12-10-10 log removal credits). The log reduction refers to the treatment of raw sewage prior to the recycled water reaching a drinking water well. Each treatment barrier must achieve at least 1.0-log reduction and no treatment process can be credited with more than 6-log reduction. A project is also credited with 1-log virus reduction for each month the recycled water is retained underground (up to 6-logs) based on a tracer test.

Metropolitan would be required to validate the log reduction credits for each of the treatment processes by utilizing challenges tests and/or submitting a report for DDW approval. It is presently envisioned that the proposed AWT demonstration facility described in Section 6 would help accomplish this. Evidence must be provided to DDW that demonstrates the ability of the treatment process to reliably and consistently meet the log reduction requirements. The log reductions must be verified using a monitoring procedure approved by DDW. Metropolitan would utilize data collected during the demonstration phase of the Program to provide validation of pathogen log reduction. Once operating a groundwater recharge project, failure to meet the specified reductions would require notification to DDW and the RWQCB, investigation, and/or discontinuation of recycled water use until the problem is corrected.

5.2.4 Nitrogen Control

The concentration of total nitrogen in recycled water must meet 10 milligrams per liter (mg/L) before or after subsurface application. Failure to meet this value requires follow-up sampling, notification to DDW and the RWQCB, and/or discontinuation of recycled water use until the problem is corrected. It should be noted that Basin Plan requirements for specific groundwater basins may employ more stringent nitrogen limits. Basin Plan requirements associated with groundwater basins being evaluated as part of the Program are described later in this section. As the JWPCP secondary process does not remove nitrogen, meeting nitrogen limits for protection of the AWT system (ammonia reduction to minimize membrane fouling) as well as the end use of the recycled water (meeting nitrate Basin Plan limits or antidegradation requirements) will be a focus during the demonstration phase.

5.2.5 Regulated Chemicals Control

The recycled water must be monitored for regulated chemical constituents and meet primary and secondary drinking water MCLs. Failure to meet MCLs requires follow-up sampling, notification to DDW and the RWQCB, and/or discontinuation of recycled water use until the problem is corrected.

5.2.6 Constituents with Notification Levels

Notification Levels (NLs) represent the level of a contaminant in drinking water that DDW has determined does not pose a significant health risk but warrants notification to the public. NLs are non-regulatory, health-based advisory levels for constituents for which MCLs have not been established. Metropolitan must monitor the recycled water quarterly for NLs with accelerated monitoring and notification to DDW and the RWQCB if the result is greater than the NL.

5.2.7 Unregulated Chemicals Control

Control of unregulated or emerging chemicals for all groundwater recharge projects using 100% advanced treated water is accomplished through limits for total organic carbon (TOC) and performance of treatment for indicator compounds. TOC is used as a surrogate for unregulated and unknown organic chemicals. For surface applications (i.e., spreading), the project sponsor must assess the soil aquifer treatment (SAT) process through monitoring TOC, along with other parameters approved by DDW. The maximum TOC must be 0.5 mg/L divided by the recycled water contribution. For subsurface application projects (i.e., injection), the entire recycled water flow must be treated using RO and AOP. After treatment, TOC levels cannot exceed an average of 0.5 mg/L (with 100% recycled water contribution). Specific performance criteria for RO and AOP processes are included in the regulation.

5.2.8 Recycled Water Contribution

The Recycled Water Contribution, or RWC, is the fraction of the quantity of recycled water applied for a groundwater replenishment project divided by the total quantity of recycled water and credited diluent water (e.g., stormwater, imported water, subsurface underflow). It should be noted that diluent water must be a DDW-approved drinking water source, or specific monitoring and a source water evaluation (i.e., watershed sanitary survey) must be conducted. The initial maximum RWC from surface application projects must not exceed 0.20, or an alternative initial RWC approved by DDW. An alternative RWC up to 1.0 may be approved based on review of the Engineering Report, information obtained through public hearings, and demonstration that treatment prior to surface application will reliably achieve TOC levels less than or equal to 0.5 mg/L divided by the proposed RWC. For subsurface applications, the initial RWC may be assigned up to 1.0 based on these same criteria. Any increases in RWC during project operations must be approved by DDW and the RWQCB. It is anticipated for this Program that Metropolitan will pursue obtaining permission to utilize an RWC up to 1.0 soon after project start-up.

5.2.9 Response Retention Time

The intent of the response retention time within a groundwater basin is to provide sufficient time to identify any treatment failures so that inadequately treated recycled water does not enter a potable water system. Sufficient time must elapse to allow for a response that will protect the public from exposure to inadequately treated water, and provide an alternative source of water or remedial wellhead treatment if necessary. The response retention time is the aggregate period of time for (1) identification that the recycled water is out of compliance, (2) treatment verification samples or measurements, (3) analysis of the sample, (4) evaluation of results, (5) decisions regarding the appropriate response, (6) activation of a response, and (7) verification that the response is effective. The minimum response retention time is two months, but must be justified by Metropolitan, as the project sponsor(s) (i.e., Metropolitan and partnering groundwater agencies) and approved by DDW. Response times in existing recycling projects can vary from two to six months. A tracer study can be conducted to establish the response retention time credited.

5.2.10 Monitoring Programs

Comprehensive monitoring programs are established within the regulations for the recycled water and groundwater for regulated and unregulated constituents. If monitoring demonstrates failure to meet specific requirements, the project sponsor must notify DDW and the RWQCB, investigate cause and take corrective actions, and in some cases, discontinue use of recycled water. It should also be noted that groundwater monitoring must be conducted within potentially affected aquifers prior to the operation of a groundwater replenishment project taking into consideration seasonal variations. It is envisioned that existing groundwater monitoring wells will be utilized to the extent possible.

5.2.11 Operation Optimization Plan

Prior to operating a groundwater recharge project, project sponsors must submit an Operation Optimization Plan to DDW and the RWQCB for review and approval. The intent of the plan is to assure that the facilities are operated to achieve compliance with the Groundwater Replenishment Regulations, to achieve optimal reduction of contaminants (including achieving the credited pathogen log reductions), and to identify how the project will be operated, maintained and monitored. The Operation Optimization Plan(s) would address both the AWT facilities and the groundwater injection/extraction systems. Considering the regional nature of this Program, coordination between

Metropolitan, partnering groundwater agencies, and regulators will be required to determine whether separate plans will be completed to address each of these facilities, or if a combined plan is appropriate. High levels of operator expertise along with specialized and ongoing training will be critical to the success of the Program and must be described in the plan(s). The Operation Optimization Plan(s) must also be updated periodically to represent current project operations.

5.2.12 Drinking Water Well Locations

For each recharge area, Metropolitan and partnering groundwater agencies must establish a "zone of controlled well construction," representing horizontal and vertical distances which reflect underground retention times required for pathogen control and response retention time determination. Drinking water production wells cannot be located in this zone. The project sponsors must also create a secondary boundary that represents a zone of potential controlled well construction—this may be beyond the zone of controlled well construction and would require additional study before a new drinking water well is sited.

5.2.13 Managerial and Technical Capability

Metropolitan would be required to demonstrate to DDW and the RWQCB that it possesses adequate managerial and technical capabilities to comply with all applicable regulations. DDW developed a Technical Managerial and Financial Assessment form for public water systems to demonstrate their capability to provide a safe drinking water supply. For groundwater replenishment projects, DDW has indicated that project sponsors can use portions of the form to demonstrate compliance with the managerial and technical capability requirements in the Groundwater Replenishment Regulations. Metropolitan would provide required information on project operational capabilities including information on certified operators, training, and emergency response.

5.2.14 Alternatives

Alternatives to any of the provisions in the Groundwater Replenishment Regulations are allowed if the project sponsor demonstrates that (1) the alternative provides the same level of public health protection, (2) the alternative has been approved by DDW, and (3) and an expert panel has reviewed the alternative unless otherwise specified by DDW. In addition, if required by DDW and the RWQCB, the project sponsor must conduct a public hearing on the proposed alternative. Further, prior to operation of a groundwater recharge project, Metropolitan and partnering groundwater agencies must have a

DDW-approved plan that outlines the steps to provide an alternative source of water supply, or a wellhead treatment mechanism, that would ensure protection of public health in the event of (1) an MCL violation, (2) degraded groundwater quality that is no longer a safe drinking water source, or (3) failure to meeting pathogen reduction criteria.

5.2.15 Public Hearing

As indicated earlier in this section, Metropolitan in conjunction with DDW would be required to hold a public hearing (or multiple hearings as necessary) prior to DDW submitting its recommendations to the RWQCB for the initial permit. In addition, a public hearing would be required to be held when increases in the maximum RWC is proposed, if not addressed in a prior hearing. Relevant project information must be made accessible to the public for at least 30 days prior to the hearing.

5.3 Surface Water and Groundwater Plans and Policies

The RWQCB regulates groundwater recharge projects under its Water Quality Control Plans (Basin Plans), and other applicable regulations and policies to protect water quality and the beneficial uses of surface water and groundwater. These regulatory plans and policies are described below.

5.3.1 Basin Plans

Basin Plans reflect applicable portions of a number of national and statewide water quality plans and policies, including the CWC and Clean Water Act. RWQCB Permit requirements are based on the beneficial uses of surface waters and groundwater, and the applicable numeric or narrative water quality objectives. CWC defines water quality objectives as "… the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area" (CWC §13050(h)).

For groundwater recharge projects, the type of recharge application affects which beneficial uses apply. For example, if the surface application utilizes surface waters, the inland surface waters and groundwater beneficial uses apply. If the surface application uses "off-stream" spreading basins or is a subsurface application, only the groundwater beneficial uses apply. In addition, the Basin Plan includes waste load allocations resulting from Total Maximum Daily Loads (TMDLs), which impact surface water requirements. TMDLs are developed for those waterbodies that are included on the State's 303(d) list of impaired waterbodies and represent the maximum amount of a pollutant that a waterbody can receive and still meet its water quality objectives.

Several groundwater basins are being initially considered by Metropolitan as part of the potential Program and are listed in Table 5-2 and shown in Figure 5-1. Beneficial uses for these basins include municipal and domestic water supply (MUN), industrial service supply (IND), industrial process supply (PROC), and agricultural supply (AGR). As MUN is typically the most stringent standard, permit limits are often based on protection of this beneficial use. To protect the MUN beneficial use, Basin Plans include groundwater objectives based on primary and secondary MCLs, numeric objectives for coliforms, narrative objectives to prevent taste and odor issues, and basin-specific mineral objectives. Basin Plan water quality objectives that apply to the groundwater basins currently being considered for the Program are shown in Table 5-3.

Table 5-2: Groundwater Basins Investigated in Program

Basin	County	Basin Plan Region	Beneficial Uses
Central Basin	Los Angeles	Los Angeles (Region 4)[5]	MUN IND PROC AGR
West Coast Basin	Los Angeles	Los Angeles (Region 4)	
Raymond Basin	Los Angeles	Los Angeles (Region 4)	
Main San Gabriel Basin	Los Angeles	Los Angeles (Region 4)	
Orange County Basin	Orange County	Santa Ana (Region 8)[6]	
Chino Basin	San Bernardino/Riverside	Santa Ana (Region 8)	
Temescal Basin	Riverside	Santa Ana (Region 8)	
Arlington Basin	Riverside	Santa Ana (Region 8)	

[5] http://www.waterboards.ca.gov/losangeles/water_issues/programs/basin_plan/
[6] http://www.swrcb.ca.gov/santaana/water_issues/programs/basin_plan/index.shtml

Figure 5-1 Groundwater Basin Map

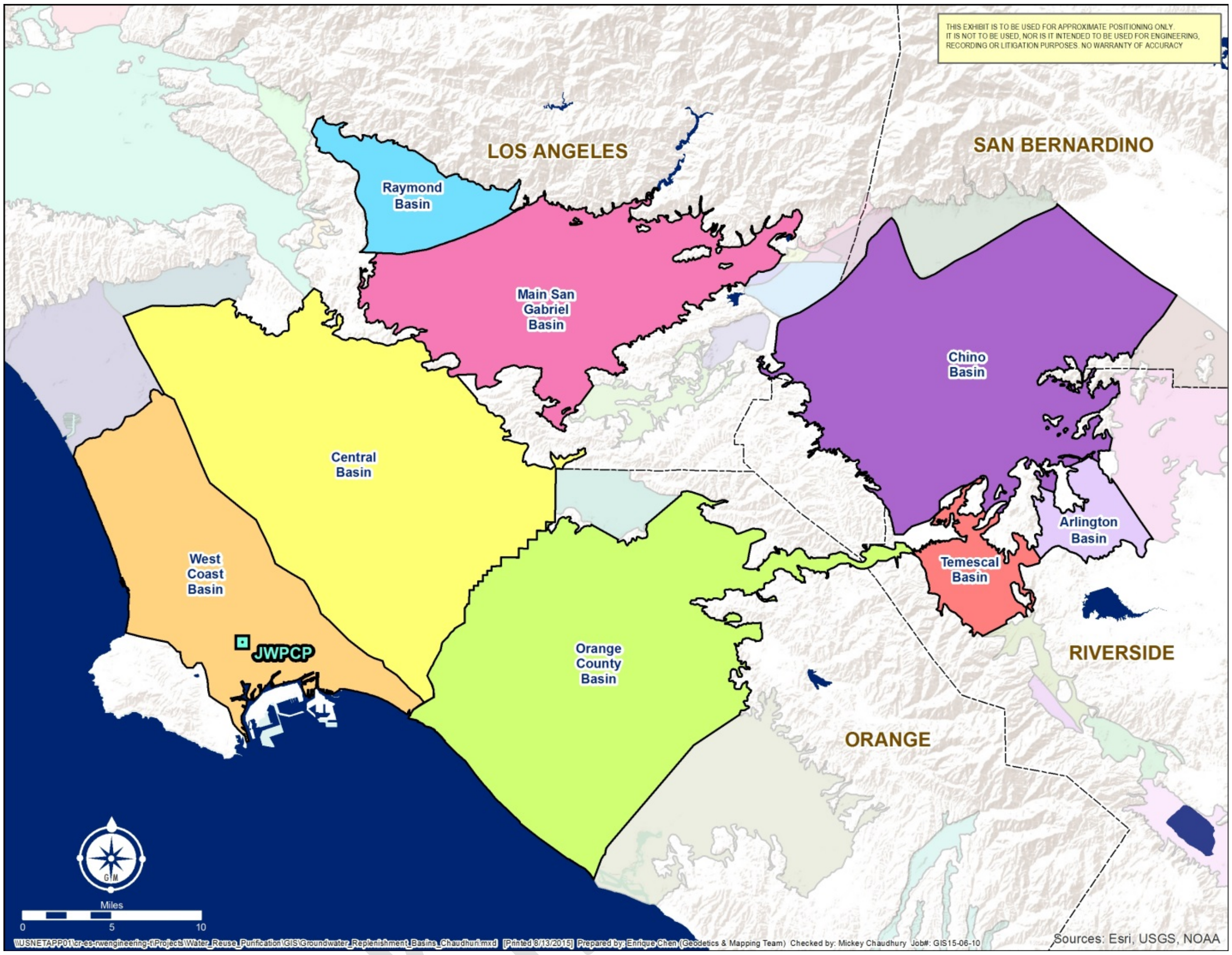

Table 5-3 Basin Plan Water Quality Objectives for Select Constituents

Constituent	Central Basin	West Coast Basin	Raymond Basin	Main San Gabriel Basin	Orange County Basin	Chino Basin	Temescal Basin	Arlington Basin
Aluminum	1.0 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L	NA[7]	NA[7]	NA[7]	NA[7]
Antimony	0.006 mg/L	0.006 mg/L	0.006 mg/L	0.006 mg/L	NA[7]	NA[7]	NA[7]	NA[7]
Arsenic	0.01 mg/L	0.01 mg/L	0.01 mg/L	0.01 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L
Bacteria, Coliform	1.1/100 mL[2]	1.1/100 mL[2]	1.1/100 mL[2]	1.1/100 mL[2]	2.2/100 mL[2]	2.2/100 mL[2]	2.2/100 mL[2]	2.2/100 mL[2]
Barium	1.0 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L
Boron	1.0 mg/L	1.5 mg/L	0.5 mg/L	0.5 mg/L	0.75 mg/L	0.75 mg/L	0.75 mg/L	0.75 mg/L
Beryllium	0.004 mg/L	0.004 mg/L	0.004 mg/L	0.004 mg/L	NA[7]	NA[7]	NA[7]	NA[7]
Cadmium	0.005 mg/L	0.005 mg/L	0.005 mg/L	0.005 mg/L	0.01 mg/L	0.01 mg/L	0.01 mg/L	0.01 mg/L
Color	NA[7]	NA[7]	NA[7]	NA[7]	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses
Copper	NA[7]	NA[7]	NA[7]	NA[7]	1.0 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L
Chloride	150 mg/L	250 mg/L	100 mg/L	100 mg/L	500 mg/L	500 mg/L	500 mg/L	500 mg/L
Chromium	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L
Cobalt					0.2 mg/L	0.2 mg/L	0.2 mg/L	0.2 mg/L
Cyanide	0.15 mg/L	0.15 mg/L	0.15 mg/L	0.15 mg/L	0.2 mg/L	0.2 mg/L	0.2 mg/L	0.2 mg/L
Fluoride	2.0 mg/L	2.0 mg/L	2.0 mg/L	2.0 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L
Gross Alpha	15 pCi/L	15 pCi/L	15 pCi/L	15 pCi/L	15 pCi/L	15 pCi/L	15 pCi/L	15 pCi/L
Gross Beta	50 pCi/L[8]	50 pCi/L[8]	50 pCi/L[8]	50 pCi/L[8]	50 pCi/L[8]	50 pCi/L[8]	50 pCi/L[8]	50 pCi/L[8]
Hardness	NA[7]	NA[7]	NA[7]	NA[7]	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses
Iron	NA[7]	NA[7]	NA[7]	NA[7]	0.3 mg/L	0.3 mg/L	0.3 mg/L	0.3 mg/L
Lead	NA[7]	NA[7]	NA[7]	NA[7]	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L
Manganese	NA[7]	NA[7]	NA[7]	NA[7]	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L
MBAS[3]	NA[7]	NA[7]	NA[7]	NA[7]	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L
Mercury	0.002 mg/L	0.002 mg/L	0.002 mg/L	0.002 mg/L	0.002 mg/L	0.002 mg/L	0.002 mg/L	0.002 mg/L
Nickel	0.1 mg/L	0.1 mg/L	0.1 mg/L	0.1 mg/L	NA[7]	NA[7]	NA[7]	NA[7]

Constituent	Central Basin	West Coast Basin	Raymond Basin	Main San Gabriel Basin	Orange County Basin	Chino Basin	Temescal Basin	Arlington Basin
Nitrate (as N)	10 mg/L[6]	10 mg/L[6]	10 mg/L[6]	10 mg/L[6]	3.4 mg/L[5]	2.9 mg/L[4]	10 mg/L	10 mg/L
Oil and Grease	NA[7]	NA[7]	NA[7]	NA[7]	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses
Perchlorate	0.006 mg/L	0.006 mg/L	0.006 mg/L	0.006 mg/L	NA[7]	NA[7]	NA[7]	NA[7]
pH	NA[7]	NA[7]	NA[7]	NA[7]	Between 6 and 9	Between 6 and 9	Between 6 and 9	Between 6 and 9
Radium-226 and Radium-228 (combined)	5 pCi/L	5 pCi/L	5 pCi/L	5 pCi/L	5 pCi/L	5 pCi/L	5 pCi/L	5 pCi/L
Selenium	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.01 mg/L	0.01 mg/L	0.01 mg/L	0.01 mg/L
Silver	NA[7]	NA[7]	NA[7]	NA[7]	0.05 mg/L	0.05 mg/L	0.05 mg/L	0.05 mg/L
Sodium					180 mg/L	180 mg/L	180 mg/L	180 mg/L
Strontium-90	8 pCi/L	8 pCi/L	8 pCi/L	8 pCi/L	8 pCi/L	8 pCi/L	8 pCi/L	8 pCi/L
Sulfate	250 mg/L	250 mg/L	100 mg/L	100 mg/L	500 mg/L	500 mg/L	500 mg/L	500 mg/L
Taste and Odor	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses
Thallium	0.002 mg/L	0.002 mg/L	0.002 mg/L	0.002 mg/L	NA[7]	NA[7]	NA[7]	NA[7]
Total Dissolved Solids	700 mg/L	800 mg/L	450 mg/L	450, 600 mg/L[1]	580 mg/L[5]	250 mg/L[4]	770 mg/L	980 mg/L
Toxic Substances	NA[7]	NA[7]	NA[7]	NA[7]	No detrimental physiological responses in human, plant, animal, aquatic life	No detrimental physiological responses in human, plant, animal, aquatic life	No detrimental physiological responses in human, plant, animal, aquatic life	No detrimental physiological responses in human, plant, animal, aquatic life
Tritium	20,000 pCi/L	20,000 pCi/L	20,000 pCi/L	20,000 pCi/L	20,000 pCi/L	20,000 pCi/L	20,000 pCi/L	20,000 pCi/L
Uranium	20 pCi/L	20 pCi/L	20 pCi/L	20 pCi/L	20 pCi/L	20 pCi/L	20 pCi/L	20 pCi/L

[1] Dependent on location in basin (Western Area, Eastern Area)

[2] Median over any seven-day period
[3] Methylene Blue-Activated Substances
[4] Lowest based on antidegradation objectives, unless maximum benefit to the people of the state is demonstrated; then objective is 5.0 mg/L for nitrate and 420 mg/L for TDS
[5] Based on assimilative capacity findings
[6] Also shall not exceed 10 mg/L nitrogen as nitrate-N plus nitrite-N
[7] Not specifically addressed in Basin Plan; would default to MCL where applicable
[8] 4 millirem/year annual dose equivalent to the total body or any internal organ

Of particular note are the varying nitrate limits between the individual groundwater basins. Central, West Coast, Raymond, Main San Gabriel, Temescal, and Arlington Basins each have nitrate limits of 10 mg/L as N, matching the nitrate MCL. Due to basin-specific nitrate issues in Orange County and Chino Basins, lower nitrate limits have been applied by the RWQCB. Due to a nitrate-N Basin Plan limit of 3.4 mg/L in the Orange County Basin, the Orange County's GWRS permit requires meeting a nitrate-N level of 3 mg/L. Therefore, in addition to the Groundwater Replenishment Regulations, Basin Plan objectives will help to dictate the treatment technologies applied at Metropolitan's AWT facility proposed for the Program. Another example of basin-specific limits applied to a constituent is boron. The state NL for boron is 1 mg/L, however Basin Plan limits for the Main San Gabriel and Raymond Basins are 0.5 mg/L. Elevated boron levels impact the AGR beneficial use, particularly for use on citrus crops. The JWPCP pilot study conducted between 2010 and 2012 indicated boron levels exceeding 0.5 mg/L at times. Therefore, treatment or source control measures must be taken to remove boron prior to groundwater replenishment.

5.3.2 Recycled Water Policy

The SWRCB adopted a Recycled Water Policy in 2009, and later amended it in 2013 to address monitoring requirements for constituents of emerging concern.[7] The purpose of the policy is to increase use of recycled water in a manner consistent with existing regulations. The Recycled Water Policy established a goal for California to increase the use of recycled water over 2002 levels by at least one million acre-feet per year by 2020, and by at least two million acre-feet per year by 2030.

A key element to this policy is the development of salt and nutrient management plans for every groundwater basin in California (further details provided later in this section). These plans are to be tailored to address basin-specific water quality issues associated with salt and nutrients, as well as other constituents found in recycled water that may impact groundwater basins. These include CECs, for

[7] http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/docs/rwp_revtoc.pdf

which the SWRCB amended the policy to include a monitoring strategy for CECs based on recommendations by an expert panel.[8] The panel report must be updated every five years and take into account the improved understanding of CECs and their impact on public health and the environment.

In addition to salt and nutrient management planning, the draft policy provides guidance on conformance with the State's Antidegradation Policy (discussed in the following section) by allowing a project to utilize up to 10% of a groundwater basin's assimilative capacity, or up to 20% for multiple projects, with an antidegradation analysis completed and submitted to the RWQCB for approval.

In order to accelerate implementation of groundwater recharge projects, the policy also includes the following language for groundwater recharge projects using surface spreading:

> *"Projects that utilize surface spreading to recharge groundwater with recycled water treated by reverse osmosis shall be permitted by a Regional Water Board within one year of receipt of recommendations from CDPH [DDW]. Furthermore, the Regional Water Board shall give a high priority to review and approval of such projects."*

As Metropolitan would likely pursue an AWT approach using RO, the policy condition noted above would help to expedite permitting of surface spreading projects being proposed as part of the potential Program.

Finally, the Recycled Water Policy indicates the potential need for additional permit requirements based on the effect a groundwater replenishment project may have on the fate and transport of a contaminant plume in a specific groundwater basin. For example, there are areas of groundwater contamination in the San Gabriel Valley, included on USEPA's National Priorities List, which may need to be considered for a groundwater recharge project in the Main San Gabriel Basin. The policy also requires evaluation of the effect that a groundwater replenishment project may have on the geochemistry of an aquifer that could cause dissolution of chemicals, such as arsenic, from the geologic formation into groundwater. Depending on the groundwater basin considered, this will be an important issue for Metropolitan and groundwater agency partners to investigate and address as part of its Engineering Report.

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8 http://www.waterboards.ca.gov/water_issues/programs/water_recycling_policy/docs/cec_monitoring_rpt.pdf

5.3.3 Antidegradation Policy

Federal antidegradation regulations are identified in CFR Title 40 §131.12. The Federal Antidegradation Policy requires states to adopt policies and implementation practices consistent with the following requirements, which would have application to IPR projects.

The SWRCB has interpreted federal policy through adoption of Resolution No. 68-16, *Statement of Policy with Respect to Maintaining High Quality of Waters in California*,[9] which established antidegradation policy in California and included the following requirement:

> *"Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses of such water and will not result in water quality less than that prescribed in the policies."*

This policy applies to both surface water and groundwater in California. The SWRCB has also developed implementing guidelines (APU 90-004)[10] for its Antidegradation Policy. It should be noted that the Antidegradation Policy is not an absolute bar to reductions in water quality. The policy may allow lowering of water quality in surface water or groundwater if the change is consistent with providing a maximum benefit to the people of the State and does not unreasonably affect present and anticipated beneficial uses. However, some RWQCBs have taken a very conservative approach towards antidegradation and, for some water recycling projects, have not allowed any changes in water quality above ambient groundwater constituent levels. The SWRCB is currently reviewing its existing Antidegradation Policy to examine whether the policy or its implementation guidelines needs to be updated, both in terms of its application to surface water and groundwater.

5.3.4 Salt and Nutrient Management Plans

Recognizing that some groundwater basins contain salts and nutrients that exceed or threaten to exceed water quality objectives established in the applicable Basin Plans and that recycled water can contribute to salt and nutrient loading, as noted earlier, Salt and Nutrient Management Plans (SNMPs)

[9] http://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/1968/rs68_016.pdf
[10] http://www.swrcb.ca.gov/water_issues/programs/npdes/docs/apu_90_004.pdf

have been mandated by the SWRCB. The Recycled Water Policy required local water and wastewater entities, together with local stakeholders, to develop a SNMP for each groundwater basin in California by May 2014. The purpose of the plans is to ensure preservation or attainment of Basin Plan water quality objectives. Several groundwater basins have received extensions for the submittal of their plans. Current status of the SNMPs for each of the groundwater basins being investigated in the Program is shown in Table 5-4. Metropolitan must consider and ensure compliance with the SNMP for the individual groundwater basins in the implementation of the potential Program. For example, as the proposed Program was not included in the SNMPs, groundwater modeling and an assimilative capacity analysis would need to be conducted. Effects on the specific basin, considering the volume of recycled water recharged, for constituents such as total dissolved solids (TDS), chloride, and nitrate would need to be fully evaluated and incorporated into future updates of the SNMP.

Table 5-4: Status of Salt and Nutrient Management Plans for Select Groundwater Basins

Salt/Nutrient Mgmt Plan	Agency Lead	Status
Central and West Coast Basins SNMP	Water Replenishment District of Southern California	Basin Plan amendment adopted by Los Angeles RWQCB in February 2015[11,12]
Main San Gabriel SNMP	Main San Gabriel Basin Watermaster	Draft SNMP under review by Los Angeles RWQCB with anticipated adoption as Basin Plan amendment by May 2016
Raymond Basin SNMP	Raymond Basin Management Board	Draft SNMP under review by Los Angeles RWQCB with anticipated adoption as Basin Plan amendment by May 2016
Santa Ana Region SNMP[a]	Santa Ana Watershed Project Authority	Basin Plan amendments adopted by Santa Ana RWQCB in January 2004 and April 2014[13]

[a] Includes Orange County Basin and Chino Basin

5.3.5 California Toxics Rule

In 2000 (and amended in 2001), USEPA adopted the California Toxics Rule (CTR) which included new criteria for the state for toxic constituents that did not have standards associated with them[14]. The CTR

[11] http://www.waterboards.ca.gov/losangeles/water_issues/programs/basin_plan/RECUR/2015_06/FinalBasinPlanAmendmentCentralandWestCoastBasins'SNMP.pdf

[12] http://www.waterboards.ca.gov/losangeles/water_issues/programs/basin_plan/RECUR/2015_06/150212_FINALSaltNutrientMngtPlanforCentral&WestCoastBasins.pdf

[13] http://www.swrcb.ca.gov/santaana/water_issues/programs/basin_plan/index.shtml

contains numeric aquatic life criteria for 23 priority pollutants and numeric human health criteria for 57 priority toxic pollutants. The criteria are implemented by the SWRCB *Policy for Implementation of Toxic Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California*.[15] CTR human health criteria apply for any surface waters and can result in very stringent permit requirements, in some cases, lower than MCLs or NLs. The criteria will be particularly important for Metropolitan to consider for an IPR project using surface water augmentation.

5.3.6 Other State Water Reclamation Policies

Further State policies addressing water reuse include Resolution No. 77-1, *Policy with Respect to Water Reclamation in California*,[16] which includes principles that encourage and recommend implementation of water recycling and its use in water-short areas of the State. The Los Angeles RWQCB also adopted Resolution No. 88-012, *Supporting Beneficial Use of Available Reclaimed Water in Lieu of Potable Water for the Same Purpose*, which encourages the beneficial use of recycled water and supports water recycling projects.

5.4 Future Potable Reuse Options

The following section provides a brief overview of additional potable reuse options: surface water augmentation (another form of IPR) and DPR. As described earlier in this section, per SB 918 DDW is in the process of developing specific regulatory criteria surface water augmentation. Significant efforts are also underway investigating the feasibility of regulating DPR in the future.

5.4.1 Surface Water Augmentation

Surface water augmentation involves the process of adding advanced treated water to an existing surface water supply (e.g., river, lake, and reservoir) that would eventually be used for drinking water after further treatment. Although limited regulatory guidance currently exists for surface water augmentation, DDW has been charged to develop and adopt Water Recycling Criteria for surface water augmentation by December 2016. To facilitate that development, an expert panel has been convened

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14 http://www.epa.gov/waterscience/standards/rules/ctr/index.html
15 http://www.waterboards.ca.gov/water_issues/programs/state_implementation_policy/docs/final.pdf
16 http://swrcb2.swrcb.ca.gov/board_decisions/adopted_orders/resolutions/1977/rs77_001.pdf

to advise DDW on public health issues, and scientific and technical matters, regarding the development of surface water augmentation criteria.

5.4.1.1 Regulatory Criteria

Current law allows surface water augmentation through a case-by-case review by DDW to evaluate potential impacts on public health. CHSC §116551 addresses surface water augmentation as follows:

"The department [DDW] shall not issue a permit to a public water system or amend a valid existing permit for the use of a reservoir as a source of supply that is directly augmented with recycled water, as defined in subdivision (n) of Section 13050 of the Water Code, unless the department does all of the following:

(a) Performs an engineering evaluation that evaluates the proposed treatment technology and finds that the proposed technology will ensure that the recycled water meets or exceeds all applicable primary and secondary drinking water standards and poses no significant threat to public health.

(b) Holds at least three duly noticed public hearings in the area where the recycled water is proposed to be used or supplied for human consumption to receive public testimony on that proposed use. The department shall make available to the public, not less than 10 days prior to the date of the first hearing held pursuant to this subdivision, the evaluations and findings made pursuant to subdivision (a)."

San Diego's Pure Water Program is also helping to drive the regulatory development of surface water augmentation criteria. This project would supplement San Vicente Reservoir (approximately 240,000 acre feet capacity) with advanced treated water produced at the City's North City Water Reclamation Plant. Advanced treated water, mixed in the reservoir with imported water and local runoff, would then be a source of San Diego's drinking water supply, with further treatment at a drinking water treatment plant. An initial 15-MGD water treatment facility is planned to be in operation by 2023, with a long term goal of producing 83 MGD by 2035. San Diego constructed a 1-MGD AWT demonstration facility to evaluate the feasibility of a full-scale surface water augmentation project.[17] Tertiary-treated wastewater is sent to the demonstration facility equipped with membrane filtration, RO, and ultraviolet light (UV)/AOP—a process similar to what has been successfully applied by Orange County's GWRS. Although the 1-year demonstration phase is complete, the City continues to operate the facility for public education and to test additional treatment processes (e.g., ozone and biological granular activated carbon) for consideration of a potential future DPR treatment train. San Diego has received

[17] http://www.sandiego.gov/water/purewater/pdf/projectreports/wpdpfinalprojectreport.pdf

conceptual approval from DDW that “the project, as conceived, when properly designed, constructed, and operated, will not compromise the quality of the water derived from the San Vicente Reservoir."[18]

The permitting process for a surface water augmentation project is anticipated to be significantly more involved than that for groundwater replenishment. As the project involves releases into a surface waterbody, a full NPDES permit would be required along with USEPA approval. In addition, the project sponsor will need to demonstrate that the reservoir provides a sufficient “environmental buffer” and provides the necessary blending of recycled water with other sources. The reservoir would need to provide sufficient retention that would allow for some contaminant degradation but with a primary purpose of enabling agencies to respond to an unexpected failure that may occur in the upstream treatment process.

Although draft Water Recycling Criteria for surface water augmentation has not yet been released for public review, recent presentations by DDW and experts involved in the regulatory development have highlighted criteria that will likely be part of the draft regulation anticipated to be released in summer 2015. Much of the regulatory criteria mirror the Groundwater Replenishment Regulations, but specific criteria will be focused on reservoir retention and dilution requirements. Some of the draft criteria currently being considered, known as of February 2015, are shown in Table 5-5:

Table 5-5 Draft Criteria Considered for Surface Water Augmentation

Minimum 100:1 dilution of advanced treated recycled water with ambient reservoir water
Minimum 10:1 dilution of advanced treated recycled water with ambient reservoir water and a redundant 1-log pathogen reduction
Reservoir retention time of at least six months
Advanced treated recycled water becomes ambient water after 24 hours of residence time in the reservoir (based on assumption that “off-spec” water would detected within 24 hours)
Each month of retention in the reservoir will allow 1-log virus reduction credit
Thermocline may be used to help meet retention time requirements (e.g., recycled water entering reservoir above thermocline, with reservoir withdrawal below thermocline)
Reservoirs must be in operation as an approved surface water for a sufficient period of time to establish a baseline record of raw water quality and treated drinking water quality
Public water systems using the reservoir must have sufficient control over the operation of the reservoir

[18] http://www.sandiego.gov/water/purewater/pdf/projectreports/publicoutreachappendixb.pdf

Should surface water augmentation be allowed in the future, Metropolitan may consider Lake Mathews as a potential option for a future surface water augmentation project. All discharges to surface waters are subject to the requirements of the Basin Plans administered by the RWQCB. In the example of Lake Mathews, requirements of the Basin Plan for the Santa Ana Region[19] must be adhered to. This would require meeting all beneficial use requirements for Lake Mathews. In addition, antidegradation requirements would apply which would be challenging to meet for select constituents. For example, Lake Mathews maintains very low nutrient levels as the Colorado River is an oligotrophic or nutrient-limited system. Nitrate levels are typically below 0.4 mg/L as N, and total phosphorus levels are approximately 0.01 mg/L. Nutrient removal processes will be critical for the AWT system should surface water augmentation be a viable future option for Lake Mathews. Further discussion of the treatment implications of a surface water augmentation alternative is contained in Section 6 of this report.

5.4.1.2 Limnology and Reservoir Management

A complete understanding of reservoir hydrodynamics is essential to the design and management of a surface water reservoir that is intended to provide a barrier for the protection of public health. San Diego and their expert panel convened for the Pure Water Program conducted extensive study of San Vicente Reservoir to determine its ability to meet anticipated regulations. If surface water augmentation is to be pursued, tracer studies would be required along with development of a 3-dimensional dynamic lake model to better understand the hydrodynamics of the reservoir. Temperature differences between the water in the reservoir and that of the recycled water will affect the degree of mixing in the reservoir and can reduce the effective retention time. The potential for reservoir short-circuiting needs to be fully examined, as this can result from individual, discrete events. Seasonal changes and reservoir stratification/destratification can also alter the quality of water released. The effluent insertion point would need to be studied with respect to meeting the blending and retention time criteria. For example, multiple insertion points may prove beneficial.

The limnology of any reservoir proposed for surface water augmentation needs to be fully studied. Algae production, toxins, and taste-and-odors are concerns should the recycled water have elevated nutrient levels when compared to the ambient water. Introduction of recycled water could impact the ecology and behavior of organisms, thereby potentially impacting the quality of the water.

[19] http://www.waterboards.ca.gov/santaana/water_issues/programs/basin_plan/index.shtml

Metropolitan's ability to manage reservoirs to address operations and supply issues, water quality, and invasive species control may be constrained when considering surface water augmentation regulatory requirements. For example, enhancing stratification, reservoir drawdown, and/or controlling releases through specified outlet tiers may adversely impact the blending and retention time requirements that need to be adhered to from a regulatory perspective.

5.4.1.3 Source Water Reporting

For a surface water augmentation project, the addition of a new source of water will require specific regulatory reporting requirements of Metropolitan. DDW has established the Drinking Water Source and Assessment Program (DWSAP)[20] in response to requirements of the 1996 amendments to the Federal Safe Drinking Water Act, and as required in CHSC §11672.60. In addition, California's Surface Water Treatment Rule (Title 22 CCR) requires that every public water system treating surface water conduct a comprehensive Sanitary Survey of its watershed every five years. Finally, Title 22 §64480 requires water systems to annually prepare a Consumer Confidence Report to inform the public of the sources and quality of their water supply. Adding recycled water to Metropolitan's source water portfolio will require these additional source water reporting requirements.

5.4.1.4 Environmental Permitting

Discharges to regulated surface waters may require additional water quality and environmental permits from state and federal regulatory agencies. For example, it is envisioned that augmenting Lake Mathews with advanced treated water would require construction of an intake structure, and therefore physical disturbance within a jurisdictional water of the U.S./State. As such, the project may require RWQCB Water Quality Certification per Section 401 of the Clean Water Act[21], a U.S. Army Corps of Engineers Permit per Section 404 of the Clean Water Act[22], and potentially a California Department of Fish and Wildlife Lake or Streambed Alteration Agreement per Section 1600 of the California Fish and Game Code[23]. Metropolitan would need to ensure early coordination with these resource agencies for successful and timely receipt of necessary permits.

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[20] http://www.cdph.ca.gov/certlic/drinkingwater/pages/dwsap.aspx
[21] http://www.waterboards.ca.gov/water_issues/programs/cwa401/
[22] http://www.spl.usace.army.mil/regulatory/
[23] https://www.wildlife.ca.gov/Conservation/LSA

5.4.2 Direct Potable Reuse

No regulatory guidance is currently provided for DPR. In general, DPR refers to the direct augmentation of a water supply with advanced treated water without an intervening environmental or storage buffer. To date, a consistent, clear definition does not exist for DPR as the term has been applied to the entry of advanced treated water to a raw water supply and/or a drinking water treatment plant, or directly into a treated water distribution system (also termed "pipe-to-pipe"). The risks associated with each of those options can significantly vary and it will be critical to establish a clear distinction between these applications. Primary concerns associated with DPR are the lack of currently available real-time monitoring capabilities in the absence of extended storage, as well as insufficient reaction times to potential system failures at the upstream treatment plants. In future regulatory development, additional treatment barriers will undoubtedly be necessary to compensate for the loss of an environmental buffer.

As indicated earlier, DDW has been charged through the CWC §13563 to investigate and report to the Legislature by December 2016 on the feasibility of developing uniform water recycling criteria for DPR. The expert panel that has been convened to advise DDW on surface water augmentation criteria is also assisting DDW for assessing the feasibility of DPR criteria development. The expert panel will also be identifying additional areas of research that will be needed, as well as an approach for accomplishing this research, in order to establish DPR criteria in the future. An advisory group—consisting of regulators, water and wastewater agencies, environmental organizations, and the business community—has also been convened to provide feedback to the expert panel regarding DPR criteria development.

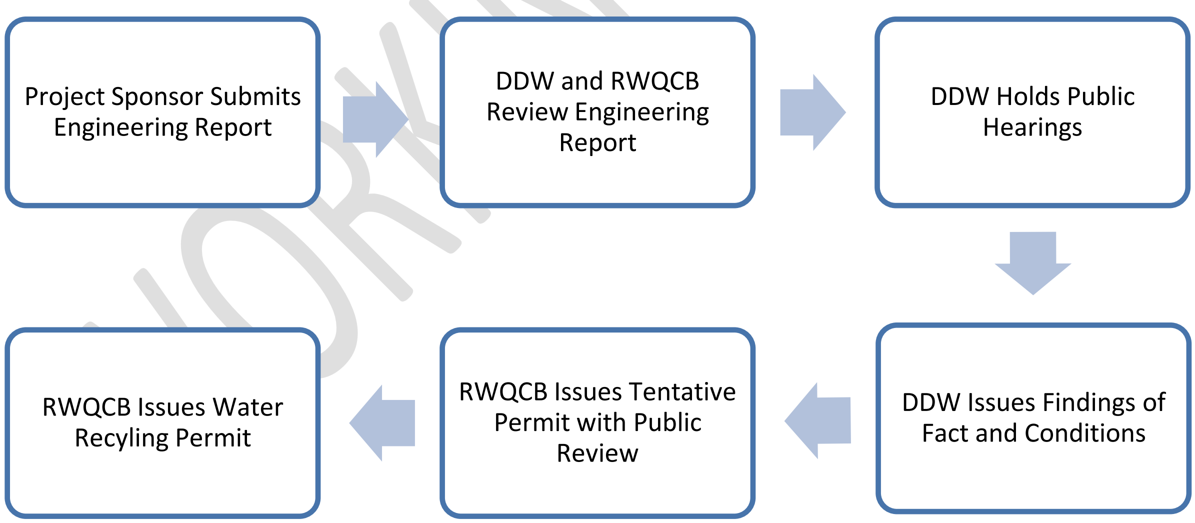
Significant research is currently being conducted to investigate the feasibility of DPR. The WateReuse Research Foundation, in partnership with WateReuse California, launched a DPR initiative in 2012 to advance DPR as a viable future water supply option in California. Metropolitan will continue to monitor and engage in research, technical assessments, and regulatory development of DPR for consideration of its future application in Metropolitan's service area.

5.5 Regulatory Roadmap

Metropolitan's close coordination and collaboration with regulators and partnering agencies from the onset will be critical to ensure success of the potential Program. Although the eventual WRR/WDR permits are issued by the RWQCB, DDW is the primary agency that will be involved in the technical review of Program elements that have the potential to impact public health. It should be noted that permits from both the Los Angeles and Santa Ana RWQCBs will be required, depending on the specific groundwater basins that will ultimately be pursued for recharge. Another option may be to seek permitting through the SWRCB due to the Program's large regional influence. Details on the specific permitting approach will be developed in coordination with regulators and partnering groundwater agencies as the project proceeds.

Extensive regulatory guidance has been developed for groundwater replenishment along with the implementation of several successful projects in southern California. Therefore, it is anticipated that the process for securing regulatory approvals for a groundwater replenishment project would be far more direct than that required for a surface water augmentation IPR project. Figure 5-2 identifies the general steps in the DDW and RWQCB approval process for permitting an IPR project.

Figure 5-2: Permit Approval Process for IPR Projects



5.5.1 Demonstration Facility

An AWT demonstration facility has been has been proposed to provide the data necessary to present to DDW and ultimately secure the RWQCB permit. Results from pilot testing conducted by the Sanitation Districts and Metropolitan between 2010 and 2012 will help to advise the process design for a demonstration facility that can treat JWPCP effluent to reliably meet all regulations. Information on the pilot study results and the proposed demonstration facility treatment train is contained in Section 2.2 of this report.

A demonstration facility is necessary for a variety of reasons, particularly for a program of this scale. It will provide necessary information and water quality data for Metropolitan and partners to complete the Engineering Report—a prerequisite for the WDRs/WRRs issued by the RWQCB. During operation of the demonstration facility, Metropolitan will validate each of the treatment processes based on challenge tests and/or literature values to meet the pathogen 12-10-10 log removal requirements, and submit a report to DDW to demonstrate the ability of the treatment system to reliably and consistently achieve these criteria. A testing and monitoring plan for the demonstration phase must be prepared, with review by an independent advisory panel, and submitted to DDW for approval. Operation of the facility will also demonstrate to DDW Metropolitan's capacity to reliably operate an AWT facility treating secondary wastewater effluent. Prior to operating a full-scale AWT facility for potable reuse, Metropolitan must submit an Operation Optimization Plan to DDW and the RWQCB for approval. It is anticipated that Metropolitan will regularly communicate with DDW throughout the development and operation of the demonstration facility.

As the JWPCP effluent has not been used for beneficial reuse to date, collecting data to demonstrate the AWT facility's ability to meet applicable regulatory criteria will be critical. Additional challenges may be realized due to the industrial nature of a portion of the sewer-shed. The demonstration facility will provide an opportunity for Metropolitan and the Sanitation Districts to cooperate on actions that may be necessary, through source control or additional treatment, to address constituents that may be problematic for the AWT facility or the end use of the water.

In addition to demonstrating Metropolitan's ability to meet water quality regulatory compliance issues, the demonstration facility will help to gather information on equipment reliability, capital and operating costs, and energy consumption that could be expected for a full-scale AWT facility. A demonstration phase also allows for assessment and response to unanticipated and emerging operational issues.

Further, the demonstration facility will help meet public education and outreach needs to ensure a high degree of public acceptance of this regional groundwater replenishment program.

Close coordination between Metropolitan and the Sanitation Districts during the demonstration facility testing will be critical to the success of the Program. Many successful IPR programs are operated by a single agency that has authority over wastewater and water treatment (e.g., City of Los Angeles' Terminal Island AWT facility). City of San Diego similarly retains responsibility in their Pure Water Program for the entire treatment process and distribution. Although Orange County's GWRS was implemented through a partnership between OCWD and OCSD, these agencies have collaborated for decades prior through Water Factory 21 and are geographically located next to one another. In addition, both agencies were equal partners in the construction of GWRS. An added benefit for initiating the potential Program with a demonstration facility will allow for Metropolitan and the Sanitation Districts to gain experience and collaborate on the operation of the wastewater and AWT systems, both of which play a critical role in ensuring high quality water is reliably produced meeting all regulatory requirements.

A summary of the areas that will be focused upon during the demonstration phase to ensure regulatory acceptability is outlined below in Table 5-6:

Table 5-6 Demonstration Testing Focus Areas

Enhanced source control measures
Pilot study validation
Full-scale AWT process train design
Pathogen control through 12-10-10 log removals
Control of nitrogen compounds
TOC limits
Emerging constituents monitoring
Reliability and redundancy of treatment processes
Monitoring and response plan to address unanticipated operational issues
Technical and managerial capacity for AWT operation
Operational collaboration between Metropolitan and Sanitation Districts
Capital and operating cost estimates for full-scale project
Hydrogeologic assessments and groundwater modeling
Public education and outreach

It should be noted that hydrogeologic assessments and groundwater modeling would need to be conducted in partnership with the appropriate groundwater agencies for a program that focuses on groundwater recharge. Following one year of operation of the demonstration facility, a report will be submitted to DDW and the RWQCB. Feedback from both agencies on this report will provide the regulatory framework for the full-scale project.

5.5.2 Independent Advisory Panel

DDW requires an independent advisory panel (IAP) for review of groundwater replenishment projects seeking alternatives to existing regulations. Although not explicitly required by DDW, it is recommended that an IAP be commissioned for this Program due to its scale and considering that other noted projects such as OCWD's GWRS and San Diego's Pure Water Program have and continue to successfully utilize its panels of experts to review and validate their programs. This panel will provide input during the planning phases, as well as on-going review during the operation of the project. The IAP will review water quality and monitoring requirements and make recommendations to the regulatory authorities, as well as Metropolitan, Sanitation Districts, and groundwater agency partners. Establishing the panel allows for an objective third-party review of operational, regulatory, and environmental issues associated with the Program. Both DDW and RWQCB staff should be invited to meetings of the IAP regarding review of the Program.

As noted above, established projects including GWRS continue to utilize an IAP to evaluate project performance as well as any modifications proposed. One of the GWRS permit provisions requires that the panel meet at least annually during the first five years of operation. The IAP for GWRS was appointed and is administered by the National Water Research Institute (NWRI), and is made up of experts in the field of toxicology, chemistry, microbiology, hydrogeology, environmental engineering, public health, wastewater treatment and water treatment. The panel, currently consisting of ten members, prepares annual reports on GWRS performance that is provided to DDW and the RWQCB. As the Metropolitan-Sanitation Districts potential Program will gain from the experiences of GWRS and other successful IPR projects in southern California, an IAP consisting of fewer panel members than what was employed by Orange County may be sufficient. Metropolitan would likely commission its panel during the design of the demonstration facility to provide guidance and expert peer review of the approach taken. An external facilitator should be utilized to organize and manage the IAP. It is recommended that the IAP consist of academics and industry professionals with longstanding expertise in water reuse. A minimum of five members is recommended to provide guidance for a groundwater recharge project. As part of a public outreach plan to be developed, Metropolitan may consider also adding a communications strategist or a member of the public to the IAP. At a minimum the IAP should maintain the following technical expertise as shown in Table 5-7:

Table 5-7: Recommended Expertise for Independent Advisory Panel

Wastewater Treatment Engineer
Drinking Water Treatment/AWT Process Engineer
Microbiologist
Hydrogeologist
Chemist/Toxicologist

5.5.3 Regulatory Milestones

Multiple permitting scenarios may be considered and will be discussed with the regulators at the onset, considering the unique nature of this regional program. If the project were to move forward, Metropolitan would be producing advanced treated water at the JWPCP site, and delivering that water to various replenishment sites. As currently envisioned groundwater basin managers and/or producers would receive this water and utilize spreading or injection facilities to recharge the advanced treated recycled water, meeting all permit requirements. As Metropolitan does not have authority over management of the groundwater basins, one approach is for Metropolitan to seek a permit as a "producer" for the advanced treated recycled water (Metropolitan would be identified as the permittee). Additional permit(s) would then be pursued for the individual replenishment sites for "users" for which the partnering groundwater agencies would be envisioned as the permittees with Metropolitan listed as a co-permittee. It should be noted that this is a unique permitting arrangement (multiple permits for an individual groundwater replenishment project), and to our knowledge has not yet been pursued with the RWQCBs. Therefore, seeking this permitting alternative will require discussions with and concurrence from the RWQCB and DDW. Another permitting alternative is to obtain a single permit for each basin/site, and establish the necessary agreements between Metropolitan and groundwater agencies to delineate compliance responsibilities. It should be noted that ownership of the injection facilities may dictate the entity responsible for compliance within the groundwater basin (e.g., groundwater monitoring and reporting responsibilities). Yet another option may be to seek a permit from the SWRCB for the Program, as there are potentially multiple use sites that cover multiple RWQCB jurisdictions. The unique nature of this regional program may necessitate creative permitting approaches that will need to be developed in collaboration with the regulators and project partners.

Metropolitan should establish an initial meeting with both DDW and the RWQCB (Los Angeles and Santa Ana Regions) to present the Program concept and objectives, and receive initial input. Although Metropolitan's primary technical coordination will be with DDW as the authority over public health issues, RWQCB coordination is also necessary as the quality of water that will be produced at the AWT facility must be suitable to meet RWQCB water quality objectives outlined in the Basin Plan, which in some cases are more stringent than Title 22 standards.

The IAP, described in the previous section, should be commissioned shortly following formal approval by Metropolitan and the Sanitation Districts of study of the potential Program. The panel will provide guidance and technical review throughout the Program and for all submittals to the regulating authorities. It is recommended that DDW and the RWQCB be invited to all meetings held with the IAP to maintain close communication during both the development and implementation of the Program.

Metropolitan should plan to seek conceptual approval of the Program prior to initiating demonstration testing. This is a similar approach that San Diego employed to pursue IPR through surface water augmentation. It is recommended that conceptual approval be sought from the regulating authorities to establish early buy-in and support an aggressive permit approval process, considering the strong need to implement the project in a timely manner considering the current water supply crisis in California.

Prior to initiating the demonstration phase, Metropolitan would also be required to prepare an AWT testing and monitoring workplan to be submitted to DDW for approval. At least two meetings should be scheduled with the IAP and regulators during the demonstration phase. Following completion of demonstration testing, an AWT demonstration project report and an operation optimization plan should be prepared and submitted to DDW. It should be noted that additional monitoring and operational plans associated with managing groundwater facilities (e.g., injection and extraction well operation, travel time to drinking water wells, groundwater monitoring) will need to be developed to meet permit requirements. It is anticipated that these plans will be prepared by partnering groundwater agencies in coordination with Metropolitan. Further details of this approach will be determined after initial Program discussions with groundwater basin managers.

Feedback from DDW on these reports will provide guidance for the next major milestone, which would be preparing and submitting the Engineering Report to DDW for review and approval. DDW review of the Engineering Report is anticipated to span approximately one year. After DDW's approval of the Engineering Report, and their consultation and recommendations to the RWQCB, a public hearing is held (it should be noted that multiple public hearings may be required). Although DDW is considered the lead for the public hearings, the hearings would be arranged by Metropolitan as the project sponsor, with project information presented by Metropolitan and IAP members. Following the public hearings and subsequent comment periods, DDW will submit its *Summary of Public Hearing, Findings of Fact and Conditions*, which the RWQCB then incorporates into WDRs/WRRs through a permit issued for the project and its proposed use.

A summary of key milestones leading to the regulatory approvals by DDW and the RWQCB are listed below in Table 5-8. The projected timeline noted is contingent on the design and construction schedule for the proposed demonstration facility. It should also be noted that the estimated timeline below represents a fairly aggressive permit approval schedule that will require close coordination with DDW and the RWQCB prior to and throughout the demonstration phase of the Program. As indicated earlier, there may be multiple permitting alternatives for this Program. For a groundwater recharge program, Metropolitan may seek to approach the RWQCB and DDW on an option for permitting Metropolitan as the recycled water "producer" with appropriate groundwater agencies as lead permittee for "user" permits for each targeted replenishment site. Another option would be for permits to be issued for each basin or replenishment site, with Metropolitan and appropriate groundwater agencies listed as the co-permittees. Due to the unique nature of this regional program, the milestones and timeline noted below will be confirmed following discussions with the appropriate groundwater agencies and regulators when determining the specific permitting approach that will be applied to this Program.

Table 5-8: Key Regulatory Milestones and Estimated Timeline for Approval of an IPR Project

Regulatory Milestones	Projected Timeline
Initial meeting with DDW and RWQCB	Q1 2016
Independent Advisory Panel Commissioning	Q1 2016
Meetings with IAP and Regulators	2x per year, TBD
Design and Construction of Demonstration Plant	Q1 2016 – Q3 2017
DDW/RWQCB Conceptual Approval	Q4 2016
Demonstration Testing and Monitoring Work Plan	Q2 2017
Demonstration Testing (one-year)	Q4 2017 – Q4 2018
AWT Demonstration Report	Q4 2018
Operation Optimization Plan	Q4 2018
Report of Waste Discharge to RWQCB	Q1 2019
Title 22 Engineering Report to DDW, RWQCB	Q2 2019
Public Hearing(s)	Q2, Q3 2019
DDW Summary of Public Hearing, Findings of Fact and Conditions, Recommendations to RWQCB	Q4 2019
RWQCB WRRs/Permit	Q1 2020

5.6 Conclusion

Several IPR projects have been implemented in southern California using surface spreading and subsurface injection. This has been ongoing for decades and significant experience has been developed in assessing the impacts on public health. DDW finalized its Groundwater Replenishment Regulations which provide direct guidance for the protection of public health. Therefore the regulatory basis and framework, as well as precedence-setting models such as Orange County's GWRS, has been established for groundwater replenishment projects which make it a viable option for the reuse of JWPCP effluent from a regulatory perspective.

Planned surface water augmentation with recycled water has not yet been implemented in California; however, regulatory criteria will be established in 2016 with San Diego's Pure Water Program helping to guide that development. Planning and implementation of a surface water augmentation project could span well over a decade. DPR is currently being extensively studied in California, accelerated as the result of record drought experienced by the State. DPR is also being considered in other drought-stricken states, and recently implemented in Texas. Although the feasibility of regulating DPR is being currently investigated, the development of regulations for DPR is likely to be many years off.

Implementing a groundwater recharge project will require close coordination with DDW, as well as the RWQCB. Metropolitan is proposing to initially proceed with a demonstration phase (which will include construction of an AWT demonstration facility), in partnership with the Sanitation Districts and select groundwater agencies, to provide the information necessary for regulatory approval of the full-scale Program. The demonstration facility will validate the ability of the AWT facility to reliably produce advanced treated water that meets all regulatory requirements and ensures long-term protection of the groundwater basins proposed for the full-scale project. Completion of the Engineering Report will be a major milestone to be met following conclusion of the demonstration testing and is a prerequisite of the water recycling permit ultimately issued by the RWQCB. An independent advisory panel must also be commissioned to provide guidance and validation during the demonstration and full-scale phases of the Program. Metropolitan's partnership and close collaboration with the Sanitation Districts, and groundwater basin managers and end-users, throughout the development of the Program will help to ensure its success, meeting all applicable regulations, and ensuring protection of public health.

6 Advanced Water Treatment

The proposed Program would develop a series of projects wherein Metropolitan would employ advanced water treatment (AWT) to treat effluent from the Sanitation Districts' JWPCP and produce up to 150 MGD of high quality water for beneficial reuse. It is recommended that a demonstration project be conducted in order to generate the information necessary for the regulatory approval and permitting process for a full-scale AWT facility, as well as to gain a better understanding of the operational performance and maintenance requirements of each unit process. The purpose of this section is to provide the rationale for and description of the treatment train(s) that should be evaluated during a demonstration phase in preparation for the potential full-scale AWT facility.

6.1 Potential Reuse Applications

The pilot results described in Section 2 will not suffice for design of a full-scale treatment facility. Among other areas, a major change from the 2008 DGGR to the recently finalized groundwater replenishment regulations include the requirement to demonstrate pathogen removal of 12-log enteric virus, 10-log *Giardia* cyst, and 10-log *Cryptosporidium* oocyst from raw wastewater to finished water. Although validation testing typically requires surrogate monitoring and/or seeding studies at full-scale, a demonstration facility could be used to obtain the necessary information regarding pathogen removal efficacy for each unit process to support regulatory approval and permitting of a full-scale reuse project. Indirect and direct integrity monitoring techniques and performance reliability measures should be evaluated for each unit process at a demonstration scale which could then be used at a full-scale facility. The potential reuse applications of AWT facility effluent and the associated regulatory requirements are as shown in Table 6-1.

Table 6-1: Potential Reuse Applications and Associated Regulatory Requirements

Reuse Application	Requirements per California Code of Regulations
Groundwater Replenishment through Surface Application	Article 5.1, sections 60320.100 to 60320.130
Groundwater Replenishment through Subsurface Injection	Article 5.2, sections 60320.200 to 60320.230
Surface Water Augmentation	Draft regulatory criteria in development; must be adopted by December 31, 2016
Direct Potable Reuse (upstream of a drinking water treatment facility)	Feasibility must be reported on by December 31, 2016; public draft report must be completed by June 30, 2016

The following subsections describe the data gaps and the issues that need to be resolved during the demonstration phase before moving forward with a full-scale reuse project, based upon the potential reuse applications for the AWT facility currently under consideration. Because the requirements for groundwater replenishment through subsurface injection are more stringent than for surface application, the discussion for groundwater replenishment is with respect to subsurface injection requirements. Draft regulatory criteria are being developed for surface water augmentation and were presented at a meeting between DDW and an Expert Panel convened in July 2014 to advise DDW on public health issues, and scientific and technical matters, regarding the development of surface water augmentation criteria[24]. Discussion is provided in this section regarding surface water augmentation although this application is a future potential use, as groundwater replenishment is the current focus of the Program. Lastly, discussion regarding DPR (sending AWT effluent directly upstream of a conventional drinking water plant) is not provided in this section since regulatory criteria may be more than several years away. A more thorough discussion on regulatory aspects related to potable reuse through groundwater replenishment and surface water augmentation can be found in Section 5.

Table 6-2 provides a summary of nutrients and minerals in the following locations:

- AWT influent (JWPCP secondary effluent) and RO permeate during the Pilot Study

[24] http://www.nwri-usa.org/documents/VOLIIINWRIDDWPanelReportJuly2014.pdf

- OCWD GWRS permit levels (RWQCB Order Nos. R8-2004-0002 and R8-2008-0058)
- Santa Ana and Los Angeles Region Basin Plan Water Quality Objectives for Groundwater
- Metropolitan source water lakes representing Colorado River and State Water Project water

Pilot Study AWT influent and RO permeate water quality provide an overview of the performance observed by the UF-RO and MBR-RO treatment trains. The OCWD GWRS discharge permit provides an idea of some of the more stringent requirements that could be applied in addition to the Santa Ana and Los Angeles Region Basin Plan water quality objectives for a full-scale AWT project. The water quality objectives that are specified in the Basin Plans for each of these potential replenishment basins provide minimum criteria that must be met in order for AWT effluent to be used for groundwater replenishment in any of these basins. Lastly, if surface water augmentation of one of Metropolitan's source water lakes were to be pursued, water quality that met or exceeded that observed in the lake would likely be required prior to discharge. Further discussion of these constituents of interest for the demonstration phase is provided in subsequent sections. Only water quality objectives for groundwater basins currently of interest for AWT effluent from this Program are listed in Table 6-2. A more comprehensive table summarizing many more water quality constituents analyzed throughout the Pilot Study is included in Appendix B.

Table 6-2 – Nutrients and Minerals in OCWD GWRS Permit, Basin Plan Objectives, AWT Influent and Effluent, and Metropolitan Source Water Lakes (Median Values Unless Noted Otherwise)

Constituent	Units	OCWD GWRS Permit	Water Quality Objectives for Groundwater Basin Plans						JWPCP Secondary Effluent^	UF Train (UF-RO) **	MBR Train (MBR-RO)**	Lake Mathews (2000-2014)***	Silverwood Lake (2000-2014) ***
			Los Angeles Region				Santa Ana Region						
			Central	West Coast	Main San Gabriel	Raymond	Orange County	Chino					
Nitrite	mg N/L	—	1	1	1	1	—	—	—	<0.01	<0.01	<0.005†	0.009†
Nitrate	mg N/L	3	10	10	10	10	3.4§	2.9§§	<0.1	<0.10	2.8	0.2†	0.7
Total Nitrate, Nitrite	mg N/L	—	10	10	10	10	—	—	—	< 0.1^^	2.8^^	—	—
Ammonia	mg N/L	—	—	—	—	—	—	—	39.5	1.9	< 1.0	<0.03†	<0.03†
Total Nitrogen	mg/L	5	—	—	—	—	—	—	41*	1.9^^	2.8^^	—	—
Organic Nitrogen	mg N/L	—	—	—	—	—	—	—	2.6	<1.0^	—	—	—
TKN	mg N/L	—	—	—	—	—	—	—	39.5**	2.0	<1.0	0.22†	0.33†
Phosphate	mg P/L	—	—	—	—	—	—	—	0.5**	<0.13	<0.13	—	—
Phosphorus, Total	mg/L	—	—	—	—	—	—	—	0.5	<0.02^	<0.02^	0.01	0.07
TDS	mg/L	500	700	800	450, 600±	450	580	250§§	1400	36	34	599	256
Boron	mg/L	—	1.0	1.5	0.5	0.5	0.75^^^	0.75^^^	0.9	0.64	0.62	0.13	0.15
Chloride	mg/L	55	150	250	100	100	500^^^	500^^^	470	8.7	5.8	86	76
Sulfate	mg/L	100	250	250	100	100	500^^^	500^^^	220	<0.5	<0.5	232	37

±Dependent on location in basin (Western Area, Eastern Area)
* LACSD Data – Maximum value from 2006-2007.
**LACSD Data – Median values from routine water quality analyses conducted during the Pilot Study (Tables 5-1 and 5-2) unless noted otherwise.
*** Metropolitan Data – Median values from Annual Water Quality report averages.
^LACSD Data – Median values from Pilot Study Title 22+ sampling data unless otherwise noted; see this report's Appendix C.
^^LACSD Data – Data from Pilot Study Tables 8-2 and 8-3.
†Metropolitan Data – Median values taken from Metropolitan laboratory information management system (LIMS) data.
§Based on assimilative capacity findings.
§§Lowest based on antidegradation objectives, unless maximum benefit to the people of the state is demonstrated; then objective is 5.0 mg/L for nitrate and 420 mg/L for TDS.
^^^General water quality objective for Santa Ana Region groundwater.
Note: For calculation of median values, ND was assumed to be equal to the reporting limit for LACSD data and half of the detection limit for Metropolitan data

6.1.1 Groundwater Recharge

Metropolitan is currently evaluating the potential for groundwater recharge in four Los Angeles Region Basins (West Coast Basin, Central Basin, Raymond Basin, and Main San Gabriel Basin), Chino Basin, Orange County Basin, and several other basins in the Southern California region (see Section 9 of this report for more information regarding potential groundwater recharge basins). The discussion that follows compares Pilot Study treated water quality with the Basin Plan objectives and the OCWD Permit, as shown in Section 5 and in more detail in Appendix B. In addition to the water quality targets, some of the key issues that would need to be resolved during a demonstration phase for a groundwater recharge designated AWT facility are discussed below.

6.1.1.1 Membrane Fouling

The irreversible fouling of the UF membrane within the two year pilot test period was likely caused by the high organic loading on the membrane compared with the UF membrane in the MBR tank. It should be noted that other wastewater treatment facilities using the membrane tested during the Pilot Study (Siemens 10LV) were also experiencing significant fouling issues, and currently the membrane is no longer used for wastewater treatment. Even if an MBR process were not used in the ultimate treatment train, a biological nitrification step upstream of the UF train would be beneficial, and should be evaluated, to extend the life of the membrane and reduce the potential for irreversible fouling. The biological nitrification occurring in the MBR tank provided many advantages over the UF train, leading to better treated water quality and lower overall chemical usage.

6.1.1.2 Nitrogen Removal

Both the UF and MBR trains met nutrient MCLs, limits set forth in the OCWD GWRS Permit, and water quality objectives for groundwaters established in the Santa Ana and Los Angeles Region Basin Plan. Total nitrogen levels were at 1.9 mg/L (mostly as ammonia) and 2.8 mg/L (mostly as nitrate) for the UF and MBR trains, respectively, which are lower than the OCWD GWRS permit limit of 5 mg/L. However, nitrate levels in the MBR train (2.8 mg N/L as a median value) were nearly at the stringent limits in the OCWD GWRS permit and the Santa Ana Region Basin Plan (Chino) objective of 3 mg/L and 2.9 mg/L, respectively (see Section 5 regarding maximum benefit objective of 5 mg/L for the Chino basin; a conservative value is used here for discussion of worst-case scenario). Although RO can remove a significant percentage of ammonium and nitrate, the remaining nitrate levels may still be too high relative to Basin Plan objectives if upstream nitrification occurs without a subsequent denitrification step. Hence, further reduction of nitrate in the AWT train should be evaluated through a denitrification step and/or an ion exchange process downstream of the RO membrane or UV AOP process. A lower advanced treated water nitrate level would provide a greater margin of safety with potential groundwater basin objectives.

6.1.1.3 Minerals Removal

Both the UF and MBR trains met mineral water quality limits in the OCWD GWRS Permit and the Los Angeles and Santa Ana Region Basin Plan objectives based on the current replenishment basins under consideration for most minerals (TDS, chloride, and sulfates), except boron. The UF and MBR trains typically treated boron levels down to 0.6 mg/L, whereas many Los Angeles Region groundwater basin objectives for boron are at 0.5 mg/L. Boron removal could be achieved by raising the pH and converting the boron species from uncharged boric acid to borate ion, which could then be removed through ion exchange or a second pass RO stage. However, source control was noted in the Pilot Study as a more cost effective option. The Sanitation Districts' Source Control Program, discussed in Section 4.3, notes that "source control methods may be used to help safeguard [Metropolitan's] advanced treatment process and the end use of the water." Further boron treatment should be evaluated during the demonstration phase to ensure that boron levels from the AWT facility would meet these low groundwater basin objectives if source control methods do not resolve the issue.

6.1.1.4 TOC Removal

TOC samples for the Pilot Study were taken on a weekly basis. While this would suffice for determining compliance with the Groundwater Replenishment Regulations, more frequent monitoring would be necessary to monitor RO integrity to demonstrate pathogen log removal per CCR Section 60320.201(b) which requires that on-going performance monitoring (typically TOC or conductivity) be used to verify membrane integrity. In addition, CCR Section 60320.201(a)(2) states that the full-scale RO membrane must also be able to meet < 0.25 mg/L TOC during the first 20 weeks of operations, 95% of the time. The capability of the RO membrane to achieve this level of treatment was not evaluated as part of the Pilot Study.

6.1.1.5 Post Stabilization

pH and alkalinity adjustment of the RO permeate was not evaluated during the Pilot Study, but would be required to bring up the AWT facility effluent pH to within allowable limits for groundwater recharge. OCWD had experienced arsenic mobilization from subsurface sediments through recharge of highly purified recycled water via the GWRS. It was determined that the purity of the water led to this occurrence and that post-treatment stabilization, in combination with a comprehensive geochemical characterization of the aquifer, was a critical process element to eliminate issues of arsenic or other potential metals leaching in the aquifer. The pH range target is 6 to 9 for the OCWD GWRS permit, as well as for the Santa Ana Region Basin Plan groundwater water quality objective. An evaluation of pH adjustment chemicals would be beneficial during a demonstration phase to better estimate chemical costs, assess potential operational difficulties, and ultimately select an optimum method to raise the pH, whether through caustic soda and calcium chloride addition, or decarbonation and lime slurry addition, for example.

6.1.1.6 AOP Process Operation and Validation

Section 60320.201(d)(1) of the CCR allows the demonstration of 0.5-log reduction of 1,4-dioxane to verify the capability of the oxidation process. This is likely the option that would be used for full-scale AOP process design; however, surrogate and/or operational parameters such as UVT, UV Intensity (UVI), flow rate, and UV dose need to be established to validate that the oxidation process is achieving the target reduction. For permitting purposes, these parameters can be confirmed during full-scale operations at start-up or with third-party validation of an actual reactor that would be used at full-scale because inactivation levels are reactor specific. However, it would be beneficial to test a UV process during a demonstration phase to better understand operational aspects of a continuous flow UV reactor, unlike the reactors which were used during the Pilot Study in an intermittent mode. In addition, although the AOP doses to meet requirements for 0.5-log reduction of 1,4-dioxane would likely be much higher than that required for 6-log pathogen inactivation, DDW could still require additional microbial seeding studies to demonstrate pathogen inactivation. It is possible that this could be done during a demonstration phase.

One consideration for the AWT facility is the use of UV/Cl_2 instead of UV/H_2O_2 for the AOP process. In the UV/Cl_2 process, aqueous chlorine in the form of HOCl or ClO^- is used to generate OH^- hydroxyl radicals. One of the major advantages of using HOCl is that the UV absorbance of HOCl is higher than

H_2O_2, indicating that less UV energy is required to create an effective hydroxyl radical. In addition, the scavenging rate (consumption of OH^- radicals) of HOCl is lower than H_2O_2 or ClO^-[25]. If free chlorine were applied to RO permeate, which is typically at pH levels below 7.0, a greater percentage of available chlorine would be in the form of HOCl than OCl^-. An added benefit of the UV/Cl_2 process is that the residual free chlorine in the UV AOP effluent could be used to obtain additional virus inactivation credit, whereas residual H_2O_2 could require chemical addition to quench residual hydrogen peroxide. Although only UV/H_2O_2 was tested during the Pilot Study, it would be beneficial to evaluate both chemical oxidants for the UV AOP process during the demonstration phase. The UV/Cl_2 process will be implemented at the AWT facility as part of the Los Angeles Bureau of Sanitation (LA BOS) Terminal Island Treatment Plant expansion from 5 to 12 MGD. Based on preliminary evaluation, disinfection byproducts such as THMs were found to not be an issue for LA BOS, due to low THM precursors as indicated by TOC levels in RO permeate. An assessment of THM formation should be performed during the AWT demonstration phase for this project as well.

6.1.1.7 Pathogen Removal Requirements and Credits

CCR Section 60320.208, Pathogenic Microorganism Control for groundwater replenishment requires that log reduction validation be conducted for every process used to meet the requirements of 12-log enteric virus reduction, 10-log *Giardia* cyst reduction, and 10-log *Cryptosporidium* oocyst reduction from raw wastewater to finished water. Demonstration phase testing could be used to evaluate the performance of each unit process for pathogen removal to support the regulatory approval and permitting process prior to full-scale validation testing. The range of typical log removal credits that would be given to each unit process in a standard AWT train are summarized and compared with regulatory requirements in Table 6-3.

Note that pathogen log removal credit for certain processes may be given based on previous studies, however, DDW could potentially request that additional surrogate seeding studies be conducted to demonstrate pathogen removal in non-standard, special circumstances. Log removal credit by underground retention time through a groundwater basin is typically demonstrated with a tracer study.

[25] http://www.awwa.org/publications/journal-awwa/abstract/articleid/38030166.aspx

Table 6-3 – Range of Log Removal Credits with an AWT Train and Log Removal Requirements for Groundwater Replenishment

Pathogen	Typical Log Removal Credits per Process							Total Log Removal Required
	WWTP	MF/UF	RO	UV	Free Cl_2 Disin-fection	Under-ground Retention	Total	
Virus	0-2	0-1*	1.5-2	6	0-6	2-6**	9.5-23^	12
Cryptosporidium	0-1	4	1.5-2	6	-	-	11.5-13	10
Giardia	0-2	4	1.5-2	6	-	-	11.5-14	10

*OCWD GWRS was able to achieve 1-log virus credit through indigenous coliphage monitoring.
**Since underground retention time must be a minimum of two months per CCR Section 60320.224, minimum of 2.0 log virus would be obtained.
^The treatment process should be appropriately designed such that the total virus removal meets the minimum 12-log removal required. This could be accomplished, for example, with the use of free chlorine disinfection for additional virus log removal.

6.1.1.7.1 Wastewater Treatment Plant

Some IPR projects have been able to obtain an additional 1 to 2 log pathogen removal credit for the wastewater treatment plant process from the influent through secondary treatment, such as at the Leo Vander Lans Water Treatment Facility. This is achieved by comparing the wastewater treatment plant processes upstream of the AWT facility with previous studies by Olivieri et al. (2007) and Rose et al. (2004), which demonstrated log reductions for *Cryptosporidium*, *Giardia*, and virus through various types of wastewater treatment plants. Again, this would need to be accepted on a case-by-case basis by DDW, but could be investigated as an option for achieving the required log removal of virus, *Cryptosporidium*, and *Giardia*.

6.1.1.7.2 MF/UF Membrane

MF/UF membrane pathogen log removal credits for *Cryptosporidium* and *Giardia* are typically given based on previous conditional acceptance by DDW of validation tests completed by third parties. In contrast, MBRs are not currently credited by DDW with log removal of any of these pathogens as MBRs are typically used in wastewater treatment for enhanced organics and suspended solids removal, not for pathogen removal. More discussion about this topic is provided in the MBR subsection below. Any additional pathogen log removal credit for the UF membrane would be on a case-by-case basis, such as the OCWD GWRS. The GWRS was able to achieve 1-log virus credit for the submerged UF membrane through indigenous coliphage monitoring.

6.1.1.7.3 RO System

Pathogen log removal credits for RO are generally based on demonstration of TOC or conductivity reduction since these parameters can be analyzed continuously and serve as an indicator of RO membrane integrity. Although actual studies on RO membranes show much greater log removal of pathogens, currently no surrogate indicator is available so that the RO membrane can be credited with more than 2-log removal. In addition, while up to 2.0-log removal can be credited for pathogen removal through an RO membrane, only 1.5 log of TOC was removed based on data from the Pilot Study (using a conservative estimate that the RO permeate TOC was equal to the reporting limit of 0.5 mg/L). If desired, additional data than what was provided in the Pilot Study report is needed to increase the pathogen log removal credited to the RO process for the proposed AWT facility.

6.1.1.7.4 UV System

Based on the UV Disinfection Guidance Manual[26], the highest minimum UV dose to achieve 6-log inactivation of the three target pathogens is 286 mJ/cm^2 (186 mJ/cm^2 for 4-log virus inactivation, plus 100 mJ/cm^2 for an additional 2-log virus inactivation). Since the dose required for 1,4-dioxane 0.5-log reduction is much greater than this dose, additional studies with surrogates may be waived, as is the case for other IPR projects, such as at the Leo Vander Lans Water Treatment Facility.

6.1.1.7.5 MBR Membrane

Similar to what has been observed at the OCWD GWRS, the absence of an upstream nitrification step in the Pilot Study UF train likely caused the high degree of UF membrane fouling such that it was irreversibly fouled within the two year test period. The Pilot Study MBR train had many advantages over the UF train; however, if an MBR were to be used in lieu of a UF membrane in the AWT process, mimicking the MBR train from the Pilot Study, an additional treatment process would be needed to meet pathogen log removal requirements under the current regulatory environment. As shown in Table 6-4, the total log credits achieved from the wastewater plant, an MBR, RO, and UV process train, would potentially be up to 2.5-log less than the required removal for *Cryptosporidium* and *Giardia* (see cells shaded in gray in Table 6-4).

[26] http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf

A study is currently being conducted by a consulting firm and various MBR membrane suppliers to demonstrate to DDW that MBRs are capable of achieving a minimum 2.5-log removal of *Cryptosporidium* and *Giardia* at 12 different wastewater treatment plants, while developing a surrogate parameter to monitor the integrity of the membrane (such as turbidity)[27]. If DDW were to accept their findings and credit MBRs with a minimum 2.5-log *Cryptosporidium* and *Giardia* removal credit, this would enable the use of MBRs in lieu of an MF/UF membrane in an AWT plant while still meeting the pathogen removal requirements for groundwater replenishment. The project is slated to be completed by the end of 2015. The demonstration facility proposed for this Program should allow testing of an AWT train utilizing an MBR both with and without a subsequent MF/UF process.

Table 6-4 – Range of Log Removal Credits with an MBR/RO/UV Train and Log Removal Requirements for Groundwater Replenishment

Pathogen	Typical Log Removal Credits per Process							Total Log Removal Required
	WWTP	MBR*	RO	UV	Free Cl_2 Disin-fection	Under-ground Retention	Total	
Virus	0-2	0	1.5-2	6	0-6	2-6**	9.5-22^	12
Cryptosporidium	0-1	0	1.5-2	6	-	-	7.5-9	10
Giardia	0-2	0	1.5-2	6	-	-	7.5-10	10

*MBRs are currently not credited with pathogen log removal; however, a current study is seeking to demonstrate a minimum 2.5-log removal *Cryptosporidium* and *Giardia* removal for MBRs.
**Since underground retention time must be a minimum of two months per CCR Section 60320.224, a minimum of 2.0 log virus would be obtained.
^ The treatment process should be appropriately designed such that the total virus removal meets the minimum 12-log removal required. This could be accomplished, for example, with the use of free chlorine disinfection for additional virus log removal.

6.1.1.7.6 Free Chlorine

Free chlorine can be used to achieve virus removal credit up to the maximum allowed 6-log per treatment process under the Groundwater Replenishment Regulations. Padre Dam Municipal Water District (Padre Dam) is seeking to implement an IPR project with the minimum underground storage requirement of 2 months. To ensure that adequate virus removal is achieved at the point of groundwater extraction, Padre Dam is in the process of testing a 100,000 gallon per day Advanced Water Purification Demonstration Project using free chlorine upstream of an AWT train to obtain 6-log virus credit upfront. While this is one approach to applying free chlorine, the free chlorine residual

[27] Meeting between Andy Salveson from Carollo Engineers and Metropolitan staff on June 11, 2015.

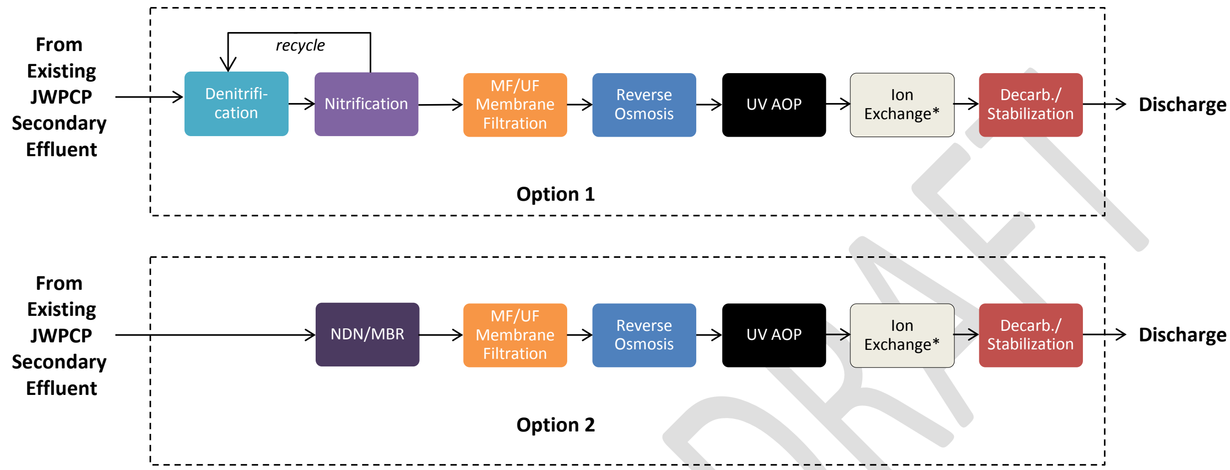
remaining from a UV/Cl_2 AOP process could also be used to obtain this virus credit. Chlorination of wastewater secondary effluent with high organic load could cause other unwanted issues such as increased THM formation.

6.1.1.8 Proposed Treatment Train for Groundwater Replenishment

Figure 6-1 shows the proposed demonstration phase AWT train options for a groundwater replenishment project with either surface spreading or subsurface injection. The two options provide for either a (1) biological NDN step without membranes (such as a conventional activated sludge, trickling filter, or hybrid system), or an (2) NDN/MBR (biological NDN in conjunction with an MBR membrane), upstream of an AWT train. The demonstration phase would ideally test both options if possible. The NDN process in Option 1 is recommended to evaluate the potential improvement in overall process performance and longer membrane equipment life due to decreased organic loading on the UF membrane, as well as overall total nitrogen/nitrate reduction. The NDN/MBR process in Option 2 should be evaluated for reduction in nitrate levels since the median nitrate level of 2.8 mg N/L in the MBR train during the Pilot Study, which did not employ denitrification, is nearly at the Santa Ana Region Basin Plan nitrate objective of 2.9 mg N/L for one of the potential replenishment basins (Chino Basin, based on a potential worst-case scenario; see Section 5 for further discussion). If DDW eventually credits MBRs with *Cryptosporidium* and *Giardia* log removal (at least 2.5-log removal credits required), the MF/UF membrane may be considered a redundant barrier with the MBR membrane and would not be necessary to meet regulatory requirements. Therefore, a bypass of the MF/UF process may be tested as well during the demonstration project.

Pilot Study UF and MBR train boron levels were above Los Angeles Region Basin Plan objectives; therefore, reduction of boron levels should be evaluated within the proposed treatment trains (possibly through pH adjustment and additional treatment) in the case that source control methods do not mitigate the issue. Boron removal using high pH and ion exchange could be implemented on a sidestream of total treatment process flow, and downstream of the pH adjustment step – a variation of the process train shown in Figure 6-1. A UV AOP process should be tested with both Cl_2 and H_2O_2 addition for 1,4-dioxane and nitrosamine reduction. The final decarbonation/stabilization step is included in each of the treatment train options to increase alkalinity and pH levels to within target ranges before discharge. RO permeate pH was typically below 6 and would need to be increased within the target range of 6 to 9.

It should be noted that the NDN processes are proposed within the bounds of the AWT train because of the difficulty of integrating these processes into the existing JWPCP secondary processes through a retrofit[28]. If in the future a NDN process is incorporated into JWPCP, the nitrified or potentially denitrified secondary effluent could bypass the nitrification or denitrification steps in the AWT process.



**Ion exchange may occur downstream of the decarbonation/stabilization step for high pH boron removal.*

Figure 6-1 – Proposed Demonstration-Phase Treatment Process Train for Groundwater Replenishment

6.1.2 Surface Water Augmentation

Metropolitan is also evaluating surface water augmentation as a potential future option for AWT effluent. However, the surface water augmentation regulatory criteria are currently in draft form undergoing review by the Expert Panel. DDW will adopt the regulatory criteria only if it is determined that the proposed criteria would adequately protect public health. At a minimum, additional testing would likely be needed to evaluate advanced treatment nutrient, mineral, and pathogen removal capability before implementation of an AWT facility for surface water augmentation. The data needs presented below for the surface water augmentation application are based on Pilot Study results and the projected regulations being developed.

6.1.2.1 Nutrients Removal

One of the more significant considerations for surface water augmentation projects involving Metropolitan's source water reservoirs is that the quality of the AWT effluent should be of similar or

[28] See Appendix D.

better quality than Metropolitan's surface waters rather than simply meet Basin Plan water quality objectives. Some constituents, although present at higher concentrations than those in Metropolitan's surface waters, would not be as concerning as others due to the significant dilution (100:1 dilution currently proposed) that would occur as part of the discharge requirements for AWT effluent for surface water augmentation. However, nutrients in AWT effluent such as nitrogen and phosphorus that could be detrimental to existing lakes would likely not be acceptable above existing levels in Metropolitan's source waters. For example, Lake Mathews exhibits low productivity and any increase in nutrients, particularly phosphorus, can stimulate algal growth. As such, the discussion in the previous section regarding the need for additional treatment to reduce total nitrogen levels for groundwater replenishment would apply for surface water augmentation, and potentially to a greater degree.

As shown in Section 2, although the MBR train provided significant nitrification of ammonia to nitrate, the final effluent from the MBR train still had approximately 2.8 mg/L of NO_3-N. Final effluent from the UF train had approximately 1.9 mg/L of NH_3-N. Differences in effluent total nitrogen levels between the two trains are likely due to the differences in removal of ammonium ion (which was likely the dominant species in RO feed for the UF train), versus nitrate (which was likely the dominant species in the RO feed for the MBR train) by the RO membrane, as observed in other studies[29]. In order for the final effluent from an AWT facility to be used for surface water augmentation, nutrient levels would likely need to be less than those observed at the lake of interest. In general, Lake Mathews observes between 0.1 and 0.4 mg/L as NO_3-N, with a median of 0.2 mg/L as NO_3-N, and non-detect levels of total ammonia (< 0.03 mg N/L). NDN would be needed to convert ammonia to nitrate and reduce nitrate levels to below background levels, or another option would be to convert ammonia to nitrate and remove nitrates at the end of the treatment process downstream of the RO process, through ion exchange.

Lake Mathews total phosphorus levels are generally around 0.01 mg/L. Total phosphorus levels in the Pilot Study were non-detect (< 0.02 mg P/L) from the UF-RO and MBR-RO permeate (see Appendix B). Hence, additional treatment will likely not be required for phosphorus removal.

6.1.2.2 Minerals Removal

Minerals in Table 6-2 from the UF and MBR trains were at or below levels in Metropolitan source waters with the exception of boron, which were approximately 0.6 mg/L from the UF and MBR trains as a

[29] https://www.watereuse.org/files/images/91212_c.pdf

median value. In contrast, Metropolitan source waters have boron levels between 0.1 to 0.2 mg/L, which is lower than those in the Los Angeles Region Basin Plan mineral water quality objectives. Although unlikely, it is possible that additional treatment could be warranted for boron reduction to levels at or below what is observed in Metropolitan's source waters.

6.1.2.3 Pathogen Removal

Existing regulatory criteria being developed for surface water augmentation criteria propose that the level of pathogen control will also be 12-log enteric virus, 10-log *Giardia* cyst, and 10-log *Cryptosporidium* oocyst reduction from the raw sewage to the finished drinking water. Another requirement in the draft regulatory criteria is that the pathogen reduction between the raw sewage to the AWT effluent be 8-log enteric virus, 7-log *Giardia* cyst, and 8-log *Cryptosporidium* oocyst, prior to discharge to the reservoir. The reservoir itself may be credited with 1-log virus reduction for each month that the recycled water is retained in the reservoir; however, this will require extensive hydrodynamic modeling, taking into consideration factors such as short circuiting, stratification, turnover, thermoclines, and reservoir withdrawal. The draft regulatory criteria being considered allow the pathogen removal achieved by the conventional drinking water treatment plant to be applied to the overall pathogen removal requirements.

A more conservative approach to meeting the overall required pathogen removal would be to not take any credit for reservoir retention time or the conventional drinking water plant and meet pathogen removal requirements at the AWT facility. This would provide a significant safety factor for pathogens and response retention time by not relying on any downstream processes or treatment facilities to meet regulatory requirements, as well as provide a different perspective of viewing the augmented surface water as a true storage buffer upstream of a drinking water facility. Table 6-5 provides a range of typical pathogen log removal credits with an AWT train, and requirements for surface water augmentation. Based on the subtotal range of pathogen log removal credits that can be achieved by the end of an AWT system, it is possible to meet all required log removal without any log removal credit from the reservoir or drinking water treatment facility. This kind of conservative treatment train would not rely on downstream processes for additional treatment credit.

6.1.2.4 Proposed Treatment Train for Surface Water Augmentation

The proposed demonstration phase AWT train options if the end use were surface water augmentation would be the same as those proposed for groundwater replenishment in Figure 6-1. The greater degree of required constituent and pathogen removal for surface water augmentation compared to groundwater replenishment application could be achieved with the same treatment processes. Again, the only difference between Option 1 and Option 2 is that an MBR membrane would be tested upstream of the AWT train in Option 2. To deal with the high organic level in JWPCP secondary effluent in both options, the NDN step would be the first process, the AWT trains (MF/UF, RO, and UV AOP) would provide the bulk of the required regulatory treatment and pathogen removal, and lastly the ion exchange process would deal with any low level nitrate or boron removal requirements. If boron removal with high pH was to be used, one consideration would be to have the ion exchange process downstream of the pH adjustment step. Ultimately both trains would have a stabilization process to increase pH and alkalinity before discharge.

Table 6-5 – Range of Log Removal Credits with an AWT Train and Log Removal Requirements for Surface Water Augmentation

Pathogen	Typical Log Removal Credits per Process (Before Reservoir)						Log Removal			
	WWTP	MF/UF	RO	UV	Free Cl_2 Disin-fection	Sub-total	Required Before Reservoir	Achieved through Conventional Drinking Water Treatment	Credits Subtotal	Overall Required
Virus	0-2	0-1*	1.5-2	6	0-6	7.5-17	8	4	11.5-21†	12
Cryptosporidium	0-1	4	1.5-2	6	-	11.5-13	8	2^	13.5-15	10
Giardia	0-2	4	1.5-2	6	-	11.5-14	7	3	14.5-17	10

*OCWD GWRS was able to achieve 1-log virus credit through indigenous coliphage monitoring.
^Assuming Bin 1 classification.
†The treatment process should be appropriately designed such that the total virus removal meets the minimum 12-log removal required. This could be accomplished, for example, with the use of free chlorine disinfection for additional virus log removal.

6.2 Proposed Demonstration Phase Treatment Process Train

Figure 6-2 shows the two proposed demonstration phase treatment trains for the initial Phase I and optional Phase II test periods with the main difference between the two trains being the inclusion of an integrated NDN/MBR process in one train (Train 2) but not in the other (Train 1). Each train would likely be 0.5 million gallons per day (MGD) in capacity, for a total plant capacity of 1 MGD. The second demonstration test phase, Phase II, incorporates an ozone/biologically active filter process in each train. Each train and phase is described in more detail below.

A one-year demonstration testing period is proposed. The main goal of the demonstration phase would be to generate the necessary information to supplement the regulatory approval and permitting process for a full-scale facility. Some of the key objectives of the demonstration phase would be as follows:

- Demonstration that the two AWT trains meet existing groundwater replenishment regulations, and could meet the draft regulatory criteria currently under development for surface water augmentation, especially with respect to water quality performance.
- Evaluate nutrient removal performance to meet groundwater basin objectives.
- Establish direct and indirect integrity monitoring methods and performance reliability measures which could be used to correlate the capability of each unit process to achieve water quality performance.
- Monitor and collect operational performance and maintenance requirements (such as chemical, equipment replacement, measurement of energy use, or pretreatment costs) of AWT train equipment.

For reference, MF/UF membrane and RO system treatment has been used in many existing AWT/reclamation facilities in Southern California, as shown in Table 6-6 since 1995. The MF/UF membrane operating fluxes range from 18 to 40 gallons per square foot of membrane per day (gfd), whereas the RO membranes generally operate between 10 and 12 gfd. The existing facilities range in capacity from 3 to 100 MGD and the facilities that produce water for seawater barriers and groundwater replenishment include a UV AOP process. Note that the demonstration phase AWT effluent may be used for non-potable uses around the Sanitation Districts' property and/or sent back to the head of the JWPCP.

6.2.1 Phase I – Overall Treatment Train

The proposed design for Phase I demonstration testing shown in Figure 6-2 enables evaluation of two trains, namely (1) NDN, and (2) NDN/MBR for significant organics reduction in JWPCP secondary effluent upstream of AWT trains. For the AWT portion of the treatment trains, either an MF or UF membrane, or both, could be tested in the demonstration phase. For reference, the final report for the City of San Diego's Advanced Water Purification (AWP) Demonstration Project (1 MGD capacity) concluded that the UF and MF parallel testing showed the UF provided more virus rejection with similar energy costs[30]. The RO system tested during the demonstration phase should be able to provide design criteria and operational parameters that meet water quality goals. The UV AOP process should evaluate both chlorine and hydrogen peroxide oxidants for nitrosamine and 1,4-dioxane reduction. As a polishing step for further reduction of nitrate or boron, an ion exchange process should be evaluated downstream of the AOP process. Since boron removal could be achieved with ion exchange at high pH, one consideration would be to treat a sidestream of the treatment process flow with ion exchange after the pH adjustment step. Both trains should ultimately include post-treatment stabilization processes before discharge to provide the level of treatment that meets regulatory requirements for both groundwater replenishment and surface water augmentation end use. Demonstration phase testing will enable a side-by-side evaluation of both processes with respect to water quality performance, chemical and power usage, and ease of operation and maintenance.

The range of pathogen removal credits achievable by the proposed treatment trains would be as shown in Table 6-3 and Table 6-5 up through the free chlorine disinfection step.

Table 6-7 summarizes how Train 1 and Train 2 should be operated to evaluate the treatment processes that would be used in the case of groundwater replenishment and surface water augmentation of the advanced treated water. Each train will require the use of bypasses around the denitrification and/or ion exchange processes to evaluate the need for these processes depending on how well each train performs overall, as well as in order to evaluate the different treatment process configurations based on the AWT effluent application. For example, for groundwater replenishment, if the treatment trains were able to meet nitrate objectives of the Basin plans without a denitrification step, this process as well as the ion exchange process could be bypassed. If, however, there were a significant level of boron in

[30] http://www.sandiego.gov/water/purewater/pdf/projectreports/wpdpfinalprojectreport.pdf

the AWT effluent, the ion exchange process could be used to removal boron downstream of the stabilization process (i.e. at high pH), followed by readjustment of pH such that the effluent would be within pH limits for discharge (typically 6 to 9). With respect to Train 2, a bypass of the MF/UF process for Train 2 should be provided considering potential for future pathogen reduction credit for MBRs. If sufficient regulatory credit is granted for MBRs in the future, pathogen log removal requirements for an AWT train could potentially be met without the MF/UF process.

For a surface water augmentation application, if nitrate removal with NDN/MBR or NDN followed by MF/UF, RO, and UV did not bring AWT effluent water quality to within Metropolitan source water reservoir levels, additional removal would be needed such as through ion exchange. It is likely that the denitrification step would be needed for surface water augmentation since the nitrate levels are 0.2 and 0.7 mg N/L for Lake Mathews and Silverwood Lake, respectively, as opposed to 2.9 mg N/L for the most stringent groundwater basin currently under consideration.

6.2.2 Phase II – Ozone and Biologically Active Filtration

Adequate space and flexibility should be provided in the Phase I demonstration treatment process trains such that ozone and biologically granular activated carbon (BGAC) treatment processes could be installed upstream of the MF/UF membranes during a future optional Phase II of the demonstration facility. The proposed incorporation of an ozone/BGAC into each of the two treatment train configurations for Phase II is shown in Figure 6-2. Recent research has shown many benefits of using ozone and BGAC in reuse applications, including for enhanced destruction of CECs and other unregulated constituents. Although not required to meet current regulations for groundwater replenishment, ozone with and without BGAC is being implemented and evaluated upstream of AWT trains in Southern California (see Table 6-6). Phase II testing would be used to evaluate cost effective options for membrane pretreatment, but also to evaluate ozone/BGAC as an additional treatment barrier. Depending on the final regulatory requirements for surface water augmentation and direct potable reuse, this process could be used to meet requirements of future reuse applications. Note that if pathogen reduction credit is desired for the ozone process for groundwater replenishment, a minimum of 1-log removal must be consistently demonstrated through this process.

6.2.2.1.1 Ozone/BGAC Process

Ozone transforms wastewater effluent organic matter from hydrophobic, complex, high molecular weight fractions into more hydrophilic, low molecular weight organic matter. Ozonation alone provides cost effective destruction of many trace organic compounds, although some compounds are known to be more resistant to oxidation (meprobamate, phenytoin, primidone, and tris[2-carboxyethyl]phosphine or TCEP).

Some of the undesirable effects of wastewater ozonation include disinfection byproduct formation, such as bromate and NDMA, which can vary widely in magnitude depending on the precursor loads[31]. Some studies have shown that ozonation can convert target compounds into “unknown” transformation products, which can elevate the toxicity of the treated effluent. However, ozonation followed by BGAC has demonstrated significant removal of CECs, comparable to RO-UV/H_2O_2 processes[32], and although NDMA formation through ozonation of secondary effluent is high, much of the NDMA formed was demonstrated in some studies to be removed (by as much as 78%) through BGAC to pre-ozone levels[33]. In addition, NDMA can be readily reduced to target levels with an adequately designed downstream UV process.

Bromate formation with ozonation will not likely be an issue provided that RO membranes, which are effective at bromate rejection, are provided downstream of the ozone process. Therefore, if an ozone process were to be added to the demonstration treatment train, it is recommended to be upstream of the RO process and coupled with a downstream BGAC step for bromate and NDMA removal, respectively.

6.2.2.1.2 Existing Applications

At the City of San Diego AWP Demonstration Project facility, an ozone/BGAC process is being evaluated upstream of the existing AWT treatment train (shown in Table 6-6) to evaluate the effectiveness of an additional treatment barrier to protect public health in anticipation of a future potential direct potable reuse scenario and the associated regulatory environment[34]. The AWP Demonstration Project was

[31] https://www.watereuse.org/product/11-02-3
[32] https://www.watereuse.org/product/08-05-1
[33] https://www.watereuse.org/product/11-02-3
[34] http://www.sandiego.gov/water/pdf/purewater/fs_researchstudies.pdf

originally conducted in preparation for a potential IPR application through surface water augmentation of the City of San Diego's San Vicente Reservoir.

At the West Basin Municipal Water District (MWD) Edward C. Little Water Recycling Facility (E.C. Little WRF), ozone/BGAC is used as a pretreatment for their existing AWT treatment process (shown in Table 6-6). The WateReuse Research Foundation Study summarized findings from a Pilot Study conducted at the West Basin MWD E.C. Little WRF and concluded that ozonation improved feed water quality, reduced the need for coagulant addition upstream of the membranes, reduced membrane fouling and chemical cleaning requirements, and lastly, improved membrane flux[35]. The study concluded that monitoring secondary effluent UVT was an effective approach to automate ozone dose.

6.3 Conclusion

In summary, the Pilot Study conducted between 2010 and 2012 provided valuable information regarding UF membrane performance in the presence of high ammonia levels (median influent level of 37 mg N/L) and the need for a nitrification step upstream of a UF membrane to reduce the organic loading which led to irreversible fouling on the membrane. Secondary benefits of biological nitrification were observed in the MBR train, with lower overall chemical usage (sulfuric acid and peroxide) due to lower alkalinity and higher UVT compared with the UF train. All 1,4-dioxane and nitrosamine targets were met through the AOP processes for both trains, except for NDEA. It is likely that if higher UV/H_2O_2 doses were tested during the Pilot Study, NDEA target levels would have been achieved. In general, both the UF and MBR trains were able to meet target levels for all constituents except for boron. Additional work is needed to determine the best method to reduce boron levels in the AWT effluent, whether through the Districts' Source Control Program or additional treatment.

If groundwater replenishment were the only end use of the AWT facility, a demonstration phase treatment train for JWPCP secondary effluent should consist of NDN or NDN/MBR, followed by a standard advanced treatment train. Another option in lieu of, or in addition to, denitrification would be an ion exchange unit downstream of the AWT train. Additional boron removal may need to be evaluated for groundwater replenishment, such as pH adjustment with additional RO membrane treatment, or also with ion exchange. If surface water augmentation is considered a possible end use, treatment for additional nutrient removal should be evaluated through the same aforementioned

[35] https://www.watereuse.org/product/10-11-1

processes; NDN and/or ion exchange. Regardless of the AWT effluent application, the RO system should be evaluated for TOC and/or conductivity removal as a surrogate for pathogen removal, and the UV AOP process should be evaluated with both Cl_2 and H_2O_2 for 1,4-dioxane and nitrosamine reduction, as well as for any additional microbial testing to demonstrate adequate pathogen removals to meet groundwater replenishment regulations for virus, *Cryptosporidium*, and *Giardia* if needed. Lastly, a stabilization process consisting of pH and alkalinity adjustment prior to discharge of the treated water should be evaluated during a demonstration phase.

Figure 6-2 shows how the demonstration phase proposed treatment process in Phase I includes two trains for evaluation, (1) Train 1 consists of NDN, MF/UF membrane, RO membrane, UV AOP, ion exchange, and stabilization, and (2) Train 2 consists of NDN/MBR, MF/UF membrane, RO membrane, UV AOP, ion exchange, and stabilization. Bypasses should be provided around the denitrification and ion exchange processes for both trains such that the overall treatment processes can be evaluated with and without their impact. Depending on the AWT effluent application and overall performance of the treatment trains, these two processes may not be needed. It should be noted that the NDN processes are proposed within the bounds of the AWT treatment train because of the difficulty of integrating these processes into the existing JWPCP through a retrofit[36]. These processes could be bypassed in the future if a NDN process were to be incorporated into the JWPCP facility. In addition, Train 2 (MBR train) may incorporate a bypass of the MF/UF process in consideration of potential future pathogen reduction credit for MBRs.

In Phase II of the demonstration testing, an ozone/biologically active filter process is proposed upstream of the MF/UF membrane for both treatment trains as shown in Figure 6-2. Recent research has shown many benefits of using ozone and BGAC in reuse applications, including reducing membrane fouling, reduction of chemical membrane cleaning, and destruction of trace organic compounds. Although not required to meet current regulations for groundwater replenishment, ozone with and without BGAC is being implemented and evaluated upstream of advanced water treatment trains in Southern California. Phase II testing would be needed to evaluate ozone/BGAC as an additional treatment barrier for a DPR application, and to evaluate cost effective options for membrane pretreatment.

The demonstration phase should evaluate the capability of the two proposed treatment trains (Phase I and Phase II), and the efficacy of each unit process, for a potential 150 MGD AWT facility to meet

[36] See Appendix D.

existing and/or draft regulatory requirements for groundwater replenishment and surface water augmentation, respectively.

7 Grant and Loan Funding Opportunities

The following are the primary sources of external funding available for a potential project: 1) The WaterSMART Program administered by the U.S. Bureau of Reclamation (USBR); and 2) California's Recycled Water Funding Program (Proposition 1). The following sections provide overviews of the two funding sources and the potential funding opportunities for the demonstration plant and the full-scale facilities.

7.1 WaterSMART Program

The WaterSMART program includes funding through Title XVI of the Reclamation Wastewater and Groundwater Study and Facilities Act of 1992 for projects that reclaim and reuse municipal, industrial, domestic or agricultural wastewater and naturally impaired ground and surface waters. Title XVI provides up to $20 million or 25% of project costs. Project sponsors provide the remaining 75% of the funding necessary to carry out the projects. According to USBR website, there are currently 43 Title XVI projects authorized by Congress, 17 of which are located in Southern California. Adding new projects to the congressionally authorized project list are unlikely until the existing projects are completed or withdrawn. Recent legislation proposed by Senator Feinstein has proposed providing $ 200 million for new Title XVI projects and eliminating the Congressional authorization requirement. A recent Title XVI funding announcement provided $1.3 million for feasibility studies in 2015 to evaluate the use of municipal wastewater for other beneficial uses. Approximately $407 million in Title XVI grants has been provided to projects in Metropolitan's service area. Between Fiscal Year (FY) 2010 through FY 2015, approximately $54 million has been obligated.

The WaterSMART Grants program also includes approximately $20 million annually for projects that offset potable water demand through conservation, watershed management, and innovative technologies including some small recycled water projects. Metropolitan received a $2.5 million grant in 2014 to supplement the On-Site Retrofit Pilot program authorized by the Board.

7.2 California's Recycled Water Funding Program

SWRCB is the primary state agency responsible for funding recycled water projects. The SWRCB's Division of Financial Assistance administers the Water Recycling Funding Program (WRFP) and the State

Clean Water and Drinking Water State Revolving Fund (CWSRF and DWSRF) programs that provide low interest loans for capital funding of water quality and water recycling projects that offset or augment water supplies, including the planning, design, and construction of treatment and distribution systems. Loan payment proceeds go back to the Fund to provide loans to other projects.

On January 17, 2014, as part of the Governor's emergency drought declaration, $800 million in 1% loans through the CWSRF program was authorized for water recycling projects that offset or augment State water supplies and can be completed within 3 years. Projects must apply for the funding through the SWRCB by December 2, 2015. As of May 27, 2015, over 30 projects had applied requesting more than $1.6 billion in funding. Four of those projects have executed agreements totaling approximately $95 million.

On November 4, 2014, voters approved Proposition 1 (Assembly Bill 1471, Rendon) which authorized $7.545 billion in general obligation bonds for water projects including surface and groundwater storage, ecosystem and watershed protection and restoration, and drinking water protection. Chapter 9 of Proposition 1 authorized $725 million for water recycling and desalination projects. $625 million will be administered through SWRCB's WRFP for water recycling and treatment technology projects and $100 million through the Department of Water Resources (DWR) for desalination projects. Of the $625 million, there is approximately $210 million appropriated for FY 2015-2016. The remaining $415 million is expected to be appropriated over the next several years starting in FY 2016-2017. The funding will be split by SWRCB for 50% grants and 50% loans. Both planning and construction projects are eligible for funding with up to $75,000 available for planning grants and $15 million for construction grants. Water recycling projects may receive grant funds in the amount of up to 35% of actual eligible construction costs incurred up to a maximum of $15 million. At least 50% local cost share match must be provided by the project sponsor. The applicant could satisfy the local match requirement through other sources, including its own revenues, other grants or loans, costs for studies and other directly associated planning and design costs incurred prior to the grant award date. Local cost share may be provided by SWRCB with CWSRF financing. The remaining project cost above the $15 million cap could be funded through low interest long-term loans from Proposition 1 or CWSRF. Loans would be available at one-half general obligation bond rates (~1.6%) with repayment within 30 years. Repayment of loans would be used to fund future projects in order to sustain available funding. In future years the $15 million maximum grant amount per project could be reduced if the repayment revenues cannot support the maximum grant benefit.

Applications for WRFP will be continuously accepted by SWRCB. Only one application per project is needed. SWRCB will use the exiting FAAST on-line application process for both Proposition 1 and CWSRF funding. Project proponents are encouraged to apply as soon as possible. Proponents are not required to have finalized documents before submitting an application. However, grants or loans will not be approved before submittal of the project's complete CEQA documents. If funding runs out during a fiscal year, the SWRCB will hold the application until sufficient funding is available. Because some funding may be through CWSRF which includes federal funding, CEQA evaluations should include federal NEPA cross cutting items, which have been considered in the CEQA approach to this Program. Projects are expected to be funded on a first come and ready-to-proceed basis. Projects must meet at least 50% annual deliveries within 5 years of completion of construction or demonstrate adequate future demands.

Enclosed is the link to the SWRCB Proposition 1 Recycled Water Funding Program page. http://www.waterboards.ca.gov/water_issues/programs/grants_loans/proposition1.shtml

7.3 Potential Funding

- **Grants may/may not be available in FY 2015-2016**

There is $210 million of the $725 million in Proposition 1 Chapter 9 for water recycling, desalination, and AWT projects identified in the State of California's FY 2015-2016 Budget. Approximately half of the FY 2015-2016 Proposition 1 funding will be used for grants and the other half used for low interest loans. SWRCB staff has estimated that the remaining funding would likely be appropriated in FY 2016-2017 and FY 2017-2018.

- **Demonstration plant can apply for state funding based on estimated project cost of $10 million**

Eligible pilot projects may receive grant funds in the amount of up to 35% of actual eligible Pilot Study construction costs incurred up to a maximum of $1 million. Applicants must demonstrate pilot projects will develop new information that does not currently exist and increase the body of knowledge regarding new technologies that help understand how potable reuse can be effectively achieved through innovative application of current and new technologies.

- **CEQA is expected to be in place**

Applicants must provide adequate and complete environmental documentation to allow the SWRCB to fulfill its responsibilities under CEQA. Applicants for CWSRF funding would need to complete federal NEPA cross-cutting requirements. In addition, a completed CEQA document needs to be submitted before a State WRFP application would be approved.

- **Levels of state funding that might be in place for the demonstration plant**

The WRFP guidelines have limited funds of up to 35% or maximum of $1 million available for pilot projects. The pilot project must demonstrate new information that increases the body of knowledge of new technologies or how potable reuse could be achieved through innovative application or new technologies.

- **Approach to future funding for full-scale facilities**

Based on current information, a full-scale facility project application should be submitted as soon as possible to compete for the available CWSRF loans and Proposition 1 funding (total $625 million from SWRCB). Metropolitan should anticipate that local funding for 50% of the project would be needed. The WRFP guidelines indicate that the local match may be satisfied with CWSRF funding. However, staff should be cautious on expecting more than 50% funding due to high demands for the funding and competition from other projects. Support from other agencies and political leaders may facilitate receiving additional funding above 50% of the project costs.

8 Approach to CEQA and NEPA Compliance

Metropolitan is assessing the potential to build an AWT facility to recycle up to 150 MGD of treated wastewater effluent from the Sanitation Districts' JWPCP in Carson, California. The AWT facility would be built onsite at the JWPCP and would connect to a new pipeline network to convey the advanced treated water from the JWPCP to various endpoint uses that may include spreading grounds, groundwater injection, surface water augmentation, industrial water use or other potable water uses.

As a first step to complete this potential project Metropolitan is considering to construct a 1-MGD demonstration AWT plant at the site of the JWPCP. The demonstration plant would be used to test the effectiveness of various advanced treatment options such as a membrane bio-reactor, microfiltration or ultrafiltration, reverse osmosis, UV/advanced oxidation process (utilizing hydrogen peroxide or chlorine), and possibly ozone/biologically active filtration (reference Chapter 6.0 of this report). All water and wastewater generated by the plant would be returned to the JWPCP site for treatment and discharge. If the operation of the demonstration plant is successful, with Board approval, Metropolitan would design and construct an AWT facility, using a proven treatment train, tested by the demonstration plant, to produce up to 150 MGD of recycled water. If the treatment technologies tested do not prove effective, design of the full-scale project would be suspended.

Construction of the demonstration plant, the AWT facility, and the pipeline distribution system would be subject to the California Environmental Quality Act (CEQA). The level and complexity of CEQA review for each project would be determined by an initial review of the environmental effects of construction and operation of these facilities. The following actions are recommended to expedite the construction of the demonstration plant and, ultimately, the full 150 MGD AWT and associated pipelines:

8.1 CEQA/NEPA Considerations for Demonstration Plant

Based upon review of CEQA documents prepared for the construction of the JWPCP and similar projects, construction and operation of the demonstration project would not result in a significant environmental effect and qualifies for a categorical exemption from CEQA. A limited number of environmental studies will be required to confirm and support this determination including: air quality analysis, noise analysis, cultural resources analysis, limited biological studies, and an analysis of transportation impacts.

The demonstration project is not expected to require any federal action and, as such, will not require compliance with NEPA. NEPA studies will not be performed.

8.2 CEQA/NEPA Considerations for AWT Facility

If the demonstration plant proves successful in treating water from the JWPCP, and Metropolitan's and the Sanitation District's respective Boards agree to move forward with the program, a full-scale AWT project would be designed and built. To achieve minimal permitting and environmental compliance delays, environmental staff would work jointly with Metropolitan's engineering and design staff during the preliminary design, to identify potential environmental hazards and identify feasible changes in facility design, construction or operation of the AWT facility to avoid these hazards. These hazards may include: endangered species and their habitats; waters of the State or the United States or wetlands; cultural resource sites; hazardous material sites; sensitive noise receptors; airports; oil and gas pipelines; emergency services; hospitals; historic buildings or cultural sites. The hazards would be identified and mapped for use by design.

Once this design phase has been completed, a formal CEQA review would be initiated, and a proposed project description would be required to be developed that will be used to complete a CEQA initial study and preliminary review. During this initial review, effects that are determined to be insignificant will be dismissed; the reason(s) for dismissal will be documented for the record. Those effects found to be significant or potentially significant will be carried forward for further environmental analysis and identification of potential mitigation or avoidance measures. If all significant effects identified during this initial study and preliminary review period are able to be mitigated to less than significant levels then a Mitigated Negative Declaration (MND) will be prepared and circulated for public review. The MND, all supporting documentation, and public comments will then be forwarded to Metropolitan's Board for consideration and adoption.

The AWT facility is not expected to require any federal action and, as such, will not require compliance with NEPA. NEPA studies will not be performed.

8.3 CEQA/NEPA Considerations for AWT Facility Pipeline Distribution System

On June 24, Governor Brown signed Senate Bill 88, which will waive CEQA for projects that "consist of construction or expansion of recycled water pipeline and directly related infrastructure within existing rights of way, and directly related groundwater replenishment, if the project does not affect wetlands or sensitive habitat, and where the construction impacts are fully mitigated consistent with applicable law". Metropolitan believes that SB 88 exempts the proposed recycled water pipeline distribution system from the provisions of CEQA if we comply with the requirements that construction impacts be fully mitigated and that the project be designed within existing rights of way and not affect wetlands or sensitive habitat. To meet these conditions, Metropolitan will complete a set of detailed environmental studies that will identify and quantify potential impacts associated with the construction and operation of the project and will propose avoidance and/or mitigation measures that will fully mitigate these impacts. The studies that will be conducted for this portion of the project will be robust enough to use in a CEQA/NEPA document should Metropolitan determine a full environmental review is necessary.

The pipeline distribution system may cross or be co-located on federally owned or managed property or facilities, which will require Metropolitan comply with NEPA. The scope and scale of any NEPA studies will depend on the final alignment design chosen and the types of impacts the design may have on federal property or facilities. At this time, Metropolitan believes that a limited NEPA review will be required based on the limited number of subsurface crossings of Federal Property or Facilities expected.

8.4 Studies Required for State Revolving Fund Grants/Loans

Metropolitan would likely apply for State grants and/or State low interest loans for the design and construction of some, or all, of this project. The AWT facility is not likely to require NEPA compliance, however State grants and low interest loans require a set of federal cross-cutting requirements as part of the application process. Cross-cutting requirements conducted for the AWT facility and the pipeline distribution system will be submitted as part of the State grant and low interest loan application process.

The construction of the pipeline distribution system may cross, or be located within Federal property or facilities, such as the Los Angeles River. If this occurs, then NEPA studies will be prepared and will be used as part of State Revolving Fund Applications and no "NEPA-like cross-cutting" studies will be needed.

8.5 Tasks Required for CEQA and the SB88 Exemption Analysis

Task I. Aesthetics

- Identify all scenic vistas along the project route.
- Identify all state scenic highways.

Task II. Agriculture and Forestry Resources

- Identify Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency.
- Identify existing zoning for agricultural use, or a Williamson Act contracts.
- Identify existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)), timberland (as defined by Public Resources Code section 4526), or timberland zoned Timberland Production (as defined by Government Code section 51104(g))

Task III. Air Quality

- EPT will work with design and engineering to complete a construction scenario that will be used to analyze GHG and Air Quality impacts.
- Identify sensitive receptors along the proposed route.

Task IV. Biological Resources

- Identify species located along the route via the CNDDB (candidate, sensitive, fully protected, F&G protected or special status species).
- Identify riparian habitat.
- Identify habitat found in any NCCP HCP or recovery plans for listed or regulated species.
- Identify wetlands using the DFG protocol (including, but not limited to, marsh, vernal pool, coastal, etc.).
- Identify native resident or migratory fish or wildlife species migratory wildlife corridors or nursery sites.
- Identify local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance.

Task V. Cultural Resources

- Identify historical resources (as defined in PRC § 15064.5) that are listed on the State or Federal Historic Registers.
- Identify, if possible, known archaeological resources (as defined in PRC 15064.5).

- Identify, if possible, unique paleontological resources or sites or unique geologic features.
- Identify known human remains and formal cemeteries.

Task VI. Geology and Soils

- Identify distance from the right away to homes or structure.
- Identify known earthquake faults, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. Refer to Division of Mines and Geology Special Publication 42.
- Identify areas with a known risk of seismic-related ground failure, including liquefaction.
- Identify areas with soils known to be unstable.
- Identify expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994).

Task VII. Greenhouse Gas Emissions

- EPT will work with design and engineering staff to complete a construction scenario that will be used to analysis GHG and Air Quality impacts.

Task VIII. Hazards and Hazardous Materials

- EPT will work with design and engineering staff to complete operation and construction scenarios that will be used in hazards and hazardous material analysis.
- Identify HazMat release sites including sites compiled pursuant to Government Code Section 65962.5.
- Identify potential affected airports and private airstrips.
- Locate emergency response plans or emergency evacuation plans and identify the routes.
- Identify wild lands and high fire areas.

Task IX. Hydrology and Water Quality

- Identify streams and storm water channels.
- Identify 100-year flood hazard areas.
- Identify tsunami and mud flow areas.
- Identify climate change predicted sea level rise areas.

Task X. Land Use and Planning

- Identify zoning along the route.
- Identify habitat conservation plan or natural community conservation plan areas.

Task XI. Mineral Resources

- Identify any aggregate or mineral mines (including oil/gas rigs/pipelines) along the route.

Task XII. Noise

- Compile noise ordinance and noise element data and suggested mitigation measures.
- Compile noise data from each jurisdiction.
- Identify airports and private airstrips.
- Identify schools, hospitals, nursing homes and other sensitive receptors.

Task XIII. Population and Housing

- Determine effects, if any, of the project on future growth.

Task XIV. Public Services

- Identify fire protection, police protection, schools, parks, and other public facilities.

Task XV. Recreation

- Identify regional parks or other recreational facilities.

Task XVI. Transportation/Traffic

- Identify modes of transportation including mass transit (bus routes), pedestrian and bicycle paths, and other routes.
- Identify areas likely to need road expansion work (LOS F).

Task XVII. Utilities and Service Systems

- Identify stormwater drainage facilities.

Task XVIII. Mandatory Findings of Significance

- Identify rare, endangered, or special status plant or animal species including their habitat and ranges.
- Identify known historical resources and tribal cultural resources.
- Conduct Native American tribal consultations to identify and avoid or mitigate known tribal cultural resources. Consultation is required for the SRF funding.

9 Potential Demands for Groundwater Storage

This section evaluates the feasibility of groundwater storage and extraction of recycled water from the JWPCP. For each of the groundwater basins considered for this Program, this preliminary analysis will discuss:

- The existing processes for storage within each groundwater basin
- The potential feasibility of storage of the recycled water from the JWPCP in the groundwater system.
- The potential participation for the use of recycled water from the JWPCP for each groundwater basin
- Assumptions behind groundwater recharge participation projections
- Need for use of injection wells and spreading basins
- Impacts on nearby wells and pumpers
- Identification of member agencies that would be partnered with and identification of governing bodies

The following Table 9-1 provides a summary of the potential yield for the groundwater recharge option for use in the West Coast, Central, Main San Gabriel and Raymond Basins in Los Angeles County as well as Orange, Chino, Temescal and Arlington Basins in Orange, Riverside and San Bernardino Counties, respectively. Each basin is discussed in detail in the following sections.

Table 9-1: Potential Participation for Potable Reuse through Groundwater Recharge (MGD)

Basin	Potential Participation in Potable Reuse(MGD)
Los Angeles County	
West Coast Basin	10
Central Basin	65
Main San Gabriel Basin	25-50
Raymond Basin	5
Subtotal	**105-120**
Outside Los Angeles	
Orange County Basin	20-60
Chino/Cucamonga Basin	25
Temescal Basin	15
Arlington Basin	5
Subtotal	**65-105**
Total	**170-225**

The analysis includes moderately conservative assumptions that could likely be implemented by 2025. The basic assumptions are:

- Average 2020 and 2030 demands for imported water are projected using Metropolitan's IRPSIM model (Sales Model 24)
- Recycled water will be stored in the groundwater basins by spreading and/or injection
- Stored water will be extracted by partnering agencies
- Wells are assumed to produce about 1,200 AFY per well during injection and about 1,800 AFY per well during extraction
- 100% recycled water could be recharged, unless otherwise indicated

9.1 West Coast Basin

Groundwater storage and extraction in West Coast Basin is governed by the basin adjudication. An amended judgment establishing water rights of 64,478 AF and enjoining excess extractions was filed in 1977 and most recently amended in 2014.

Total storage in the West Coast Basin is estimated to be approximately 6.5 million AF. Unused storage space is estimated to be approximately 1.1 million AF. Of the unused storage space, the amount available for groundwater storage is only 120,000 AF because the upper 75 feet cannot be used for groundwater storage (WRD, 2006). A recent judgment amendment makes provisions for establishment of storage accounts with provision of increased pumping of stored water or for enhanced recharge and increased production. The amended judgment allows each rights holder to store and extract up to 40% of their annual adjudicated pumping allocation (APA, or annual pumping rights under the judgment) subject to review and approval. Regional storage projects would be allowed to use up to 9,600 AF of space. Approximately 50,000 AF of dewatered storage space would be designated as Basin Operating Reserve and held for replenishment operations of the Water Replenishment District of Southern California (WRD).

Under the adjudication amendment, groundwater producers within the West Basin MWD and the City of Torrance service areas would have the ability to store and extract up to 40% of their annual production rights of 63,000 AFY, or an additional 26,000 AFY. Because of basin constraints such as water quality, blending requirements or reduction in operational flexibility, project participation is estimated to be 50%, or 13,000 AFY. It is estimated that 10 MGD could be recharged for this project and will be refined later with modeling.

Because there are no spreading locations available in this area, the proposed project would need to include new injection wells. This Project could be implemented directly with the West Basin MWD and the city of Torrance, with storage accomplished through partnerships with Los Angeles County Department of Public Works (LACDPW) and/or WRD, and extraction accomplished by producers, as applicable. It is not anticipated that the proposed Program would impact the recycled water injection at the seawater barriers. A summary of the facilities required and the potential impacted wells within West Coast Basin is provided in Table 9-2.

9.2 Central Basin

Central Basin was adjudicated in 1965, and the judgment was amended in 1991 and again in 2014. Total storage in the Central Basin is estimated to be approximately 13.8 million AF. Unused storage space is estimated to be approximately 1.1 million AF. Of the unused storage space, the amount available for groundwater storage is approximately 330,000 AF assuming that up to 75 feet below the ground surface is actually available (WRD, 2006). Basin parties have agreed with study findings that 330,000 AF of unused storage space exists in the Central Basin. Following extended negotiations among basin rights holders, a recent judgment amendment allows beneficial use of the 330,000 AF of storage space.

Metropolitan member agencies Compton, Central Basin MWD, Long Beach and Los Angeles overlie the Central Basin. The Central Basin Watermaster is composed of three bodies:

- Water Rights Panel
- Administrative Body (WRD)
- Storage Panel

For any storage project, a storage agreement would need to be executed with the Central Basin Watermaster.

The managed safe yield of Central Basin is equal to the allowable pumping allocation amount (APA) of 217,367 AFY, which is substantially higher than the natural safe yield. This higher yield is possible because of artificial recharge maintained by WRD. Under the terms of the judgment amendment, agencies within the Central Basin would have the ability to store and extract up to 50% of their Annual Pumping Allocation, or APA (108,750 AF). A new community storage pool was also developed (111,250 AF) with priority to smaller rights holders. The remaining storage space is allocated to WRD for long-term basin management. Metropolitan could store water in either the agencies' accounts or within the community storage pool.

Spreading basins in the Montebello Forebay area and the San Gabriel River channel within the Central Basin cover more than 1,000 acres with a capacity of about 350 MGD. However, the actual amount that can be spread is limited by mounding and other factors. Total average annual spreading for the past 20 years has been approximately 135,000 AFY. Spreading utilizes local runoff, untreated imported water, and recycled water. There is about 21,000 AFY of imported water replenishment demand at the Montebello Forebay. WRD is proposing the GRIP project, which will replace this demand with recycled water. If WRD does not move forward with their project, the demand could be part of the proposed Program. Due to mounding concerns, it is estimated that 10 MGD can be spread at the Montebello Forebay and 10 MGD will need to be injected in new injection wells for a total of 20 MGD. It is not expected that the proposed Program will impact the existing recycled water recharge.

The Los Angeles Forebay was historically a recharge area for the Los Angeles River. This forebay's recharge capacity has been substantially reduced since the river channel was lined. Recharge is now limited to deep percolation of precipitation, in-lieu when available, and subsurface inflow from the Montebello Forebay to the east, the Hollywood Basin and relatively small amounts from the San

Fernando Valley through the Los Angeles Narrows. Therefore, the only feasible recharge method for this area is an injection wellfield. The City of Los Angeles currently has rights to pump 18,500 AFY. Using their own storage account and part of the community storage pool, they can storage about 15 MGD.

The demand for recycled water is an important consideration for the parties within Central Basin MWD's service area. The boundary conditions include: adjudication limits and demand limits. The maximum allowable pumping is 40% of the APA of 161,836 AFY is 64,734 AFY. Assuming that a Metropolitan program could only use 50% of the parties' storage, the limit based upon the adjudication would be 32,367 AFY. Central Basin MWD's projected average MWD demand (Sales Model 24) is projected to be 42,568 AFY in 2030. Assuming that only 50% of Central Basin MWD's demand could be converted to groundwater, the potential for recharge within Central Basin MWD's service area is 21, 284 AFY. Therefore, additional storage of about 20 MGD would be possible. This would require an additional 10 injection wells. Fourteen existing wells would be impacted based upon proximity of existing wells to the proposed project.

The APA for the City of Long Beach is 32,692 AFY. Forty percent of the APA is 13,077 AFY. Metropolitan already has a 13,000 AF CUP program with the City of Long Beach so it is assumed that the CUP program could be used for storage. Long Beach's projected average MWD demand (Sales Model 24) is projected to be 30,249 AFY in 2030. Assuming that only 50% of Long Beach's demand could be converted to groundwater, the potential for recharge within Central Basin MWD's service area is 15,125 AFY. Using the CUP Program, there is a potential to store and extract about 10 MGD. The City of Long Beach currently has 4 injection wells that could be used. This would largely be used to fill an existing pumping hole within the City.

Any analysis would need to address impacts to water local water levels due to pumping depressions and movement of any contamination. Even under the most conservative assumptions, there is a moderate risk that during wet periods or various demand periods that the entire amount of recycled water could not be stored or extracted. This situation would result in the need to have the water delivered directly to the Los Angeles River. A summary of the facilities required for groundwater replenishment within Central Basin is provided in Table 9-2.

9.3 Main San Gabriel Basin

The Main San Gabriel Basin was originally adjudicated in 1973, with the Judgment most recently amended in 2014. The judgment specifies annual pumping rights (prescriptive pumping rights total to 197,634 AFY) while establishing a Watermaster that determines the percentage of rights that can be pumped each year without incurring an obligation to pay for replacement water. There is no firm cap on pumping. Since 1995, annual groundwater production has ranged from approximately 250,000 AFY to 275,000 AFY. The Judgment specifies a basin operating range tied to the key well elevation (200 to 250 feet) that provides for 400,000 AF of groundwater production. The Judgment was recently amended to allow storage above the established operating range.

Metropolitan member agencies Upper District and Three Valley MWD as well as the San Gabriel Valley Water District overlie the Basin. The Main San Gabriel Basin Watermaster manages the Basin. For any storage project, a supplemental storage agreement would need to be executed with the Main San Gabriel Basin Watermaster.

The production of this basin is supported by storm water captured behind a series of four dams on the San Gabriel River and by over 1,000 acres of spreading basins. Imported water is used to supplement this recharge, and recycled water could be used in place of the imported water. Active spreading of runoff and imported water recharges 100,000 to 140,000 AFY in average years with substantial swings in dry and wet years (60,000 AFY to over 400,000 AFY). However, in wet years the demand for supplemental replenishment water is substantially reduced. This water could be used for blend water if necessary.

The total amount of water in storage for the Main San Gabriel Basin is approximately 8.6 million AF (Main San Gabriel Watermaster, 2006). Usable storage within the operating range is approximately 800,000 AF while the unused storage space is currently about 560,000 AF. Total average Metropolitan firm demands in 2020 for Upper San Gabriel Valley MWD (Upper District) are projected to be less than 1,000 AFY in 2020 and beyond with an average projected replenishment demand for Upper District, Three Valleys MWD, and San Gabriel Valley MWD of about 50,000 AFY. Metropolitan previously estimated that sufficient capacity for 50 MGD would be available greater than 95% of the time.

Upper District is also considering a 10 MGD recycled water project using water from the San Jose Creek Plant, which could impact the proposed project. The project is still in the early stages of development.

The spreading grounds (i.e. Santa Fe Spreading Grounds) in the Main San Gabriel Basin are operated by LACDPW, while the member agencies arrange for delivery of water supplies for those operations. A similar partnership between Metropolitan, member agencies, LACDPW, and the Main San Gabriel Basin Watermaster would be the most likely mechanism for implementation. The Santa Fe spreading grounds have a surface area of 338 acres and a long-term spreading capacity of about 178 MGD.

The Main San Gabriel Basin is upstream of the Central Basin. There is a moderate risk that during wet years when large quantities of water are spread in the Main San Gabriel Basin that mounding can occur in Central Basin, thereby reducing the amount that can be stored in Central Basin. In addition, there is various groundwater treatment facility is associated with Superfund sites in the Main San Gabriel Basin that may be affected by changes in water level. Like Central Basin, there is moderate risk to Metropolitan that the water would not be used even under the most conservative assumptions. Under the aggressive assumption, the risks are substantially higher to both Metropolitan and the Sanitation Districts. A summary of the facilities required for groundwater replenishment within Main San Gabriel Basin is provided in Table 9-2.

9.4 Raymond Basin

The Raymond Basin was first adjudicated in 1943, with the judgment modified and restated in 1984. The judgment specifies pumping rights, provides for 10% over pumping to be made up the following year, and for 10% carryover of unpumped rights for one year.

Total storage in the Raymond Basin is 1.37 million AF with an unused storage space of about 570,000 AF. Only 250,000 AF of that unused storage space, the Raymond Basin Management Board estimates, would be available for storage programs or Long-term Storage Accounts. Individual parties may also enter into a Long Term Storage Account to add or extract groundwater during the year subject to the Raymond Basin Management Board (RBMB) adopted Groundwater Storage Policies. Metropolitan member agencies Upper District, Pasadena, Foothill, and San Marino as well as the San Gabriel Valley Water District overlie the Basin. The Raymond Basin Management Board manages the Basin. For any storage project, a supplemental storage agreement would need to be executed with the Raymond Basin Management Board.

There is currently an injection capacity of about 8,000 AFY and a spreading capacity of about 23,000 AFY in the Pasadena subarea, the largest of the three subareas of Raymond Basin.

In January 2008, the RBMB approved a resolution to voluntarily reduce groundwater production by 30% over 5 years in the Pasadena subarea. This action has resulted in reduced production of about 5,300 AFY. Recycled water recharge of about 5 MGD would allow for the basin levels to recover so that the production can resume. The recharge can be done at the existing Eaton Canyon Spreading Grounds. The Eaton Canyon Spreading Grounds consist of 28 acres of ponds and have a capacity of about 14 cubic feet per second (9 MGD).

Some caution is warranted in developing a major storage and extraction program in Raymond Basin. A Superfund clean-up of perchlorate is underway at the NASA Jet Propulsion Laboratory in the northwestern portion of the basin (Monk hill sub-area in Foothill MWD's service area). Substantial perchlorate contamination has also impacted production to the south of JPL in Pasadena's service area and shut down nine wells. JPL has maintained that this perchlorate has other sources and is not an extension of the contamination from their site. A summary of the facilities required for groundwater replenishment within Raymond Basin is provided in Table 9-2.

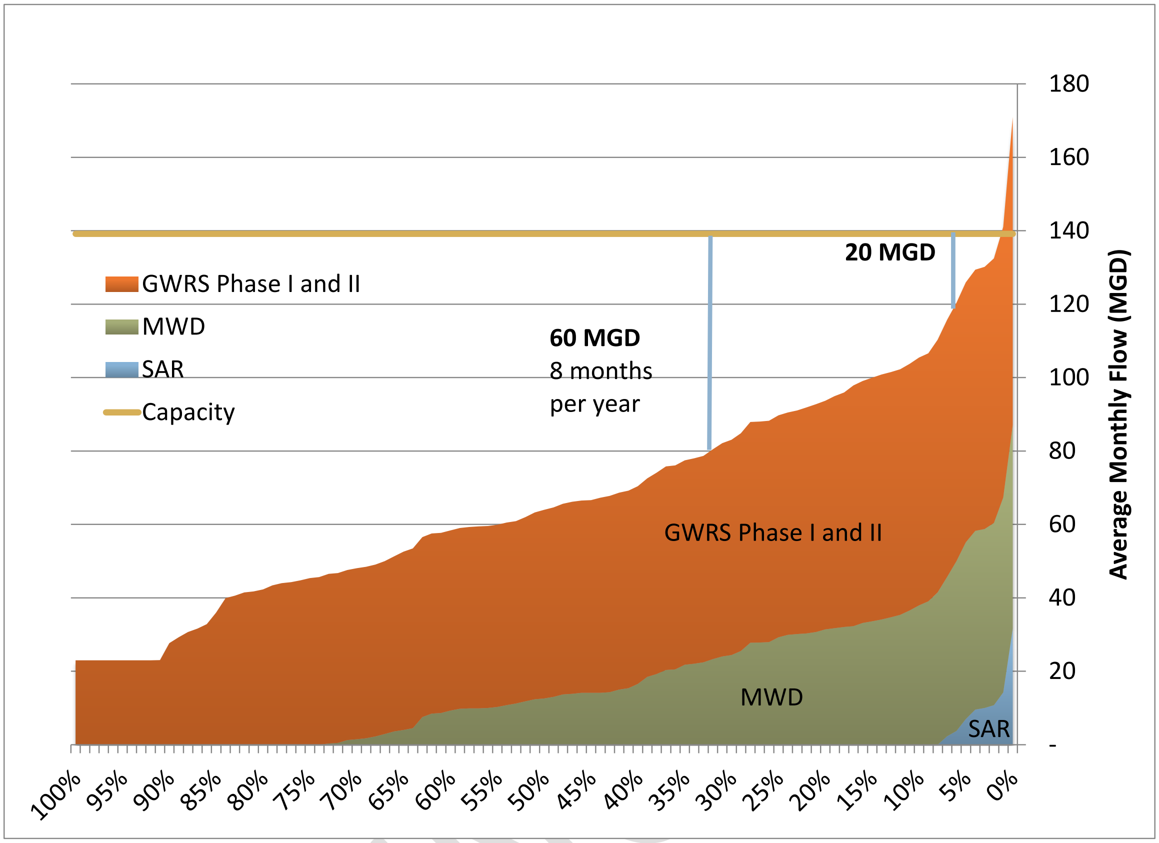
9.5 Orange County Basin

The Orange County Basin is a managed basin. OCWD has managed the Orange County Basin since 1933 pursuant to a special act of the State legislature (West's Annotated California Codes, Water Code Appendix Chapter 50 as amended and Deering's California Codes Annotated Water Uncodified Acts. Act 5683). OCWD has managed the basin based upon the principle of seeking to increase supply rather than restricting access and to provide for uniformity of cost. Any storage agreement in the basin would need to include OCWD and possibly MWDOC. The basin groundwater pumping is not operated on a safe-yield basis each year. Rather, the goal is to maintain an approximate balance over a period of several years. The amount of production from the basin is governed through financial incentives based on establishing an annual Basin Production Percentage (BPP), which is the percentage of groundwater production out of the total water demand for the Orange County Basin. Pumping up to the BPP is charged a fee on a per AF basis, i.e., the Replenishment Assessment (RA). Groundwater production above the BPP is charged the RA plus the Basin Equity Assessment (BEA). The BEA is typically set so that the cost of groundwater production above the BPP is similar to the cost of purchasing alternative supplies. Pumping agencies do not accrue individual storage rights if they pump less than the BPP, which is a major difference compared to most adjudicated basins. Additionally, agencies cannot transfer groundwater-pumping rights.

Metropolitan member agencies Anaheim, Fullerton, Municipal Water District of Orange County (MWDOC), and Santa Ana overlie the Basin. OCWD manages the Basin. For any storage project, a storage agreement would need to be executed with OCWD.

Currently about 30,000 AFY (~27 MGD) of imported water is spread for groundwater recharge. In addition, OCWD delivers about 98,000 AFY of advanced treated recycled water from the Groundwater Replenishment System (GWR) to the Kraemer, Miraloma, and Miller spreading basins in Anaheim (GWR Phase I and II). The operational maximum capacity of these basins is about 140 MGD based upon the maximum monthly spreading. OCWD is currently considering Phase III expansion of GWR to 130,000 AFY. Figure 9-1 shows the probability that sufficient spreading capacity exists in the three spreading basins for the project with GWR Phases I and II. The data show that there is at least 60 MGD of available capacity during about 8 months of the year and at least 20 MGD available about 4 months out of the year. At least 20 MGD would be available 95% of the time. The total water spread, assuming 8 months at 60 MGD and 4 months at 20 MGD would yield an annual average of 46,800 AF. Assuming a 75% BPP, the amount of recharge would not exceed the replenishment demand for the water. There would not be enough demand at the 75% BPP level for GWR Phase III with the MWD project. The imported water and Santa Ana River flows would provide enough blend water for both the GWR and the proposed project – GWR currently requires a 25% blend of non-recycled water sources.

Figure 9-1 – Analysis of Available Capacity in Miraloma, Kraemer, and Miller Spreading Basins



No additional facilities will be required. A summary of the facilities required for groundwater replenishment within Orange County Basin is provided in Table 9-2.

9.6 Chino Basin

The Chino Basin is an adjudicated basin. The groundwater rights and storage capacity within the Chino Basin were established by San Bernardino Superior Court Case No. 164327 in Chapter IV – Groundwater Basin Reports *Chino Basin Municipal Water District v. City of Chino*, et al. in 1978, now designated No. RCV 51010 (referred to herein as the Chino Basin Judgment). In the Chino Basin Judgment, the Chino Basin Watermaster was appointed to administer and enforce the provisions of the Judgment and any subsequent instructions or orders of the Court.

The Chino Basin Judgment defines the natural safe yield as 140,000 AFY (Judgment, 1978). The safe yield is allocated among three pools as follows:

1) Overlying Agricultural Pool (dairy farmers and the State of California): 82,800 AFY;

2) Overlying Non-Agricultural Pool (industrial users): 7,366 AFY; and
3) Appropriative Pool (water for municipalities and other government agencies): 49,834 AFY

An additional 5,000 AFY (200,000 AF of controlled overdraft, averaged over 40 years) is allocated to the Appropriative Pool, which defines the safe yield per the Chino Basin Judgment as 145,000 AFY. Parties are allowed to pump in excess of the safe yield as needed, provided replenishment water is later purchased and restored to the basin. Groundwater not pumped by the agricultural users (Overlying Agricultural Pool) is re-allocated to the Appropriative Pool for municipal use (Chino Basin Judgment, 1978).

Metropolitan member agencies Three Valley MWD, Inland Empire Utilities Agency, and Western MWD overlie the Basin. The Chino Basin Watermaster manages the Basin. For any storage project, a supplemental storage agreement would need to be executed with the Chino Basin Watermaster.

Recharge potential in Chino Basin is estimated to be about 25 MGD. The water can be spread in existing spreading basins. A summary of the facilities required for groundwater replenishment and potentially impacted wells within Chino Basin is provided in Table 9-2.

9.7 Temescal and Arlington Basins

The Temescal Basin is not adjudicated. The City of Corona and the City of Norco are the primary pumpers from the Temescal Basin. Current production in the Temescal Basin ranges from approximately 23,000 to 30,000 AFY. Estimated yield of the basin is approximately 12,000 AFY. Recycled water recharge needs would range from 11,000 to 18,000 AFY. Therefore, 15 MGD is the estimated project size for Temescal Basin. Since there are no spreading basins in the Temescal Basin, approximately 15 new injection wells would be required for this project.

The Arlington Basin is not adjudicated. Western MWD reports on the conditions of the Arlington Basin in addition to other groundwater basins in the Santa Ana River Watershed within its service area. Basin pumping activities are not formally regulated. The Arlington Basin is part of the Santa Ana River Watershed and falls under the jurisdiction of the Santa Ana Watershed Project Authority (SAWPA). The Arlington Desalter is the primary pumper in the Arlington Basin. Western MWD estimates that the desalter will be expanded to a capacity of 10.7 MGD in mid-2017. This expansion will require additional recharge to the basin. According to the Arlington Basin Groundwater Management Plan (2009), an additional 7,500 AFY of recharge will be needed. It is estimated that there is about 5 MGD recycled water recharge potential. Because there are no spreading basins in the Arlington Basin, approximately 5 new injection wells would be required. A summary of the facilities required for groundwater replenishment and potentially impacted wells within Temescal and Arlington Basins is provided in Table 9-2.

Western MWD overlies both the Temescal and Arlington Basins. Although the basins are not formally adjudicated, an agreement with Western MWD would be required for any storage project.

9.8 Summary

This section has shown that there is a potential to store up to 195 MGD within these chosen groundwater basins of Southern California as shown in Table 9-2. The target of 150 MGD for the JWPCP plant is definitely achievable. The project could require as many as 140 new injection wells and potentially replaced wells.

Water quality issues, inability to store or extract, or basin-specific issues will continue to be risks for Metropolitan in developing a program in groundwater basins. Each basin is different and will require careful consideration of all the issues in that basin.

Table 9-2: Summary of Groundwater Recharge Facility Requirements

Basin	Size (MGD)	Type of Recharge	New Injection Wells	Replaced Wells	Key Agencies	Assumptions
West Coast	10	Injection	10	5	Torrance, West Basin, WRD	50% of allowed storage accounts and/or regional storage
Central	65	Spreading/Injection	50	22	LA, Long Beach, Central Basin, WRD	Injection wells to meet 50% of MWD demand + 10.5 TAF of replenishment demand from the Montebello Forebay (due to mounding). Existing wells in Long Beach can be used.
Raymond Basin	5	Spreading	0	3	Pasadena, Raymond Basin Management Board	Intended to recover lost pumping rights in the basin
Main San Gabriel	25-50	Spreading	0	10	Upper District, Three Valleys, SGVMWD Main San Gabriel Watermaster	50 MGD = Full replenishment demand for all 3 agencies. Assumes Chino Basin pipeline would not be built. In addition, includes additional amount Watermaster plans to purchase. 25 MGD = Partial replenishment demand for 3 agencies. Assumes pipeline for Chino Basin spreading would be built.
Orange County	20-60	Spreading	0	0	OCWD MWDOC	Capacity remaining in the spreading grounds. Replaces replenishment demand.
Chino	0-25	Spreading		10	IEUA Chino Basin Watermaster	Based upon historical replenishment deliveries to Chino Basin.
Arlington	5	Injection	5	0	Western	Recharge needed to replace storage due to Arlington Desalter.
Temescal Basin	15	Injection	15	8	Western	Recharge needed to replace storage due to expansion of Temescal Desalter.
Total	**145-235**		**80**	**58**		

IEUA – Inland Empire Utilities Agency
LA – Los Angeles
MWDOC – Municipal Water District of Orange County
SGVMWD – San Gabriel Valley Municipal Water District
WRD – Water Replenishment District
OCWD – Orange County Water District

10 Assessment of Potential Potable Reuse Alternatives

Based on the analysis and conclusions of the previous chapters, benefits and risks were considered for groundwater recharge, surface water augmentation, and direct potable reuse alternatives. This chapter provides a brief discussion of the three potable reuse alternatives that were identified in the earlier chapters, and presents recommendations for selecting one of these options for further study.

10.1 Groundwater Recharge Reuse

On average, groundwater production makes up approximately one-third of the region's water supply. In Metropolitan's 2010 Integrated Resources Plan (IRP) Update, groundwater storage was identified as a critical resource for sustainable water supplies for Southern California during dry periods, and groundwater recharge as a critical element in the maintenance of a healthy groundwater system. As a result of the recent drought, local groundwater basin levels have reached or are near historic lows, and groundwater production is approximately 250,000 AFY less than projected in the 2010 IRP Update.

The following are benefits of utilizing the advanced treated water for groundwater recharge:

- IPR through groundwater recharge has a defined regulatory pathway, which could potentially lead to faster implementation.
- IPR through groundwater recharge has been practiced within Southern California for decades and other successful projects can be identified.
- Groundwater recharge can support a 150 MGD or greater project.
- A large-scale groundwater recharge project will help to maintain healthy basin levels, and improve average groundwater production yield.
- Groundwater recharge of advanced treated water will potentially improve the overall quality of the groundwater in the long-term.
- Groundwater recharge will potentially require less advanced treatment than surface water augmentation or direct potable.
- The JWPCP is favorably located to supply multiple groundwater basins/member agencies.
- The advanced treated water introduced into the basins is not subject to algae blooms.
- The project could be constructed utilizing a phased approach.

The following are risks/challenges of utilizing the advanced treated water for groundwater recharge:

- A groundwater recharge project would require partnerships/agreements with multiple water agencies, basin Watermasters, and other agencies (e.g. Los Angeles County Department of Public Works).

- Spreading of advanced treated water in wet weather conditions might be in conflict with spreading of storm water. If this issue materializes, dedicated could be in contention with storm water capture. Would likely require dedicated spreading area for advanced treated water.

- Recharge of groundwater basins in pressure areas would require a significant number of new wells in heavily congested areas.

- Demands for advanced treated water assume some member agencies will agree to replace a portion of their firm demand by pumping from their groundwater basins.

10.2 Surface Water Augmentation Reuse

Similar to groundwater storage, surface water storage was identified as a critical component for providing water to Southern California during dry periods. As stated in Section 5, draft criteria being considered for surface water augmentation projects require that reservoirs must be in operation for sufficient time to establish a baseline record of water quality. Therefore, only existing reservoirs can be used for a surface water augmentation program. Metropolitan owns and operates three storage reservoirs as shown in Table 10-1.

Table 10-1: Storage Capacities of Major Metropolitan Reservoirs

Reservoir	Total Storage Capacity	Usable Capacity (AF)
Lake Mathews	182,000	178,500
Lake Skinner	44,000	43,800
Diamond Valley Lake	810,000	798,500
	1,036,000	**1,020,800**

Diamond Valley Lake has the greatest capacity of all the reservoirs. However, a project including DVL would be cost prohibitive due to the length of large diameter pipeline and the lift that would be required to convey the water from the JWPCP. Lake Skinner would not be suitable for a surface water augmentation program because its smaller size and current operating restrictions would limit the potential project capacity. The lake is also the furthest from the JWPCP. Given its size and proximity relative to DVL and Lake Skinner, Lake Mathews appears to be the most viable of Metropolitan's reservoirs for the surface water augmentation project.

Lake Mathews is the terminus reservoir for the Colorado River Aqueduct and is used to regulate Metropolitan's Colorado River supply into its treatment and distribution network in the western service area. The lake is subject to a wide range of volumes and outflows to accommodate the various supply and demand scenarios that Metropolitan sees from year to year. For example, the lake volume dropped to approximately 42,000 acre-feet last year for several months in the midst of the current drought, and deliveries from the Lake were high as a result a 5% allocation of State Water Project supplies. Regulatory requirements for 6-month retention of advanced treated water within the lake would have limited the operational flexibility needed to meet member agency demands during this time.

The following are benefits of a potential surface water augmentation project utilizing Lake Mathew Reservoir:

- Metropolitan would manage the water from advanced treatment to the point where it is considered ambient raw water.
- Project would not require multiple agreements as would be needed for IPR through groundwater replenishment.
- Project would utilize existing Metropolitan infrastructure to distribute to member agencies.
- Precedence within United States for IPR through surface water augmentation
- Regulations for surface water augmentation required by December 2016.

The following are potential risks/challenges of a surface water augmentation project utilizing Lake Mathews Reservoir:

- Dilution and retention requirements (based on current draft criteria under consideration) would impact the operational flexibility of the lake, particularly at lower lake levels.
- Dilution and retention requirements may limit the potential size of a surface water augmentation project or not make a project viable at this time.
- Project may require greater levels of advanced treatment than groundwater replenishment to meet the existing ambient reservoir water quality

10.3 Direct Potable Reuse

For the purpose of this study, it is assumed that a direct potable reuse arrangement would require that the advanced treated water be introduced into the water system upstream of a conventional water treatment plant. This arrangement would allow for the blending of the advanced treated water with raw water and would provide an additional barrier for public safety.

Given the above mentioned arrangement for a direct potable reuse project, the following benefits would apply to a direct potable reuse alternative:

- Metropolitan would manage the water from advanced treatment to the point where it is considered ambient raw water.
- Project would not require multiple agreements as would be needed for IPR through groundwater recharge.
- Project would utilize existing Metropolitan infrastructure to distribute to member agencies.

The following are potential risks/challenges of a direct potable reuse program:

- There is no timetable for regulations for direct potable reuse projects.
- There are no draft regulations being considered for direct potable reuse at this time.
- There is no precedence within the United States for a direct potable reuse program.
- Dilution requirements (if similar to surface water augmentation) would limit the operational flexibility of the system or raw water system entering treatment plants.
- Dilution requirements could limit the potential size of direct potable reuse project.
- A direct potable project would likely require additional advanced treatment beyond that needed for groundwater recharge.

10.4 Conclusion

A goal of this conceptual study was to identify potential reuse options that could be employed in the near-term, and was not reliant on the development of future regulations. Due to the uncertainty of the potential regulatory requirements for direct potable reuse and the lack of a timetable for potential regulatory guidance, planning for a large-scale reuse program around a future potential for direct potable reuse is not viable at this time. Consequently, a program that solely incorporates a direct potable reuse approach to utilize 100% of the AWT product water from the JWPCP is not suitable for further evaluation.

Although there is some guidance for a project utilizing surface water augmentation, a program that solely relies on this approach is not currently viable for Metropolitan as the potential operational impacts to Lake Mathews due to retention of the advanced treated water negates the viability of a project, the impracticability of such a program at DVL or Skinner, and the inability to utilize a "new" reservoir as part of a program scheme. Given the restrictions for large scale direct potable and surface water augmentation programs, the most favorable option to immediately utilize the available advanced treated water appears to be a groundwater recharge program. However, it is acknowledged that a program based primarily on groundwater recharge could be designed to accommodate a future surface water augmentation or direct potable reuse option once future regulatory guidance is developed that makes these options favorable to Metropolitan.

11 Project Scenarios

Three potential project implementation scenarios were developed for consideration for potable reuse programs that are primarily based around a groundwater recharge approach to recycled water reuse. For Scenario 1, a maximum 150 MGD of groundwater recharge was used, which is based on the lower end estimates of potential recharge provided in Section 9. Scenarios 2 and 3 utilize a total of 150 MGD of recycled water in order to normalize the comparisons. The three scenarios are listed below:

- Scenario 1 – 150 MGD Groundwater Recharge Only
- Scenario 2 - 115 MGD Groundwater Recharge and 35 MGD Surface Water Augmentation
- Scenario 3 – 125 MGD Groundwater Recharge and 25 MGD Direct Potable.

Scenario 1 assumes that 100% of the product water produced from the AWT facility at the JWPCP can be used for groundwater recharge, either through surface spreading at existing spreading basins, or though injection well application. Scenarios 2 and 3 were developed recognizing the fact that large scale surface water augmentation and direct potable projects do not appear to be presently viable for Metropolitan (as discussed in the previous chapter). However, it is recognized that these options could possibly be implemented on a smaller scale in the future to supplement a groundwater recharge option by making alterations to the initial recharge-only distribution system. Such additions/alterations to the initial system would create a hybrid reuse program consisting of multiple methods for reusing AWT water from the JWPCP. However, the ability to make this hybrid approach system work will be largely dependent on the evolution of future regulations.

This chapter provides a description of the project options, an overview of the analysis of facility requirements, and a conceptual estimate of capital and operation and maintenance costs for each option. All conveyance and injection facilities assumed for these project options are based on engineering judgment, and have not been validated with site investigations or detailed engineering analysis. The purpose was to develop an order-of-magnitude cost estimate (Class 5 estimate) for comparison of the potential project alternatives.

11.1 Main Conveyance Facilities

Conveyance facilities to transport advanced treated water from the JWPCP to the various discharge points include pump station, pipelines, distribution laterals and injection wells. The placement of these facilities in a complex urban environment will be subject to extensive alternative analyses and environmental investigations, if this program continues into the next phase of planning. These analyses and investigations are outside the scope of this current study. For this study, pipeline alignments were developed for the purpose of approximating the length of pipeline required for conceptual cost estimates. The alignments shown on Figures 11-1, 11-2, 11-3, and 11-4 do not denote preferred alignments or actual points of discharge.

No sources outside of Metropolitan were contacted during the development of these alignments in order to confirm or reject potential pipeline routes. Pipeline alignments and lengths were determined using Google Earth and the Metropolitan database set as primary sources. General ground elevations were determined using Google Earth terrain elevation, and aerial photos from Google Earth were the basis for alignment specific surface conditions, and were used to develop locations for pump stations. All conveyance facilities were developed using public right of way. Neither site visits along the alignments nor utility research were performed due to the limited schedule for the study. Pipeline diameters were based on an assumed 5 feet per second flow velocity. Shored construction was assumed for the main line and laterals for cost estimating purposes as a way to minimize impacts to public rights of way. Tunnel options to avoid construction in city streets were not investigated in this study.

11.1.1 General Conveyance System Criteria

11.1.1.1 Pump Stations

The costs for pump stations were developed based on estimated losses from various pipe segments based on ultimate flows and assumed losses through the well field distribution network. A more refined analysis in subsequent phases of the program will define the preferred pumping scheme, including the configuration, number and locations of pumping plants. This study did not evaluate the availability of land for pump stations.

11.1.1.2 Wells

In areas where surface spreading of advanced treated water is not available, injection wells were assumed to be used for the delivery of the water into the groundwater aquifer. In order to quantify the number of injection wells required for the program, an injection rate of 1 MGD per well was conservatively estimated; this rate will allow for down time for well maintenance on an annual basis. By contrast, the OCWD's Mid-basin Injection Project test well is averaging 2MGD injection. Due to the nature of this initial study, actual well locations were not identified. Additional analysis, in conjunction with groundwater modeling, will be required in the next phases of the program to determine the optimal locations for well siting, to determine the impacts to nearby wells and groundwater quality, and to assess regulatory compliance related to detention time in the respective basins prior to extraction.

11.1.1.3 Laterals

It is assumed that smaller diameter pipelines will branch off of the main trunk lines to convey water to the injection wells. Due to the conceptual nature of the study, costs for these laterals were scaled on a per MGD basis from a previous conceptual study that looked at well distribution within Los Angeles County. Actual lateral alignments were not considered for this new study.

11.1.1.4 Blending

Based on current IPR regulations the potential program could begin with an initial 100% RWC (no blend requirement) assuming that the advanced treatment utilizes reverse osmosis and advanced oxidation processes. This study assumes that no blend water is required. If blending of AWT supplies prior to injection is indeed required, sources of blend water will have to be identified. Such blend water would be supplied through either existing infrastructure or new service connections from existing Metropolitan facilities. Blend water could be raw or treated depending on location and proximity to the available supply.

11.2 Scenario Descriptions

A summary comparison of the project scenarios including assumed regulatory requirements, proposed treatment, and conveyance and pumping facilities is given below in Table 11-1.

11.2.1 Scenario 1 - Groundwater Recharge

Scenario 1 proposes delivering 150 MGD of advanced treated water from the Sanitation Districts' JWPCP in Los Angeles County for recharge of groundwater basins in Los Angeles, Orange, and San Bernardino Counties (Figure 11-1). Following the minimum required retention period in the groundwater basin, the water would be extracted by partnering member agencies for potable water distribution. This option assumes a 100% RWC (no blend water).

Table 11-1: Summary of Potential Potable Reuse Scenarios

Project Scenario (Yield)	Potable Reuse Project	Key Regulatory Assumptions	Assumed AWT Processes	Assumed Conveyance Facility Requirements
1 (150 MGD)	Groundwater Recharge Only	Initial 100% RWC	BN/DN, MF/UF, RO,UV/AOP, DPS	Main Trunk - 38 miles (90"-54") Laterals to spreading basins/well field locations – 77 miles (36” – 18”) Well field distribution pipeline –TBD 85 new injection/monitoring wells 5 pump stations
2 (150 MGD)	Groundwater Recharge And Surface Water Augmentation (Lake Mathews Reservoir)	Groundwater: Initial 100% RWC Surface Water: Flow into reservoir will be assumed to comply with regulations TBD	BN/DN,MF/UF, RO, UV/AOP, DPS at JWPCP With remote AWT facility near reservoir for O_3, BGAC,IE	Main Trunk - 70 miles (90”-48") Laterals to spreading basins/well field locations – 27 miles (48” – 18”) Well field distribution pipeline –TBD 110 new injection/monitoring wells 4 pump stations
3 (150 MGD)	Groundwater Recharge And Weymouth Water Treatment Plant	Groundwater: Initial 100% RWC DPR: Flow into WTP will be assumed to comply with regulations TBD	BN/DN,MF/UF, RO, UV/AOP, DPS With remote AWT facility near Weymouth WTP for BGAC	Main Trunk - 34 miles (90”-66") Laterals to spreading basins/well field locations – 36 miles (54” – 24”) Well field distribution pipeline –TBD 85 new injection/monitoring wells 3 pump stations

Notes:

BN/DN – Biological Nitrification/Denitrification MF – Microfiltration UF - Ultrafiltration
RO – Reverse Osmosis UVP – Ultraviolet/Peroxide DPS – Decarbonation and Post Stabilization
O_3 – Ozone BGAC – Biological Granular Activated Carbon IE – Ion Exchange

An analysis of the AWT requirements for a groundwater recharge project is presented in Section 6 for the purposes of this study (including the development of a Class 5 cost estimate). The assumed AWT processes for Scenario 1 includes biological nitrification/denitrification, microfiltration/ultrafiltration, reverse osmosis, UV/advanced oxidation process (with hydrogen peroxide or chlorine), and decarbonation and post stabilization. The recommended demonstration plant project will determine if fewer, additional or alternative processes would be required to meet water quality and regulatory requirements.

Scenario 1 would require approximately 115 miles of new pipelines and distribution laterals with estimated sizes ranging from 90 to 18 inches diameter to convey the water from the JWPCP to the various project locations. Additional small diameter piping would be required for the well field distribution networks. Five pump stations are assumed to lift the water from the JWPCP to the different injection and spreading facilities. Sixty new injection wells and 35 monitoring wells are assumed to be required. An estimated additional 40 production wells would have to be relocated outside of the estimated 6-month aquifer retention zone. If a shorter retention period is allowed, it is possible that a lower number of production wells would require relocation.

It is assumed that injection wells would be capable of reliably recharging advanced treated water into groundwater basins on a continuous basis. However, due to seasonal variances in the available capacity within spreading basins, further analysis would be required to analyze options to reliably deliver water to spreading basins. Options could include construction of additional spreading capacity, dedicating existing spreading capacity for AWT water, construction of additional injection wells or oversizing the capacity of the AWT facility to deliver more water to the spreading grounds when available.

11.2.2 Scenario 2 - Groundwater Recharge and Surface Water Augmentation

Scenario 2 provides 115 MGD to Los Angeles, Orange, and Riverside Counties for groundwater recharge and 35 MGD to augment supplies into Lake Mathews (Figure 11-2) for a total project size of 150 MGD:

Under this scenario, a majority of the water would be utilized for groundwater recharge. As regulatory requirements for surface water augmentation are codified, the program would be expanded to include the delivery of AWT supplies to Metropolitan's Lake Mathews facility. At Lake Mathews, the advanced treated water would be blended with water from Metropolitan's Colorado River Aqueduct (CRA), retained in the reservoir for the minimum required period based on regulations. Following the minimum retention time required by regulations, the water would be conveyed to Robert B. Diemer WTP and Weymouth WTP for additional treatment and distribution through Metropolitan's existing infrastructure to Los Angeles and Orange Counties. It is assumed that any water that is placed into Lake Mathews would meet regulatory requirements for blending and dilution. Reservoir modeling and detailed analysis of the disposition of advanced treated water into Lake Mathews would have to be conducted at the appropriate time in the future prior to advancing a surface water augmentation project.

An analysis of the recommended AWT process for a combination groundwater and surface storage augmentation project is given in Section 6. For the purposes of developing the Class 5 estimate, the assumed AWT processes include biological nitrification/denitrification, microfiltration/ultrafiltration, reverse osmosis, UV/advanced oxidation process (with hydrogen peroxide or chlorine), and carbonization and post stabilization. Additionally, to minimize treatment costs by over-treating water going into the groundwater basins, a remote treatment facility equipped with ozone and BGAC, and ion exchange would be required for further treatment at the reservoir.

This scenario assumes 4 pump stations to deliver water to the different groundwater recharge facilities and Lake Mathews in Riverside County. The length of main trunk is estimated to be approximately 70 miles; laterals to the individual project locations would require another approximate 27 miles of pipeline not including the well distribution network. In order to replenish the groundwater aquifers for this option, 80 new wells are assumed for injection and 30 monitoring wells. An estimated additional 35 existing groundwater production wells are assumed to be relocated outside of the estimated 6-month retention zone. If a shorter retention period is allowed, it is possible that a lower number of production wells would require relocation.

11.2.3 Scenario 3 - Groundwater Recharge and Direct Potable Reuse

Scenario 3 provides 125 MGD of advanced treated water from Sanitation Districts' JWPCP for recharge of basins within Los Angeles County, and 25 MGD upstream of the Weymouth WTP for additional conventional treatment for a total project size of 150 MGD (Figure11-3).

Due to the fact that this option places water upstream of the Weymouth WTP, it allows for distribution of the water through Metropolitan's existing infrastructure to Los Angeles and Orange Counties. However, since the regulations for DPR have not been developed, and there is currently no reference for potential guidelines, it is not known if the component of the program that delivers 25 MGD upstream of the Weymouth WTP can be implemented to meet future regulatory requirements. Additionally, it is uncertain when/if DPR may be a regulated option in the future.

Scenario 3 assumes 3 pump stations to deliver water through approximately 70 miles of new pipelines with estimated sizes ranging from 90 inches to 24 inches diameter to convey the advanced treated water from the JWPCP to the various project locations. Additional small diameter piping would be required for the well distribution networks. This option assumes 60 new injection wells, 25 monitoring wells, and the relocation of approximately 37 existing production wells. If a shorter retention period is allowed, it is possible that a lower number of production wells would require relocation.

11.3 Opinion of Probable Cost

Due to the limited detailed engineering data collected for this conceptual level study, a Class 5 (Order-of-Magnitude) estimate as defined by the American Association of Cost Engineers (AACE) was developed for each option. A Class 5 estimate is used when 0% to 2% of engineering design for a project has been completed. The expected accuracy range for the Class 5 estimate is from +50% to -30% of final project cost. The Class 5 estimate prepared in this study utilized stochastic estimating methods such as cost curves, scale-up or down of similar projects such as the GWRS, and ratios or percentages of historical costs. A 35% contingency was added to the estimate to address the relative uncertainty of many aspects of the potential program based on the level of analysis conducted for this study.

A summary of capital and O&M costs for each scenario is presented in Table 11-2 below. The estimated costs in Table 11-2 will need to be further refined as the project options and advanced treatment requirements are more greatly defined during future studies.

Although Option 3 appears to have the lowest cost of the three scenarios studied, the lack of regulatory guidance for direct potable reuse prohibits the potential for a successful project utilizing the full 150 MGD available in the near term. It is anticipated that Scenario 2, which includes surface water augmentation would limit operational flexibility of Lake Mathews, and has not yet been successfully been implemented within the state. Therefore, given the pros and cons of the three program options and the estimated costs, Scenario 1 appears the most favorable.

Table 11-2: Opinion of Probable Costs for Potable Reuse Scenarios

	Scenario 1 GWR[1]	Scenario 2 GWR + SWA[2] (Lake Mathews)	Scenario 3 GWR + DPR to Weymouth
JWPCP Plant Product Flow	150 MGD (168,000 Acre-Ft/Yr)	150 MGD (168,000 Acre-Ft/Yr)	150 MGD (168,000 Acre-Ft/Yr)
Capital [3]			
Advanced Water Treatment	$915,776,000	$994,007,000	$933,083,000
Conveyance and Distribution	$1,142,814,000	$1,235,738,000	$897,299,000
Wells[4]	$171,500,000	$194,800,000	$154,100,000
Sub-Total Capital	**$2,230,090,000**	**$2,424,545,000**	**$1,984,482,000**
Admin / Eng / CM (20%)	$446,018,000	$484,909,000	$396,896,400
Sub-Total - Construction/Engineering	**$2,676,108,000**	**$2,909,454,000**	**$2,381,378,400**
Scope Contingency (35%)	$780,531,500	$848,590,750	$694,568,700
Total - Capital	**$3,456,639,500**	**$3,758,044,750**	**$3,075,947,100**
Amortization (4.0%, 30 years)	$199,897,805	$217,328,100	$177,882,326
$/AF	**$1,190**	**$1,294**	**$1,059**
O&M			
Advanced Water Treatment	$149,122,000	$149,729,000	$149,268,000
Conveyance & Wells	$38,790,000	$47,242,000	$34,609,000
Costs to Sanitation Districts[5]	$100,000	$100,000	$100,000
Sub-Total - O&M	**$188,012,000**	$197,071,000	$183,977,000
$/AF	**$1,119**	**$1,173**	**$1,095**
Total $/AF (In 2015$)[6]	**$2,309**	**$2,467**	**$2,154**

(1) Groundwater Recharge
(2) Surface Water Augmentation
(3) Capital construction costs
(4) Costs include injection wells, monitoring wells, and replacement of potentially impacted wells
(5) Land use cost for AWT facility on JWPCP land ($5,000 per acre per year)
(6) Cost estimate is considered a Class 5 (Order-of-Magnitude) estimate due to the limited engineering conducted for this study, and has an estimated accuracy range of +50% to -30%..

11.4 Alternative Groundwater Replenishment Options

For the reasons stated above, Scenarios 2 and 3 were eliminated from further cost refinement studies due to regulatory uncertainties or potential operational impacts to Metropolitan's distribution system. The Groundwater recharge scenario (Scenario 1) was carried on to the next phase of the study to examine the potential to reduce unit costs of this option by investigating alternative cost scenarios.

Under this approach, an alternative to Scenario 1 was developed (Scenario 1A) to determine the potential range of costs for a groundwater recharge alternatives.

Scenario 1A utilizes many of the features of Scenario 1, but deletes the portions of Scenario 1 which require high lift pumping to the Raymond and Chino Basins. Lifting the water to both of these basins is feasible; however it requires additional capital and operational costs that could be avoided if all of the AWT water can be utilized within the lower elevation applications. Hence, Scenario 1A maximizes replenishment within lower elevations within Los Angeles and Orange Counties. Figure 11-4 shows the spreading and injection locations for the alternative groundwater replenishment scenario as well the estimated amounts for each location. The estimated capital and O&M costs for Scenario 1 and Scenario 1A are provided in Table 11-3.

Table 11-3: Comparison of Groundwater Replenishment Options[1]

	GWR[2] - Scenario 1	GWR - Scenario 1A
JWPCP Plant Product Flow	150 MGD (168,000 Acre-Ft/Yr)	150 MGD (168,000 Acre-Ft/Yr)
Capital [3]		
Advanced Water Treatment	$915,776,000	$915,776,000
Conveyance and Distribution	$1,142,814,0000	$905,817,000
Wells[4]	$171,500,000	$154,100,000
Sub-Total Capital	**$2,230,090,000**	**$1,975,693,000**
Admin / Eng / CM (20%)	$446,018,000	$395,138,600
Sub-Total - Construction/Engineering	**$2,676,108,000**	**$2,370,831,600**
Scope Contingency (35%)	$780,531,500	$691,492,550
Total - Capital	**$3,456,639,500**	**$3,062,324,150**
Amortization (4.0%, 30 years)	$199,897,805	$177,094,509
$/AF	**$1,190**	**$1,054**
O&M		
Advanced Water Treatment	$149,122,000	$149,121,000
Conveyance & Wells	$38,790,000	$27,461,000
Costs to Sanitation Districts[5]	$100,000	$100,000
Sub-Total - O&M	**$188,012,000**	$176,682,000
O&M $/AF	**$1,119**	**$1,052**
Total $/AF (In 2015$)	**$2,309**	**$2,106**

(1) Cost estimate is considered a Class 5 (Order-of-Magnitude) estimate due to the limited engineering conducted for this study, and has an estimated accuracy range of +50% to -30%.
(2) Groundwater Recharge
(3) Capital construction costs
(4) Costs include injection wells, monitoring wells, and replacement of potentially impacted wells
(5) Land use cost for AWT facility on JWPCP land ($5,000 per acre per year)

The conceptual level estimates developed for each scenario were used to estimate the per-unit cost of the potential program water. The estimated per-unit cost is important because it can be directly compared to costs of other alternative water resources. This comparison can give weight to the practicality of a specific project. Figure 11-5 is adapted from the IRP 2015 Update and shows the range of cost for various alternative water resources. This assumes both capital and operation and maintenance costs. The vertical lines represent the range of costs for alternative water resource projects identified through the IRP process. The boxes capture the unit costs for projects between the 25th percentile and 75th percentile. As shown Figure 11-5, the cost for a majority of recycled water projects is between $1,200 and $3,300 per acre-foot.

The estimated per-unit cost of the produced/distributed water for the potential regional program hinges on a number of factors. The prevailing interest rate on borrowed funds is a significant factor; as is the availability of grant funds from state and federal sources. In addition, wastewater agencies have, at times, contributed to recycled water projects when they can avoid costly new investments. Finally, the operation of the system, such as peaking or base-loaded deliveries, can impact the capital and operations and maintenance (O&M) expenditures.

A cost sensitivity analysis was conducted considering the above mentioned factors (Table 11-4). The sensitivity analysis covered conventional Metropolitan funding of the entire program cost at a bond interest rate of 4% and a payback period of 30 years and an alternative financing approach which utilized low-interest state issued loans at 1.6% for 30 years. Lastly, assumptions for outside direct capital contributions (grant funding and "cost sharing") in addition to the low interest loan funding were included. Assumed outside direct capital contributions ranged from 0% to 50% of estimated capital costs. Figure 11-6 gives a graphical representation of the potential cost range for the alternative scenarios rounded off to reflect the relative uncertainties within the program to this point. As shown, Scenario 1 has a potential unit cost range between $1,600 and $2,300 per acre-foot, and Scenario 2 between $1,400 and $2,100 per acre-foot depending on the financial assumptions.

The findings suggest that the potential IPR program costs under all assumptions are well within the range of other recycled water programs and alternative water resources. The actual costs will depend on multiple factors still to be determined such as the configuration of the AWT process, the size of the distribution system, finance terms, and levels of grants and contributions. While this analysis centered exclusively on full build out scenarios, it is useful baseline information as it is currently proposed that a feasibility analysis for a first phase of construction commence in 2016.

Table 11-4: Range of Costs for Potential Regional Recycled Water Supply Program (150 MGD Ultimate Build-out)

	GWR -Scenario 1 150 MGD Central Basin, West Basin, Orange County Basin, Main San Gabriel Basin, Raymond Basin, Chino Basin	GWR-Scenario 1A 150 MGD Central Basin, West Basin, Orange County Basin, Main San Gabriel Basin
Total Capital - 35% Contingency	**$3,456,639,500**	**$3,062,324,150**
Total Annual O&M	**$188,012,000**	**$176,682,000**
Cost Per Acre Foot - 30 yrs @ 4%; $0 Contributions		
Capital Cost	$1,190	$1,054
O&M	$1,119	$1,052
Total	**$2,309**	**$2,106**
Cost Per Acre Foot - 30yrs @ 1.6%; $0 Contributions		
Capital Cost	$869	$769
O&M	$1,119	$1,052
Total	**$1,988**	**$1,821**
Cost Per Acre Foot - 30yrs @ 1.6%; $250M Contributions		
Capital Cost	$806	$707
O&M	$1,119	$1,052
Total	**$1,925**	**$1,759**
Cost Per Acre Foot - 30yrs @ 1.6%; $500M Contributions		
Capital Cost	$743	$644
O&M	$1,119	$1,052
Total	**$1,862**	**$1,696**
Cost Per Acre Foot - 30yrs @ 1.6%; 50%Contributions		
Capital Cost	$435	$385
O&M	$1,119	$1,052
Total	**$1,554**	**$1,437**

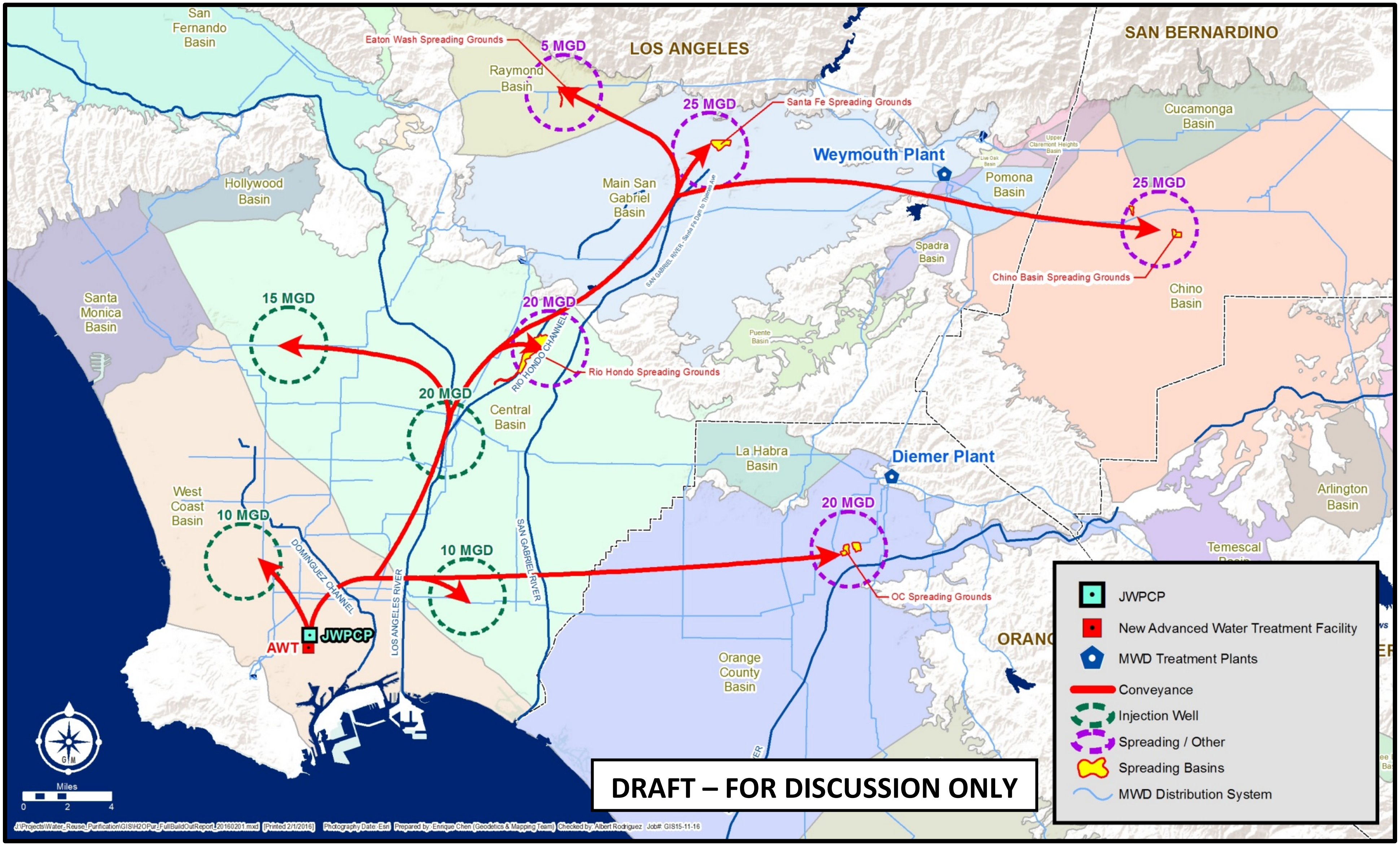


Figure 11-1: Scenario 1 – 150 MGD Groundwater Replenishment Program

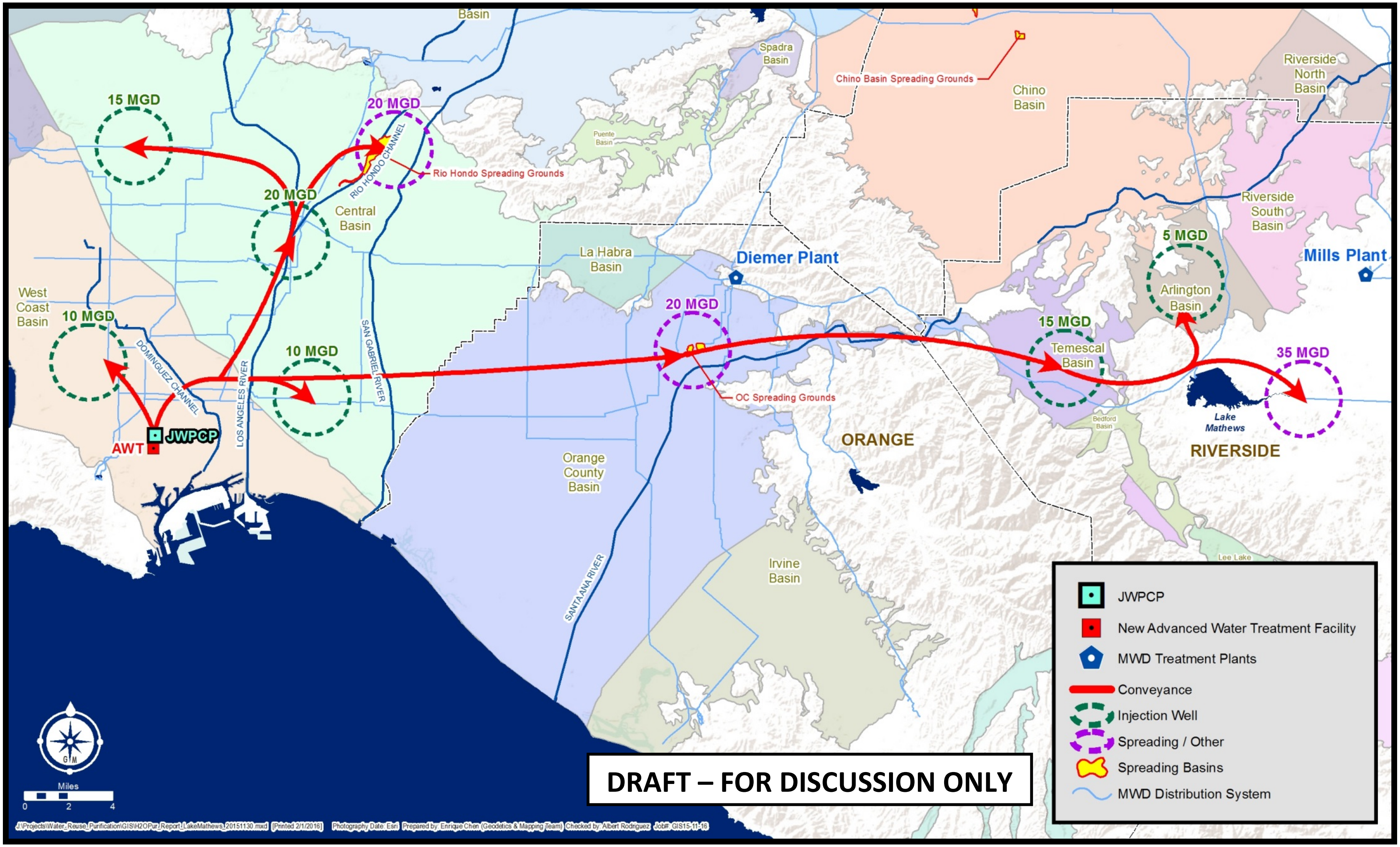


Figure 11-2: Scenario 2 – 150 MGD Groundwater Recharge plus Surface Water Augmentation

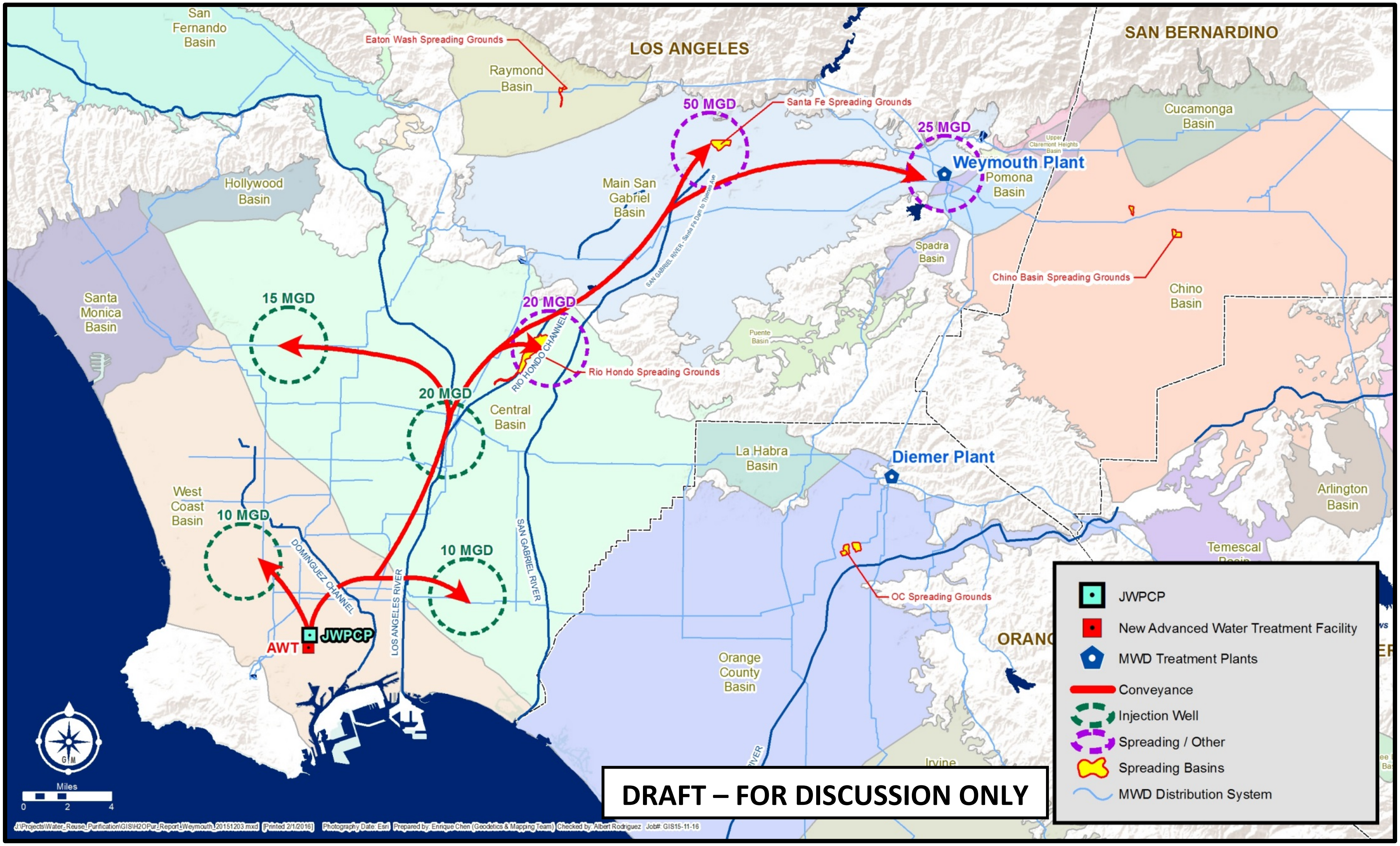


Figure 11-3: Scenario 3 – 150 MGD Groundwater Recharge plus Direct Potable Reuse

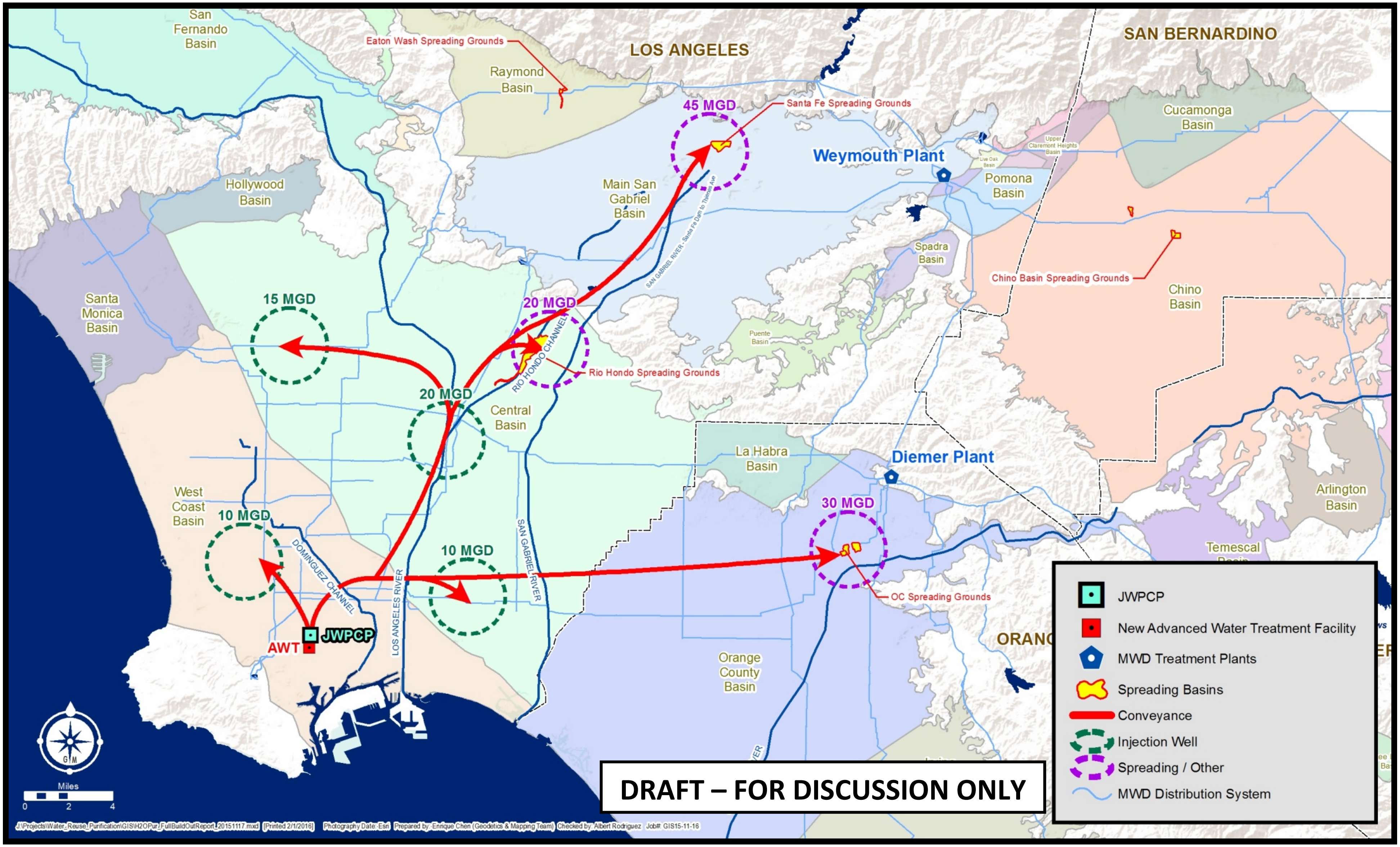
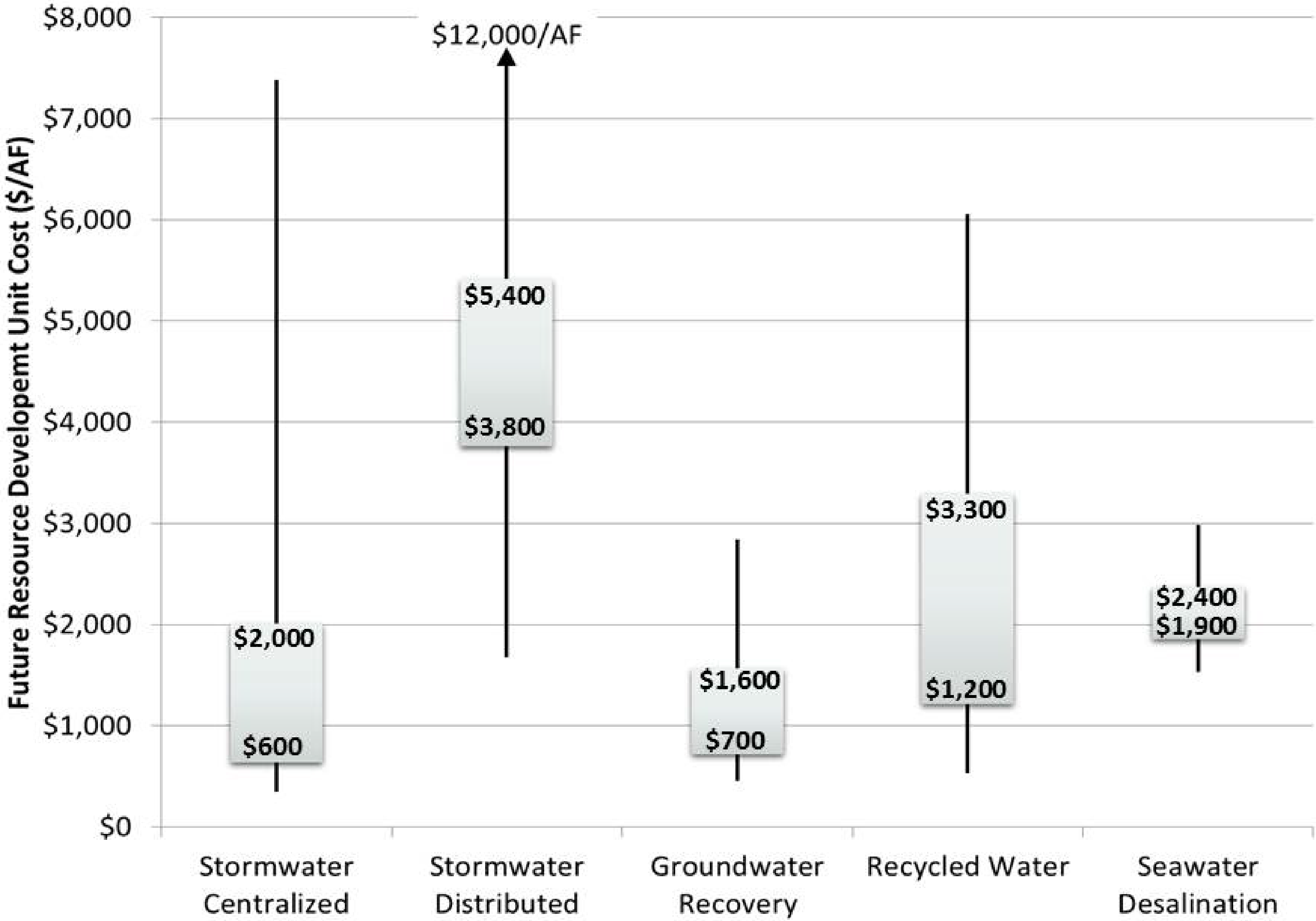


Figure 11-4: Scenario 1A - 150 MGD Groundwater Recharge Program

Figure 11-5: Per-Unit Range of Costs for Alternative Water Resources



Source: adapted from Integrated Resources Plan 2015 Update

*Costs per acre foot include capital and operation and maintenance costs.

**Vertical lines represent full range of unit cost per resource and boxes represent the 25th to 75th percentile project costs of the low and high unit values.

Figure 11-6: Estimated Per-Unit Cost Range for Potential Regional Recycled Water Supply Program (150 MGD Build-out)

12 Summary and Next Steps

The purpose of this historical review and 2015 update was to provide an initial assessment of potential end uses for a potential regional recycled water supply program as well as the potential facility, regulatory and treatment requirements. The document is intended as an historical reference and update and includes information that was available in 2015 serving as the basis for staff recommendations to Metropolitan's Board for approval of a demonstration project in November 2015.

Due to the present lack of regulatory guidance for DPR and the uncertain timing for development of any guidelines, a DPR-based program is not considered to be a feasible option at this time. Although Metropolitan owns three large surface water reservoirs, surface water augmentation does not appear to be a practical alternative due to the lack of proximity of Metropolitan's reservoirs to the JWPCP and the potential operational restrictions that the regulatory guidelines currently under consideration would place on the reservoirs. Consequently, it is not recommended to move forward with these a surface water augmentation or DPR program at this time.

An IPR program focusing on groundwater recharge is the most feasible option for implementation in the near term. This type of project has a defined regulatory pathway due to the finalization of regulatory criteria for groundwater recharge in June 2014, and has been successfully practiced within Southern California for a number of years. These factors could potentially lead to faster implementation. However, a project that utilizes multiple groundwater basins would require a significant number of partnerships/agreements with multiple water agencies, basin Watermasters, and other agencies (e.g. Los Angeles County Department of Public Works for use of spreading facilities). Lastly, conceptual cost estimate of the program shows that the per-unit cost of the recycled water is in line with costs of other alternative water resources being considered under local projects.

Recommended future studies and actions to further evaluate a potential regional IPR program through groundwater recharge are provided below:

- Develop the proposed 1-MGD demonstration facility to aid with the regulatory process and provide input into design and costs for full-scale facilities.
- Assess the feasibility of constructing large diameter pipelines within a highly urbanized area.
- Conduct groundwater modeling to optimize injection well locations and evaluate potential effects to local basins (also required as part of the regulatory approval process)

- Work with member agencies to validate or revise the demand assumptions within this document and get a better understanding of their need for purified water.
- Refine cost estimates based on feasibility-level investigations on treatment system, conveyance system, and groundwater injection/spreading components
- Meet with state and federal agencies to determine the potential for grant funding and low interest loans.
- Identify opportunities for cost sharing to reduce Metropolitan’s capital contributions to the Program.
- Meet with regulatory agencies to introduce the program concept and gain feedback on a potential permitting roadmap for a regional recycling program.

Appendix A – JWPCP Process Descriptions and Water Quality Data

Appendix B – Pilot Study Design Criteria, Operational Information, and Water Quality Data

Appendix C – Title 22+ Sampling Data

Appendix D – JWPCP Background and NDN