THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

Regional Recycled Water Program
Conceptual Planning Studies Report

Report No. 1618

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Executive Summary

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1.0 EXECUTIVE SUMMARY

The Conceptual Planning Studies Report presents the results of further technical studies and analyses related to the Regional Recycled Water Program (RRWP) being considered by the Metropolitan Water District of Southern California (Metropolitan/MWD) and the Sanitation Districts of Los Angeles County (Sanitation Districts). These conceptual planning studies build upon the initial analyses presented in the November 2016 “Potential Regional Recycled Water Program Feasibility Study – Report No. 1530” (Feasibility Study). This report was presented to Metropolitan’s Board in January 2017 as well as the Sanitation Districts’ Board. While the Feasibility Study established that the indirect potable reuse (IPR) program described in the RRWP is feasible given the assumptions used, this report addresses specific issues regarding its potential path to implementation and anticipated performance. In broad terms, the studies presented here evaluate the opportunities for program phasing; further delineate and refine the major program elements; present additional groundwater modeling evaluations associated with introducing purified water into the groundwater basins; and examine the potential for the program to accommodate direct potable reuse (DPR) opportunities in the future.

The RRWP provides an opportunity to develop a local and sustainable water supply for the region with the objective of providing water to replenish groundwater basins. Groundwater has always been an important resource for Southern California as it is a key component of regional reliability and integrally related to the management of imported water supplies and surface storage. Groundwater storage levels are also important because they impact how the groundwater basins can be used during times of shortage. If the groundwater storage levels are too low, basins may not be able to serve as a source of water when needed by the region and the basins’ demands for imported supplies or surface storage will likely increase. Therefore, maintaining stable higher groundwater levels enables these basins to provide critical supply during shortages or emergencies.

Metropolitan delivers imported water for groundwater replenishment; however, replenishment deliveries in the basins have not been sufficient to maintain groundwater basin water levels. A number of factors contribute to this, including water supply availability due to drought, regulatory restrictions, and replenishment purchase patterns. Due to drought conditions within the service area, groundwater demand has increased, groundwater replenishment has decreased, and groundwater storage has dropped since 2005. Without continued replenishment of the groundwater basins, groundwater storage is expected to continue to decline due to increased demand and limitations on other sources for natural and incidental recharge. For the basins to continue to provide benefits for regional reliability, water deliveries to the groundwater basins for recharge are essential. The RRWP can provide stable year-to-year deliveries of a new supply for groundwater replenishment to improve the supply reliability conditions for the region. With the program, imported supplies that would have gone toward meeting local agency groundwater recharge demands would instead be available to meet other regional demands or go into Metropolitan storage programs. By implementing the program, storage levels in Metropolitan’s regional storage portfolio are likely to be higher over most or all conditions.

1.1 Program Concept

As configured in the Feasibility Study, the RRWP would produce up to 150 million gallons per day (mgd) or 168 thousand acre-feet per year (TAFY) of purified water in partnership with the Sanitation Districts. A new advanced water treatment facility would be located at the Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) in Carson and a new regional conveyance system would deliver a reliable source of IPR water to recharge four regional groundwater basins: Central, West Coast, Main San Gabriel, and Orange County. An overview of the IPR concept is shown in Figure 1.1.

Figure 1.1: Program Overview

Actions to Date

For more than 8 years, Metropolitan and the Sanitation Districts have been evaluating a regional collaboration to jointly develop recycled water. From June 2010 through July 2012, pilot-scale studies were conducted by Metropolitan and the Sanitation Districts at the JWPCP to evaluate the feasibility of advanced treatment of the JWPCP's secondary effluent. The results of these studies determined that advanced treatment of JWPCP secondary effluent for producing water suitable for IPR through groundwater recharge is technically feasible.

In November 2015, Metropolitan and the Sanitation Districts entered into an agreement for development of a demonstration facility at the JWPCP. Both organizations also established a proposed framework of terms and conditions for development of a full-scale RRWP. For the full-scale project, the initial set of terms and conditions were nonbinding; however, they set forth key conditions anticipated to be in a future full-scale agreement. Building upon these initial terms, subsequent discussions with the Sanitation Districts in 2016, and future finalized California Environmental Quality Act (CEQA) documentation, staff would develop, for approval by the two boards of directors, a final binding agreement between Metropolitan and the Sanitation Districts for a full-scale project.

In addition, at its November 2015 meeting, the Metropolitan Board authorized staff to design a demonstration facility that would allow Metropolitan to optimize an advanced water treatment (AWT) process for production of water for groundwater recharge. Although the earlier pilot-scale studies indicated that an IPR project was technically viable, Metropolitan and the Sanitation Districts are undertaking a demonstration project to refine, demonstrate, and receive regulatory approval for an alternative treatment process train that could provide significant capital and operational cost savings. As a value engineering measure, the project team determined that a 0.5-mgd demonstration facility would be sufficient to test, monitor, and optimize the treatment process and produce the water quality data needed to seek the necessary regulatory approvals. The demonstration facility also provides a means for Metropolitan and the Sanitation Districts to evaluate the envisioned treatment process, coordinate operations, and serve as an effective venue for public outreach. Construction of the demonstration facility is complete, and operations are expected to begin in early 2019.

Metropolitan and the Sanitation Districts are coordinating with the State Water Resources Control Board (SWRCB) through the Division of Drinking Water (DDW) and the individual Regional Water Quality Control Boards (RWQCBs) for the Los Angeles and Santa Ana regions on the testing and monitoring plan for the demonstration project. Metropolitan is working to receive final approval by the agencies prior to initiating demonstration testing in March 2019.

In early 2016, Metropolitan and the Sanitation Districts convened a panel of eight subject matter experts to provide independent review and critical input on the scope and direction of the program during the development of the Feasibility Study and demonstration facility. In November 2017, a subcommittee of the panel was convened to review the evaluation of alternative nitrogen management process trains. The subcommittee completed the work of the panel with its review of the Nitrogen Management Report included in Appendix C.

In April 2018, a new independent scientific advisory panel was established to provide review of the scientific, technical, and regulatory aspects of the demonstration project.

Metropolitan staff continues to meet periodically with the member agencies and groundwater management agencies that would be directly affected by the program. The discussions provide opportunities to explore how this water resource could be incorporated into the region's water supply portfolio given each basin's unique operating regime and requirements. The meetings also include conceptual discussions on potential arrangements for delivery and use of the water, including potential arrangements with member agencies, groundwater management agencies, and groundwater pumpers.

Metropolitan and the Sanitation Districts meet at an executive level on a bi-monthly basis to discuss key programmatic issues, develop and coordinate planning strategies, and review progress on various project components.

As recommended in the Feasibility Study, further consultations with member agencies, groundwater management agencies, and other potential program participants (e.g., Los Angeles County Department of Public Works, United States Army Corps of Engineers) are planned. Discussions will focus on the development of mutually agreed-upon terms and conditions that would accompany implementation if the program proceeds. The results of these efforts will be reported on separately.

In addition to this report, several other activities identified and recommended in the Feasibility Study have also been initiated: (1) development of institutional and financial arrangements for the management and operations of the program, and (2) development of a public outreach plan associated with the demonstration facility. The results of these additional activities will be reported on separately and are not included in the Conceptual Planning Studies Report.

1.2 Program Implementation and Cost Estimate

The Feasibility Study assumed that the 150-mgd program would be implemented in a single phase. One of the primary goals of the conceptual planning studies is to evaluate implementation phasing alternatives. Generally, program phasing can be advantageous when (1) there are uncertainties regarding the ultimate demands, availability of source water supply, or needed capacity of a program; (2) potential benefits can be achieved by bringing portions of a program online as quickly as possible (e.g., addressing urgent needs and early creation of revenues); (3) the program has sufficient modularity to be functional in discrete stages; (4) time is needed to evaluate potential future opportunities (e.g., incorporation of a DPR option); and (5) additional benefits may accrue from the acquisition of operational and technology experience.

From an infrastructure perspective, the primary questions examined involve (1) appropriate sizing of the AWT plant and process train(s) used; (2) the distance, capacity, and expected deliveries of the conveyance system; (3) the certainty of expected demands at various delivery points; and (4) the opportunities for future flexibility to integrate DPR (in addition to IPR) if desired. The evaluation process included the following steps:

1. Establish objectives, evaluation criteria, and performance metrics for potential phasing of the program.
2. Assess potential water demands and certainty for replenishment and consumptive uses.
3. Configure simplified, logical program phasing alternatives for preliminary evaluation.
4. Develop capital, operating, and finance costs for each simplified alternative.
5. Eliminate inferior alternatives deemed less likely to achieve objectives.
6. Identify additional potential benefits and options that could enhance the remaining alternatives.
7. Develop a proposed implementation strategy that (a) achieves program goals, (b) minimizes demand uncertainties, (c) reduces the risk of stranded investments, (d) is cost effective, and (e) preserves future flexibility.

Phasing Alternatives and Cost Estimate

The initial step in the development of phasing scenarios was the establishment of overall phasing objectives for the potential program. Each phase of every alternative was developed to achieve the following objectives:

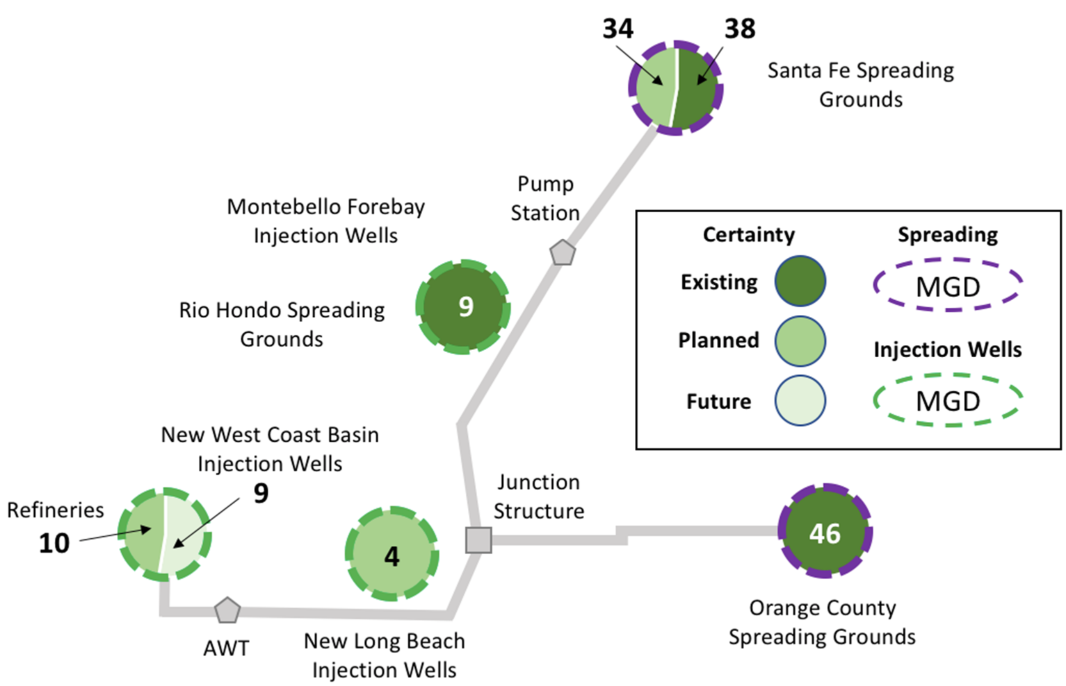
1. Perform as a fully functional and cost-effective stand-alone project.
2. Provide a significant addition to regional recycled water supply.

3. Include groundwater recharge as a major portion of deliveries.
4. Provide for future expansion to the full-scale program.
5. Achieve regulatory approvals consistent with those needed for the full-scale program.
6. Offer flexibility to accommodate future opportunities such as DPR.

Based on these objectives, evaluation criteria were established to compare the relative performance of phasing alternatives. The evaluation criteria were used to develop a multi-objective decision analysis (MDA) assessing the relative performance of the first phase of each alternative under consideration. The MDA process was intended to provide both quantitative and qualitative input to the development of a proposed phased implementation approach.

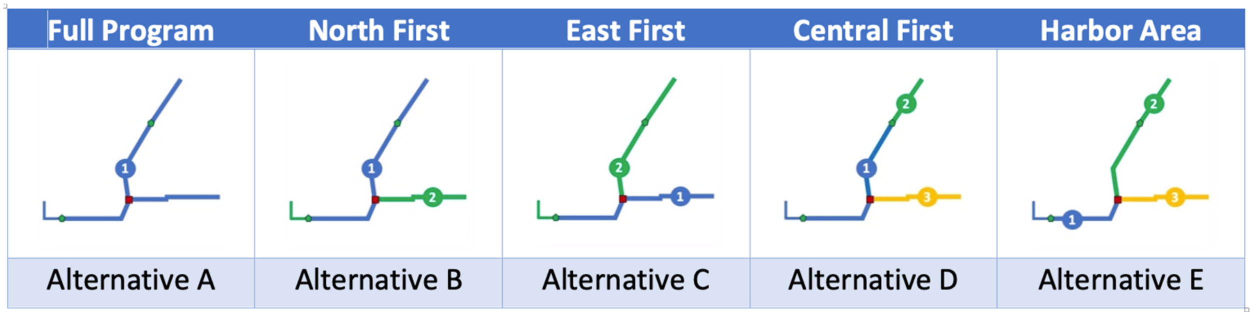
The development of various phasing alternatives proceeded from a consideration of options within the AWT plant and conveyance elements of the program. A schematic of the full RRWP is shown in Figure 1.2. The demand certainty is based on discussions with potentially affected member agencies and water masters, together with additional groundwater modeling in the Central, West Coast, Main San Gabriel, and Orange County groundwater basins. Demand certainty is characterized into three categories: **existing** (demands already served by Metropolitan); **planned** (expected demands on Metropolitan, new injection wells needed, and significant operational changes needed); and **future** (possible future demands on Metropolitan, new injection wells needed, and significant new facilities and operational changes needed).

Figure 1.2: RRWP Schematic and Demand Certainty



As illustrated in Figure 1.3 and described below, five phasing alternatives were evaluated.

Figure 1.3: Summary of Alternative Phasing Scenarios

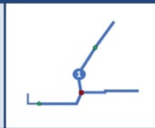
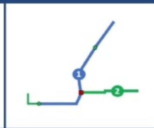
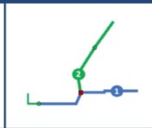


Legend: Phase 1 (Blue), Phase 2 (Green), Phase 3 (Yellow)

1. **Alternative A (Full Program):** a single-phase scenario based on the program presented in the 2016 Feasibility Study as the Base Case.
2. **Alternative B (North First):** a two-phase scenario that initially extends from the AWT plant to the Santa Fe Spreading Grounds in the first phase and subsequently reaches the Orange County Spreading Grounds and West Coast Basin in the second phase.
3. **Alternative C (East First):** a two-phase scenario that extends to the Orange County Spreading Grounds first and subsequently extends to the Santa Fe Spreading Grounds and West Coast Basin in the second phase.
4. **Alternative D (Central First):** a three-phase scenario that initially extends from the AWT plant to the West Coast Basin, Rio Hondo Spreading Grounds, and Montebello Forebay injection wells, followed by two subsequent phases to the Santa Fe Spreading Grounds and Orange County Spreading Grounds, respectively.
5. **Alternative E (Harbor Area):** a three-phase scenario that focuses initially on the demands near the AWT plant, followed by two subsequent phases to the Santa Fe Spreading Grounds and Orange County Spreading Grounds, respectively.

The alternatives are summarized in Table 1.1 with the AWT production and estimated pipeline segments installed for each phase, as well as the estimated capital costs and operations and maintenance (O&M) costs for each alternative. A detailed description and figures for each alternative are presented in Chapter 3, Program Implementation and Cost Estimate. The advantages and disadvantages of each alternative are summarized in Table 1.2.

Table 1.1: Comparison of Phasing Alternatives

Legend: Phase 1 (blue), Phase 2 (green), Phase 3 (yellow)	Alternatives				
					
Selected Criteria	**A**	**B**	**C**	**D**	**E**
Number of Phases	**1**	**2**	**2**	**3**	**3**
Description	**Full Program**	**North First**	**East First**	**Central First**	**Harbor Area**
AWT Production (mgd)	150	150	150	150	150
Phase 1	150	100	50	50	25
Phase 2		50	100	50	75
Phase 3				50	50
Conveyance (miles)	62	62	62	62	62
Phase 1	62	46	37	36	21
Phase 2		16	25	10	25
Phase 3				16	16
Capital Costs ($M)[1]	$3,080	$3,193	$3,292	$3,344	3,410
Phase 1	$3,080	$2,546	$1,642	$1,836	$1,177
Phase 2		$647	$1,651	$847	$1,574
Phase 3				$661	$659
Annual O&M Costs ($M)	$134	$134	$134	$134	$134
Phase 1	$134	$75	$43	$33	$15
Phase 2		$59	$91	$41	$43
Phase 3				$59	$75
Annual Financing Costs ($M)	$155	$161	$173	$176	$181
Phase 1	$155	$126	$86	$96	$62
Phase 2		$34	$87	$45	$83
Phase 3				$35	$35
Total Annual Costs ($M)	$288	$294	$307	$309	$314
Phase 1	$288	$201	$129	$129	$78
Phase 2		$93	$178	$86	$127
Phase 3				$94	$110
Total Unit Cost ($/acre-ft [AF])	$1,752	$1,788	$1,862	$1,880	$1,909
Phase 1	$1,752	$1,803	$2,345	$2,347	$2,831
Phase 2		$1,703	$1,621	$1,575	$1,540
Phase 3				$1,717	$2,000
Avg. MWD Cost Increase ($/AF)[2]	$170	$173	$180	$182	$185
Phase 1	$170	$118	$76	$76	$46
Phase 2		$55	$105	$51	$75
Phase 3				$55	$65

[1]2018 Dollars

[2]When project is fully operational and based on Metropolitan's 2017/18 Budget of 1.70 MAF.

Table 1.2: Phasing Alternatives – Advantages and Disadvantages

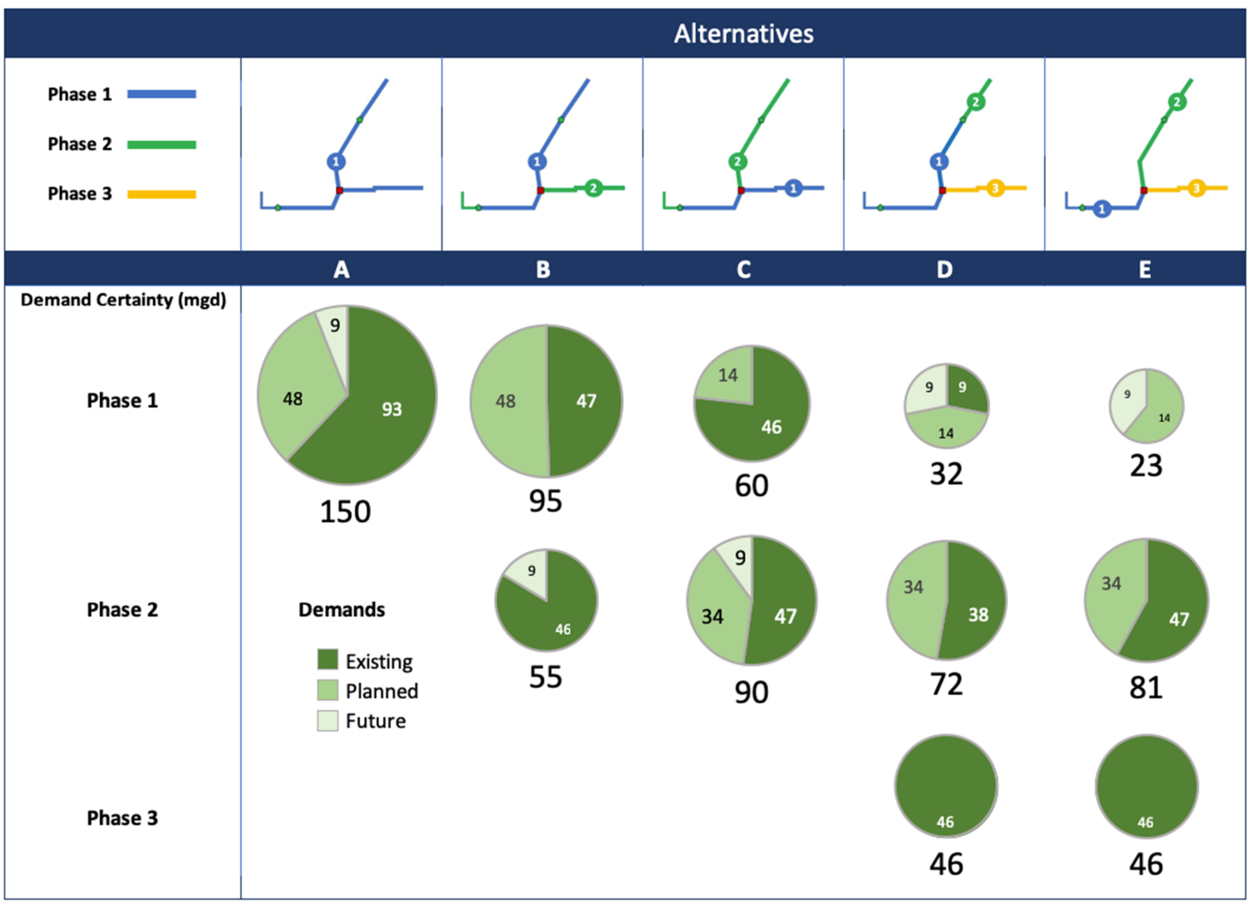
	Advantages	Disadvantages
Full Program (Alternative A) Initial Production Capacity: 150 mgd	• Most rapid completion of the overall program. • Maximum economies of scale. • Largest regional benefits to the groundwater basins and Metropolitan in its initial phase. • Less vulnerable to inflation and other cost increases.	• Largest initial commitment of funding. • Highest initial increase in MWD overall costs. • Vulnerable to changing external circumstances (recycled water demand uncertainty and future wastewater flow declines). • Commits all flows to IPR uses, reducing flexibility to incorporate DPR. • Most rapid operational learning curve.
North First (Alternative B) Initial Production Capacity: 100 mgd	• Provides the largest amount of water for replenishment in Phase 1 of the multi-phase alternatives. • Serves stressed groundwater basins with limited sources of replenishment water first. • Requires lower treatment costs during the Phase 1 to achieve basin plan nitrate limits. • Requires approvals from a single permitting agency – Los Angeles RWQCB. • Provides economies of scale. • Provides means of implementing DPR (when permitted) by extension of conveyance to both Weymouth and Diemer WTPs. • Reserves approximately 60 mgd of secondary effluent for either IPR or DPR uses.	• Highest initial capital costs of multi-phase alternatives. • Initially pumps to the highest elevation (500 ft) with the highest pumping costs. • Requires measures during Phase 1 to achieve required boron limits in the Main San Gabriel basin.
East First (Alternative C) Initial Production Capacity: 50 mgd	• Offers a lower pumping elevation (223 ft) and pumping costs in Phase 1 than northern pipeline alignment. • Utilizes full AWT plant capacity to meet demands in Phase 1. • Provides a lowest cost means of implementing DPR (when permitted) by adding an additional transmission pipeline to the Diemer WTP.	• May compete with other sources of water available for replenishment in Orange County. • Requires higher level of treatment and treatment costs in Phase 1 to meet basin plan nitrate targets. • Requires multiple RWQCB permitting approvals.
Central First (Alternative D) Initial Production Capacity: 50 mgd	• Flexibility in decision regarding implementation of additional phases. • Lower initial capital costs. • Lower impact on MWD overall cost increase in Phase 1.	• Relies heavily on consumptive demands in the Harbor Area and Central Basin. • Depends on injection wells for recharge. • Currently identified demands are insufficient to use 50 mgd AWT capacity. • Does not reach most reliable replenishment demands in Phase 1.

	Advantages	Disadvantages
Harbor Area (Alternative E) Initial Production Capacity: 25 mgd	• Lowest initial capital costs. • AWT plant initially sized to meet near-term Harbor and Central Basin needs. • Most rapid Phase 1 implementation schedule. • Most flexibility in decision regarding implementation of additional phases.	• Phase 1 relies on least certain replenishment demands. • A large percentage of production serves consumptive demands in Phase 1. • Depends on injection wells for recharge. • Does not reach most reliable replenishment demands in Phase 1. • Lacks economies of scale.

Assessment of Demand Certainty by Phase

Figure 1.4 presents a breakdown of the certainty (existing, planned, and future) in the demands expected in each phase of the five alternatives. Alternatives B and C can reach spreading basins in the first phase of implementation and avoid reliance on future replenishment demands in the West Coast Basin. The first phase of Alternatives D and E are both reliant on a high percentage of future demands and compare unfavorably to other alternatives in this regard.

Figure 1.4: Expected Demands and Assessment of Certainty by Phase



Flexibility for Future DPR Options

The Feasibility Study focused solely on a potential IPR program for groundwater replenishment. The conceptual planning studies considered the future potential of adapting the program to meet the requirements of forthcoming DPR regulations. Based on the status of DPR regulations, it appears that blending and retreatment of the AWT water at one or more of Metropolitan's existing treatment plants may become feasible in the future.

Three of the alternatives (A, B, and C) provide sufficient initial infrastructure to allow for the addition of DPR capabilities following the first phase of implementation in the form of raw water augmentation at the F.E. Weymouth Water Treatment Plant (Weymouth WTP) and the Robert B. Diemer Water Treatment Plant (Diemer WTP). The availability of a DPR option allows significant operational flexibility when used in conjunction with IPR deliveries and may significantly expand the benefits of the program.

The location of both WTPs in relation to the proposed RRWP facilities provides a unique opportunity for purified water to supplement raw water supplies to a drinking water treatment plant, once DPR regulations are approved. Regulations for the raw water augmentation form of DPR could be established by the end of 2023, based on the state of scientific and technical research at that time. In pursuing DPR options for the RRWP, several enhancements would likely be required by future regulations to compensate for the loss of the environmental buffer (i.e., groundwater basin).

Source control programs under a DPR application are expected to be more prescriptive than those required for an IPR project. Further optimization of wastewater treatment processes may also be needed to help reduce certain compounds prior to the water reaching the advanced water treatment facility. It is anticipated that higher levels of advanced water treatment will also be required by future raw water augmentation regulations. Treatment redundancy through multiple independent barriers is expected, including a greater degree of pathogen control. Responding to treatment failures becomes even more critical in a DPR treatment scheme; therefore, more rigorous monitoring and enhanced tools will be required to respond to "off-spec" events. In addition, minimum dilution requirements will likely be required by regulators when blending advanced treated recycled water with other raw waters at the Weymouth or Diemer WTPs. Initial blending requirements may be conservative until greater experience on raw water augmentation projects is gained in the future. Operational changes or investments at the Weymouth or Diemer WTPs would also need to be evaluated when considering DPR integration.

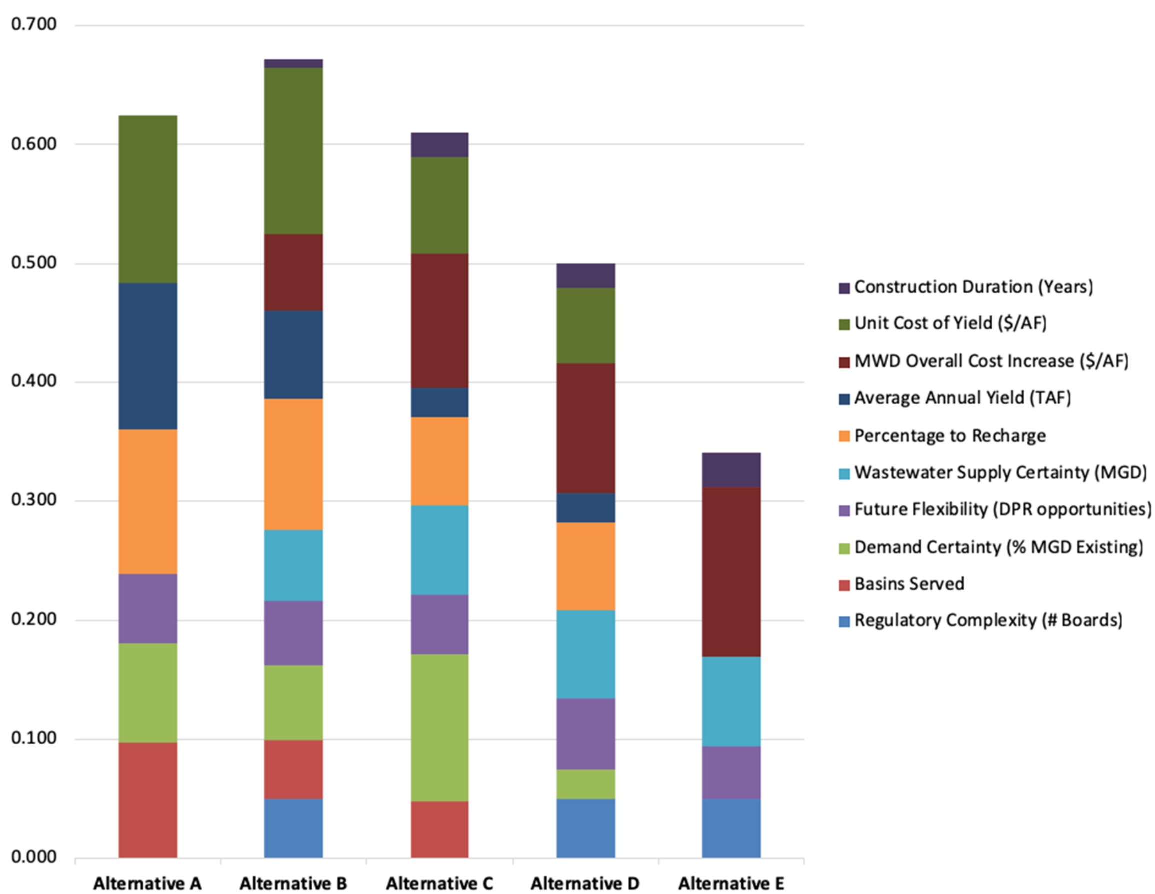
Additional conveyance facilities would be required for potential future integration of raw water augmentation for the RRWP. A connection from the Santa Fe Spreading Grounds area to the Weymouth WTP would require additional pipeline reaches and pump stations. Connecting the RRWP system to the Weymouth WTP would also allow advanced treated water to be brought to the Diemer WTP via Metropolitan's existing Yorba Linda Feeder. A connection from the RRWP system just south of the Whittier Narrows area could also be established to the Diemer WTP, requiring additional pipeline reaches and pump stations. Additional engineering studies are needed to further evaluate these conveyance options.

Raw water augmentation may be a viable future opportunity for the RRWP, but additional work is needed to fully evaluate it. Metropolitan continues to actively engage with the water industry on the regulatory development of DPR. Funding through Metropolitan's Future Supply Actions program has recently been provided to help advance several potable reuse studies and fill DPR research gaps. Metropolitan will be conducting technical evaluations through the upcoming demonstration project at the demonstration facility and developing future research programs associated with potable reuse, including raw water augmentation applications. Finally, it should be emphasized that the primary purpose of the RRWP is to provide a drought-proof supply for replenishing regional groundwater basins to meet demands on Metropolitan and maintain the long-term basin health and reliability. This long-term replenishment need would remain, with or without the potential integration of DPR in the future.

Multi-Objective Decision Analysis (MDA)

In order to develop a refined comparison of the five alternatives, a weighted MDA was developed utilizing the objectives, criteria, and performance metrics, and weightings provided by senior Metropolitan project team members. Figure 1.5 presents a bar chart comparison of the values developed through this methodology. As illustrated in the figure, Alternatives A and B are closely matched, with Alternative C slightly lower than the two highest ranking alternatives. Alternatives D and E are clearly inferior to the top 3 alternatives. Further, the analysis suggests that a multi-phase approach (Alternative B) performs as well or better than implementing the entire program in a single phase (Alternative A). Further discussion of the MDA process, along with its associated criteria and metrics, is included in Chapter 3.

Figure 1.5: Breakdown of Overall Alternative Score by Criterion



The evaluation of phasing alternatives demonstrates that the program will likely benefit from implementation in two phases, with a 100-mgd first phase project designed to extend from the JWPCP in Carson to the Santa Fe Spreading Grounds in Irwindale. The potential advantages of the proposed two-phased approach include the following:

1. Greater certainty regarding future demands sufficient to use the production from a 100-mgd AWT plant.
2. Greater certainty regarding the long-term availability of sufficient secondary effluent from the JWPCP to meet initial production needs.
3. Increased flexibility by allowing multiple pathways to serve Orange County groundwater needs and potential DPR applications in the future.
4. Lower initial capital and O&M costs reducing the initial impact on Metropolitan's overall cost increases.
5. Unit costs of production that are nearly equivalent to the unit cost estimates for the full-scale program.

Proposed Implementation Strategy (Backbone System)

Through the analysis described above, a proposed implementation strategy emerged. The proposed approach provides: (1) an AWT plant sized to meet near-term existing and planned future demands, (2) a pipeline sized to accommodate both existing and potential future uses, and (3) the flexibility to adapt the initial system for DPR once applicable regulations are established. Any DPR option would supplement the initial IPR program, not replace it. The strategy represents a modification to Alternative B (North First) and provides treatment for up to 100 mgd of purified water conveyed from the AWT plant in Carson to the Santa Fe Spreading Grounds through a pipeline appropriately sized for up to 150 mgd (the full program capacity). This reconfigured version of Alternative B has been characterized as the "backbone conveyance system" (Backbone System). Although the Backbone System serves the refinery demands adjacent to the JWPCP, it does not include the pipeline and injections wells needed for future West Coast Basin replenishment demands.

Early Delivery Opportunities

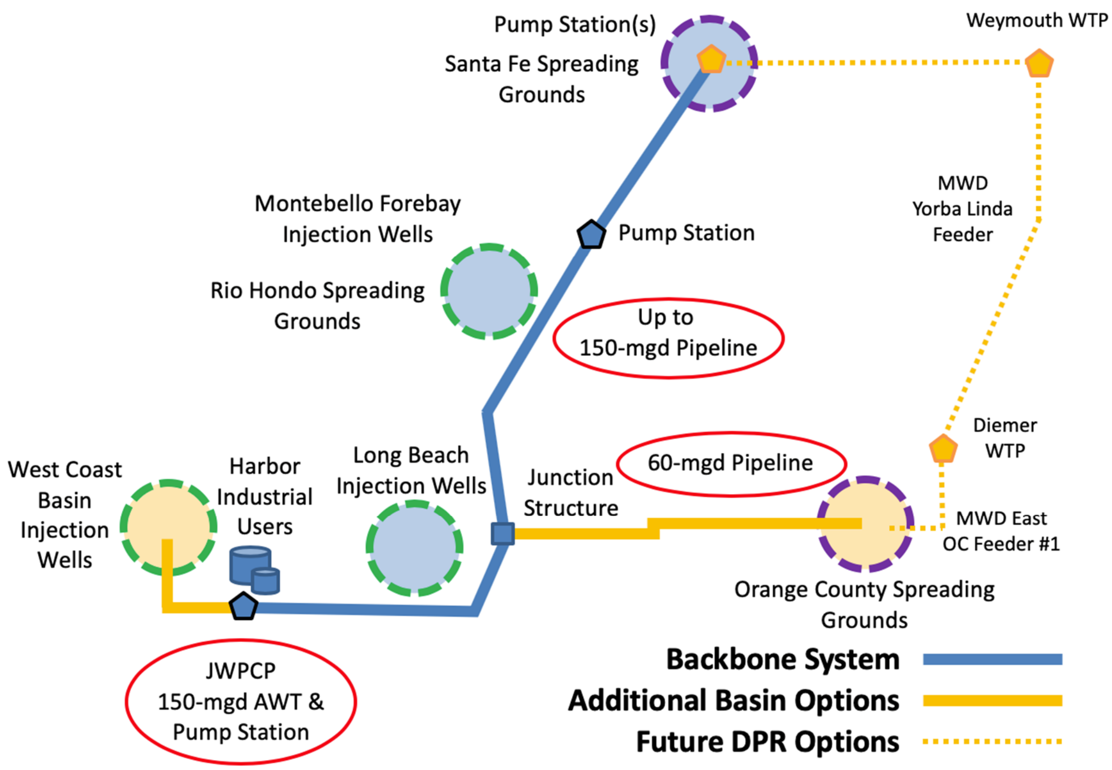
As part of the implementation strategy, it is recommended that opportunities to make early deliveries of purified water be considered during the overall Backbone System development plan. As indicated in the demand assessment earlier in this chapter, there is potentially 23 mgd of purified water demand within an 8-mile radius of the AWT plant. Documented demands include up to 10 mgd of refinery demands in the Harbor Area, 4 mgd of replenishment demand in Long Beach, and potentially 9 mgd or more of replenishment demand in the West Coast Basin. Additionally, there may be opportunities to provide purified water to industrial demands in the Long Beach Harbor area that have not yet been fully defined or quantified.

Early deliveries to these potential customers (and others along the pipeline alignment) would provide operational experience at scale, immediate supply benefits, and some initial water sales for the program. Further, the modular design of many AWT processes is conducive to progressive expansion of treatment capacity as the conveyance system is completed.

Following the environmental planning process, approximately 10 to 11 years will be needed to complete the 100-mgd Backbone System, including the construction of approximately 38 miles of pipeline from Carson to the Santa Fe Spreading Grounds. Early deliveries to customers close to the AWT plant could potentially begin within 5 to 6 years after completion of the environmental process. The timing and sequence of the planning, design, and construction of infrastructure to meet these early delivery objectives would be more fully examined during subsequent CEQA and preliminary design efforts.

Figure 1.6 presents a schematic of the overall proposed Regional Recycled Water Program, including both IPR and DPR options for the future.

Figure 1.6: Proposed Regional Recycled Water Program



The groundwater basin options (solid yellow lines) can be implemented at any time after the Backbone System is completed. The DPR options (dashed yellow) will require further regulatory developments before the technical requirements and costs can be fully evaluated. The flexibility to provide several possible pathways to 150 mgd (or even higher flows) is one of the major benefits offered by the proposed Backbone System.

Table 1.3 presents a summary comparison of the Full Program Alternative A and the different phases of the Backbone System alternative. For the purposes of this comparison, the second phase of the Backbone System alternative is assumed to be the IPR pipeline from the junction structure to the Orange County

Spreading Grounds, as described in Alternatives A through E. Given the uncertainty of future DPR requirements at this time, it does not include the cost of any of the future DPR options shown in Figure 1.6.

Table 1.3: Comparison of Full Program and Proposed Two-Phase Program

		Proposed Program		
Performance Metrics	Full Program (Alternative A)	Phase 1 (Backbone System)	Phase 2 (OC IPR Option)	Complete Program
AWT Production Capacity (MGD)	150	100	50	150
Starting Location	Carson	Carson	Cerritos	Carson
Terminus	Complete	Santa Fe SG	Anaheim	Complete
Basins Served	All	Central and MSG	West Coast and OC	All
Annual Demands (MGD)	150	86	65	150
Annual Demands (TAFY)	168	96	73	168
Miles of Conveyance in Phase (miles)	62	38	24	62
Highest Elevation (ft.)	500	500	200	500
AWT Production Capacity (MGD)	150	100	50	150
AWT Production Capacity (TAFY)	168	112	56	168
Average Yield (MGD)	147	98	49	147
Average Annual Yield (TAF)	165	110	55	165
Capital Cost of Phase ($Million)[1]	$3,080	$2,615	$782	$3,397
JWPCP Modifications	$150	$150	$0	$150
Advanced Water Treatment Plant	$570	$431	$188	$577
Conveyance Facilities	$899	$840	$190	$1,031
Well Facilities	$205	$128	$85	$213
Engineering Costs (25%)	$456	$387	$116	$493
Contingency (35%)	$798	$678	$203	$862
Annual O&M Cost of Phase ($Million)	$134	$69	$60	$129
Advanced Water Treatment	$108	$56	$52	$108
Conveyance	$24	$13	$7	$20
Well Field and Spreading Facilities	$1	$1	$1	$1
Annual Financing Costs ($Million)[2]	$155	$130	$42	$171
Total Average Annual Costs ($Million)	$288	$199	$102	$301
Unit Cost of Yield by Phase ($/AF)	$1,752	$1,813	$1,853	$1,826
Avg. MWD Cost Increase of Phase ($/AF)[3]	$170	$117	$60	$177
Construction Duration (Years)	11	10	6	16

[1] 2018 Dollars
[2] Assumes a 30 year term and 4.00% per annum interest rate.
[3] When project is fully operational and based on Metropolitan's 2017/18 Budget of 1.70 MAF.

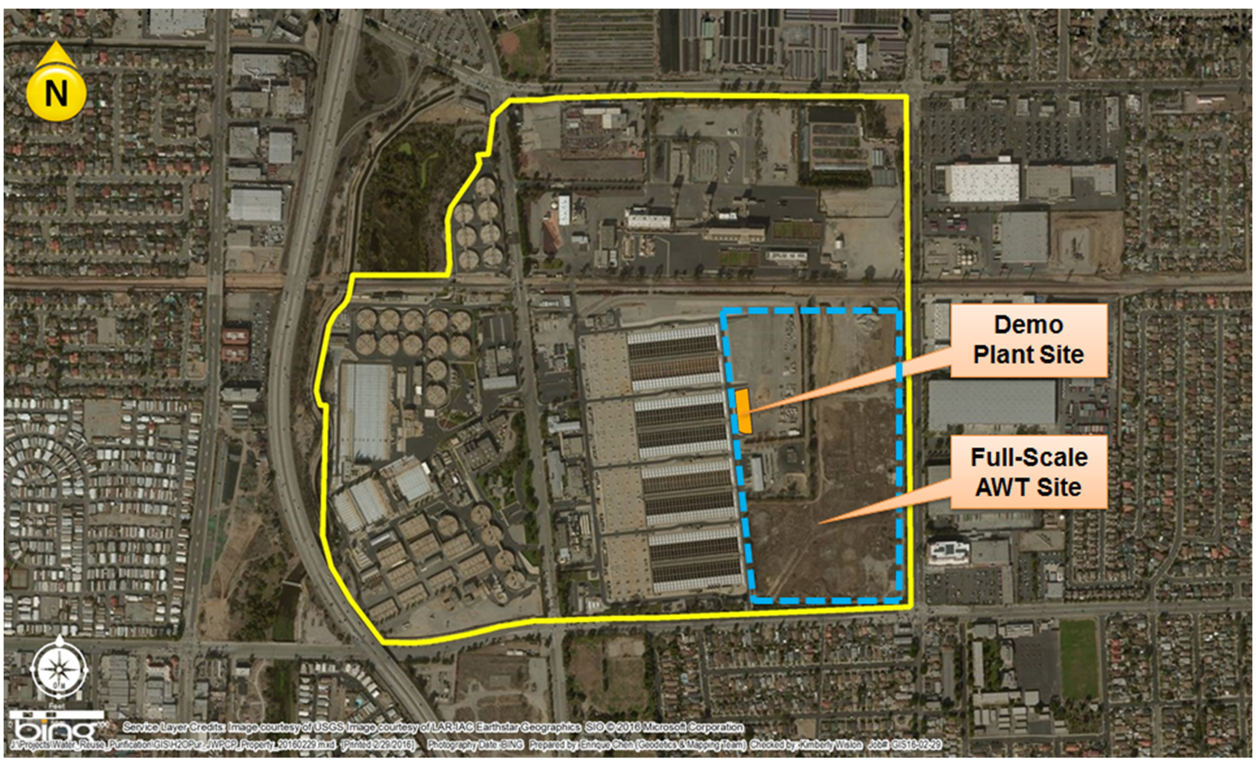
In summary, initial implementation of the proposed first phase Backbone System provides:

1. Significant new replenishment supply conveyed to the largest existing and planned groundwater recharge demands.
2. Unit production costs are competitive with the overall program (3% higher than full program implementation).
3. Lower initial impact on Metropolitan's overall cost increases resulting from lower total annual costs (31% lower than full program implementation).
4. Reduced regulatory complexity.
5. Greatest flexibility to adapt to future regulatory changes that may permit the incorporation of DPR into the program.
6. Greater certainty of secondary effluent flows needed to meet production goals.

1.3 Advanced Water Treatment Plant

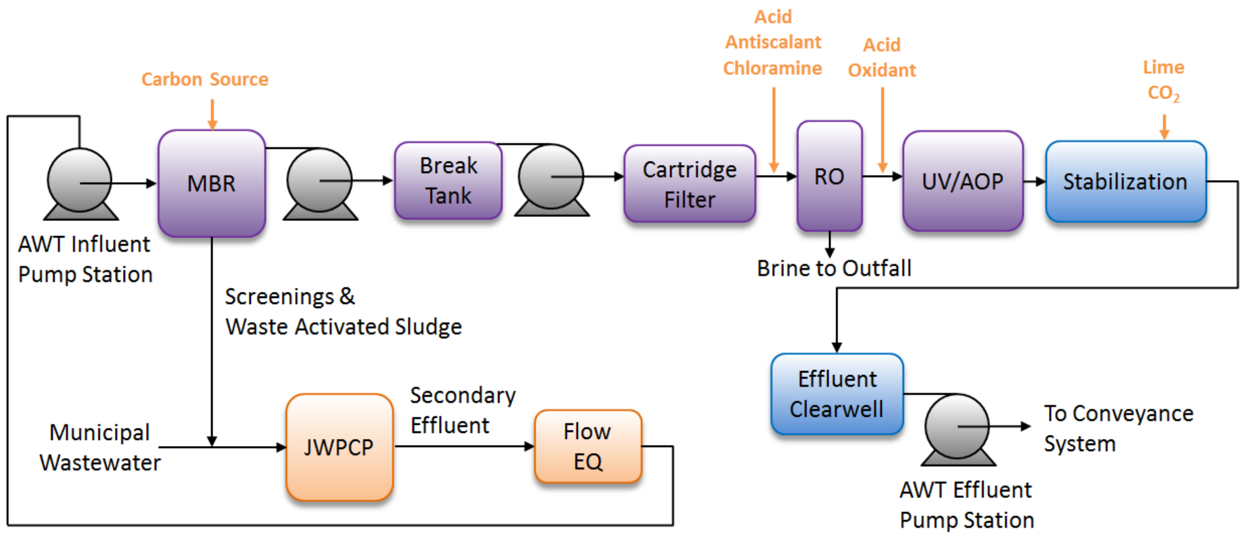
The new full-scale AWT plant would be located within the Sanitation Districts' JWPCP in Carson, as shown in Figure 1.7.

Figure 1.7: Proposed Location of AWT Facilities at JWPCP



The AWT plant would receive unchlorinated, non-nitrified secondary effluent from the adjacent wastewater treatment facilities. It would be designed to produce up to 150 mgd (168 TAFY) of high-quality water that meets the requirements for IPR through groundwater recharge. The product water quality goals would be achieved through the collaborative efforts of Metropolitan and the Sanitation Districts using source control measures and advanced water purification technologies. The AWT plant process train currently envisioned and shown in Figure 1.8 includes a tertiary membrane bioreactor (MBR) followed by reverse osmosis (RO) and ultraviolet/advanced oxidation processes (UV/AOP). The process could be modified in the future with advancements in treatment technology or changes to regulatory requirements. Due to diurnal flow patterns at the JWPCP, flow equalization will be required upstream of the AWT plant to ensure sufficient secondary effluent is available to the AWT plant at full 150-mgd capacity.

Figure 1.8: Process Flow Schematic for the Full-Scale AWT Plant



Water Quality

Regulatory oversight of water reuse projects is carried out by the SWRCB through the DDW and the individual RWQCBs. DDW and the RWQCBs regulate groundwater recharge projects under Title 22 California Code of Regulations Division 4, Chapter 3. Groundwater replenishment regulations address the protection of public health with respect to chemicals, microorganisms, and constituents of emerging concern. In addition to the Title 22 criteria, recycled water must also comply with water quality standards and objectives in applicable basin plans, salt and nutrient management plans, and other applicable regulations and policies to protect water quality and the beneficial uses of surface water and groundwater.

Los Angeles RWQCB Basin Plan objectives for the Main San Gabriel, West Coast, and Central Basins have nitrate and nitrate + nitrite limits of 10 milligrams per liter as nitrogen (mg/L-N). However, a lower nitrate limit of 3.4 mg/L-N is required by the Santa Ana RWQCB in the Orange County Basin due to basin-specific nitrate issues. Therefore, a total nitrogen (TN) water quality goal of TN $\leq$ 3.4 mg/L is established for the AWT plant product water to serve the Orange County Basin.

A primary purpose for building and operating the demonstration facility is to optimize the treatment process train for a full-scale AWT plant. One of the many water quality criteria the full-scale plant will have to comply with addresses nitrogen levels in the recycled water during and after its treatment – with both operational and public health requirements. A Nitrogen Management Committee, consisting of technical staff from both Metropolitan and the Sanitation Districts, explored cost-effective and reliable alternatives to help identify a holistic nitrogen management strategy, considering potential treatment options at both the JWPCP and new AWT plant. The committee's report is discussed in Chapter 4, Advanced Water Treatment Plant and included in Appendix C.

Boron management is also needed. JWPCP effluent boron concentration is currently about 0.9 mg/L. To protect agricultural beneficial uses, particularly for citrus crops, the California State boron notification level is 1 mg/L; the Main San Gabriel Basin Plan limit is 0.5 mg/L. Source control to reduce boron in the sewershed and additional treatment measures at the AWT plant are being considered.

1.4 Conveyance System

The conveyance system will consist of approximately 60 miles of pipeline and a series of pump stations as shown in Figure 1.9. The system will deliver up to 150 mgd of purified water as far east as the Orange County Spreading Grounds in Anaheim and as far north as the Santa Fe Spreading Grounds in Irwindale. Delivery locations along the alignment will consist of either existing groundwater spreading basins, new or existing injection wells, or industrial users in the Harbor area. For planning purposes, the pipeline alignment has been divided into five segments; the numbering is used to clarify the analysis and does not indicate any priority or construction order.

Additional analyses were completed to verify and refine the alignments presented in the Feasibility Study. The analysis revealed a topographic high point along Segment 1, near Signal Hill. Numerous concept level alternatives were identified and evaluated for conveying flows over (or around) the high point. A two-pump station system alternative was determined to be most advantageous.

Feedback was solicited from internal and external project stakeholders to ensure that the alignment to date is constructible and financially feasible, minimizes construction impacts to communities, and avoids or minimizes environmental impacts.

Proposed First Phase Backbone Conveyance System

As described above, the proposed Backbone System would include upsized conveyance that would accommodate existing and future uses and have the flexibility to accommodate DPR applications in the future once applicable regulations are established. A sensitivity analysis validated that an 84-inch diameter pipeline for Segment 1 (AWT to Junction Structure near Cerritos) is appropriate. A minimum of two pump stations will be necessary to convey up to 150 mgd from the AWT site to the vicinity of the Santa Fe Spreading Grounds. Further assessment of the hydraulics and operation of this backbone system will be conducted during preliminary design. Verification will be needed to ensure that an upsized pipeline can be constructed within the previously identified alignment.

1.5 Groundwater Modeling

The RRWP would recharge four groundwater basins as shown in Figure 1.10. These basins were selected based on their proximity to the JWPCP and their ability to accommodate up to 150 mgd (168 TAFY) of recharge water.

Existing groundwater models for each basin were used to aid in evaluating the ability of individual basins to receive the water and identify possible effects that the recharge may have on them. Assumptions and operational criteria for the demand analysis and groundwater modeling were developed through coordination with member agencies, basin managers, and the Los Angeles County Department of Public

Works. As a part of the conceptual planning efforts, additional groundwater modeling, beyond that conducted for the Feasibility Study, was performed to refine anticipated replenishment demands in each basin.

Figure 1.9: Overview of the Conveyance System

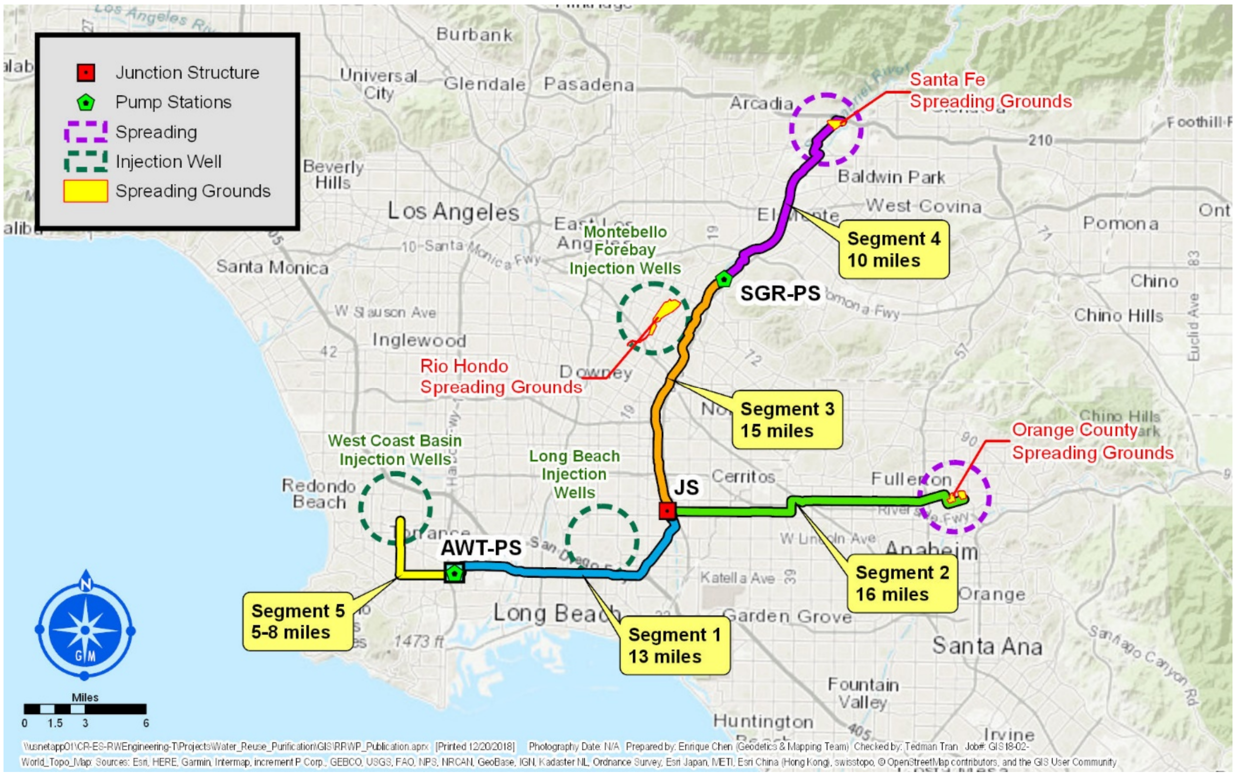
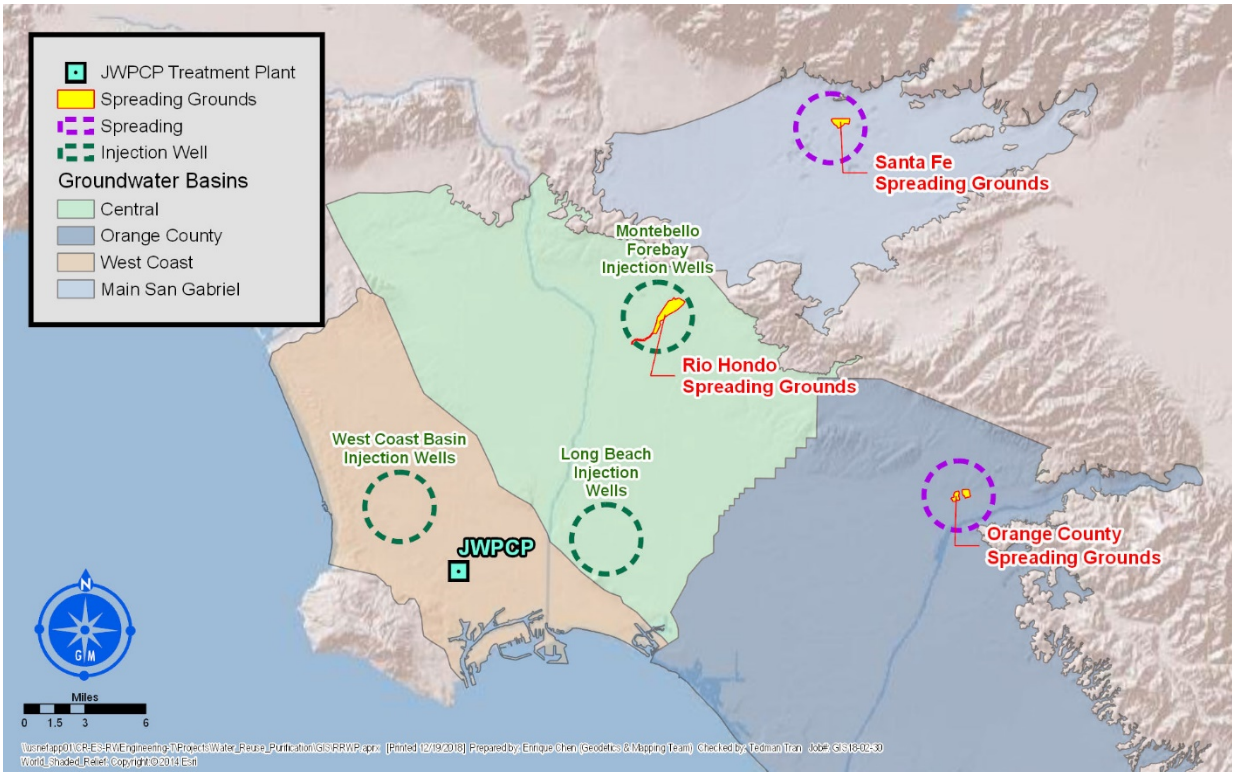


Figure 1.10: Groundwater Basins and Recharge Locations



Within the Main San Gabriel Basin, results of the groundwater modeling indicate the contamination plume associated with the United States Environmental Protection Agency (USEPA) Baldwin Park Operable Unit (BPOU) cleanup may be partially affected, particularly in the western portion of the BPOU remediation area. However, it appears that the impacts are minor and can be contained by the existing BPOU remedial systems. Key findings for the Main San Gabriel Basin are as follows:

- Without the delivery of 81 TAFY of purified water from the RRWP, water levels would be 110 feet mean sea level (MSL) (70 feet below current basin levels) assuming historical pumping and recharge activities. Because water levels drop below the threshold for maintaining well capacity in the basin, pumping capability would diminish due to these declining water levels.
- With the delivery of 81 TAFY of purified water from the RRWP, water levels would be about 70 feet above current levels (or about 250 feet MSL). Water levels peak at 303 feet MSL, which is still below the upper threshold water level at the key well.

Within the Central and West Coast Basins, groundwater modeling results suggest that in the Long Beach area, introduction of purified water from the RRWP would increase water levels by as much as 6 feet. In the Montebello Forebay area, the groundwater table is expected to rise as much as 7 feet. In the Carson area, the groundwater table would rise by a maximum of approximately 24 feet.

For the Orange County Basin, the Orange County Water District (OCWD) currently spreads about 37 TAFY of recycled water from its Groundwater Replenishment System (GWRS) facility and about 150 TAFY of stormwater from the Santa Ana River into the Orange County Basin. OCWD expects to purchase about 65 TAFY (58 mgd) of imported water from Metropolitan in the future. Spreading basins owned by OCWD have the capacity to receive all the 65 TAFY of additional recharge from the RRWP during normal and dry periods, particularly during the summer months. However, during wet periods and some winter months, the existing spreading basins may be limited to 22 TAFY (20 mgd) of additional recharge from the RRWP.

Table 1.4 summarizes the levels of potential daily recharge expected approximately 85% of the year (totaling 150 mgd). During the remaining 15% of the year, total potential recharge capacity is expected to periodically decline to a low of approximately 100 mgd. This fluctuation in demands is captured in the expected yield for each of the alternatives (98% of the peak production capacity of the AWT, or 147 mgd) and is consistent with the Feasibility Study.

Table 1.4: Average Annual Replenishment Deliveries by Basin

Groundwater Basin	Annual Replenishment Deliveries	
	TAFY	**mgd**
Main San Gabriel	81	72
Orange County	52	46
Central	14	13
West Coast	21	19[1]
Total – All Basins	**168**	**150**

[1]West Coast Basin deliveries include 10 mgd of industrial consumptive demand.

Additional groundwater modeling was conducted for the conceptual studies to assess any impacts resulting from storing and pumping purified water in the basins and to refine the delivery flows and schedules associated with a full-scale program. The results of these evaluations are presented in Chapter 6, Groundwater Modeling.

1.6 Environmental Planning

Implementation of the RRWP will require environmental review under the CEQA and the National Environmental Policy Act (NEPA), and possibly permitting under the Clean Water Act, California Fish and Game Code, and/or state and federal Endangered Species Acts. A Programmatic Environmental Impact Report (PEIR) and a Programmatic Environmental Impact Statement (PEIS) are types of CEQA/NEPA documents designed to be used for large projects with multiple components that would require multiple agency approvals or multiple construction contracts. Based on preliminary environmental analysis, project schedule, and program constraints, the preparation of a PEIR is recommended for the overall program with additional project-level tiered documents, which will support future phases of the program. The PEIR will allow Metropolitan to consider broad policy alternatives and program-wide mitigation measures early in the program design and will provide greater flexibility to consider design alternatives to avoid, minimize, and develop mitigation measures for identified impacts and to ensure adequate cumulative impact analysis.

1.7 Technology Acceptance and Permitting

Metropolitan and the Sanitation Districts have engaged in meetings with the regulators (DDW and Los Angeles and Santa Ana RWQCBs) since early 2016. In 2017, coordination with the regulators became focused on the testing strategy for the demonstration project. A technical memorandum, *Advanced Water Treatment Demonstration Facility Testing Strategy,* was submitted to DDW providing details on the general framework for the proposed AWT demonstration testing. The accepted framework focused on an approach for technology acceptance testing of the MBR process.

Because the JWPCP effluent has yet to be used for beneficial reuse, collecting data to establish the AWT plant's ability to meet applicable regulatory criteria will be critical, especially because of the industrial nature of a portion of the sewershed. The demonstration phase 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 plant or the end use of the water.

MBRs have been widely used in nonpotable reuse applications, benefitting from its small footprint and high-quality effluent. A primary challenge facing implementation of an MBR in a potable reuse treatment train is the lack of pathogen reduction credits granted to date. A key component of the regulatory process will be to receive technology acceptance of an MBR process. Through the demonstration project, Metropolitan will be seeking pathogen log reduction credits and technology acceptance from DDW for an MBR as a key pathogen barrier in a potable reuse treatment train. Membrane filtration, an approved process train for nonpotable reuse applications, could be implemented should the technology acceptance for an MBR process not be granted by DDW. Metropolitan will also demonstrate that all the AWT processes will achieve the water quality and operational goals established for the demonstration project.

Metropolitan and the Sanitation Districts prepared a draft testing and monitoring plan for the demonstration facility. The plan outlines the work to be conducted in the demonstration project in three phases over a period of 15 months beginning in early 2019. Metropolitan and the Sanitation Districts presented the draft demonstration testing and monitoring plan to the independent scientific advisory panel and the regulators in August 2018, gaining key feedback. Staff is working to receive final approval by the regulatory agencies prior to initiating demonstration testing in March 2019. Use of the demonstration facility could continue following the first 15 months of operation for additional data to develop process design criteria and optimize process train operations.

1.8 Findings and Recommendations

The conceptual studies presented in this report focused on program phasing opportunities, potential DPR options, water quality related to nitrogen management and boron control, refining the configuration of the conveyance system, and further groundwater modeling and characterization of demand certainty. The following are the findings and conclusions from the analyses and technical investigations. This section concludes with recommendations for next steps.

Importance of the First Phase

Because all five alternatives ultimately achieve a 150-mgd program, the initial decision regarding program implementation is largely driven by the first phase considerations and performance metrics. The first objective of the phasing assessment called for each phase of every alternative to "perform as a fully functional and cost-effective stand-alone project." This objective reduces the risk of stranded assets if the implementation of subsequent phases is delayed or indefinitely postponed. The assessment objectives also recognized the value of flexibility to accommodate future DPR opportunities. Alternative B – with 100 mgd of production and conveyance to the Santa Fe Spreading Grounds in the first phase – offers the most balanced approach, including significant economies of scale and proximity to both the Weymouth and Diemer WTPs (similar to Alternative A) at lower overall uncertainty (similar to Alternative C). Furthermore, a multi-phase approach offers the ability to initiate program development without foreclosing on emerging opportunities for increased efficiency, effectiveness, and operational control that may result from the availability of DPR as a viable option. For these reasons, Alternative B (North First) was considered the most desirable among the five alternatives considered and served as the basis for the proposed Backbone System. The Backbone System offers the following benefits:

1. Significant new replenishment supply conveyed to the largest existing and planned groundwater recharge demands.
2. Unit production costs are competitive with the overall program (3% higher than full program implementation).
3. Lower initial impact on Metropolitan's overall cost increases resulting from lower total annual costs (31% lower than full program implementation).
4. Reduced regulatory complexity.
5. Greatest flexibility to adapt to future regulatory changes that may permit the incorporation of DPR into the program.
6. Greater certainty of secondary effluent flows needed to meet production goals.

In addition to an expansion to meet Orange County Basin replenishment demands, other potential future program components that could be implemented in conjunction with the Backbone System include (1) a future purified water tie-in from a future AWT plant at the City of Los Angeles Hyperion Water Reclamation Plant, and (2) IPR in the Raymond and Chino groundwater basins.

Direct Potable Reuse

The location of both the Weymouth and Diemer WTPs in relation to the proposed first phase Backbone facilities provides an opportunity for purified water to supplement the raw water supply to a drinking water treatment plant after DPR regulations are approved. The potential benefits of incorporating DPR in the full-scale program (once approved) are considered significant enough to warrant phasing program implementation enabling retention of future flexibility.

Nitrogen Management Options

Effective nitrogen management through the AWT process is crucial to ensuring optimum overall treatment process efficiency, as well as ensuring that the product water from the plant meets the TN and nitrate goals for the groundwater basins that will be receiving the purified water. Several process trains were selected for further detailed evaluation. Some of these potential processes can be readily examined at the demonstration facility, and modifications to the plant were made during construction to facilitate further testing and examination of nitrogen management. The Nitrogen Management Committee recommended that testing of these alternative processes be undertaken after the initial demonstration facility testing is completed.

Boron Source Control and Treatment

Boron is present in the flow streams entering the JWPCP and the boron concentration in the effluent leaving the plant is currently about 0.9 mg/L. However, the source and quantification of these flows was not previously well understood. The Sanitation Districts undertook a boron source investigation study and determined that most of the boron is entering the plant from the oil field industries in the Long Beach and Signal Hill areas. With the current basin objective in place for the Main San Gabriel Basin, this program may need additional measures to reduce boron, either through source control or with additional treatment. Treatment could potentially be provided at either the JWPCP site or at a satellite treatment facility near the Santa Fe Spreading Grounds. Methods of boron source control, including bench-scale tests, are currently being investigated by the Sanitation Districts. This work should be continued to determine the feasibility of cost-effective source control.

Refined Conveyance System Configuration

The conveyance pipeline system was refined from the configuration presented in the Feasibility Report base case system. These refinements were made to realize improved efficiencies to the overall system, as well as to address the potential for phasing of the overall program. Key refinements and improvements made include (1) establishing a hydraulic control point in Signal Hill to facilitate the implementation of a phased system, (2) considering elimination of one pump station along the alignment to reduce costs and simplify system operations, (3) reassessing the need for and configuration of trenchless crossings at critical locations to better reflect actual conditions and to refine cost estimates, (4) confirming preliminary utility and other major buried infrastructure information with impacted stakeholders to further refine potential construction impacts and costs, and (5) identifying conceptual-level pipeline alignments to convey AWT water from the current terminus of the system at the spreading basins to Metropolitan's Weymouth and Diemer WTPs as part of a potential future DPR scenario.

Demands for Replenishment Water

Significant additional groundwater modeling efforts were undertaken in close coordination with the potentially affected member agencies and water masters. The results of this modeling were used to refine near-term and future potential replenishment demands beyond what had been previously identified in the Feasibility Study. A separate assessment characterized the relative certainty of replenishment demands in the groundwater basins. This qualitative assessment supports phasing alternatives that reach significant levels of existing demand during the first phase of the program.

Recommended Next Steps

Based on the results of the analyses completed for these conceptual planning studies, the following next steps are recommended should Metropolitan's Board decide to move implementation of the RRWP forward:

1. **Proceed with environmental review process.** The analyses completed thus far in the Feasibility Study and Conceptual Planning Studies Reports for the RRWP allows for Metropolitan to proceed with the environmental review process at a programmatic level for the full program, including potential future IPR and DPR options. Project-level environmental review can also be

prepared for initial construction projects planned for the first phase. Because of the complexity and long lead time needed to complete the environmental permitting process, it is recommended that the environmental process proceed while further program development and evaluations continue to take place. Engineering activities will be needed to support the environmental process; the extent to which preliminary design is completed for a program element during the environmental review process can impact the overall implementation schedule.

2. **Further refine treatment options for a full-scale AWT plant.** While initial demonstration testing and monitoring for regulatory acceptance of MBR proceeds, additional testing work should be planned to help finalize a recommended treatment train for the full-scale AWT plant. This additional testing should include refinement of process design criteria for a full-scale AWT plant; further evaluation of selected process trains for nitrogen management; and further analysis of source control and treatment for boron.
3. **Further develop the conveyance system.** Metropolitan should continue to engage key stakeholders, including the United States Army Corps of Engineers (USACE), Southern California Edison, and Los Angeles County Department of Public Works, and the cities and municipalities involved to refine pipeline alignments and right-of-way requirements. The hydraulic characteristics of the system should be finalized, and infrastructure requirements needed at groundwater recharge locations evaluated. Further assessment of pipeline appurtenances as well as pipeline coatings should be conducted, and design criteria established for seismic events, fault crossings, river crossings, and major infrastructure crossings.
4. **Conduct additional groundwater analysis.** Metropolitan should work with the groundwater basin managers to perform physical tracer studies to confirm results of solute transport and particle tracking and perform water compatibility studies for the injection wells and the spreading basins to assess whether there will be any potentially adverse interactions between the purified water and the native groundwater. Based on the results, siting of the proposed injection wells and relocated production wells should be confirmed.
5. **Establish preliminary commitments.** Efforts should be undertaken to confirm the willingness of potential recipients of the purified water to commit to the delivery schedule, operational requirements, and financial needs of the overall program.
6. **Evaluate program cost recovery.** Present information to the Metropolitan Board to obtain policy direction as to preferred cost recovery methods.
7. **Ensure consistency with the IRP.** Continue evaluation of the program's regional water supply benefits in the context of Metropolitan's IRP.
8. **Adjust for current and future needs.** The RRWP should be phased to "right size" the initial investment in AWT facilities based on the established commitments of potential recipients. The infrastructure provided for conveyance should consider the availability of purified water and the needs of the full program over time. An analysis of implementation sequencing should be prepared for overall program development as well as individual projects within a given phase.
9. **Strengthen collaborative management.** Program development should include participation from all agencies needed to make the overall integration of many utility functions (a "system-of-systems") to perform reliably over time. From a high-level perspective, the RRWP is a multi-agency undertaking that requires close collaboration and coordination among Metropolitan, the Sanitation Districts, member agencies, groundwater basin managers, Los Angeles County

Department of Public Works, and others. To ensure reliable operations of the full program, a collaborative management structure should be in place during the planning, development, implementation, and ongoing operations of the system. Although this may not require the creation of a new organization, a formal acknowledgment of the program's overall mission and goals by all participants is important.

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Chapter 2

Background and Overview

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2.0 BACKGROUND AND OVERVIEW

2.1 Introduction

The Conceptual Planning Studies Report presents the results of preliminary investigations related to the potential RRWP being considered by Metropolitan and the Sanitation Districts. These conceptual planning studies build upon the analysis in the Feasibility Study (dated November 2016), which was presented to Metropolitan's Board and to the Sanitation Districts' Board. The Feasibility Study determined that the RRWP is a feasible program and recommended the completion of the studies included in this report.

In broad terms, the studies presented here evaluate the opportunities for program phasing; further delineate and refine the major program elements; present additional groundwater modeling evaluations associated with introducing purified water into the groundwater basins; and examine the potential for the program to accommodate DPR opportunities in the future. While the Feasibility Study established that the RRWP is a viable program given the assumptions used, this report addresses specific issues regarding its potential implementation and performance.

Several other activities identified and recommended in the Feasibility Study have also been initiated: (1) construction of the demonstration facility and development of a testing and monitoring plan, (2) development of preliminary institutional and financial arrangements for the management and operations of the program, and (3) development of a public outreach plan associated with the demonstration facility. The results of these additional activities will be reported on separately and are not included in the Conceptual Planning Studies Report.

2.2 Program Concept

The RRWP consists of a new AWT plant at the Sanitation Districts' JWPCP in Carson and a new regional conveyance system. These facilities would produce and deliver a reliable source of purified water to recharge regional groundwater basins. These groundwater resources are vital to the region's water supply reliability and currently rely, in part, on imported water for replenishment. In the future, the program may provide a source of water for other indirect or direct potable uses.

The Feasibility Study determined that up to 168 TAFY could be produced and recharged into the basins, resulting in higher, more stable groundwater levels and increased storage in the region. This would improve supply reliability for the region by, among other things, offsetting demands for groundwater replenishment that could be stored instead, for use, particularly in dry years or other shortage conditions. It would also provide emergency storage benefits by making the basins a more reliable water supply during emergencies when in-region storage and uninterrupted recycled supplies are critical. As the 2015 IRP target for local resources reflects, stable local supplies for the region are essential to Metropolitan's resource planning. Additionally, local supplies directly produced and owned by Metropolitan would provide supply directly and indirectly for all its member agencies.

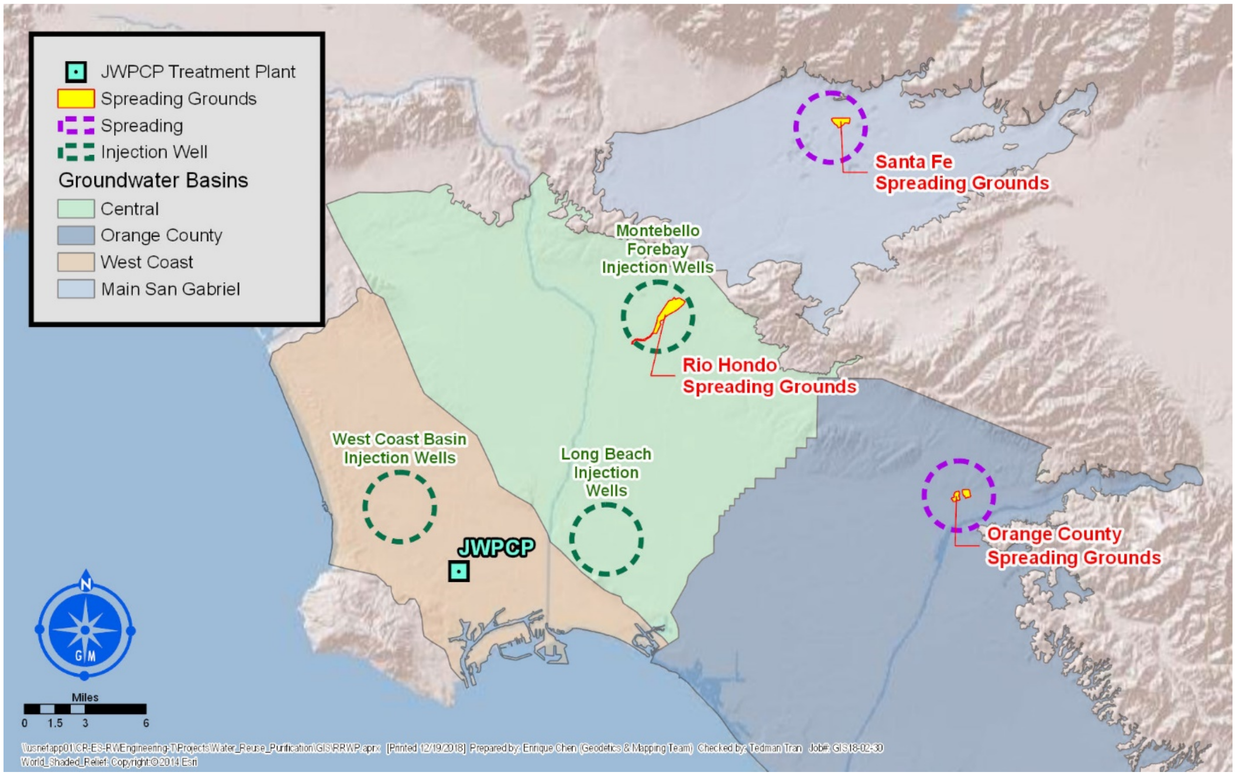
An overview of the current RRWP concept is shown in Figure 2.1, beginning with wastewater collected from homes, businesses, and industries. The collected wastewater then undergoes conventional wastewater treatment by the Sanitation Districts at the JWPCP followed by advanced treatment at the new AWT plant. The purified water is then conveyed to groundwater basins for recharge and over time reused as a potable supply.

Figure 2.1: Program Overview

As mentioned above, this new water resource would require two major infrastructure components: an AWT plant located within the existing JWPCP site, and a new regional water conveyance system to deliver the water from the AWT plant to the groundwater basins and potentially, to other locations for DPR in the future. The AWT plant would be designed for an ultimate capacity of up to 150-mgd (168 TAFY) of water with a quality that meets the requirements for IPR through groundwater recharge. The water quality criteria would be achieved through the collaborative efforts of Metropolitan and the Sanitation Districts using source control measures, a fully functional secondary wastewater treatment process, and advanced water purification technologies.

The new conveyance system would include a network of pipelines and pump stations to deliver the water from the AWT plant in Carson to existing spreading basins and new and existing injection wells that will recharge four basins: Main San Gabriel, Orange County, Central, and West Coast (see Figure 2.2). The water could also be delivered to meet existing consumptive demands of refineries in the Harbor Area of the West Coast Basin. In the future, the conveyance system could also be used to deliver water to other locations for DPR. Currently, it is anticipated that Metropolitan would own and operate the AWT plant and the conveyance system. Metropolitan would cooperate with the operators of the spreading basins, allowing variability in the volume and timing of deliveries to accommodate facility maintenance and storm events.

Figure 2.2: Groundwater Basins and Recharge Locations



Source of Water for RRWP

Water for the program would originate from the Sanitation Districts' operation of the JWPCP, which serves approximately 3.5 million people throughout Los Angeles County. This facility is one of the largest wastewater treatment plants in the world and the largest in the Sanitation Districts' system. It provides primary and secondary treatment for approximately 260 mgd (2017 data) of wastewater and has a total permitted capacity of 400 mgd. The treated wastewater is currently discharged to the Pacific Ocean through a system of tunnels and outfalls. No water reclamation currently takes place at this facility. With a new AWT plant located next to the secondary treatment processes at the JWPCP, a significant amount of secondary effluent could be further treated and reused to benefit the region.

2.3 Actions to Date

For more than 8 years, Metropolitan and the Sanitation Districts have been evaluating a regional collaboration to jointly develop a recycled water supply. The following subsections summarize the actions taken to date.

Pilot-Scale Studies

In March 2010, Metropolitan's Board authorized staff to collaborate with the Sanitation Districts to study a regional IPR program and to perform pilot-scale treatment studies to evaluate the feasibility of advanced treatment of the JWPCP's secondary effluent. Between June 2010 and July 2012, these pilot studies were conducted jointly by the two districts using two 18-gallon-per-minute (gpm) pilot facilities located at the JWPCP. The pilot-scale studies also evaluated how Metropolitan could meet then-draft Title 22 Groundwater Replenishment Regulations administered by the California Department of Public Heath (now the State Water Resources Control Board DDW). The results of the pilot-scale studies demonstrated that advanced treatment of JWPCP secondary effluent for producing water suitable for IPR through groundwater recharge is technically feasible.

Development of Terms and Initial Agreement with the Sanitation Districts

In 2015, Metropolitan and the Sanitation Districts entered into an agreement for development of a demonstration facility at the JWPCP. The districts also established a framework of terms and conditions for development of a full-scale RRWP, if both boards approve the implementation of the program. The objectives of this framework are to enable the potable reuse of up to 150 mgd of treated effluent from the JWPCP; share potential costs and investments; establish responsibilities between Metropolitan and the Sanitation Districts; reserve the use of a Sanitation Districts' site for the AWT plant; and ensure that this program would avoid conflict or duplication with other recycled water plans. The agreement and framework of terms and conditions for a full-scale plant are included in the Feasibility Study appendices. For the full-scale project, the initial set of terms and conditions are nonbinding; however, they set forth key conditions that both organizations would be responsible for in a future full-scale program agreement. Building upon these initial terms, and subsequent discussions with the Sanitation Districts, staff would prepare for Metropolitan Board approval and Sanitation Districts Board approval of a final binding agreement between Metropolitan and the Sanitation Districts for a full-scale AWT plant at the JWPCP site.

Metropolitan Board Action

In November 2015, the Metropolitan Board appropriated $15 million and authorized (1) an agreement with the Sanitation Districts for development of a potential regional recycled water supply program and (2) the design of a demonstration-scale recycled water treatment plant (Minute Item 50299). The demonstration project as described in the board action includes the three components presented below.

Demonstration Facility

Under the proposed agreement, a 0.5 mgd demonstration-scale recycled water treatment facility will be designed and constructed to (1) verify criteria for the quality of source water from the JWPCP for the AWT plant, (2) confirm the treatment processes required for regulatory acceptance of the purified product water for groundwater recharge, and (3) characterize the brine and residuals for disposal. Many of the key process components of the demonstration facility are full-size units, which will aid in confirming treatment performance. The demonstration facility will also help confirm capital and operating costs for the full-scale plant, provide water quality data for regulatory acceptance, and include a visitor center for public outreach and education. The demonstration facility site is located within the operational boundary of the JWPCP.

Feasibility Studies of the Delivery System

Metropolitan will conduct feasibility studies of the delivery system that will distribute the purified water to member agencies for the recharge of groundwater basins within the service area and potentially to

Metropolitan water treatment plants in the future for DPR. The anticipated activities of the feasibility studies include the development of program capacity, phasing, and timing; coordination with member agencies and stakeholders on groundwater recharge requirements; investigation of delivery system facilities, alignments, rights-of-way, and substructures; development of initial costs; and identification of regulatory and environmental requirements.

Financing Plan

Metropolitan will also prepare a financing plan to assess the economic viability of a regional program. The financing plan would establish water delivery arrangements with member agencies for the delivery of purified water for recharge of groundwater basins, evaluate the potential for state and federal grants and loans, determine cost-sharing opportunities, and assess funding and cost recovery methods.

Demonstration Project

As described above, Metropolitan's Board authorized staff to design a demonstration facility that would allow Metropolitan to optimize an AWT process to produce purified water for groundwater recharge. Building upon earlier pilot-scale studies that indicated that an IPR project was technically viable, Metropolitan opted to undertake a demonstration project to refine and demonstrate an alternative treatment process train, which could provide significant capital and operational cost savings. In addition, the demonstration project will provide an opportunity for both districts to better understand how to manage nitrogen in the finished water supply. As a value engineering measure, the project team determined that a 0.5-mgd demonstration facility will be sufficient to test, monitor, and optimize the treatment process and produce the water quality data needed to seek the necessary permits. The demonstration facility will also provide a means for Metropolitan and the Sanitation Districts to coordinate operations. Finally, it will serve as an effective tool for public outreach.

Metropolitan issued a competitive Request for Proposal (RFP-PL-1116) to select a consultant for design and operation of the demonstration facility. In August 2016, Metropolitan issued a Request for Qualifications (RFQ No. 1137) to qualify firms providing treatment equipment to the demonstration facility. In March 2017, Metropolitan issued a request for bids (Specification No. 1879) to construct the AWT demonstration facility; in July 2017, Metropolitan awarded a $13.9 million construction contract for the facility to a contractor selected through that competitive bid process. The initial board appropriation of $15 million was increased to $17 million when the construction contract was awarded. Construction of the demonstration facility is complete, and operations will begin in early 2019. The demonstration facility will be operated for 15 months to compile information needed for regulatory review and approval. The adopted O&M budget for fiscal year (FY) 2018/19 and 2019/20 includes a total of $9.8 million for demonstration facility operations.

Nitrogen Management Alternatives Evaluation

A primary purpose for building and operating the demonstration facility is to optimize the treatment process train for a full-scale AWT plant. One of the many water quality criteria that the full-scale plant must meet is the nitrogen level in the recycled water during and after its treatment – with both operational and public health requirements. In April 2017, a Nitrogen Management Committee, consisting of technical staff from both Metropolitan and the Sanitation Districts, was formed. The committee's charter was to explore cost-effective and reliable alternatives and identify a holistic nitrogen management strategy, considering the potential treatment options at both the JWPCP and AWT plant. The committee's report, entitled "Nitrogen Management Evaluation for Full-scale Advanced Water Treatment Facility" (Nitrogen Management Report), is further discussed in Chapter 4, Advanced Water Treatment Plant, and is included in Appendix C. The committee will continue to evaluate treatment options as data are obtained from operations of the demonstration facility.

Coordination with Regulatory Agencies

Metropolitan and the Sanitation Districts have been collaborating with the regulatory agencies throughout the development of the demonstration facility, the Feasibility Study, and this report. The agencies involved are the California State Board's DDW, Los Angeles RWQCB, and Santa Ana RWQCB. Through a series of meetings which commenced in early 2016, Metropolitan and the Sanitation Districts have sought the regulating agencies' input and guidance on the potential program, including the treatment process for the demonstration facility. Metropolitan and the Sanitation Districts have engaged the regulating agencies in the development of testing and monitoring protocols for the demonstration period, as well as future work to be developed for ultimate permitting of the proposed program if the RRWP goes forward. This coordination is further discussed in Chapter 8, Technology Acceptance and Permitting.

Advisory Panels

In early 2016, Metropolitan and the Sanitation Districts convened a panel of eight subject matter experts to provide independent review and critical input on the scope and direction of the program during the development of the Feasibility Study and demonstration facility. The panel met several times in 2016 in a workshop format to provide input on the following: overall program feasibility and work plans; design of the demonstration facility; groundwater basins and water delivery assessments; and ideas and approaches to program implementation.

The eight-member advisory panel included the following experts in AWT and recycled water programs:

- Richard Atwater, Co-Chair: Former Executive Director of Southern California Water Committee; expert on recycled water programs.
- Margie Nellor, Co-Chair: Nellor Environmental Associates, Inc.; expert on recycled water reuse programs, pretreatment, and related regulatory issues. (Nellor retired from the panel effective August 22, 2016.)
- Shivaji Deshmukh: Assistant General Manager of West Basin Municipal Water District; expert on recycled water engineering and operation of AWT facilities.
- Thomas Harder: Thomas Harder and Associates; expert on southern California's groundwater basins and hydrogeology.
- David Jenkins: Professor Emeritus, University of California, Berkeley; expert on biological wastewater treatment processes, and water and wastewater chemistry.
- Edward Means: President, Means Consulting LLC; expert on water quality and water resources management.
- Joseph Reichenberger: Professor, Loyola Marymount University; expert on water, wastewater, and recycled water systems and treatment.
- Paul Westerhoff: Professor, Arizona State University; expert on AWT processes.

The workshop discussions and panel comments were considered and implemented as appropriate by the project technical team during the design of the demonstration facility and the preparation of the Feasibility Study.

In November 2017, a subcommittee of the panel (David Jenkins, Ed Means, Joseph Reichenberger, and Paul Westerhoff) was convened to review and comment on the evaluation of alternative nitrogen management process trains developed in the Nitrogen Management Report described above. The subcommittee completed the work of the panel with its review of the Nitrogen Management Report, which is included in Appendix C.

In April 2018, a new independent scientific advisory panel was established to provide review of the scientific, technical, and regulatory aspects of the demonstration project. An RFP was issued in fall 2017 for a facilitator and panel, and the National Water Research Institute (NWRI) was selected through this process. NWRI was charged to provide a panel facilitator with extensive experience in the water reuse industry, working with water agencies, wastewater agencies, and regulators. NWRI also assembled a panel of experts to assist Metropolitan and its partners during the demonstration project. The first workshop of the independent scientific advisory panel was held in August 2018 to provide input on the testing and monitoring plans for the demonstration facility. This panel is discussed in Chapter 8, Technology Acceptance and Permitting.

Consultations with Member Agencies and Groundwater Management Agencies

Metropolitan staff has met periodically with the member agencies and groundwater management agencies that would directly receive water from the program. The discussions provided opportunities to explore how this water resource could be incorporated into each basin's unique operating regime and requirements. The meetings also included conceptual discussions on potential arrangements for delivery and use of the water, including potential arrangements with member agencies, groundwater management agencies, and groundwater pumpers.

During preparation of the Feasibility Study, Metropolitan contracted with the groundwater management agencies to conduct groundwater modeling, with specific scopes of work to identify the potential for the program to recharge and pump water from the subject basins. Additional groundwater modeling was conducted for the conceptual studies to assess any impacts resulting from the introduction of purified water into the basins and to refine the delivery flows and schedules associated with a full-scale program. The results of these evaluations are presented in Chapter 6, Groundwater Modeling.

As recommended in the Feasibility Study, further consultations with member agencies, groundwater management agencies, and other potential program participants (e.g., Los Angeles County Department of Public Works) are planned. Discussions will focus on the development of mutually agreed-upon terms and conditions that would accompany implementation if the program proceeds. The results of these efforts will be reported on separately.

Feasibility Study Report

Metropolitan completed the Feasibility Study report in November 2016 and presented the findings and recommendations to the Metropolitan Board in January 2017. The report addressed specific questions regarding the technical, institutional, and economic viability of a potential program that would produce up to 150 mgd of purified water for groundwater recharge. The overall findings were summarized in the report's Executive Summary as follows:

> The Feasibility Study finds that the RRWP is technically feasible, from the AWT process, to the conveyance system, to the recharge and pumping of the groundwater basins. The study also acknowledges that a project of this complexity and geographic scope has considerable institutional challenges, none of which appear to be insurmountable, but will require significant effort to address. In addition, the RRWP can be implemented through the existing regulatory process, making its approval feasible as well. (Feasibility Study, page 1-1)

2.4 Conceptual Planning Studies Report

The conceptual planning studies presented in this report address recommendations in the Feasibility Study. The studies complete the November 2015 Metropolitan Board-approved scope with additional evaluations "of program capacity, phasing, and timing; coordination with member agencies and stakeholders on groundwater recharge requirements; investigation of delivery system facilities, alignments, rights-of-way, and substructures." This report addresses the following topics:

- **Program Implementation and Cost Estimate.** Chapter 3 evaluates potential phasing alternatives for the implementation of a full-scale program. The evaluation includes five alternative phasing scenarios and compares the durations, costs, expected demands, and flexibility associated with each alternative. The evaluation demonstrates that the program will likely benefit from implementation in two phases, with the first phase project designed to extend from the JWPCP in Carson to the Santa Fe Spreading grounds in Irwindale. Based on this conclusion, a proposed first phase project is presented that would provide treatment of up to 100 mgd of purified water conveyed from the AWT plant in Carson to the Santa Fe Spreading Grounds through a "backbone conveyance system" with capacity to deliver up to 150 mgd, increasing its flexibility for both additional IPR and DPR options.
- **Advanced Water Treatment Plant.** Chapter 4 provides an analysis of the capacity and water quality criteria associated with the phasing alternatives presented in Chapter 3. It also presents a summary of nitrogen and boron management strategies, source water quality and control, as well as a discussion of operational considerations.
- **Conveyance System.** Chapter 5 provides an analysis of pipelines, pumping stations, and alignments associated with the phasing alternatives presented in Chapter 3, including the proposed first phase backbone system project.
- **Groundwater Modeling.** Chapter 6 presents the results of additional groundwater modeling conducted during the conceptual planning studies to assess impacts resulting from the introduction of purified water into the basins and to refine the delivery flows and schedules associated with a full-scale program.
- **Environmental Planning.** Chapter 7 discusses environmental constraints and the overall approach to environmental permitting at the programmatic and project levels.
- **Technology Acceptance and Permitting.** Chapter 8 provides a general overview of the steps being taken to achieve regulatory approval of the RRWP, including technology acceptance for an MBR in a potable reuse treatment train.

- **Findings and Recommendations.** Chapter 9 concludes the conceptual planning studies report with a summary of findings and proposed next steps in the development of the RRWP should the boards of Metropolitan and the Sanitation Districts decide to proceed.

Since the November 2015 Board approval, staff has also begun review of the potential for DPR of water from the RRWP.

2.5 Additional Activities

As mentioned earlier, other activities delineated in the November 2015 Metropolitan Board action, recommended in the Feasibility Study and necessary prior to board action regarding implementation of a full-scale program, are underway. These activities will be reported on separately and include the following:

Institutional Agreements

Several legal agreements will be required to implement the program. Topics addressed in these agreements include the volume, timing, and location of water deliveries for replenishment; use of spreading basins and other delivery facilities needed to recharge the basins; water quality specifications; groundwater monitoring requirements; and other details associated with potential water deliveries. Metropolitan will collaborate with member agencies, groundwater managers, and other essential stakeholders to develop preliminary terms and conditions that would be mutually acceptable if the program proceeds.

Consistency with Integrated Resources Plan (IRP)

Although the Feasibility Study established the broad regional benefits that could be realized as a result of the program, a more detailed assessment and Metropolitan Board discussion regarding the RRWP's consistency and relationship with Metropolitan's IRP 2015 Update will be undertaken. This will evaluate its potential impact on regional reliability and how it would work with other local resources programs that Metropolitan could develop.

Evaluation of Cost Recovery

Finally, staff will seek policy directions from the Metropolitan Board as to cost recovery methods, before beginning a cost of service review of the project costs.

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Chapter 3

Program Implementation and Cost Estimate

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3.0 PROGRAM IMPLEMENTATION AND COST ESTIMATE

3.1 Introduction

The 2016 Feasibility Study addressed broad questions regarding the ability to implement the RRWP, its estimated costs, and its potential regional benefits. The Feasibility Study assumed the 150-mgd program would be implemented in a single phase with a duration of 11 years and an estimated program cost of $2.7 billion (2016 dollars). This chapter focuses on an assessment of potential program phasing alternatives to the single-phase 150-mgd program described in the Feasibility Study. The description and evaluation of potential approaches to program phasing is one of the overall goals of the conceptual planning studies.

This phasing assessment involves consideration of several variables. From an infrastructure perspective, the primary questions examined in this chapter involve (1) appropriate sizing of the AWT plant and process train(s); (2) the distance, capacity, and expected deliveries of the conveyance system; (3) the certainty of expected demands at various delivery points; and (4) the opportunities for future flexibility to integrate DPR (in addition to IPR) if desired.

Since the completion of the Feasibility Report in 2016, interest in DPR has steadily increased. In April 2018, the SWRCB released its *Proposed Framework for Regulating Direct Potable Reuse in California*, which focused on the regulatory development of raw water augmentation. California's Assembly Bill 574 (AB 574) requires that the SWRCB adopt uniform water recycling criteria for raw water augmentation by the end of 2023; however, stipulations may extend that timeline based on the state of available scientific and technical research at that time. Under the raw water augmentation approach to DPR, Metropolitan would most likely re-treat the AWT product water at one of its water treatment plants.

With the continued progress in regulatory developments related to DPR, there is a strong likelihood that regulatory requirements may be in place prior to the full implementation of the program. Consequently, a significant amount of consideration took place in the conceptual planning studies to assess how the implementation of the RRWP could be structured to accommodate future opportunities that might emerge. A discussion regarding integration of DPR into the RRWP is provided in Section 3.9 of this chapter.

Evaluation Process

The evaluation process included the following steps:

1. Establish objectives, evaluation criteria, and performance metrics for potential phasing of the program.
2. Assess potential water demands and certainty for replenishment and consumptive uses.
3. Configure simplified, logical program phasing alternatives for preliminary evaluation.
4. Develop capital, operating, and finance costs for each simplified alternative.
5. Eliminate inferior alternatives deemed less likely to achieve objectives.
6. Identify additional potential benefits and options that could enhance the remaining alternatives.

7. Develop a proposed implementation strategy that (a) achieves program goals, (b) minimizes demand uncertainties, (c) reduces the risk of stranded investments, (d) is cost effective, and (e) preserves future flexibility.

3.2 Program Implementation Objectives

Generally, phased implementation can be advantageous when (1) there are uncertainties regarding the ultimate demands, availability of source water supply, or needed capacity of a program; (2) potential benefits can be achieved by bringing portions of a program online as quickly as possible (e.g., addressing urgent needs and early creation of revenues); (3) the program has sufficient modularity to be functional in discrete stages; (4) time is needed to evaluate potential future opportunities (e.g., incorporation of a DPR option); and (5) additional benefits may accrue from the acquisition of operational and technology experience.

The initial step in the development of phasing scenarios was the establishment of overall phasing objectives for the potential program. Each phase of every alternative was developed to achieve the following objectives:

1. Perform as a fully functional and cost-effective stand-alone project.
2. Provide a significant addition to regional recycled water supply.
3. Include groundwater recharge as a major portion of deliveries.
4. Provide for future expansion to the full-scale program.
5. Achieve regulatory approvals consistent with those needed for the full-scale program.
6. Offer flexibility to accommodate future opportunities such as DPR.

Based on these objectives, evaluation criteria were developed to compare the relative performance of various phasing alternatives. The evaluation criteria were used to develop a MDA assessing the relative performance of the first phase of each alternative under consideration. Because full-program performance is similar in all the alternatives (see Table 3.17), the MDA evaluation focused on the relative performance of the first phase of each alternative. In fact, it is the extent of the first phase investment that differentiates the five alternatives and constitutes the foundation for an overall implementation strategy. The MDA process was intended to provide both quantitative and qualitative input to the development of a proposed phased implementation approach.

3.3 Evaluation Criteria

Based on the objectives above, Table 3.1 provides the criteria and performance metrics used to evaluate and compare the first phase of each of the alternatives, including an alternative that would build the entire program in a single phase (see Alternative A).

Table 3.1: MDA Evaluation Criteria and Metrics

Evaluation Criterion	Phase 1 Performance Metrics
Complexity of regulatory approvals in Phase 1	• Number of regional boards needed for implementation
Groundwater basins receiving purified water in Phase 1	• Number of basins served
Amount and certainty of demands in Phase 1	• Quantification of recharge demands in basins (mgd/TAFY) • Identification of existing versus new replenishment demands • Characterization of demand certainty • Quantification of replenishment versus consumptive demands
Flexibility to accommodate future opportunities for DPR in Phase 1	• Additional facilities needed to reach Metropolitan water treatment plants (Weymouth and Diemer) • Amount of future wastewater supply not committed to IPR
Amount and certainty of purified water produced in Phase 1	• Recycled water produced (mgd/TAFY) • Characterization of wastewater supply certainty • Percentage of production for groundwater replenishment • Percentage of production for consumptive demands
Phase 1 costs and potential Metropolitan overall cost increases	• Capital and O&M cost estimates • Annual financing costs • Production unit costs • Increase to Metropolitan's overall costs
Phase 1 implementation duration	• Years needed to bring the initial phase on line

Simplified Alternatives Development

The development of simplified phasing scenarios proceeded from a consideration of options within the AWT and conveyance elements of the program. The baseline one-phase alternative was established from information developed in the Feasibility Study for the Base Case facilities. Some modifications and optimizations to the design concepts presented in the Feasibility Study are described in Chapter 4, Advanced Water Treatment Plant and Chapter 5, Conveyance System of this report.

In addition to the single-phase alternative, two separate scenarios were established for both the two-phase and three-phase approaches, creating a total of five phasing alternatives for evaluation. These five scenarios provide a sufficient range of alternatives to differentiate among approaches and illustrate the tradeoffs among scenarios. Based on information learned during the evaluation, a proposed first phase implementation strategy was developed and further evaluated. It is acknowledged that there are additional possible variations on the basic alternatives provided in this analysis, and further investigation of construction sequencing during the preliminary design of the proposed phasing approach is expected.

Cost Estimates

The cost estimates prepared for the Feasibility Study were based on 2016 dollars. As part of the conceptual planning studies, the 2016 cost estimate was updated to capture (1) refinements and scope changes to the program; (2) escalation of construction costs to 2018 dollars; (3) updated unit prices; and (4) where appropriate, new quantity take-offs.

Several key scope changes to the Feasibility Study Base Case included: (1) process refinement at the AWT facility, (2) refinements to the conveyance alignment and overall system hydraulics, (3) refinements to some of the trenchless construction configurations, and (4) an increased number of injection wells. Details of these scope revisions can be found in Chapters 4, 5 and 6.

Like the 2016 estimate, the 2018 estimate is a Class 4 Opinion of Probable Construction Cost (OPCC) as defined by Association for the Advancement of Cost Engineering (AACE) International. The estimate has an expected range of accuracy of -20% to +40%. Cost escalation from 2016 to 2018 was based on a combination of the Caltrans Highway Construction Price Index, the TBD Consultants Price Index, the Leland Saylor Associates Price Index, and the Engineering News-Record (ENR) City Cost Index for the Los Angeles region, all applied as appropriate.

Consistent with the Feasibility Study estimate, a 25%-line item for project management, engineering design, project administration, and construction management is included in the estimated total capital costs. In addition, a 35% overall project scope contingency was added as well.

Tables 3.2 and 3.3 present side-by-side comparisons of the capital and O&M cost estimates for the 2016 Feasibility Study and the current report, which presents costs in 2018 dollars.

Table 3.2: Opinion of Probable Construction Cost Comparison

	Feasibility Study Full Scale Program (2016 dollars)	Conceptual Study Full Scale Program (2018 dollars)	Increase
Materials and Construction			
AWT (including JWPCP Modifications)	$681,600,000	$720,300,000	5.7%
Conveyance (Pump Stations, Pipelines)	$769,700,000	$899,500,000	16.9%
Well Facilities (Monitoring & Relocated)	$155,000,000	$205,400,000	32.5%
Subtotal Materials and Construction	**$1,606,300,000**	**$1,825,100,000**	**13.6%**
Project Management and Engineering			
PM/CM/Design/Administration (25%)	$401,600,000	$456,300,000	
Contingency (35%)	$702,800,000	$798,500,000	
Total Capital Cost	**$2,710,700,000**	**$3,079,800,000**	**13.6%**

*Class 4 cost estimate. Expected range of accuracy is -20% to +40%.

Table 3.3: Estimated Annual O&M Cost Comparison

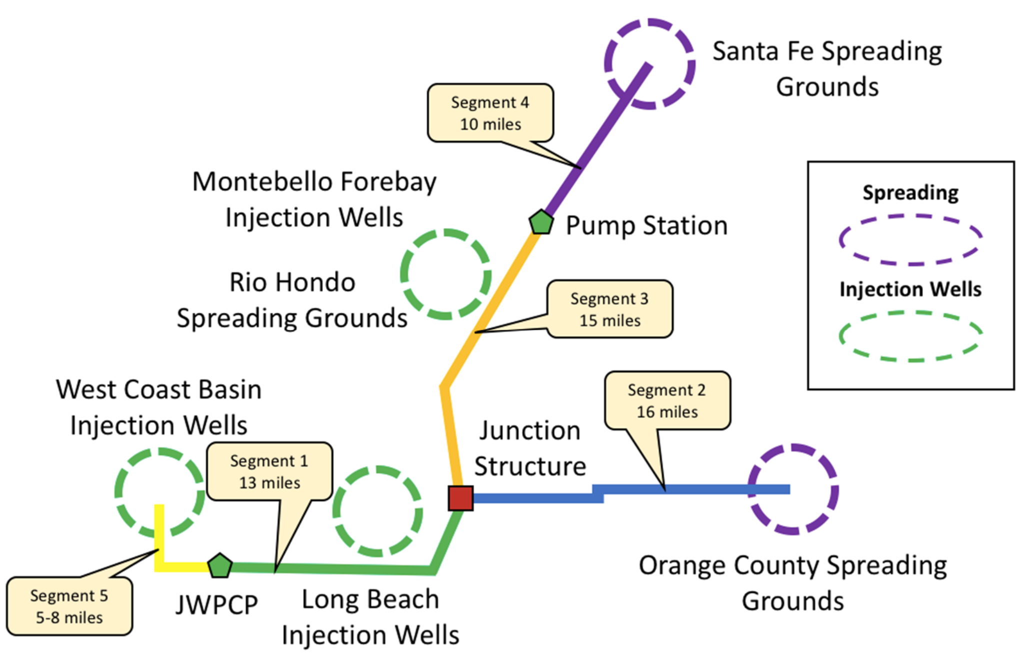
	Feasibility Study Full Scale Program (2016 dollars)	Conceptual Study Full Scale Program (2018 dollars)	Variance
Operations & Maintenance			
Advanced Water Treatment Plant	$99,700,000	$108,000,000	8.3%
Conveyance (Pump Stations, Pipelines)	$28,100,000	$24,400,000	-13.2%
Well Field and Spreading Facilities	$1,200,000	$1,400,000	16.7%
Total Annual O&M Costs	**$129,000,000**	**$133,700,000**	**3.6%**

*O&M costs shown reflect turndown of equipment during wet periods for long-term average production of 147 mgd.

Program Overview

Figure 3.1 presents a simplified schematic illustrating program facilities and destinations for recycled water. Facilities include the AWT plant and pump station located at the JWPCP, major pipeline segments (1 through 5), a control/ junction structure located in Cerritos, and a second pump station at the junction of pipeline reaches 3 and 4 near the Whittier Narrows Dam. The groundwater basin delivery locations and means of recharge (spreading basins versus injection wells) are also presented in Figure 3.1.

Figure 3.1: Simplified Conveyance Schematic



Demand Evaluation

The 2016 Feasibility Study presented an evaluation of potential demands for recharge water in the four groundwater basins (Orange County, Central, West Coast, and Main San Gabriel) served by the potential program. During the preparation of this report, the 2016 demand estimates were updated based on discussions with potentially affected member agencies and water masters, together with additional groundwater modeling in the Central, West Coast, Main San Gabriel, and Orange County groundwater basins. Along with the quantification of potential demands, an assessment of the relative certainty of demands was completed according to the three criteria presented in Table 3.4 and further described below. Demand certainty was evaluated and characterized into three categories: existing, planned, and future.

Table 3.4: Demand Certainty Assessment

Evaluation Criteria	Existing	Planned	Future
Meets Existing Demands on Metropolitan	Current	Expected	Possible
New Injection Wells Needed	No	Yes	Yes
Significant Operational Changes	No	Yes	Yes

Existing Demands. The first consideration addresses whether the demands are already being served by Metropolitan. For example, Metropolitan has a long history of providing water to the Main San Gabriel and Orange County groundwater basins for replenishment. During the Feasibility Study, discussions with member agencies and basin managers identified needs for additional replenishment water that have been characterized as expected to occur. High levels of certainty were assigned to those alternatives in which the program's water would replace an existing delivery of Metropolitan supplies. The lowest levels of certainty were assigned to those alternatives that would require member agencies, in coordination with other agencies, to develop new groundwater extraction and treatment facilities to use the program's water for replenishment purposes.

Planned Demands. Cases in which new injection wells are required to use replenishment water are deemed more uncertain than demands that can be met using existing spreading grounds. Exchange agreements between agencies, especially those that have already been contemplated, have more near-term certainty than other scenarios.

Future Demands. Because water produced by the program must be delivered daily and year-round, some potential recipients may have to modify their financial and operational replenishment processes to accommodate a regional recycled water program. These cases are further complicated when additional treatment may be required for water extracted from the basin at certain locations (e.g., West Coast Basin). The timing and extent of these changes poses the most uncertainty in demand forecasts.

The following subsections describe each of the potential groundwater basin demands and the basis for categorization according to the criteria presented in Table 3.4.

West Coast Basin Consumptive Demands. Discussions with member agencies and the groundwater basin manager for the West Coast Basin identified two categories of potential demands. The first is potential replacement of existing consumptive demands at several refineries in the South Bay and Harbor areas. Currently, refineries either pump groundwater or use potable water connections with member agencies to meet their need for industrial process water. Up to 10 mgd of potential refinery demands were identified.

The program would include sufficient capacity for purified water to be provided to member agencies for delivery to the refineries as replacement water for their current use of potable or groundwater supplies. In these cases, the member agencies would be responsible for connecting directly to the RRWP conveyance pipeline (at locations to be determined), in a fashion similar to current Metropolitan service connections. The member agencies would be responsible for making the delivery of the purified water to the industrial end user (e.g., refineries). The potential demand for purified water to meet refinery demands was assessed as having a high level of certainty because the use is currently ongoing and the required infrastructure can be made available with minimal cost and complication. These demands were categorized as “planned” when evaluated under the criteria set forth in Table 3.4.

West Coast Basin Replenishment Demands. A second potential demand for purified water in the West Coast Basin consists of water for replenishment purposes. Under this approach, a potential future demand of up to 9 mgd was identified. To serve this demand, a new pipeline would be constructed from the AWT plant and would extend north and west from Carson into Torrance. In conjunction with detailed groundwater modeling, a series of injection wells would be developed along the alignment of the new pipeline. Up to 10 new injection wells have been included in developing alternatives. The exact location and sizing of the wells would not be finalized until discussions with member agencies and the basin water master take place in conjunction with additional groundwater modeling.

In addition to the Metropolitan-provided injection wells, this alternative is not feasible until new pumping from the basin is developed. Such groundwater pumping will likely require treatment to ensure that the extracted water is suitable for potable uses. In this context, the potential demand for additional replenishment water in the West Coast Basin was categorized as a “future” potential demand when evaluated under the criteria in Table 3.4.

Central Basin Replenishment Demands (Long Beach). Two potential replenishment demands for purified water in the Central Basin were identified in the Feasibility Study and conceptual studies. These include approximately 4 mgd in the Long Beach area and approximately 9 mgd in the Rio Hondo area. Discussions with the water master and the City of Long Beach identified the potential to inject up to 4 mgd of purified water into the Central Basin aquifer at sites to be determined, generally located north of Interstate 405. Metropolitan would install up to four injection wells, and the City would then operate four existing extraction wells in such a manner to achieve an ongoing replenishment program in this portion of the Central Basin. The extracted water would then be treated at an existing City facility prior to introduction into the potable water supply. Because the extraction wells already exist, and because the City has withdrawn water from these wells for potable use, this potential demand for purified water was characterized as “planned” under the criteria in Table 3.4.

Central Basin Replenishment Demands (Rio Hondo). The second potential site for replenishment demands in the Central Basin is at or near the existing Rio Hondo Spreading Grounds in Pico Rivera. A potential demand of up to 9 mgd has been established at this location based on discussions with the water master and evaluation of groundwater modeling results. Application of the replenishment water at this location may take two forms: either by spreading in the existing basins or by use of injection wells. The final application method will be determined at a later date. Because the spreading basins already exist, and because there is a long-standing history of using this site for groundwater replenishment, this potential demand for purified water was categorized as “existing” when evaluated under the criteria in Table 3.4. Furthermore, it was determined that even if the replenishment supplies cannot be delivered to the spreading basins, injection wells can be installed by Metropolitan to make the deliveries.

Main San Gabriel Basin Replenishment Demands. Three potential replenishment demands in the Main San Gabriel Basin were identified in the Feasibility Study and the conceptual studies. For all of these demands, Metropolitan would deliver purified water to the existing Santa Fe Spreading Grounds in Irwindale. Up to 38 mgd of replenishment water reflects the current long-term average amount of water that Metropolitan supplies at this location. Consequently, this potential demand for purified water was categorized as “existing” under the criteria in Table 3.4.

A second potential use of the purified water at this location includes up to 22 mgd of additional replenishment water to “stabilize” the long-term groundwater levels of the basin. The potential need for this additional replenishment supply was identified through discussions with the water master and through groundwater modeling. Because this additional supply is not currently provided but the spreading capacity is available at the Santa Fe Spreading Grounds, this potential demand was categorized as “planned,” under the criteria in Table 3.4.

Finally, the water master and the local agencies identified a third potential demand for replenishment water at this location involving a “transfer” of supplies to both the Raymond Basin and Six Basins jurisdictions through cooperative agreements between the basin pumpers and water supply agencies in the San Gabriel Valley. If fully implemented, this arrangement could increase use of purified water for replenishment purposes at the Santa Fe Spreading Grounds by an additional 12 mgd. Because the facilities to spread the replenishment water already exist, but the implementation of such exchange/transfer agreements do not exist, the potential demand of purified water for this use was categorized as “planned” when evaluated under the criteria set forth in Table 3.4. Taken together, the future ultimate demand for purified water for replenishment at the Santa Fe Spreading Grounds is assessed to be approximately 72 mgd.

Orange County Basin Replenishment Demands. The potential demand for replenishment water in the Orange County Basin was identified in the Feasibility Study and conceptual studies as approximately 46 mgd. This quantity was validated through discussions with the basin agencies and by additional groundwater modeling. Replenishment supplies would be delivered to the Orange County Spreading Grounds in Anaheim. This quantity of replenishment water reflects the current long-term average amount of water that Metropolitan supplies to this location. Consequently, this potential demand for purified water was categorized as “existing” under the criteria in Table 3.4.

Based on these considerations, a summary of the expected demands for each basin and the associated certainty of those demands is shown in Table 3.5.

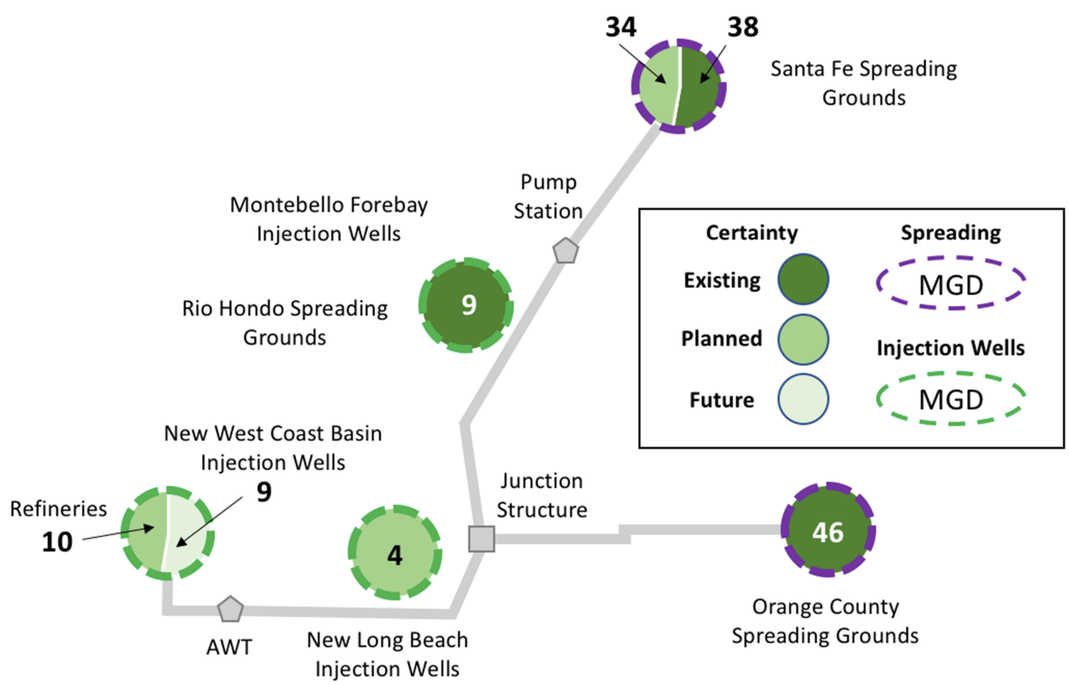
Table 3.5: Demand Certainty by Basin

Basin	Existing		Planned		Future	
	mgd	TAFY	mgd	TAFY	mgd	TAFY
Main San Gabriel (MSG) Basin	38	43	22	25		
MSG (Raymond & Six Basins)			12	13		
Central Basin	9	10	4	4		
Orange County Basin	46	52				
West Coast (Refineries)			10	11		
West Coast (Injection)					9	10
Totals	93	105	48	53	9	10

The summary shown in Table 3.5 reflects the levels of potential daily recharge expected approximately 85% of the year (totaling 150 mgd). During the remaining 15% of the year, total potential recharge capacity is expected to periodically decline to a low of approximately 100 mgd. This fluctuation in demands is captured in the expected yield for each of the alternatives (98% of the peak production capacity of the AWT, or 147 mgd) and is consistent with the Feasibility Study Report.

Figure 3.2 illustrates how the expected daily recharge demands are distributed among groundwater basins served by the RRWP. For example, delivery of purified water to Harbor Area refineries (10 mgd) would replace existing refinery pumping of groundwater and in the future may serve consumptive demands. The figure also presents the level of certainty associated with the expected demands as presented in Table 3.5.

Figure 3.2: Groundwater Replenishment Demands and Uncertainty



Presentation of Simplified Alternatives

In the following sections, five alternative scenarios are described and evaluated:

1. **Alternative A (Full Program):** a single-phase scenario based on the program presented in the 2016 Feasibility Study as the Base Case.
2. **Alternative B (North First):** a two-phase scenario that initially extends from the AWT plant to the Santa Fe Spreading Grounds and West Coast Basin in the first phase and subsequently reaches the Orange County Spreading Grounds in the second phase.
3. **Alternative C (East First):** a two-phase scenario that extends to Orange County Spreading Grounds first and subsequently extends to the Santa Fe Spreading Grounds and West Coast Basin in the second phase.
4. **Alternative D (Central First):** a three-phase scenario that initially extends from the AWT plant to the West Coast Basin, Rio Hondo Spreading Grounds, and Montebello Forebay injection wells, followed by two subsequent phases to the Santa Fe Spreading Grounds and Orange County Spreading Grounds, respectively.
5. **Alternative E (Harbor Area):** a three-phase scenario that focuses initially on the demands near the AWT plant, followed by two subsequent phases to the Santa Fe Spreading Grounds and Orange County Spreading Grounds, respectively.

Table 3.6 presents a distribution of expected demands in each phasing scenario. Under the phasing alternative designations, A through E, the blue cells represent inclusion in Phase 1, green cells indicate inclusion in Phase 2, and orange cells indicate Phase 3. This color scheme for phases is maintained throughout the remainder of this report.

Table 3.6: Distribution of Demands by Phase

		Phasing of Demands by Alternatives					Demands by Basin	
Basin	**Status**	**A**	**B**	**C**	**D**	**E**	**MGD**	**TAFY**
Existing Demands (mgd)							**93**	**105**
Main San Gabriel	Existing	1	1	2	2	2	38	43
Central	Existing	1	1	2	1	2	9	10
Orange County	Existing	1	2	1	3	3	46	52
New Demands (mgd)							**57**	**63**
Main San Gabriel	Planned	1	1	2	2	2	22	25
MSG (Raymond & Six Basins)	Planned	1	1	2	2	2	12	13
Central	Planned	1	1	1	1	1	4	4
West Coast (Refineries)	Planned	1	1	1	1	1	10	11
West Coast (Injection)	Future	1	2	2	1	1	9	10
Total							**150**	**168**

The following subsections provide a description of each alternative phasing scenario, as well as a summary of possible advantages and disadvantages of each. For the multi-phase scenarios, the extent of delay between phases has not been estimated or considered.

3.4 Alternative A: Single-Phase Scenario (Full Program)

Alternative A consists of the single-phase 150-mgd scenario that formed the Base Case program described in the Feasibility Study. As illustrated in Figure 3.3, it completes the entire AWT and conveyance system over a duration of approximately 11 years. Table 3.7 summarizes the program, and Table 3.8 summarizes its advantages and disadvantages.

Figure 3.3: Alternative A (Full Program)

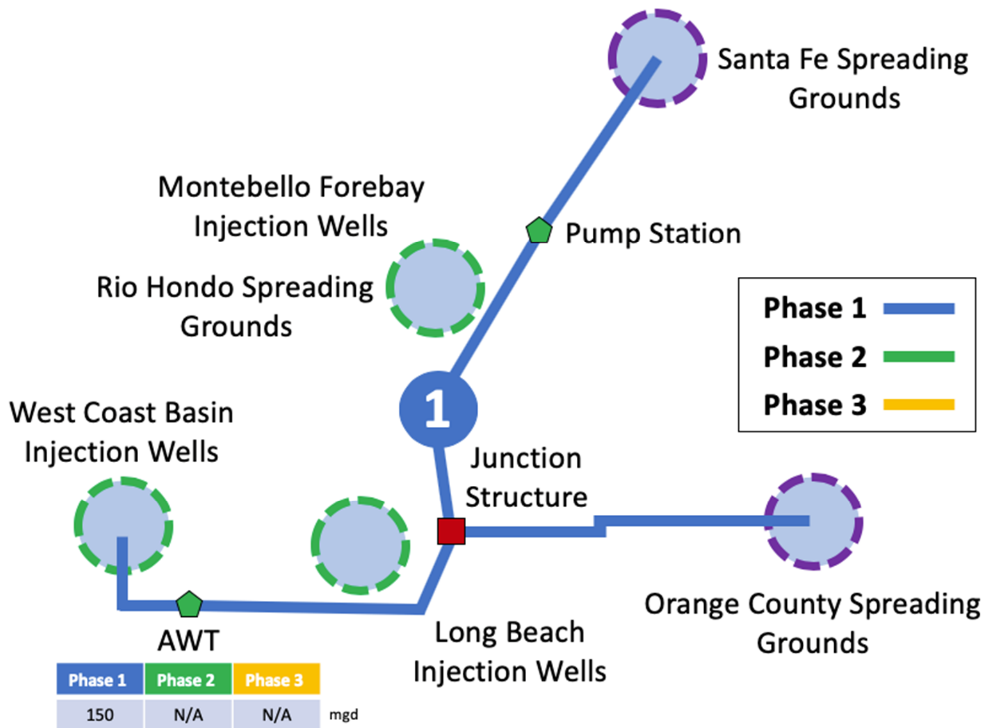


Table 3.7: Alternative A (Full Program) Description

Alternative A: Full Program				
1	Potential Demands	150 mgd	Length of Pipelines	62 miles
	AWT Capacity	150 mgd	Implementation Time	11 years

Table 3.8: Alternative A (Full Program) Advantages and Disadvantages

Advantages	Disadvantages
• Most rapid completion of the overall program. • Maximum economies of scale. • Largest regional benefits to the groundwater basins in its initial phase. • Less vulnerable to inflation and other cost increases.	• Largest initial commitment of funding. • Highest initial impact on Metropolitan's overall cost increases. • Vulnerable to changing external circumstances (recycled water demand uncertainty and future wastewater flow declines). • Commits all flows to IPR uses, reducing flexibility to incorporate DPR. • Most rapid operational learning curve.

3.5 Alternative B: Two-Phase Scenario (North First)

Alternative B is a two-phase scenario that completes the conveyance system to the Santa Fe Spreading Grounds in the first phase of the program and subsequently implements the conveyance needed to reach the Orange County Spreading Grounds and West Coast Basin in the second phase (shown in Figure 3.4). Phase 1 of this approach is estimated to take approximately 10 years to complete, with an additional 5 years needed to complete Phase 2. Table 3.9 summarizes the alternative, and Table 3.10 summarizes advantages and disadvantages.

Figure 3.4: Alternative B (North First)

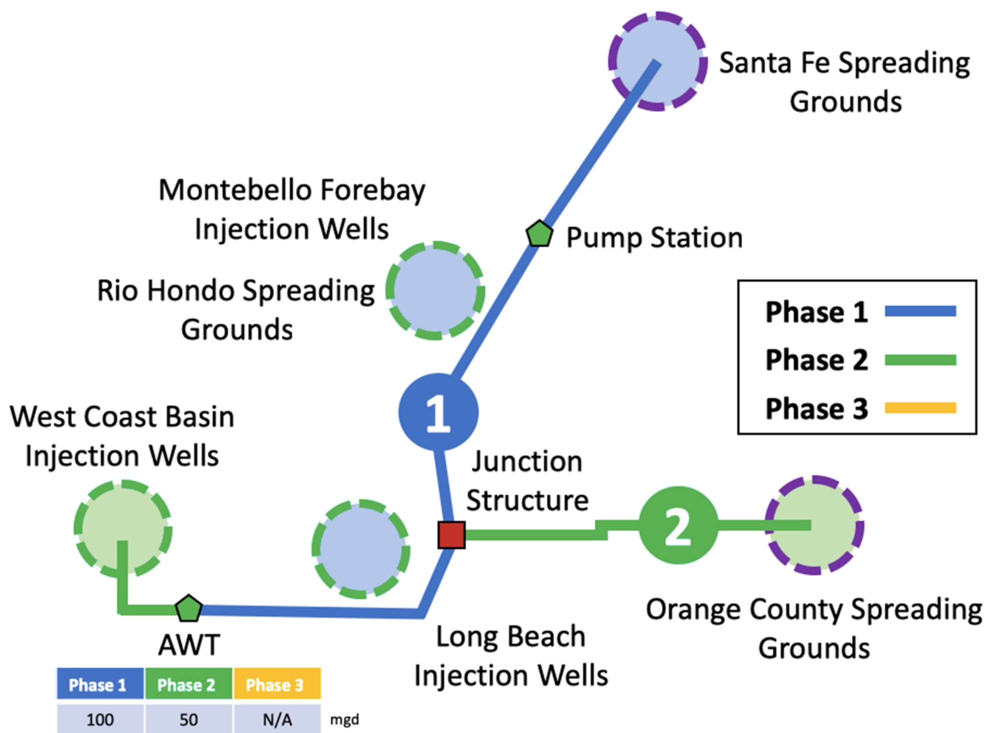


Table 3.9: Alternative B (North First) Description

Alternative B: North First					
1	Potential Demands	95 mgd*	Length of Pipelines	38 miles
	AWT Capacity	100 mgd	Implementation Time	10 years
2	Potential Demands	55 mgd	Length of Pipelines	24 miles
	AWT Capacity	50 mgd	Implementation Time	6 years

*Expected potential demands in Phase 1 fall short of AWT plant capacity.

Table 3.10: Alternative B (North First) Advantages and Disadvantages

Advantages	Disadvantages
• Provides the largest amount of water for replenishment purposes in Phase 1 of the multi-phase alternatives. • Serves stressed groundwater basins with limited sources of water first. • Requires lower treatment costs during Phase 1 to achieve basin plan nitrate limits. • Requires single permitting agency approvals – Los Angeles RWQCB. • Provides economies of scale. • Provides means of implementing DPR (when permitted) by extension of conveyance to either Weymouth or Diemer WTPs.	• Highest initial capital costs of multi-phase alternatives. • Initially pumps to the highest elevation (500 ft) with the highest pumping costs. • Requires measures during Phase 1 to achieve boron limits in the Main San Gabriel basin.

3.6 Alternative C: Two-Phase Scenario (East First)

As illustrated in Figure 3.5, Alternative C reverses the order of implementation described in Alternative B, completing the conveyance needed to reach the Orange County Spreading Grounds in Phase 1 of the program. The conveyance needed to reach the Santa Fe Spreading Grounds and the West Coast Basin is provided in Phase 2. The time needed to complete the first phase of this alternative is estimated to be approximately 8 years, with the remaining second phase implementation taking approximately 6 years to complete. The expected demand in the Central and Orange County Basins is sufficient to take the full production of a 50-mgd AWT plant if necessary, thereby diminishing the potential impacts of uncertainty associated with West Coast Basin demands. Table 3.11 summarizes the alternative, and Table 3.12 summarizes its advantages and disadvantages.

Figure 3.5: Alternative C (East First)

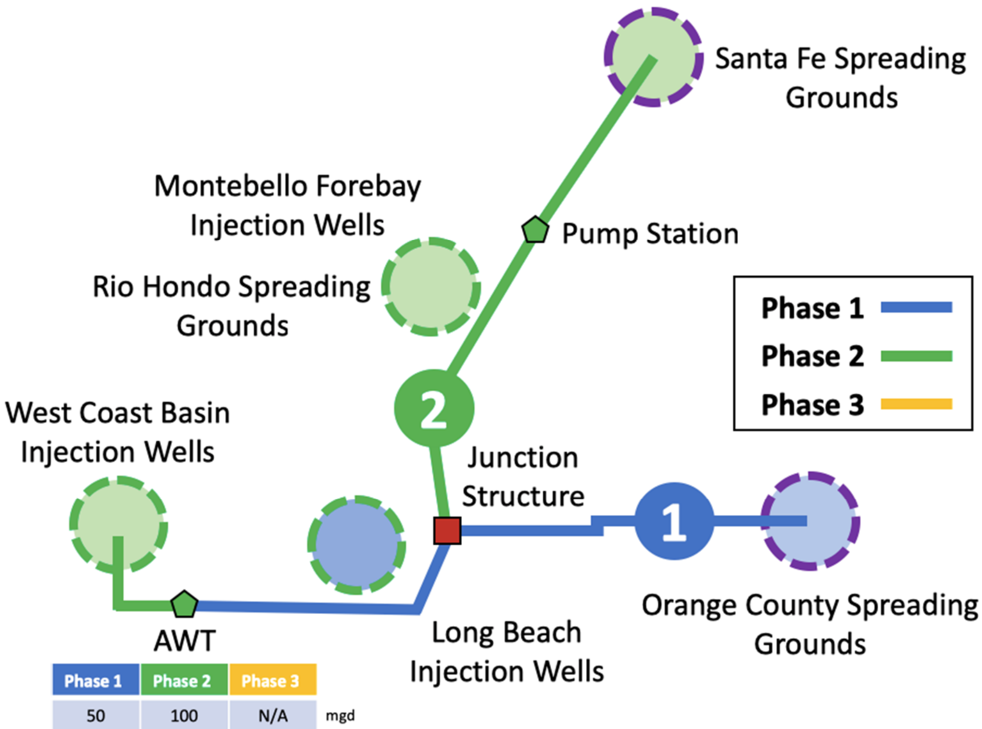


Table 3.11: Alternative C (East First) Description

Alternative C: East First					
1	Potential Demands	60 mgd	Length of Pipelines	29 miles
	AWT Capacity	50 mgd	Implementation Time	8 years
2	Potential Demands	90 mgd	Length of Pipelines	33 miles
	AWT Capacity	100 mgd	Implementation Time	7 years

Table 3.12: Alternative C (East First) Advantages and Disadvantages

Advantages	Disadvantages
• Offers a lower pumping elevation (223 ft) and pumping costs in Phase 1 than northern pipeline alignment. • Utilizes full AWT plant capacity to meet demands in Phase 1. • Provides a lowest cost means of implementing DPR (when permitted) by adding an additional transmission pipeline to the Diemer WTP.	• May compete with other sources of water available for replenishment in Orange County. • Requires higher level of treatment and treatment costs in Phase 1 to meet basin plan nitrate targets. • Requires multiple RWQCB permitting approvals.

3.7 Alternative D: Three-Phase Scenario (Central First)

As illustrated in Figure 3.6, Alternative D is a three-phase approach that provides for expansion of the AWT plant in three 50-mgd steps and initially extends the conveyance system to the West Coast Basin, Rio Hondo Spreading Grounds, and Montebello Forebay. In Alternative D, the second and third phases of the program extend the conveyance system to the Santa Fe Spreading Grounds and the Orange County Spreading Grounds, respectively. Table 3.13 summarizes the alternative, and Table 3.14 summarizes its advantages and disadvantages.

Figure 3.6: Alternative D (Central First)

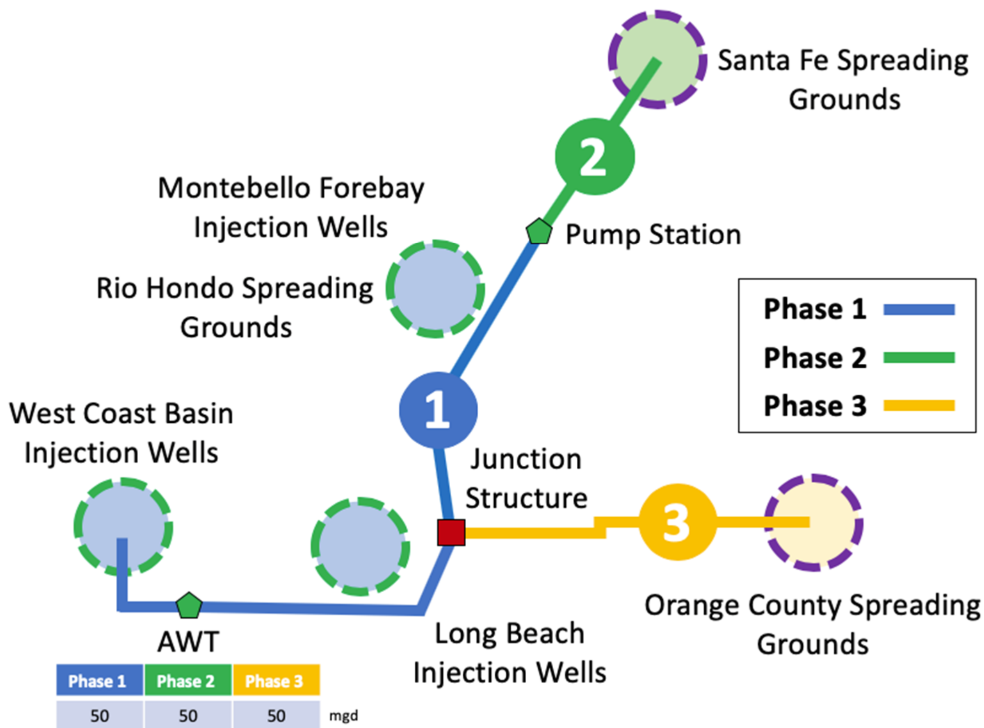


Table 3.13: Alternative D (Central First) Description

Alternative D: Central First					
1	Potential Demands	32 mgd*	Length of Pipelines	36 miles
	AWT Capacity	50 mgd	Implementation Time	8 years
2	Potential Demands	72 mgd	Length of Pipelines	10 miles
	AWT Capacity	50 mgd	Implementation Time	6 years
3	Potential Demands	46 mgd	Length of Pipelines	16 miles
	AWT Capacity	50 mgd	Implementation Time	6 years

*Expected potential demands in Phase 1 fall short of AWT plant capacity.

This scenario offers flexibility in terms of the order in which conveyance beyond Phase 1 is implemented. It suffers, however, from a significant shortfall of demands in the first phase of development. For this alternative to perform in a cost-effective manner, additional demands in the West Coast and Central Basins would have to be identified and developed. While this possibility exists (e.g., the Water Replenishment District's Regional Brackish Water Reclamation Feasibility Study is investigating a potential for increasing pumping in the West Coast Basin), the outcomes are not certain at this point.

For the purposes of comparing the potential performance of both three-phase approaches, it is assumed that additional demands can be identified to use the full yield of the Phase 1 AWT plant. As stated for the two-phase alternatives (B and C), under these three-phase alternatives, the extent of delay between phases has not been estimated or considered.

Table 3.14: Alternative D (Central First) Advantages and Disadvantages

Advantages	Disadvantages
• Flexibility in decision regarding implementation of additional phases. • Lower initial capital costs. • Lower impact on Metropolitan's overall costs in Phase 1.	• Relies heavily on consumptive demands in the Harbor Area and Central Basin. • Depends on injection wells for recharge. • Currently identified demands are insufficient to use 50-mgd AWT capacity. • Does not reach most reliable replenishment demands.

3.8 Alternative E: Three-Phase Scenario (Harbor Area)

Finally, the second three-phase scenario (Alternative E) initiates the program with the smallest-scale initial investment of all the alternatives considered. As illustrated in Figure 3.7, the initial phase of this scenario extends from the AWT plant to the control/junction structure in Cerritos. From there, the second and third phases of the program extend to the Santa Fe Spreading Grounds and the Orange County Spreading Grounds, respectively. As in Alternative D above, this scenario offers flexibility with respect to the order of implementation for Phases 2 and 3, while minimizing the initial investment and time needed to bring a working project online. Table 3.15 summarizes the alternative, and Table 3.16 summarizes its advantages and disadvantages.

Figure 3.7: Alternative E (Harbor Area)

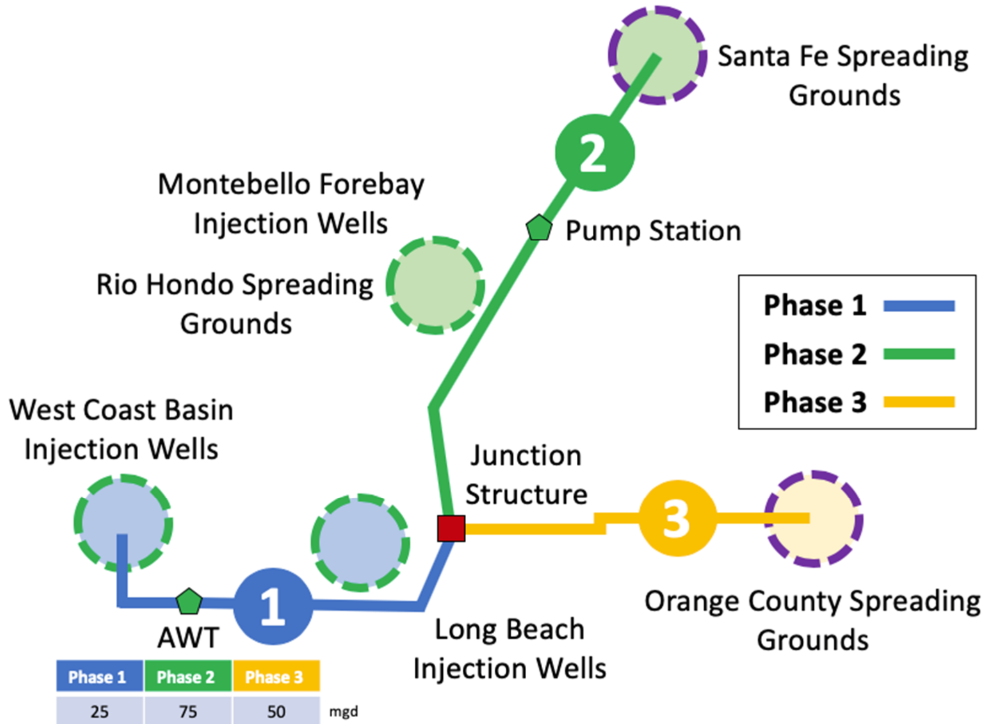


Table 3.15: Alternative E (Harbor Area) Description

Alternative E: Harbor Area				
1	Potential Demands	23 mgd	Length of Pipelines	21 miles
	AWT Capacity	25 mgd	Implementation Time	7 years
2	Potential Demands	81 mgd	Length of Pipelines	25 miles
	AWT Capacity	75 mgd	Implementation Time	7 years
3	Potential Demands	46 mgd	Length of Pipelines	16 miles
	AWT Capacity	50 mgd	Implementation Time	6 years

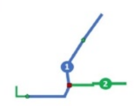
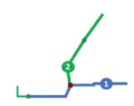
Table 3.16: Alternative E (Harbor Area) Advantages and Disadvantages

Advantages	Disadvantages
• Lowest initial capital costs. • AWT plant initially sized to meet near-term Harbor and Central Basin needs. • Most rapid Phase 1 implementation schedule. • Most flexibility in decision regarding implementation of additional phases.	• Phase 1 relies on least certain replenishment demands. • A large percentage of the production would serve consumptive demands. • Depends on injection wells for recharge. • Does not reach most reliable replenishment demands.

3.9 Program Phasing Evaluation Findings

This section compares the phasing scenario alternatives according to selected quantitative evaluation criteria. The summary of cost data provided in Table 3.17 presents a side-by-side comparison of each phase of the five alternatives for selected performance metrics.

Table 3.17: Comparison of Phasing Alternatives

	Alternatives				
Legend Phase 1 (blue) Phase 2 (green) Phase 3 (yellow)					
Selected Criteria	**A**	**B**	**C**	**D**	**E**
Number of Phases	1	2	2	3	3
Description	Full Program	North First	East First	Central First	Harbor Area
AWT Production (mgd)	150	150	150	150	150
Phase 1	150	100	50	50	25
Phase 2		50	100	50	75
Phase 3				50	50
Conveyance (miles)	62	62	62	62	62
Phase 1	62	46	37	36	21
Phase 2		16	25	10	25
Phase 3				16	16
Capital Costs ($M)[1]	$3,080	$3,193	$3,292	$3,344	3,410
Phase 1	$3,080	$2,546	$1,642	$1,836	$1,177
Phase 2		$647	$1,651	$847	$1,574
Phase 3				$661	$659
Annual O&M Costs ($M)	$134	$134	$134	$134	$134
Phase 1	$134	$75	$43	$33	$15
Phase 2		$59	$91	$41	$43
Phase 3				$59	$75
Annual Financing Costs ($M)	$155	$161	$173	$176	$181
Phase 1	$155	$126	$86	$96	$62
Phase 2		$34	$87	$45	$83
Phase 3				$35	$35
Total Annual Costs ($M)	$288	$294	$307	$309	$314
Phase 1	$288	$201	$129	$129	$78
Phase 2		$93	$178	$86	$127
Phase 3				$94	$110
Total Unit Cost ($/acre-ft [AF])	$1,752	$1,788	$1,862	$1,880	$1,909
Phase 1	$1,752	$1,803	$2,345	$2,347	$2,831
Phase 2		$1,703	$1,621	$1,575	$1,540
Phase 3				$1,717	$2,000
Avg. MWD Cost Increase ($/AF)[2]	$170	$173	$180	$182	$185
Phase 1	$170	$118	$76	$76	$46
Phase 2		$55	$105	$51	$75
Phase 3				$55	$65

[1]2018 Dollars

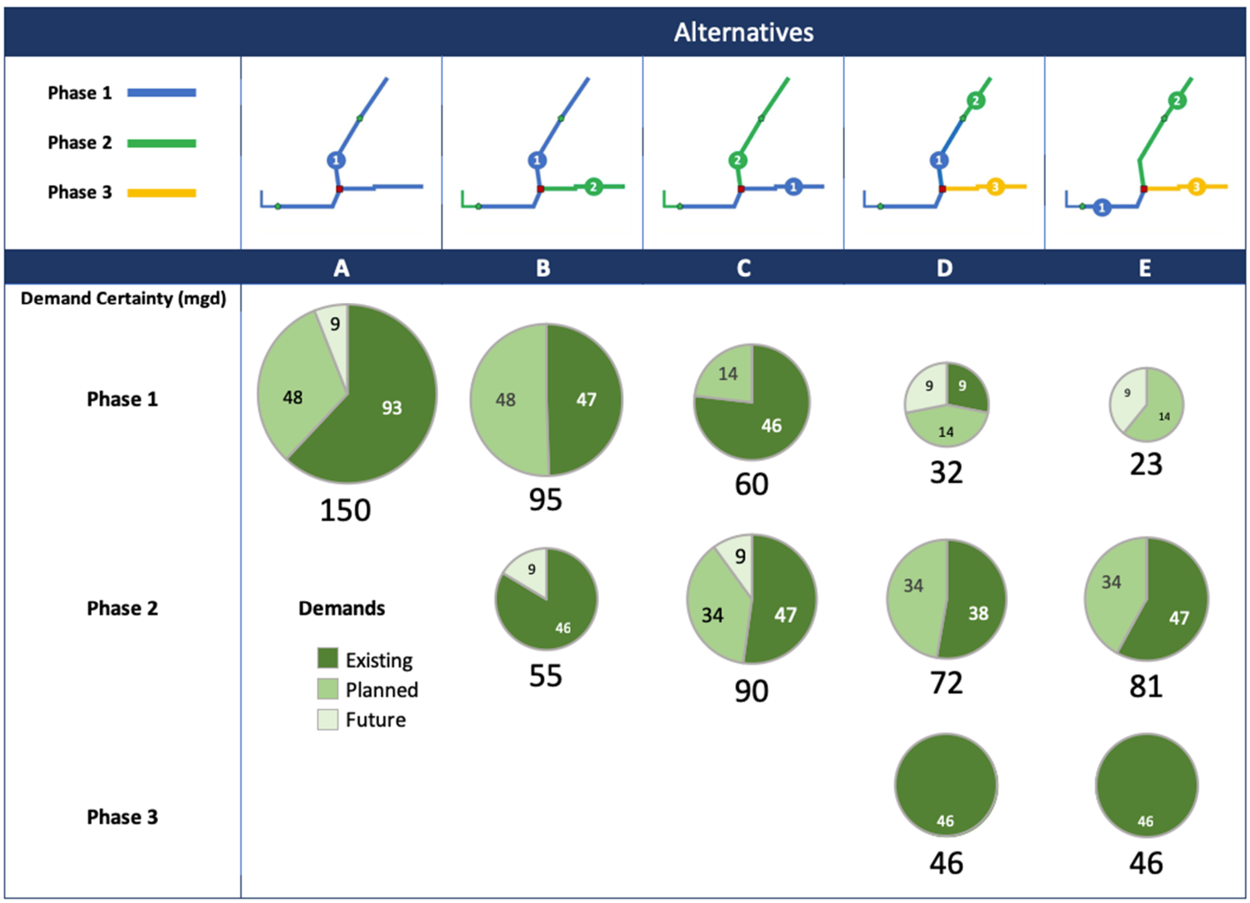
[2]When project is fully operational and based on Metropolitan's 2017/18 Budget of 1.70 MAF.

A more detailed breakdown of the incremental costs in each phase of Alternatives A through E is provided in Appendix A.

Assessment of Demand Certainty by Phase

Figure 3.8 presents a breakdown of the certainty (existing, planned, and future) in the demands expected in each phase of the five alternatives. The pie-chart size is proportional to the volume of daily peak demands in million gallons per day (mgd). Alternatives B and C can reach spreading basins in the first phase of implementation and can avoid reliance on future replenishment demands in the West Coast Basin, if necessary. Conversely, the first phase of Alternatives D and E are both reliant on a high percentage of future demands and compare unfavorably to other alternatives in this regard.

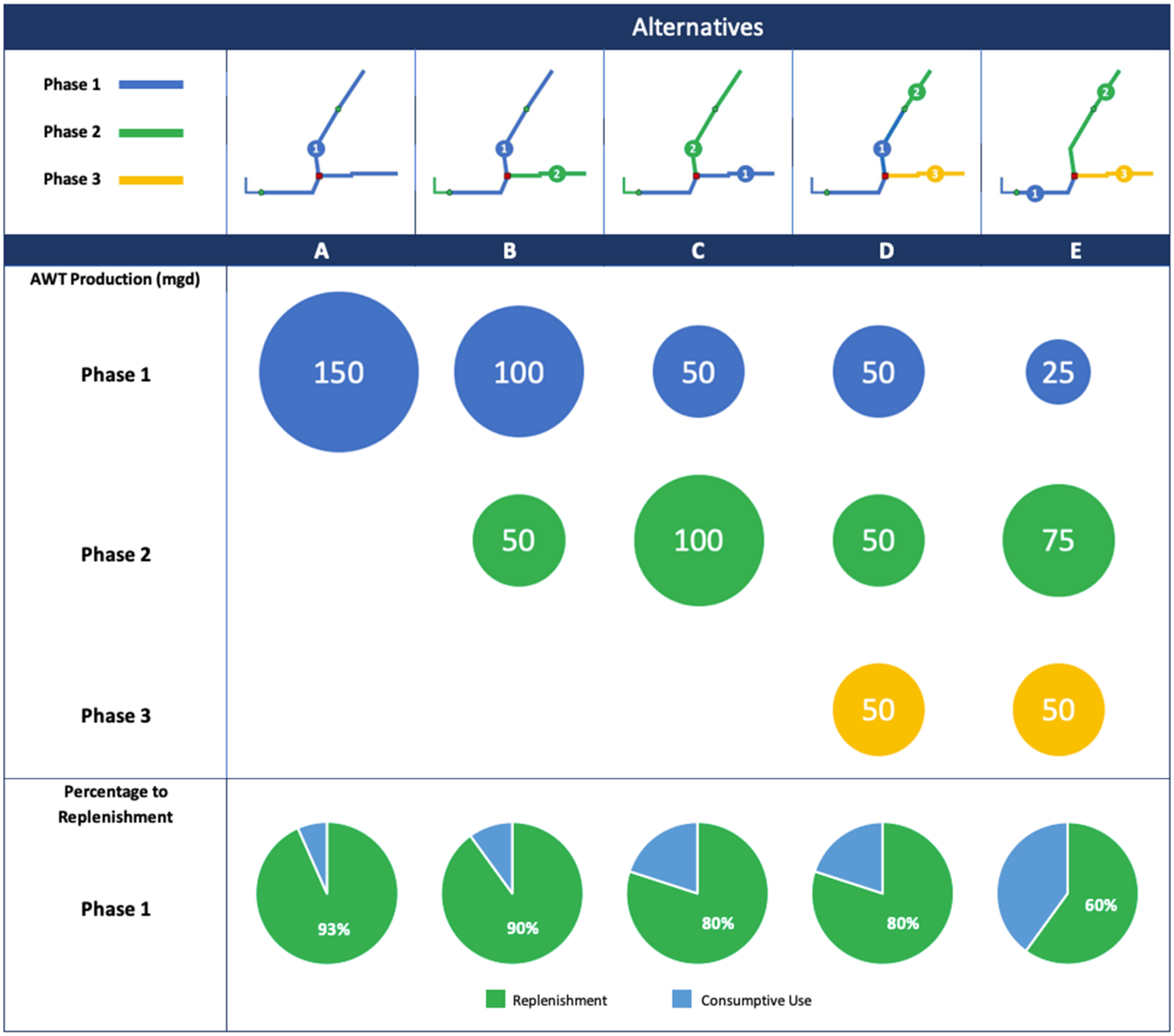
Figure 3.8: Expected Demands and Assessment of Certainty by Phase



Assessment of Replenishment Demands by Phase

Figure 3.9 presents the AWT production capacity assumed for each alternative scenario. It also shows the percentage of production that would serve replenishment demands in the first phase of each alternative. Because the forecasted consumptive demands are fully served in the first phase of every alternative, all subsequent phases are assumed to serve 100% replenishment demands (and are therefore not shown).

Figure 3.9: AWT Production Capacity by Phase and Phase 1 Replenishment Percentage



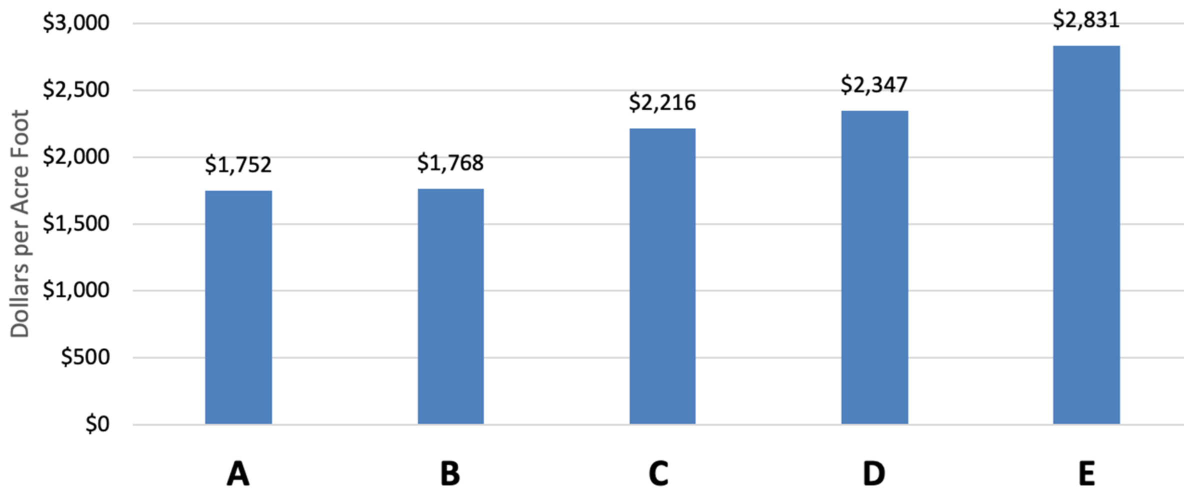
Note: Alternative C could deliver 100% of its Phase 1 production to Orange County Basin replenishment.

The first phase of both Alternatives C and D assume an initial 50-mgd AWT plant. Consequently, both indicate 20% of production going to existing consumptive demands in the Harbor Area. It should be noted that Alternative C, which reaches the Orange County Basin in Phase 1, could bypass the Harbor Area refineries and deliver 100% of its initial capacity to Orange County, if necessary. Also, worth noting is the heavy reliance of Alternative E on refinery demands in the first phase, which is inconsistent with the program phasing objective of producing a significant portion of any phase's supply for groundwater recharge.

Unit Production Costs

As shown in Figure 3.10, at $1,768 per acre-foot (AF), the unit cost of delivered water in the first phase of Alternative B (North First) is nearly equivalent to the total unit cost for the full-scale program (Alternative A) at $1,752/AF. As indicated in Table 3.17, the unit costs of delivered water in every alternative ranges from a low of $1,752/AF (Alternative A) to a high of $1,909/AF (Alternative E) when the full-scale 150-mgd program is implemented.

Figure 3.10: Phase 1 Unit Production Costs by Alternative ($ per/AF)

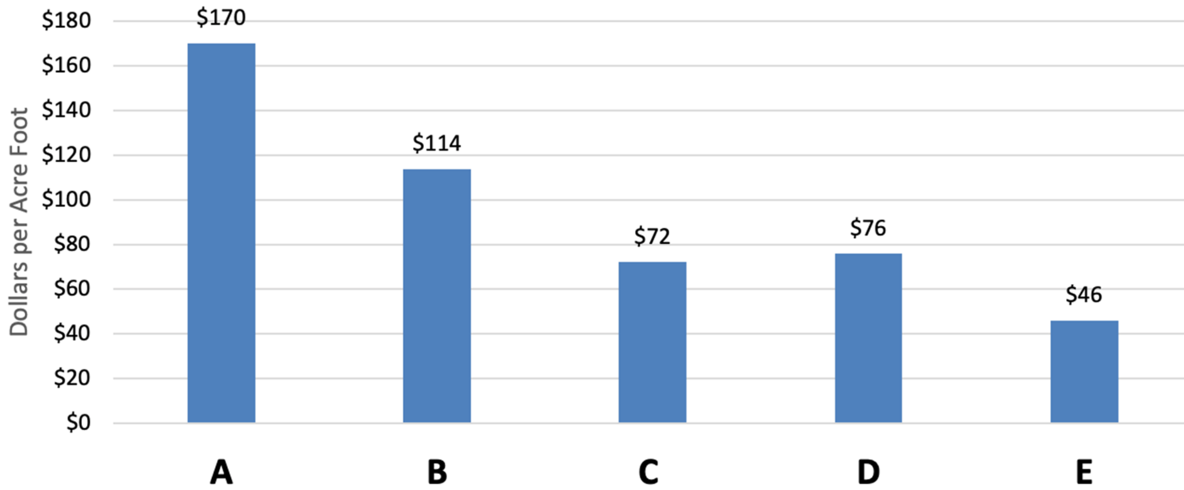


Initial Impacts on Metropolitan's Average Cost per Acre-Foot

Metropolitan's overall cost increases per AF represent the increased costs for Metropolitan's water services and is calculated by spreading annual project costs across Metropolitan's projected water sales and exchange transactions of 1.7 MAF, as budgeted for 2017/18. The calculation is made for illustrative purposes only and does not reflect a cost allocation of the project costs of any kind.

As illustrated in Figure 3.11, the impact of the first phase of Alternative B (North First) on Metropolitan's costs per AF is 33% less than building the full-scale Alternative A, and Alternatives C (East First) and D (Central First) are 58% and 55% less than Alternative A, respectively. Again, as presented in Table 3.17, Metropolitan's costs increase from a low of $170/AF (Alternative A) to a high of $185/AF (Alternative E) when the full-scale 150-mgd program is implemented. The calculation of average cost per AF increases are based on fully operational projects and Metropolitan's 2017/18 budget of 1.7 MAF.

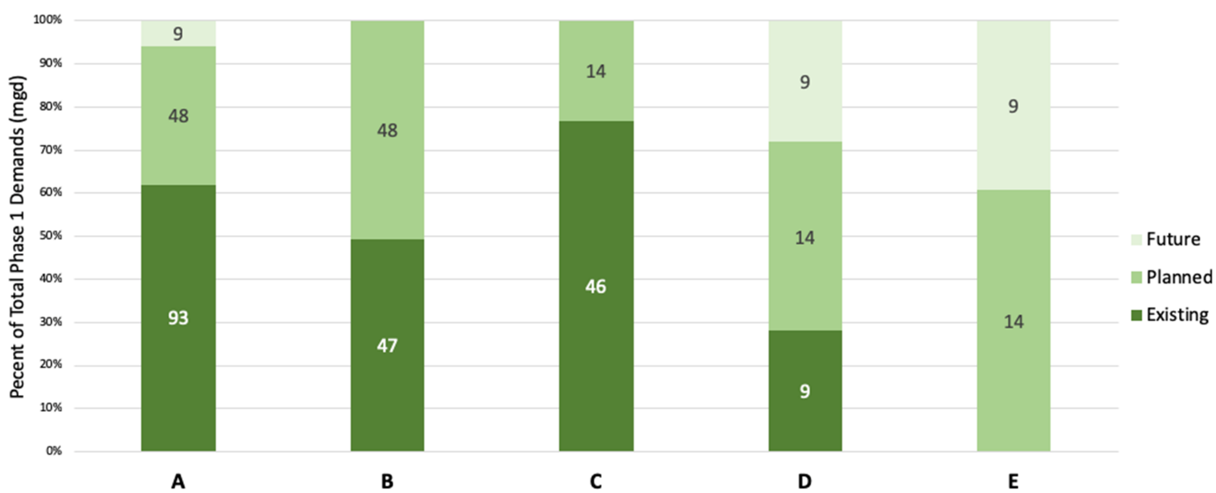
Figure 3.11: Phase 1 Average Metropolitan Overall Cost Increase ($/AF)



Certainty of Phase 1 Demands

As illustrated in Figure 3.12, the certainty of demand for the first phases of Alternatives B (North First) and C (East First) is considerably higher than when compared to the first phases of Alternatives D (Central First) and E (Harbor Area). When the uncertainty of demand is combined with the cost sensitivity to lower-than-expected demands, Alternative D (Central First) and Alternative E (Harbor Area) are both considered undesirable in comparison to the other alternatives.

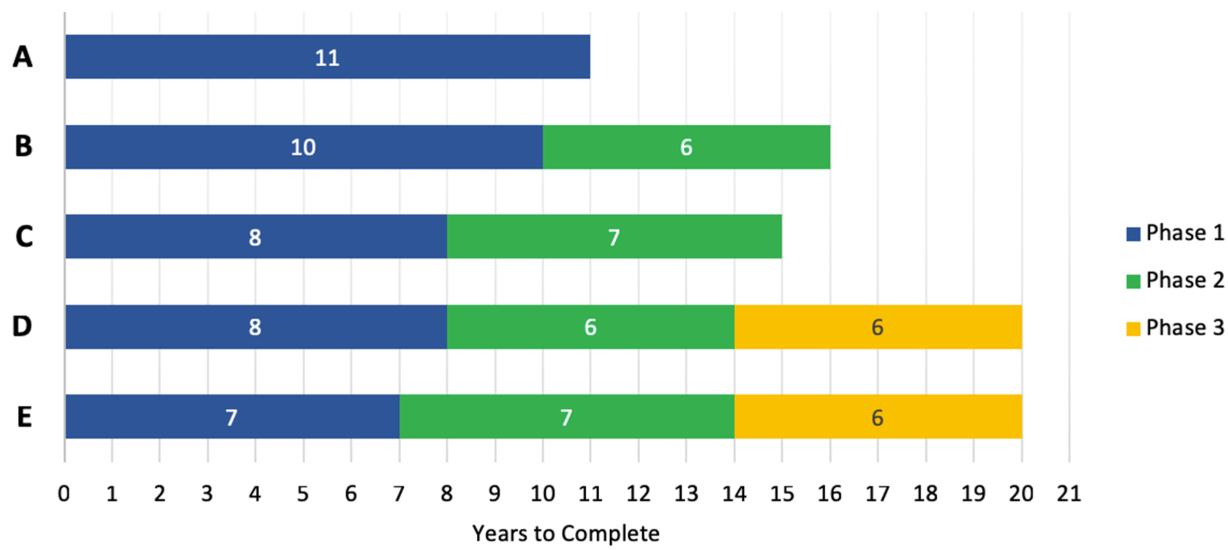
Figure 3.12: Percentage of Existing, Planned, and Future Demands (Phase 1)



Overall Program Implementation Time

As shown in Figure 3.13, the overall duration of the program could be extended by up to 6 additional years (Alternative D), assuming subsequent phases begin, without significant delays, following completion of the prior phase. Due to the uncertainties associated with future conditions, it is not possible to forecast the likelihood of achieving the assumed timing. It is fair to suggest that more phases increase the risks of unexpected delays or barriers to completion of the full program. All the multi-phase alternatives offer first-phase completion durations that are shorter than the full-scale program (Alternative A).

Figure 3.13: Implementation Durations by Alternative and Phase (Years)



Regulatory Complexity Phase 1 Alternatives

The regulatory complexity of the first phases of Alternative B (North First), Alternative D (Central First), and Alternative E (Harbor Area) is less than those alternatives that require coordination with and approvals from two RWQCBs. Alternative A (Full Program) and C (East First) both require approvals (i.e., water recycling permits) from two regional boards.

Flexibility for Future DPR Options

Three of the alternatives (A, B, and C) could allow for the addition of DPR capabilities following the first phase of implementation in the form of raw water augmentation at the Weymouth WTP and the Diemer WTP. The availability of a DPR option allows significant operational flexibility when used in conjunction with IPR deliveries and may significantly expand the benefits of the program.

The location of both WTPs in relation to the proposed RRWP facilities provides a unique opportunity for purified water to supplement raw water supplies to a drinking water treatment plant, once DPR regulations are approved. Regulations for the raw water augmentation form of DPR could be established by the end of 2023, based on the state of scientific and technical research at that time. In pursuing DPR options for the RRWP, several enhancements would likely be required by future regulations to compensate for the loss of the environmental buffer (i.e., groundwater basin).

Source control programs under a DPR application are expected to be more prescriptive and further optimization of wastewater treatment processes may also be needed. It is anticipated that higher levels of advanced water treatment will also be required by future raw water augmentation regulations. In addition, minimum dilution requirements will likely be required by regulators when blending advanced treated recycled water with other raw waters at the Weymouth or Diemer WTPs. Initial blending requirements may be conservative until greater experience on raw water augmentation projects is gained in the future. Operational changes or investments at the Weymouth or Diemer WTPs would also need to be evaluated when considering DPR integration.

Additional conveyance facilities would be required for potential future integration of raw water augmentation for the RRWP. A connection from the Santa Fe Spreading Grounds area to the Weymouth WTP would require additional pipeline reaches and pump stations. Connecting the RRWP system to the Weymouth WTP would also allow advanced treated water to be brought to the Diemer WTP via Metropolitan's existing Yorba Linda Feeder. A connection from the RRWP system just south of the Whittier Narrows area could also be established to the Diemer WTP, requiring additional pipeline reaches and pump stations. Additional engineering studies are needed to further evaluate these conveyance options.

Raw water augmentation may be a viable future opportunity for the RRWP, but additional work is needed to fully evaluate it. Metropolitan continues to actively engage with the water industry on the regulatory development of DPR. Section 8.9 and Appendix B provide additional details on various elements that must be considered for DPR as a viable future option in the RRWP.

3.10 Multi-Objective Decision Analysis (MDA)

In order to develop a refined comparison of the five alternatives, a weighted MDA was developed utilizing the objectives, criteria, and performance metrics presented in Section 3.3, and weightings provided by 11 senior Metropolitan project team members[1]. Building on the performance metrics presented earlier in Table 3.1, the following Table 3.18 of nonredundant values was developed for comparing alternatives. For comparative purposes, redundant metrics were eliminated (e.g., "Total Annual Costs" was not included because "MWD Overall Cost Increase" reflects the same attribute).

[1] Team members included: Arabshahi, J; Bednarski, J; Chaudhuri, M; Harding, R; Hacker, M; Johnson, G; Lai-Bluml, G; McGeeney, K; Napoli, T; Schaffer, C; and Stalvey, M.

Table 3.18: Phase 1 Alternatives Evaluation Criteria and Performance

Program Phase 1 Performance Metrics					
Evaluation Criteria	1 Phase	2 Phases		3 Phases	
	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Starting Location	AWT	AWT	AWT	AWT	AWT
Terminus	Complete	Santa Fe SG	OC Spreading	Rio Hondo	Cerritos JS
Regulatory Complexity (# Boards)	2	1	2	1	1
Basins Served	4	3	3	2	2
Demand Certainty (% MGD Existing)	63%	47%	92%	18%	0%
Future Flexibility (DPR opportunities)	2	3	4	1	5
Wastewater Supply Certainty (MGD)	150	100	50	50	25
Percentage to Recharge	93%	90%	80%	80%	60%
Average Annual Yield (TAF)	165	110	55	55	27
MWD Overall Cost Increase ($/AF)*	$170	$114	$72	$76	$46
Unit Cost of Yield ($/AF)	$1,752	$1,768	$2,216	$2,347	$2,831
Construction Duration (Years)	11	10	8	8	7

*When project phase is fully operational and based on Metropolitan's 2017/18 Budget of 1.70 MAF.

Note: Colors range from Dark Green for Highest Rank to Red for Lowest Rank

For each of the criteria, a range of dimensionless scores from the highest ranked alternative (assigned a score of 1) to the lowest ranked alternative (assigned a score of 0) was developed. Scores between the highest and lowest performance were assigned based on a linear distribution of the intermediate values on the scale from 0 to 1. For example, Table 3.19 illustrates the conversion of average annual yield for each alternative (presented in thousand acre-feet) to relative scores from 0 to 1.

Table 3.19: Conversion of Performance Data to Relative Values

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Average Annual Yield (TAF)	165	110	55	55	27
Average Annual Yield (Relative Score)	1.000	0.601	0.203	0.203	0.000

To further illustrate the method of assigning relative scores, Figure 3.14 provides a scatter plot of the performance metric values and relative scores included in Table 3.19. This method allows for a comparison of the relative performance of alternatives without the need to convert a diverse assortment of performance metrics into a common dollar-denominated quantitative measure.

Figure 3.14: Plot of Performance Values and Relative Scores for Average Annual Yield

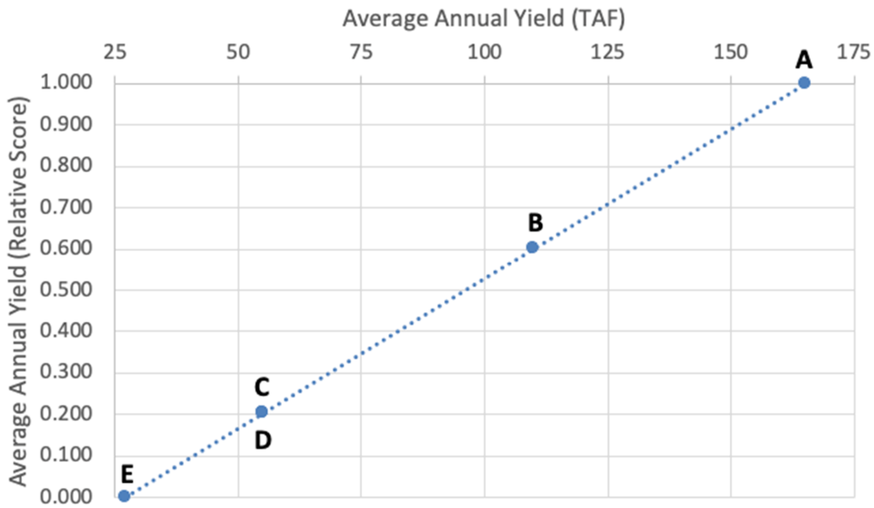


Table 3.20 presents each of the criteria performance metrics in Table 3.18 expressed on a relative score basis. At this stage, all the criteria are equally weighted, and the totals do not indicate the importance of respective objectives.

Table 3.20: Unweighted Partial and Total Scores

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Partial Values					
Regulatory Complexity (# Boards)	0.000	1.000	0.000	1.000	1.000
Basins Served	1.000	0.500	0.500	0.000	0.000
Demand Certainty (% MGD Existing)	0.681	0.511	1.000	0.196	0.000
Future Flexibility (DPR opportunities)	0.600	0.560	0.520	0.611	0.451
Wastewater Supply Certainty (MGD)	0.000	0.800	1.000	1.000	1.000
Percentage to Recharge	1.000	0.909	0.606	0.606	0.000
Average Annual Yield (TAF)	1.000	0.601	0.203	0.203	0.000
MWD Overall Cost Increase ($/AF)	0.000	0.452	0.790	0.758	1.000
Unit Cost of Yield ($/AF)	1.000	0.985	0.570	0.449	0.000
Construction Duration (Years)	0.000	0.250	0.750	0.750	1.000
Overall Unweighted Score	5.281	6.568	5.939	5.572	4.451

For all the evaluation criteria except wastewater supply uncertainty, the assignment of relative scores is based on simple linear relationships among the alternative performance metrics ranging from the highest to the lowest, as described above. For the wastewater supply criterion, a simplified hyperbolic function was applied, recognizing that as the AWT plant capacity declines from 150 mgd, the certainty of available wastewater effluent rapidly increases to nearly 100% and remains at that value regardless of further reductions in capacity.

Finally, the ranking of alternatives related to future flexibility was developed from a composite score comprised of sub-criteria including additional infrastructure needed to reach the Weymouth WTP and Diemer WTP, as well as the volume of purified water remaining after groundwater replenishment demands are met. The proximity of conveyance to water treatment plant sites included in each alternative increased scores, while smaller volumes of wastewater effluent available for direct potable uses lowered scores. The combination of these factors is represented in the future flexibility ranking in Table 3.20.

Weighting the Criteria

Because each criterion is not deemed equally important, a weighting process was conducted to assign subjective weightings to each objective. Senior Metropolitan project team members were asked to complete an individual ranking of the importance of each criterion through a process of forced paired comparisons. The results of those rankings were consolidated to produce the overall weighting shown in Table 3.21.

Table 3.21: Consolidated Weighting of Evaluation Criteria

Evaluation Criteria	Points	Percentage
Regulatory Complexity (# Boards)	25	5%
Basins Served	48	10%
Demand Certainty (% MGD Existing)	61	12%
Future Flexibility (DPR opportunities)	48	10%
Wastewater Supply Certainty (MGD)	37	7%
Percentage to Recharge	60	12%
Average Annual Yield (TAF)	61	12%
MWD Overall Cost Increase ($/AF)	71	14%
Unit Cost of Yield ($/AF)	70	14%
Construction Duration (Years)	14	3%
	495	100%

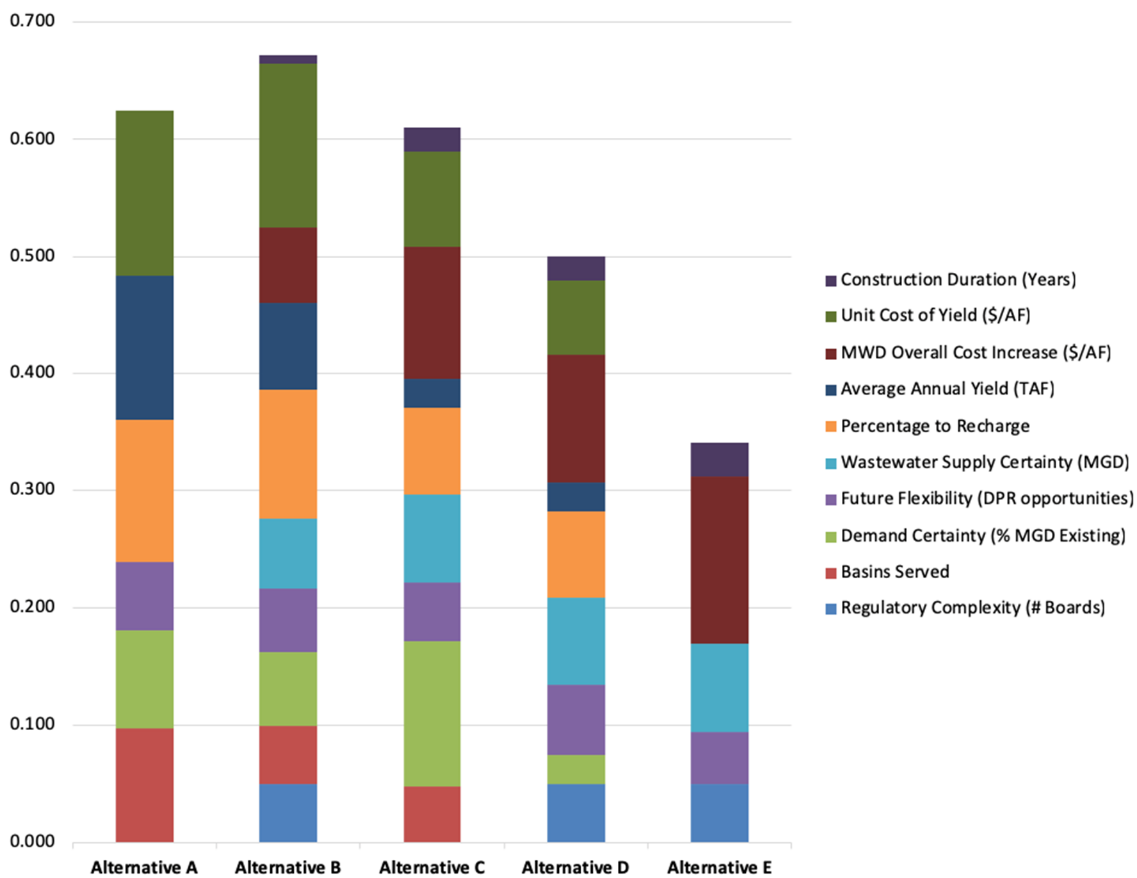
When the weightings in Table 3.21 are applied to the raw scores in Table 3.20, the resulting weighted scores for each alternative are presented in Table 3.22.

Table 3.22: Weighted Partial and Total Scores

	Alternative A	Alternative B	Alternative C	Alternative D	Alternative E
Weighted Partial Values					
Regulatory Complexity (# Boards)	0.000	0.051	0.000	0.051	0.051
Basins Served	0.097	0.048	0.048	0.000	0.000
Demand Certainty (% MGD Existing)	0.084	0.063	0.123	0.024	0.000
Future Flexibility (DPR opportunities)	0.058	0.054	0.050	0.059	0.044
Wastewater Supply Certainty (MGD)	0.000	0.060	0.075	0.075	0.075
Percentage to Recharge	0.121	0.110	0.073	0.073	0.000
Average Annual Yield (TAF)	0.123	0.074	0.025	0.025	0.000
MWD Overall Cost Increase ($/AF)	0.000	0.065	0.113	0.109	0.143
Unit Cost of Yield ($/AF)	0.141	0.139	0.081	0.063	0.000
Construction Duration (Years)	0.000	0.007	0.021	0.021	0.028
Overall Weighted Score	0.625	0.672	0.611	0.500	0.341

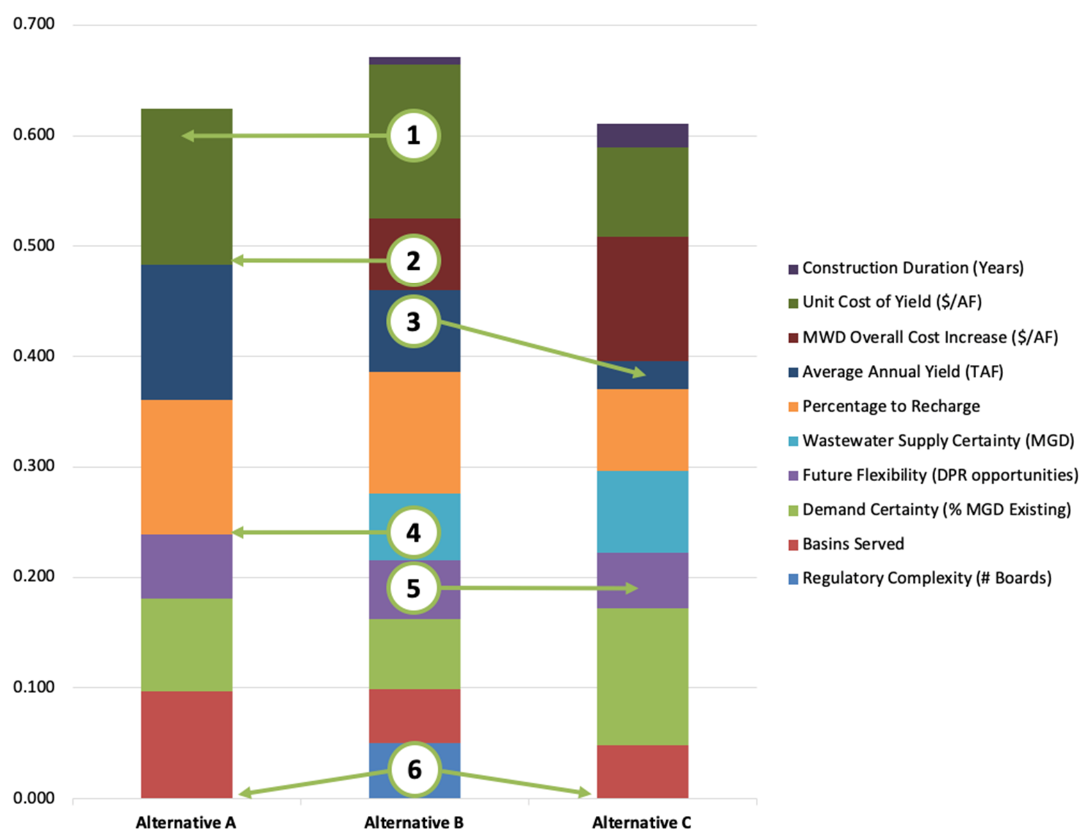
Figure 3.15 presents a bar chart comparison of the values presented in Table 3.22. As illustrated in the figure, Alternatives A and B are closely matched, with Alternative C slightly lower than the two highest ranking alternatives. Alternatives D and E are clearly inferior to the top 3 alternatives. Further, the analysis suggests that a multi-phase approach (Alternative B) performs as well or better than implementing the entire program in a single phase (Alternative A). This is an important finding that will be discussed further in this chapter.

Figure 3.15: Breakdown of Overall Alternative Score by Criterion



To further illustrate the information contained in this comparison, Figure 3.16 highlights some of the key factors that differentiate Alternative B from Alternatives A and C.

Figure 3.16: Alternative B Compared to Alternatives A and C



Alternative B balances several of the strengths of Alternatives A and C. Following the numbered callouts on Figure 3.16, Alternative B offers the following advantages:

1. Unit cost of yield of production is nearly equivalent to Alternative A.
2. Impacts on Metropolitan's overall cost increases are reduced from Alternative A.
3. Average annual yield is higher than Alternative C.
4. Risk of lower than expected wastewater flows is reduced from Alternative A.
5. Future flexibility to incorporate DPR includes a Weymouth WTP option.
6. Regulatory complexity is reduced from both Alternatives A and C.

While the top three alternatives are scored within a range of approximately 10% of one another, Alternative B offers the most balanced approach, including significant economies of scale and proximity to both Metropolitan WTPs (similar to Alternative A) at lower overall uncertainty (similar to Alternative C). For these reasons, Alternative B (North First) was considered the most desirable among the five alternatives considered.

3.11 Conclusion

The evaluation of phasing alternatives demonstrates that the program will likely benefit from implementation in two phases, with the first phase project designed to extend from the JWPCP in Carson to the Santa Fe Spreading Grounds in Irwindale.

In summary, the potential advantages of the proposed two-phased approach include the following:

1. Greater certainty regarding future demands sufficient to use the production from a 100-mgd AWT plant.
2. Greater certainty regarding the long-term availability of sufficient secondary effluent from the JWPCP to meet initial production needs.
3. Increased flexibility by allowing multiple pathways to serve Orange County groundwater needs and potential DPR applications in the future.
4. Lower initial capital and O&M costs reducing the initial impact on Metropolitan's overall cost increases.
5. Unit costs of production that are nearly equivalent to the unit cost estimates for the full-scale program.

It should be noted that the comparison of alternatives in this evaluation does not incorporate any forecast of delays, cost increases, or regulatory changes between phases. Any time a large program is implemented in discrete stand-alone phases, unforeseen changes in circumstance and conditions could significantly alter the final program costs.

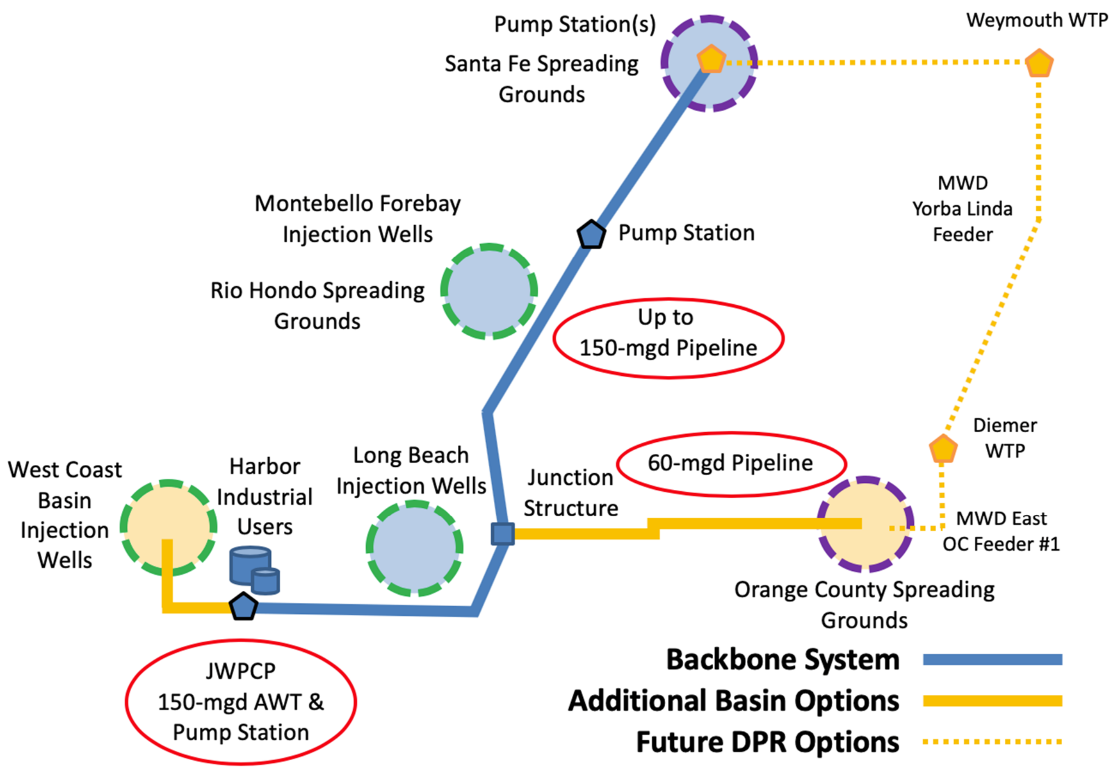
3.12 Proposed First Phase Project (Backbone System)

Building upon the conclusion that Alternative B (North First) was the most desirable option, a proposed implementation strategy was developed. The proposed approach provides: (1) an AWT plant sized to meet near-term existing and planned future demands, (2) a pipeline sized to accommodate both existing and potential future uses, and (3) the flexibility to adapt the initial system for DPR once applicable regulations are established. Any DPR option would supplement the initial IPR program, not replace it.

The proposed implementation strategy represents a modification to Alternative B (North First) and provides treatment for up to 100 mgd of purified water conveyed from the AWT plant in Carson to the Santa Fe Spreading Grounds through a pipeline sized for up to 150 mgd (the full program capacity). To implement this approach, approximately 25 miles of pipeline between Cerritos and the Santa Fe Spreading Grounds have been upsized from 60 inches to 84 inches internal diameter. This reconfigured version of Alternative B has been characterized as the Backbone System. Although the Backbone System serves the refinery demands adjacent to the JWPCP, it does not include the pipeline and injections wells needed for future West Coast Basin replenishment demands.

Figure 3.17 presents a schematic of the overall proposed Regional Recycled Water Program, including both IPR and DPR options for the future.

Figure 3.17: Proposed Regional Recycled Water Program



The additional groundwater basin options (solid yellow lines) can be implemented at any time after the Backbone System is completed. The DPR options (dashed yellow) will require further regulatory developments before the technical requirements and costs can be fully evaluated. Both the Yorba Linda Feeder and the East Orange County Feeder #1 (East OC Feeder #1) are existing Metropolitan pipelines.

The flexibility to provide several possible pathways to 150 mgd (or even higher flows) is one of the major benefits offered by the proposed Backbone System. Figure 3.18 presents the proposed first phase Backbone System on its own.

Figure 3.18: Proposed First Phase Project (Backbone System)

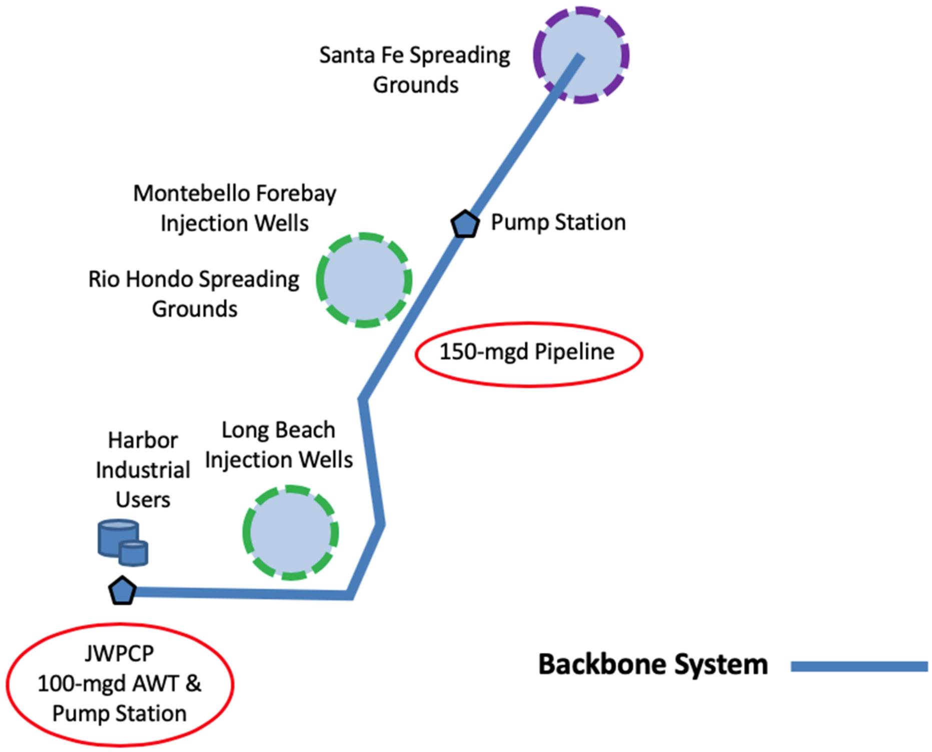


Table 3.23 presents a summary comparison of the Full Program Alternative A and the two phases of the Backbone System alternative. For the purposes of this comparison, the second phase of the Backbone System alternative is assumed to be the IPR pipeline from the control/junction structure to the Orange County Spreading Grounds, as described in Alternatives A through E. Given the uncertainty of future DPR requirements, it does not include the cost of any of the future DPR options shown in Figure 3.17.

The Backbone System includes an additional $192 million of capital costs associated with increasing the conveyance capacity to the Santa Fe Spreading Grounds. As indicated in Table 3.23, those increased capital costs combined with an estimated $125 million in costs related to multiple phases of implementation, increase the capital cost of the complete proposed program (with the Orange County IPR option) to $3.397 billion, a roughly 10% increase over the single-phase full program implementation capital cost of $3.080 billion. This premium is deemed reasonable given the reduced risk and increased flexibility of the proposed approach.

Table 3.23: Comparison of Full Program and Proposed Phased Approach

Performance Metrics	Full Program (Alternative A)	Proposed Program: Phase 1 (Backbone System)	Proposed Program: Phase 2 (OC IPR Option)	Proposed Program: Complete Program
AWT Production Capacity (MGD)	**150**	**100**	**50**	**150**
Starting Location	Carson	Carson	Cerritos	Carson
Terminus	Complete	Santa Fe SG	Anaheim	Complete
Basins Served	All	Central and MSG	West Coast and OC	All
Annual Demands (MGD)	150	86	65	150
Annual Demands (TAFY)	168	96	73	168
Miles of Conveyance in Phase (miles)	62	38	24	62
Highest Elevation (ft.)	500	500	200	500
AWT Production Capacity (MGD)	150	100	50	150
AWT Production Capacity (TAFY)	168	112	56	168
Average Yield (MGD)	147	98	49	147
Average Annual Yield (TAF)	165	110	55	165
Capital Cost of Phase ($Million)[1]	$3,080	$2,615	$782	$3,397
JWPCP Modifications	$150	$150	$0	$150
Advanced Water Treatment Plant	$570	$431	$188	$577
Conveyance Facilities	$899	$840	$190	$1,031
Well Facilities	$205	$128	$85	$213
Engineering Costs (25%)	$456	$387	$116	$493
Contingency (35%)	$798	$678	$203	$862
Annual O&M Cost of Phase ($Million)	$134	$69	$60	$129
Advanced Water Treatment	$108	$56	$52	$108
Conveyance	$24	$13	$7	$20
Well Field and Spreading Facilities	$1	$1	$1	$1
Annual Financing Costs ($Million)[2]	$155	$130	$42	$171
Total Average Annual Costs ($Million)	**$288**	**$199**	**$102**	**$301**
Unit Cost of Yield by Phase ($/AF)	$1,752	$1,813	$1,853	$1,826
Avg. MWD Cost Increase of Phase ($/AF)[3]	**$170**	**$117**	**$60**	**$177**
Construction Duration (Years)	11	10	6	16

[1] 2018 Dollars
[2] Assumes a 30 year term and 4.00% per annum interest rate.
[3] When project is fully operational and based on Metropolitan's 2017/18 Budget of 1.70 MAF.

Early Delivery Opportunities

As part of the implementation strategy, it is recommended that opportunities to make early deliveries of purified water be considered during the overall Backbone System development plan. As indicated in the demand assessment earlier in this chapter, there is potentially 23 mgd of purified water demand within an 8-mile radius of the AWT plant. Documented demands include up to 10 mgd of refinery demands in the Harbor Area, 4 mgd of replenishment demand in Long Beach, and potentially 9 mgd or more of replenishment demand in the West Coast Basin. Additionally, there may be opportunities to provide purified water to industrial demands in the Long Beach Harbor area that have not yet been fully defined or quantified.

Early deliveries to these potential customers (and others along the pipeline alignment) would provide operational experience at scale, immediate supply benefits, and some initial water sales for the program. Further, the modular design of many AWT processes is conducive to progressive expansion of treatment capacity as the conveyance system is completed.

Following the environmental planning process, approximately 10 to 11 years will be needed to complete the 100-mgd Backbone System, including the construction of approximately 38 miles of pipeline from Carson to the Santa Fe Spreading Grounds. Early deliveries to customers close to the AWT plant could potentially begin within 5 to 6 years after completion of the environmental process. The timing and sequence of the planning, design, and construction of infrastructure to meet these early delivery objectives would be more fully examined during subsequent CEQA and preliminary design efforts.

Summary of Proposed First Phase Project Performance Compared to Objectives

In Section 3.1, the implementation objectives for the RRWP were described as follows:

1. Perform as a fully functional and cost-effective stand-alone project.
2. Provide a significant addition to regional recycled water supply.
3. Include groundwater recharge as a major portion of deliveries.
4. Provide for future expansion to the full-scale program.
5. Achieve regulatory approvals consistent with those needed for the full-scale program.
6. Offer flexibility to accommodate future opportunities such as DPR.

Table 3.24 presents a comparison of the full program Base Case and the proposed Backbone System in accomplishing each of the stated objectives.

Table 3.24: Comparison of Base Case and Proposed First Phase Project

Objectives	Full Program Implementation	Proposed First Phase Project
Cost-effective, stand-alone project	• Yes. Project is a fully functional stand-alone system • Unit production cost: $1,752 per AF • Metropolitan overall cost increase: $170 per AF	• Yes. Project is a fully functional stand-alone system • Unit production cost: $1,813 per AF • Metropolitan overall cost increase: $117 per AF
Significant additional supply	• Creates up to 168 TAFY • Some demands uncertain	• Creates up to 112 TAFY • All demands existing or planned
Significant groundwater recharge	• 93% of water produced for groundwater replenishment	• 90% of water produced for groundwater replenishment
Future expansion	• Complete at 150 mgd • Provides conveyance capacity for IPR deliveries only	• Multiple pathways to 150+ mgd • Provides additional conveyance capacity for expansion and DPR
Regulatory approvals	• Approvals needed from two regional water quality control boards • Requires additional treatment to meet basin plan nitrate requirements in Orange County	• Approvals needed from one regional water quality control board • Avoids initial capital and O&M costs for basin plan nitrate requirements in Orange County
Flexibility for DPR	• All wastewater flow dedicated to IPR • Short pipeline needed to reach Diemer WTP	• Future wastewater flow available for DPR, if needed • Multiple DPR options to both WTPs

In addition to an expansion to meet Orange County Basin replenishment demands, other potential future program components that could be implemented in conjunction with the Backbone System include (1) a future purified water tie-in from a future AWT plant at the City of Los Angeles Hyperion Water Reclamation Plant, and (2) IPR in the Raymond and Chino groundwater basins.

In summary, initial implementation of the proposed first phase Backbone System provides:

1. Significant new replenishment supply conveyed to the largest existing and planned groundwater recharge demands.
2. Unit production costs are competitive with the overall program (3% higher than full program implementation).
3. Lower initial impact on Metropolitan's overall cost increases resulting from lower total annual costs (31% lower than full program implementation).
4. Reduced regulatory complexity.
5. Greatest flexibility to adapt to future regulatory changes that may permit the incorporation of DPR into the program.
6. Greater certainty of secondary effluent flows needed to meet production goals.

3.13 Next Steps

Based on a Metropolitan Board decision to proceed with the proposed first phase Backbone System, the following implementation steps are recommended:

1. Prepare a programmatic environmental impact report (EIR) for the entire RRWP (including DPR options).
2. Prepare project-specific environmental documents for projects within the proposed first phase Backbone System.
3. Begin preliminary design for the proposed first phase Backbone System conveyance system infrastructure.

Chapter 4

Advanced Water Treatment Plant

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4.0 ADVANCED WATER TREATMENT PLANT

This chapter provides an analysis of the treatment capacity, water quality, and water treatment infrastructure associated with the phasing alternatives presented in Chapter 3. It also summarizes the product water quality criteria and presents an update on the strategies for nitrogen and boron management.

4.1 Overview

The full-scale AWT plant would be sited within the Sanitation Districts' JWPCP in Carson and would receive unchlorinated, non-nitrified secondary effluent from the adjacent wastewater treatment facilities (see Figure 4.1). The full-scale AWT plant would be located on the Sanitation Districts' former Fletcher Oil and Refinery Company (FORCO) property east of the JWPCP secondary treatment facilities. The AWT plant would be designed to produce up to 150 mgd (168 TAFY) of high-quality water that meets the requirements for IPR through groundwater recharge. The product water quality goals would be achieved through the collaborative efforts of Metropolitan and the Sanitation Districts using source control measures and advanced water purification technologies, including tertiary MBR, RO, and UV/AOP processes. The process flow schematic for the AWT plant is presented in Figure 4.2.

Figure 4.1: Proposed Location of AWT Facilities at JWPCP

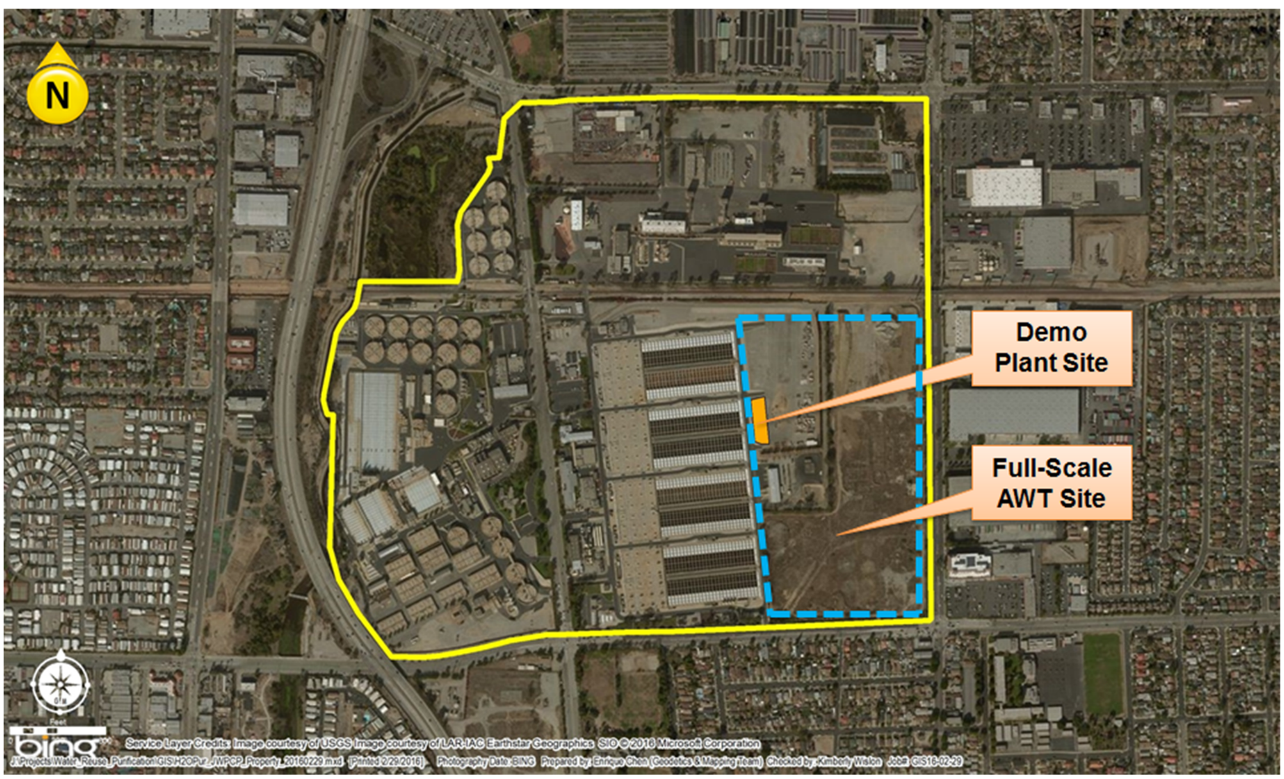
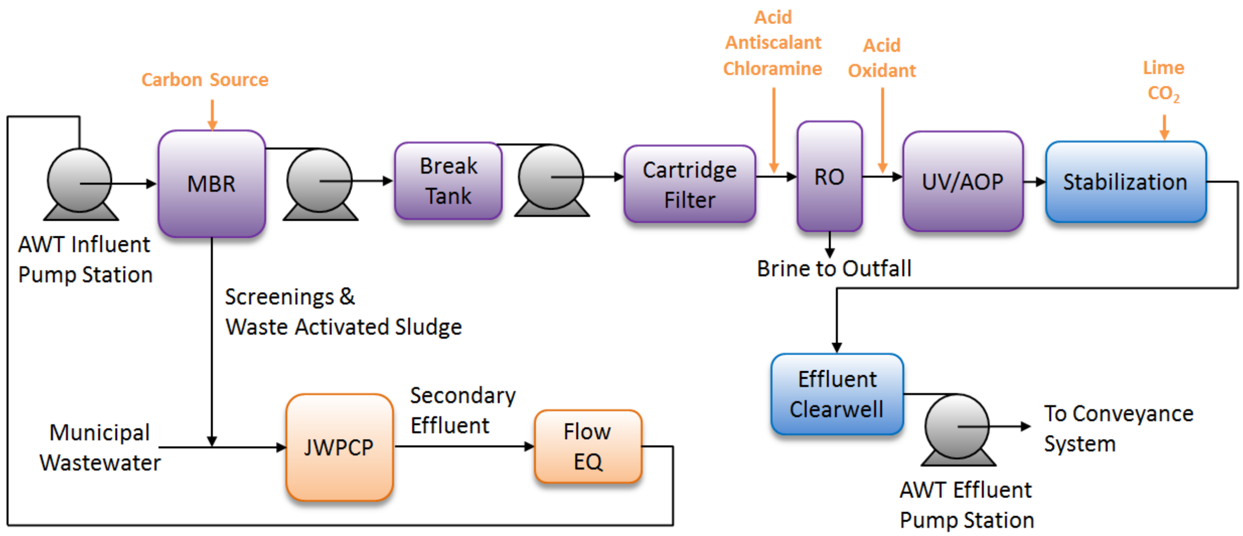


Figure 4.2: Process Flow Schematic for the Full-Scale AWT Plant



MBR will be used to completely nitrify and partially denitrify JWPCP's non-nitrified secondary effluent. Additional nitrate removal can be achieved through the downstream RO process. The level of denitrification would depend on the target nitrate objective for the receiving groundwater basin(s), as described below.

4.2 AWT Product Water Quality Criteria

Regulatory oversight of water reuse projects is carried out by the SWRCB through the DDW and the individual RWQCBs. The RWQCBs have the exclusive authority to enforce water reclamation requirements through permit enforcement. The RWQCBs rely on DDW's expertise to establish the permit conditions to protect public health. DDW and the RWQCBs regulate groundwater recharge projects under Title 22 California Code of Regulations (CCR) Division 4, Chapter 3. Final regulations for groundwater replenishment projects using surface application (i.e., spreading) and subsurface application (i.e., injection) went into effect in June 2014. These groundwater replenishment regulations address the protection of public health with respect to chemicals, microorganisms, and constituents of emerging concern.

In addition to the Title 22 criteria, recycled water must also comply with water quality standards and objectives in applicable basin plans, salt and nutrient management plans (SNMPs), and other applicable regulations and policies to protect water quality and the beneficial uses of surface water and groundwater. In addition to the water quality objectives established (and presented previously in the Feasibility Study) for pathogen reduction and compliance with the drinking water maximum contaminant levels (MCLs) and notification levels (NLs), two other key requirements of the Basin Plan objectives for TN and boron must be defined for the AWT product water.

Total Nitrogen

The basin plans issued by the Los Angeles RWQCB for the Main San Gabriel, West Coast, and Central Basins have nitrate and nitrate + nitrite limits of 10 mg/L-N (as nitrogen). Practically speaking, because any ammonia remaining in the product water would still have the potential to nitrify after leaving the AWT plant, a nitrate limit would be adhered to by ensuring an equivalent TN limit of the AWT product water. Therefore, one water quality goal of TN ≤ 10 mg/L will be established for the AWT product water to serve these three groundwater basins.

However, a lower nitrate limit of 3.4 mg/L-N is required by the Santa Ana RWQCB in the Orange County Basin Plan due to basin-specific nitrate issues. The OCWD's permit (Order No. R8-2016-0051) for the GWRS facility requires an even lower nitrate level of 3 mg/L-N to be met, based on a 12-month running average and a minimum monthly sampling frequency. This analysis assumes a nitrate goal corresponding to the Basin Plan objective of 3.4 mg/L-N in the AWT product water when serving the Orange County Basin. Likewise, a product water quality goal of TN ≤ 3.4 mg/L is established for the AWT product water to serve the Orange County Basin.

The JWPCP currently uses a high-purity oxygen activated sludge (HPOAS) system with a low solids retention time (SRT) for secondary treatment. The 90th percentile TN concentrations in the primary and chlorinated secondary effluent were 63 and 48.8 mg/L, respectively. Given the water quality goal of either TN ≤ 10 mg/L for the Main San Gabriel, West Coast, and Central Basins, or TN ≤ 3.4 mg/L for the Orange County Basin, nitrogen removal is a key issue and must be addressed.

Boron

Boron is a naturally occurring element that is widely distributed throughout the environment in rock, soil, and water. Boron compounds are often present in surface and groundwater as well as wastewater. To protect agricultural beneficial uses, particularly for citrus crops, the California state boron NL is 1 mg/L and the Basin Plan limit is 0.5 mg/L for the Main San Gabriel Basin. Consequently, the target boron concentration in the AWT product water is 0.5 mg/L.

4.3 Nitrogen Management Strategy

To address the operational and regulatory requirements associated with the nitrogen levels in the AWT influent and product water, a Nitrogen Management Committee, consisting of technical staff from both Metropolitan and the Sanitation Districts, was established in April 2017. The committee's charter was to explore cost-effective and reliable alternatives and identify a holistic nitrogen management strategy with consideration given to the potential treatment options at both the JWPCP and AWT plant. Five base treatment process trains were identified for evaluation, most of which stemmed from the most feasible unit processes identified in the Sanitation Districts' October 2016 Nitrogen Management Report. These included the following:

- Secondary MBR + RO
- Tertiary MBR + RO
- Tertiary biologically active filter (BAF) + Microfiltration (MF) + RO
- MF + RO
- Nitrification–denitrification (NdN) Secondary MBR + RO

Multiple variants for each of these base trains were also evaluated, totaling 17 different process trains evaluated by the committee. The MBR process is referred to as "Secondary MBR" when treating primary effluent for organics and nitrogen removal. It is referred to as "Tertiary MBR" when treating secondary effluent primarily for nitrogen removal.

Biological processes within the process trains were evaluated with nitrification only (N-only) for complete nitrification, and NdN for complete nitrification and partial denitrification. The level of denitrification for NdN trains was chosen so that the biologically treated effluent, when further treated with RO, would meet the water quality goal of TN $\leq$ 3.4 mg/L. RO is expected to further reduce the ammonia, nitrate, and organic nitrogen remaining from the upstream treatment by 85%, 80%, and 95%, respectively. Selected trains were also evaluated with sidestream centrate treatment for ammonia removal at the JWPCP.

This work effort identified several process trains that are potentially well suited to meet the RRWP's nitrogen management objectives. Potential issues were identified; further literature searches, process modeling, detailed conceptual design, expert review, and field testing are required. Modifications and enhancements to the demonstration facility would be needed to facilitate testing of these trains. After additional investigations and demonstration testing have been conducted, the Nitrogen Management Committee will further evaluate the alternative process trains to eventually provide the recommended process train for the full-scale AWT plant.

The work effort of the Nitrogen Management Committee was documented in a Nitrogen Management Report. This report has been reviewed by a subcommittee of the original technical advisory panel from the Feasibility Study and is included in Appendix C. Comments from the subcommittee and responses to those comments from the Nitrogen Management Committee are attached to the Nitrogen Management Report.

4.4 Boron Management Strategy

The Sanitation Districts recently completed a detailed Boron Source Investigation Report (Appendix D) and identified the majority of boron contribution from the oil field industry in the Long Beach and Signal Hill areas. JWPCP effluent boron concentration is currently about 0.9 mg/L. Partial removal of boron through the RO process at the AWT plant would not be sufficient to achieve the 0.5-mg/L objective; therefore, additional source control and/or treatment measures will be needed.

Two options are currently being considered for meeting the boron objective of 0.5 mg/L in the AWT product water, as described below.

Source Control

One potentially cost-effective approach for boron management is to reduce it at the source(s). The Sanitation Districts currently implement a well-established source control program upstream of each of their plants and have reviewed boron data collected from approximately 300 industrial dischargers spanning 35 industrial categories between 2010 and 2016. The extensive source investigation discovered that the combined boron loading from the top ten industrial categories accounts for approximately 97% of the total industrial boron contribution to the JWPCP. The industrial category that was the largest boron contributor has been identified as oil fields.

Electrocoagulation appears to be the most cost-effective pretreatment method for wastes generated from oil fields based on a literature search on potential technologies. Ion exchange would require pretreatment for oils, grease, and other impurities, and is more challenging to implement. The Sanitation Districts are currently conducting bench-scale tests with various electrode materials to assess the effectiveness of electrocoagulation for boron removal and are in the process of developing the treatment costs. A removal of 80% to 90% is targeted to achieve the groundwater recharge requirement.

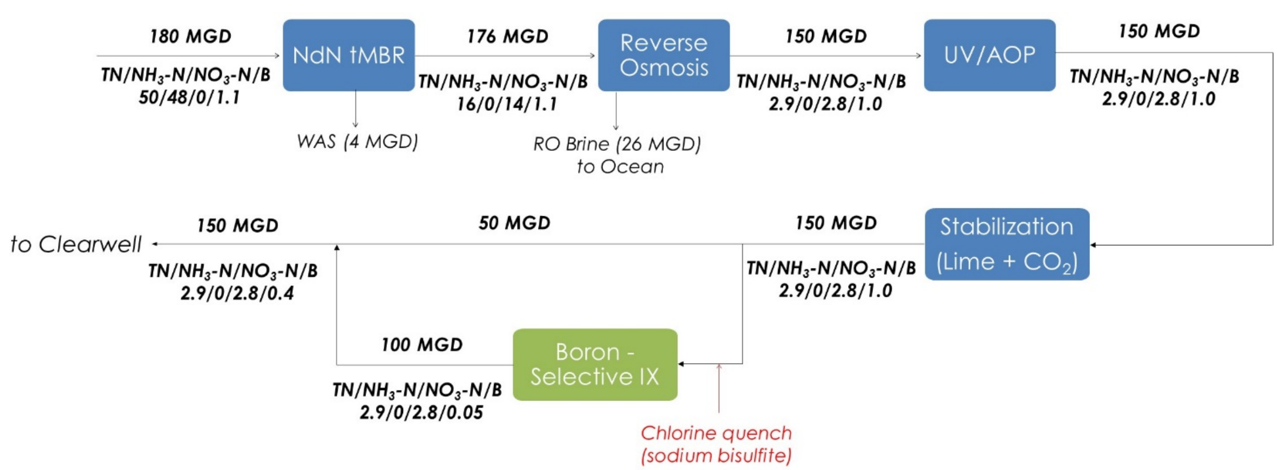
Additional investigations have also been initiated to identify specific industrial companies that are potentially significant sources of boron.

Additional Treatment at AWT Plant

An ion exchange (IX) process could be incorporated in the AWT treatment train for boron removal using either a boron-selective resin or strong base anion resin. Different water quality conditions, process configurations, and pre-and post-treatment would be required to optimize boron removal through these resins. A study has been performed to conceptually develop the design criteria, site layouts at the AWT plant, and the implementation costs (Appendix E).

The boron-selective IX process would be used in conjunction with the tertiary MBR + RO + UV/AOP treatment train described in the Feasibility Study and used in the demonstration facility (Figure 4.3). The IX process was designed as a split-stream treatment after stabilization and was sized to produce a final blended boron concentration of less than 0.4 mg/L in the product water. The boron-selective IX process will need to treat 100 mgd of the 150-mgd product water flow with this alternative. Because the boron-selective resin primarily removes boron only, a biological denitrification step is required in the tertiary MBR for nitrate removal.

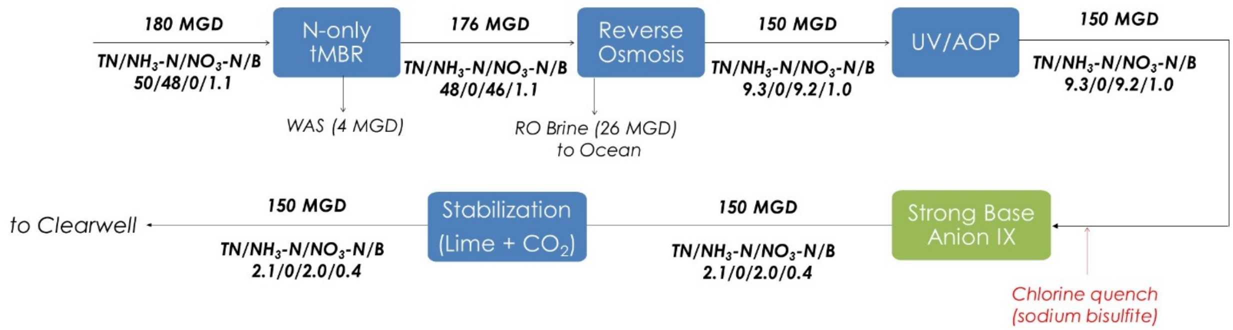
Figure 4.3: Boron-selective IX Process Train



The strong base anion (SBA) IX process would be used in conjunction with a N-only) tertiary MBR + RO + UV/AOP + Stabilization train (Figure 4.4). This train relies on nitrifying-only tertiary MBR for complete conversion of ammonia to nitrate and RO for partial removal (80%) of nitrate. An SBA IX process is added following lime stabilization to lower both nitrate and boron concentrations sufficiently to meet the water quality goals for those parameters for all four groundwater basins (NO_3-N < 3.4 mg/L and

Boron < 0.5 mg/L). Because the SBA IX is applied after the RO in this alternative, it must remove a much smaller fraction of nitrate compared to the Base Case process train to meet the product water quality goal.

Figure 4.4: Strong Base Anion IX Process Train



Both IX processes are feasible in removing boron to meet the water quality target of < 0.5 mg/L. Because the SBA IX process can achieve both nitrate and boron removal, biological denitrification could be eliminated with a potential cost benefit. The need and type of boron treatment will be addressed when the Sanitation Districts complete the source control bench tests.

4.5 Phasing Evaluation

Chapter 3 describes five phasing alternatives for implementation of a full-scale program. A summary of the treatment capacity for each phasing alternative is presented in Table 4.1.

Table 4.1: Treatment Capacity by Phase

Phasing Alternatives	Phase 1	Phase 2	Phase 3
Alternative A: Single-Phase Scenario (Full Program)	150 mgd	—	—
Alternative B: Two-Phase Scenario (North First)	100 mgd	50 mgd	—
Alternative C: Two-Phase Scenario (East First)	50 mgd	100 mgd	—
Alternative D: Three-Phase Scenario (Central First)	50 mgd	50 mgd	50 mgd
Alternative E: Three-Phase Scenario (Harbor Area)	25 mgd	75 mgd	50 mgd

Facilities required for the AWT plant include the advanced treatment processes presented in Figure 4.2, below-grade RO feed tanks, inter-process pumps and storage tanks, post-treatment stabilization, chemical storage and feed systems, a new electrical substation, an operations building with a water quality laboratory and operations control center, a public education center (at the demonstration facility site), maintenance and shop facilities, access roads, and parking. The AWT effluent clearwell and pump station are addressed in Chapter 5 as part of the RRWP conveyance system.

Assumptions

The treatment process train is assumed to be the same for each of the five phasing alternatives. However, capacity, product water quality, and infrastructure requirements differ across the implementation phases.

To simplify the analysis of various treatment process train configurations, four specific treatment process capacities are used in the various alternatives (25, 50, 100, and 150 mgd).

Site Issues and Plant Layout. The entire 150-mgd plant fits within the FORCO property limits with available space for potential future expansion. The FORCO site was previously used for refining and storing petroleum products. Site remediation activities at the FORCO site to date include excavation and treatment or disposal of impacted materials and recovery of approximately 1.6 million pounds of hydrocarbon using a vapor extraction system with groundwater air sparging. The Sanitation Districts will be responsible for removing, disposing, and/or treating all pre-existing hazardous wastes and contamination, and for remediating the site as needed to allow for construction of the full-scale project. Relocation of existing utilities may also be required.

Common Infrastructure. It is assumed that the first phase of each alternative will construct site infrastructure, utilities, hydraulic capacity, and operational facilities that can be used or easily expanded to accommodate the full-scale 150-mgd AWT plant. Thus, this assumption creates common infrastructure associated with all alternatives regardless of treatment capacity. Common infrastructure includes the following:

- General site development
- All yard piping
- Drum screen and influent pump station structure
- Maintenance building
- RO feed tank
- Electrical building
- All major equipment concrete slabs (RO, UV)
- RO flush tank
- Electrical substation
- Chemical facility structure
- Lime system concrete slab
- Administrative building
- Generator concrete slab
- Site improvements at the FORCO site

Equipment Sizing and Redundancy. To develop site layouts for the individual phases of alternatives delineated above, major equipment components were sized and quantities of each were identified to achieve product water production capacities of 25, 50, 75, 100, and 150 mgd, as shown in Table 4.2.

Table 4.2: Major Equipment Components Required for Various Capacities

Major Equipment	150 mgd	100 mgd	75 mgd	50 mgd	25 mgd
Influent Pumps	14	10	8	5	3
Fine Screens	13	9	7	5	3
MBR Basins	12	8	6	4	2
RO Skids	50	34	25	17	6
UV/AOP Skids	18	12	8	6	4

For cases in which equipment cannot be divided evenly based on capacity increments, standby equipment components were included in the earlier phase(s) to ensure adequate redundancy for all phases. To have a fair comparison of costs, the total quantity of process equipment units remains the same among all phasing alternatives. As an example, 14 influent pumps would be provided under the single phase for Alternative A, which is equivalent to the total of the three phases in Alternative D, as demonstrated below:

Phase 1: 50 mgd – 4+1 (duty + standby) pumps
Phase 2: 50 mgd – 4+1 (duty + standby) pumps
Phase 3: 50 mgd – 4+0 (duty only – redundancy provided in Phases 1 and 2)

Addition of Centrate Treatment Facilities. For cost effectiveness, it was assumed that the JWPCP would only incorporate centrate treatment in its process when the AWT plant capacity reaches 100 mgd, such as the first phase of Alternative B or the second phase of Alternative C. The cost of the centrate treatment facilities would be added to those phases accordingly.

Incorporation of Denitrification. MicroC 2000™ (carbon source for biological denitrification) would be added to the tertiary MBR process when biological denitrification becomes essential to meet the product water quality goal for nitrate. Two-pass RO would be an option to meet the nitrate goal and may provide a cost benefit. This higher quality requirement is triggered when the AWT plant starts serving the Orange County Basin. This would occur in conjunction with:

- First phase for Alternatives A and C
- Second phase for Alternative B
- Third phase for Alternatives D and E

The resulting capacity, product water quality, and infrastructure requirements are evaluated in the following sections for each of the five phasing alternatives.

Alternative A: Single-Phase Scenario (Full Program)

Alternative A completes the entire 150-mgd full-scale AWT plant in a single phase. This alternative produces high-quality water that meets the requirements for indirect potable reuse through groundwater recharge at the Main San Gabriel, West Coast, Central, and Orange County Basins. The water quality target for this alternative is TN ≤ 3.4 mg/L to meet the Orange County Basin Plan objective, which is the most stringent of the four basins. The site plan for this scenario alternative is presented in Figure 4.5.

Figure 4.5: Site Plan – Alternative A: Single-Phase Scenario (Full Program)

Alternative B: Two-Phase Scenario (North First)

Alternative B completes the first phase of the program with an initial treatment plant capacity of 100 mgd to recharge the Main San Gabriel and Central Basins, achieving a water quality target of TN $\leq$ 10 mg/L. The second phase of the project includes a 50-mgd treatment plant expansion to recharge the Orange County Basin and West Coast Basin. Upon completion of this second phase, the entire 150-mgd plant would be operated to achieve the more stringent Orange County Basin Plan objective of TN $\leq$ 3.4 mg/L. Additional removal of nitrogen would be achieved by adding carbon in the form of MicroC 2000™ to the MBR process. The site plan for this alternative is presented in Figure 4.6.

Figure 4.6: Site Plan – Alternative B: Two-Phase Scenario (North First)

Alternative C: Two-Phase Scenario (East First)

Alternative C reverses the order of implementation, completing the first phase with an initial treatment plant capacity of 50 mgd to recharge the Orange County and the Long Beach portion of the Central Basin. This is followed by a 100-mgd expansion in the second phase to deliver replenishment water to the Main San Gabriel Basin and West Coast Basin. In this scenario, carbon addition would be required in the first phase to meet the Orange County Basin Plan objective of TN $\leq$ 3.4 mg/L. Upon completion of the second phase, the entire 150-mgd plant would be operated to achieve TN $\leq$ 3.4 mg/L. The site plan for this scenario alternative is presented in Figure 4.7.

Figure 4.7: Site Plan – Alternative C: Two-Phase Scenario (East First)

Alternative D: Three-Phase Scenario (Central First)

Alternative D initially completes the first 50-mgd phase of the program to recharge the West Coast and Central Basins, achieving a water quality target of TN ≤ 10 mg/L. The second phase of the program would expand the treatment capacity by 50 mgd to recharge the Main San Gabriel Basin, achieving the same level of nitrogen removal. The third and final phase of the program would expand the treatment capacity by 50 mgd to recharge the Orange County Basin. Upon completion of the third phase, the entire 150-mgd plant would be operated to achieve the more stringent Orange County Basin Plan objective of TN ≤ 3.4 mg/L with the addition of carbon. The site plan for this scenario alternative is presented in Figure 4.8.

Figure 4.8: Site Plan – Alternative D: Three-Phase Scenario (Central First)

Alternative E: Three-Phase Scenario (Harbor Area)

Alternative E initiates the program with the smallest initial investment of all the alternatives considered. The initial 25-mgd phase of this scenario recharges the West Coast Basin and Long Beach portion of the Central Basin and meets consumptive demands of industrial users in the Harbor area. The second phase expands the treatment capacity by an additional 75 mgd to serve the Rio Hondo Spreading Grounds and Santa Fe Spreading Grounds, and the third phase expands the treatment capacity by another 50 mgd to recharge the Orange County Basin. Thus, the first two phases would be operated to achieve a water quality target of TN $\leq$ 10 mg/L to meet the Basin Plan objectives for the West Coast, Central, and Main San Gabriel Basins. Upon completion of the third and final phase, the entire 150-mgd plant would be operated to achieve the more stringent Orange County Basin Plan objective of TN $\leq$ 3.4 mg/L with the addition of carbon.

As in Alternative D, this scenario offers flexibility with respect to the order of implementation of phases while minimizing the initial investment and time needed to bring the project online. The site plan for this scenario alternative is presented in Figure 4.9.

Figure 4.9: Site Plan – Alternative E: Three-Phase Scenario (Harbor Area)

4.6 Proposed First Phase Project (Backbone System)

As described in Chapter 3, a proposed implementation strategy provides an AWT plant sized to meet near-term existing and planned future demands. This strategy would be based on Alternative B (North First) and would include treatment to produce up to 100 mgd of purified water that meets the water quality goal of TN < 10 mg/L as required in the basin plans for the Main San Gabriel, West Coast, and Central Basins.

Early Delivery Opportunities

The implementation of the proposed Backbone System approach offers opportunities for early deliveries of purified water to meet demands in the West Coast and Central Basins. The configuration developed as Alternative E could serve as the basis for further development of an early delivery strategy. Under this approach, initial AWT treatment capacity would likely be 25 to 50 mgd. Process design treatment studies at the demonstration facility would need to be organized to allow testing results to be integrated into the initial full-scale AWT plant design in a timely manner. The estimated design and construction duration of the AWT facilities needed in Alternative E is approximately 5 years following the completion of the environmental planning process.

4.7 Next Steps

The following list presents potential next steps associated with the AWT system if the program is approved to move to the next phase.

1. Complete demonstration testing and monitoring, including the testing required for regulatory approval of MBR and subsequent testing for process design criteria.
2. Continue dialogue with regulators on technology acceptance of the potential treatment process train for the full-scale AWT plant.
3. Conduct literature searches, process modeling, detailed conceptual design, expert review, and field testing to evaluate the selected trains for nitrogen management. Modifications and enhancements to the demonstration facility would be required to facilitate the testing. After these additional investigations and demonstration testing have been conducted, the Nitrogen Management Committee will further evaluate the alternative process trains and provide the recommended process train for the full-scale AWT plant.
4. Identify specific industrial companies that are potentially significant sources of boron.
5. Complete source control bench testing and evaluation on pretreatment of boron containing wastes. The need for and type of boron treatment will then be addressed.
6. Establish design criteria once the process train for the full-scale AWT plant is established.
7. Identify the potential site development issues and requirements at the FORCO site.
8. Refine cost estimates and implementation schedules.

These activities will support the program as it moves into the environmental permitting and design phases.

Chapter 5

Conveyance System

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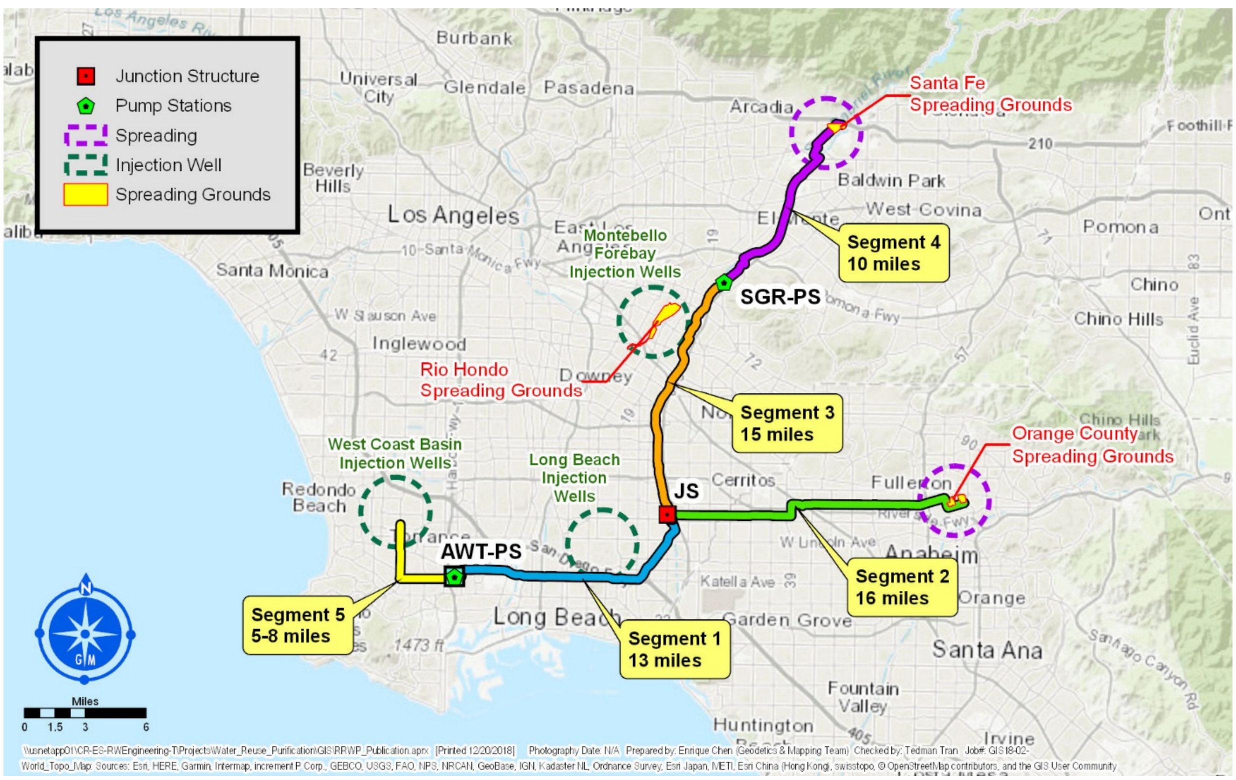
5.0 CONVEYANCE SYSTEM

This chapter provides an analysis of the conveyance system and infrastructure associated with the phasing alternatives presented in Chapter 3. It also presents further refinements to the system's pipeline alignment, pipeline design, system hydraulics, and pump stations.

5.1 Overview

As described in the Feasibility Study, the conveyance system will consist of approximately 62 miles of pipeline and two pump stations. The system will deliver up to 150 mgd of purified water as far east as the Orange County Spreading Grounds in Anaheim and as far north as the Santa Fe Spreading Grounds in Irwindale. Delivery locations along the alignment will consist of either existing groundwater spreading basins, new or existing injection wells, or industrial users in the Harbor area.

Figure 5.1: Overview of the Conveyance System



For planning purposes, the pipeline alignment has been divided into five segments. The numbering is used to clarify the analysis and does not indicate any priority or construction order. In the future preliminary and final design phases, these five conveyance segments may be further divided into smaller construction contract packages. Each pipeline segment is described below.

Segment 1 is approximately 13 miles long, starts at the AWT Pump Station (PS), and ends at the Junction Structure (JS) of the pipelines going east to the Orange County Spreading Grounds and north to the Santa Fe Spreading Grounds. From west to east, this segment passes through the city of Carson; a short stretch of unincorporated Los Angeles County; and the cities of Long Beach, Signal Hill, Lakewood and Cerritos. A majority of the alignment is within public street right-of-way (ROW), with a short stretch adjacent to the San Gabriel River. This pipeline would convey up to 150 mgd and is anticipated to have an internal diameter of 84 inches.

Segment 2 is approximately 16 miles long, starts at the JS, and ends at the Orange County Spreading Grounds in Anaheim Lakes in the City of Anaheim. From west to east, the alignment passes through the cities of Cerritos, La Palma, Buena Park, Fullerton, Placentia, and Anaheim. Approximately 6 miles of the alignment lie within the Southern California Edison (SCE) ROW; the remaining 10 miles falls within public street ROW. The pipeline would convey up to 60 mgd with an internal diameter of approximately 54 inches.

Segment 3 is approximately 15 miles long, begins at the JS, and ends at the San Gabriel River (SGR)-PS near Whittier Narrows Dam. From south to north, the alignment passes through the cities of Cerritos, Bellflower, Downey, and Pico Rivera. Most of the alignment falls within SCE ROW paralleling the San Gabriel River. Due to the narrow SCE corridor and some environmentally sensitive areas along the San Gabriel River, the pipeline may have to be placed within the confines of the river and public street ROW for a portion of the alignment. The pipeline would convey up to 150 mgd with an internal diameter of approximately 60 inches.

Segment 4 is approximately 10 miles long, starts at SGR-PS, and ends at the Santa Fe Spreading Grounds in the City of Irwindale. A majority of the alignment falls within the SCE and Los Angeles County Flood Control District (LACFCD) ROW, with a portion falling within public street ROW. The pipeline would convey up to 150 mgd with an internal diameter of approximately 60 inches.

Segment 5 is anticipated to be 5 to 8 miles long. It would start at the AWT-PS and end at injection wells to be installed in the general vicinity of the City of Torrance to provide groundwater injection into the West Coast Basin and supply purified water to industrial users in the Harbor area. The pipeline would convey up to 15 mgd with an internal diameter of approximately 30 inches.

5.2 Pipeline Alignment Refinement

Additional analyses were completed to verify and refine the alignments presented in the Feasibility Study. Feedback was solicited from internal and external project stakeholders to ensure that the alignment to date is constructible and financially feasible, minimizes construction impacts to communities, and avoids or minimizes environmental impacts.

Further refinements have been completed to identify the methods for pipeline construction. Four construction method groups have been identified: roadways, SCE easements, LACFCD easements, and trenchless. Three types of trenchless methods have been identified for this project: jack and bore, microtunneling, and traditional tunneling. Table 5.1 shows the pipeline construction method, length in feet, and the percent of total in the entire project.

Table 5.1: Pipeline Construction Methods

Construction Method	Length (ft)	Percent of Total
Roadways	174,600	59
SCE Easements	46,830	16
LACFCD Easements	41,900	14
Trenchless	33,060	11

Note: Segment 5 to West Coast Basin is not included in this table.

Using geographic information system (GIS) mapping and ROW information, conceptual alignment cross sections were developed to depict the approximate location of the pipeline alignment relative to known major utilities and key surface features. The proposed location of the pipeline alignment was developed based on extensive research of existing utilities. In general, the pipeline will be installed with an 8-foot minimum cover while in public ROW. While in SCE and LACFCD ROW, the depth of cover generally decreases to a 4-foot minimum except when installed in an unlined (earthen) river channel bed, where a 10-foot minimum cover is required to protect against scour and ensure that flotation of the pipeline does not occur. Further refinement to the horizontal and vertical alignment will continue in subsequent design phases.

Meetings with SCE, LACFCD and the USACE have been conducted to determine the regulatory and design requirements for constructing pipelines in these agencies' ROWs. Stakeholder meetings with these key agencies will continue into the preliminary and final design phases.

5.3 Conveyance System Hydraulics and Pump Stations

Further analysis following the Feasibility Study revealed a topographic high point along Segment 1, near Signal Hill. Numerous concept level alternatives were identified and evaluated for conveying flows over (or around) the high point. The options included either tunneling this stretch to maintain hydraulic grade or increasing the pumping head at the AWT-PS to overcome this hydraulic high point. A two-pump station system alternative was determined to be most advantageous and is carried forward in this analysis.

Under this alternative, the AWT-PS will be used to pump flow directly to the Orange County Spreading Grounds and the SGR-PS. The pumping head requirement from the AWT-PS will significantly increase due to the higher delivery elevations at the Orange County Spreading Grounds and SGR-PS. This increase in pressure will require excess pressure to be dissipated if any additional delivery locations are identified in Segment 1.

The conveyance system requires a control facility at the JS for operational flexibility and to adjust flow delivery to each delivery location. This control facility will consist of control valves and flowmeters that can control and split the flow to the various delivery locations. Flow will be regulated in one combined control/JS located along the alignment to the points of delivery (with flexibility in site selection). Table 5.2 summarizes a two-pump station system.

Table 5.2: Two-Pump Station System

Pump Station	General Location	Preliminary Firm Pumping Capacity	Delivery Location
AWT-PS	AWT at JWPCP, Carson	Pump Bank A: 15 mgd at 90 ft (2 × 350-hp duty pumps + 1 standby)	Pump Bank A: West Coast Basin
		Pump Bank B: 150 mgd at 430 ft (4 × 5,000-hp duty pumps + 1 standby)	Pump Bank B: Long Beach, Orange County Spreading Grounds, SGR-PS Forebay
SGR-PS	Near Whittier Narrows, Pico Rivera	Pump Bank A: 80 mgd at 414 ft (3 × 2,750-hp duty pumps + 1 standby)	Pump Bank A: Santa Fe Spreading Grounds

5.4 Pipeline Design Criteria

Pipelines will consist of cement mortar lined and coated welded steel pipe with inner diameters ranging from 30 to 84 inches. Pipe sizing was initially analyzed to optimize the pipe size based on hydraulic losses. The pipe sizing was subsequently analyzed to balance pumping power costs with capital construction costs. The analysis compared the amortized capital costs and the annual energy consumption to determine the most cost-effective pipe diameter. Pipeline plate thicknesses were also analyzed. The steel plate thickness is determined based on four loading conditions: permanent loads, semi-permanent loads, transient loads, and exceptional loads. Loads include both internal and external conditions. Table 5.3 summarizes the steel cylinder thickness. Note that Segment 5 to the West Coast Basin is still under analysis pending injection well locations.

Table 5.3: Pipeline Design Criteria

Segment	Pipeline Diameter (in.)	Plate Thickness (in.)
1	84	0.500
2	54	0.375
3	60	0.375
4	60	0.375
5	30	TBD

5.5 Water Delivery Facilities

Table 5.4 shows the number of relocated, repurposed, monitoring, and new injection wells for each groundwater basin. Further assessment of the specific water delivery facilities, such as coordination with LACFCD, will be completed in subsequent design phases.

Table 5.4: Well Locations and Quantities

Location	Relocated Wells	Repurposed Wells	Monitoring Wells	New Injection Wells
West Coast Basin	0	0	5	15
Central Basin	7	4	8	9
Main San Gabriel Basin	7	0	5	0
Orange County Basin	1	0	0	0

5.6 Phasing Evaluation

Chapter 3 describes five phasing alternatives for implementation of a full-scale program. Required facilities for the conveyance system include 62 miles of pipeline as well as the appurtenances associated with pipelines, two pump stations, a junction structure, injection wells, and groundwater spreading facilities. Table 5.5 summarizes the conveyance system project components.

Table 5.5: Conveyance Components

Pipeline Segment	Description	Pipeline Length
1	Pipeline from AWT-PS to JS	13 miles
2	Pipeline from JS to Orange County Spreading Grounds	16 miles
3	Pipeline from JS to SGR-PS	15 miles
4	Pipeline from SGR-PS to Santa Fe Spreading Grounds	10 miles
5	Pipeline from AWT-PS to West Coast Basin	5–8 miles

Note that Segments 1 and 5 are dependent on the AWT-PS being constructed. The junction structure where the main conveyance system bifurcates will be constructed with Segment 2 or 3, whichever segment is constructed first. Segment 4 depends on SGR-PS being constructed. Table 5.6 summarizes the project components and the phases that will be constructed in each phasing alternative.

Table 5.6: Conveyance System Phasing

Project Component	Phasing Alternative & Phase										
	Alt A: Full Program	Alt B: North Alignment First		Alt C: East Alignment First		Alt D: Central Alignment First			Alt E: Harbor Area First		
	1	1	2	1	2	1	2	3	1	2	3
Segments 1 and 5	X	X		X		X			X		
Segment 2	X		X	X				X			X
Segment 3	X	X			X	X				X	
Segment 4	X	X			X		X			X	
AWT-PS	X	X		X		X			X		
JS	X	X		X		X				X	
SGR-PS	X	X			X		X			X	

Alternative A: Single-Phase Scenario (Full Program)

Alternative A would construct the full-scale project in one phase. The AWT plant would produce 150 mgd with a complete conveyance system to deliver the water to all four groundwater basins.

Figure 5.2: Conveyance System – Alternative A: Single-Phase Scenario (Full Program)

Alternative B: Two-Phase Scenario (North First)

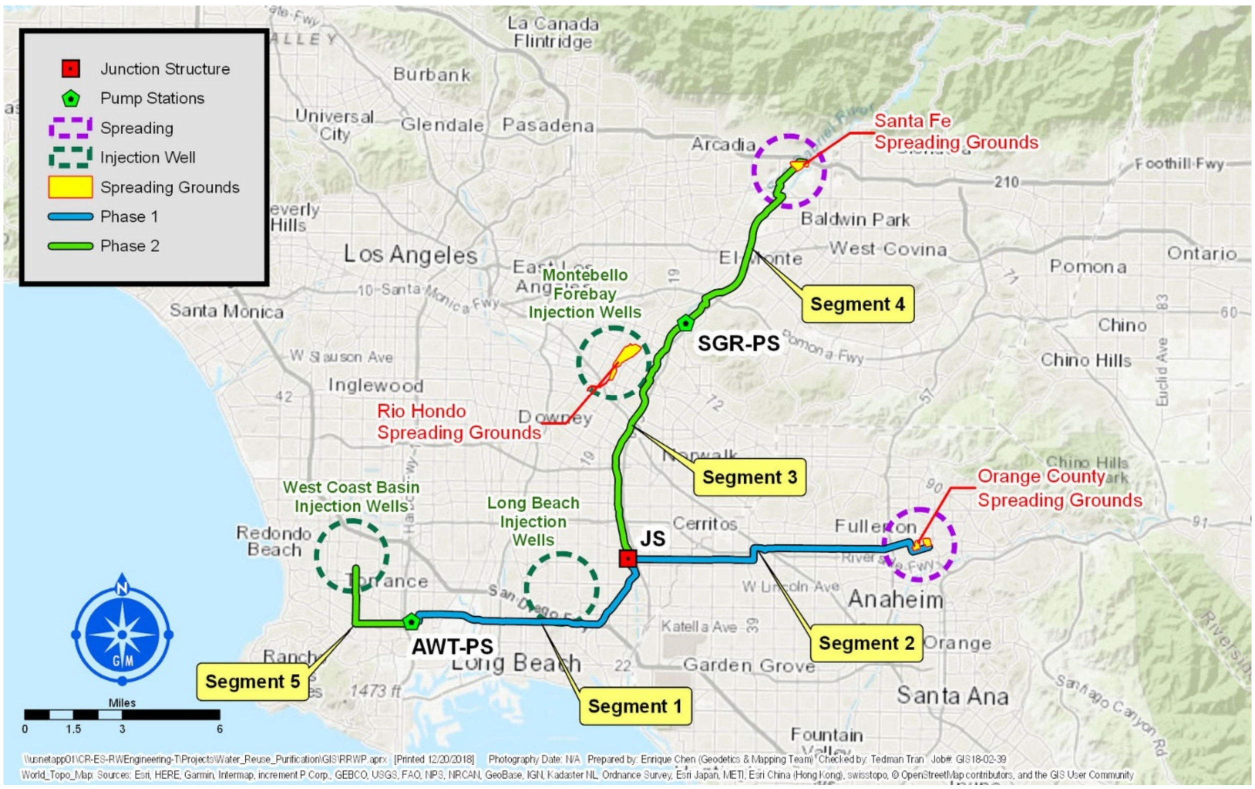
Alternative B constructs the first phase of the program with an initial treatment plant capacity of 100 mgd to recharge the Main San Gabriel and Central Basins. Segments 1, 3, and 4 would be constructed in the first phase along with AWT-PS, SGR-PS, and the JS. The second phase of the project implements a 50-mgd treatment plant expansion to recharge the Orange County and West Coast Basins. Segment 2 from the JS to the Orange County Spreading Grounds and Segment 5 to the West Coast Basins would be constructed in the second phase.

Figure 5.3: Conveyance System – Alternative B: Two-Phase Scenario (North First)

Alternative C: Two-Phase Scenario (East First)

Alternative C reverses the order of implementation, constructing the first phase with an initial treatment plant capacity of 50 mgd to recharge the Orange County Basin and the Long Beach portion of the Central Basin. This is followed by a 100-mgd expansion in the second phase to deliver replenishment water to the Rio Hondo and Santa Fe Spreading Grounds and the West Coast Basin. In this scenario, Segments 1 and 2 are constructed in the first phase, along with the AWT-PS and JS. Segments 3, 4, and 5 and the SGR-PS are constructed in the second phase.

Figure 5.4: Conveyance System – Alternative C: Two-Phase Scenario (East First)



Alternative D: Three-Phase Scenario (Central First)

Alternative D constructs the first 50-mgd phase of the program to recharge the West Coast and Central Basins. The second phase of the program would expand the treatment capacity by 50 mgd to recharge the Main San Gabriel Basin. The third and final phase of the program would expand the treatment capacity by 50 mgd to recharge the Orange County Basin. In the first phase, Segments 1, 3, and 5 would be constructed along with AWT-PS and the JS. In the second phase, Segment 4 and the SGR-PS would be constructed. Segment 2 would be constructed in the third and final phase of the program.

Figure 5.5: Conveyance System – Alternative D: Three-Phase Scenario (Central First)

Alternative E: Three-Phase Scenario (Harbor Area)

Alternative E constructs the program with the smallest initial investment. The initial 25-mgd treatment capacity of this alternative serves the injection wells in the Long Beach and Torrance areas. In the first phase, Segments 1 and 5 would be constructed along with the AWT-PS. The second phase expands the treatment capacity by an additional 75 mgd to serve the Rio Hondo and Santa Fe Spreading Grounds. In the second phase, Segments 3 and 4, SGR-PS, and the JS would be constructed. The third phase expands the treatment capacity by another 50 mgd and constructs Segment 2 to convey purified water to the Orange County Basin.

Figure 5.6: Conveyance System – Alternative E: Three-Phase Scenario (Harbor Area)

5.7 Proposed First Phase Project (Backbone System)

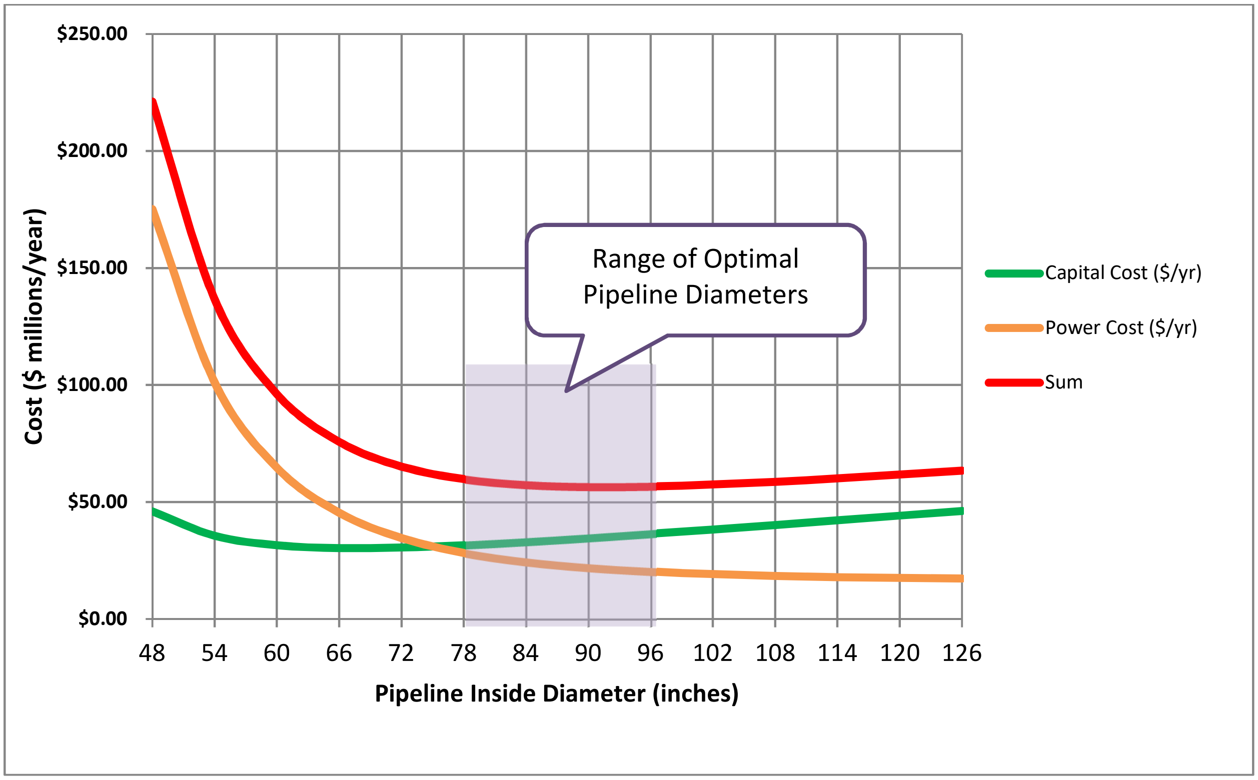
As described in Chapter 3, a proposed implementation strategy based on Alternative B (North First) includes a first phase Backbone System capable of delivering up to 150 mgd of purified water from the AWT site to the vicinity of the Santa Fe Spreading Grounds. This Backbone System would include upsized conveyance that would accommodate existing and future uses and have the flexibility to accommodate DPR applications in the future once applicable regulations are established.

The pipeline alignment of the Backbone System will follow the same alignment described in Section 5.1. However, it will not initially include Segment 5, the reach between the AWT-PS and the West Coast Basin injection wells. At its core, the backbone conveyance system includes Segments 1, 3, and 4. The Backbone System would require Segment 3, the reach between the JS and SGR-PS, and Segment 4, the reach between SGR-PS and Santa Fe Spreading Grounds, to be upsized to accommodate this increased flow. Significant pumping would be required to lift 150 mgd of purified water 38 miles from the AWT site in Carson (elevation 40 feet) to the vicinity of the Santa Fe Spreading Grounds (elevation 525 feet). A sensitivity analysis was conducted to optimize the pipeline diameter of this Backbone System to balance pumping power cost with capital construction cost. The analysis compared the amortized capital costs and the annual energy consumption to determine the most cost-effective pipe diameter. It should be noted that this analysis does not take into account constructability or ROW needed to construct pipelines of larger diameters. Table 5.7 highlights the pipeline optimization assumptions and Figure 5.7 graphically illustrates the results of this sensitivity analysis.

Table 5.7: Pipe Optimization Assumptions for Backbone System

Variables	Amount	Units
Flow	150	mgd
Pipeline Length	38	miles
Pipeline Cost	30	$/inch-diameter/linear foot
Pump Station Power Cost	0.15	$/kWh
Pump Efficiency	80	%
Pump Station Maximum Lift	350	feet/each pump station
Annual Interest Rate	4	%
AWT-PS Elevation	50	feet
Discharge Elevation	535	feet

Figure 5.7: Pipe Optimization Curves for Backbone System



The shaded box in Figure 5.7 defines the optimal pipeline diameter range. The sensitivity analysis validated that an 84-inch diameter pipeline for Segment 1 is appropriate. An 84-inch diameter pipeline was carried forward for this Backbone System. Table 5.8 below shows a comparison of the pipeline diameters between the Base Case from the Feasibility Study and the Backbone System. A minimum of two pump stations will be necessary to convey up to 150 mgd from the AWT site to the vicinity of the Santa Fe Spreading Grounds. The locations of the two pump stations are kept the same; however, the SGR-PS will need to be upsized to accommodate the additional flow. Further assessment of the hydraulics and operation of this backbone system will be conducted during preliminary design. Verification will be needed to ensure that the upsized pipeline can be constructed within the previously identified alignment.

Table 5.8: Pipeline Inside Diameter Comparison

Pipeline	Pipeline Inside Diameter (inches)	
	Feasibility Study Base Case	Backbone System
Segment 1 – AWT-PS to JS	84	84
Segment 2 – JS to Orange County Spreading Grounds	54	54
Segment 3 – JS to SGR-PS	60	84
Segment 4 – SGR-PS to Santa Fe Spreading Grounds	60	84
Segment 5 – AWT to West Coast Basin	30	30

Backbone System Phasing

It is envisioned that the Backbone System would be constructed in two phases as shown on Figure 5.8. With the exception of Segment 5 being excluded, the phasing of the Backbone System is similar to the Alternative B phasing scenario outlined in Section 5.6. The first phase of the program will begin with an initial treatment plant capacity of 100 mgd to recharge the Main San Gabriel and Central Basins. Segment 1, 3, and 4 would be constructed in the first phase along with the AWT-PS, SGR-PS, and the JS. One possibility for the second phase of the project implements a 50-mgd treatment plant expansion to recharge the Orange County Basin. Segment 2 from the JS to the Orange County Spreading Grounds would be constructed in the second phase. Segment 5 from the AWT to the West Coast Basin could also be constructed in the second phase. Alternatively, it is possible that one of the DPR options identified during the evaluation may be the preferred second phase choice.

Figure 5.8: Backbone System (Full Program)

Early Delivery Opportunities

As indicated in the description of Alternative E, segmentation of the conveyance system readily lends itself to early deliveries of purified water to some of the industrial customers and replenishment needs that are within close proximity to the JWPCP. This could include completion of Segment 5 (AWT to West Coast Basin) as part of the Backbone System, should demands for replenishment water in the West Coast Basin materialize during the timeframe that the environmental planning and initial engineering investigations are underway. Segment 1 is the large-diameter 84-inch pipeline that serves as the beginning of the Backbone System. It will be designed to serve demands located to the east and north-east of the AWT facility. Segment 5 is an independent 30-inch diameter pipeline that can be implemented as needed.

The estimated time need to complete Segments 1 and 5 is approximately 5 years following the completion of the environmental planning process (see Chapter 3 Program Implementation and Cost Estimate).

5.8 Next Steps

The following list presents potential next steps associated with the conveyance system if the program is approved to proceed to the next phase.

1. Continue to engage key stakeholders, including USACE, SCE, LACFCD, and the cities and municipalities involved.
2. Further refine pipeline alignments with input from key stakeholders.
3. Finalize the hydraulic characteristics of the system, including the pipeline diameters and pump station characteristics.
4. Evaluate infrastructure requirements needed at groundwater recharge locations.
5. Further assess pipeline appurtenances as well as pipeline coatings.
6. Establish design criteria for seismic events and fault crossings.
7. Refine cost estimates and implementation schedules.

These activities will support the program as it moves into the environmental permitting and design phases.

Chapter 6
Groundwater Modeling

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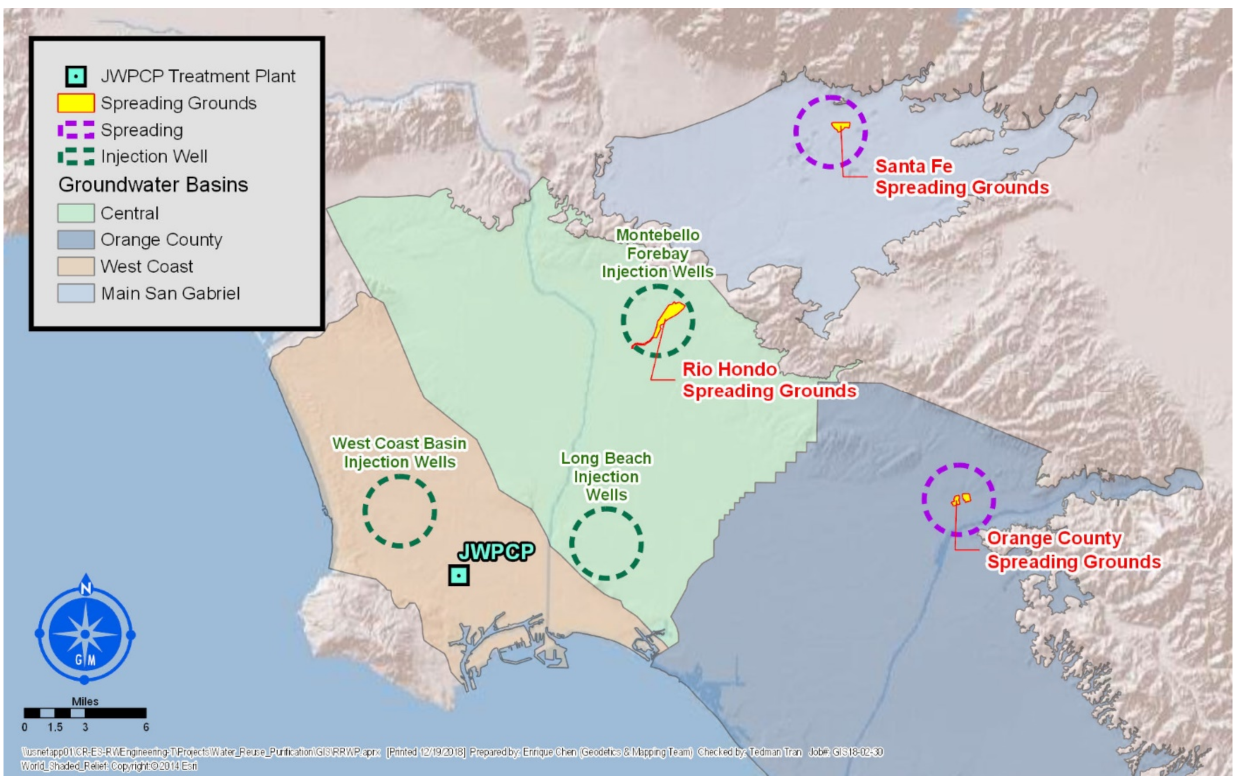
6.0 GROUNDWATER MODELING

This chapter presents the results of additional groundwater modeling to assess impacts resulting from the introduction of RRWP purified water in groundwater basins and to refine the delivery flows and schedules associated with a full-scale program.

6.1 Introduction

The Feasibility Study presented an in-depth analysis of recharge and extraction of RRWP water in four groundwater basins: Central, West Coast, Main San Gabriel, and Orange County (see Figure 6.1). These basins were selected due to their proximity to the JWPCP and their ability to accommodate up to 150 mgd of purified water from the RRWP. This chapter includes a general description of the groundwater basins, demand analysis, groundwater modeling, and facility requirements in support of the 150-mgd (168-TAFY) Alternative A (Full Program) scenario. The groundwater basin analysis focused on demand analysis, operational issues, and impacts to existing and planned basin operations. Continued groundwater modeling investigations are recommended to understand changes to existing basin water quality and potential groundwater level changes, if a full-scale program is implemented.

Figure 6.1: Groundwater Basins and Recharge Locations



6.2 Groundwater Modeling and Optimization of Replenishment Objectives

Existing groundwater models were used to evaluate the ability of each basin to receive the water (demand analysis), operational issues, and to identify the possible effects of recharge, including water quality and impacts to existing wells. Assumptions and operational criteria for the demand analysis and groundwater modeling to evaluate operational issues and impacts were developed through coordination with member agencies, basin managers, and the Los Angeles County Department of Public Works, which operates the Santa Fe and Rio Hondo Spreading Grounds. The following subsections summarize the modeling results completed for this report. Complete modeling reports are provided in Appendix F.

Main San Gabriel Basin

The three-dimensional (3D) basin model for the Main San Gabriel Basin was developed using the United States Geological Survey (USGS) modular structure MODFLOW-2005 code to perform the regional steady-state and transient groundwater flow analysis. The 3D basin model was calibrated from fiscal year 1973/1974 to 2014/2015 in the shallow, intermediate, and deep water bearing formations, including interactions between groundwater and surface water. The 3D basin model is also coupled with the USGS MT3DMS and MODPATH to perform solute transport and particle tracking.

About 43 TAFY of imported water is currently spread in the Main San Gabriel Basin. For the RRWP, it was assumed that about 81 TAFY of purified water would be spread at the Santa Fe Spreading Grounds. Additionally, about 13 TAFY of additional groundwater would be pumped from the Main San Gabriel Basin for users outside the basin. Therefore, the net recharge to the basin would be 68 TAFY.

The USEPA has established operable units for areas within the basin that have been contaminated by volatile organic compounds and require groundwater cleanup. The Baldwin Park Operable Unit (BPOU) at the San Gabriel Valley Area 2 Superfund Site includes groundwater contamination underlying portions of the cities of Azusa, Irwindale, Baldwin Park, West Covina, La Puente, and Industry. Water treatment facilities have been constructed to treat contaminated water underlying these cities and are operated based on conditions within the basin.

Results of the groundwater modeling indicate the contamination plume associated with the USEPA BPOU cleanup may be partially affected by additional recharge, particularly in the western portion of the BPOU remediation area. Although there is a slight increase in the areal extent of the normalized concentrations, the impacts appear to be minor and can be contained by the existing BPOU remedial systems.

The results of the analysis on groundwater level changes in the basin are shown in Table 6.1. For this analysis, the current water level (as of January 2018) is 180 feet MSL. The target water level for the modeling is between 200 feet MSL (the lower end of the established operating range) and 311 feet MSL (75 feet below ground surface – the highest safe level in the basin). In addition, if water levels drop below 170 feet MSL wells begin to lose capacity and may go out of service.

Table 6.1: Groundwater Level Changes – Main San Gabriel Basin

Scenario	Water Level after 32 years (feet MSL)	Maximum Water Level (feet MSL)
Current (Historical Pumping and Recharge)	110	190
With Additional RRWP Water	250	303

Key findings are summarized below:

- Without the delivery of 81 TAFY of purified water from the RRWP, water levels would be 110 feet MSL (70 feet below current basin levels) assuming historical pumping and recharge activities. Because water levels drop below the threshold for maintaining well capacity in the basin, pumping capability would diminish due to these declining water levels.
- With the delivery of 81 TAFY of purified water from the RRWP, water levels would be about 70 feet above current levels (or about 250 feet MSL). Water levels peak at 303 feet MSL, which is still below the upper threshold water level at the key well.

The analysis also evaluated impacts to existing wells. For a new project, there is a 12-month retention time limit and a maximum of 50% recycled municipal wastewater contribution (RWC). For this analysis, a relatively conservative assumption was used such that a well would have to be relocated if it is within the 1-year travel envelope (capture area) or has more than 50% RWC. Seven wells may have to be relocated because they are in the 12-month capture area and one may require relocation because it is in the area that has more than 50% RWC. Further analysis, including tracer analysis and well siting studies for the relocated wells, should be performed.

Central and West Coast Basins

The existing Water Replenishment District (WRD) model was used for the groundwater modeling analyses for the Central and West Coast Basins. The model uses the USGS MODFLOW program, which was tailored to the Central and West Coast Basins by the USGS. The model includes separate layers for the basins' four main aquifer systems.

Currently, Metropolitan currently delivers approximately 20 TAFY for groundwater replenishment in the Central Basin. With the completion of the Arthur Robles Center (ARC) for Water Recycling, formerly known as GRIP, this demand will be fulfilled by water from the ARC.

With the RRWP, about 35 TAFY of purified water will be delivered to the Central and West Coast Basins. The modeling scenario is based on delivery at the Montebello Forebay (9 mgd), Long Beach injection wells (4 mgd), West Coast Basin injection wells (10 mgd), and industrial users in the Harbor area (9 mgd). This is consistent with the phasing alternatives presented in Chapter 3 and the conveyance system alternatives discussed in Chapter 5. Model results suggest that in the Long Beach area, introduction of purified water from the RRWP would increase water levels by as much as 6 feet. In the Carson area, the groundwater table would rise by a maximum of approximately 24 feet while hydraulic head in the injection zone would rise by 33 feet, similar to historic changes in water levels. The groundwater table is expected to rise as much as 7 feet in the Montebello Forebay area with as much as 9 feet of head in the injection wells. This scenario results in a cumulative deficit of about 120,000 acre-feet over the 40-year simulation period, which is caused largely by the decrease in flow from the Main San Gabriel Basin. While the changes in water level at each storage location aren't expected to have any negative impacts on operations, the loss in storage of 120,000 acre-feet in Central and West Coast Basins is a significant issue.

Modeling also included particle tracking analyses for 3-, 6-, and 12-month travel times. For the well impact analysis, it is assumed that a well would likely be affected and would have to be relocated if it is within the 1-year travel envelope. Four wells in the Montebello Forebay and one in the West Coast Basin would potentially be impacted. The particle tracking analyses are provided in the modeling report in Appendix F. Further analysis, including tracer analysis and well siting studies for the relocated wells, should be performed.

Table 6.2 summarizes the groundwater level increases and potential wells impacted within the 12-month travel time.

Table 6.2: Summary of Water Level Increases and Particle Tracking Analyses – Central and West Coast Basins

Area	Maximum Increase in Water Table Level	Number of Wells Potentially Impacted
Montebello Forebay	7 feet	4
Long Beach Wells	6 feet	0
West Coast Basin	24 feet	1
Total		5

Orange County Basin

The OCWD Basin model encompasses the entire basin and extends approximately 5 miles into the Central Basin in Los Angeles County. MODFLOW was used as the base modeling code for the mathematical model. The groundwater model is calibrated from 1990 to 2000.

Currently, OCWD spreads about 37 TAFY of recycled water from its Groundwater Replenishment System facility and about 150 TAFY of stormwater from the Santa Ana River into the Orange County Basin. OCWD expects to purchase up to 65 TAFY (58 mgd) of imported water from Metropolitan for replenishment in the future. Up to 65 TAFY of water could be supplied through the RRWP, thereby reducing the need for imported water during normal and dry periods, particularly during the summer months. However, during wet periods and some winter months, the existing spreading basins (Mira Loma, Kraemer, Miller, and La Palma) may be limited to 22 TAFY (20 mgd) of recharge water from the RRWP. Therefore, the average annual deliveries are estimated to be about 52 TAFY.

Particle tracking analyses were conducted for the well impact analysis, to determine the impact of recharging 52 TAFY. It is assumed that a well would likely be impacted and would have to be relocated if it is within the 1-year travel envelope. Based on the modeling data, six wells could be impacted and would have to be relocated: one below the existing spreading basins and five surrounding Anaheim Lake. Further analysis, including evaluation of previous tracer studies (or potentially new tracer analysis) and well siting studies for the relocated wells, should be performed.

6.3 Approach to Meeting Overall Basin Objectives

In the Central Basin and the Orange County Basin, imported water, stormwater, and recycled water are all currently spread, and there could be competing interests for spreading operations. For example, in the Montebello Forebay stormwater capture is a priority; therefore, during rainfall events all supplemental recharge operations that are not stormwater are suspended. Consequently, adequate spreading capacity may not be available at all times and new injection wells would be required. For the Santa Fe Spreading Grounds, adequate spreading capacity is available at least 94% of the year. For the Orange County Basin, adequate spreading capacity is available at least 10 months of the year. Unlike the Montebello Forebay area, the Orange County Spreading Grounds are prioritized for recycled water over stormwater.

All of these activities will require coordination amongst the respective agencies to ensure that the spreading operations for each of these water sources are achieved and that the overall basin objectives and water quality goals are met. These institutional arrangements and coordinated operations will be addressed in the agreements to be executed for implementation of a full-scale program. Metropolitan will be collaborating with member agencies, groundwater managers, and other essential stakeholders to develop preliminary terms and conditions that would be mutually acceptable if the program proceeds.

6.4 Determination of Delivery Amounts and Schedule by Basin

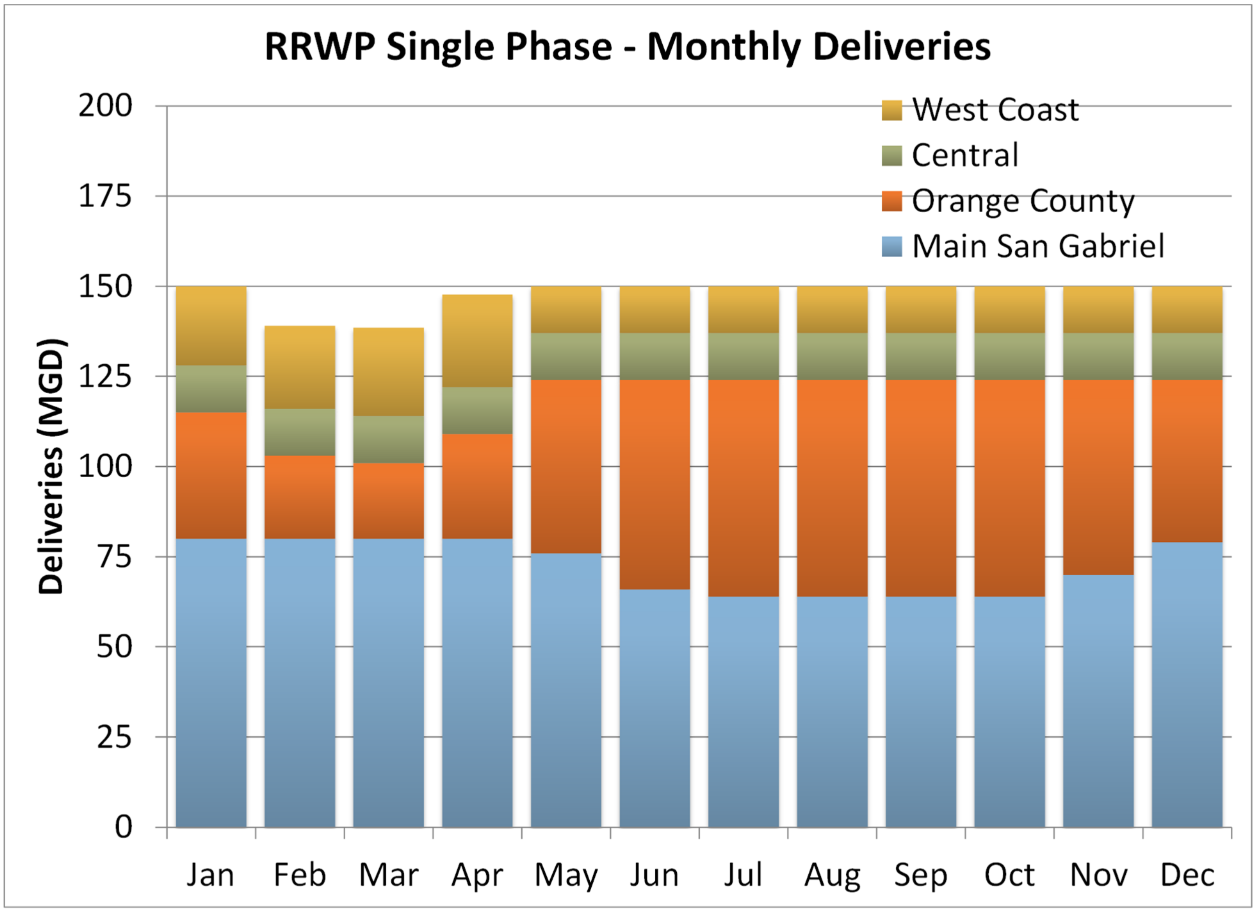
Table 6.3 reflects average annual recharge amounts expected from the program and provides the assumptions made for those amounts, as discussed previously. These deliveries are expected to be feasible approximately 85% of the time (totaling 150 mgd). During the remaining 15% of the year, total potential recharge capacity is expected to periodically decline to a low of about 100 mgd. This fluctuation in demands is captured in the expected yield for each alternative (98% of the peak production capacity of the AWT plant) and is consistent with the Base Case scenario in the Feasibility Study. The monthly delivery schedule for the RRWP is shown in Figure 6.2.

The program depends on the willingness of partnering agencies to enter into a storage and extraction agreement. For the program to work, the agencies must pump out the water that is stored via the program. In the West Coast Basin and within the City of Los Angeles' service area, adjudicated groundwater rights are not currently fully used; the RRWP will provide an opportunity to increase the utilization of these valuable water resources.

Table 6.3: Average Annual Replenishment Deliveries by Basin

Groundwater Basin	Annual Replenishment Deliveries		Notes/Assumptions
	TAFY	mgd	
Main San Gabriel			
Existing	43	38	Historical replenishment deliveries
Planned	25	22	Additional deliveries to meet projected replenishment needs
Planned	13	12	Additional deliveries to Main San Gabriel Basin that will be used in Raymond and Six Basins
Total	81	72	
Orange County			
Existing	52	46	Limited by spreading basin capacity
Total	52	46	
Central			
Projected (under construction)	10	9	WRD Groundwater Reliability Improvement Project in operation; Manhattan Wellfield begins pumping
Planned	4	4	Long Beach injection wells
Total	14	13	
West Coast			
Planned	11	10	Refineries in Harbor area; consumptive use
Future	10	9	West Basin injection wells
Total	21	19	
Total – All Basins	**168**	**150**	

Figure 6.2: Monthly Deliveries per Basin (Existing and Planned)



6.5 Next Steps

The following additional groundwater investigations are recommended:

1. Perform physical tracer studies to confirm results of solute transport and particle tracking. Tracer analysis will help to determine the RWC and travel time requirements and the impacts to existing wells.
2. Perform water compatibility studies for the injection wells and the spreading basins to assess whether there will be any potential interactions between the purified water and the native groundwater. If a potential interaction is determined to be possible, additional actions may be needed to prevent biofouling in the wells or precipitation of minerals.
3. Confirm siting of the proposed injection wells and relocated production wells.

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Chapter 7

Environmental Planning

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7.0 ENVIRONMENTAL PLANNING

7.1 Background

Implementation of the RRWP will require environmental review under CEQA and NEPA, and possibly permitting under the Clean Water Act/Porter-Cologne Water Quality Control Act, California Fish and Game Code, state and federal Endangered Species Acts, and other applicable laws. For the RRWP, Metropolitan is the lead agency under CEQA (Public Resources Code [PRC] Section 21067) and is responsible for complying with the requirements of CEQA. Among other things, the environmental documents for the program will inform decision makers and the public about the potentially significant environmental effects of the proposed activities and identify the ways that significant environmental effects can be avoided or reduced.

CEQA is a public process designed to create informed decision-making. If a project may cause significant adverse environmental impacts, the public agency must prepare an EIR. An EIR contains in-depth studies of potential impacts, measures to reduce or avoid those impacts, and an analysis of project alternatives. A key feature of the CEQA process is the opportunity for the public to review and provide input on the environmental document. If the program is implemented in phases, as proposed, Metropolitan anticipates that a program-level EIR and associated project-level environmental documents will be prepared.

Similar to CEQA, NEPA is a federal law that requires federal agencies to perform environmental analyses for any project that triggers a federal action (such as a permit, lease agreement, or grant funding) and to determine the environmental consequences of their proposed actions before they act. The initial step of environmental review for projects subject to NEPA is generally the preparation of an environmental assessment, which may be prepared by Metropolitan in consultation with the federal lead agency. If the federal lead agency finds that the action could have a significant environmental effect, the federal lead agency will direct the preparation of an Environmental Impact Statement (EIS) in consultation with Metropolitan. The final preferred RRWP conveyance system alignment will cross federal property and federally-controlled structures (e.g., bridges, storm channels, or dams), thus it is likely that Metropolitan will have to acquire federal permits, easements or other approvals, which will trigger compliance with NEPA.

Both CEQA and NEPA require lead agencies to publish drafts of their EIR/EIS documents and to receive and consider public comments before making a final decision on the project. Metropolitan will coordinate the public review process and respond to comments, as outlined by the CEQA/NEPA process.

7.2 Potential Environmental Constraints

Metropolitan conducted preliminary, screening level surveys of a number of potential pipeline alignments to identify and, where feasible, modify the project design to avoid potential environmental effects from the program. The California Department of Fish and Wildlife's California Natural Diversity Database and field site visits were used to identify species of concern; the California Department of Toxic Substances Control EnviroStor database was used to identify hazardous waste and Superfund sites; leaking underground fuel tank data were obtained from the SWRCB; and California State Parks' Registry of Historic Resources and the Federal Registry of Historic Places were used to locate potentially affected cultural resources. Los Angeles and Orange County datasets were used to identify the presence of sensitive receptors (e.g., hospitals, schools, and nursing homes), public parks, and other potentially affected public facilities.

Biological Species

Metropolitan staff developed pipeline alignments that avoid and reduce direct affects to biological species, critical habitat, and other environmental resources to the extent feasible. Limited portions of the final preferred alignment have the potential to affect federal and state Endangered Species Act listed species or species of concern, including three listed bird species: least Bell's vireo (*Vireo bellii pusillus*), southwestern willow flycatcher (*Empidonax trailii*), and coastal California gnatcatcher (*Polioptila californica*). A portion of the alignment runs along the San Gabriel River, which has many bridges and other suitable roosting habitat for bats.

Critical Habitat

The design effort has focused on alignments that avoid sensitive resources, especially wetlands and critical habitat. However, the final preferred alignment may cross near lands designated as state or federal wetlands or federal critical habitat for the coastal California gnatcatcher. Any resulting impacts will be studied during the CEQA process.

Air Quality, Greenhouse Gas Emissions, and Climate Action Plan

The proposed project site is in the South Coast Air Basin (Basin), within the jurisdiction of the South Coast Air Quality Management District. Pollutants that are monitored within the Basin are subject to state and federal emissions standards. These pollutants include ozone, carbon monoxide, nitrogen dioxide, and suspended particulates. Temporary and operational emissions will be modeled, and design modifications will be made to reduce emissions, where feasible.

Greenhouse gas (GHG) emissions trap heat from the sun and warm the planet's surface. Such emissions are projected to produce severe climate changes, such as sea level rise and a reduction in precipitation, throughout California over the next 100 years. California has set GHG reduction goals to reverse the effects of climate change. In 2006, California passed Assembly Bill 32 (AB 32), the Global Warming Solutions Act of 2006, which sought to reduce California's GHG emissions to their 1990 levels by 2020. Senate Bill 32, passed in 2016, requires the state board to ensure that statewide greenhouse gas emissions are reduced to 40% below the 1990 level by 2030. Though California's GHG reduction targets are mandatory for state agencies, the targets have not specifically been applied to local public water agencies.

CEQA requires analysis of whether a project's construction and operational impacts conflict with an applicable plan, policy, or regulation adopted for the purposes of reducing GHG emissions. The construction and operation of the facilities for the RRWP will produce new GHG emissions that must be addressed during the CEQA process. GHG emissions can be offset through the purchase of carbon credits on the open market, applying techniques to reduce emissions such as purchasing conserved forest lands, building solar facilities to offset emissions, or using a Climate Action Plan (CAP) (CEQA Guidelines Section 15183.5). A CAP allows an agency's existing conservation programs to be quantified and used to offset future project GHG emissions. Metropolitan is currently preparing a CAP and will analyze GHG emissions from foreseeable projects and operations, presenting a realistic district-wide net carbon footprint for Metropolitan activities. GHG reductions from existing water and energy savings programs like the turf removal program, solar and hydroelectric plants, rideshare programs, and conservation of natural and working lands, will be used to offset emissions from future operations.

Transportation/Traffic Impacts

Construction of the conveyance system will largely be through urban environments and will involve street closures or rerouting of traffic. During CEQA review, a traffic study will be prepared that will identify project related increases in vehicle trips and will identify measures that could be implemented to reduce or mitigate impacts.

7.3 CEQA/NEPA Compliance Strategy

A PEIR and a PEIS are types of CEQA/NEPA documents designed to be used for large projects with multiple components that would require multiple agency approvals or multiple construction contracts. Based on preliminary environmental analysis, project schedule, and program constraints, the preparation of a PEIR is recommended for the overall program, with additional project-level tiered documents to support future phases of the program. The PEIR will allow Metropolitan to consider broad policy alternatives and program-wide mitigation measures early in the program design; and will provide greater flexibility to consider design alternatives to avoid, minimize, and develop mitigation measures for identified impacts and to ensure adequate cumulative impact analysis. In addition, the proposed first phase of the program will be analyzed at the project level to allow Metropolitan to immediately move into design, real property acquisition, and permitting for the initial phase.

The PEIR will require the completion of detailed technical studies in numerous technical disciplines, which will commence upon board approval to proceed with the CEQA/NEPA analysis. Engineering support will be needed to analyze the potential environmental impacts of the proposed first phase at a project level. During CEQA and/or NEPA review, technical studies will include biological surveys to identify species or habitat that could reasonably be impacted by the construction or operation of the RRWP's AWT plant or conveyance system. If sensitive biological resources are identified, Metropolitan will work with the appropriate federal and state natural resource agencies to develop strategies to avoid or reduce potential impacts or compensate for any unavoidable impacts likely to occur.

Metropolitan will also coordinate with federal and state agencies during the CEQA and/or NEPA environmental review to ensure that these documents support any permits, approvals, or other actions required from the California Department of Fish and Wildlife, United States Fish and Wildlife Service, California RWQCBs, or USACE.

Lastly, state law requires lead agencies to consult with interested Native American tribes on projects subject to CEQA review to determine if these projects have any effect on tribal cultural resources. Metropolitan will notify selected tribes and, if requested, consult with these tribes in good faith in an effort to reach an agreement on measures to mitigate or avoid any significant effects, if significant effects on tribal cultural resources are reasonably foreseeable. The duration and timeline for this consultation process is not set in law and will be determined on a case-by-case basis. Federal tribal consultation may occur if the project requires NEPA review.

7.4 Next Steps

The following actions are recommended to prepare for potential board authorization of CEQA/NEPA review:

1. Continue to identify environmental constraints and potential solutions for the proposed alignments.
2. Conduct initial meetings with regulatory agencies to help develop the scope of work necessary to obtain regulatory permits and CEQA clearances.
3. Develop engineering data needed for project level clearance of the proposed first phase of the program.
4. Prepare the scope of work and budget for environmental review.

Chapter 8

Technology Acceptance and Permitting

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8.0 TECHNOLOGY ACCEPTANCE AND PERMITTING

8.1 Introduction

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. As defined in AB 574, approved into law in October 2017, "IPR for groundwater recharge" means the planned use of recycled water for replenishment of a groundwater basin or an aquifer that has been designated as a source of water supply for a public water system. IPR for groundwater recharge, the focus of the RRWP, has been conducted for decades in California with the most recent groundwater replenishment regulations incorporated into Title 22 of the California Code of Regulations (Title 22) in June 2014.

The regulatory framework for the RRWP was discussed in detail in Chapter 7 of the Feasibility Study. It provides a general overview of regulations and policies associated with IPR through groundwater replenishment, the roles and responsibilities of the regulatory agencies that have oversight of water recycling, and the application of these regulations to the RRWP. The chapter also describes a potential permitting approach that Metropolitan would pursue in partnership with the Sanitation Districts and groundwater agencies.

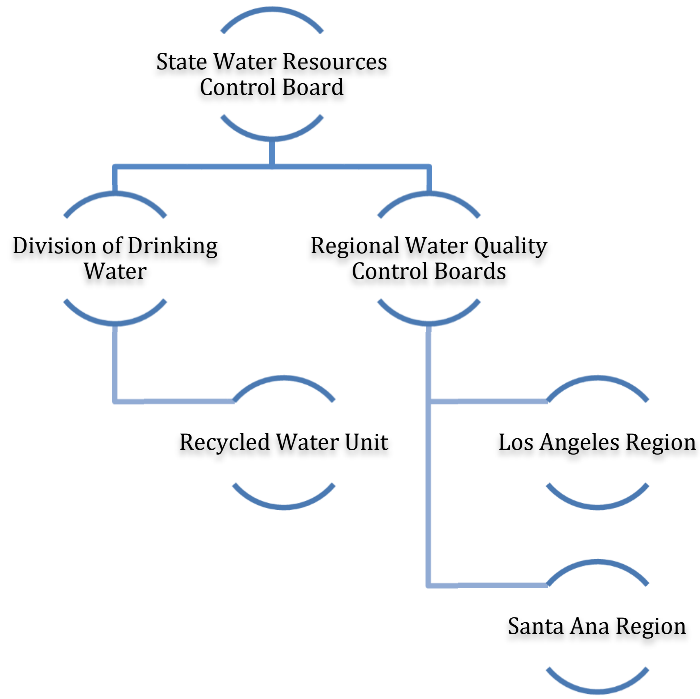
This chapter provides a general overview of the steps being taken to achieve regulatory approval of the RRWP. A key component of this regulatory process will be to receive technology acceptance of an MBR process. Metropolitan will seek SWRCB DDW acceptance of MBR as a treatment technology that complies with water recycling criteria codified in Title 22. Metropolitan's approach to achieve this, as well as overall regulatory acceptance of the proposed treatment train, will be largely accomplished through the upcoming demonstration facility at the JWPCP site. Over the past 3 years, Metropolitan has worked closely with the regulatory agencies on the RRWP and will continue this collaboration. This chapter describes these coordination efforts, along with a general timeline and associated milestones for securing a water recycling permit for the proposed program.

8.2 Regulatory Coordination

Metropolitan's close coordination and collaboration with regulators and partnering agencies is critical to ensure the success of the RRWP. Although the Waste Discharge Requirements/Water Recycling Requirements (WDR/WRR) permits are issued by the RWQCBs, DDW is the primary agency that will be involved in the technical review of program elements that could affect public health. For the RRWP, permits from both the Los Angeles and Santa Ana RWQCBs would be required, depending on the specific groundwater basins that will ultimately be pursued for recharge. A general overview of an anticipated permitting approach is discussed later in this chapter.

Figure 8.1 identifies the regulating authorities associated with permitting of the RRWP, as well as their general organization structure.

Figure 8.1: Regulatory Oversight of Program



Metropolitan and the Sanitation Districts have engaged in meetings with the regulators (DDW and the Los Angeles and Santa Ana RWQCBs) since early 2016. Following each meeting, a summary document of key discussion items and feedback was distributed to all participants, along with information presented at the meeting. As documents are generated or milestones are reached, Metropolitan continues to inform the regulators of program progress and direct them to Metropolitan's RRWP webpage for posted information.

Meetings in 2016 introduced the regulators to the proposed program. Topics covered included an overview of the program, past pilot studies, source control efforts for the JWPCP, the process train for the AWT demonstration facility, groundwater basin analyses, and preliminary permitting timelines. In addition to facilitating technical exchange, these meetings helped to establish a high level of confidence with the regulatory authorities that Metropolitan and the Sanitation Districts are well suited to successfully implement a program of this magnitude.

In 2017, coordination with the regulators focused on the testing strategy for the demonstration project. Metropolitan and the Sanitation Districts met with the regulators in March 2017. A primary focus of that meeting was to present an approach for AWT demonstration testing and Metropolitan's intent to pursue technology acceptance for an MBR as a key pathogen barrier in an IPR treatment train. In addition, a technical memorandum, *Advanced Water Treatment Demonstration Facility Testing Strategy,* was submitted to DDW to provide details on the general framework for the proposed AWT demonstration testing. The accepted framework focused on an approach for technology acceptance testing of the MBR process.

Discussions in 2018 and early 2019 have focused on finalizing the testing and monitoring protocols for the demonstration project. A meeting was held with the regulators in August 2018 to present the draft testing and monitoring plan and to gain input. The regulators concurred with the overall approach for demonstration testing and provided valuable input. A second meeting was held in January 2019 to discuss the revised plan. Metropolitan is working to receive final approval by the agencies prior to the March 2019 demonstration testing. Table 8.1 provides an overview of the regulator meetings held to date.

Table 8.1: Program Meetings with Regulators

Meeting Date	Meeting Focus/Objective
February 23, 2016	Kickoff meeting and overview of RRWP
May 23, 2016	Demonstration plant process train design
September 15, 2016	Groundwater modeling and basin assessments
March 10, 2017	Demonstration project testing strategy
August 9, 2018	Draft demonstration project testing and monitoring plan
January 17, 2019	Final demonstration project testing and monitoring plan

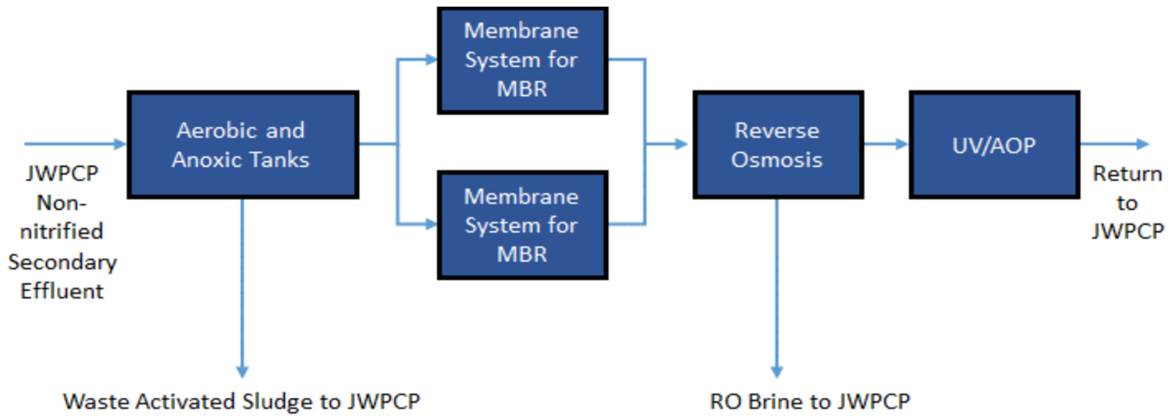
8.3 Demonstration Project

As described above, the demonstration project is being pursued to provide the data necessary to present to regulating authorities and ultimately secure a water recycling permit. Metropolitan's Board authorized the design and operation of a demonstration facility in November 2015. The project, now called the Regional Recycled Water Advanced Purification Center (Advanced Purification Center), will build upon the work completed at the smaller pilot scale and will demonstrate the ability to reliably and cost-effectively treat JWPCP effluent at the larger scale while meeting all regulatory requirements and operational objectives.

In addition to supporting the regulatory approval process, the Advanced Purification Center will be used to develop and optimize full-scale design, establish capital and operational costs, facilitate operational coordination between Metropolitan and the Sanitation Districts, and serve as a vehicle for public outreach and acceptance. The Advanced Purification Center will operate for at least 1 year to provide the necessary data to support the regulatory process and would continue operations thereafter to support other project objectives noted above.

Figure 8.2 illustrates the AWT process train that was selected for the 0.5-mgd Advanced Purification Center. Non-nitrified effluent from the JWPCP's high-purity oxygen secondary treatment system will be delivered to the facility and will be treated to levels that meet relevant regulatory requirements for groundwater replenishment. In the future, the facility is also expected to be able to receive primary effluent from the JWPCP as feed water. The treatment train consists of a nitrifying-denitrifying MBR, RO, and UV/AOP. The MBR system includes two biological tanks (aerobic and anoxic) that operate in series and two parallel 0.25-mgd MBR tanks (allowing the testing of two MBR manufacturers). During this initial testing period treating the secondary effluent, the MBR system will operate as a tertiary MBR in NdN mode. The combined MBR filtrate will feed the RO system, and 20 gpm of the RO permeate will be sent to the UV/AOP system for further treatment. The RO permeate that bypasses the UV/AOP system will be combined with the effluent from the Advanced Purification Center, as well as waste streams including brine concentrate, and will be routed back to the head of the JWPCP.

Figure 8.2: Schematic of Advanced Purification Center Process Train



A unique aspect of the demonstration project is the application of an MBR. Because the JWPCP produces non-nitrified effluent, ammonia must be removed (nitrified) from the effluent to prevent premature fouling of membranes in the AWT process and denitrified to maintain nitrate levels that meet Basin Plan objectives. Currently, pathogen credits are not granted to the MBR process in California, although this is an area that DDW has been very engaged in industry research efforts. The demonstration project's treatment train will be used to determine MBR performance for *Cryptosporidium* and *Giardia* removal. Most AWT treatment trains in California to date have applied a microfiltration/ultrafiltration (MF/UF) step upstream of RO-UV/AOP. Because of the need to manage nitrogen in the JWPCP source supply, an MBR is proposed (without the addition of MF/UF) as the optimal process in a potential full-scale AWT treatment train. If sufficient log reduction credits are granted by regulators for the MBR process, significant savings in capital and operating costs could be realized.

Table 8.2 describes the pathogen log removal credits that are currently granted for AWT processes by regulators, as well as the potential log reduction credits that could be granted to an AWT process using an MBR without the MF/UF treatment step. These additional credits will be pursued through demonstration testing of the MBR. Additional log reduction credits may also be pursued through the RO process in a future phase of testing. It should also be noted that the regulations allow up to 1-log virus reduction for each month in which the recycled water is retained underground.

Table 8.2: Approaches to Achieving Pathogen Log Reduction Credits

Unit Process	Currently Approved AWT Train			Alternate AWT Train Using MBR[1]		
	Virus	Crypto	Giardia	Virus	Crypto	Giardia
MBR	—	—	—	0	2.5[2]	2.5[2]
MF/UF	0	4	4	—	—	—
RO	1.5	1.5	1.5	1.5	1.5	1.5
UV/AOP	6	6	6	6	6	6
Free Cl_2	6	0	0	6	0	0
Total	13.5	11.5	11.5	13.5	10	10
Regulatory requirement	12	10	10	12	10	10

[1]Pathogen log removal credits currently not granted for MBRs by regulator.
[2]Requires demonstration and approval by regulator.

Because the JWPCP effluent has yet to be used for beneficial reuse, collecting data to establish the demonstration facility's ability to meet applicable regulatory criteria will be critical, especially because of the industrial nature of a portion of the sewershed. The demonstration phase 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 full-scale AWT plant or the end use of the water.

Results from the demonstration project will provide the information and water quality data necessary for Metropolitan and its partners to complete the Title 22 Engineering Report – a prerequisite for the WDRs/WRRs ultimately issued by the RWQCB. Operation of the facility will also demonstrate to the regulators Metropolitan's capacity to reliably operate an AWT facility treating secondary wastewater effluent. The demonstration project will allow both 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 that high-quality water is reliably produced and meets all regulatory requirements. Regulatory feedback on demonstration project performance and continued demonstration facility operations are concurrent activities to other RRWP elements.

8.4 Technology Acceptance

MBRs have been widely used in non-potable reuse applications, benefitting from the MBR's small footprint and high-quality effluent. A primary challenge facing implementation of an MBR in a potable reuse treatment train is the lack of pathogen reduction credits granted to date. As noted earlier, groundwater replenishment regulations in California require full advanced treatment through MF/UF, RO, and UV/AOP to achieve 12, 10, and 10-log reduction of virus, *Cryptosporidium*, and *Giardia*, respectively. Several national and international efforts have pursued quantifying pathogen log reduction values (LRVs) achieved by the MBR process. MBRs in these research efforts have been applied as a secondary wastewater treatment process (e.g., replacing a conventional activated sludge process) in a potable reuse treatment scheme. Notably, Branch and Le-Clech (2015) demonstrated LRVs for pathogens through MBRs, and the Australian Water Recycling Centre of Excellence developed multitiered protocols to aid in developing validation guidelines for MBRs used for potable reuse. In addition, Santa Clara Valley Water District (2017) and partners have worked with MBR suppliers to research MBR LRVs, reaffirming many conclusions from Australia.

Australia's MBR validation protocol presents a three-tiered approach to achieve specific pathogen LRV credits for MBR systems. The Tier 1 approach grants default LRVs of 1.5, 2, and 4 for viruses, protozoa, and bacteria, respectively, under specific operating conditions. The Tier 2 approach validates MBR systems under a different operational envelope when testing is performed to achieve superior LRVs compared to the Tier 1 default levels. The Tier 3 approach involves a specific investigation to demonstrate a correlation between an online parameter and MBR pathogen removal performance. The Australian protocol currently describes Tier 3 as hypothetical, requiring peer-review and testing in full-scale settings.

Metropolitan has discussed the Australian MBR validation efforts with DDW and received positive feedback in terms of its application to California Title 22 requirements. In April 2017, Metropolitan submitted a letter and technical memorandum, *Advanced Water Treatment Demonstration Facility Testing Strategy,* to DDW that provided details on the general framework for the proposed AWT demonstration testing. This correspondence focused on the approach for alternative technology acceptance testing of the MBR process. DDW replied in May 2017, concurring with Metropolitan's overall approach for its demonstration project while providing technical feedback to be incorporated into the demonstration testing and monitoring plan. Correspondence between Metropolitan and DDW associated with the demonstration project's testing strategy is available on Metropolitan's RRWP webpage.

Testing at the Advanced Purification Center will include the demonstration of integrity monitoring of the MBR process to consistently achieve pathogen LRVs for *Cryptosporidium* and *Giardia*. Following the testing period, Metropolitan will prepare a report that presents the testing and monitoring results. This report will be provided to DDW to demonstrate that the MBR technology has been fully evaluated and has been shown to comply with Title 22 requirements on the JWPCP-specific wastewater source. The demonstration project results must satisfactorily show that the MBR technology provides a degree of treatment and reliability equal to the other technologies listed in Title 22 in order to receive technology acceptance from DDW (Title 22 Section 60320.5). If additional data is needed to assess the MBR technology beyond the testing and monitoring period, further assessment of the treatment strategy and demonstration facility operations can be evaluated. It should be noted that once a proposed treatment technology is accepted by DDW, it must undergo the RWQCB water reclamation permitting process to be approved for use at a specific water utility. DDW reviews and provides comments during this permitting process to confirm full compliance with applicable treatment and reliability features required by Title 22.

8.5 Demonstration Testing and Monitoring Plan

Metropolitan and the Sanitation Districts have prepared a testing and monitoring plan for the demonstration project at the Advanced Purification Center. This plan builds upon the framework described in the technical memorandum, *Advanced Water Treatment Demonstration Facility Testing Strategy,* and incorporates input from DDW and the RWQCBs.

The testing and monitoring plan outlines the work to be conducted in the demonstration project in three phases over a period of 15 months, which includes 3 months of equipment testing, process acclimation, and analytical methods development as part of a "pre-testing" initial shakedown period. Some of this work will occur concurrently with the construction contractor's startup and commissioning of the Advanced Purification Center. The next two phases of testing are expected to be completed within 1 year. Phase 1 will include testing under steady-state or baseline conditions. Phase 2 will include testing under compromised system conditions, which will include challenge testing to evaluate the robustness and overall tolerances of the system under worst-case conditions. A brief description of the testing planned for each treatment process is shown in Table 8.3. As indicated in the table, the testing and monitoring plan includes simultaneous testing of the unit processes to maximize the amount of time available for testing and the amount of useful data produced during the test period.

Table 8.3: Demonstration Testing and Monitoring Plan Schedule

Phase	Duration	Study Focus		
		MBR	RO	UV/AOP
Pre-testing	3 months	Equipment testing Process acclimation Method development	Equipment testing Process acclimation	Equipment testing Collimated beam testing UV/AOP dose calibration
1	4 months	Baseline performance testing	Baseline performance testing	Analysis of dose-response curve Testing of UV/H_2O_2 Testing of UV/Cl_2
2	8 months	Compromised system challenge testing	Evaluation of fouling during compromised MBR system testing	

A workshop was conducted in August 2018 to present the draft demonstration testing and monitoring plan to DDW and the RWQCBs and gain further input. Input from the independent scientific advisory panel, as described in the following section, was also received. A second meeting with the regulators was held in January 2019 to discuss the revised plan. Metropolitan is working to receive final approval by the agencies prior to the March 2019 demonstration testing.

8.6 Future Testing Needs

Following the first year of testing, which focuses largely on pathogen removal performance of an MBR and AWT treated water quality, other objectives of the demonstration project will be addressed. These objectives include the following:

1. Demonstrate that a treatment train of MBR-RO-UV/AOP can fully satisfy all regulatory requirements.
2. Develop data for the Title 22 Engineering Report.
3. Determine optimum design and operating criteria for a full-scale AWT facility.

The impact on MBR and RO membranes of varying biological process operational parameters, such as solids retention time and mixed liquor suspended solids concentration, as well as optimization of the downstream unit processes (RO and UV/AOP), and post-treatment will be assessed. Enhanced pathogen removal testing will be conducted on the RO membrane to determine if higher LRVs can be consistently demonstrated through continuous monitoring of surrogates other than online total organic carbon and conductivity, which typically can only demonstrate between 1- to 2-log reduction due to detection limits and/or low feed concentrations. Removal through the RO membrane of other naturally-occurring or spiked surrogates, such as a continuously added fluorescent dye (i.e., TRASAR), strontium, or sucralose, will be assessed. Dose optimization for UV and the appropriate oxidant (hydrogen peroxide or sodium hypochlorite) to achieve the most effective AOP reduction of target constituents, namely nitrosamines and 1,4-dioxane, will be conducted. In addition, post-treatment stabilization processes will also be tested using pipe loops.

The draft testing and monitoring plan focuses on testing an AWT process train that incorporates a tertiary MBR receiving secondary effluent from the JWPCP. However, future plans will include testing variants of the main treatment train, such as a secondary MBR configuration or testing a nitrification-only MBR with a double-pass RO membrane configuration. The RO membrane system that is currently being constructed at the Advanced Purification Center can be reconfigured to operate as a double-pass RO system. Metropolitan and the Sanitation Districts continue to discuss the optimal means of managing nitrogen as part of the overall treatment process train. Beginning in early 2017, both agencies participated in a Nitrogen Management Committee with the objective of evaluating alternatives and identifying a holistic nitrogen management strategy for the combined JWPCP and AWT facilities. The committee's report, *Nitrogen Management Evaluation for Full-scale Advanced Water Treatment Facility*, is included in Appendix C. (See Chapter 4, Advanced Water Treatment Plant for further discussion.)

Flexibility has been incorporated into the Advanced Purification Center design and site layout to support additional unit processes, if needed, for the evaluation of alternative process trains in the future. At the end of 2016, the SWRCB released its report, which concluded that it is feasible to develop and adopt regulations for direct potable reuse, provided that certain research and key knowledge gaps are addressed. AB 574, enacted as law in October 2017, requires the SWRCB to adopt uniform water recycling criteria for direct potable reuse through raw water augmentation by the end of 2023.

In April 2018, the SWRCB released its draft *Proposed Framework for Regulating Direct Potable Reuse in California*. This framework focuses on the raw water augmentation form of DPR, which is defined as the planned placement of recycled water into a pipeline or aqueduct that delivers raw water to a drinking water treatment plant. This differs from the treated drinking water augmentation form of DPR, which is the planned placement of recycled water directly into a treated water distribution system (also termed "flange-to-flange DPR"). There is no known regulatory timeline for this latter form of DPR and the SWRCB has indicated it will not pursue this regulatory development until raw water augmentation regulations are established. In addition, the SWRCB recently completed rulemaking for surface water augmentation. These regulations have been approved by the state's Office of Administrative Law with an effective date of October 1, 2018. It should be noted that the SWRCB will be amending these regulations in the next 2 years (and redefining this form of IPR as reservoir water augmentation) to incorporate language that will include conveyances feeding a source water reservoir to be covered under the regulation.

Metropolitan continues to monitor and engage in research, technical assessments, and regulatory developments of these additional forms of potable reuse. Long-range plans for the Advanced Purification Center may include use of the facility to optimize existing treatment processes or assess the viability of new treatment processes to meet changing or future regulations that have yet to be fully defined.

8.7 Independent Scientific Advisory Panel

An independent scientific advisory panel (ISAP) has been established to provide review of the scientific, technical, and regulatory aspects of the demonstration project to be conducted at the Advanced Purification Center. A RFP was issued in Fall 2017 for a facilitator and panel, and NWRI was selected through this process. NWRI was charged to provide a panel facilitator who has extensive experience in the water reuse industry, working with water agencies, wastewater agencies, and regulators in this capacity. NWRI also assembled a panel of experts that will assist Metropolitan and its partners during the demonstration project.

California's groundwater recharge reuse regulations (Title 22 CCR §60320.130) require the review by an ISAP for projects that may seek alternatives to existing regulations. Per Title 22, panel members must include, at a minimum, a toxicologist, a registered engineering geologist or hydrogeologist, an engineer licensed in California with at least 3 years of experience in wastewater treatment and public drinking water supply, a microbiologist, and a chemist. The objective of the ISAP for the demonstration project is to provide independent review of the technical, scientific, regulatory, and public health aspects of the demonstration project. This review will be used to develop design criteria for the potential full-scale AWT plant, clarify capital and operational costs for advanced treatment, and ultimately to obtain regulatory permits for a full-scale program.

Table 8.4 identifies the panel members for the demonstration project. Mr. Ed Means of Means Consulting, LLC, serves as the facilitator for the panel. The primary expertise of each panel member is also identified in the table. It should be noted that the panel members may have additional expertise that offers value to the demonstration project and the ultimate development of a full-scale RRWP.

Table 8.4: Independent Scientific Advisory Panel

Panel Member	Expertise
Richard Bull, PhD	Toxicology
Joseph Cotruvo, PhD	Chemistry
Chuck Haas, PhD (chair)	Microbiology
Thomas Harder, RG	Hydrogeology
Michael Stenstrom, PhD, PE	Wastewater Treatment
Adam Olivieri, PhD, PE	Water Regulations, Permitting
Vernon Snoeyink, PhD	Pipeline Corrosion, Water Chemistry
Paul Westerhoff, PhD, PE	Drinking Water Treatment, Advanced Water Treatment

The first workshop of the ISAP was held on August 8 and 9, 2018. The workshop included 48 participants, which consisted of the panel members and representatives from Metropolitan, Sanitation Districts, NWRI, and consultant teams. Presentations were provided by Metropolitan and Sanitation Districts staff to familiarize the panel with the overall program and the detailed testing and monitoring plans associated with the demonstration facility. The panel members were given several key questions to focus its review. Overall, the panel concurred with the testing approach and found no fatal flaws.

The panel offered several recommendations to be considered and incorporated, as appropriate, as Metropolitan and the Sanitation Districts finalize the testing and monitoring plan for regulatory submittal. The panel produced a report of its review and findings that was available to regulators as they reviewed the draft plan. As indicated earlier in this chapter, final approval of the testing and monitoring plan by the regulators is expected to be received prior to the March 2019 demonstration testing.

The ISAP will participate throughout the testing period for the demonstration facility, and completion of the demonstration project and MBR technology acceptance report(s) to be submitted to regulators for approval. If a full-scale program is approved by Metropolitan and the Sanitation Districts at a later time, an independent panel of a similar makeup or with additional/alternative expertise as desired is expected to continue to provide guidance and technical review throughout the development and implementation of the RRWP.

8.8 Permitting Approach and Timeline

Considering the regional nature of this program – spanning multiple groundwater basins, counties, and RWQCB jurisdictions – a number of permitting scenarios could be considered for the RRWP. If the program is approved to move forward, Metropolitan would engage in detailed discussions with its partners and the regulators on the permitting approach. It is currently envisioned that individual permits (WDR/WRRs) will be required for each groundwater basin. When multiple recharge sites are proposed for a groundwater basin (e.g., recharge sites in Long Beach Forebay and Montebello Forebay are proposed for Central Basin), all sites could be covered under a single permit.

This approach is similar to OCWD's GWRS in which multiple spreading and injection sites are included in a single permit issued by the Santa Ana RWQCB. Also, in line with other permits for groundwater recharge facilities in southern California, it is anticipated that agency partners for the proposed program may also be listed as co-permittees, where appropriate, based on their specific roles for the facility or project. Table 8.5 indicates key regulatory elements of a water recycling permit and some of the agencies that could play a role in those permitted activities. It should be noted that the basin managers are indicated in Table 8.5 because of their potential partnering role in the permitting process; however, activities such as groundwater extraction would be undertaken by individual pumpers within the groundwater basin and coordination would also be needed with these agencies.

The unique nature of this regional program with multiple partners may require that creative permitting approaches are developed in collaboration with the regulators and project partners. In addition to the permits themselves, agreements would be necessary between Metropolitan and its partners to identify specific roles and responsibilities, including those associated with program implementation, project operations, and permit compliance.

Table 8.5: Key Coordinating Agencies on Program Permitting Elements

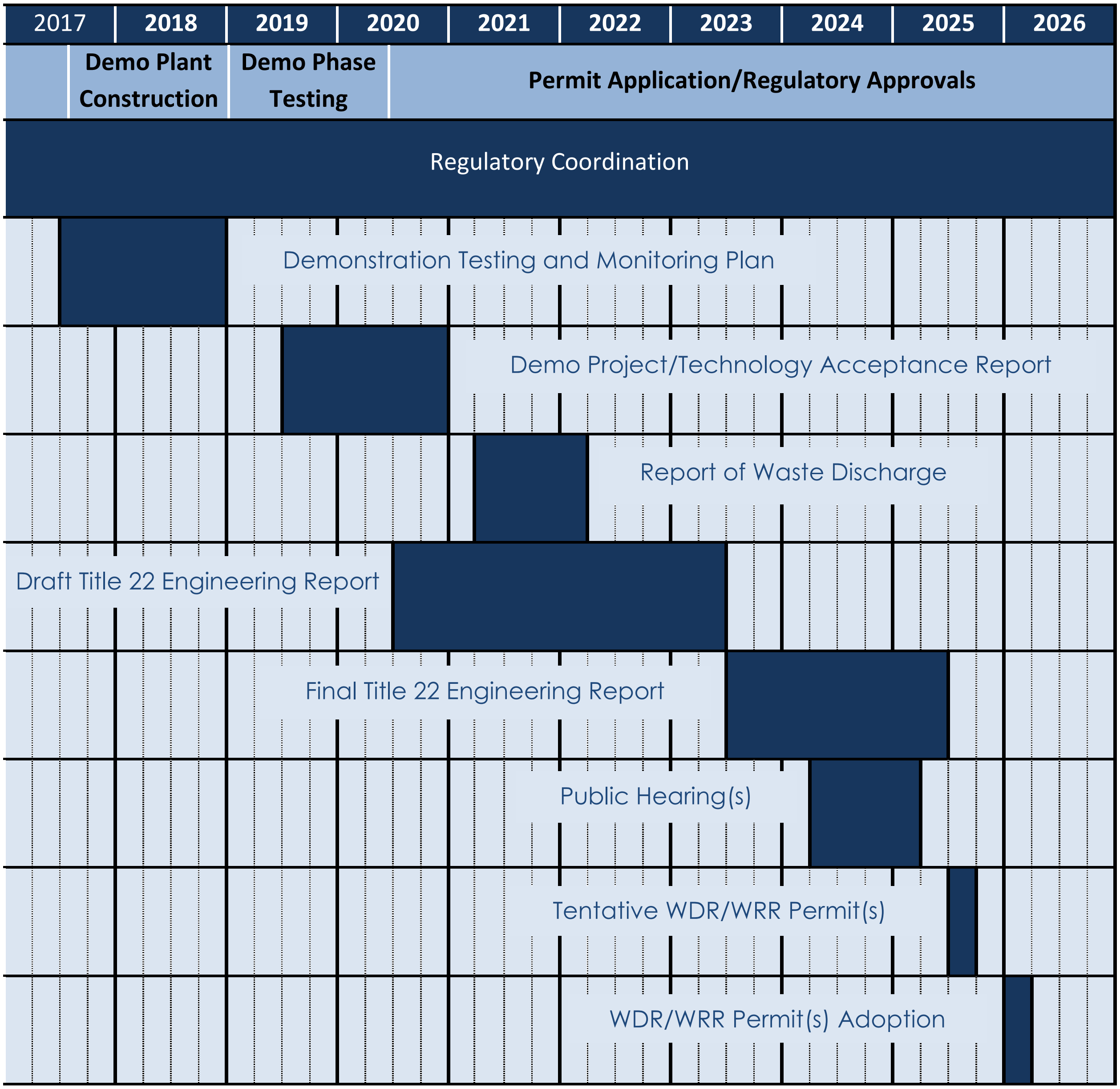
Permitting Element	Coordinating Agencies
Wastewater Treatment	Sanitation Districts of Los Angeles County
Advanced Water Treatment	Metropolitan Water District of Southern California
Spreading and/or Injection Site Operations	Metropolitan Water District of Southern California Los Angeles County Flood Control District Orange County Water District Water Replenishment District Main San Gabriel Basin Watermaster
Groundwater Extraction	Central Basin Municipal Water District West Basin Municipal Water District Orange County Water District Main San Gabriel Basin Watermaster
Groundwater Monitoring	Water Replenishment District Central Basin Municipal Water District West Basin Municipal Water District Orange County Water District Main San Gabriel Basin Watermaster

The key technical document that contributes to the permitting process is the Title 22 Engineering Report. Results and data generated from the demonstration project will be used to develop this report. Hydrogeological assessments and modeling for each groundwater basin will also be conducted as a part of the Title 22 Engineering Report development. Because the regional nature of this program encompasses multiple groundwater basins and RWQCB jurisdictions, the structure and development of the program's Title 22 Engineering Report could be approached in several ways. In addition, phasing of the program (e.g., pursuing an initial phase at a lower capacity directed to one groundwater basin, versus a full buildout of multiple basins at 150-mgd capacity) may necessitate an engineering report that is flexible in nature and appended as additional program phases and groundwater basins are pursued. Options and approaches will be further discussed with regulators and partners as the program progresses.

Metropolitan will work closely with its partners and the regulating authorities to maintain an aggressive schedule for securing a water recycling permit. Key to the overall permitting timeline will be the construction of the demonstration facility and completion of the testing period. A report of waste discharge is projected to be submitted to the RWQCBs in 2022; this report essentially serves as a permit application. The Title 22 Engineering Report is the major milestone in the permitting process; the draft report is expected to be submitted to DDW and the RWQCBs in 2023. Following a period of review and consultation with the regulating authorities on the Draft Title 22 Engineering Report, the final report is expected to be issued in 2025. Public hearings with DDW would be conducted prior to its issuance. A tentative permit would then be issued and final adoption of the WDR/WRRs by the RWQCBs would be in 2026.

Key milestones leading to the regulatory approvals by DDW and the RWQCBs are shown in Figure 8.3.

Figure 8.3: Key Regulatory Submittals and Estimated Timeline



8.9 Assessing Direct Potable Reuse Options

The location of both the Weymouth WTP and the Diemer WTP in relation to the proposed RRWP facilities provides an attractive opportunity for purified water to supplement the raw water supply to a drinking water treatment plant, once DPR regulations are approved. A summary of the various elements that Metropolitan and the Sanitation Districts must consider for DPR as a viable future option for the RRWP is described below. A more detailed analysis is contained in Appendix B.

Regulatory Outlook

Although currently not regulated in California, there has been an increasing focus on DPR in recent years. In general, DPR refers to the direct augmentation of a water supply with advanced treated water without an intervening environmental buffer (e.g., groundwater basin or reservoir). There are various forms of DPR. It should be noted that this evaluation of DPR as a future opportunity for the RRWP is solely focused on the raw water augmentation form of DPR. Therefore, the terms “DPR” and “raw water augmentation” may be used interchangeably throughout this report.

As noted earlier, raw water augmentation is defined as the planned introduction of recycled water into a pipeline that delivers raw water to a drinking water treatment plant. In April 2018, the SWRCB released its *Proposed Framework for Regulating Direct Potable Reuse in California*, which focused on the regulatory development of raw water augmentation. California’s AB 574 requires that the SWRCB adopt uniform water recycling criteria for raw water augmentation by the end of 2023; however, stipulations may extend that timeline based on the state of available scientific and technical research at that time.

In pursuing DPR options for the RRWP, several enhancements are anticipated to be required by future regulations to compensate for the loss of the environmental buffer (i.e., groundwater basin) and all of its benefits (e.g., dilution, additional treatment, and response time). Similar to the approach taken for the RRWP demonstration project, Metropolitan would also engage an independent scientific advisory panel on technical, scientific, and public health issues associated with development of raw water augmentation, if it is considered as a program element in the future.

Source Control and Wastewater Treatment Optimization

Source control programs under a DPR application are expected to be more prescriptive than those required for an IPR project. Requirements may have to be enhanced to address short-term chemical peaks, and local limits could be used to control the discharge of certain chemicals. Public outreach to industrial, commercial, and residential communities as part of a comprehensive source control program would likely be further strengthened. Further optimization of wastewater treatment processes may also be needed to help reduce certain compounds prior to the water reaching the AWT facility. The Sanitation Districts continue to assess opportunities to enhance existing source control programs and wastewater treatment operations as part of the RRWP. These efforts would be of even greater significance under a DPR scenario.

Advanced Water Treatment

With respect to the advanced treatment process, higher levels of treatment are expected to be required by future raw water augmentation regulations. Treatment redundancy through multiple independent barriers (e.g., physical, biological, or chemical) is expected. By eliminating the environmental barrier, higher levels of pathogen control (i.e., log reduction requirements) will likely be needed. Based on the SWRCB’s increased pathogen control requirements for surface water augmentation compared to groundwater replenishment, a reasonable estimate for the required pathogen log reduction for raw water augmentation would be 15/13/13 log removal of virus/*Cryptosporidium*/*Giardia*. Current groundwater replenishment regulations require 12/10/10 log removal of these pathogens. The SWRCB may require all pathogen removal credit to be obtained at the AWT facility, with the downstream drinking water plant (i.e., Weymouth or Diemer WTP) providing redundant treatment. A potential DPR advanced water treatment train that has been evaluated by the SWRCB through industry research is the addition of ozone and biological activated carbon upstream of membrane filtration, RO, and UV/AOP.

Monitoring and Response Actions

With the loss of the environmental buffer, responding to treatment failures (microbial or chemical breakthrough) becomes even more critical in a DPR treatment scheme. More rigorous monitoring and enhanced tools will be required to respond to "off-spec" events. The need for control systems that automatically respond to performance data in real time will also become more important in a DPR application. Engineered storage may be considered as an alternative to the environmental buffer, providing increased holding times to respond to treatment failures or water quality issues prior to entering the conveyance pipeline or drinking water treatment plant. As the RRWP's system provides long pipeline reaches up to approximately 38 miles from the AWT facility, travel time within the pipeline could also serve as additional response time to address off-spec events. Locations for diverting off-spec water would also have to be identified. The lengthy pipeline reach provides a further benefit by allowing for increased chlorine contact time for disinfection.

Blending at Drinking Water Treatment Plants

The SWRCB has indicated that blending requirements will likely be incorporated into future raw water augmentation regulations. Recently adopted surface water augmentation regulations require a minimum 10:1 or 100:1 dilution (ambient reservoir water to the advanced treated recycled water) based on the level of pathogen removal applied in advanced water treatment. It is unclear at this time the level of dilution that will be required for raw water augmentation to the Weymouth or Diemer WTPs, but the SWRCB is expected to take a relatively conservative approach initially until greater experience is gained in California on projects of this type. Therefore, a potential future application of raw water augmentation for the RRWP may require a phased approach in which higher amounts of advanced treated recycled water could be applied in future years based on demonstration to regulators of operational reliability and public health protection.

Additional areas of focus for Metropolitan, if it pursues raw water augmentation in the future, would be the potential effects at the Weymouth or Diemer WTPs. Additional research would be needed to assess effects of blending this alternative source water into Metropolitan's system. This would be accomplished through pilot- or demonstration-scale testing. In addition, any operational changes at Metropolitan's water treatment plants, such as increased ozone or chemical dosages, or any potential modifications to those systems, would have to be assessed. Potential investments in additional water treatment processes or monitoring capabilities would also have to be further evaluated to ensure that the Weymouth or Diemer WTPs continue to operate reliably and that the water produced continues to meet all regulatory requirements.

Conveyance System

Implementing raw water augmentation as a future opportunity for the RRWP would require additional conveyance infrastructure. A system connection from near the Santa Fe Spreading Grounds to the Weymouth WTP would require up to 15 miles of additional pipeline, as well as additional pump stations to overcome approximately 600 feet of static lift. Connecting the RRWP system to the Weymouth WTP would also allow for the recycled water to be brought to the Diemer WTP via Metropolitan's existing Yorba Linda Feeder. A system connection just south of the Whittier Narrows area to the Diemer WTP would require up to 19 miles of additional pipeline, as well as an additional pump station to overcome approximately 650 feet of static lift. Additional analysis on the pipeline diameter, alignment, and hydraulics will be conducted if either of these DPR options is pursued further. Additional studies would be conducted regarding the use of Metropolitan's existing pipelines and feeders to deliver purified water to the Weymouth and Diemer WTPs.

Moving Forward

The current focus of the RRWP is IPR through groundwater replenishment, as groundwater basins serve a vital function in the region's diversified water portfolio. Therefore, a primary objective of this program is to provide a drought-proof supply of replenishment water to these basins to maintain the long-term health and reliability of groundwater basins within the region. This long-term replenishment demand is anticipated to remain, with or without the opportunity to integrate DPR in the future. Raw water augmentation may be a viable future opportunity for the RRWP; however, as described above, additional work would be needed to fully evaluate this option to deliver advanced treated water to the Weymouth or Diemer WTPs.

Metropolitan continues to actively engage with the water industry on the regulatory development of DPR. Funding through Metropolitan's Future Supply Actions program has recently been provided to help advance several potable reuse studies and fill research gaps identified by the expert panel advising the SWRCB on DPR regulatory development. Metropolitan staff will also be conducting technical evaluations through the upcoming demonstration project at the Regional Recycled Water Advanced Purification Center and developing future research programs associated with potable reuse, including raw water augmentation applications. All these efforts will play a significant role in advancing the science and understanding of all forms of potable reuse in Metropolitan's service area and statewide. Retaining the flexibility to implement DPR options as part of the RRWP creates the possibility to benefit significantly from this emerging opportunity.

8.10 Next Steps

Metropolitan will continue to coordinate with the Sanitation Districts on the following near-term actions related to the demonstration project and regulatory acceptance of the proposed treatment process.

1. Begin operations at the Advanced Purification Center and initiate the 15-month demonstration testing period in March 2019. Primary focus of the initial testing period will be to demonstrate pathogen removal through the MBR process, while ensuring water quality from all unit processes meet established treatment goals.
2. Develop a testing and monitoring plan for a future testing phase that will focus on treatment process optimization and development of full-scale design criteria.
3. Continue coordination with the regulatory agencies and the independent scientific advisory panel throughout the demonstration project.
4. Continue to monitor and engage in research, technical assessments, and regulatory developments of additional forms of potable reuse, including DPR, and evaluate future opportunities for DPR.

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Chapter 9

Findings and Recommendations

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9.0 FINDINGS AND RECOMMENDATIONS

9.1 Introduction

The conceptual planning studies presented in this report build upon the analysis of the RRWP that was initiated in the initial pilot-scale studies and further advanced through the 2016 Feasibility Study. As authorized by Metropolitan's Board, the conceptual planning studies evaluated the opportunities for program phasing; further refined the major program elements of treatment and conveyance; and conducted additional groundwater modeling evaluations associated with introducing purified water into the groundwater basins. Detailed technical analyses completed for this report include the following:

1. Evaluation of alternatives for program implementation and phasing.
2. Assessment of potential DPR options.
3. Joint investigation with Sanitation Districts of nitrogen management alternatives.
4. Investigations by Sanitation Districts of potential source control for boron.
5. Refined conveyance system configuration.
6. Additional groundwater modeling and characterization of demand certainty.

The following subsections describe the findings and conclusions for each of these efforts, followed by recommendations for next steps.

9.2 Implementation and Phasing

The Feasibility Study assumed that the 150-mgd program would be implemented in a single phase with a duration of 11 years and an estimated program cost of $2.7 billion (2016 dollars). An objective of the conceptual planning studies was to identify, evaluate phasing alternatives for implementation, and update costs to 2018 dollars. Several program phasing alternatives were assessed to achieve the full program implementation. Table 9.1 summarizes the alternatives.

Table 9.1: Summary of Phasing Alternatives

	Advantages	Disadvantages
Full Program (Alternative A) Initial Production Capacity: 150 mgd	• Most rapid completion of the overall program. • Maximum economies of scale. • Largest regional benefits to the groundwater basins and Metropolitan in its initial phase. • Less vulnerable to inflation and other cost increases.	• Largest initial commitment of funding. • Highest initial increase in MWD overall costs. • Vulnerable to changing external circumstances (recycled water demand uncertainty and future wastewater flow declines). • Commits all flows to IPR uses, reducing flexibility to incorporate DPR. • Most rapid operational learning curve.

	Advantages	Disadvantages
North First (Alternative B) Initial Production Capacity: 100 mgd	• Provides the largest amount of water for replenishment in Phase 1 of the multi-phase alternatives. • Serves stressed groundwater basins with limited sources of replenishment water first. • Requires lower treatment costs during the Phase 1 to achieve basin plan nitrate limits. • Requires approvals from a single permitting agency – Los Angeles RWQCB. • Provides economies of scale. • Provides means of implementing DPR (when permitted) by extension of conveyance to both Weymouth and Diemer WTPs. • Reserves approximately 60 mgd of secondary effluent for either IPR or DPR uses.	• Highest initial capital costs of multi-phase alternatives. • Initially pumps to the highest elevation (500 ft) with the highest pumping costs. • Requires measures during Phase 1 to achieve required boron limits in the Main San Gabriel basin.
East First (Alternative C) Initial Production Capacity: 50 mgd	• Offers a lower pumping elevation (223 ft) and pumping costs in Phase 1 than northern pipeline alignment. • Utilizes full AWT plant capacity to meet demands in Phase 1. • Provides a lowest cost means of implementing DPR (when permitted) by adding an additional transmission pipeline to the Diemer WTP.	• May compete with other sources of water available for replenishment in Orange County. • Requires higher level of treatment and treatment costs in Phase 1 to meet basin plan nitrate targets. • Requires multiple RWQCB permitting approvals.
Central First (Alternative D) Initial Production Capacity: 50 mgd	• Flexibility in decision regarding implementation of additional phases. • Lower initial capital costs. • Lower impact on MWD overall cost increase in Phase 1.	• Relies heavily on consumptive demands in the Harbor Area and Central Basin. • Depends on injection wells for recharge. • Currently identified demands are insufficient to use 50-mgd AWT capacity. • Does not reach most reliable replenishment demands in Phase 1.
Harbor Area (Alternative E) Initial Production Capacity: 25 mgd	• Lowest initial capital costs. • AWT plant initially sized to meet near-term Harbor and Central Basin needs. • Most rapid Phase 1 implementation schedule. • Most flexibility in decision regarding implementation of additional phases.	• Phase 1 relies on least certain replenishment demands. • A large percentage of production serves consumptive demands (40%) in Phase 1. • Depends on injection wells for recharge. • Does not reach most reliable replenishment demands in Phase 1. • Lacks economies of scale.

Importance of the First Phase

When looked at in their entirety, each Alternative A through E delivers comparable performance when the full 150-mgd program is fully implemented (see Table 3.17). Consequently, the initial decision regarding program implementation is largely driven by the first phase considerations and performance metrics. The first objective of the phasing assessment (see Section 3.2) called for each phase of every alternative to "perform as a fully functional and cost-effective stand-alone project." This objective is intended to reduce the risk of stranded assets if the implementation of subsequent phases is delayed or indefinitely postponed. The assessment objectives also recognized the value of flexibility to accommodate future DPR opportunities. As discussed in Section 3.10, Alternative B – with 100 mgd of production and conveyance to the Santa Fe Spreading Grounds in the first phase – offers the most balanced approach, including significant economies of scale and proximity to both the Weymouth and Diemer WTPs (similar to Alternative A) at lower overall uncertainty (similar to Alternative C). For these reasons, Alternative B (North First) was considered the most desirable among the five alternatives considered.

Phase Implementation

The overall assessment showed clear advantages to implementing the program in multiple phases rather than all at once. Although implementation of the full program in a single phase (Alternative A) offers the lowest unit costs of production and shortest completion schedule, it raised concerns regarding a lack of flexibility, demand uncertainty, potential for stranded assets, and the steep learning curve associated with a 150-mgd AWT plant brought online all at once. A multi-phase approach offers the ability to initiate program development without foreclosing on emerging opportunities for increased efficiency, effectiveness, and operational control that may result from the availability of DPR as a viable option in the future.

Backbone System

An implementation strategy emerged during the analysis that includes construction of a first phase Backbone System. Based on a modification to Alternative B (North First), the strategy provides treatment for up to 100 mgd of purified water conveyed from the AWT plant in Carson to the Santa Fe Spreading Grounds through a pipeline sized for up to 150 mgd. To implement this approach, approximately 25 miles of pipeline between roughly Cerritos and the Santa Fe Spreading Grounds have been upsized from 60 inches to 84 inches internal diameter. Although the Backbone System serves the refinery demands adjacent to the JWPCP, it does not include the pipeline and injection wells provided for future West Coast Basin replenishment demands. The Backbone System offers the following benefits:

1. Significant new replenishment supply conveyed to the largest existing and planned groundwater recharge demands.
2. Unit production costs are competitive with the overall program (3% higher than full program implementation).
3. Lower initial impact on Metropolitan's overall cost increases resulting from lower total annual costs (31% lower than full program implementation).
4. Reduced regulatory complexity.
5. Greatest flexibility to adapt to future regulatory changes that may permit the incorporation of DPR into the program.

6. Greater certainty of secondary effluent flows needed to meet production goals.

9.3 Direct Potable Reuse

The Feasibility Study identified future opportunities to incorporate DPR into the program as a significant benefit of the overall RRWP. The location of both the Weymouth and Diemer WTPs in relation to the proposed first phase Backbone System provides a unique opportunity for purified water to supplement the raw water supply to a drinking water treatment plant after DPR regulations are approved. The potential benefits of incorporating DPR in the full-scale program (once approved) are considered significant enough to warrant phasing program implementation to retain that flexibility.

Further, a program that incorporates a combination of IPR and DPR uses would provide Metropolitan with greater operational control and freedom to use the full production capacity of the AWT under all conditions affecting groundwater recharge. Consequently, future DPR (in combination with IPR uses) would increase the certainty of full utilization of the purified water regardless of periodic demand variability in groundwater basin recharge capabilities. The DPR option (if available) also strengthens the regional benefits of the program by adding direct regional access to the new supply benefits created by the program.

As groundwater basins serve a vital function in the region’s diversified water portfolio, it should be noted that a primary objective of the RRWP is to provide a drought-proof supply of replenishment water to maintain the long-term health and reliability of the groundwater basins. It is anticipated that this long-term replenishment need would remain, with or without the opportunity to integrate DPR in the future.

9.4 Advanced Water Treatment

Nitrogen Management Options

A comprehensive evaluation was undertaken of alternative methods to manage nitrogen in the AWT process. Effective nitrogen management through the AWT process is crucial to ensuring overall treatment process efficiency, as well as ensuring that the product water from the plant meets the TN and nitrate goals for the groundwater basins that will be receiving the purified water. Seventeen treatment alternatives were examined by the Nitrogen Management Committee, a joint team consisting of technical staff from both Metropolitan and the Sanitation Districts. The committee’s charter was to explore cost-effective and reliable alternatives and to identify a holistic nitrogen management strategy, considering the potential treatment possibilities at both the JWPCP and AWT plant.

From these investigations, several process trains were selected for further detailed evaluation. Some of these potential processes can be readily examined at the demonstration facility, and modifications to the plant were made during its construction to facilitate further testing and examination of nitrogen management. The modifications include (1) installing an influent pipeline to convey primary effluent from the JWPCP to the demonstration facility, and (2) modifying the originally specified RO equipment to add a second pass RO capability to the overall RO skid. The committee recommended that testing of these alternative processes be undertaken after the initial demonstration plant technology acceptance testing is completed.

Boron Source Control and Treatment

It has long been known that boron is present in the flow streams entering the JWPCP and that the boron concentration in the effluent leaving the plant is currently about 0.9 mg/L. However, the source and quantification of these flows was not previously well understood. The Sanitation Districts undertook a boron source investigation study and determined that most of the boron is entering the plant from the oil field industries in the Long Beach and Signal Hill areas. Partial removal of boron through the RO process at the AWT plant will not be sufficient to reduce the boron to meet the 0.5-mg/L basin objective in the Main San Gabriel Basin.

This boron basin objective was initially established to protect agricultural beneficial uses, particularly citrus crops. With the current basin objective in place, this program may need additional measures to reduce boron, either through source control or with additional treatment. Treatment could be provided at either the JWPCP site or at a satellite treatment facility near the spreading grounds. Methods of boron source control, including bench-scale tests, are currently being investigated by the Sanitation Districts. This work should be continued to determine the feasibility of cost-effective source control.

A paper study of full-scale ion exchange treatment was conducted to understand the nature of potential additional treatment costs if boron removal is undertaken at the AWT plant. Such treatment to remove boron to meet groundwater basin objectives was determined to be feasible; however, it affects the cost of the overall AWT process. Costs for a satellite treatment plant at the groundwater basin were not investigated as part of the conceptual planning studies. Future evaluations should continue to investigate boron control to determine the most feasible and cost-effective method to achieve the basin objectives.

9.5 Conveyance System

Refined Conveyance System Configuration

During the conceptual planning studies, the conveyance pipeline system was refined from the configuration presented in the Feasibility Report base case system. These refinements were made to realize improved efficiencies to the overall system when compared to the Base Case conveyance system, as well as to address the potential for phasing of the overall program. Key refinements and improvements made include: (1) establishing a hydraulic control point in Signal Hill to facilitate the implementation of a phased system, (2) considering elimination of one pump station along the alignment to reduce costs and simplify system operations, (3) reassessing the need for and configuration of trenchless crossings at critical locations to better reflect actual conditions and to refine cost estimates, (4) confirming preliminary utility and other major buried infrastructure information with impacted stakeholders to further refine potential construction impacts and costs, and (5) identifying conceptual-level pipeline alignments to convey AWT water from the current terminus of the system at the spreading basins to Metropolitan's Weymouth and Diemer WTPs as part of a future DPR scenario.

9.6 Demands for Replenishment Water

Significant additional groundwater modeling efforts were undertaken in close coordination with the potentially affected member agencies and water masters. The results of this modeling were used to refine near-term and future potential replenishment demands beyond what had been previously identified in the Feasibility Study. This work also characterized the relative certainty of replenishment demands stemming from the program. Those immediate near-term or existing replenishment demands were considered more likely than potential future demands that may not materialize (see Tables 3.4 and 3.5). This qualitative assessment strongly supports phasing alternatives that reach significant levels of existing demand during the first phase of the program.

The results of the groundwater modeling performed for the conceptual planning studies indicated that the introduction of purified water from the RRWP would have an overall positive impact on the groundwater levels in the following groundwater basins:

1. **Main San Gabriel Basin.** Providing 81 TAFY of replenishment water (38 TAFY above current replenishment) from the RRWP would raise groundwater levels about 70 feet above current levels over a 32-year period. Conversely, water levels would drop 70 feet below current levels over the same period without the additional replenishment water based on historical pumping and recharge activities.
2. **Central and West Coast Basins.** Providing 35 TAFY of purified water to the Central and West Coast Basins from the RRWP would increase groundwater levels about 7 feet in the Montebello Forebay, about 6 feet in the Long Beach area, and up to 24 feet in the West Coast Basin.
3. **Orange County Basin.** OCWD currently recharges approximately 65 TAFY of imported water from Metropolitan in spreading basins owned by OCWD. The proposed 52 TAFY of replenishment from the RRWP has the positive benefit of replacing a similar amount of imported water which would have been purchased from Metropolitan for replenishment purposes.

9.7 Recommended Next Steps

Based on the results of the analyses completed for these conceptual planning studies, the following next steps are recommended should Metropolitan's Board decide to move implementation of the RRWP forward:

1. **Proceed with environmental review process.** The analyses completed thus far in the Feasibility Study and Conceptual Planning Studies Reports for the RRWP allows for Metropolitan to proceed with the environmental review process at a programmatic level for the full program, including potential future IPR and DPR options. Project-level environmental review can also be prepared for initial construction projects planned for the first phase. Because of the complexity and long lead time needed to complete the environmental permitting process, it is recommended that the environmental process proceed while further program development and evaluations continue to take place. Engineering activities will be needed to support the environmental process; the extent to which preliminary design is completed for a program element during the environmental review process can impact the overall implementation schedule.
2. **Further refine treatment options for a full-scale AWT plant.** While initial demonstration testing and monitoring for regulatory acceptance of MBR proceeds, additional testing work should be planned to help finalize a recommended treatment train for the full-scale AWT plant. This additional testing should include refinement of process design criteria for a full-scale AWT plant; further evaluation of selected process trains for nitrogen management; and further analysis of source control and treatment for boron.
3. **Further develop the conveyance system.** Metropolitan should continue to engage key stakeholders, including the USACE, SCE, and Los Angeles County Department of Public Works,

and the cities and municipalities involved to refine pipeline alignments and ROW requirements. The hydraulic characteristics of the system should be finalized, and infrastructure requirements needed at groundwater recharge locations evaluated. Further assessment of pipeline appurtenances as well as pipeline coatings should be conducted, and design criteria established for seismic events, fault crossings, river crossings, and major infrastructure crossings.

4. **Conduct additional groundwater analysis.** Metropolitan should work with the groundwater basin managers to perform physical tracer studies to confirm results of solute transport and particle tracking; and perform water compatibility studies for the injection wells and the spreading basins to assess whether there will be any potentially adverse interactions between the purified water and the native groundwater. Based on the results, siting of the proposed injection wells and relocated production wells should be confirmed.
5. **Establish preliminary commitments.** Efforts should be undertaken to confirm the willingness of potential recipients of the purified water to commit to the delivery schedule, operational requirements, and financial needs of the overall program.
6. **Evaluate program cost recovery.** Present information to the Metropolitan Board to obtain policy direction as to preferred cost recovery methods.
7. **Ensure consistency with the IRP.** Continue evaluation of the program's regional water supply benefits in the context of Metropolitan's IRP.
8. **Adjust for current and future needs.** The RRWP should be phased to "right size" the initial investment in AWT facilities based on the established commitments of potential recipients. The infrastructure provided for conveyance should consider the availability of purified water and the needs of the full program over time. An analysis of implementation sequencing should be prepared for overall program development as well as individual projects within a given phase.
9. **Strengthen collaborative management.** Program development should include participation from all agencies needed to make the overall integration of many utility functions (a "system-of-systems") to perform reliably over time. From a high-level perspective, the RRWP is a multi-agency undertaking that requires close collaboration and coordination among Metropolitan, the Sanitation Districts, member agencies, groundwater basin managers, Los Angeles County Department of Public Works, and others. To ensure reliable operations of the full program, a collaborative management structure should be in place during the planning, development, implementation, and ongoing operations of the system. Although this may not require the creation of a new organization, a formal acknowledgment of the program's overall mission and goals by all participants is important.

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Acronyms and Abbreviations

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ACRONYMS AND ABBREVIATIONS

3D	three-dimensional
AACE	Association for the Advancement of Cost Engineering
AB	Assembly Bill
Advanced Purification Center	Regional Recycled Water Advanced Purification Center
AF	acre-foot/feet
AOP	advanced oxidation process
ARC	Arthur Robles Center
AWT	advanced water treatment
Backbone System	backbone conveyance system
BAF	biologically active filter
Basin	South Coast Air Basin
BPOU	Baldwin Park Operable Unit
CAP	Climate Action Plan
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
DDW	Division of Drinking Water
Diemer WTP	Robert B. Diemer Water Treatment Plant
DPR	direct potable reuse
Draft Nitrogen Management Report	Draft Nitrogen Management Evaluation for Full-scale Advanced Water Treatment Facility
EIR	environmental impact report
EIS	environmental impact statement
ENR	Engineering News-Record
Feasibility Study	Potential Regional Recycled Water Program Feasibility Study – Report No. 1530
FORCO	Fletcher Oil and Refinery Company
FY	fiscal year
GHG	greenhouse gas
GIS	geographic information system
gpm	gallons per minute
GWRS	Groundwater Replenishment System
HPOAS	high-purity oxygen-activated sludge
IPR	indirect potable reuse
IRP	Integrated Resources Plan
ISAP	independent scientific advisory panel

IX	ion exchange
JS	junction structure
JWPCP	Joint Water Pollution Control Plant
LACFCD	Los Angeles County Flood Control District
LRV	log reduction value
MBR	membrane bioreactor
MCL	maximum contaminant level
MDA	multi-objective decision analysis
Metropolitan	Metropolitan Water District of Southern California
MF	microfiltration
mgd	million gallons per day
mg/L	milligrams per liter
mg/L-N	milligrams per liter as nitrogen
MSL	mean sea level
MWD	Metropolitan Water District of Southern California
NdN	nitrification–denitrification
NEPA	National Environmental Policy Act
NL	notification level
N-only	nitrification only
NWRI	National Water Research Institute
O&M	operations and maintenance
OCWD	Orange County Water District
OPCC	Opinion of Probable Construction Cost
PEIR	Programmatic Environmental Impact Report
PEIS	Programmatic Environmental Impact Statement
PRC	Public Resources Code
PS	pump station
RFP	request for proposal
RFQ	request for qualification
RO	reverse osmosis
ROW	right-of-way
RRWP	Regional Recycled Water Program
RWC	recycled municipal wastewater contribution
RWQCB	Regional Water Quality Control Board
Sanitation Districts	Sanitation Districts of Los Angeles County
SBA	strong base anion
SCE	Southern California Edison

SGR	San Gabriel River
SNMP	salt and nutrient management plan
SRT	solids retention time
SWRCB	State Water Resources Control Board
TAFY	thousand acre-feet per year
TN	total nitrogen
UF	ultrafiltration
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UV	ultraviolet
Weymouth WTP	F.E. Weymouth Water Treatment Plant
WDR	Waste Discharge Requirements
WRD	Water Replenishment District
WRR	Water Recycling Requirements
WTP	Water Treatment Plant

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