Regional Brackish Water Reclamation Program Feasibility Study

Final

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Water Replenishment District of Southern California

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Acronyms and Abbreviations

AF	acre-feet
AFY	acre-feet per year
Cal Water	California Water Service Company
CAPEX	capital expenditure
CCRO	closed-circuit reverse osmosis
CEQA	California Environmental Quality Act
CH2M	CH2M HILL Engineers, Inc.
CSDPR	Conceptual System Design and Program Requirements
GSWC	Golden State Water Company
HDPE	high-density polyethylene
HERO	high-efficiency reverse osmosis
I&C	instrumentation and control
JWPCP	Joint Water Pollution Control Plant
LACSD	Los Angeles County Sanitation Districts
LADWP	Los Angeles Department of Water and Power
MCL	maximum contaminant level
mg/L	milligram(s) per liter
mgd	million gallons per day
MND	mitigated negative declaration
MODA	multi-objective decision analysis
NPV	net present value
O&M	operations and maintenance
OMP	Facility Operations and Maintenance Plan
OPEX	operational expenditure
P3	public-private partnership
PEAP	Project Entitlements and Acquisition Plan
PSP	Power Supply Plan
RO	reverse osmosis
SCADA	supervisory control and data acquisition
SCE	Southern California Edison
TDS	total dissolved solids
TM	technical memorandum
TON	threshold odor number
VfM	Value for Money
WBMWD	West Basin Municipal Water District
WRD	Water Replenishment District of Southern California
ZLD	zero liquid discharge

Executive Summary

Regional Brackish Water Reclamation Program Feasibility Study

1. Program Background

The Water Replenishment District of Southern California (WRD) is responsible for managing and replenishing both the West Coast and Central Coast groundwater basins. In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, Lynwood, and Lower San Pedro (equivalent to Sunnyside) aquifers due to historical seawater intrusion and the subsequent implementation of two injection barriers. To more fully utilize the West Coast Basin, WRD has initiated the Regional Brackish Water Reclamation Program (Program) to evaluate ways to reclaim this impaired water supply and put it to beneficial use. Program components include treatment of the saline plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process.

As a part of the Program, WRD initiated a regional planning study to evaluate the feasibility of treating the saline plume, working with seven additional stakeholders (known as the Stakeholder Group) who have expressed interest in treating the saline plume or receiving the treated water. The members of the Stakeholder Group either pump, hold water rights, or have other key roles in supporting the basin operations.

The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

WRD retained CH2M HILL Engineers, Inc. (CH2M) (a wholly owned subsidiary of Jacobs Engineering Group [Jacobs]) to help conduct this Feasibility Study. The study provides a first step towards understanding the approach to treating the historical saline plume for beneficial use. The recovery of groundwater contaminated by the saline plume could provide a multitude of benefits, including additional water supply to meet potable and non-potable water demands, replenishment water for the basin, basin water quality improvements, and basin storage.

This Feasibility Study evaluates the following components: where to extract the plume water, where and how to treat the plume water, how to convey the treated potable water to the Program stakeholders, and how to manage the brine waste stream. The Feasibility Study includes the analysis of numerous "Projects," consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of the above components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed as dollars per acre-foot (AF) of treated water.

Saline plume treatment through the Program will create a substantial amount of locally sourced potable water for the region and will remove salts from the saline plume, thereby reducing its concentration and expanse within the basin. Due to hydrogeological uncertainties associated with saline plume water extraction and barrier water injection, including the lack of a comprehensive fate and transport model, it is unclear if the saline plume can be fully remediated to the point that the groundwater in those locations can be used as a potable source without treatment. However, for simplicity in developing the economics of saline plume treatment over the assumed 30-year finance duration, this Feasibility Study assumes that treatment of the saline plume water can lead to "remediation" of the saline plume over a finite time range of treatment. Thus, treatment costs presented include a range of required treatment durations less than and up to 30 years. For treatment durations of less than 30 years, well pumping with minimal treatment (disinfection and fluoridation) is assumed thereafter to extend the project cost analysis to the full 30-year time period. This is explained further in Section 3.2 below.

2. Feasibility Study Development and Stakeholder Involvement

This Feasibility Study was developed using a collaborative approach between the Stakeholder Group and Jacobs. The study was initiated in May 2018, with a Kickoff Meeting held by WRD and Jacobs. Initiation was followed by individual interviews with each of the stakeholder agencies to solicit their thoughts on their own agency's participation and priorities, project governance, and potential implementation constraints. Following the interviews, stakeholders provided information on properties and facilities that may be available for Project development.

To guide development of the Program and Project alternatives, the Stakeholder Group was invited to participate in four workshops throughout the duration of the study. Workshop 1 was held on August 2, 2018 to achieve consensus on the Program's purpose, need, and objectives; review the properties and facilities identified for consideration; and define the evaluation criteria that would be used to screen the Project options for each of the Project components. Project components consist of extraction, treatment location, treatment type, consumed flow/destination, brine disposal, and replenishment volume. A Potential Project is a combination of Project components that constitute a full Project that will meet the Program goals.

An initial master list of options for each component was provided to the stakeholders in a Program Context Technical Memorandum (TM), which was revised to include additional component options based on feedback from the stakeholders. These components were then formulated into a master list of 29 Potential Projects that were drafted by the Feasibility Study team. The evaluation criteria discussed in Workshop 1 and subsequently refined via feedback on the Program Context TM was applied to the master list of Potential Projects to identify a shortlist of Potential Projects for further analysis. A Potential Projects and Recommended Shortlist TM was provided to the stakeholders for consideration prior to Workshop 2.

In Workshop 2 on November 14, 2018, the 29 Potential Projects were discussed, along with the project team's recommendations for the shortlist of projects to carry forward into the Feasibility Study. During Workshop 2, 11 Potential Projects were selected for further development. Additional development of the Projects included evaluations of treatment, brackish water extraction, brine discharge, product water delivery, facility layouts, cost estimates, and a multi-objective decision analysis (MODA) screening process to rank and refine a subset of Preferred Projects that would undergo additional analysis and evaluation.

The MODA process is a decision science evaluation method used to aid in decision making while considering both financial (cost) and non-financial criteria. The non-financial criteria are defined to establish a common understanding of how they would apply to the Potential Projects, and measurement scales are assigned to score the performance of each Project relative to each criterion. The relative importance of each criterion is then established via weighting factors. Stakeholders were asked to weight the set of criteria. The weightings, along with further refined project costs, enabled the stakeholders to consider the benefits of the Potential Projects relative to their estimated costs.

Workshop 3 was held on March 20, 2019 to discuss the preliminary results and recommendations with the stakeholders. Refinements to the recommendations from Workshop 3 resulted in the selection of six Preferred Projects to carry forward in the development of the following planning documents:

- Facility Operations and Maintenance Plan (OMP)
- Power Supply Plan (PSP)
- Site Civil Plan
- Facility Renderings
- Environmental Review Plan
- Project Permitting Plan

- Project Costs and Funding Plan
- Project Delivery Plan
- Project Entitlements and Acquisition Plan (PEAP)

The technical basis for the process conducted over the course of the first three workshops was documented in the Conceptual System Design and Program Requirements (CSDPR) TM that was prepared with stakeholder review and input.

Workshop 4 was held on June 26 to review and discuss the findings presented in the Draft Feasibility Study Report, which includes the CSDPR and the plans noted above, and identify next steps for the Program. Each of the four workshops was designed to solicit input and guidance from the Stakeholder Group regarding Project components, desired project outcomes, and Potential Projects. The workshops were also used to achieve consensus on key decisions used to guide the project development and screening. Figure ES-1 illustrates the workshop process.

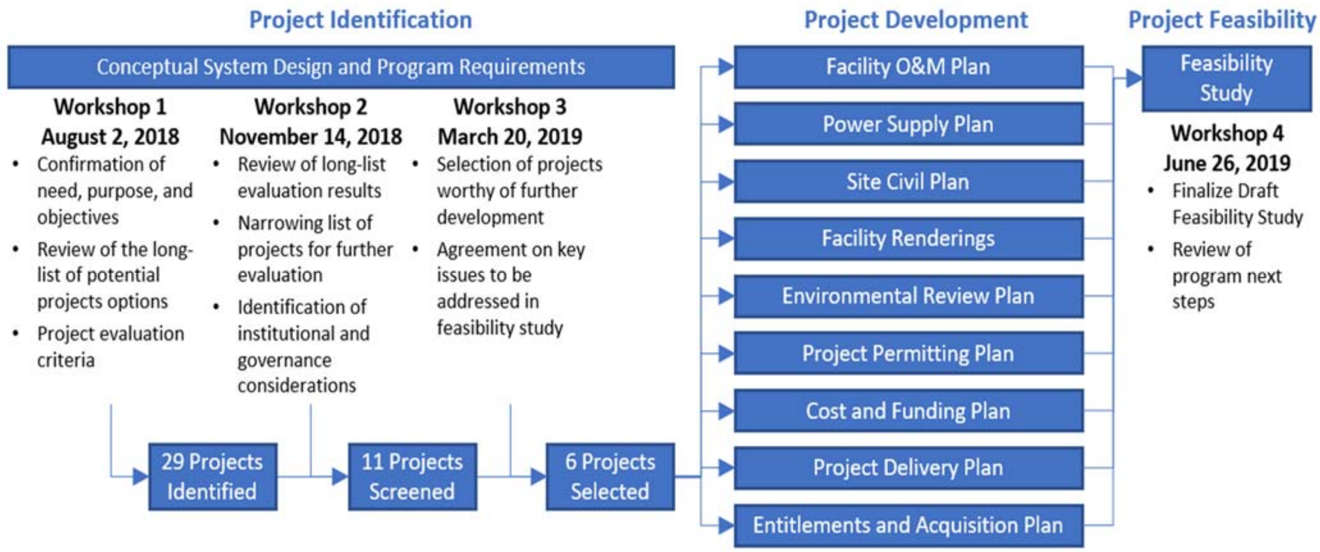


Figure ES-1. Feasibility Study Development and Workshop Process

3. Conceptual System Design and Program Requirements

The CSDPR was developed to identify the overall Program scope and key project components, develop a master list of Potential Projects, and narrow the master list down to a recommended shortlist. The CSDPR document is an accumulation of numerous TMs addressing the following topics, as summarized in this section and included in Appendix A:

- Program Context
- Potential Project Development
- Source Water Quality and Conveyance
- Brine Waste Management and Conveyance
- Product Water Quality and Conveyance
- Treatment Technologies
- Project Screening

Based on stakeholder input, 29 initial Potential Projects were generated for consideration, with each Project containing a variation of Project components. Project components include the following: where to extract the plume water, where and how to treat it, how to convey the treated potable water to the Program stakeholders, and how to dispose of the brine. Project capacity and quantity delivered to each stakeholder are also Project components. This section summarizes the analysis performed to narrow the Potential Projects down to six Preferred Projects that underwent further development as described in Sections 4 through 12.

3.1 Program Context

The Program Context was developed using stakeholder input and consensus to establish the Program's need, purpose, and objectives statement, as well as foundational assumptions to guide development of the project alternatives.

Originally, the saline plume was estimated to be 600,000 AF for chloride concentrations above 250 milligrams per liter (mg/L). However, the Stakeholder Group agreed to increase the target groundwater chloride level for extraction and treatment from 250 to 500 mg/L, which represents the upper limit of California's secondary maximum contaminant level (MCL) for chloride, thereby reducing the saline plume volume targeted for treatment from 600,000 AF to 375,000 AF. The 375,000 AF are distributed in three different aquifers, with 64 percent of the water in the deeper (roughly 600 to 1,000 feet below grade) Lower San Pedro aquifer, as shown on Figure ES-2. The three aquifers and saline plume distribution are as follows:

- Gage aquifer – 22,000 AF
- Silverado aquifer – 113,000 AF
- Lower San Pedro aquifer – 240,000 AF

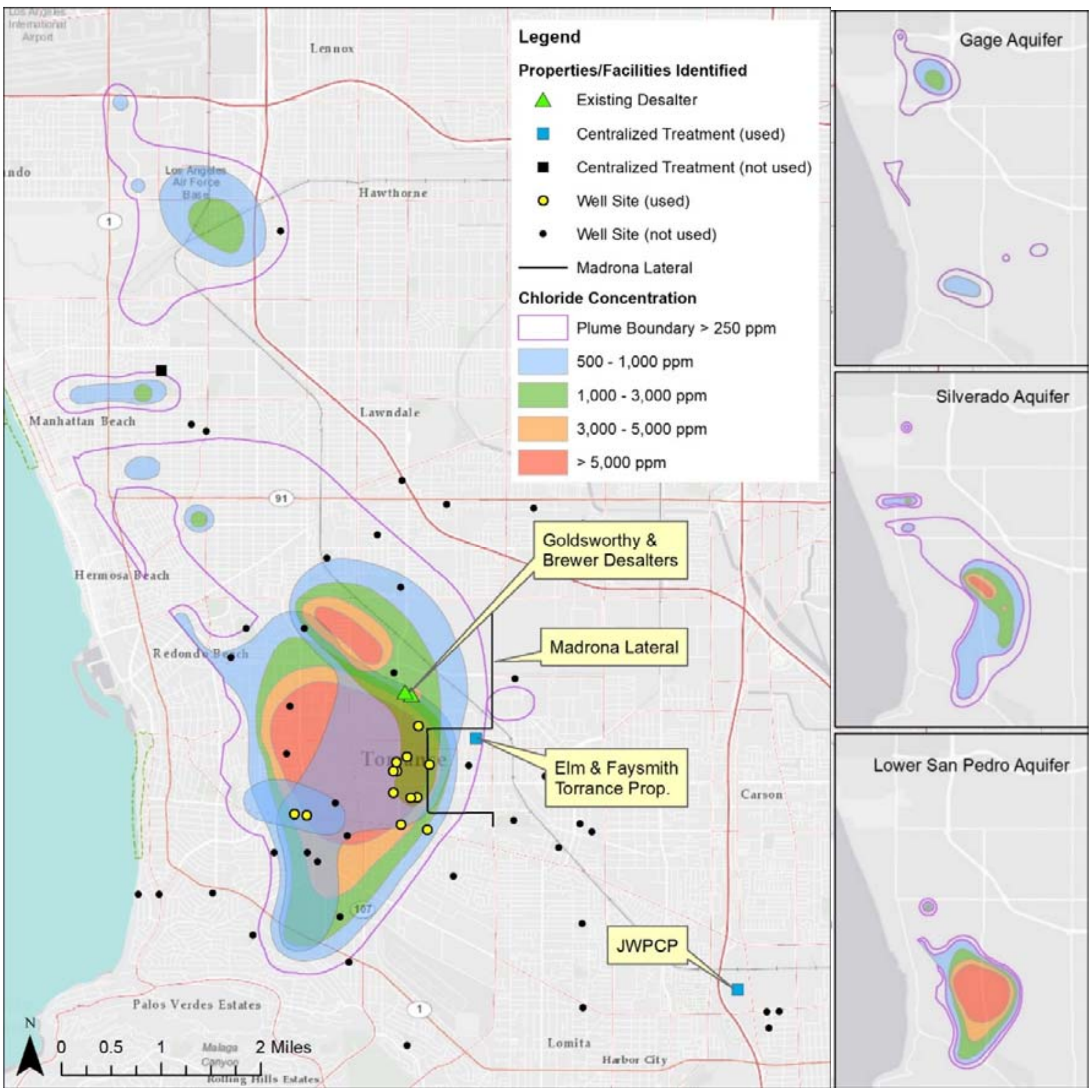


Figure ES-2. West Coast Basin Saline Plume and Potential Program Properties and Facilities Identified by Stakeholders

Each stakeholder provided a list of properties and facilities available for incorporation into the Program, and locations of existing and potential future drinking water distribution system interties that could be used in developing a range of Project alternatives. The properties and facilities that were initially identified are shown on Figure ES-2. The figure also identifies properties used in project development (see ES-4 for more detail). As shown in Table ES-1, the stakeholders also established their maximum water demands for the Project during the Project Context phase. Project evaluation criteria were also established to screen future project alternatives and include the cost of water, permitting difficulty, Potential Project phasing, greenhouse gas emissions, proximity to other contaminant plumes, and ability to meet the Project purpose and objectives.

Table ES-1. Maximum Acceptable Product Water Demand by Purveyor

Purveyor	Maximum Product Water Amount Purveyor May Be Willing to Accept (AFY)
Cal Water	9,500
GSWC	13,000
LADWP	10,000
City of Lomita	2,500
City of Manhattan Beach	3,620
City of Torrance	5,000

Notes: WBMWD does not have any water rights within the adjudication area.

AFY = acre-feet per year

The Elm and Faysmith (also known as Old City Yard) site was identified by the City of Torrance as an available property where a centralized treatment facility could be located. The Elm and Faysmith area is shown on Figure ES-3. The vacant, 2-acre lot in a residential area was the location of previous groundwater wells that have since been demolished. For this reason, the facility is adjacent to the city's water main, with access to the distribution system. The property is located on the leading edge of the plume and is an ideal location for facility siting. Therefore, this property was used as the basis of project development for a centralized facility throughout the completion of all Feasibility Study tasks.

The City of Torrance also identified several properties for potential new extraction wells to feed the centralized facility. Ten sites were selected and considered for project development, as shown on Figure ES-2. Potential alternative locations for the centralized treatment plant were investigated. Similarly, potential alternative properties for well extraction sites in proximity to the northernmost saline plume in the Gage aquifer were explored. Maps of alternative locations are included in Appendix J.

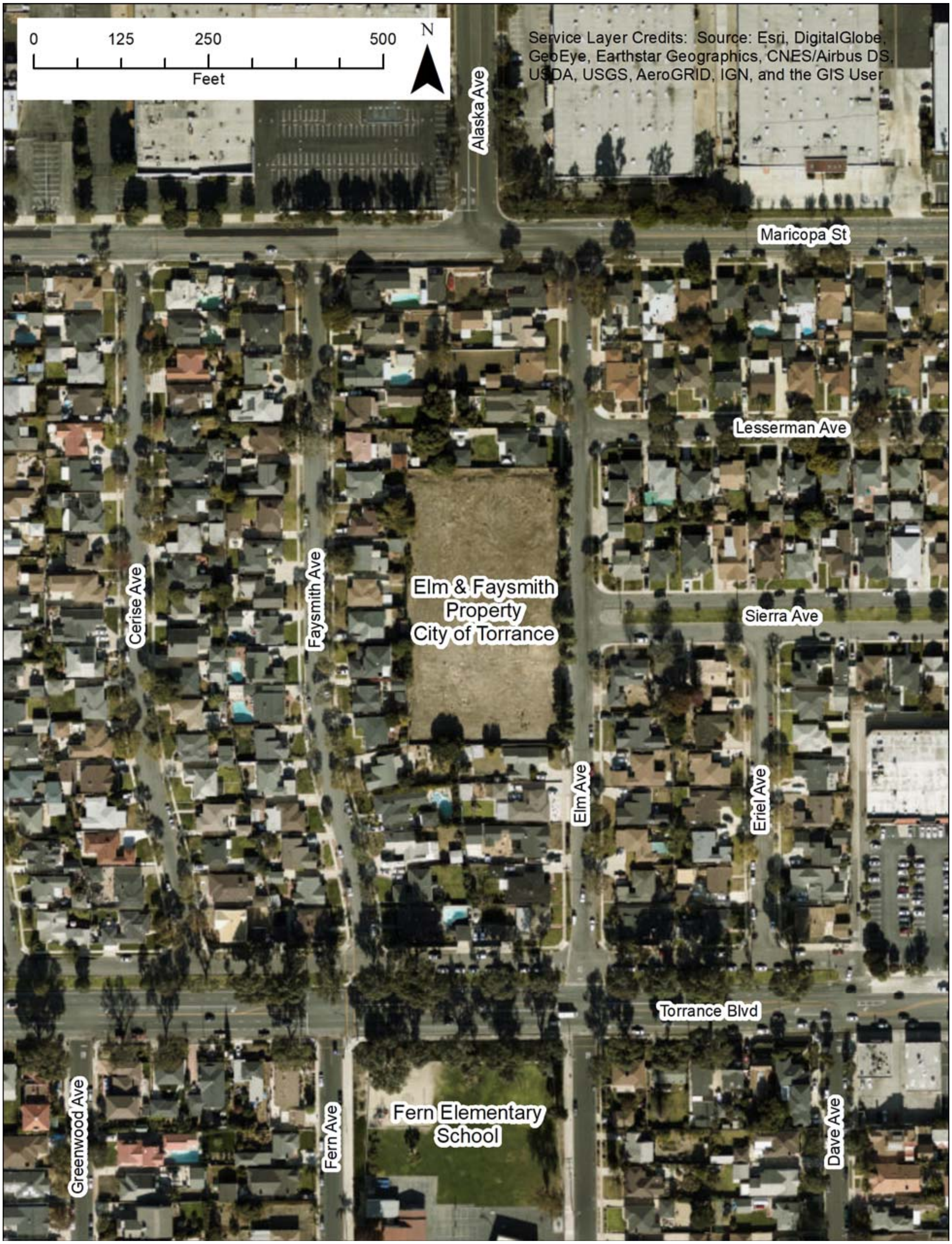


Figure ES-3. Aerial View of the Elm and Faysmith Property

3.2 Potential Project Development

After a thorough analysis of possible options and combinations of options into Potential Projects, prioritized based on stakeholder input, 29 Potential Projects were generated for consideration, with each Project containing variations of Project components. Projects were initially formulated with a particular goal in mind, such as delivering water to all stakeholders, or taking advantage of existing infrastructure, such as the Madrona Lateral. Different Projects were developed by varying one or more Project components, such as lower delivery volumes or different distribution piping configurations (e.g., use of interties or no interties). Such variations determined the sensitivity of the Projects to changes in project configuration and aided in the development of the shortlist of 11 Projects. Each Potential Project consisted of combinations of options for each of the following Project components:

- Brackish water extraction
- Brackish water treatment
- Conveyance of:
  - Brackish water to treatment
  - Treated product water to purveyors
- Brine disposal
- Groundwater replenishment volume

Initial development of the Potential Projects considered the following three primary factors: the target plume volume, a range of extraction rates, and a project financing period of 30 years that established the project duration.

Recommended Project desalination plant capacities, which ranged from 5,200 AFY to 20,000 AFY of extracted water for treatment, were based on possible plume remediation durations of as low as 30 and 14 years, respectively, when targeting the 375,000 AF plume in combination with the existing Goldsworthy and Brewer groundwater desalter capacities. All Project costs are based on a 30-year duration for comparative consistency between the Projects. When the plume is assumed to be remediated prior to the full 30-year duration, the subsequent costs involved in producing potable water include extraction well pumping, chlorination, and fluoridation only because no further treatment would be required. With replenishment water injection and treatment of the plume during the treatment period, at the end of the treatment period it is anticipated, and thus assumed for the purpose of this Feasibility Study, that all constituents in the plume will have levels that are acceptable for drinking water. As an example, a 12,500-AFY Project, in combination with the existing Goldsworthy and Brewer Desalters (with combined capacities of 7,300 AFY), would require a minimum treatment duration of 20 years assuming 350 days per year of extraction and treatment. Therefore, the lower range of the costs for this Project over a 30-year period would include the capital cost of the extraction, transmission and treatment equipment, the operating cost of extraction, treatment and transmission for 20 years, and the operating cost of extraction with minimal chemical addition for the last 10 years. The upper range of the costs for this Project assumes that treatment is required for the full 30-year period.

3.3 Source Water Quality and Conveyance

A detailed analysis of the pertinent existing monitoring well data was performed to estimate the composition of the future extracted high-chloride groundwater (source water) for Project treatment. Approximately 64 percent of the plume is in the Lower San Pedro aquifer; the source water to the treatment facility would be primarily a blend of Lower San Pedro and Silverado Aquifer waters.
The analysis revealed that the source water would contain approximately 4,000 mg/L of chloride and approximately 6,500 mg/L of TDS, well above their respective secondary MCLs. The Projects also need to treat the source water for manganese and odor because each exceeds respective drinking water standards. In addition, the source water is anticipated to contain approximately 7 mg/L of methane. Although this is less than the 10- to 28-mg/L level recommended for air quality monitoring (to prevent the surrounding air from becoming flammable),[1] the methane will be removed by the air stripper required for

[1] Water Research Center "Methane and other Gases in Drinking Water and Groundwater," https://www.water-research.net/index.php/about/13-in-drinking-water/51-methane-and-other-gases-in-drinking-water-and-groundwaterV esim

odor removal, even though methane does not have a federal or California drinking water limit. The complete water quality analysis of the anticipated source water includes more than 100 constituents and is presented in the Source Water Characterization TM contained in the CSDPR (Appendix A).

The new extraction wells will be placed along the leading, eastern edge of the saline plume. A hydraulic gradient exists from west to east, resulting from injection of fresh water at the coast intended to prevent seawater intrusion. The saline plume migrates eastward at a rate of approximately 250 feet per year. Placement of the extraction wells along the eastern edge has two benefits: (1) the majority of the extracted water will be drawn from the higher salinity, western side of the wells; and (2) over time, the plume will migrate toward the extraction wells.

Because of the depth of the saline plume, which extends to roughly 1,000 feet below grade, vertical wells are recommended for extraction. The design basis includes the use of 20-inch-diameter, 316 stainless steel wells, each extracting 2,000 AFY at up to 10 different locations. However, the transmissivity of the Lower San Pedro aquifer is anticipated to be less than the transmissivity of the Upper Silverado aquifer and may limit the yield of a single well to below the target extraction rate. Therefore, numerous smaller-diameter wells may be more suitable. This will be evaluated during subsequent phases of the Program.

New conveyance infrastructure is needed to move the brackish water from the extraction wells to the centralized treatment facility. During the analysis of the brackish water extraction conveyance piping, property ownership of the well locations and the pipe routing to the centralized treatment plant site were examined. Some potential well locations are not owned by the City of Torrance and will require easements. High-density polyethylene (HDPE) is the recommended pipe material. All conveyance piping from the extraction wells to the proposed Project will be located in city street rights-of-way (ROWs), and no easements are required for the pipelines. Entitlements and ROWs are further discussed in Section 12, PEAP. The conceptual conveyance layout is shown on Figure ES-4.

3.4 Brine Waste Management and Conveyance

Brine is the concentrated salts resulting from treatment of the brackish water, and brine disposal is an important factor in treatment economics. Options for brine waste management were investigated, including the following: (1) discharge to the existing Los Angeles County Sanitation Districts (LACSD) collection system (sewer); (2) construction of a dedicated “brine line” to the outfall of either the LACSD Joint Water Pollution Control Plant (JWPCP) or the City of Los Angeles’ Hyperion Water Reclamation Plant; (3) zero liquid discharge; (4) deep well injection; (5) a new ocean outfall; and (6) trucking of the brine to the JWPCP.

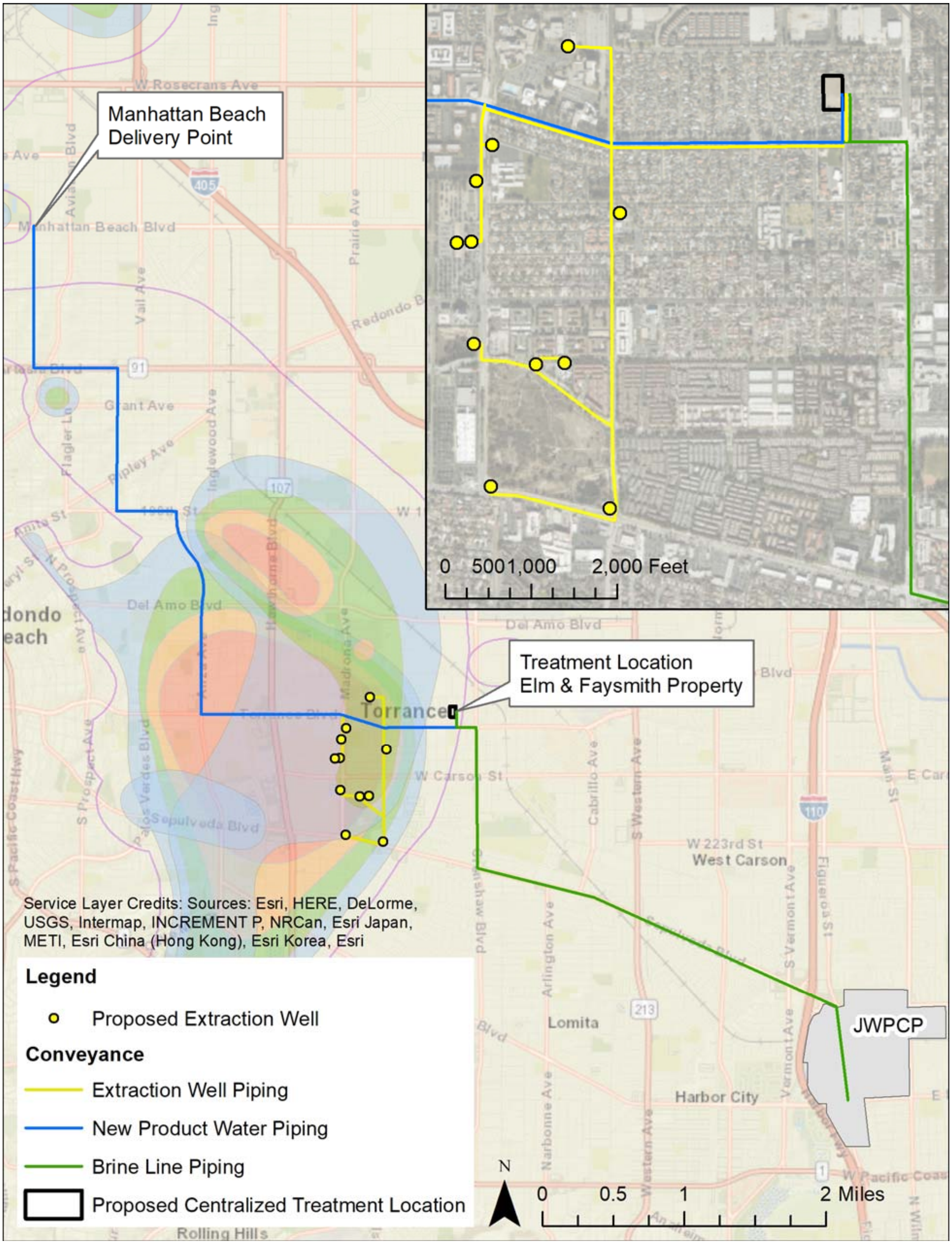


Figure ES-4. Conceptual Project Layout

A new ocean outfall would have significant permitting hurdles. Zero liquid discharge, deep well injection, and trucking would each be expensive. Of all the disposal options that can be fully estimated, the cost of sewer disposal is the least expensive. A direct brine line to the JWPCP outfall may be a viable option worthy of further exploration. Table ES-2 shows the costs for options for a sample treatment plant capacity of 12,500 AFY, assuming a reverse osmosis (RO) recovery rate of 85 percent.

Table ES-2. Brine Management Costs[a] Including CAPEX and Annual OPEX

Discharge (12,500 AFY[b])	CAPEX	OPEX
Sewer	$17.5 million	$0.5 million
New brine line to JWPCP	$12.6 million	Unknown
New brine line to Hyperion	$27 million	Unknown
Trucking to JWPCP	--	$6 million
Deep Well Injection	$25.4 million	$1.9 million
New outfall and discharge	$22.5 million	~$0.7 million
Zero Liquid Discharge	$35 million	$8.7 million

[a] Costs are based on an assumed system recovery rate of 85 percent

[b] Use of the 12,500-AFY Project in this table is for illustrative purposes and does not imply a recommendation of this particular Project size for the Program.

Note:

CAPEX = capital expenditure

OPEX = operational expenditure

During the pipeline route analysis for the dedicated brine line, we investigated the potential pipe routing from the Elm and Faysmith treatment site to the JWPCP effluent tunnel/outfall system. The piping would be located in a city street ROW. Trenchless crossings and permits would be required at one railroad and two highway crossings. Easements would also be required for the crossing of Interstate-110. HDPE piping is recommended for this service. Entitlements and ROWs are further discussed in Section 12, PEAP. The conceptual conveyance layout is shown on Figure ES-4.

3.5 Product Water Quality and Conveyance

Potable water produced by the Project needs to be compatible with the water quality in the distribution systems for each stakeholder receiving the product water. The potable water quality within each stakeholder's distribution system was evaluated and compatibility requirements were examined to ensure the Project product water would be compatible. The product water quality targets listed in Table ES-3 include both the compatibility requirements and the key water quality constituents that will ensure compliance with California and federal drinking water requirements. The facility is also being designed to meet the more stringent water quality goals that have been set for this project and that are summarized in Table ES-3.

Table ES-3. Key Treated Water Quality Goals and Regulations

Constituent	Goal	MCL	Regulation
Chloride, mg/L	200	250	Secondary MCL
Manganese, mg/L	0.02	0.05	Secondary MCL
Methane, mg/L	0.2	-	-
Odor, TON	2	3	Secondary MCL
TDS, mg/L	400	500	Secondary MCL

Notes:

- = not applicable

TON = threshold odor number

The Elm and Faysmith Project site is in Torrance, and the majority of product water will be pumped into the Torrance distribution system for routing through existing interties to all stakeholders, with the exception of the City of Manhattan Beach. Manhattan Beach does not have an existing intertie with Torrance, so a new pipe could be routed from the Project location to Manhattan Beach. During the product water conveyance system analysis, we examined the new conveyance equipment and routing. The proposed piping alignment is approximately 6.5 miles long and extends wholly within the public ROW within the cities of Torrance and Manhattan Beach. No easements will be required. Entitlements and ROWs are further discussed in Section 12, PEAP. The conceptual conveyance layout is shown on Figure ES-4.

3.6 Treatment Technologies

The initial project screening assumed that conventional RO would be used. The Treatment Technologies TM within the CSDPR evaluated several technologies to determine which would best meet the Project requirements, considering economics, product water quality goals, and treatment facility footprint. Footprint must be considered because the most likely treatment site at Elm and Faysmith has only 1 acre of the 2-acre site available for the Project.

The treatment technologies evaluated include the following:

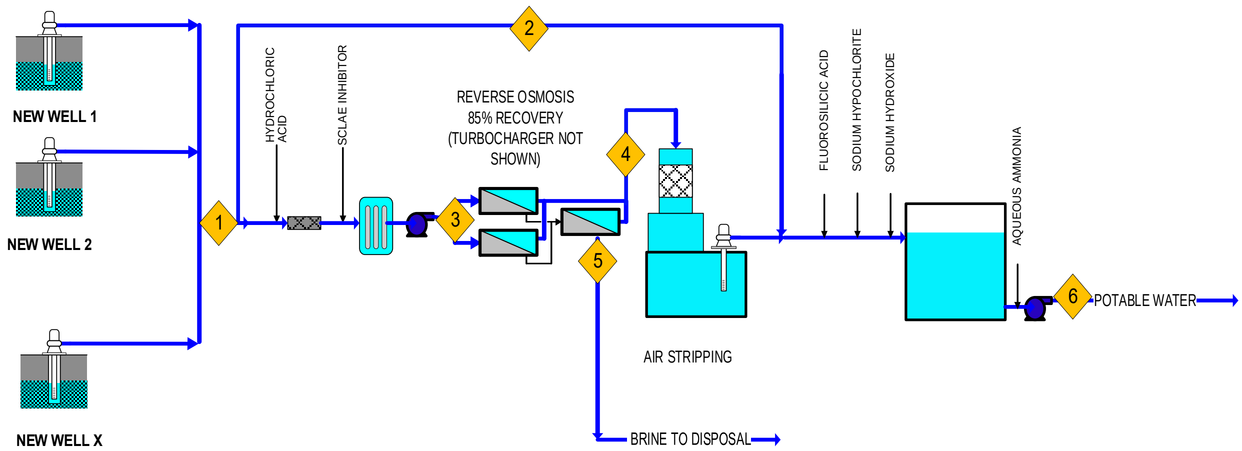
- Conventional RO
- Closed-Circuit RO (CCRO)
- High-Efficiency RO (HERO)
- A sacrificial (final stage) of RO (added on to conventional RO)
- Nanofiltration
- Ion exchange
- Electrodialysis reversal
- Interstage (RO) lime softening (pellet reactor)

Nanofiltration will not meet the product water quality goals. CCRO, ion exchange, HERO, and electrodialysis reversal will all be more expensive than conventional RO for this application because the source water TDS and hardness are high. There is insufficient footprint available for the interstage lime softening, and this process would not be economical even if space were available.

Brine handling was considered as part of the treatment economics. Treatments using the conventional RO brine to reduce the volume via CCRO, a sacrificial (final stage) RO, or HERO are all uneconomical because relatively high-salinity well water and a sewer option for disposal that costs approximately $100 per AF of water treated. Therefore, conventional RO is the preferred treatment technology.

3.6.1 Baseline Treatment Design

With the source water characterization and treatment investigation complete, and the product water quality goals and preferred treatment approach established, a baseline process was developed consisting of conventional RO operating at 85 percent recovery. RO recovery is limited by the saturation of barium sulfate and silica, and a slight pH depression will likely be required in the RO feed to achieve this recovery by increasing calcium carbonate solubility. The RO permeate will be sent to an air stripper for removal of methane and odor. The air stripper may require off-gas treatment to capture or neutralize the odor-causing compounds if there are regulatory or other constraints associated with discharging the off-gas to the atmosphere. Further investigation is required to characterize the nature of the odor, which would be other than methane because methane is odorless. A small bypass around the RO process will be beneficial in minimizing the remineralization chemical addition required in post-treatment, including elimination of the need for calcium addition. The bypass is limited by the treatment goal for chloride, TDS, and other constituents. Figure ES-5 displays a process flow diagram of an example 12,500-AFY Project.



Stream #	1	2	3	4	5	6
Flow, AFY	12489	161	12327	10478	1849	10640
Flow, gpm	7743	100	7643	6497	1146	6597
TDS, mg/L	6580	6580	6580	140	43073	350
Pressure, psig	60	60	375	10	0	100

Figure ES-5. Project Process Flow Diagram for a 12,500-AFY Project

3.6.2 Treatment Layouts

The study team met at the Elm and Faysmith site to discuss the Project layout with representatives from the City of Torrance. Based on input from the City of Torrance, layouts for 12,500-, 16,000-, and 20,000-AFY desalination plants were developed. Since the area surrounding this site is primarily residential, most of the treatment equipment will be housed inside a building. Chemical facilities are located in the front of the property, inside the treatment building, and adjacent to the street to allow for ease of truck filling. Setbacks of 20 feet (north) and 30 feet (back of west) are provided for the residential neighbors. The air stripper blowers will likely require sound enclosures because the blowers will emit about 80 decibels on the A-weighted scale. The layout for an example 12,500-AFY project is shown on Figure ES-6.

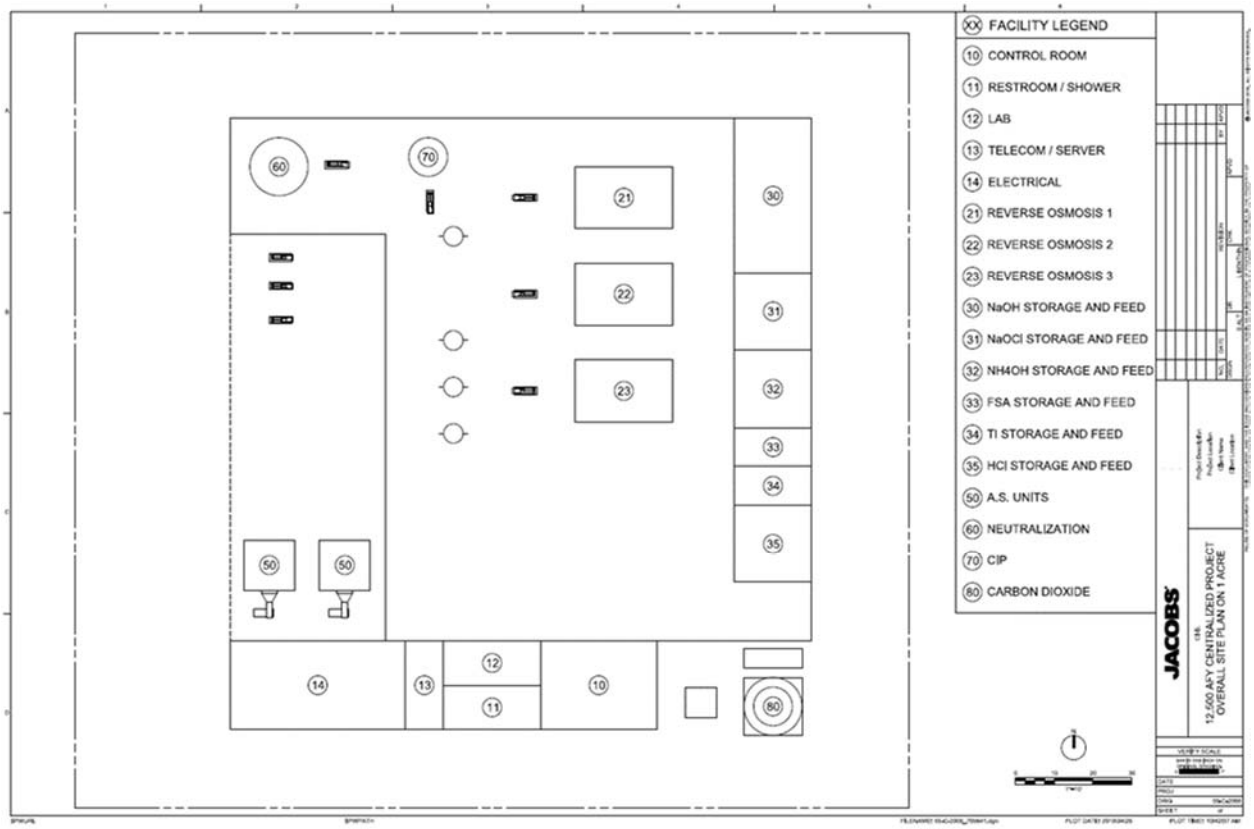


Figure ES-6. Conceptual Layout for the 12,500-AFY Centralized Treatment Facility

An option to provide portable wellhead treatment will allow treatment of the smaller Gage and upper Silverado aquifer areas of the plume that are distant from the centralized desalter. These areas would be logistically difficult and expensive to connect to the centralized desalter. The portable treatment equipment will require a footprint of approximately 5,600 square feet (6,500 square feet including the extraction well). Figure ES-7 shows the layout for the portable system. Three sites have been recommended for portable wellhead treatment, as follows:

- The existing Sepulveda 2 well site on Sepulveda Boulevard between Evalyn Avenue and Kathryn Avenue
- Meadows Avenue Elementary School in Manhattan Beach, where the well at the elementary school is 0.27 mile from the potential treatment site at the City of Manhattan Beach's Peck Reservoir
- Glasgow Park (north) or Hollyglen Park in Hawthorne

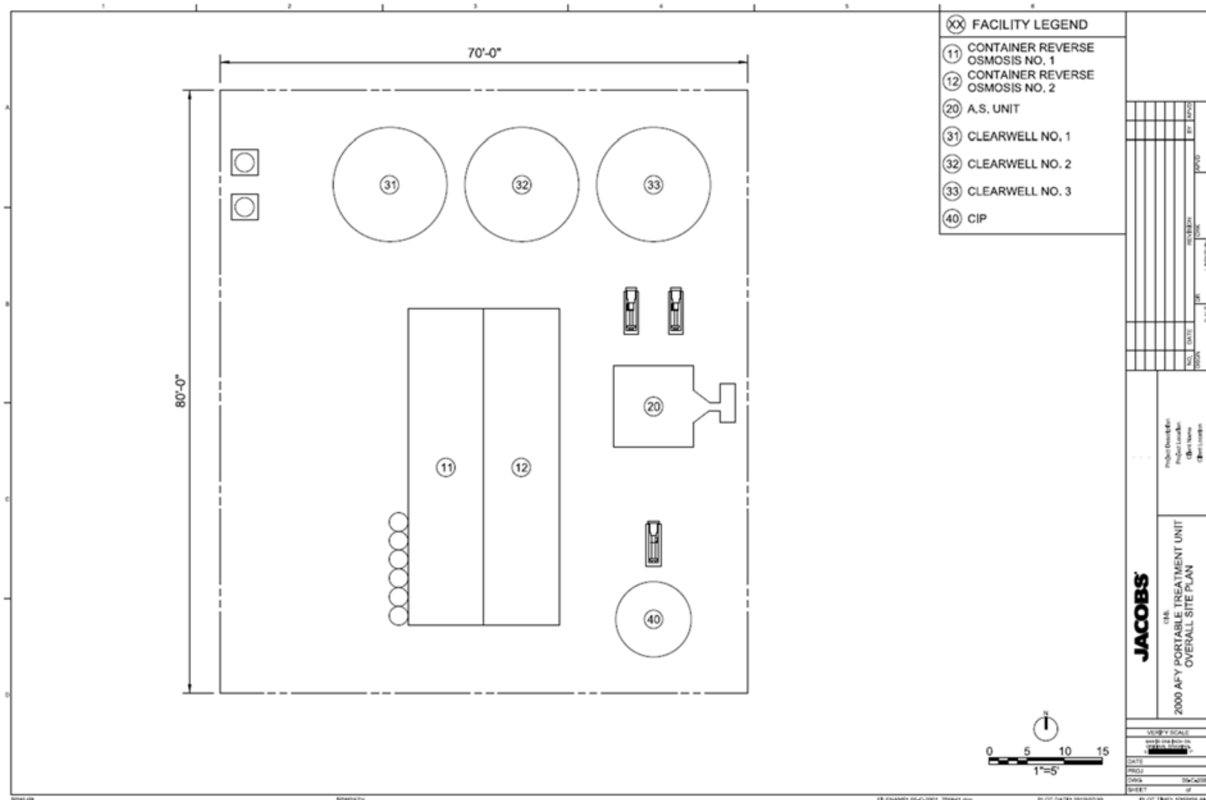


Figure ES-7. Conceptual Layout for the 2,000-AFY Portable Treatment Facility

3.7 Potential Project Screening

A MODA process was used to rank the Projects according to the weighted criteria from the Stakeholder Group and the performance of each Project against the criteria. A MODA sensitivity analysis revealed that two projects (Number [No.] 18 and No. 19) were consistently ranked in the top three positions regardless of the criteria weighting. Using the source water quality and product water quality goals, together with the recommended treatment and brine disposal methods, Project costs for each alternative were refined. A layout of the conceptual project is shown on Figure ES-4.

Based on costs and MODA scoring, three Projects were recommended for final consideration at a stakeholder meeting. WRD requested that the three Projects be expanded to six Projects. The expansion includes an intermediate extraction flow rate of 16,000 AFY and the option for a 2,000-AFY portable wellhead treatment unit included at the three different extraction flow rates of 12,500 AFY, 16,000 AFY, and 20,000 AFY. The portable wellhead treatment allows the Upper Gage aquifer sections of the high-salinity plume to be treated. The final six projects for further Program evaluation are presented in Table ES-4 and summarized as follows:

- 12,500 AFY Total Extraction:
  - **Project 18**: 12,500-AFY desalter with 7 new extraction wellheads
  - **Project 19**: 10,500-AFY desalter with 10 new extraction wellheads with 2,000-AFY portable wellhead treatment
- 16,000 AFY Total Extraction:
  - **Project 41**: 16,000-AFY desalter with 9 new extraction wellheads
  - **Project 42**: 14,000-AFY desalter with 12 new extraction wellheads with 2,000-AFY portable wellhead treatment
- 20,000 AFY Total Extraction:
  - **Project 43**: 20,000-AFY desalter with 11 new extraction wellheads
  - **Project 44**: 18,000-AFY desalter with 14 new extraction wellheads with 2,000-AFY portable wellhead treatment

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Table ES-4. List of Preferred Projects for Further Evaluation

Project No.	Preferred Project - General Description	New Extraction Wells	Treatment Locations			Total New Extraction (AFY)	Water Delivery Locations						Total New Product Water Delivery (AFY)
			Old City Yard (Torrance)	Remote Wellhead Treatment	Goldsworthy and Brewer		Torrance	GSWC	Manhattan Beach	LADWP	Cal Water	Lomita	
12,500 AFY Total Extraction													
18	*Centralized treatment only* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach	7	12,500	-	7,300	12,500	3,872	850	944	2,597	1,417	944	10,625
19	*Centralized and remote wellhead treatment* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach and Remote Wellhead Treatment	10	10,500	2,000	7,300	12,500	3,872	850	944	2,597	1,417	944	10,625
16,000 AFY Total Extraction													
41	*Centralized treatment only* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach	9	16,000	-	7,300	16,000	3,900	900	1,700	2,900	2,900	1,300	13,600
42	*Centralized and remote wellhead treatment* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach and Remote Wellhead Treatment	12	14,000	2,000	7,300	16,000	3,900	900	1,700	2,900	2,900	1,300	13,600

Table ES-4. List of Preferred Projects for Further Evaluation

Project No.	Preferred Project - General Description	New Extraction Wells	Treatment Locations			Total New Extraction (AFY)	Water Delivery Locations						Total New Product Water Delivery (AFY)
			Old City Yard (Torrance)	Remote Wellhead Treatment	Goldsworthy and Brewer		Torrance	GSWC	Manhattan Beach	LADWP	Cal Water	Lomita	
20,000 AFY Total Extraction													
43	*Centralized treatment only* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach	11	20,000	-	7,300	20,000	4,500	900	1,700	4,200	4,200	1,500	17,000
44	*Centralized and remote wellhead treatment* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach and Remote Wellhead Treatment	14	18,000	2,000	7,300	20,000	4,500	900	1,700	4,200	4,200	1,500	17,000

[a] The City of Torrance has recently indicated a maximum demand of 3,000 AFY, and LADWP has expressed the desire for more water; thus, 1,200 AFY has been reallocated from Cal Water to LADWP for Projects 43 and 44, and between 872 and 1,500 AFY has been reallocated from Torrance to LADWP in all Projects. In addition, an hydraulic modeling study conducted by the City of Torrance has indicated that the existing Torrance distribution system piping and pumping is limited to transferring approximately 3,000 AFY to Cal Water, but can deliver 7,300 AF to LADWP.

Note:

- = component not included in Project

4. Facility Operations and Maintenance Plan

The OMP (see Appendix B) describes the economics and operations and maintenance (O&M) criteria to be considered for the Projects. O&M is a necessary portion of the Program. Effective O&M ensures that Project equipment lasts for its intended lifespan and that chemicals and resources meet water quality regulations and standards. The Facility Operations and Maintenance Plan (FOMP) provides an overview of the operating parameters that would be used to guide the operation of the facility. The plan identifies key drinking water regulations enforced by the California State Water Resources Control Board Division of Drinking Water. The Projects in the Program are designed with the capability to meet applicable primary and secondary drinking water standards. The primary regulatory drivers for water treatment include regulations that address contaminant removal and disinfection by-product limits.

Operating staff are needed to verify the finished, potable drinking water quality; monitor performance; and confirm the proper operation of the treatment plant. California regulations do not have a specific requirement for the number of staff needed to operate a treatment facility. Each utility is required to designate at least one chief and one shift operator, and these individuals must be onsite at all times, unless an equal degree of operational oversight and reliability is provided, and the operator is able to be contacted within 1 hour. The quantity of Project staffing will depend on the entity selected to operate the facility, and whether or not that entity can draw on existing resources to remotely monitor the Project. The level of staffing is considered the same for all six Projects in the Program. The portable wellhead treatment system will be tied into the supervisory control and data acquisition (SCADA) system at the centralized treatment plant and covered by the centralized operators, including regular monitoring via the SCADA system. In accordance with Title 22 California Code of Regulations 64413.1, the wells and distribution system will need to be maintained by a Class D4 distribution system operator because the Project will likely supply potable water to between 50,000 and 5 million people.

Two operating scenarios were considered:

- **Project Monitored Remotely by Another Existing Facility:** If the Project SCADA system can be monitored remotely by an existing facility using existing resources, an approximation of the O&M labor would include one new treatment plant operator (T3), one new distribution operator to service as many as 11 new wells and the distribution system, and the part-time assistance of an existing operator and an existing maintenance/instrumentation and control (I&C) individual for equipment calibration and servicing. The part-time individuals would be existing full-time workers with only part of their time allocated to the Program. The annual cost for this scenario is estimated to be $366,104, including overtime contingency.
- **Stand-alone Facility:** If the O&M staff for the Project cannot be drawn or shared from existing local resources, the plant will need to be staffed to handle remote monitoring 24 hours a day and 7 days per week. This staffing will include a supervision T3 operator, three additional T2 grade operators, one D4 distribution operator, and one maintenance/I&C worker. The annual cost for this scenario is estimated to be $921,773, including overtime contingency.

At a minimum, support facilities will be required at the centralized Projects for the electrical control room, onsite laboratory water quality testing, and operator control room. The electrical control room will house the switchgear required for all equipment. Onsite laboratory testing will consist of analyses such as pH, conductivity, free and total chlorine, and others, that can be performed with a Hach test kit and that are required for water quality and analyzer verification. The operators will spend most of their time onsite, monitoring and controlling the process from the SCADA system screens located in the operator control room.

In addition to staffing, the annual O&M budget needed to operate the facility also includes energy, chemicals, other consumables, equipment repair and replacement, and analysis costs. O&M cost is directly related to the concentration of brackish water treated by the facility. The total O&M is displayed in Table ES-5 for three different feed water salinities: Year 1, midpoint, and the last year of treatment plant operation as the plume is being remediated. The energy needed will vary with what is anticipated to be decreasing salinity over time. The Projects are assumed to operate at design capacity for 350 days per year, leaving 15 days for maintenance and unexpected shutdowns. The FOMP is included in Appendix B.

Table ES-5. Total Annual O&M Costs for the Preferred Projects

Total Annual O&M Costs	Year 1 6,500 mg/L TDS ($)	Midpoint 3,500 mg/L TDS ($)	Last Year 600 mg/L TDS ($)
Project 18	8,000,000	7,400,000	6,500,000
Project 19	9,000,000	8,400,000	7,500,000
Project 41	9,700,000	8,800,000	7,700,000
Project 42	10,500,000	10,000,000	8,600,000
Project 43	11,500,000	10,700,000	9,600,000
Project 44	12,500,000	11,500,000	10,100,000

5. Power Supply Plan

The PSP presents the evaluation of power supply needs and options for the centralized treatment facility and is included in Appendix C. The goal of the PSP is to analyze and recommend the most applicable, feasible, environmentally efficient, cost-effective, and long-term equipment configurations to meet the electric power demand loads for running the treatment plant. This assessment provides a screening of power options, including conventional generation and renewable energy that meet the needs of the overall energy strategy in comparison to the “baseline” purchased electricity.

A methodical evaluation of power-generating facility selection began with the establishment of the Project baseline for the amount of purchased electricity required from the utility provider for each of the new water treatment facility projects. The PSP details the extent of the transmission infrastructure that may be required, and reviews purchased power from Southern California Edison (SCE), a community choice aggregation or a wholesale market broker. Based on the evaluation of the power requirements for each of the Projects, it appears that each facility will require new electrical service, which creates necessary coordination with SCE for transmission line easements.

Through the feasibility evaluation, the analysis determined that there is not significant cost savings to service equipment loads outside of the water treatment facility with the power-generating equipment options. Therefore, it is recommended that power be purchased from SCE to service the individual wellhead locations and portable wellhead treatment. Determination should be made after a more detailed evaluation is performed. As such, only the loads at the centralized desalter for the various project capacities were evaluated in this study.

With input from WRD, an equipment grading matrix was created with several grading criteria, each weighted differently to prioritize several factors. The recommended option is fuel cell servers and the preferred alternative is reciprocating engines for most of the feasible Project treatment plant sizes. Both technologies have some advantages and disadvantages but will ultimately meet the requirements of the facility. Further investigation will be needed on both options.

6. Site Civil Plan

A Site Civil Plan was created to develop preliminary grading to estimate earthwork and identify existing and proposed utility locations at the centralized treatment facility (preliminarily located at the Elm and Faysmith site). The Site Civil Plan is included in Appendix D.

7. Facility Renderings

The facilities were rendered into three-dimensional models. Renderings were generated for the three different centralized treatment facility sizes and the portable unit. A majority of the equipment will be housed in a building with an exterior façade selected to blend into the surrounding neighborhood. A more detailed visual simulation will be developed as part of the environmental review process. Figures E-8 and E-9 show the renderings for the 20,000 AFY centralized facility and the portable unit, respectively. Additional renderings are shown in Appendix E.

Figure ES-8. Rendering of the Centralized Treatment Facility

Figure ES-9. Rendering of Portable Treatment Unit

8. Environmental Review Plan

The Environmental Review Plan provides a high-level environmental screening of the Preferred Projects and is included in Appendix F. This high-level screening was based on the January 2019 amended California Environmental Quality Act (CEQA) Initial Study Checklist. It includes a desktop review that differentiates potential environmental impacts by Project, and identifies resource areas where additional technical studies will be needed to support a project-specific CEQA evaluation.

Of the resources identified where the Project may result in direct and indirect adverse impacts, the areas of greatest concern include aesthetics, air quality, and noise. Potential impacts related to these resources are of greatest concern because they could directly affect the adjacent residential property owners. To support a thorough evaluation of potential impacts and identification of appropriate mitigation measures as part of a project-specific CEQA review, visual impact analysis, air emissions calculations, and noise evaluation studies are recommended.

Following selection of a proposed Project, a complete environmental review would be conducted to determine which environmental resources would be impacted and to what level the impacts would occur. As part of the project-specific environmental review, appropriate mitigation measures would be identified to avoid or minimize potentially significant environmental impacts. The level of significance will need to be determined during a project-specific CEQA review.

9. Project Permitting Plan

The Project Permitting Plan has been prepared to identify applicable federal, state, and local laws and regulations, potential permits and approvals, additional technical studies needed to support permit applications, the acquisition schedule, and the acquisition approach. The Project Permitting Plan, as shown in Appendix G, includes a table of activities and the associated permits, approvals, and technical studies that would be required. Early consultation with regulatory agencies is recommended to further identify and refine the requisite permits or regulatory approvals required for Project construction and operation.

The Project Permitting Plan includes a preliminary identification of potential permits or regulatory approvals that may be required.

Several key approval/permitting items and approaches are the following:

- **Land Use:** Coordination with the City of Torrance on status and timing to address inconsistent zoning at the proposed desalter property, and a zone change to public use to be consistent with the land use designation in the General Plan should occur early in the project review process. The proposed zone change to public use would need to be included in the project-specific CEQA evaluation.
- **California Environmental Quality Act:** At selection of the proposed Project, an initial study would be prepared pursuant to CEQA to determine whether the Project may have a significant effect on the environment. Based on the Environmental Review Plan included in the Feasibility Study (Appendix F), it is anticipated that the initial study would not identify substantial evidence that the Project or any of its aspects would have a significant effect on the environment. Hence, the lead agency could prepare a mitigated negative declaration (MND). An MND is a short document that describes the proposed Project, presents findings related to environmental conditions, includes a copy of the initial study (which documents the reasons to support the findings), and includes mitigation measures, if any, included in the Project to avoid potentially significant effects.
- **Other Permits/Approvals:** Opportunities to expedite the schedule and maximize cost efficiencies should be considered following selection of the proposed Project. For example, waste discharge requirements for discharge of well development and well purging of groundwater may take time to acquire. Alternate discharge opportunities, such as to the sanitary sewer in instances where there is an adjacent manhole, may be appropriate. Prior to discharge to the sanitary sewer, a sewer discharge permit would be needed from the applicable sewer service provider. Similarly, discharge of well purge water to a temporary storage tank, such as a Baker tank, and transport via vacuum truck to the JWPCP may be appropriate depending on selected well locations.

10. Project Costs and Funding Plan

The Project Costs and Funding Plan was developed to identify potential financing and funding options and better understand the total lifecycle cost associated with the six Potential Projects. Public-private partnerships (P3), green bonds, municipal revenue bonds, and the Enhanced Infrastructure Financing District were evaluated as potential financing options available from the private sector. The plan also evaluates potential local, state, and federal grant and loan funding options that are available to offset the development costs for each of the six Potential Projects.

A Cost of Water Analysis was prepared for each of the six Potential Projects and assumes the Project will be constructed using a traditional design-bid-build basis. Table ES-6 summarizes capital and total annual O&M costs for each of the six Potential Projects. Because the individual items that constitute the annual O&M costs have different durations, the individual O&M costs are presented separately in Table ES-6.

Table ES-6. Capital and Annual O&M Costs, in 2018 Dollars

Project Number	Capital Cost ($ millions)	Annual O&M Costs ($ millions)			
		Well Energy and Maintenance[a]	Treatment Plants[b]	Brine Disposal[b]	Total Annual O&M
Project 18	$139	$1.2	$6.8	$0.48	$8.5
Project 19	$180	$1.2	$7.8	$0.48	$9.5
Project 41	$165	$1.5	$8.2	$0.60	$10.3
Project 42	$203	$1.5	$9.0	$0.60	$11.1
Project 43	$185	$1.9	$9.6	$0.75	$12.3
Project 44	$227	$1.9	$10.6	$0.75	$13.3

Notes:

[a] These costs are assumed to occur every year of the 30-year study period.

[b] These costs will occur over the following durations, 20-30 years for Projects 18 and 19; 17-30 years for Projects 41 and 42; 14-30 years for Projects 43 and 44.

Using the above assumptions and the costs shown in Table ES-6, a lifecycle cost analysis was developed. The net present value (NPV) of the total costs (in 2018 dollars) for each of the six Potential Projects is shown in Table ES-7. The NPV calculation in the analysis uses an end-of-year expenditure convention.

Table ES-7. WRD Desalter Project Lifecycle Cost Analysis Summary, in 2018 Dollars

Project Alternative	Feed Capacity		NPV Total Lifecycle Costs (millions)	Cost Range per 1,000 Gallons	Cost Range per AF	NPV Replenishment Cost per AF	NPV Total Cost Range per AF	NPV Cost Range per AF with 3% Financing
	AFY	mgd						
Project 18	12,500	11.2	$286 - 341	$2.87 – 3.41	$934 – 1,111	$235	$1,168- 1,345	$1,193 – 1,369
Project 19	12,500	11.2	$343 - 404	$3.43 – 4.04	$1,117 – 1,318	$235	$1,351 – 1,552	$1,382 – 1,584
Project 41	16,000	14.3	$324 - 411	$2.54 – 3.22	$827 – 1,048	$235	$1,062 – 1,283	$1,084 – 1,305
Project 42	16,000	14.3	$372 - 466	$2.91 – 3.65	$949 – 1,190	$235	$1,183 – 1,424	$1,211 – 1,452
Project 43	20,000	17.9	$350 - 477	$2.19 – 2.98	$713 - 973	$235	$948 – 1,207	$968 – 1,227
Project 44	20,000	17.9	$402 - 542	$2.52 – 3.39	$821 – 1,105	$235	$1,055 – 1,339	$1,080 – 1,364

Based on the results shown in Table ES-7, Project 19 has the highest cost per AF of water, while Project 43 has the lowest cost per AF of water. In general, the larger capacity Projects are more economical from a cost-per-AF of water standpoint, but they require the highest initial capital investment. The Project Cost and Funding Plan is included in Appendix H.

11. Project Delivery Plan

The Project Delivery Plan comprises a Project Delivery Analysis TM and Value for Money Analysis TM, which are included in Appendix I.

11.1 Project Delivery Analysis

The Project Delivery Analysis TM evaluates alternative project delivery methods, respective cost impacts, and potential risks. Procurement methods and their resulting delivery models take numerous forms, ranging from standard design-bid-build techniques, through construction management at risk, to turnkey approaches with significant risk transfer, including many variants of design-build. While many of these methods have historically been referred to as "alternative" project delivery, widespread industry acceptance has shifted them to the mainstream. The spectrum of collaborative methodologies also can encompass variations that include operations scope and private financing participation. For example, methodologies that include O&M support are often designated as design-build-operate. Models that include funding support via private equity and financing (often in conjunction with O&M) are often designated as P3s. The analysis provides advantages, disadvantages, and limitations for the following delivery methods:

- Design-Bid-Build
- Construction Management at Risk
- Progressive Design-Build
- Fixed-Price Design-Build
- Design-Build-Operate
- P3

For the projects being analyzed as part of this Feasibility Study, collaborative delivery represents a viable delivery option and should be retained as an option moving forward. The delivery options are grouped into the following three categories, with assumptions as noted:

- **Traditional Delivery.** This option is primarily limited to design-bid-build. Construction management at risk may be an option for some stakeholder jurisdictions but is otherwise assumed not to be allowed.
- **Design-Build.** This option may include progressive or fixed-price approaches or combinations of both. For the purposes of this analysis (and for the Value for Money [VfM] analysis), these “flavors” of design-build are treated equally. Once specific projects and stakeholders are further refined, the differentiation between progressive and fixed-price options can be further refined. Design-build-operate is not considered a viable option, unless included in the P3 option with a financing component as per below.
- **Public-Private Partnership.** Design-build, with or without operations, with a third-party financing component is an option that has potential merits, which will be defined separately by the VfM analysis.

The following describes the favorability of applying the above models to the Potential Projects identified in this Feasibility Study:

- **Extraction Wells.** Best suited for design-bid-build unless combined with the larger project scope.
- **Treatment Facilities.** High probability of design-build being beneficial, depending on local stakeholders’ perspectives, size of project, and level of desired performance risk transfer.
- **Conveyance and Pumping Infrastructure.** Equally attractive to design-bid-build and design-build on a stand-alone basis, depending on scope, schedule requirements, and coordination risk with other facilities.
- **Combined Scope.** Highly attractive for the design-build option due to increased size and complexity and ability to transfer schedule coordination and performance risk. Final determination will be largely affected by local stakeholders’ preferences and by the results of the VfM analysis.

11.2 Value for Money Analysis

A VfM analysis is a generally accepted best practice that compares the lifecycle costs of traditional public delivery and finance with the costs of collaborative delivery and finance for various procurement methods.

The analysis includes the direct capital and operating costs of the project, and the monetized risk transfers that result from the delivery and finance options under consideration. The purpose of the VfM analysis, generally, is to determine the most advantageous financing and delivery method on a comparative lifecycle cost basis, including the value of risks shared and retained under various selected delivery methods.

Two engineering alternatives and three procurement options (traditional, design-build, and P3) were selected during the preliminary screening processes for inclusion in the VfM analysis to band the range of technical solutions and delivery models that survived preliminary screening analyses described in the earlier TMs developed for this project. Conceptual cost estimates for the direct capital and operating costs for the engineering solutions have been developed using parametric cost estimating tools and procedures consistent with a Class 4 estimating process. The team identified the relevant risk transfers and associated assumptions for this study, and Jacobs developed a model to calculate the resulting NPV of lifecycle costs, including the risk transfers.

The cost of water per AF is presented in Table ES-8. The costs presented include the capital and operating costs over the 30-year period and the monetized risks identified in the VfM analysis. For some of the identified risks, a range of adjustment factors have been applied to the traditional and design-build methods to present a “high” and “low” impact of monetized risk to the different procurement options. (These risk ranges were not applied to the P3 procurement option as it serves as a baseline against which the other two options are compared.) Although replenishment costs were not included in the VfM analysis, they are included in Table ES-8 to illustrate the fully loaded estimated cost of water. The method for determining the replenishment costs in $/AF is presented in the Project Costs and Funding Plan (Appendix H).

Table ES-8. Summary of Cost of Water Including Capital, O&M, and Monetized Risks, Project 44 – 20,000 AFY

Item	Traditional		Design-Build		P3
	High	Low	High	Low	
Net Present Value	$663,636,413	$621,313,017	$590,341,639	$555,802,845	$499,142,955
$/AF	$1,354	$1,267	$1,204	$1,134	$1,018
Replenishment Cost ($/AF)	$235	$235	$235	$235	$235
Total Cost ($/AF)	$1,495	$1,436	$1,395	$1,341	$1,253

For both engineering solutions (Project 18 and Project 44), the traditional and design-build delivery options result in a higher NPV of costs than the P3 option in the VfM analysis. The results for these two options are close to each other, with the design-build option roughly 10 percent lower in NPV than the design-bid-build option in both cases.

The NPV of cost results for the P3 (Design-Build-Finance-Operate-Maintain) option are notably lower than for the other two delivery options, primarily because the risk transfers and operating cost efficiencies provided by this delivery method are substantial and appear to outweigh the higher cost of capital for the private delivery option. For both the 12,500-AFY and 20,000-AFY options, the NPV of costs for P3 are approximately 25 percent lower than for the traditional delivery option.

A sensitivity analysis was conducted that reduced many of the risk monetization factors in half for the traditional and design-build delivery options, to see if the ranking of the options would be affected by assuming lower risk transfer costs given that the full estimated impact of some of the risk transfers may not occur. The resulting “low” case narrowed the spread in costs among the three delivery options, but did not change the order of the options. The “low” sensitivity analysis case for the design-build option is within 10 to 13 percent of the costs for the P3 option, depending on which of the engineering options is evaluated.

12. Project Entitlements and Acquisition Plan

The PEAP investigates easements and ROWs for the treatment site, well locations, and conveyance routes, and identifies each participating agency's governance structure and limitations for developing the governance concepts. The PEAP provides the framework for acquiring the necessary properties and mapping out easements and ROWs. The PEAP helps to effectively locate the Projects' necessary infrastructure to achieve the Program goals while minimizing the effort in permitting the construction of the pipelines, wellheads, and the treatment system. The following is a summary of the ROW and easement evaluation for each component:

- **Treatment Locations:** The selection of the Elm and Faysmith site for the centralized treatment plant was based on suggestions of the Program stakeholders. The property at Elm and Faysmith is large enough for a 20,000-AFY treatment plant and is reasonably close to the areas offered by the stakeholders for new extraction wells. Potential alternative locations for the centralized treatment plant were investigated. Similarly, potential alternative properties for well extraction sites in proximity to the northernmost saline plume in the Gage aquifer were explored. Maps of alternative locations are included in the PEAP in Appendix J.
- **Extraction Well Locations:** The City of Torrance suggested 10 properties as proposed locations for new extraction wells for the Program that could treat the majority of the saline plume and feed a centralized treatment facility. Six of the 10 properties are owned by the City of Torrance, and the remaining 4 properties are owned by others. Based on the proposed extraction well locations and property ownership information provided by the Los Angeles County Office of the Assessor, it appears that easements may be required for extraction wells at the following properties because they are not owned by the City of Torrance: Del Amo Sump, Del Amo Shopping Center, Madrona and Fashion site, and the Madrona Middle School.
- **Conveyance:** Brackish water, potable water, and brine conveyance routes were evaluated as part of the CSDPR. Based on the desktop analysis of the available aerial images from Google Earth and data from the Los Angeles County Geographic Information System data portal, it was found that all conveyance piping from the extraction wells to the proposed Project will be located in pubic ROW. With the exception of the brine line, which includes one railroad and two highway crossings that will require permits and coordination from owning entities, no easements will be required for constructing the pipelines. The exact route in the city ROW will need to be determined to minimize conflicts with the utility infrastructure and to avoid traffic disruption within the proposed ROW.

To develop potential governance concepts, a review of each stakeholder's charter, roles and responsibilities, and governance concepts within their service areas was conducted. After review and discussion with individual members of the Stakeholder Group, it appears that there are no institutional barriers to the successful implementation of any of the Potential Projects. The examples provided by existing desalter projects further demonstrate the feasibility of project structures that are already in place. At this stage in the Program's development, no specific recommendations for governance structure are provided, pending further discussions among Stakeholder Group members and others. This Program is not limited to the agencies who have been identified as stakeholders for this Project; others, such as the Metropolitan Water District of Southern California and LACSD, could also participate in the Project, depending on the opportunities to fulfill the regional objectives. Continued outreach with key stakeholders within the groundwater basin and the public, together with ongoing coordination with regulatory agencies, will help support the success of the Program.

13. Conclusions, Recommendations, and Next Steps

The focus of this Feasibility Study is to identify key project components and implementable projects for purposes of treating the saline plume in the West Coast Basin. Through a collaborative, stakeholder-driven approach, six feasible project alternatives were identified. Table ES-9 lists general advantages and disadvantages of each for consideration in future project selection.

Table ES-9. Overall Advantages and Disadvantages by Project

Project	Advantages	Disadvantages	Total Lifecycle Cost per AF
Project 18: 12,500-AFY central desalter	• Lowest capital cost	• Will not treat entire plume • Longer remediation period (~20 years)	$1,193 – 1,369
Project 19: 10,500-AFY central desalter with 2,00-AFY wellhead treatment	• Wellhead treatment allowed for targeted extraction of entire plume	• Most expensive (per AF) • Additional evaluation needed for wellhead treatment sites • Longer remediation period (~20 years)	$1,382 – 1,584
Project 41: 16,000-AFY central desalter	• Intermediate size project with intermediate impacts	• Will not treat entire plume	$1,084 -1,305
Project 42: 14,000-AFY central desalter with 2,000-AFY wellhead treatment	• Wellhead treatment allowed for targeted extraction of entire plume	• Additional evaluation needed for wellhead treatment sites	$1,211 – 1,452
Project 43: 20,000-AFY central desalter	• Least expensive (per AF) • Plume is remediated quicker (~14 years)	• More wells to permit • Less space for additional pretreatment if necessary • Volume of treated water may exceed Torrance distribution system capacity • Will not treat entire plume	$968 – 1,227
Project 44: 18,000-AFY central desalter with 2,000-AFY wellhead treatment	• Least expensive with wellhead unit • Plume is remediated quicker (~14 years) • Wellhead treatment allowed for targeted extraction of entire plume	• More wells to permit • Less space for additional pretreatment if necessary • Additional evaluation needed for wellhead treatment sites • Volume of treated water may exceed Torrance distribution system capacity	$1,080 – 1,364

Additional analysis is needed to continue project selection and development. The following next steps are recommended for further Project development to select a single Preferred Project:

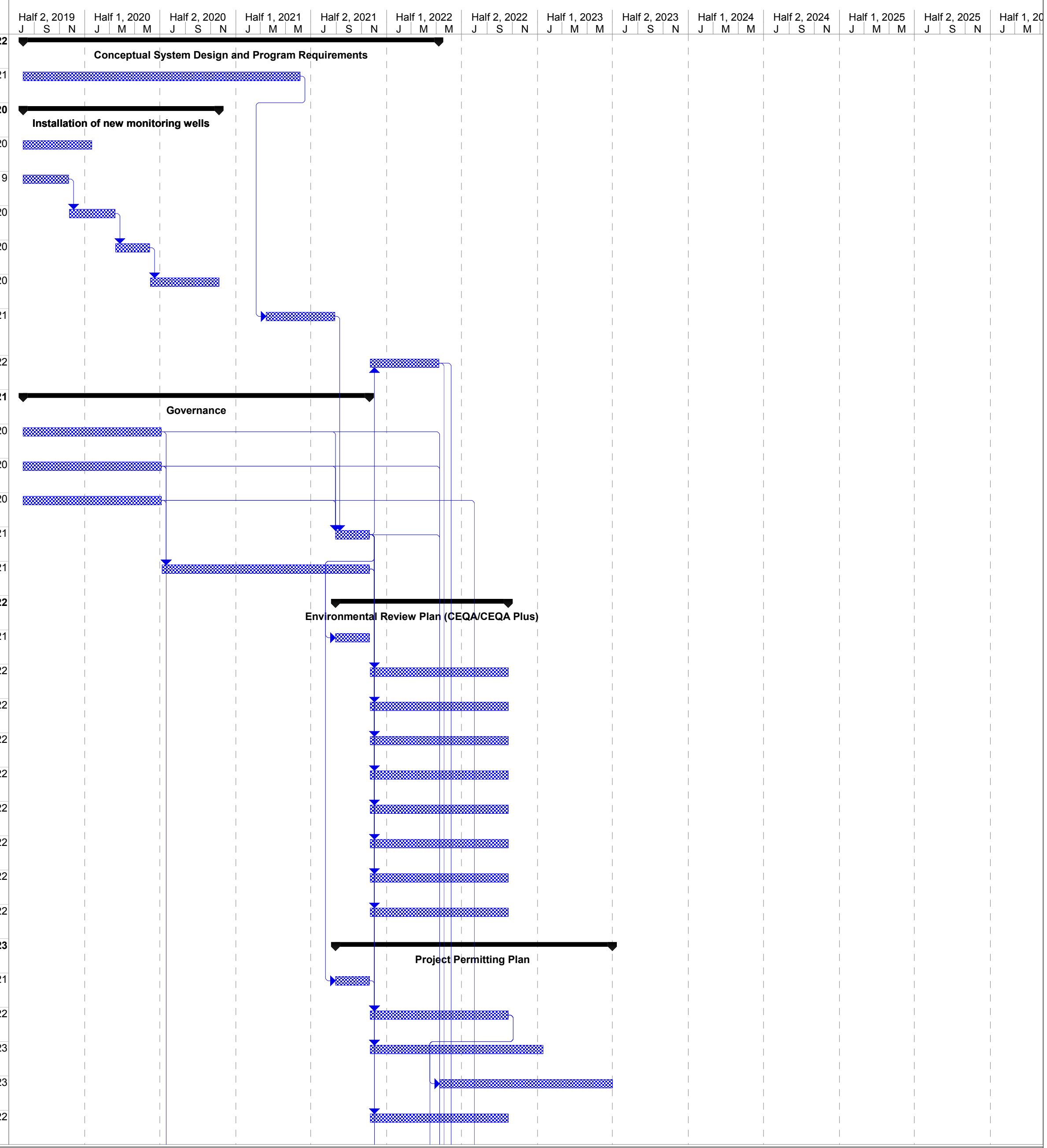
- **Additional Well Water Quality and Groundwater Modeling:** Although WRD has numerous monitoring wells, only two are in the vicinity of where new extraction wells will be placed for plume remediation. Additional monitoring wells are recommended to support the development of groundwater modeling and a solute transport model. These will help to minimize the risk and finalize the placement of new extraction wells. Additional well water quality is required because the CSDPR identified that the wells of interest in the West Coast Basin Water Quality database contain no data for numerous contaminants that have drinking water MCLs, as well as silica, strontium, and hydrogen sulfide. Groundwater modeling is also needed to identify injection volumes and locations for replenishment and to refine the proposed well locations to optimize the capture zone.
- **Replenishment:** The volume and source of water used to replenish the extracted saline plume need to be identified.
- **Lower San Pedro Seawater Barrier:** Analysis is needed to understand where additional seawater barrier wells are needed to prevent additional intrusion into the Lower San Pedro aquifer.
- **Selection of Single Preferred Project Alternative:** The final proposed project needs to be selected in order to continue subsequent development.

Once the project is fully defined, the following tasks can commence:

- **Entitlements:** Entitlements and ROWs will need to be obtained for properties not owned by stakeholders.
- **Environmental Review:** Development of the CEQA/National Environmental Policy Act documents and supporting studies, including evaluations for air emissions, noise, visual impacts, and cultural resources.
- **Governance Structure:** Additional discussion is needed around the governance of the Potential Project to understand partnership, ownership, operation, and water delivery volumes. The stakeholders need to decide who will own and receive water from the Project, and who will operate facilities.
- **Permitting:** Federal, state, and local permits will be required for the construction and operation of the treatment plant and well locations.
- **Power Supply:** Negotiations with SCE on rate structure. Evaluations of other power options, including fuel cells and turbines.
- **Project Delivery:** Will the project be delivered by traditional, design-bid-build, or an alternate delivery method?
- **Further Cost Development:** With the Project defined, the cost of water can be further refined and rate structures negotiated with the receiving stakeholders.

Once the preceding tasks are complete, the project can proceed to design and construction. Depending on the delivery method, this could extend up to 4 years.

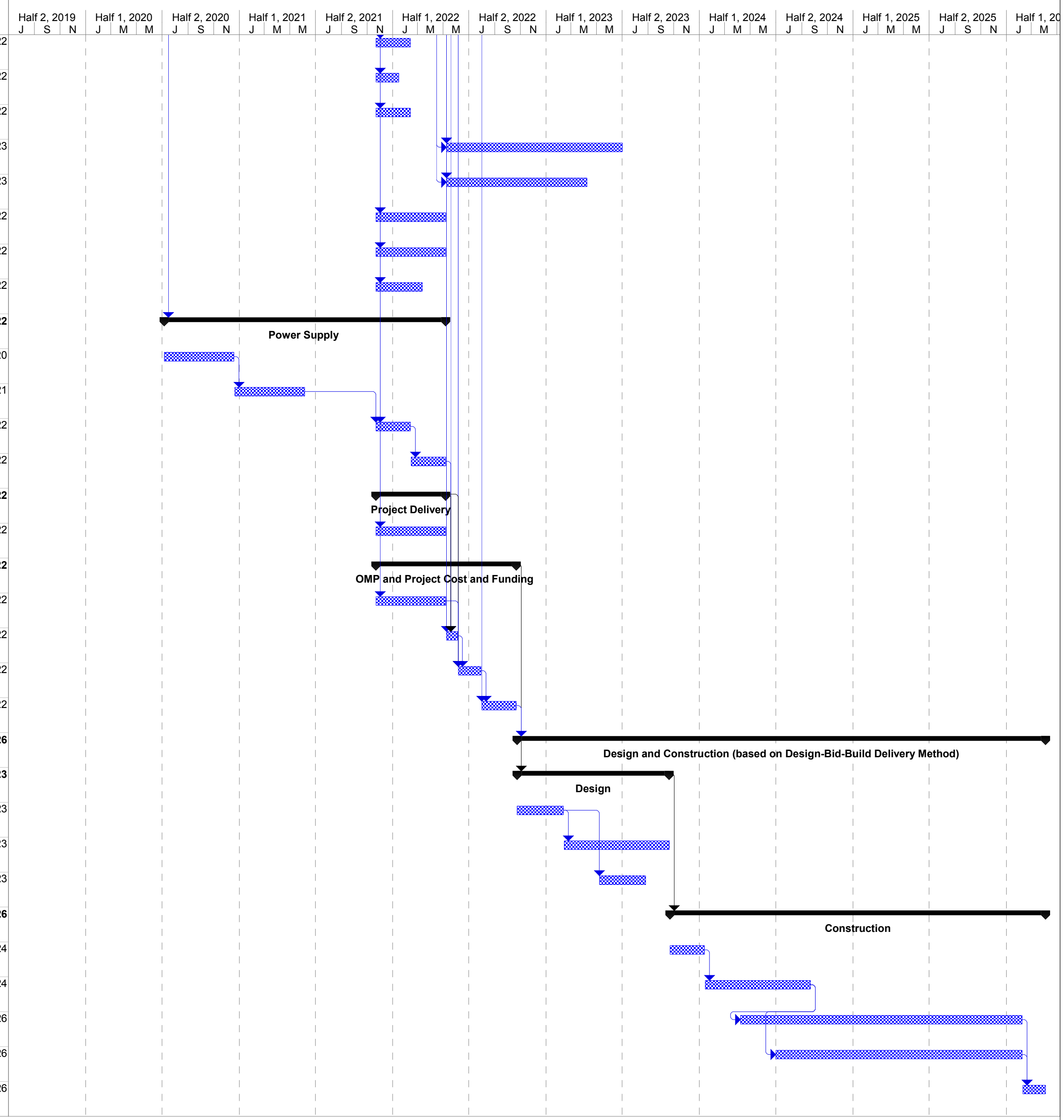
ID	Task Name	Duration	Start	Finish
1	**Conceptual System Design and Program Requirements**	**720 days**	**8/5/19**	**5/6/22**
2	Additional Water Quality	24 mons	8/5/19	6/4/21
3	**Installation of new monitoring wells**	**17 mons**	**8/5/19**	**11/20/20**
4	Permitting (CEQA Class 6 exemption)	6 mons	8/5/19	1/17/20
5	Prepare RFP and hire consultant	4 mons	8/5/19	11/22/19
6	Consultant produces well specs and driller pkg	4 mons	11/25/19	3/13/20
7	Procure driller who prepares drilling sub RFP	3 mons	3/16/20	6/5/20
8	Well Drilling , testing, development and completion	6 mons	6/8/20	11/20/20
9	Prepare RFP and hire consultant for Recharge Study and GW Modeling including calibrated GW flow model and solute transport model	6 mons	3/15/21	8/27/21
10	Establish rates for brine disposal to JWPCP and Hyperion, decide sewer or outfall	6 mons	11/22/21	5/6/22
11	**Governance**	**600 days**	**8/5/19**	**11/19/21**
12	Establish Ownership	12 mons	8/5/19	7/3/20
13	Establish O&M Entity	12 mons	8/5/19	7/3/20
14	Establish Preliminary Product Water Receivers and Quantities	12 mons	8/5/19	7/3/20
15	DEFINE Project Capacity as well as Extraction Well and Treatment Plant(s) locations	3 mons	8/30/21	11/19/21
16	Property and Easement Acquisition	18 mons	7/6/20	11/19/21
17	**Environmental Review Plan (CEQA/CEQA Plus)**	**300 days**	**8/30/21**	**10/21/22**
18	Prepare RFP and Hire Consultant	3 mons	8/30/21	11/19/21
19	Air Emissions Evaluation	12 mons	11/22/21	10/21/22
20	Bio Resource Evaluation	12 mons	11/22/21	10/21/22
21	Cultural Resource Evaluation	12 mons	11/22/21	10/21/22
22	Hazards Evaluation	12 mons	11/22/21	10/21/22
23	Hydrology/water quality analysis	12 mons	11/22/21	10/21/22
24	Noise Evaluation	12 mons	11/22/21	10/21/22
25	Transportation Evaluation	12 mons	11/22/21	10/21/22
26	Visual Impact Evaluation	12 mons	11/22/21	10/21/22
27	**Project Permitting Plan**	**480 days**	**8/30/21**	**6/30/23**
28	Prepare RFP and Hire Consultant	3 mons	8/30/21	11/19/21
29	CEQA/NEPA (USEPA WIFIA) Environmental Review*	12 mons	11/22/21	10/21/22
30	Property Development & Building Permit	15 mons	11/22/21	1/13/23
31	Water Supply Permit and Plan Review	15 mons	5/9/22	6/30/23
32	Permit to Construct and Operate	12 mons	11/22/21	10/21/22



Project: WRD FS Future Project Sched
Date: 6/19/19

Task		Project Summary		Inactive Summary		Manual Summary		External Milestone	
Split		External Tasks		Manual Task		Start-only		Progress	
Milestone		External Milestone		Duration-only		Finish-only		Deadline	
Summary		Inactive Milestone		Manual Summary Rollup		External Tasks			

ID		Task Name	Duration	Start	Finish
33		California Accidental Release Prevention Plan/Risk Management Plan	3 mons	11/22/21	2/11/22
34		Hazardous Material Business Plan	2 mons	11/22/21	1/14/22
35		Spil Prevention Control and Countermeasure Plan	3 mons	11/22/21	2/11/22
36		Extraction Well Conditional Use Permit and Plan Review	15 mons	5/9/22	6/30/23
37		Extraction Well Waste Discharge Requirment Permit	12 mons	5/9/22	4/7/23
38		Encrouchment/Excavation Permits	6 mons	11/22/21	5/6/22
39		Low Impact Development Sudy for Stormwater Retention	6 mons	11/22/21	5/6/22
40		Stormwater Pollution Prevention Plan	4 mons	11/22/21	3/11/22
41		**Power Supply**	**480 days**	**7/6/20**	**5/6/22**
42		Start coordination with SCE for grid power rate structure	6 mons	7/6/20	12/18/20
43		Additional Analysis on Turbine and Fuel Cell Options	6 mons	12/21/20	6/4/21
44		Finalize Rate structure with SCE for grid power	3 mons	11/22/21	2/11/22
45		Finalize Preferred Power Supply Option and Cost	3 mons	2/14/22	5/6/22
46		**Project Delivery**	**120 days**	**11/22/21**	**5/6/22**
47		Finalize Project Delivery Method	6 mons	11/22/21	5/6/22
48		**OMP and Project Cost and Funding**	**240 days**	**11/22/21**	**10/21/22**
49		Research financing and grants	6 mons	11/22/21	5/6/22
50		Finalize Annual O&M	1 mon	5/9/22	6/3/22
51		Finalize Cost of Water	2 mons	6/6/22	7/29/22
52		Finalize Product Water Receivers and Quantities	3 mons	8/1/22	10/21/22
53		**Design and Construction (based on Design-Bid-Build Delivery Method)**	**900 days**	**10/24/22**	**4/3/26**
54		**Design**	**260 days**	**10/24/22**	**10/20/23**
55		Prepare RFP and Hire Consultant	4 mons	10/24/22	2/10/23
56		Design	9 mons	2/13/23	10/20/23
57		Pilot Study	4 mons	5/8/23	8/25/23
58		**Construction**	**640 days**	**10/23/23**	**4/3/26**
59		Bid, Evaluation and Award	3 mons	10/23/23	1/12/24
60		Procurement	9 mons	1/15/24	9/20/24
61		Construction- Plant	24 mons	4/8/24	2/6/26
62		Construction-Wells	21 mons	7/1/24	2/6/26
63		Startup	2 mons	2/9/26	4/3/26



Project: WRD FS Future Project Sched
Date: 6/19/19

Task		Project Summary		Inactive Summary		Manual Summary		External Milestone	
Split		External Tasks		Manual Task		Start-only		Progress	
Milestone		External Milestone		Duration-only		Finish-only		Deadline	
Summary		Inactive Milestone		Manual Summary Rollup		External Tasks			

Appendix A
Conceptual System Design and Program Requirements

Regional Brackish Water Reclamation Program Feasibility Study

Conceptual System Design and Program Requirements

Final

May 2019, Updated March 2021

Water Replenishment District of Southern California

Report Overview

This report presents the findings of the initial planning effort (Task 1) of the Regional Brackish Water Reclamation Program Feasibility Study. The Conceptual System Design and Program Requirements were developed through a series of evaluations summarized in the technical memoranda (TMs) that comprise this report. The TMs describe the project definition and evaluation process, and consider options for specific components of the potential Projects that can be implemented to satisfy the needs, purpose, and objectives of the Program established as part of this planning process.

The first TM, entitled Conceptual System Design and Program Requirements, serves as an executive summary of the other TMs and provides overall recommendations related to data gaps and treatment.

With completion of Task 1 of the Feasibility Study, six potential Projects were identified for further analysis, conducted under subsequent Tasks 2 through 8. Based on feedback obtained from the Program Stakeholders, this report will be revised and included along with the TMs for Tasks 2 through 8 in a final Feasibility Study report.

Contents

1. Conceptual System Design and Program Requirements (Task 1.J)

JACOBS

Technical Memorandum

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Subject	**Conceptual System Design and Program Requirements**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019, Finalized March 26, 2021

1. Background

In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, Lynwood and Lower San Pedro (equivalent to Sunnyside) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To more fully utilize the West Coast Basin, the Water Replenishment District of Southern California (WRD) has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to treat the trapped saline plume for beneficial use.

The feasibility study will evaluate the following Program components: where to extract the plume water, where and how to treat the plume water, how to convey the treated potable water to the Program stakeholders, and how to manage the brine waste stream. The feasibility study includes the analysis of numerous "Projects," consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of the above components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed as dollars per acre-foot (AF) of treated water.

2. Conceptual System Design and Program Requirements

The Conceptual System Design and Program Requirements (CSDPR) document is an accumulation of numerous technical memoranda (TMs) addressing the following topics:

- Supply and Demand Analysis
- Potential Projects and Recommended Shortlist
- Source Water Quality and Conveyance
- Brine Waste Management and Conveyance
- Product Water Quality and Conveyance
- Treatment Technologies
- Project Screening

These TMs are summarized below; complete TMs are also included in this document. The first step in the feasibility study included the establishment of Project Siting Criteria, which includes the list of criteria for Project evaluation and the need to treat the saline plume to create a local potable water supply. Based on stakeholder input, 29 Projects were generated for consideration, with each Project containing a variation of Project components. Project components include the following: where to extract the plume water, where and how to treat it, how to convey the treated potable water to the Program stakeholders, and how to dispose of the brine. Project components also include capacity and quantity delivered to each stakeholder. The analysis included in the TMs narrowed the 29 Projects down to 6 Projects that will be analyzed in the subsequent phase of this feasibility study, as indicated in Section 3.1.

In the discussion that follows, examples are presented using a single project size (12,500 acre-feet per year [AFY]). Use of the 12,500-AFY size is for illustrative purposes only because a range of project sizes and extraction volumes are analyzed, and no specific extraction volume or project size has been recommended at this point in the Program.

2.1 Supply and Demand Analysis

The Supply and Demand Analysis TM summarizes the present and future water supplies and demands for the West Coast Basin. Water rights of the major purveyors in the basin were compared with the historical amounts extracted by pumpers to understand the utilization of the basin by individual parties and their future demands.

The stakeholders agreed to increase the target extracted and treated groundwater chloride level from 250 milligrams per liter (mg/L) to 500 mg/L, reducing the saline plume volume for treatment from 600,000 AF to 375,000 AF. The 375,000 AF are distributed in three different aquifers, with 64 percent of the water in the deeper (roughly 600 to 1,000 feet below grade) Lower San Pedro aquifer. The three aquifers and saline plume distribution are as follows:

- Gage aquifer – 22,000 AF
- Silverado aquifer – 113,000 AF
- Lower San Pedro aquifer – 240,000 AF

In addition, Project evaluation criteria were established, including cost of water, permitting difficulty, potential project phasing, greenhouse gas emissions, proximity to other contaminant plumes, and ability to meet the Program purpose and objectives. Lastly, as shown in Table 2-1, the stakeholders each established their maximum water demand for the Program as well as their preferred delivery locations.

Table 2-1. Maximum Acceptable Product Water Demand by Purveyor[a]

Purveyor	Maximum Product Water Amount Purveyor May Be Willing to Accept (AF)
Cal Water	9,500
GSWC	13,000
LADWP	10,000
City of Lomita	2,500
City of Manhattan Beach	3,620
City of Torrance	5,000
Note that WBMWD does not have any water rights within the adjudication area	

[a] Input for this table was received during the Supply and Demand Analysis, but this table was included in the subsequent Potential Projects and Recommended Shortlist TM.

Notes:

Cal Water = California Water Service Company
GSWC = Golden State Water Company
LADWP = Los Angeles Department of Water and Power
WBMWD = West Basin Municipal Water District

2.2 Potential Projects and Recommended Shortlist

The Potential Projects and Recommended Shortlist TM summarizes the information provided by the stakeholders and the way that information was used to develop the initial list of 29 Projects. Descriptions of, and cost estimates for, each of the initial 29 Projects were also provided. The following should be noted about cost estimates:

- The cost estimates do not include capital expenditure (CAPEX) financing because that will be investigated in the future Project Costs and Funding Plan (Task 7) of this feasibility study.

- These are Class IV[1] cost estimates with accuracies of +50 percent to -30 percent of actual Project cost.

The cost estimates were broken down into each Project component, which showed that costs for brine disposal via sewer were minor in comparison to treatment and groundwater replenishment costs. Eleven of the 29 Projects were shortlisted for further consideration and included Projects having one or more of the following attributes: lowest CAPEX, lowest cost per AF of water produced, ability to treat the entire plume, and ability to deliver water to all stakeholders.

Recommended Project desalination plant capacities, which ranged from 5,200 to 20,000 AFY of extracted water for treatment, were based on plume treatment durations ranging from 14 to 30 years, when targeting the 375,000 AF plume in combination with the existing Goldsworthy and Brewer groundwater desalter capacities. All Project costs are based upon a 30-year duration for comparative consistency between the Projects. When the plume is assumed to be remediated prior to the full 30-year duration, the subsequent costs involved in producing potable water will include extraction well pumping, chlorination, and fluoridation only, because no further treatment will be required. With replenishment water injection and treatment of the plume during the treatment period, at the end of the treatment period it is anticipated, and thus assumed for the purpose of this feasibility study, that all constituents in the plume will have levels that are acceptable for drinking water. As an example, a 12,500-AFY Project, in combination with the existing Goldsworthy and Brewer Desalters (with combined capacities of 7,300 AFY), would require a minimum treatment duration of 20 years, assuming 350 days per year of extraction and treat. Therefore, the lower range of the costs for this Project over a 30-year period include the initial capital costs of the extraction, transmission and treatment equipment, operating costs of extraction, and treatment and transmission for 19 years, with operating costs of extraction with minimal chemical addition for the last 11 years. The upper range of the costs for this Project assumes that treatment is provided for the full 30-year period.

2.3 Source Water Characterization

2.3.1 Source Water Quality

A detailed analysis of the pertinent existing monitoring well data was performed to estimate the composition of the future extracted high chloride groundwater (source water) for Project treatment. The analysis revealed that the source water would contain approximately 4,000 mg/L of chloride and approximately 6,500 mg/L of TDS, well above their respective drinking water maximum contaminant levels (MCLs). The Projects will also need to treat the source water for manganese and odor because each exceeds its respective drinking water standard. In addition, the source water is anticipated to contain approximately 7 mg/L methane. Although this is less than the 10 to 28 mg/L level recommended for air quality monitoring (to prevent the surrounding air from becoming flammable),[2] the methane will be removed by the air stripper required for odor removal, even though there is no federal or California drinking water MCL for methane. The complete water quality analysis of the anticipated source water includes more than 100 constituents and is presented in the Source Water Characterization TM.

The new extraction wells will be placed along the "leading," eastern edge of the saline plume. A hydraulic gradient exists from west to east, resulting from injection of fresh water along the coast intended to prevent seawater intrusion. The saline plume has migrated eastward at a rate of 250 feet per year. Placement of the extraction wells along the eastern edge has two benefits: (1) the majority of the extracted water will be drawn from the higher salinity western side of the wells; and (2) over time, a portion of the plume will migrate toward the extraction wells for treatment as part of the Program.

Because of the depth of the saline plume, which extends to roughly 1,000 feet below grade, vertical wells are recommended for extraction. The design basis includes the use of 20-inch-diameter, 316 stainless

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[1] Class IV estimates are for project screening, determination of feasibility, concept evaluation, and preliminary budget approval and reflect 1 to 15 percent of the total engineering required for design.

[2] Water Research Center "Methane and other Gases in Drinking Water and Groundwater," https://www.water-research.net/index.php/about/13-in-drinking-water/51-methane-and-other-gases-in-drinking-water-and-groundwaterV esim

steel wells, each extracting 2,000 AFY at up to 10 different locations. However, the transmissivity of the Lower San Pedro aquifer is anticipated to be less than the transmissivity of the upper Silverado aquifer and may limit the yield of a single well to below the target extraction rate. In addition, the placement of a long screen interval (typical of production wells) may lead to preferentially treating the shallower more transmissive zones rather than the Lower San Pedro. Therefore, numerous smaller-diameter wells may be more suitable and well screens may need to be strategically placed within the various aquifers requiring treatment including the Silverado and Lower San Pedro. This will be evaluated during subsequent phases of the Program.

2.3.2 Source Water Conveyance

The Brackish Water Extraction Conveyance Piping TM examined the property ownership of the well locations and the pipe routing to the centralized treatment plant site, located between Elm Avenue and Faysmith Avenue (also known as Old City Yard) in the City of Torrance. Based on the location of the proposed extraction wells, it is assumed that the City of Torrance will own the piping. Otherwise, some type of agreement/easements will be needed for the owner to lay pipe in the City's rights-of-way (ROWs). A few of the stakeholder-suggested properties are not owned by the City of Torrance and will require easements. Regarding conveyance piping, high-density polyethylene (HDPE) is the recommended pipe material. All conveyance piping from the extraction wells to the proposed Project will be located in City street ROWs, and no easements are required for the pipelines.

2.4 Brine Waste Management

Options for brine waste management were investigated, including the following: (1) discharge to the existing Los Angeles County Sanitation Districts (LACSD) collection system (sewer); (2) construction of a dedicated “brine line” to the outfall of either LACSD Joint Water Pollution Control Plant (JWPCP) or the City of Los Angeles’ Hyperion Water Reclamation Plant; (3) zero liquid discharge (ZLD); (4) deep well injection (DWI); (5) a new ocean outfall; and (6) trucking the brine to the JWPCP.

A new ocean outfall would have significant permitting hurdles. ZLD, DWI, and trucking would each be expensive. Of all the disposal options that can be fully estimated, the cost of sewer disposal is the least expensive. A direct brine line to the JWPCP outfall looks promising and is worth further investigation. Table 2-2 shows the costs for options in a sample project that is 12,500 AFY with 85 percent reverse osmosis (RO) recovery.

**Table 2-2. Brine Management Costs Including CAPEX and Annual Operating Expenditures (OPEX)
(12,500-AFY Project)**

Discharge (12,500 AFY[a])	CAPEX	OPEX
Sewer	$17.5M	$0.5M
New brine line to JWPCP	$12.6M	Unknown
New brine line to Hyperion	$27M	Unknown
Trucking to JWPCP	--	$6M
Deep well injection	$25.4M	$1.9M
New outfall and discharge	$22.5M	~$0.7M
Zero liquid discharge	$35M	$8.7M

[a] The use of the 12,500-AFY Project in this table is for illustrative purposes and does not imply a recommendation of this particular Project size for the Program.

2.4.1 Dedicated Brine Line Conveyance

The dedicated brine pipeline route analysis investigated the potential pipe routing from the Elm and Faysmith treatment site to the JWPCP effluent tunnel/outfall system. The piping will be located in City street ROWs. Trenchless crossings and permits are required at one railroad and two highway crossings.

Easements will also be required for the crossing of Interstate-110. HDPE piping is recommended for this service.

2.5 Product Water

Product water considerations include both the quality of the potable product water and its conveyance and distribution.

2.5.1 Product Water Quality

This task evaluated the potable water quality within the distribution system of each stakeholder and compatibility requirements that will ensure the Project product water is compatible with each potable supply. All stakeholders use chloramines for secondary disinfection and fluoridate for dental care. All stakeholders, with the exception of LADWP, target a positive Langelier Saturation Index (LSI) for corrosion control (LADWP uses orthophosphate).

The Project remineralization/post-treatment (of RO permeate) will therefore include fluoridation, chloramination, and the addition of carbon dioxide and sodium hydroxide to attain an alkalinity of approximately 70 mg/L and a positive LSI. The following product water quality targets include the compatibility requirements and the key water quality constituents to ensure compliance with California and federal drinking water requirements:

- TDS: 400 mg/L
- Chloramines: 2.5 mg/L
- LSI: 0.2 to 0.6
- Fluoride: 0.7 to 0.9 mg/L
- Alkalinity: 70 mg/L as calcium carbonate ($CaCO_3$)
- Manganese 0.02 mg/L
- Chloride 200 mg/L
- Methane 0.2 mg/L
- Odor 2 (threshold odor number [TON])

2.5.2 Product Water Distribution (Conveyance)

The Elm and Faysmith Project site is in Torrance, and the majority of product water will be pumped into the Torrance distribution system for routing through existing interties to all stakeholders, with the exception of Manhattan Beach and Golden State Water (GSW). An intertie location between GSW and Torrance has been identified. Manhattan Beach does not have an existing intertie with Torrance, so a new pipe is planned to be routed from the Project location to Manhattan Beach. During the product water conveyance system analysis, we examined the new conveyance equipment and routing. The proposed piping alignment is approximately 6.5 miles long and extends wholly within a public ROW within the cities of Torrance and Manhattan Beach. No easements will be required. However, as noted above in Section 2.4.2, based on the location of the proposed extraction wells, if the cities of Torrance and Manhattan Beach do not own the piping, some type of agreement/easements will be needed for the owner to lay pipe in the City's ROWs.

Because of concerns regarding the exposure of HDPE piping to the chloramines in the product water, C900 polyvinyl chloride (PVC) pipe is recommended for this service. The Project product water quality goals are compatible with all of the existing stakeholder potable water, and no additional blending is required.

2.6 Treatment Technologies

The initial Project screening assumed that conventional RO would be used. The Treatment Technologies TM evaluated several technologies to determine which would best meet the Program requirements considering economics, product water quality goals, and treatment facility footprint. Footprint must be considered because the most likely treatment site at Elm and Faysmith has only 1 acre of available property for the Project.

The treatment technologies evaluated include the following:

- Conventional RO
- Closed-Circuit RO (CCRO)
- High-Efficiency RO (HERO)
- A sacrificial (final stage) of RO (added on to conventional RO)
- Nanofiltration
- Ion exchange
- Electrodialysis reversal
- Interstage (RO) lime softening (pellet reactor)

Nanofiltration will not meet the product water quality goals. CCRO, ion exchange, HERO, and electrodialysis reversal will all be more expensive than conventional RO for this application because the source water TDS and hardness are high. There is insufficient footprint available for the interstage lime softening, and this process would not be economical even if space were available. Therefore, conventional RO is the preferred treatment technology.

Brine handling needs to be considered as part of the treatment economics. Treatments using the conventional RO brine to reduce the volume via CCRO, a sacrificial (final stage) RO, or HERO are all uneconomical because of relatively high-salinity well water and a sewer option for disposal that currently costs only ~$100 per AF of water treated. Thus, there is little economic incentive to reduce the waste further.

As an example, consider the costs of adding CCRO as a secondary process treating the conventional RO brine for a 12,500-AFY project, as shown in Table 2-3. CCRO, which provides an additional 5 percent recovered water for the Project, is not economically justifiable, primarily due to the high energy costs associated with CCRO operation at a feed pressure of 600 to 1,000 pounds per square inch gauge (psig). While the CCRO alternative has lower CAPEX, annual OPEX is approximately 33 percent higher, which results in a higher present worth compared to the conventional RO. Therefore, conventional RO without any secondary treatment to further minimize the brine volume is recommended.

Table 2-3. Unfavorable Economics for a Secondary CCRO Process (12,500-AFY Feed)

Constituent	Overall Recovery	LACSD Connection Fee (brine management)	Secondary RO CAPEX	LACSD Annual Surcharge (brine management)	Secondary RO Annual OPEX	Total CAPEX	Total Annual OPEX	Present Worth
Conventional RO only	85 percent	$17,500,000	--	$490,000	--	$17,500,000	$490,000	$27,100,000
Conventional RO with secondary CCRO	90 percent	$11,600,000	$4,000,000	$330,000	$320,000	$15,600,000	$650,000	$28,300,000

Notes:

Recovery is defined as the ratio of potable water produced divided by well water fed to the Project.

Secondary RO addition results in a smaller primary RO system. Costs related to secondary RO listed here are secondary RO costs minus the difference in primary RO costs.

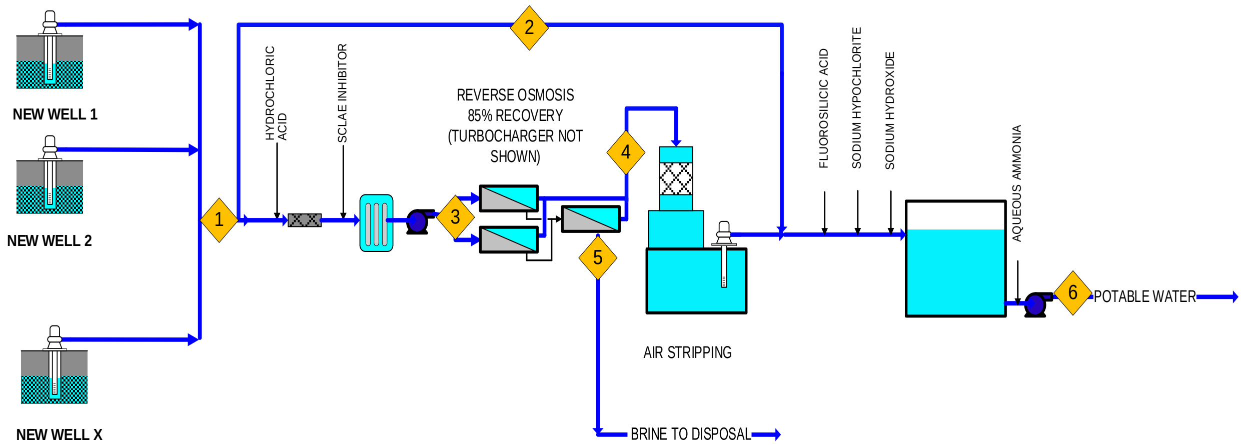
Present worth over 30 years, 3 percent discount.

-- = not applicable

2.6.1 Baseline Treatment Design

With the source water characterization and treatment investigation complete, and the product water quality goals and preferred treatment approach established, a baseline process was developed consisting of conventional RO operating at 85-percent recovery. RO recovery is limited by the saturation of barium sulfate and silica, and a slight pH depression will likely be required in the RO feed to achieve this recovery by increasing calcium carbonate solubility. The RO permeate will be sent to an air stripper for removal of odor and methane. The air stripper may require off-gas treatment to capture or neutralize the odor-causing compounds if there are regulatory or other constraints associated with discharging the off-gas to the atmosphere. Further investigation is required to characterize the nature of the odor, which would be other than methane because methane is odorless. A small bypass around the RO process will be beneficial in minimizing the remineralization chemical addition required in post-treatment, including elimination of the need for calcium addition. The bypass is limited by the treatment goal for chloride, TDS, and other constituents.

Figure 2-1 displays a process flow diagram of a 12,500-AFY Project.



Stream #	1	2	3	4	5	6
Flow, AFY	12489	161	12327	10478	1849	10640
Flow, gpm	7743	100	7643	6497	1146	6597
TDS, mg/L	6580	6580	6580	140	43073	350
Pressure, psig	60	60	375	10	0	100

Figure 2-1. Project Process Flow Diagram (12,500-AFY Project)

The mass balance in Table 2-4 indicates that the process will meet the federal (U.S. Environmental Protection Agency [EPA]) and California regulatory requirements for drinking water. The mass balance includes a 30 percent contingency to each projected RO permeate constituent (permeate quality factor of safety).

Table 2-4. Mass Balance (12,500-AFY Project)

MASS BALANCE - WRD FS										
Primary RO recovery:			**85%**		Based upon 5 year membrane age					
CCRO Recovery			**0%**							
Overall Recovery			85.1%			Arsenic Rejection		90%		
Bypass (gpm)			**100**	1.3%		Selenium Rejection		96%		
Permeate Quality factor of safety (FOS):			**1.3**	CPA6LD->CPA5LD		Arsenite Rejection		82%		
						Arsenate Rejection		98.5%		
		Conventional Primary RO System								
	RW	**ROf**	**Rowc**	**ROp**	**ROp**	**Decarb**	**Bypass**	**Blend**	**Fp**	**MCL**
	Well Feed	Feed to RO	RO Conc.	RO Perm.	RO Perm.	DC ROP	RO Bypass	Blend	Final	
PARAMETER					(w/ FOS)					
						14.96819				
Flow (mgd)	11.15	11.01	1.65	9.36	9.36	9.36	0.14	9.50	9.50	
(gpm)	7,743	7,643	1,146	6,497	6,497	6,497	100	6,592	6,592	
(AFY)	12490	12328	1849	10479	10479	10479	161	10640	10640	
Calcium (mg/L)	646	646	4279	4.8	6.2	6.2	646	15.9	15.9	
Magnesium (mg/L)	351	351	2325	2.6	3.4	3.4	351	8.7	8.7	
Sodium (mg/L)	1181	1181	7636	41.8	54.3	54.3	1181	71.5	104.2	
Potassium (mg/L)	65	65	417	2.9	3.8	3.8	65.0	4.7	4.7	
Barium (mg/L)	0.82	0.8	5.4	0.006	0.01	0.01	0.82	0.02	0.02	2
Bicarbonate (mg/L)	171	163	1052	5.8	5.8	5.8	171	8.3	100	
Sulfate (mg/L)	224	224	1487	1.1	1.4	1.4	224	4.8	4.8	250
Chloride (mg/L)	3980	3985	26119	79	102	102	3980	161	161	250
Fluoride (mg/L)	0.16	0.2	1.0	0.01	0.0	0.0	0.2	0.0	0.0	2
Nitrate (mg/L)	1.40	1.4	8.7	0.1	0.2	0.2	1.4	0.2	0.2	10
Silica (mg/L)	28	28.0	184	0.5	0.7	0.7	28.0	1.1	1.1	
Boron	0.23	0.2	0.7	0.15	0.21	0.21	0.23	0.21	0.21	1
Iron (mg/L)	0.18	0.18	1.2	0.001	0.001	0.001	0.180	0.004	0.004	0.3
Manganese (mg/L)	0.29	0.29	1.9	0.002	0.003	0.003	0.290	0.01	0.01	0.05
Nickel(ug/L)	3.2	3.2	21.2	0.02	0.03	0.03	3.2	0.08	0.08	100
Arsenic (ug/L)	3.0	3.0	19.0	0.2	0.2	0.2	3.0	0.3	0.3	10
Selenium (ug/L)	32	32	210.6	0.5	0.6	0.6	32.0	1.1	1.1	50
Methane (mg/L)	7.0	7.0	7.0	7.0	7.0	0.07	7.0	0.2	0.2	
TDS (reported)	7694	7694								
TDS (calculated)	6580	6580	43094	136	176	176	6580	273	361	500
pH	7.9	7.5	8.3	6.0	6.0	6.1	7.9	6.2	8.4	6.5-8.5
Temperature (F)	71	71	71	71	71	71	71	71	71	
CO2 (mg/L)	3.1	9.1	9.1	9.1	9.1	8.0	3.1	7.9	0.7	
LSI	1.3	0.9	3.2	-4.0	-3.9	-3.8	1.3	-3.1	0.1	

Note:

The pertinent drinking water MCLs are listed with the following color codes: black = EPA primary MCL, purple = EPA secondary MCL, green = California MCL or notification level.

2.6.2 Treatment Layouts

The study team met at the Elm and Faysmith site to discuss the Project layout with the City of Torrance. Based on input from the City of Torrance, layouts for 12,500-, 16,000-, and 20,000-AFY desalination plants were developed. Most of the treatment facilities will be housed inside a building. Chemical facilities are located in the front of the property, inside the treatment building, and adjacent to the street, to allow for ease of truck filling. Setbacks of 20 feet (north) and 30 feet (back of west) are provided for the residential neighbors. The air stripper blowers will likely require sound enclosures because the blowers will emit about 80 decibels on the A-weighted scale. The Elm and Faysmith layouts include the option for additional treatment equipment should pilot testing determine that it is necessary (see Section 3). Attachment 1 to this TM includes the three layouts of centralized treatment at Elm and Faysmith, and a 2,000-AFY portable wellhead treatment equipment option (see Sections 2.7 and 3.2 for more details on the portable treatment). The portable treatment equipment will require a footprint of approximately 5,600 square feet (6,500 square feet with extraction well).

2.6.3 Economics

A summary of treatment and brine disposal costs for the centralized 12,500-AFY and 20,000-AFY baseline RO processes is provided in Table 2-5. The energy cost was assumed to be $0.105 per kilowatt hour (kWh). The following should be noted:

- The cost estimates do not include CAPEX financing because that will be investigated in the next phase of the feasibility study (Task 7).
- These are Class IV cost estimates with accuracies of -50 percent to +100 percent of actual Project cost.

Table 2-5. Baseline Conventional RO Process Economics for Centralized Treatment

Feed Flow (AFY)	Treatment Plant CAPEX[a]	Annual Treatment Plant Power	Annual Treatment Plant Chemicals	Total Annual Treatment O&M[b]
12,500	$62,000,000	$2,600,000	$2,200,000	$8,000,000
20,000	$82,000,000	$4,050,000	$3,450,000	$12,100,000

Notes:

[a] Installed costs include permitting, engineering, and construction.

[b] Includes energy, chemicals, labor, membrane, specialty item, and other replacements.

O&M = operation and maintenance

The total cost of water for the six shortlisted Projects (Section 2.7), including wells, conveyance piping, brine disposal, and replenishment, ranges between $1,115 to $1,553 per AF, not including CAPEX financing. These costs were used for Project screening and will be refined further in Task 7 of this Program.

2.7 Project Screening

Each stakeholder was asked to weight the evaluation criteria (listed in Section 2.1). A multi-objective decision analysis (MODA) process was then used to rank the 11 shortlisted Projects using the weighted criteria and the performance of each Project against the criteria. A MODA sensitivity analysis revealed that two Projects (Number [No.] 18 and No. 19) were consistently ranked in the top three positions, regardless of the criteria weighting (see Section 2.1 for criteria). Using the source water quality and product water quality goals, together with the recommended treatment and brine disposal methods, Project costs for each alternative were refined. Project costs are Class IV in terms of accuracy and do not yet include CAPEX financing.

Based on costs and MODA scoring, three Projects were recommended for final consideration at a stakeholder meeting. WRD requested that the three Projects be expanded to six Projects. The expansion includes an intermediate extraction flow rate of 16,000 AFY and the option for a 2,000-AFY portable wellhead treatment unit included at the three different extraction flow rates of 12,500 AFY, 16,000 AFY, and 20,000 AFY. The portable wellhead treatment allows the Upper Gage aquifer sections of the high-salinity plume to be treated. The final Project shortlist for further Program work is presented in Table 2-6.

Table 2-6. List of Preferred Projects for Further Evaluation

Project No.	Preferred Project - General Description	New Extraction Wells	Treatment Locations			Total New Extraction (AFY)	Water Delivery Locations						Total New Product Water Delivery (AFY)
			Old City Yard (Torrance)	Remote Wellhead Treatment	Goldsworthy and Brewer		Torrance	GSWC	Manhattan Beach	LADWP	Cal Water	Lomita	
12,500 AFY Total Extraction													
18	*Centralized treatment only* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach	7	12,500	-	7,300	12,500	3,872	850	944	2,597	1,417	944	10,625
19	*Centralized and remote wellhead treatment* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach and Remote Wellhead Treatment	10	10,500	2,000	7,300	12,500	3,872	850	944	2,597	1,417	944	10,625
16,000 AFY Total Extraction													
41	*Centralized treatment only* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach	9	16,000	-	7,300	16,000	3,900	900	1,700	2,900	2,900	1,300	13,600
42	*Centralized and remote wellhead treatment* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach and Remote Wellhead Treatment	12	14,000	2,000	7,300	16,000	3,900	900	1,700	2,900	2,900	1,300	13,600

Table 2-6. List of Preferred Projects for Further Evaluation

Project No.	Preferred Project - General Description	New Extraction Wells	Treatment Locations			Total New Extraction (AFY)	Water Delivery Locations						Total New Product Water Delivery (AFY)
			Old City Yard (Torrance)	Remote Wellhead Treatment	Goldsworthy and Brewer		Torrance	GSWC	Manhattan Beach	LADWP	Cal Water	Lomita	
20,000 AFY Total Extraction													
43	*Centralized treatment only* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach	11	20,000	-	7,300	20,000	4,500	900	1,700	4,200	4,200	1,500	17,000
44	*Centralized and remote wellhead treatment* Product water spread across Stakeholders via interties with new pipeline to Manhattan Beach and Remote Wellhead Treatment	14	18,000	2,000	7,300	20,000	4,500	900	1,700	4,200	4,200	1,500	17,000

Notes:

\- = component not included in Project

3. Recommendations

3.1 Conceptual System Design and Program Requirements

The work described in this CSDPR presents the six Projects worthy of additional analysis in the subsequent phase of this feasibility study. The analysis will address the following: power supply options, entitlements and acquisition, environmental review, permitting, operations, financing, and delivery methods. The recommendations listed below are provided for consideration and implementation before the initiation of detailed design of the Preferred Project from the six Projects listed. However, it would be of particular benefit if the recommended water quality analysis and source water characterization listed in Tables 3-1 and 3-2 were initiated as soon as possible.

The WRD West Coast Basin database for the two monitoring wells of interest, PM-2 (Police Station) and PM-6 (Madrona Marsh), that bracket the locations of the proposed extraction wells, and which served as the basis of the Source Water Characterization, does not have data for either silica or strontium. Both are critical for desalination plant design. In addition, the cause of the odor in the Madrona Marsh well needs to be further investigated, including the measurement of hydrogen sulfide levels. Further, the contaminants listed in Table 3-1 have drinking water MCLs, yet data for each of these contaminants could not be located in the WRD West Coast Basin database for monitoring wells PM-2 and PM-6. Therefore, sampling for each is recommended.

Table 3-1. Recommended Additional Drinking Water-related Contaminants for Monitoring Well Sampling at PM-2 and PM-6

Contaminant	Contaminant	Contaminant
Silica	Atrazine	Hexachlorobenzene
Strontium	Bentazon	Hexachlorocyclopentadiene
Hydrogen Sulfide	Benzo(a) Pyrene	Lindane
	Carbofuran	Methoxychlor
1,4 Dichlorobenzene	Chlordane	Molinate
1,1,2,2, Tetrachloroethane	Dalapon	Oxamyl
1,1,2-Trichlor-1,2,2-Trifluoroethane	Dibromochloropropane	Pentachlorophenol
Alachlor	Di(2-ethylhexyl)adipate	Picloram
Asbestos	Di(2-ethylhexyl)phthalate	Polychlorinated Biphenyls
Chromium (total)	Dinoseb	Simazine
Cyanide	Diquat	Thiobencarb
Gross Alpha particle activity	Endothall	Toxaphene
Gross Beta particle activity	Endrin	1,2,3- Trichloropropane
Radium	Ethylene Dibromide	Trichlorofluoromethane (Freon 11)
Tritium	Glyphosate	2,3,7,8-TCDD (Dioxin)
	Heptachlor	2,4,5-TP (Silvex)
	Heptachlor Epoxide	

Additional data gaps and recommendations are included in Table 3-2.

Table 3-2. Additional Source Water Characterization Data Gaps and Recommendations

Data Gaps/Unknowns	Recommendations
Spatial and temporal understanding of water quality of the entire plume area • Currently, two multi-level nested monitoring wells (PM-2 and PM-6) are used for developing water quality specifications for the source water for the desalter	Given the availability of data for only two multi-level nested monitoring wells in the area of potential new extraction wells (about 0.4 square mile) identified based on available accessible properties near the leading edge of the saline plume, relative to the overall saline plume area (about 8 square miles), the water quality and hydraulic properties of the aquifers applied to the 10 extraction wells should be refined with more monitoring data. In particular, the area near the PM-2 multi-level nested monitoring well may not be suitable for achieving target production rates based on past investigation in this area (CH2M, 2016). To characterize the water quality of the plume, installation of additional monitoring wells distributed over the entire plume area is recommended. The monitoring wells could also provide additional data to evaluate local groundwater flow directions and treatment of brackish water in the West Coast Basin.
Water quality representation for all zones of aquifers	Well PM-2 is screened to a depth of 650 feet below ground surface; however, well PM-6 is screened over 1,200 feet below ground surface. To meet the objectives of the Project to treat the plume with more than 60 percent of volume in the Lower San Pedro aquifer, water quality monitoring of the deeper aquifers is recommended. The selection of the well locations and screened intervals can be guided by the investigation and monitoring results.
Movement of plume	Although WRD has estimated that the plume is moving eastward at an average rate of 250 feet per year, a detailed flow and solute transport model of the area is recommended (CH2M and RMC, 2016). In order to mitigate the effect of drawdown in aquifers due to heavy pumping of saline water, a calibrated groundwater flow model and solute transport model can simulate future recharge and pumping effects to guide Project designs while minimizing any effects to the basin. Particle tracking simulations using a calibrated groundwater flow model are recommended to evaluate the portion of the saline plume captured by the proposed new extraction wells with depth, and could also be used to estimate travel times from the hydraulically upgradient western portion of the saline plumes to reach the extraction wells and thereby provide a preliminary estimate of the time to clean up the saline plume.
Water yield from lower aquifers	The hydraulic conductivities of the Lower San Pedro aquifer system are less than 15 feet per day. Based on these low conductivities, the production from deeper zones will be energy intensive and challenging. Strategies for pumping from deeper zones of high salinities may need to be adjusted over time to achieve the Project goals.

Sources:

CH2M. 2016. Robert W. *Goldsworthy Desalter Expansion, New Source Water Wells Installation Report, Torrance, California*. Prepared for WRD.

CH2M and RMC. 2016. *Groundwater Basins Master Plan*. Prepared for WRD. September.

Regarding treatment, a pilot study is recommended prior to the initiation of full-scale Project design because unexpected RO fouling problems were observed after the expansion of the Goldsworthy Desalter. The pilot study should simulate the baseline treatment established in this TM, and should be operated for a sufficient period of time (3 months minimum) to determine whether RO fouling is observed at an unacceptable rate. If so, the cause of the fouling should be identified so that additional pretreatment requirements can be identified and evaluated. The site layouts include additional room for some pretreatment should it be deemed necessary.

The pilot study should also consider evaluating the vertical distribution of each constituent listed above and hydraulic parameters of the various target intervals including the Gage, Silverado, and Lower San Pedro. Individual well screen should be considered to isolate each aquifer and provide flexibility in creating a blended water quality sample to approximate water quality anticipated of a typical production well.

The product water distribution piping should include blind flanges at the treatment facility so that additional pipeline connections can be added at a later date.

Additional potable water quality samples should be taken at the Torrance potable distribution system intertie locations that will be used to transfer water to the other stakeholders, particularly at the connections with LADWP (because of different corrosion control methods used). Samples should be analyzed for calcium, alkalinity, pH, TDS, temperature, and phosphate. This is recommended for the proposed corrosion control approach, particularly as it pertains to LADWP.

3.2 Portable Wellhead Treatment Locations and Duration

The purpose of the portable wellhead treatment unit is to treat the portions of the saline plume that the centralized treatment plant wells will not extract. These include the Gage aquifer and the upper portion of the Silverado aquifer. The portable wellhead treatment unit's potable water would be injected into the nearest potable treatment header, and the brine would be sent to the sewer.

The following three prospective treatment sites have been identified for the portable wellhead treatment system:

- The existing Sepulveda 2 well site on Sepulveda Boulevard between Evalyn Avenue and Kathryn Avenue
- Meadows Avenue Elementary School in Manhattan Beach, where the well at the elementary school is 0.27 miles from the potential treatment site at City of Manhattan Beach's Peck Reservoir
- Either Glasgow Park (north) or Hollyglen Park in Hawthorne

The existing Sepulveda 2 well site is above all three saline aquifers, including the Gage, Silverado, and Lower San Pedro. The existing well is nearly 20 years old and is designed to draw from depths of 340 to 490 feet, which corresponds to the Silverado aquifer, not the Gage aquifer, which is of primary interest at this location. Thus, a new extraction well would likely need to be installed. Approximately 6,400 AF of saline Gage aquifer water is under this location. The 2,000-AFY portable wellhead treatment unit would require approximately 3.2 years to treat this water. If the new extraction well were perforated to draw from all three saline aquifers, the portable treatment unit could be located here for more than 10 years of treatment.

Meadows Avenue Elementary School is a good location in which to place a new extraction well to tap the upper portion of the Silverado aquifer, consisting of 6,900 AF of saline water. About 3.5 years of treatment could occur here. The well at the elementary school is just 0.27 mile from the potential treatment site at City of Manhattan Beach's Peck Reservoir.

Both Glasgow Park (north) and Hollyglen Park, each in Hawthorne, are within about 200 yards of where an extraction well could be placed to tap the 13,000 AF of Upper Gage aquifer saline water. The portable wellhead treatment unit could be placed at this location and treat water for 6.5 years.

The Manhattan Beach location (Meadows Avenue Elementary School) is close to an area of the West Coast Basin that is currently being enhanced with additional injection and monitoring wells by Los Angeles County Department of Public Works. Therefore, this should be the last treatment site where the portable system would be placed to allow for completion of this effort and to ensure protection of the groundwater basin from seawater intrusion.

For each of the wellhead treatment locations, durations of treatment and extracted well water quality will need to be further evaluated.

3.3 Fouling at Goldsworthy

As part of this Program, the Jacobs team reviewed the 2019 American Water Works Association (AWWA) Membrane Technology Conference presentation "Mitigating Severe Organic Fouling in a Brackish Groundwater RO System," and offers the following comments on the potential sources of membrane fouling at WRD's Goldsworthy Desalter facility.

The cause of the fouling may not be biological, as indicated in the presentation. Based on the information from the membrane autopsies, it is clear there is a heavy deposition of colored organics, which are humic acids. If it were biological-based organics, they would be the higher molecular weight polysaccharides and proteinaceous compounds, which do not have color. Bacterial colonization is not evident. Further, biological-based organics are not readily removed by a caustic cleaning. The assimilable organic carbon (AOC) levels in the RO feed are not very high relative to what has been determined from extensive biological fouling studies conducted by Hans Vrouwenvelder at the King Abdullah University.

It is possible that the organics are being bridged by the high calcium levels in the well water because both are concentrated in the RO system. Several years ago, the Jacobs team piloted a deep aquifer treatment system (DATS) with Irvine Ranch Water District where mixing of high organic and high calcium waters from two different parts of the aquifer caused rapid fouling. Given the very high hardness in the WRD well water, Jacobs recommends the following for Goldsworthy:

- Sample well water for total organic carbon (TOC). If the level is greater than 0.5 mg/L, analyze the samples using liquid chromatography – organic carbon detection (LC-OCD) and AOC.
- Analyze well water samples by size exclusion chromatography – dissolved organic carbon (SEC-DOC) or LC-OCD to see the percentage of humics versus other organic fractions. If humics are high, Jacobs suggests flat sheet RO runs at various recoveries to assess the rate of fouling and organics deposition.
- Sample well water for AOC to assess the biodegradability of the organics.

The above recommendations and results would benefit both the Goldsworthy operation as well as the Regional Brackish Water Reclamation Program desalter's future design. In 2020 WRD retained Jacobs to evaluate the Goldsworthy performance and determine both short- and long-term strategies to mitigate RO fouling, in an effort to achieve cost-effective design production. Jacobs performed an overall system investigation that included completing an RO membrane autopsy, flow-profiling the Delthorne Park Well (DPW) and the City Yard Well (CYW), conducting depth-specific water quality sampling at each well and water quality sampling at Goldsworthy, and completing a historical data review and analysis. Significant concentrations of hydrophobic and hydrophilic dissolved organic carbon (DOC) are present in both CYW and DPW and appear to be the main cause of RO fouling. Water from the DPW is likely more problematic for RO system operations (consistent with specific flux decline when only treating DPW water). The DPW has greater concentration of organics and has elevated color in the upper-screen area.

Inorganic/organic bridging is occurring both with intra-well mixing of upper-screen high-DOC and low inorganic waters, with lower-screen low-DOC and high-inorganic waters, as well as inter-well mixing of DPW and CYW of higher humic substances and high inorganics (e.g. calcium and sodium).

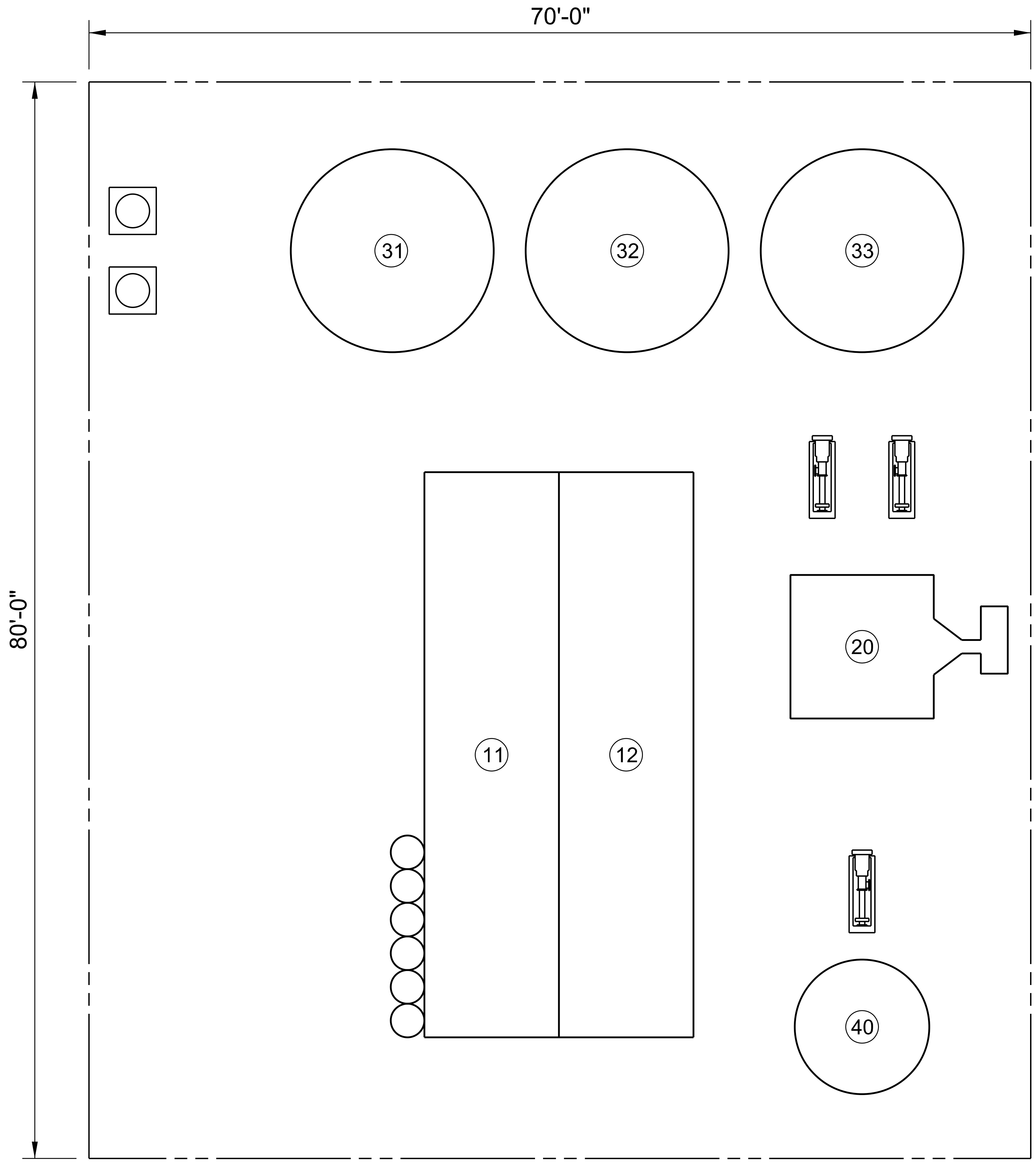
Jacobs' short term recommendations include:

- Increasing the flushing flow to displace organics from the RO membranes
- Reducing the percentage of water fed to the Goldsworthy system down to 20 to 30% DPW water (70 to 80% CYW water)

Jacobs' long-term recommendations include:

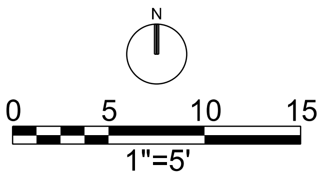
- Installation of an inflatable packer in the tailpipe of the existing DPW to reduce the contribution of highly colored water from the ~ 300 bgs elevation section of the well
- Installation of a third well to reduce the percentage of Goldsworthy Desalter feed from the DPW to less than 35 percent to avoid excessive fouling of the RO membranes. Installation of pretreatment to the RO (granular activated carbon)

Attachment 1
Project Plan View Layouts



FACILITY LEGEND

11	CONTAINER REVERSE OSMOSIS NO. 1
12	CONTAINER REVERSE OSMOSIS NO. 2
20	A.S. UNIT
31	CLEARWELL NO. 1
32	CLEARWELL NO. 2
33	CLEARWELL NO. 3
40	CIP



NO.	DATE	REVISION	BY	APVD

DSGN S.ALT DR L.BENTHIN CHK APVD

JACOBS

Project Description
Project Location
Client Name
Client Location

CIVIL

2000 AFY PORTABLE TREATMENT UNIT OVERALL SITE PLAN

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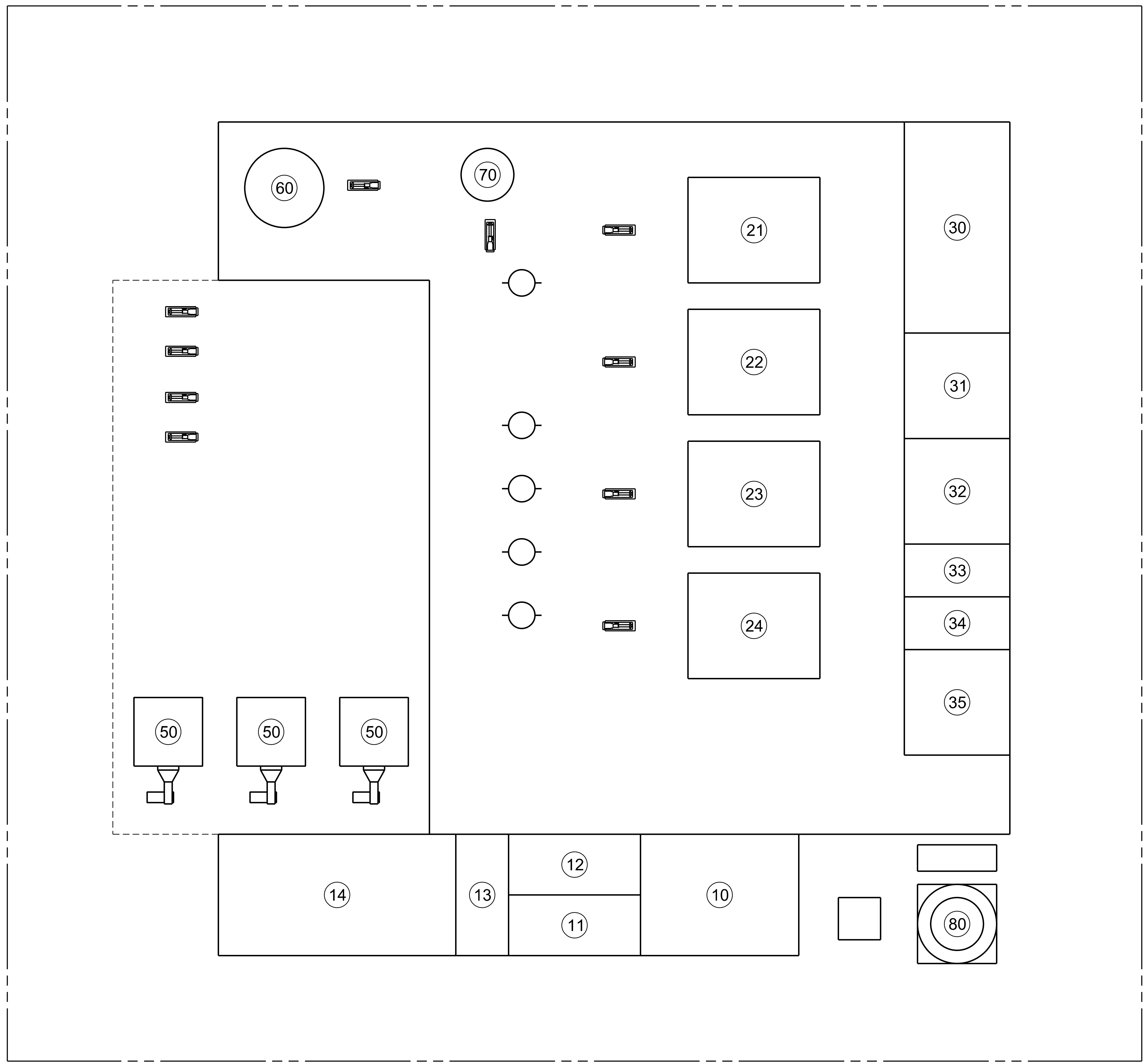

(XX) FACILITY LEGEND

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11	RESTROOM / SHOWER
12	LAB
13	TELECOM / SERVER
14	ELECTRICAL
21	REVERSE OSMOSIS 1
22	REVERSE OSMOSIS 2
23	REVERSE OSMOSIS 3
24	REVERSE OSMOSIS 4
30	NaOH STORAGE AND FEED
31	NaOCl STORAGE AND FEED
32	NH4OH STORAGE AND FEED
33	FSA STORAGE AND FEED
34	TI STORAGE AND FEED
35	HCl STORAGE AND FEED
50	A.S. UNITS
60	NEUTRALIZATION
70	CIP
80	CARBON DIOXIDE

N

0 10 20 30

1"=10'

NO.	DATE	REVISION	BY	APVD

DSGN S ALT | DR L BENTHIN | CHK | APVD

Project Description
Project Location
Client Name
Client Location

JACOBS

CIVIL

20,000 AFY CENTRALIZED PROJECT OVERALL SITE PLAN ON 1 ACRE

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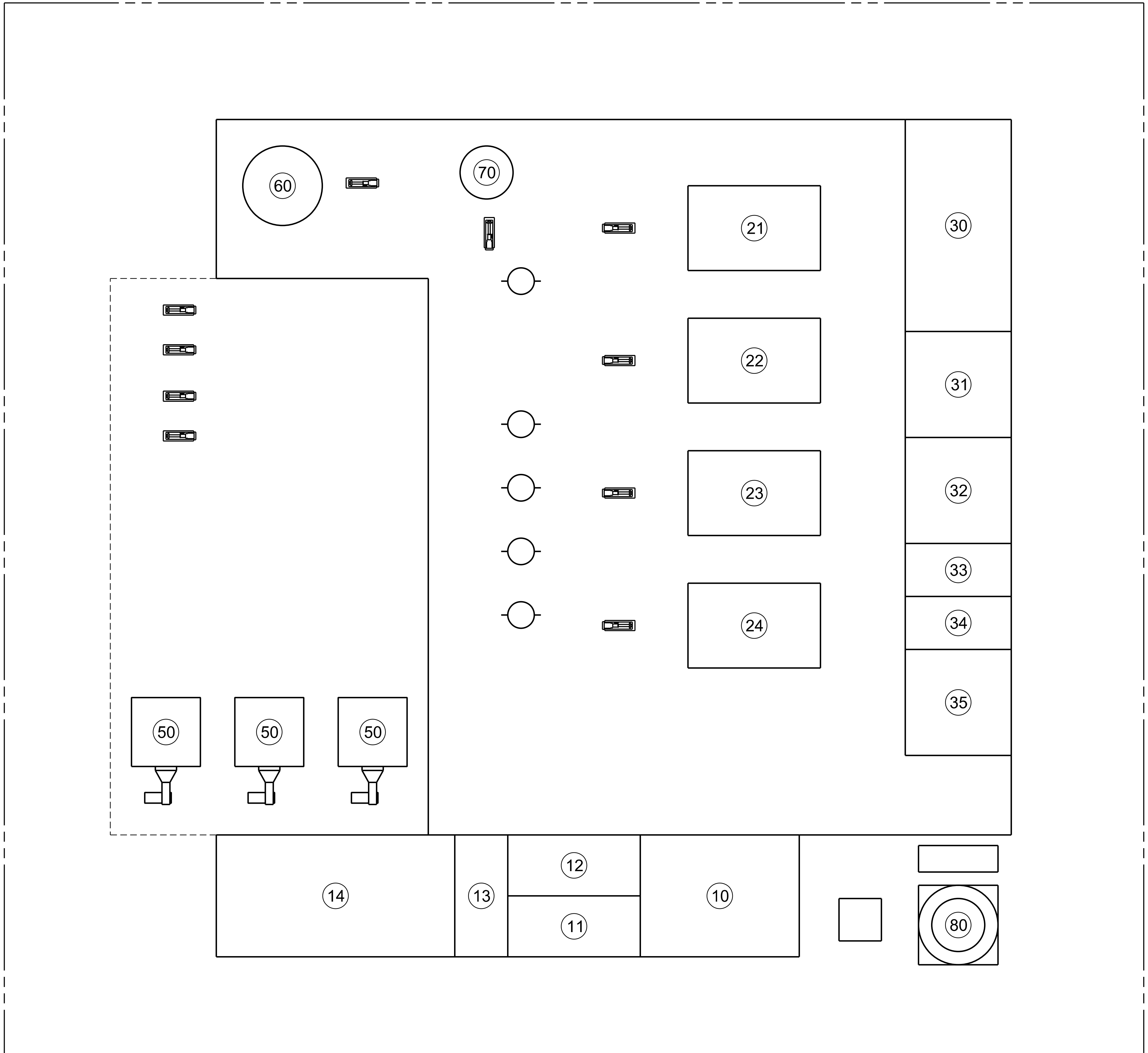
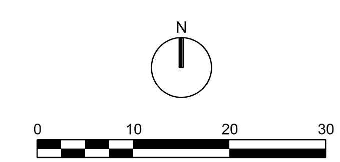


(XX) FACILITY LEGEND

10	CONTROL ROOM
11	RESTROOM / SHOWER
12	LAB
13	TELECOM / SERVER
14	ELECTRICAL
21	REVERSE OSMOSIS 1
22	REVERSE OSMOSIS 2
23	REVERSE OSMOSIS 3
24	REVERSE OSMOSIS 4
30	NaOH STORAGE AND FEED
31	NaOCl STORAGE AND FEED
32	NH4OH STORAGE AND FEED
33	FSA STORAGE AND FEED
34	TI STORAGE AND FEED
35	HCl STORAGE AND FEED
50	A.S. UNITS
60	NEUTRALIZATION
70	CIP
80	CARBON DIOXIDE



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CIVIL

16,000 AFY CENTRALIZED PROJECT
OVERALL SITE PLAN ON 1 ACRE

Project Description
Project Location
Client Name
Client Location

NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
S ALT	L BENTHIN		

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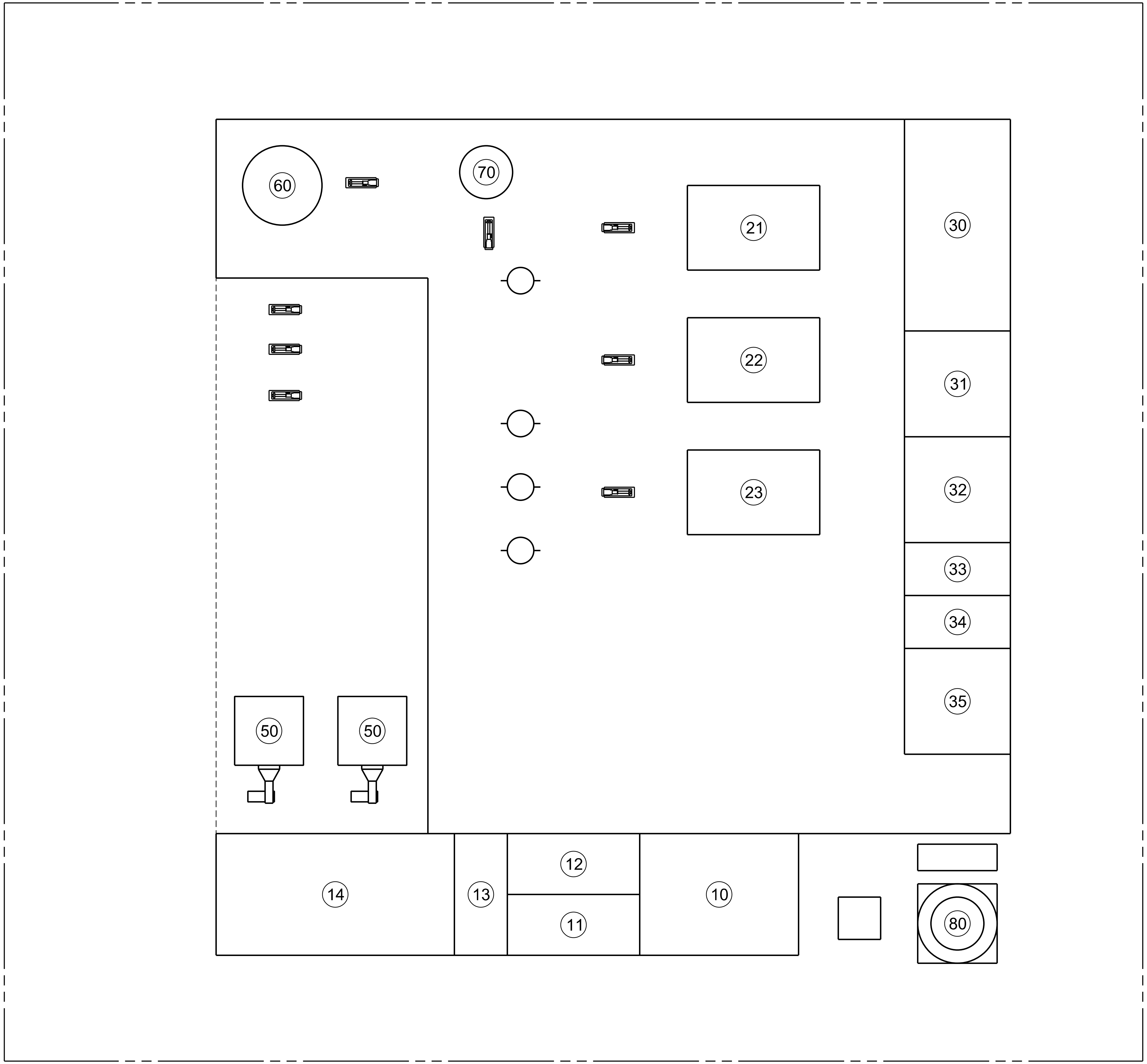
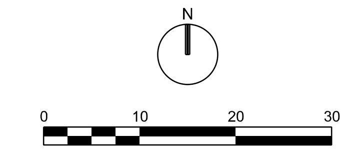


FACILITY LEGEND

XX	FACILITY LEGEND
10	CONTROL ROOM
11	RESTROOM / SHOWER
12	LAB
13	TELECOM / SERVER
14	ELECTRICAL
21	REVERSE OSMOSIS 1
22	REVERSE OSMOSIS 2
23	REVERSE OSMOSIS 3
30	NaOH STORAGE AND FEED
31	NaOCl STORAGE AND FEED
32	NH4OH STORAGE AND FEED
33	FSA STORAGE AND FEED
34	TI STORAGE AND FEED
35	HCl STORAGE AND FEED
50	A.S. UNITS
60	NEUTRALIZATION
70	CIP
80	CARBON DIOXIDE



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CIVIL

12,500 AFY CENTRALIZED PROJECT
OVERALL SITE PLAN ON 1 ACRE

Project Description
Project Location
Client Name
Client Location

NO.	DATE	REVISION	BY	APVD

DSGN	DR	CHK	APVD
S ALT	L BENTHIN		

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2. Program Context (Task 1.B)

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Technical Memorandum

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Subject	**Program Context**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019, Finalized March 26, 2021

1. Introduction

In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped due to historical seawater intrusion and the implementation of two injection barriers. These barriers are used to prevent seawater intrusion along the coast and are owned, operated, and maintained by Los Angeles County Department of Public Works (LACDPW). A recent plume map from 2018 shows that the plume within the Silverado aquifer is most the highly impacted aquifer relative to the shallower Gage aquifer and the deeper Lower San Pedro aquifer (Figure 1-1). The saline plume that was trapped inland of the barriers continues to impact the water quality of the basin, thereby increasing the cost of produced water, as salt removal is required before it can be used.

The total volume of groundwater affected by the saline plume is approximately 600,000 acre-feet (AF). The concentration of chloride ranges from 250 parts per million (ppm), which is the recommended secondary maximum contaminant level (SMCL) for chloride in drinking water, to greater than 5,000 ppm. The volume of groundwater with a chloride concentration greater than 500 ppm, which is the upper end of the SMCL, is approximately 375,000 AF, and is distributed among the three drinking water aquifers in the West Coast Basin as follows: approximately 22,000 AF in the Gage aquifer, 113,000 AF in the Silverado aquifer, and 240,000 AF in the Lower San Pedro aquifer.

To more fully utilize the West Coast Basin, the Water Replenishment District of Southern California (WRD) has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to utilize this impaired water supply. WRD has been tracking the migration of the plume with groundwater movement and has estimated that the plume is moving eastward at an average rate of 250 feet per year, or about 1 mile every 20 years (CH2M and RMC, 2016). Without this project, the continued migration of the plume may impact existing production wells.

A project for remediation of the saline plume was included in the *Groundwater Basins Master Plan* (GBMP) (CH2M and RMC, 2016), which was developed by WRD in coordination with other stakeholders in both the West Coast and Central basins. The GBMP serves as a foundational plan; concepts for additional recharge and pumping were developed and assessed in the GBMP with the goal of more fully utilizing the basins and reducing dependence on imported water. A *Program Environmental Impact Report* (EIR) was adopted by the WRD Board for the GBMP in 2016 (ESA, 2016).

As a part of the Program, WRD has initiated a regional planning effort to evaluate the feasibility of remediating the saline plume with seven additional stakeholders (known as the Stakeholder Group). The stakeholders have expressed interest in treating the saline plume, receiving the treated water, or both, as part of the Program.

The initial Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Manhattan Beach
- City of Torrance
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water or CWSC)
- West Basin Municipal Water District (WBMWD)

Additional stakeholders may be identified as the study progresses, and WRD is exploring mechanisms to engage other interested parties in the study process.

WRD has retained CH2M HILL, Inc. (CH2M) (a wholly owned subsidiary of Jacobs Engineering Group Inc.) to help conduct this feasibility study. The study provides a first step towards understanding the approach to remediate the historical saline plume to allow for future groundwater use within the basin. This regional partnership among project stakeholders would increase the use of local, groundwater resources, thus increasing regional resiliency and providing statewide benefits by reducing the region's dependence on imported water supplies. The recovery of groundwater impacted by the saline plume could provide a multitude of benefits, including providing additional water supply to meet the potable and non-potable water demands, providing opportunities for replenishment of local recycled water in the basin, improving basin water quality, and enabling use of available basin storage space.

This feasibility study will consist of the evaluation of several project configurations to remove the saline plume above the 500-ppm chloride concentration. The timeframe for reclamation of the entire plume will be targeted to match a 30-year financing period. As saline water gets extracted, additional replenishment of the basin will be necessary to maintain protective water levels in the basin and continue to prevent seawater intrusion. While this study will not directly evaluate alternative replenishment source waters or injection locations, the need for replenishment water as part of the brackish water reclamation project will be factored into the evaluation.

This technical memorandum (TM) is the first deliverable of this study that describes the Program's planning context. Specifically, the TM is organized to include the following:

- Section 1 – Introduction
- Section 2 – Project Needs, Purpose, and Objective Statement
- Section 3 – Historical and Projected Water Supply and Demand Analysis for the West Coast Basin
- Section 4 – Evaluation Criteria for Projects
- Section 5 – Initial Master List of Potential Project Options
- Section 6 – Summary and Next Steps
- Section 7 – References

The purpose of this TM is to provide the basis and context for this feasibility study. It contains the Project's need, purpose, and objectives statement that guides the Project development, and will be carried forward into future environmental documentation. A summary of historical and projected future water supplies and demands in the West Coast Basin for the stakeholder purveyors is provided, as well as descriptions of relevant aspects of the West Coast Basin Judgment.

This TM also presents a range of initial project options for individual components (i.e., extraction, treatment, conveyance, brine management, replenishment) of a complete Project that would treat the saline plume. Evaluation criteria are presented that will be applied in the alternatives analysis process to the Potential Projects identified in this feasibility study. An initial master list of Project Options was generated from information supplied by the stakeholders, including the saline plume geographic extent, water quality of the wells in the area, available properties, potential brine disposal locations, existing water distribution pipelines and wastewater infrastructure, among others. Finally, a summary of the materials presented in this TM and next steps in the feasibility study are discussed.

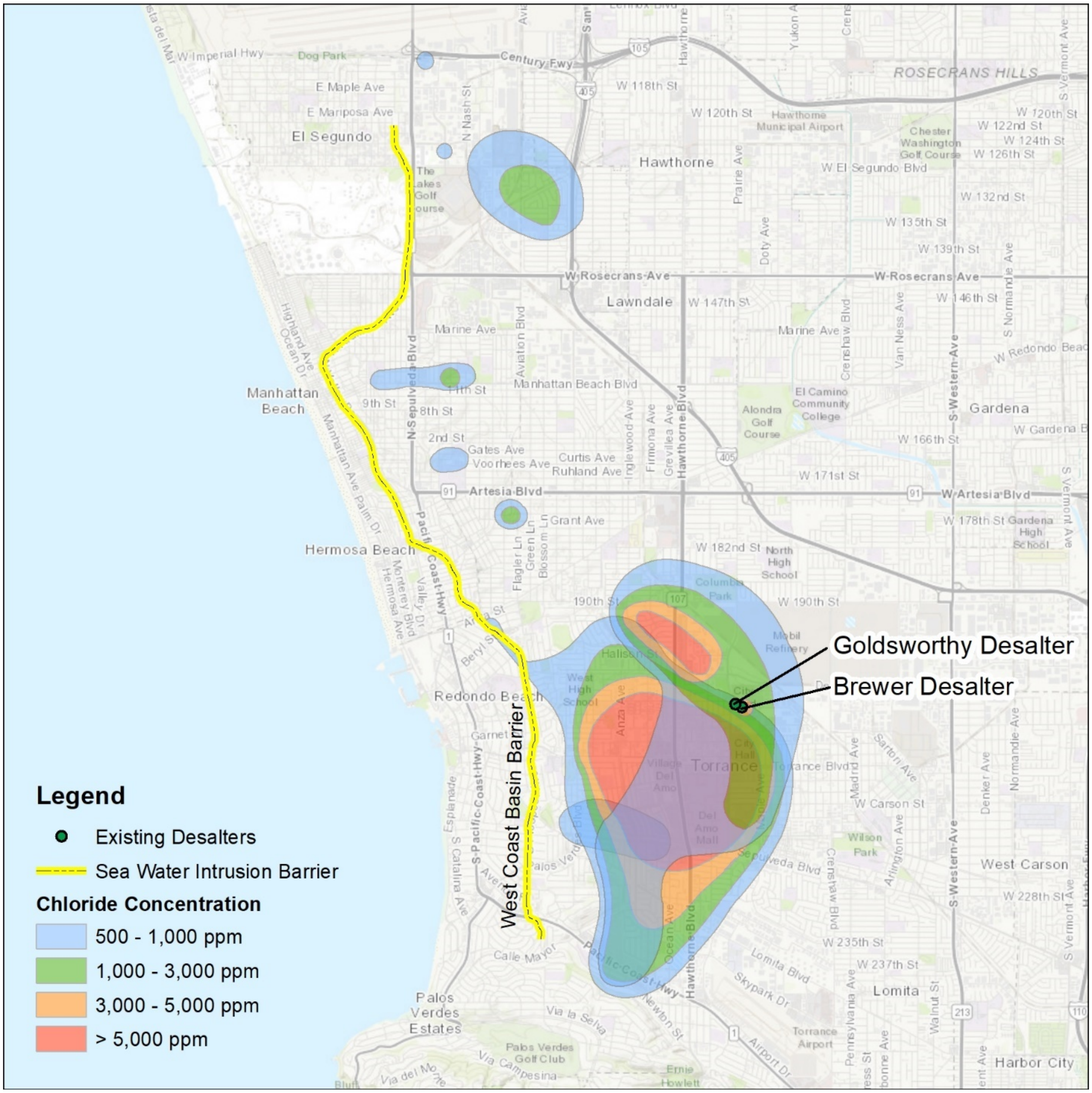


Figure 1-1. West Coast Basin Saline Plume and Existing Groundwater Desalters

2. Project Need, Purpose, and Objectives Statement

To guide development of the Program, it is important to develop a common understanding and achieve concurrence among stakeholders on its fundamental rationale. The Program's overall need, purpose, and objectives statement below will serve as standard language for the feasibility study as well as for subsequent environmental documentation for implementation of select Program Projects.

The California Environmental Quality Act (CEQA) requires that an EIR contain a statement of the objectives sought by a proposed project. This statement of objectives aids in development of a reasonable range of alternatives that will be evaluated in the EIR. The National Environmental Policy Act requires that a project's Environmental Impact Statement (EIS) include a statement of purpose and need to which the proposed project is responding. The type of environmental documentation required for this Project will be determined in a later part of the study. The Project Need, Purpose and Objectives provided herein will be included in the EIR and/or EIS for the Project.

2.1 Project Need

Between the 1900s and 1950s, groundwater was an important factor in the urbanization of the West Coast Basin. Excessive pumping in the groundwater basin caused a severe overdraft (e.g., lowered groundwater levels) and created an inland hydraulic gradient that resulted in seawater intrusion. This intrusion contaminated the coastal groundwater aquifers. To address this problem and halt intrusion, two seawater intrusion barriers were constructed in the West Coast Basin by the Los Angeles County Flood Control District. While water injection activities at the barriers were successful in halting further seawater intrusion, these efforts could not address the seawater that had already been trapped in the groundwater basin when the barriers were constructed. This large plume of high-TDS water, referred to as the saline plume, is trapped inland of the injection wells, degrading significant volumes of groundwater with high concentrations of chloride and TDS, and decreasing the ability of affected aquifers to provide groundwater storage.

Two treatment facilities currently treat water pumped from the saline plume to potable water standards: WRD's Goldsworthy Desalter and the WBMWD's Brewer Desalter. However, to remediate the saline plume, additional extraction is needed; it is estimated that approximately 600,000 AF of high-TDS water (i.e., with greater than 250 ppm chloride) remains trapped in the West Coast Basin. As a result, WRD has initiated this Program as identified in WRD's GBMP, to evaluate ways to remediate the basin.

2.2 Project Purpose and Objectives

The Project's primary purpose and objectives are as follows:

- Remediate and reclaim brackish groundwater from the saline plume trapped in the West Coast Basin.
- Treat and reuse the extracted high-TDS water for beneficial use, including increasing local water supplies.
- Increase usable storage capacity in the West Coast Basin.
- Enhance the ability of the West Coast Basin to sustainably store and deliver water supplies, thereby reducing the region's reliance on imported water.

3. Water Supply and Demand Analysis

3.1 Purpose and Scope of the Analysis

The water supply and demand analysis conducted during the development of the GBMP was based on historical data from water years 2000/01 through 2008/09. The scope of this analysis was to extend the water supply and demand analysis through current conditions (i.e., 2016/17) and develop detailed summaries of present and future water supplies and demands in the West Coast Basin based on purveyor water demands. Water demand and supply data were compiled from published documents. This TM documents the following:

- West Coast Basin Judgment and amendments, including adjudicated rights for each party
- Historical groundwater extractions by water right holders/pumpers
- Historical and projected imported, groundwater, and recycled water supplies and demands for stakeholder purveyors in the basin
- Basin-wide historical and projected total water supply portfolio
- Historical replenishment supplies in the West Coast Basin
- Current use of storage based on the groundwater storage program and available total storage capacity in the basin

3.2 Historical and Current Conditions and Operations

Groundwater extractions from the West Coast Basin are governed primarily by the legal requirements of the existing Judgment, water consumption demands, and water supplies from the local water purveyors for the areas overlying the basin. Demands include injection water for the two barrier systems that protect groundwater from seawater intrusion. Basin operations are also regulated by policies and practices related to other water quality issues that must be managed in the basin, such as the saline plume and other sources of groundwater contamination. Figure 3-1 shows the study area which is the entire West Coast Basin along with the other groundwater basins in the vicinity area. The figure shows the Project stakeholder water purveyors' service areas in the West Coast Basin and their respective extraction wells.

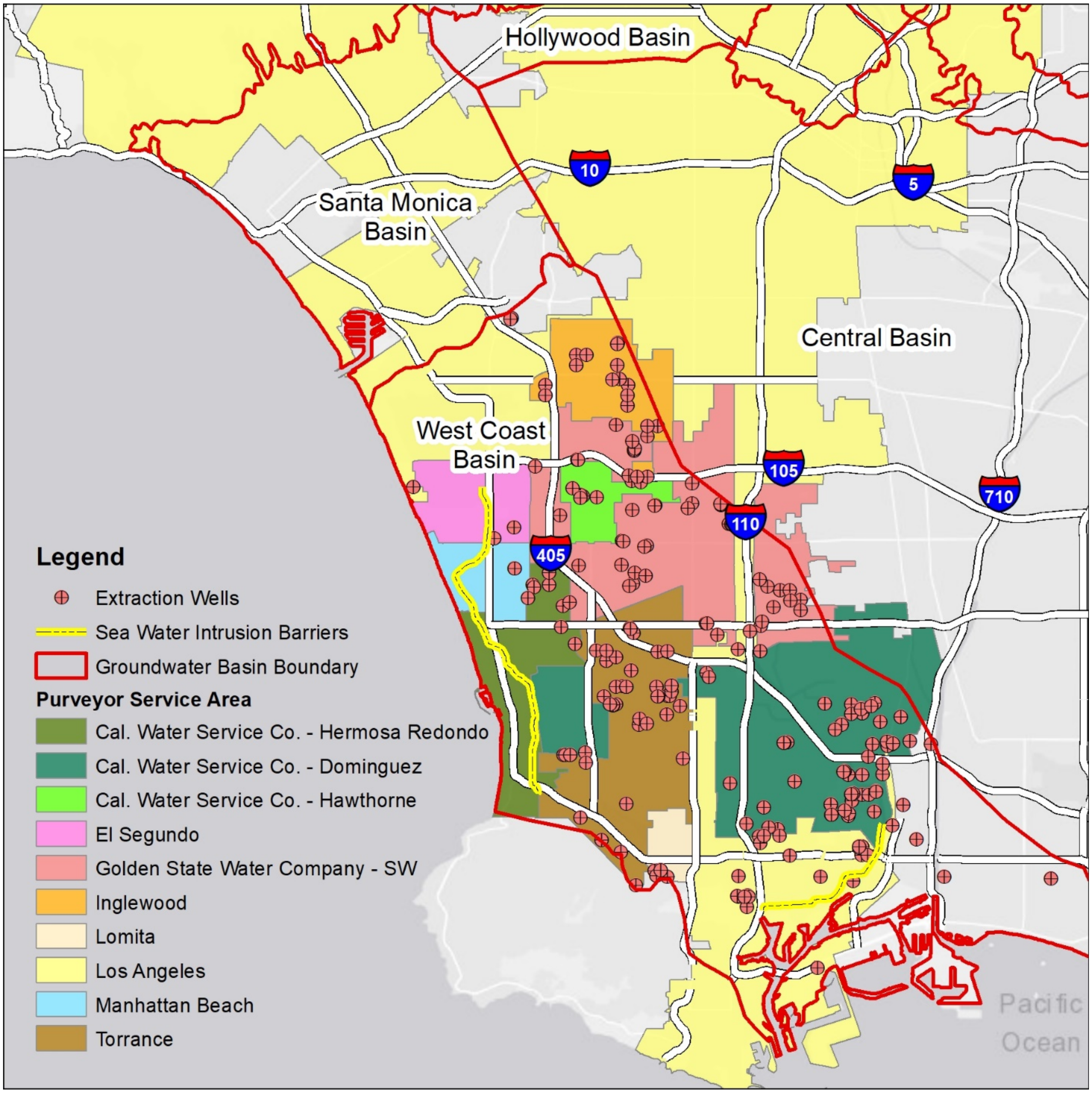


Figure 3-1. Purveyor Service Areas and Extraction Wells

3.3 West Coast Basin Judgment and Amendments

Historical extractions in excess of the basin's natural replenishment rate resulted in declining groundwater levels and seawater intrusion into the West Coast Basin. In response, the West Coast Basin was adjudicated in 1961, limiting the amount of groundwater each party to the Judgment could extract annually from the basin. These limits are monitored by a court-appointed Watermaster who administers and enforces the terms of the Amended Judgment, dated 2014, and reports annually to the court on significant groundwater-related events that occur in the basin. The court also retained jurisdiction to monitor ongoing management of the basin, including the conjunctive use of basin storage space to assure the basin will be capable of supplying sufficient water to meet current, local needs, as well as future, growth and development needs.

The West Coast Basin has total adjudicated rights of 64,468.25 AF per year (AFY), which is based on historical use and not the safe yield of the basin. Natural replenishment is limited to underflow from the Central and Santa Monica Basins and infiltration of precipitation and other applied waters, which has been estimated to supply between 20,000 to 30,000 AFY to the West Coast Basin. The adjudication is based on a physical solution that includes artificial replenishment through two injection barriers along with a combination of imported and recycled water supply to create an operational yield to allow production higher than the natural safe yield.

The Judgment contains provisions that allow for limited flexibility in the management of the West Coast Basin. Carryover of unpumped water is allowed from one administrative year to the next, up to 100 percent of the adjudicated right. However, the amount of available carryover is reduced by the amount of stored water held by the party. A reduction of this type, however, will not cause the amount of carryover to be less than 20 percent of a party's total adjudicated rights. Adjudicated rights or carryover can be leased or sold by parties to the Judgment or their successors.

Overextraction in the basin is limited to 10 percent, or 2 AF, whichever is greater. Overproduction must be made up the following year by reduced pumping (State of California et al., 2009).

Each year, adjudicated rights are transferred between parties through sales and leases. Allowable extraction in each year for each party depends on adjudicated rights, net carryover, leases, and storage. Table 3-1 shows the groundwater rights of the stakeholder purveyors along with leased pumping in 2017.

Table 3-1. Stakeholder Water Rights Accounting in the West Coast Basin

Stakeholder	Adjudicated Rights	Net Carryover 2015/2016[a]	Leases (with Flex)[b]	Leases (without Flex)[b]	Storage[c]	Allowable Extraction[d]
Cal Water – Hawthorne Lease	0.00	475.79	1,882.00	0.00	0.00	2,357.79
Cal Water – Hermosa Redondo	4,070.00	4,070.00	0.00	0.00	0.00	8,140.00
Cal Water – Dominguez	10,417.45	10,417.45	0.00	0.00	0.00	20,834.90
GSWC[e]	7,502.24	3,164.57	0.00	0.00	3,300.00	10,008.81
City of Lomita	1,352.00	770.70	-250.00	0.00	0.00	1,872.70
City of Los Angeles	1,503.00	1,503.00	0.00	0.00	0.00	3,006.00
City of Manhattan Beach	1,131.20	1,284.24	950.00	0.00	0.00	3.365.44
City of Torrance	5,638.86	0.0	0.0	0.0	5,638.86	11,277.72

Source: WMR, 2017

[a]Net Carryover is the sum of all carryover from the previous year less the amount of carryover conversion for 2017.

[b]Lease with flex includes carryover provisions. Refer to Watermaster Report 2017 for information concerning leases (WMR, 2017).

[c]Storage includes Carryover Conversion for Administrative Year 2016/17.

[d]Allowable Extraction = Adjudicated Rights + Net Carryover + Leases + Storage

[e]Includes 3,959 AF of increased extraction accounted for in Allowable Extraction (pursuant to Section IV(K) of the Central Basin Judgment).

3.3.1 Recent Judgment and Amendments

Recent amendments to both the West Coast Basin and Central Basin Judgments provide for enhanced use of the basins for groundwater storage and extraction. The effect of these amendments was to utilize unused storage space, estimated at a total of 450,000 AF in both basins. Of this total, 120,000 AF of unused storage was estimated to be available in the West Coast Basin. Most significantly, the implementation of water augmentation projects, where recharge and extraction volumes are matched in an established timeframe, allowed for pumping beyond adjudicated rights. Additional recharge to support the additional pumping can be accomplished with surplus imported water and stormwater, when available, as well as with local recycled water, which has become a more consistent and reliable source of replenishment water.

The Judgment amendments provide definitive rules for governing storage and recovery and seek to provide opportunities that were not possible prior to these amendments. The amendments contain the following principal elements that impact the types of projects that could be pursued:

- New management entities: The court-appointed watermasters for the basins did not administer unused storage space or approve new groundwater recharge projects. The Judgment amendments created a Storage Panel for each basin, made up of the WRD Board of Directors and a Water Rights Panel, to review and approve discretionary projects. Discretionary projects are those that construct new facilities, require CEQA review, and/or use more than 120 percent of a given pumper's adjudicated rights. New groundwater recharge and recovery projects are considered discretionary.
- Storage space: The prior adjudication decrees did not contain provisions for use of unused storage space in the basins. The amendments declared that "available dewatered space" exists and divided this space into the allotments shown in Table 3-2. The amendments include rules for the use of these allotments by parties and non-parties to the adjudications.

Table 3-2. West Coast Basin Storage Volume

Storage Categories	Total Volume (AF)
Individual Storage Allocation	25,800
Community Pool	35,500
Regional Storage	9,600
Basin Operating Reserve	49,100
Total	**120,000**

The rules of use define categories of storage and other elements as follows:

- **Individual storage accounts:** Each party to the judgments is assigned storage rights of 40 percent of its adjudicated right (in the West Coast Basin) or 50 percent of its allowed pumping allocation (in the Central Basin) for its exclusive use.
- **Community storage pool (CSP):** Once a party fills its individual storage account, it may access the community storage pool on a first come, first served basis. There are provisions that require parties to turn over their storage and provide access to other parties.
- **Regional storage projects:** This category provides access to, or implementation of, projects by non-parties to the amendments. Projects would need to be designed to provide various benefits to those that are parties to the amendments (e.g., reducing the Replenishment Assessment).
- **Basin operating reserve:** Reserved for use by WRD to more effectively achieve its mandate of providing replenishment to meet adjudicated pumping rights. However, it is envisioned that water augmentation projects (described below) would use space in this allotment.
- **Water rights transfers:** The amendments allow GSWC, California Water Company and the City of Los Angeles to annually transfer up to 5,000 AFY of rights from the West Coast Basin to the Central Basin for increased groundwater production in the Central Basin.

- **Water augmentation:** The original adjudication decrees establish fixed annual pumping rights for the parties. The amendments allow parties to increase their production rights by recharging the basins with new water supplies using water augmentation projects. These projects are envisioned to increase yield from the basins by matching recharge and extraction volumes on a regular basis (e.g., every 1 to 3 years). As such, these projects would not be considered storage and thus would not require a party to use adjudicated storage space and the restrictions attached to that space.

The Judgment amendment for the West Coast Basin was issued by the courts on December 5, 2014. The amendment established a new Watermaster, which replaced the California Department of Water Resources in that role. The Watermaster now consists of three separate entities with different functions as follows (WRD, 2014):

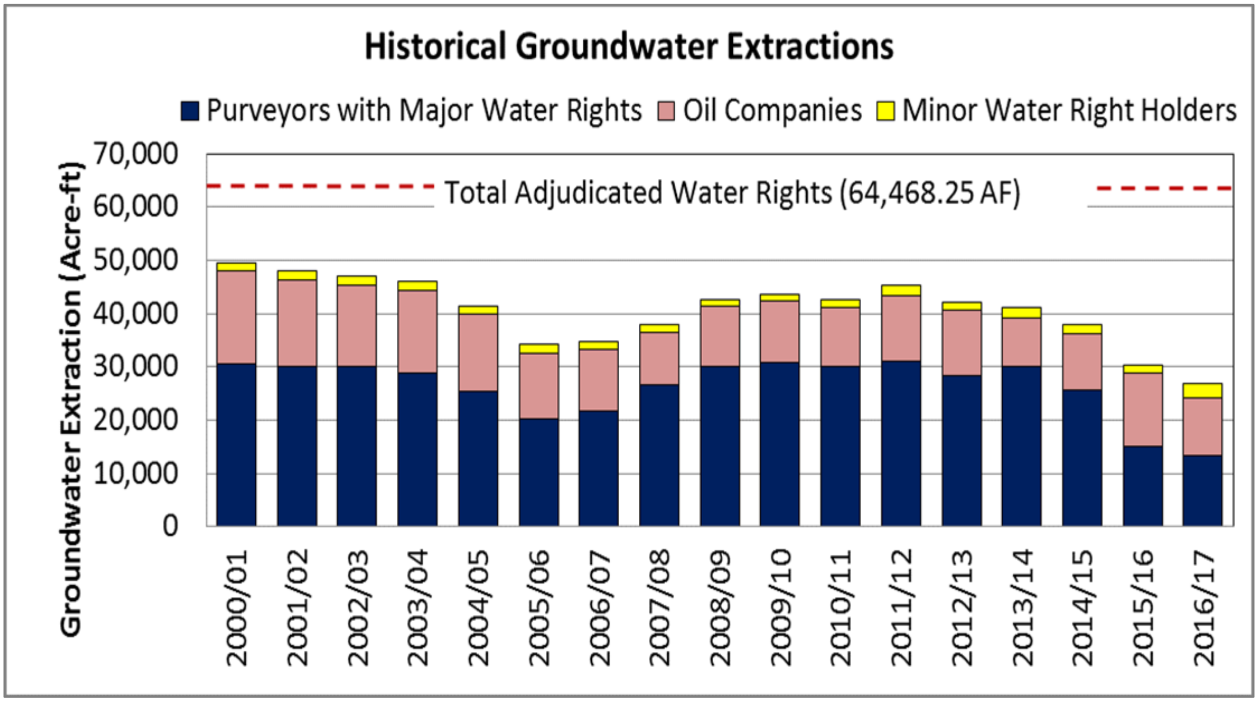
- **Administrative Body:** The Administrative Body administers the Watermaster accounting and reporting functions. WRD was appointed by the court to fulfill this role.
- **Water Rights Panel:** The Water Rights Panel enforces issues related to the pumping rights in the adjudication. The Water Rights Panel consists of five members, three of whom are the president, vice president, and treasurer of the West Basin Water Association, and two of whom are selected by the Association's Board of Directors. In addition, at least one member is required to be a non-water purveyor adjudicated rights holder with at least 1 percent of the basin's adjudicated rights.
- **Storage Panel:** The Storage Panel is comprised of the West Coast Basin Water Rights Panel and the WRD Board of Directors, which together approve certain groundwater storage efforts.

3.4 Historical Water Demands and Supplies

Water supplies in the area overlying the West Coast Basin include groundwater, imported water, and recycled water. The information presented here is based on data from Watermaster Reports from 2010 through 2017 (West Coast Basin Watermaster, 2010 through 2017). For the purposes of this analysis, major water right holders are considered those with more than 1,500 AF; minor water right holders are those with less than 1,500 AF but more than 2 AF. Those with less than 2 AF are considered statistically insignificant for the purposes of this study.

Figure 3-2 shows total water use, including groundwater, imported water, and recycled water from water year 2000/01 through 2016/17. Annual total groundwater extractions in the West Coast Basin for this period averaged approximately 41,000 AFY. Nearly two-thirds of the groundwater was extracted by major water rights holders in the basin, approximately one-third was extracted by several refineries, and a small fraction was used by minor water rights holders. As shown in Figure 3-2, pumping amounts are significantly below the basin's total water right adjudication of 64,468.25 AFY. Total extraction in water year 2016/17 was 26,805.26 AF, which was the lowest amount pumped over the last 17 years. Lower pumping rates in the last 5 years are due in part to water quality issues, drought conditions, infrastructure repair and maintenance activities, reduced demand resulting from conservation, and economic conditions.

Historical water use by major right holders, oil companies, and minor right holders is also shown in Figure 3-2. Oil companies extracted an average of approximately 13,000 AFY of groundwater for oil refining and other industrial uses from 2000 through 2017. On a percentage basis, 65 percent of groundwater extractions in the basin were by purveyors with major water rights, 31 percent was by oil companies, and 4 percent was by minor water right holders.



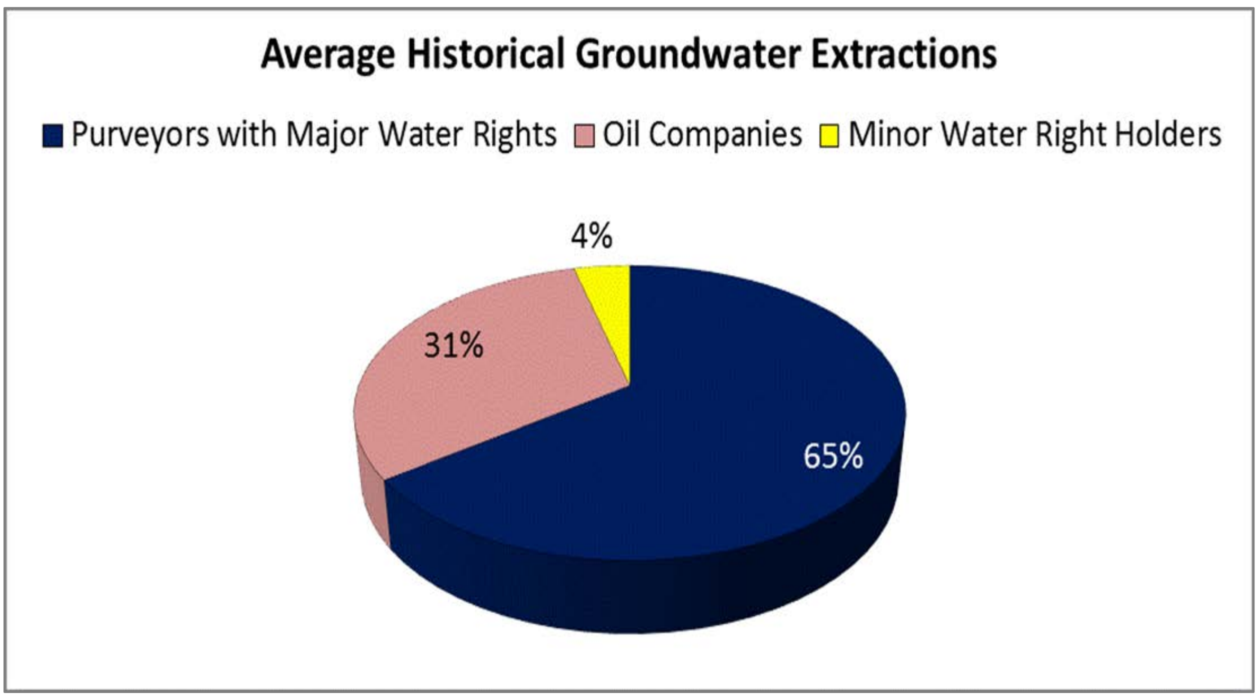


Figure 3-2. Historical Groundwater Extractions from Water Year 2000/01 through Water Year 2016/17

Historical groundwater use by major right holders and their water rights in the West Coast Basin are shown on Figure 3-3a,b. The City of Los Angeles has not used the groundwater from the West Coast Basin since 2000/01 due to the presence of iron and manganese. Cal Water-Dominguez has the maximum water rights of 10,417.45 AF in the West Coast Basin. However, the maximum groundwater use has been by GSWC, with over 14,000 AFY in 2008, 2009, and 2013. Historically, GSWC has used leased rights from other purveyors such as City of El Segundo, City of Lomita, and Cheverton USA, Inc. and has also used net carryover and storage to pump above their water rights. In 2015/16 and 2016/17, GSWC exercised its option to pump West Coast Basin rights in the Central Basin, accounting for some of the reduced West Coast Basin extractions depicted on Figure 3-3a.

The West Coast Basin's water supply is significantly augmented by imported water provided by WBMWD, LADWP, and the City of Torrance, who are member agencies of the Metropolitan Water District of Southern California (Metropolitan), the region's wholesaler of imported water. Figure 3-4 shows the average volumes of groundwater, imported water, and recycled water used in the West Coast Basin for water years 2000/01 through 2016/17. As shown on this figure, imported water has been the largest component of supply since water year 2000/01. During water year 2016/17, a total of about 140,000 AF of water was imported into the West Coast Basin, excluding water used for basin replenishment. From 2009 through 2014, imported water deliveries were over 150,000 AF.

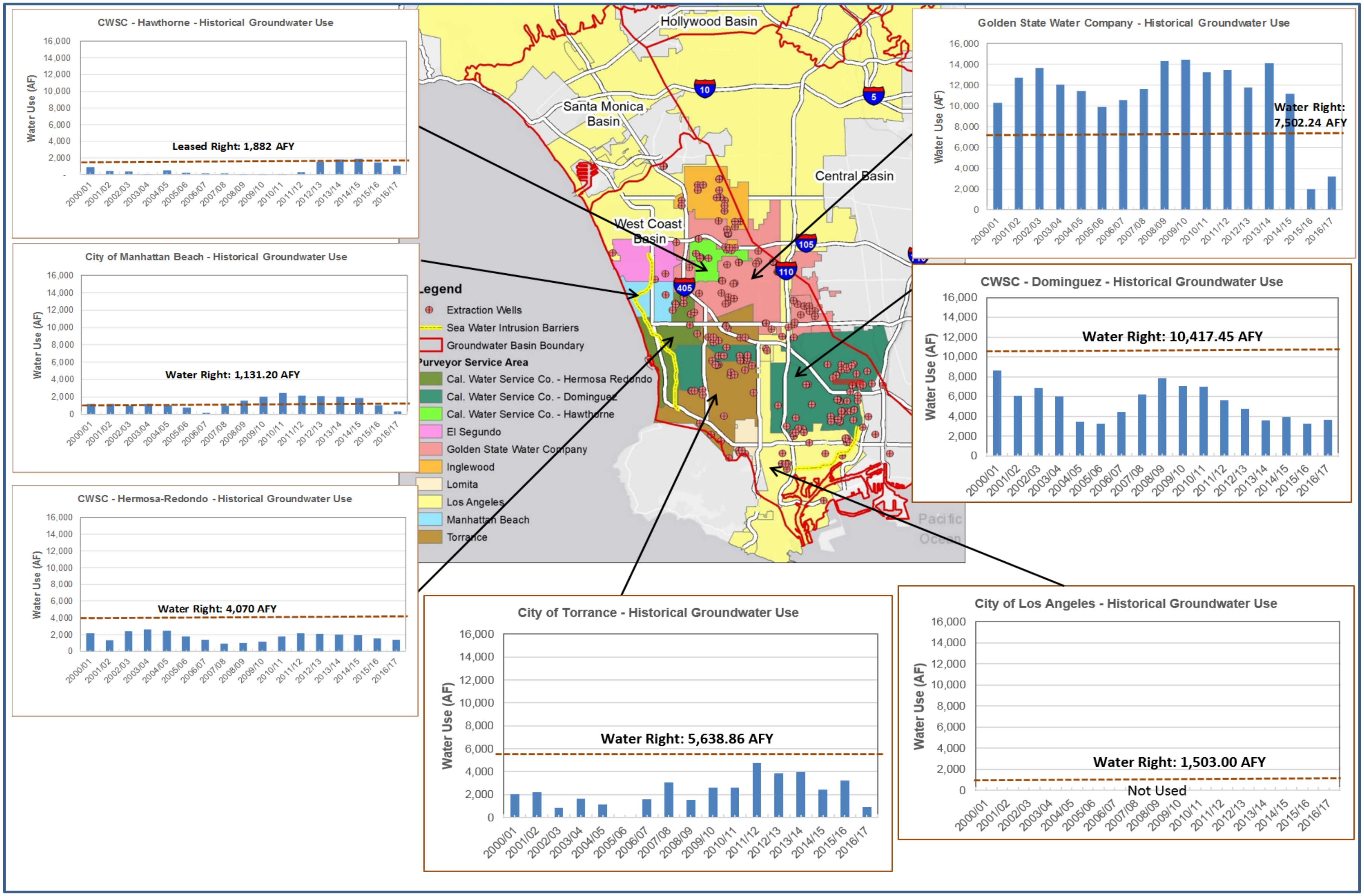


Figure 3-3a. Historical Groundwater Extractions and Groundwater Rights of Stakeholder Purveyors

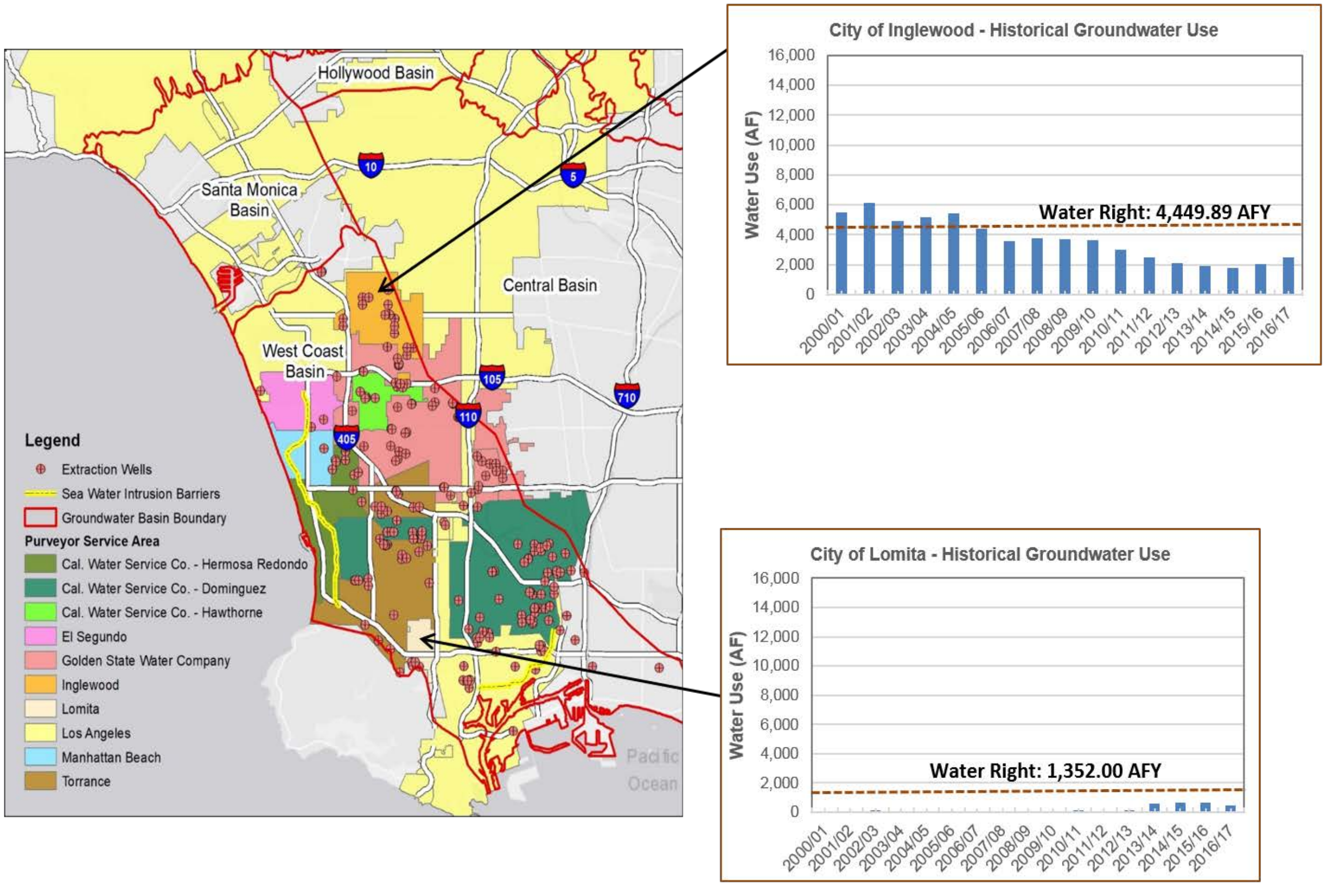
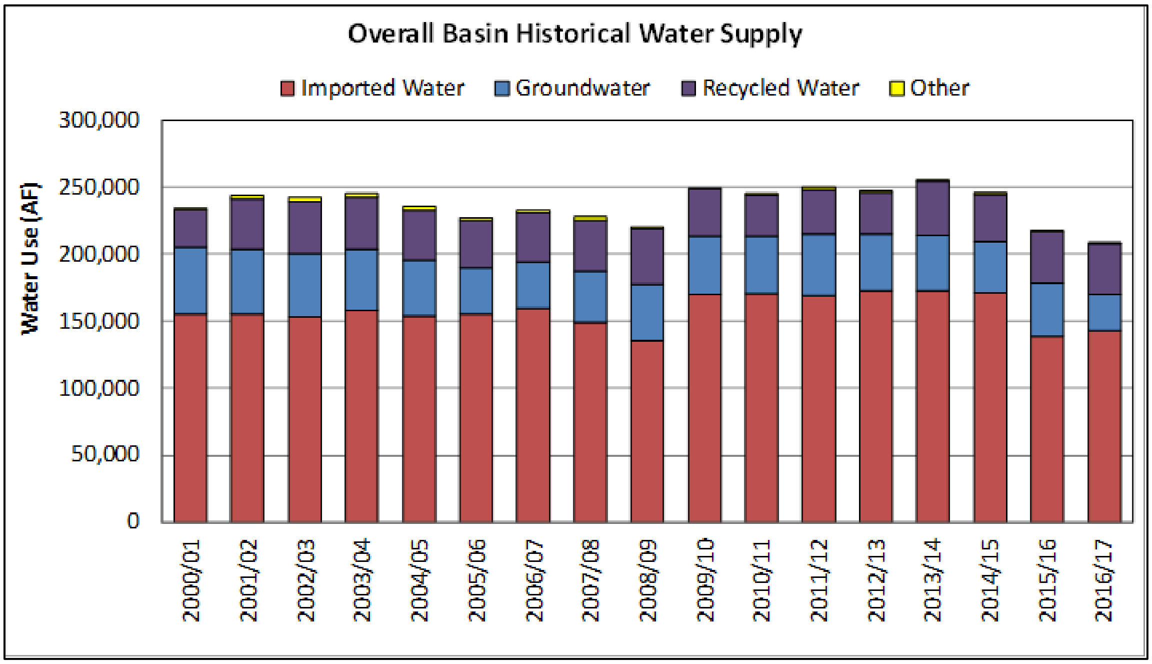


Figure 3-3b. Historical Groundwater Extractions and Groundwater Rights of Stakeholder Purveyors

In the last few years, total water use has declined in the West Coast Basin, largely due to drought and conservation conditions. This has also resulted in a decline in imported water supplies. Historically, water supply and resulting use in the basin reached about 250,000 AF, but in the last two years those were close to 210,000 AF. Also, there has been a shift in source of water supply from groundwater to recycled water. On a percent basis, imported water comprises about 60 percent of the supply (Figure 3-4). On Figure 3-4, the “other” supply consists of brackish groundwater treated by the Goldsworthy and Brewer desalters.

Figure 3-5a,b depicts historical water use from water year 2000/01 through water year 2016/17 by water source type for each of the purveyors and pumpers in the basin.



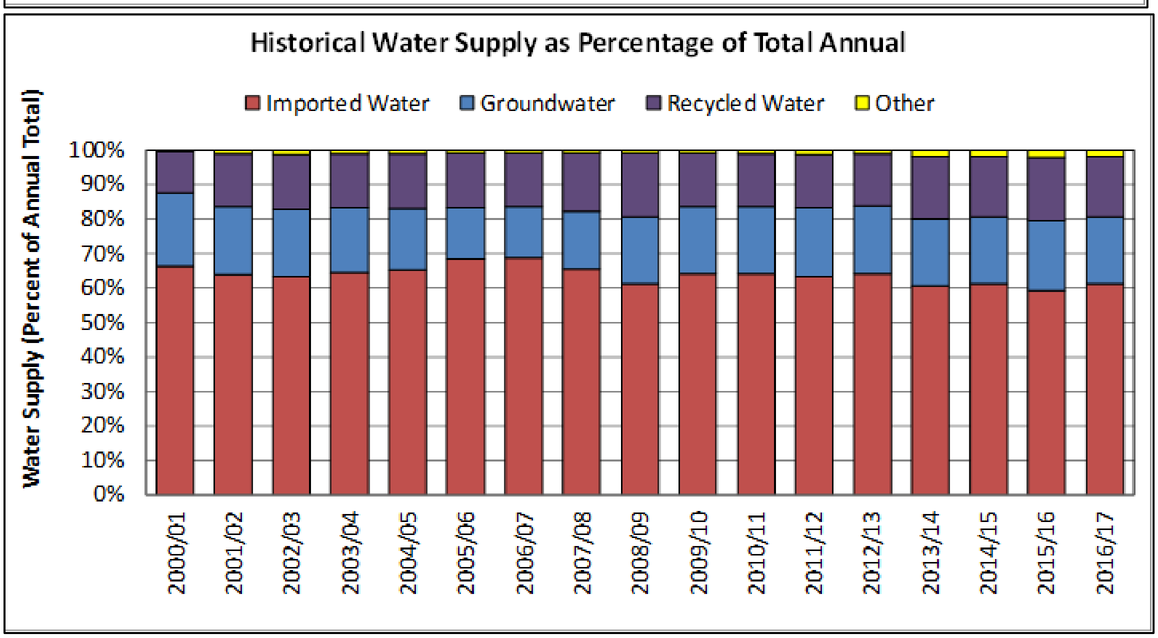


Figure 3-4. Summary of Historical Total Water Demands and Supplies (Water Years 2000 – 2017)

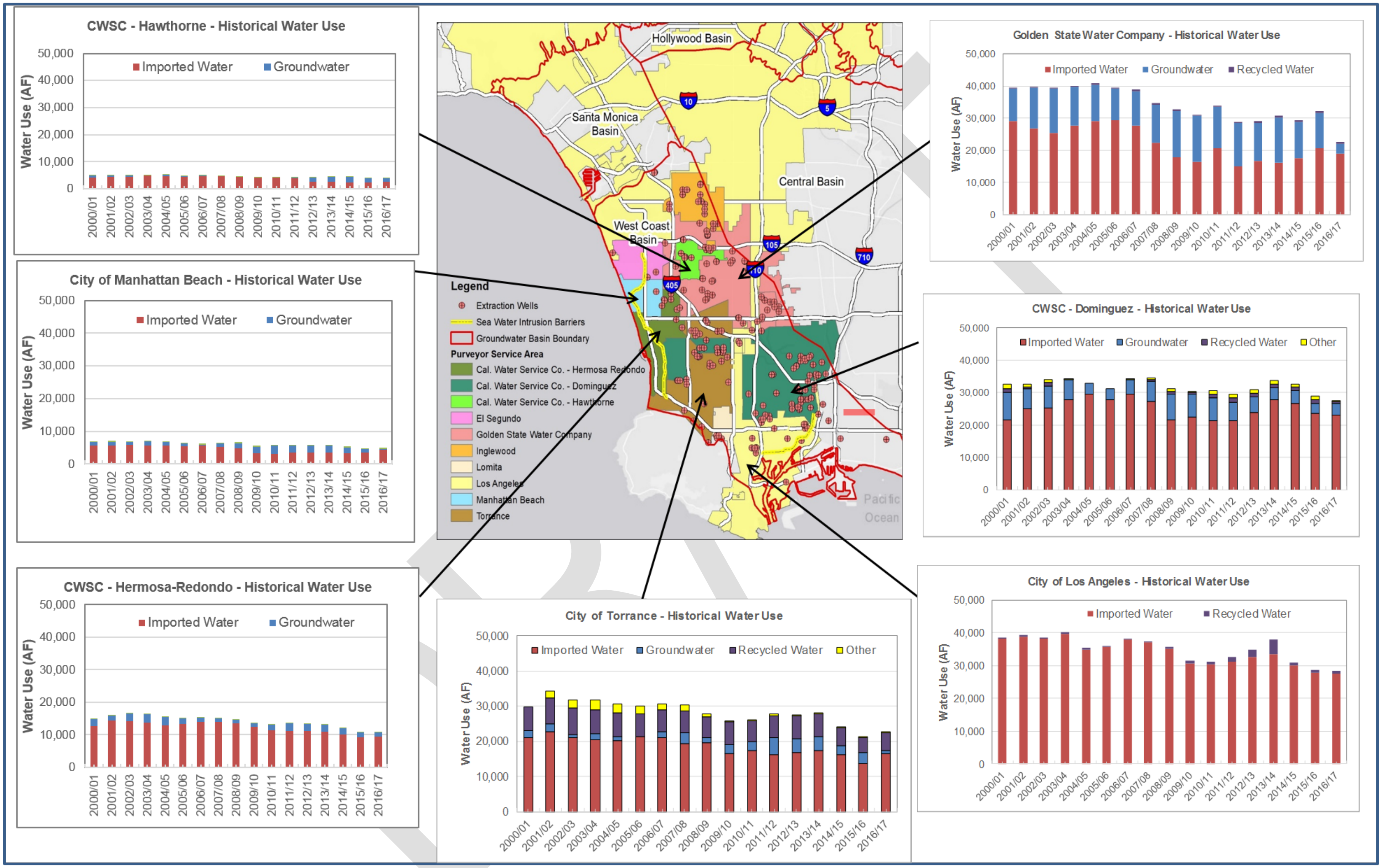


Figure 3-5a. Summary of Historical Water Demands and Supplies by Stakeholder Purveyors (2000 to 2017)

Note: CWSC-Dominguez District supply includes brackish groundwater from the Brewer Desalter (“Other”).

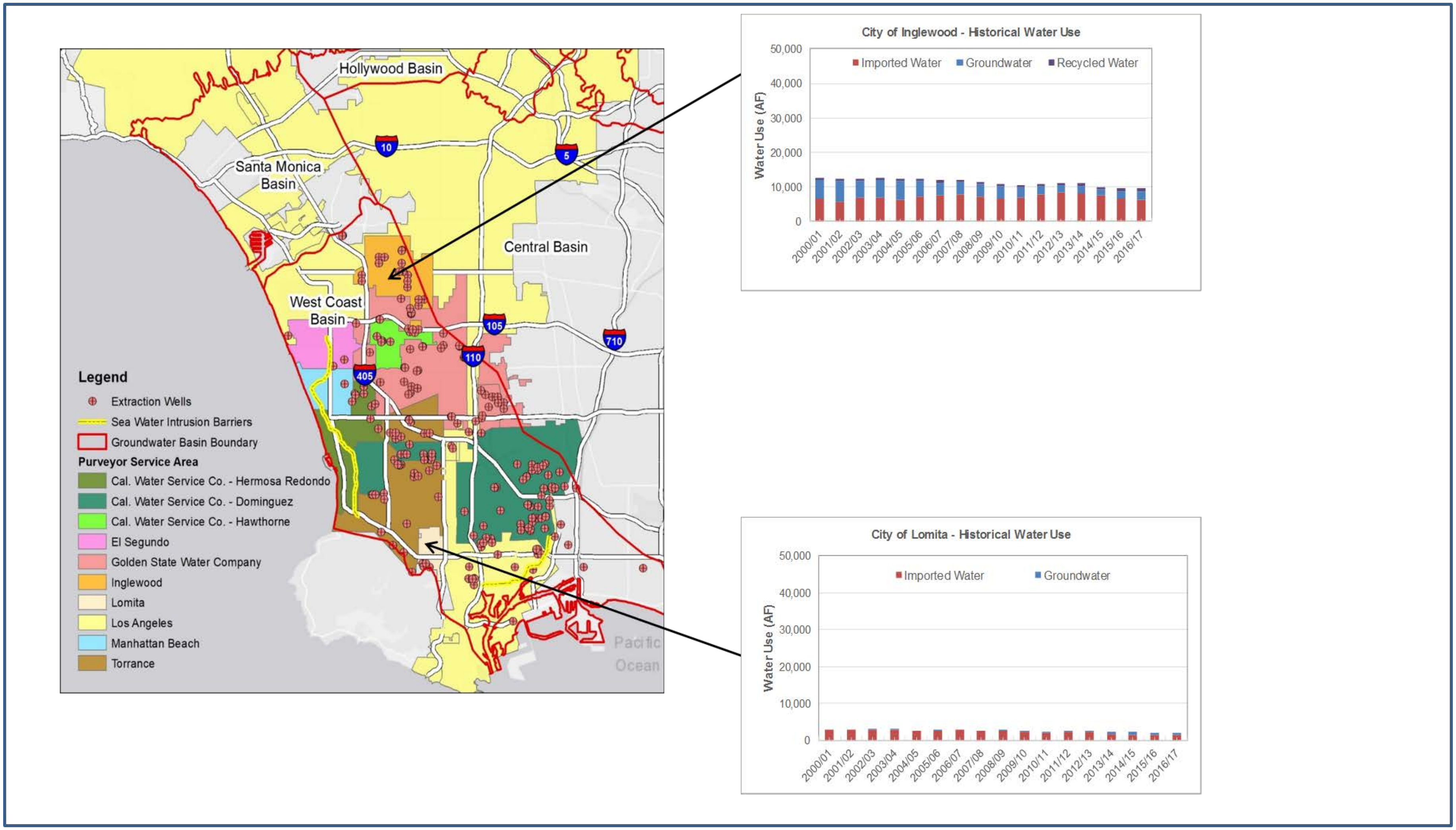


Figure 3-5b. Summary of Historical Water Demands and Supplies of Stakeholder Purveyors in the West Coast Basin (2000 to 2017)

Note: City of Torrance supply includes brackish groundwater from the Goldsworthy Desalter (“Other”).

3.5 Replenishment Supplies and Water Sources (2000/01 – 2016/17)

The two injection barriers in the West Coast Basin are located along the west coast of the Los Angeles County Coastal Plain and along the south coast in the Dominguez Gap area. The barriers are used to prevent seawater intrusion along the coast and are owned and operated by LACDPW. The West Coast Basin Barrier Project (WCBBP) consists of over 150 injection wells and extends over 9 miles from Los Angeles International Airport in the north to Palos Verdes in the south. The Dominguez Gap Barrier Project (DGBP) protects the southern coast of Los Angeles County and consists of 58 wells. The WCBBP was designed to prevent sea water intrusion from the Pacific Ocean, and the DGBP was designed to prevent intrusion from San Pedro Bay. A combination of recycled and imported water is injected into the 200-foot sand Silverado and the Lower San Pedro aquifers. Groundwater in the West Coast Basin is primarily recharged from these two barrier projects, from infiltration of precipitation and applied water, and from Central Basin and Santa Monica Basin underflow.

In addition to providing recycled water to meet demands in the basin, WBMWD has provided recycled water to the WCBBP since 1995. Prior to introduction of recycled water to the West Coast Basin, imported water was exclusively injected at both barriers. Figure 3-6 shows historical injections into both barriers since operations began in early 1950s. Figure 3-7 shows the sources of water for replenishment at these two barriers. Historical water supplies consisted of imported and recycled water from WBMWD to the WCBBP, and a combination of imported water from WBMWD and recycled water provided by LADWP for the DGBP.

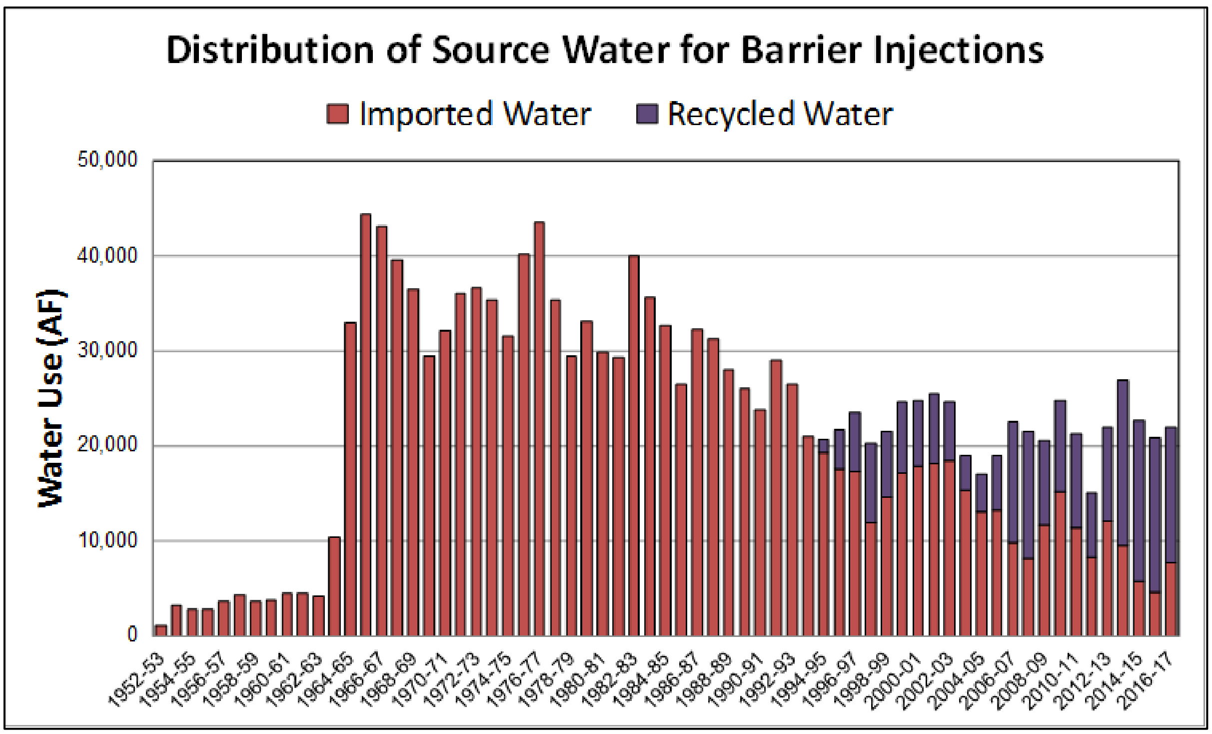


Figure 3-6. Historical Annual Total Injection into the West Coast Basin and Dominguez Gap Barriers

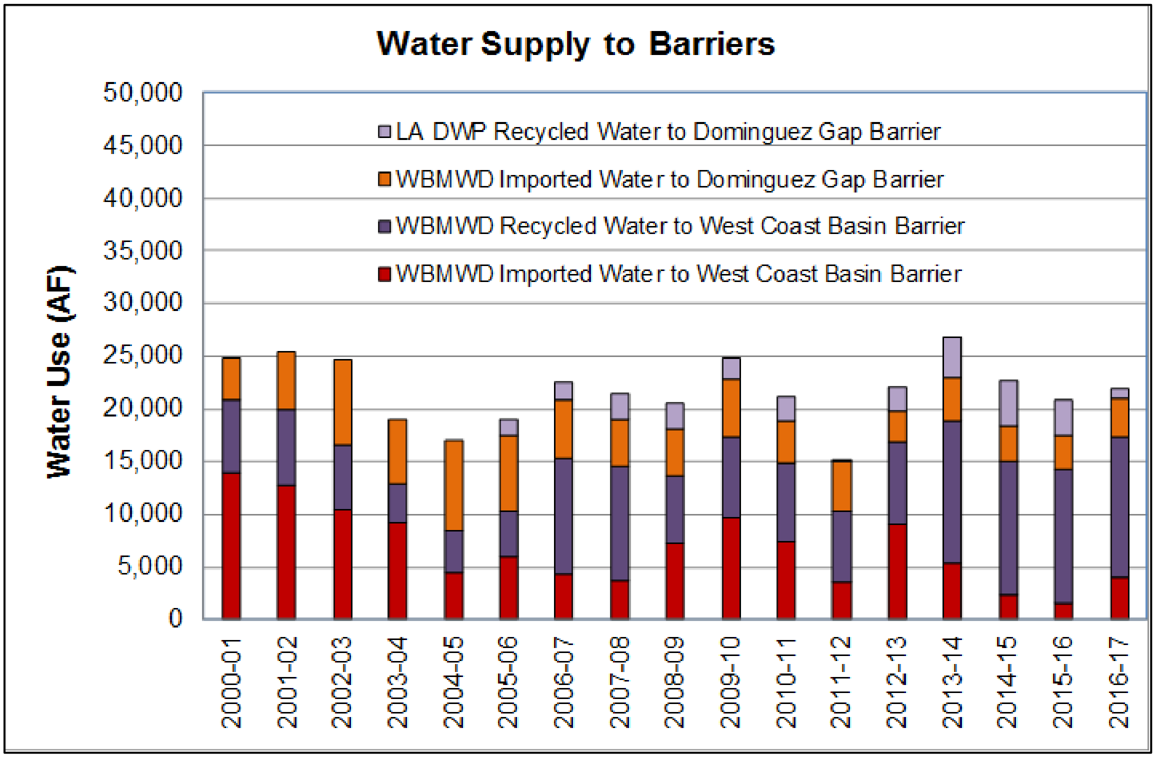


Figure 3-7. Historical Annual Injection by Supply Source into the West Coast Basin and Dominguez Gap Barriers

In 2003, increased injection can be seen in the DGBP due to the barrier extension. A decline from 2001/02 through 2005/06 in the WCBBP injection rates is apparent; this is due to both declining groundwater extractions and the declining specific capacity of the wells. Although the recycled water component of injections at the WCBBP has increased, the total injection has remained below the levels of 2000/2001. As infrastructure has aged at both barrier projects (including injection wells, pressure-reducing stations, distribution pipelines and appurtenances, and observation wells), LACDPW has been examining the condition of these facilities to assess rehabilitation and replacement needs, with the goal of maintaining and restoring barrier capacities.

From 2000 to 2017, an average approximately 15,000 AFY of combined recycled and imported water was injected into the WCBBP. In water year 2016/17, a blend of approximately 22,000 AFY of imported and recycled water was injected into the two barriers. In the same water year, injection into the WCBBP consisted of approximately 13,000 AF of recycled water and 4,000 AF of imported water for a 76 percent recycled water contribution. The Los Angeles Regional Water Quality Control Board has approved injection of a combination of up to 100 percent of reverse osmosis-treated recycled water for both the WCBBP and the DGBP. In 2019, WRD completed the Water Independence Now (WIN) Effort to secure enough recycled water supplies to meet the full demand of both barriers and imported water usage will only occur when needed due to temporary shutdowns at the recycled water treatment facilities.

3.6 Exiting Treatment in the West Coast Basin

3.6.1 Desalters

Two treatment facilities located in the City of Torrance extract water from the basin's saline plume and treat that water to potable water standards. The 1-million-gallon-per-day (mgd) capacity Brewer Desalter is owned, operated, and maintained by WBMWD, and this treated water is provided to Cal Water. The desalter originally used two wells to pump brackish water from the West Coast Basin and in 2005, the two wells were replaced with a new, more productive well. This well has the capacity to pump 1,600 to 2,400 AFY of brackish groundwater to be treated at the desalter.

The 5-mgd Goldsworthy Desalter is owned by WRD, and is operated and maintained by the City of Torrance who delivers this treated water to its customers. In 2001, the desalter was treating approximately 210 AF of saline groundwater per month. The extractions contained more than 1,000 ppm of chloride through March 2006, but the chloride concentrations have been less than 1,000 ppm since then. Effective April 23, 2007, the City of Torrance began using its water rights to operate the desalter (WMR, 2010).

Brine flows from these treatment facilities are discharged to nearby sanitary sewers for treatment downstream at Los Angeles County Sanitation Districts' (LACSD) Joint Water Pollution Control Plant (JWPCP).

3.6.2 Other Treatment

The Del Amo and Montrose Chemical Superfund sites are located near the center of the basin. Waste at the Del Amo site includes benzene, naphthalene, ethylbenzene, and phenol, which has contaminated the soil and groundwater around the site. The Montrose Chemical Corporation manufactured high-grade dichlorodiphenyltrichloroethane (DDT) at this location from 1947 to 1982.

The local oil refineries are also major water right holders in the West Coast Basin. Oil recovery and basin cleanup efforts by some of the oil companies are ongoing. Parties in the West Coast Basin petitioned WRD for a Non-Consumptive Water Use Permit (NCWUP) as part of a project to remedy or ameliorate groundwater contamination.

After the petition is granted, the party may extract the groundwater without the production counted against its production rights, so long as the extracted groundwater is unusable and cannot be economically blended for use with other water, or the proposed Program involves extraction of usable water in the same quantity as will be returned to the underground without degradation of quantity. The annual Watermaster Reports provide information on the amount of water that is extracted under NCWUPs in each reporting period. In water year 2016/17, over 500 AF of water was extracted by Montrose Chemical Corporation, Shell Oil Company and the Brewer Desalter under NCWUPs.

The Brewer Desalter facility began operating in July 1993, and was originally conceived as a five-year pilot project to see if brackish water could be economically treated to drinking water standards. As this facility was built to demonstrate desalting technology and to improve groundwater quality and management, it continues to operate under a NCWUP. (WMR, 2010).

3.7 Future Planning Efforts

3.7.1 Pertinent Planning Studies

This section presents information about the future plans of West Coast Basin water right holders for basin use. Future water supply and demand information from 2020 through 2040 are based on published planning documents and input from Program stakeholders.

Several planning efforts, including purveyors' Urban Water Management Plans (UWMPs) regarding the West Coast Basin, provide long-term water supply planning projections, and those of their wholesale suppliers. To conduct a projected future water supply and demand analysis for the West Coast Basin, analysts used water supply and demand data from all Program stakeholders' UWMPs, as discussed below. To assess basin-wide groundwater use, analysis was extended to include other major water purveyors in the West Coast Basin.

3.7.2 Projected Water Demands and Supplies (2018 to 2040)

The planning horizon for projected water demands is 2040, corresponding to the ultimate planning year for UWMPs published in 2015, which are the most recent officially adopted plans for the West Coast Basin water suppliers and purveyors. Data are presented in this section for calendar years as opposed to water years (as shown above) because UWMPs reported future water use on a calendar year or fiscal year basis.

Figure 3-8a,b depicts projected average water supply distribution for each water purveyor in the West Coast Basin from 2020 through 2040. Although groundwater and recycled water supplies are expected to increase in the future, imported water remains a significant portion of the water supply portfolio. Stakeholders in both groundwater basins are projecting a reduction in water consumption through conservation, increased recycled water use (including both non-potable and indirect potable reuse), and reducing reliance on imported water. Future water supply scenarios under single/multiple dry years and average weather conditions are projected to use groundwater replenishment with recycled water, new water conservation approaches, and increased use of captured stormwater.

Figure 3-9 summarizes basin-wide projected total water demands and supplies in the West Coast Basin from 2020 through 2040. Total water use in the West Coast Basin averaged about 236,000 AFY from 2000 through 2017, while projections estimate 228,000 AFY for the projected period, in part due to conservation and drought conditions. With a planned reduction in the use of imported water, projected water demands are anticipated to be met via a combination of groundwater, recycled water, and other supplies generated locally in the basin.

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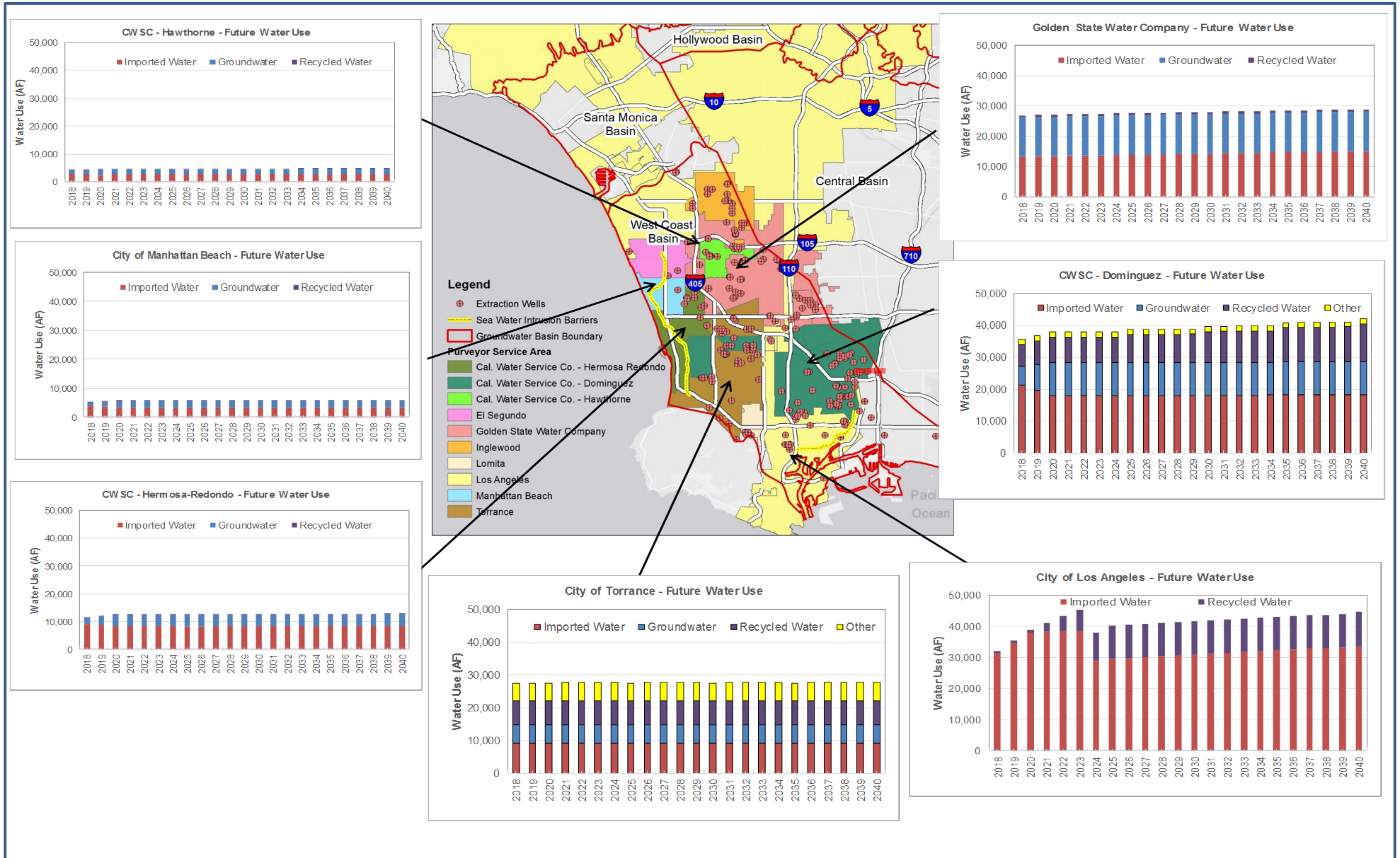

Figure 3-8a. Summary of Future Water Demands and Supplies of Stakeholder Purveyors in the West Coast Basin (2020 to 2040)

Notes: CWSC-Dominguez District supply includes brackish groundwater from the Brewer Desalter ("Other").
While the data presented for the City of Los Angeles represents overlying LA City demands, it does not account for additional demands, associated with increased extraction, that would serve the LADWP service area in its entirety.

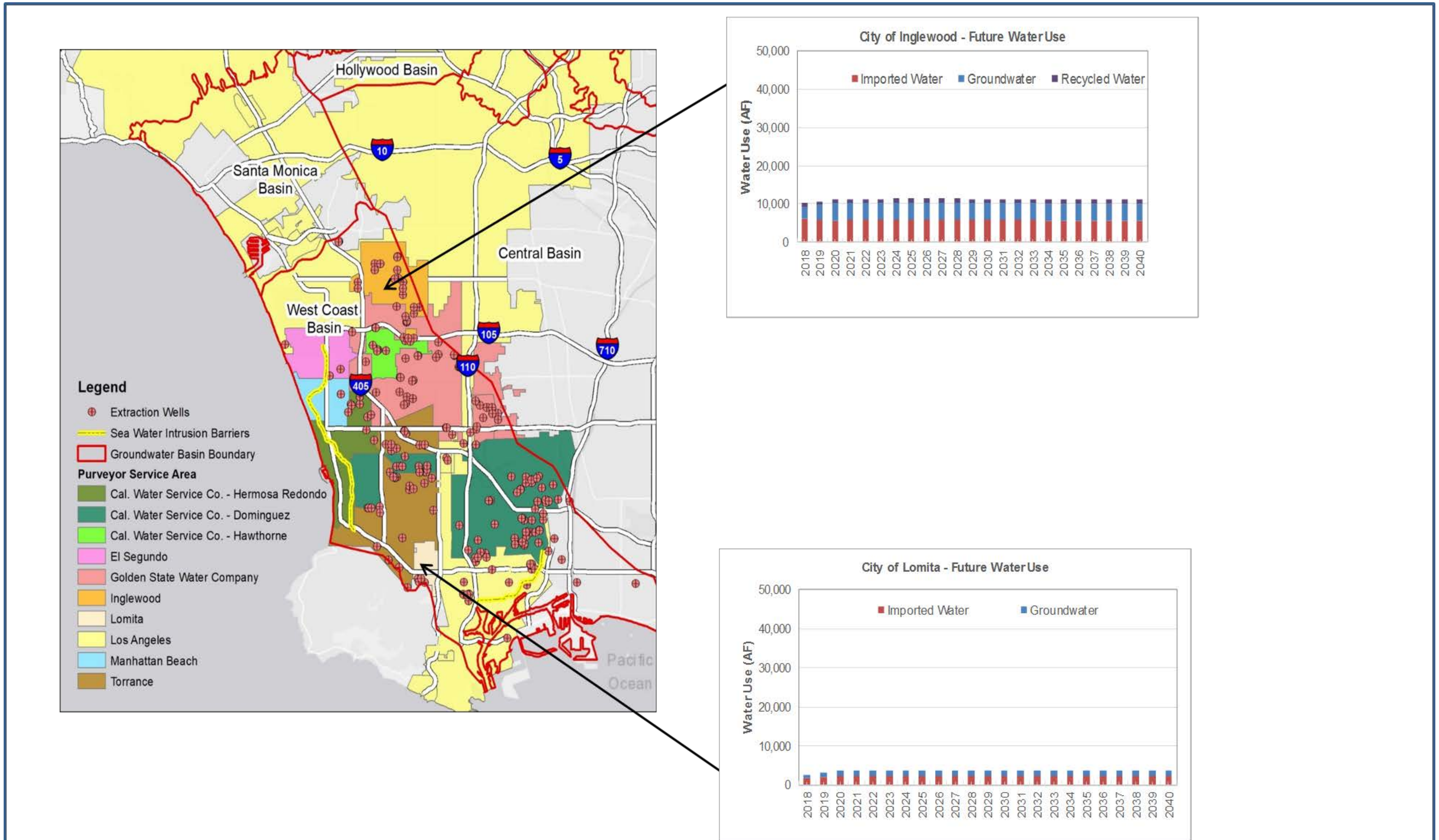

Figure 3-8b. Summary of Future Water Demands and Supplies of Stakeholder Purveyors in the West Coast Basin (2020 to 2040)

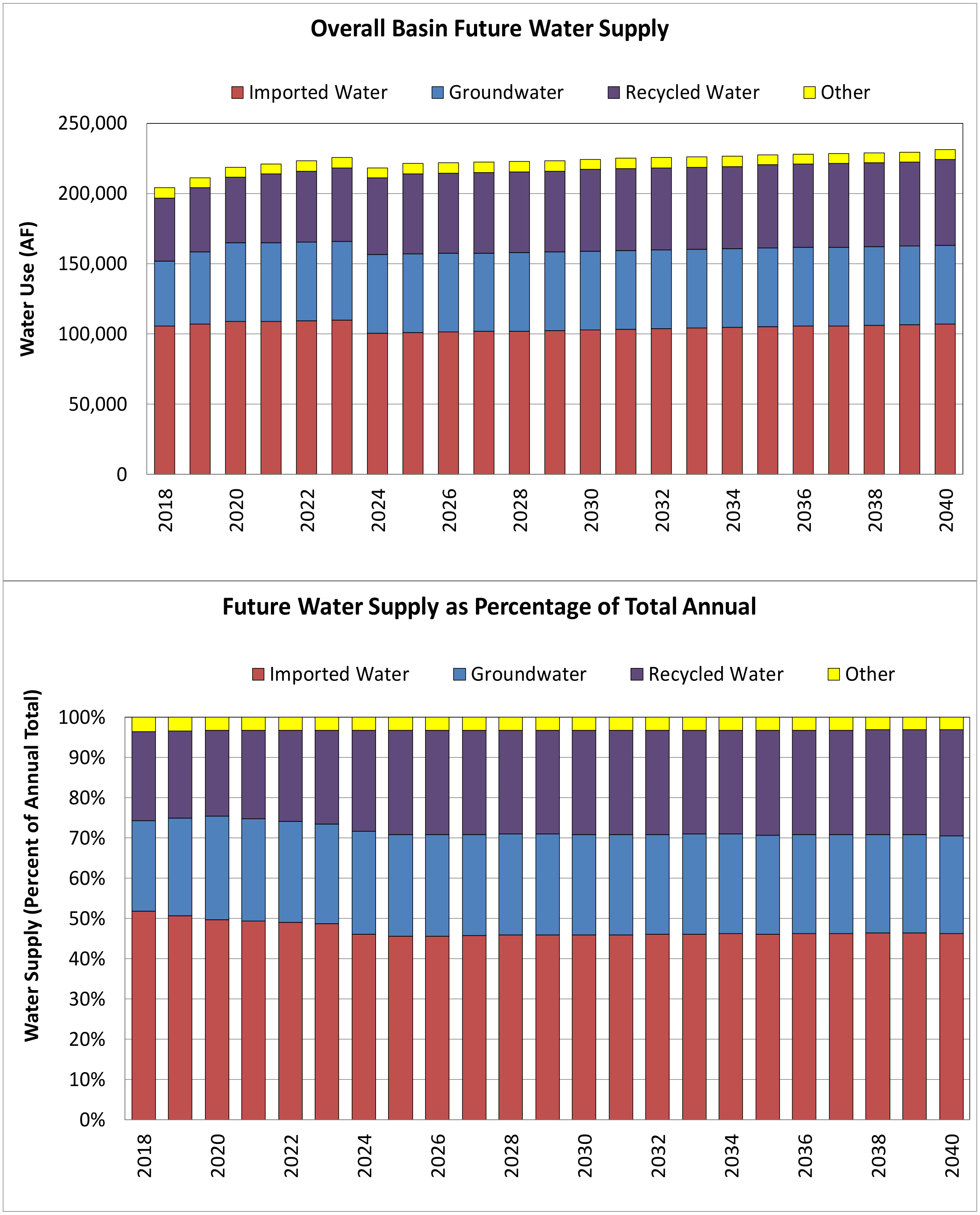

Figure 3-9. Summary of Basin-Wide Projected Total Water Demands and Supplies (2020 to 2040)

3.8 Current Groundwater Storage

The amended Judgment allows parties holding water rights to store water in the West Coast Basin for later recovery. During water year 2016/17, 4,766 AF of water was put into storage; none was extracted or transferred. All of this water was put into storage pursuant to Section V.4.B of Judgment, which allows parties to convert carryover to storage upon payment of the Replenishment Assessment to WRD. Storage categories as specified in the Judgment amendments (and described above) are individual storage allocation, CSP, regional storage, and basin operating reserve.

Figure 3-10 provides information about total available storage, the amount of water placed into storage during 2016/17, and unused/remaining available storage in the West Coast Basin since 2014. GSWC used both the individual storage allocation and CSP; the City of Torrance used the CSP to place water into storage during 2016/17. No water was extracted or transferred from storage in 2016/17. Over 5,200 AF in individual storage allocation and over 3,600 AF in CSP storage has been used and remaining storage of 61,000 AF is available, of which 18 percent is individual storage allocation, 29 percent is CSP, 9 percent is regional storage, and 44 percent is basin operating reserve. Within all four storage categories, 111,061.30 AF of water storage is available in 2016/2017 in the West Coast Basin.

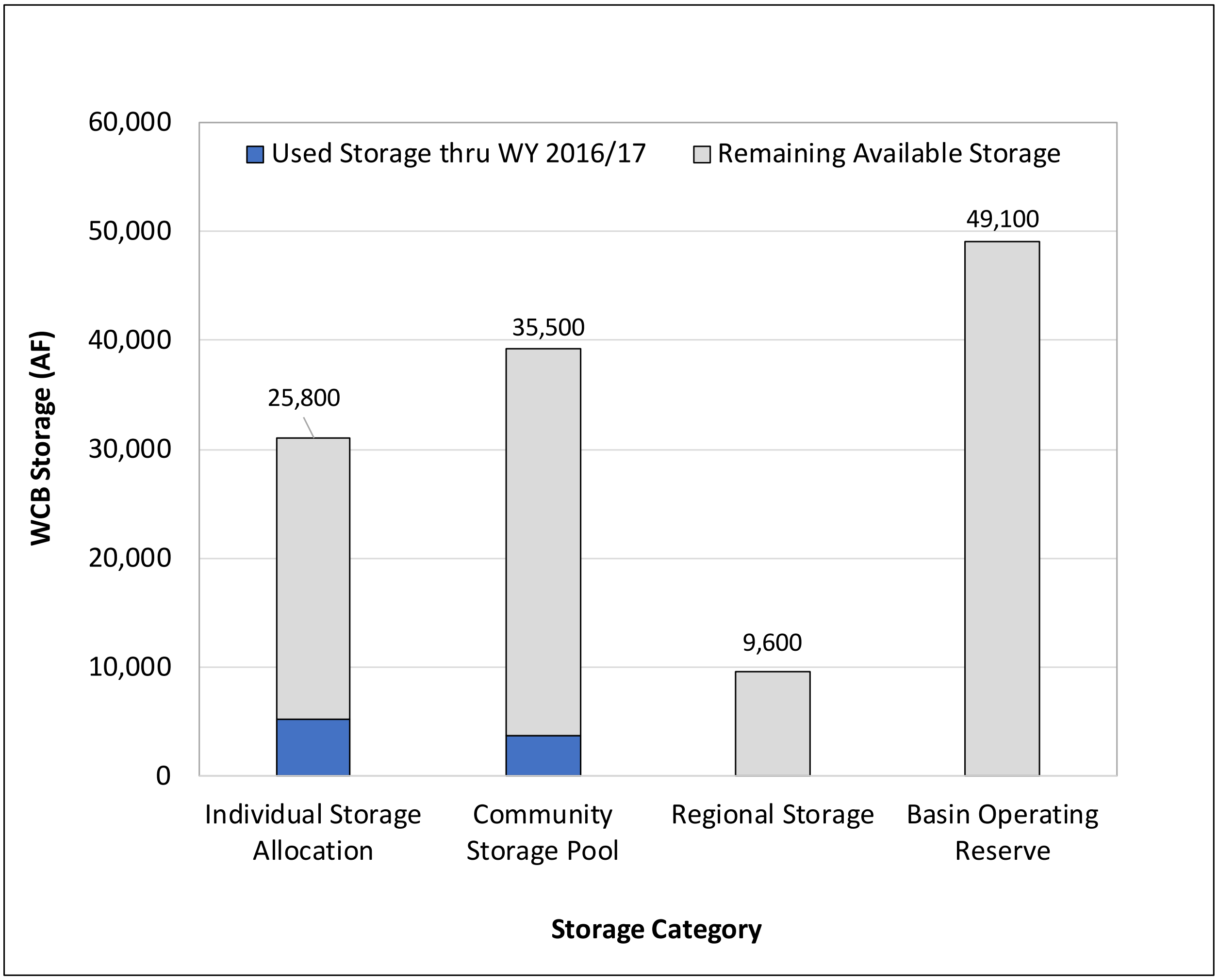

Figure 3-10. Historical Storage Use and Remaining Available Storage in the West Coast Basin

4. Evaluation Criteria

For the feasibility study, a critical first step is to determine the key project objectives, goals and constraints and range of project options to be considered and evaluated. These “Project Options” will be logically combined into full systems, from extraction, through treatment to delivery. Each of these systems will constitute a “Project” that will then undergo additional technical analysis and evaluation. A Project is defined herein as a system that treats the 375,000 AF saline plume.[1]

The Project Options, described below in Section 5, will be developed more specifically based on the following system considerations:

- Location of brackish water extraction
- Facility size based on the key project attributes, such as location, availability of land, jurisdiction, conveyance and existing water delivery system; Figure 4-1 shows the saline plume in relation to the purveyor service area
- Source water specifications to determine the treatment needed
- Product water specifications to generate suitable supply where the water demand is determined,
- Water intake type to maximize the extraction
- Facility treatment process to generate suitable water quality to meet demands
- Brine disposal locations and type
- Product water delivery locations to best utilize existing infrastructure
- Product water conveyance requirements based on the volume generated
- Treated water supply distribution system, including replenishment and storage

Determination of the most economical, logistically simple, and permittable Projects will be conducted by applying the evaluation criteria presented below in Table 4-1. An initial set of evaluation criteria will be applied to assess the Project Options and establish a list of (up to 10) “Potential Projects.” This screening process will be based on capital and operations and maintenance (O&M) costs, beneficial use of the remediated water, operation of the basin, and level of chloride concentration of the remediated water. The Project Options will first be screened against this initial set of quantitative evaluation criteria using the Jacobs’ Voyage and the Conceptual and Parametric Engineering System (CPES) tools for benefit/cost analysis. This analysis will aid in selection of Potential Projects that will be presented to the Stakeholder Group for concurrence and further development in Workshop No. 2. An additional set of criteria will then be applied to screen from the Potential Projects to (up to 5) final, feasible, and most viable Projects for future consideration. Additional criteria are included below that are recommended for consideration beyond this feasibility study when ultimately determining a preferred alternative for implementation.

[1] This amount is based on a chloride concentration of greater than 500 ppm.

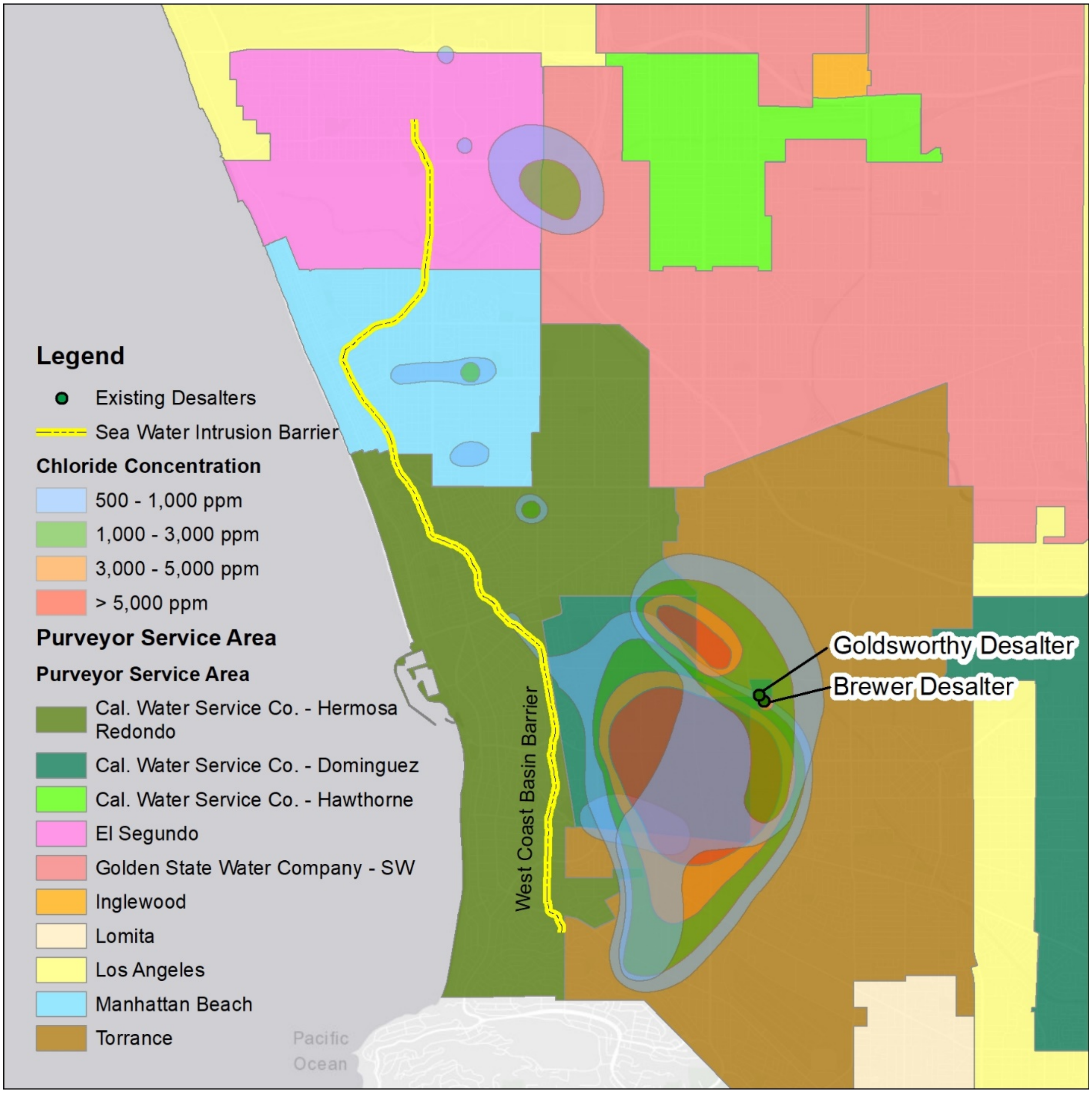

Figure 4-1. Saline Plume in Relation to Purveyor Service Areas

Table 4-1. Evaluation Criteria

No.	Performance Measure	Measure	Range of Performance Spectrum	
			Minimum Score	Maximum Score
Initial Evaluation Criteria for Screening Master List of Project Options to 10 Potential Projects (Quantitative)				
1	Capital Cost[a]	$	$$$	$
2	O&M Cost[a]	$ per AF	$$$ per AF	$ per AF
3	Beneficial Use	$\frac{\text{AF Delivered}}{\text{AF Produced}}$	All remediated water is reinjected into basin	All remediated water is delivered to distribution system
4	Operation within Water Rights	Yes or no	Operation outside of water rights	Operation within water rights
5	Remediated Concentration	mg/L Cl^-	< 500 mg/L	≥ 5,000 mg/L
Final Evaluation Criteria for Screening ~10 Potential Projects to ~5 Projects for Feasibility Study (Quantitative and Qualitative)				
1	Capital Cost[a]	$	$$$	$
2	O&M Cost[a]	$/AF	$$$/AF	$/AF
3	Beneficial Use	$\frac{\text{AF Delivered}}{\text{AF Produced}}$	All remediated water is reinjected into basin	All remediated water is delivered to distribution system
4	Proximity to Other Contaminant Plumes	Distance	Extraction wells require treatment for additional contaminants	No additional treatment is required for other contaminants
5	Permitting Difficulty	Scalable	Project has permitting hurdles that could lead to schedule delays	Project is permittable and the permitting process is not expected to cause delay
6	Ability to meet the Project Need, Purpose, and Objectives	Scalable	Project does not meet the Project Need, Purpose, and Objectives	Project meets the Project Need, Purpose, and Objectives
7	Potential Project Phasing	Scalable	Project cannot be expanded or relocated	Potential for project to be expanded or relocated after a period of operation
8	Greenhouse Gas (GHG) Emissions	Scalable	High GHG emissions	Low GHG emissions
Recommended Future Evaluation Criteria to Determine Preferred Project[b]				
1	Impacts to Existing Extraction Wells	Scalable	Project causes the saline plume is shifted and impacts other drinking water wells	Project does not cause the saline plume to move
2	Impacts to Other Existing Contamination Plumes	Scalable	Project causes other contaminant plumes to shift	Project does not exacerbate other contaminant plumes

[a]Capital and O&M costs are further developed for the final evaluation criteria.

Initial capital costs include the following items:

- Use of existing infrastructure and proximity to connection points
- Proximity to saline plume

Final capital costs include the following items:

- Available property
- Hydraulic limitations
- Conveying water to stakeholders

[b]Future evaluation criteria are recommended for analysis beyond the feasibility level.

Notes:

AF = acre-feet

Cl^- = chloride

mg/L = milligram(s) per liter

O&M = operations and maintenance

5. Initial Master List of Potential Project Options

Based on the system considerations and criteria discussed above, a list of Project Options identified thus far in the planning process are included in Table 5-1. This potential Project Options list was generated from information supplied by the stakeholders, including the saline plume GIS files, water quality of the wells in the area, available properties suggested by both the cities of Torrance and Manhattan Beach, potential brine disposal locations, existing water supply and wastewater infrastructure, among others. In general, the goal is to treat water with greater than 500 ppm chloride ion (roughly 1,000 mg/L TDS); the existing wells in the West Coast Basin containing this level of chloride ion or higher appear to be concentrated near the Madrona Marsh and northwest of the Goldsworthy and Brewer Desalters. Thus, most of the selected treatment locations are in these areas, have enough area to house a groundwater desalination plant, and are within reasonable distance from a LACSD sewer trunk line for potential brine disposal. An alternative dedicated brine line connected to the LACSD's JWPCP effluent/tunnel manifold will be also examined. In addition, other discharge alternatives including ocean discharge and deep well injection will be investigated. Additional treatment processes will be investigated, but it is likely that reverse osmosis will be the most economical treatment.

Each Project Option is listed under the component of an overall system that would constitute a full system Project to meet the Program goals. Project components include elements such as extraction from the saline plume, treatment location, treatment type, conveyance, volume consumed, exchange type, and brine disposal. Also listed for completeness are the potential groundwater replenishment sources, and potential injection locations. The feasibility study will not include an analysis of options for groundwater replenishment, but replenishment to match the volume of water extracted for the saline plume remediation to maintain the basin's water balance must be considered as part of the overall system required for implementation of any Project. Selecting one or more Project Option for each system component will make up a complete Project.

Table 5-1. Initial Master List of Potential Project Options[a]

Project Options listed by Project Components

Project Components:	Extraction	Treatment Location	Treatment Type	Conveyance to Delivery Location	Consumed Volume	Exchange	Brine Disposal	Replenishment Source Water[b]	Injection Location[b]
Project Options:	• Existing Extraction Well(s) • New Extraction Well(s) – Silverado • New Extraction Well(s) – Lower San Pedro	• Elm Ave (Torrance) • Existing Open Lot	• RO	• Existing • New	• Torrance (up to X AFY) • LADWP (up to X AFY) • MB (up to X AFY) • Cal Water (up to X AFY) • GSWC (up to X AFY)	• Existing Intertie • New Intertie • No Intertie (Paper)	• Nearby Sewer Line • Ocean Discharge via Existing Outfall • Ocean Discharge via New Brine Line • Zero Liquid Discharge (ZLD) • Deep Well Injection	• Hyperion Water Reclamation Plant (HWRP) – Existing Treatment (through WBMWD) • HWRP – with Advanced Treatment • JWPCP • Metropolitan Treated Water – Existing Supply • Metropolitan Treated Water – New Supply • Reinjected desalter product water	• Existing Injection Well(s) • New Injection Well(s)

[a] Potential project under each system component listed below will be combined to formulate alternatives that would each meet the project goals.

[b] Replenishment source and injection location are included in this list for project completeness. Analysis of these options is not included in this feasibility study.

Notes:

AFY = acre-feet per year
Cal Water = California Water Service Company
GSWC = Golden State Water Company
HWRP = Hyperion Water Reclamation Plant
JWPCP = Joint Water Pollution Control Plant
LADWP = Los Angeles Department of Water and Power
MB = City of Manhattan Beach
Metropolitan = Metropolitan Water District of Southern California
RO = reverse osmosis
Torrance = City of Torrance

6. Summary and Next Steps

This TM provides standard language for the Program need, purpose, and objectives to guide the feasibility study as well as for subsequent environmental documentation for implementation of select Program Projects.

The water supply and demand analysis conducted during development of the GBMP was extended through current conditions. Detailed summaries of present and future water supplies and demands for the West Coast Basin were provided. Water rights of the major purveyors in the basin were compared with the historical amounts extracted by pumpers to understand the utilization of the basin by individual parties and their future demands. The demands were further divided by the source of supplies, i.e., groundwater, recycled water and imported water. A summary of the current use of the groundwater storage and available storage capacity is presented.

The West Coast Basin adjudication limit is set at 64,468.25 AFY. Based on the data presented in Section 3, the groundwater production in the basin has been well below this limit, with the lowest amount pumped in water year 2016/17. Based on the projected water use in the basin, increased utilization of the West Coast Basin is planned in the future. To supplement the current water portfolio, it is envisioned that the West Coast Basin water purveyors could shift their water demands from other supply sources, such as imported water, to local groundwater that will be pumped by the desalters identified in this study. The recovery of groundwater impacted by the saline plume could provide a multitude of benefits, including additional water supply to meet the potable and non-potable water demands, replenishment water for the basin, basin water quality improvements, and basin storage.

The data presented in this TM will be reviewed by the stakeholders and revised, as needed, for the planning process and ultimate inclusion in the final Feasibility Study Report.

This TM also describes the evaluation criteria that will be applied to develop and assess Projects in this feasibility study. An initial master list of potential Project Options is also provided for consideration. This list of Project Options will be further refined and used to develop systemwide Potential Projects that will undergo additional technical analyses.

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3. Potential Projects and Recommended Short List (Task 1.C)

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Technical Memorandum

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Subject	**Potential Projects and Recommended Shortlist**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019, Finalized March 26, 2021

1. Introduction

In the West Coast Basin (basin), a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, Lynwood, and Lower San Pedro (LSP, equivalent to Sunnyside) aquifers due to historical seawater intrusion and the subsequent implementation of two injection barriers. To more fully utilize the West Coast Basin, the Water Replenishment District of Southern California (WRD) has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to treat the trapped saline plume in the West Coast Basin for beneficial use.

As a part of the Program, WRD has initiated a regional planning effort to evaluate the feasibility of treating the saline plume with seven additional stakeholders (known as the Stakeholder Group). The stakeholders have expressed interest in treating the saline plume, receiving the treated water, or both, as part of this Program. The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water or CWSC)
- West Basin Municipal Water District (WBMWD)

This feasibility study will consist of the evaluation of several project component configurations. The timeframe for reclamation of the entire plume will be targeted to match a 30-year financing period. The Program's first Technical Memorandum titled *Program Context* was finalized on September 24, 2018, and described the Program's purpose, need, and objectives; supply and demand within the West Coast Basin; and project options and evaluation criteria for subsequent project development.

This Technical Memorandum is the second deliverable of this study that describes the development and screening of the master list of Projects. Specifically, the technical memorandum (TM) is organized to include the following:

- Section 1 – Introduction
- Section 2 – Workshop 1 Outcomes
- Section 3 – Summary of Stakeholder Information
- Section 4 – Approach to Project Development
- Section 5 – Model Development
- Section 6 – Projects and Evaluation Results

- Section 7 – Recommended Project Shortlist
- Section 8 – Next Steps
- Section 9 – References

The purpose of this Technical Memorandum is to summarize the properties and facilities identified by the stakeholders to be potentially available for the Program, describe a master list of Potential Projects for development and screening, and provide recommendations on which Projects to carry forward in the study for further analysis.

The input parameters and results presented in this document are for planning purposes only and are based on the available data at the time of the project screening (late 2018). The values in this memorandum should not be considered final and do not commit any stakeholder to accepting water as part of this project.

2. Workshop 1 Outcomes

The first Stakeholder Workshop was held on August 2, 2018, at WRD headquarters. The purpose of the workshop was to bring together the Program's Stakeholder Group to reach a consensus on the goals and objectives for the Program. The workshop also provided an overview of the project development and screening process to be conducted in a subsequent task. The following key outcomes from the workshop were considered in the project development:

- The cost of replenishment water will be included in the study. However, the specific location and impacts of replenishment will be considered in future studies (not in the current scope).
- For the purposes of this study, it is assumed that future pumping will be implemented within existing aggregate West Coast Basin water rights.
- The plume consists of roughly 600,000 acre-feet (AF) of water containing chloride concentrations above 250 milligrams per liter (mg/L). However, plume extraction and treatment will target the approximately 375,000 AF of plume water with 500 mg/L chloride or greater. The distribution of the plume among the West Coast Basin aquifers is estimated as follows:
  - 22,000 AF in the Gage aquifer
  - 113,000 AF in the Silverado aquifer
  - 240,000 AF in the LSP aquifer

In addition to the items listed above, an additional Program goal was discussed that includes having Projects with as many stakeholders as possible involved in the process of receiving and/or treating water.

3. Summary of Stakeholder Information

This section summarizes information provided by the Stakeholder Group and used in the development of the master list of Potential Projects.

3.1 Available Properties

At the commencement of the Program feasibility study, potentially available properties for extraction wells or treatment facilities were solicited from the Stakeholder Group. The suggested properties are identified in Table 3-1 and shown on Figure 3-1. Properties were screened based on proximity to the plume, proximity to the centralized treatment locations, and available area. Properties nearest the plume were selected as Potential Project components and used in the project development. The properties not selected during Project development may be available for use in future detailed development of the Program, as needed.

Well locations that were selected for consideration are locations where:

- The available water quality data show that the well intercepts high-TDS water.

- The well is located in the middle or eastern edge of the plume. As more freshwater is reinjected to the barrier and brackish water is removed from the plume, it is expected that the plume will migrate to the east. Locating the wells near the eastern edge of the current plume may avoid the needing to drill new wells to access the brackish water as the plume migrates to the east, but this will require further modeling and investigation.
- One Project (No. 19 in Table 6-1) will include a portable treatment system that, together with additional extraction wells above and beyond the extraction wells shown on Figure 3-1, has potential to treat the entire plume, including the northern section of the plume in the upper aquifers (Figure 3-1). However, most of the Projects do not treat these upper aquifers of the plume because there is not enough water to support permanent treatment facilities of substantial size.

Table 3-1. Properties Identified by Stakeholder Group

Agency	Property Name	Property Address	Potential Property Use	Used in Project Development
GSWC	Oceangate Plant	5016 133 Road Hawthorne, CA 90250	Centralized Treatment	No, too far north of plume area
LACSD	Joint Water Pollution Control Plant (JWPCP)	24501 S Figueroa Street Carson, CA	Centralized Treatment	Yes, although not near the plume, this location has potential advantages for brine disposal
LADWP	Lomita 1	Campus Drive Wilmington, CA 90744	Well	No, too far from plume water
LADWP	Lomita 4	Campus Drive Wilmington, CA 90744	Well	No, too far from plume water
LADWP	Lomita 5	West Lomita Boulevard and Frigate Avenue Wilmington, CA	Well	No, too far from plume water
LADWP	Lomita 6	1744 Eudora Avenue Wilmington, CA 90744	Well	No, too far from plume water
LADWP	Lomita 7	1624 Eudora Avenue Wilmington CA 90744	Well	No, too far from plume water
Lomita		24925 Walnut Street Lomita, CA	Well	No, property is too narrow for Centralized Treatment plant and is not over the plume
Manhattan Beach	Peck Reservoir Site	1800 N. Peck Avenue Manhattan Beach, CA	Centralized Treatment	No, too far for the majority of the plume water
Manhattan Beach	8th St. Parquet	1746 Eight Street Manhattan Beach, CA	Well	No, too far for the majority of the plume water
Manhattan Beach	Southwest Corner 6th and Aviation	6th Street and Aviation Boulevard, Manhattan Beach, CA	Well	No, too far for the majority of the plume water
Torrance	Brewer Desalter	405 Maple Avenue Torrance, CA 90503	Desalter	Yes
Torrance	Goldsworthy Desalter	20520 Madrona Avenue Torrance, CA 90503	Desalter	Yes
Torrance	Elm and Faysmith	1001 Elm Avenue Torrance, CA	Centralized Treatment	Yes
Torrance	Alta Loma Park	26126 Delos Drive Torrance, CA 90505	Well	No, too far south of the plume and Centralized Treatment locations
Torrance	Columbia Park	4045 190th Street Torrance, CA 90504	Well	No, too far from Centralized Treatment locations

Table 3-1. Properties Identified by Stakeholder Group

Agency	Property Name	Property Address	Potential Property Use	Used in Project Development
Torrance	De Portola Park	25615 Lazy Meadow Drive Torrance, CA 90505	Well	No, too far south of plume water
Torrance	Delthorne Park	3401 Spencer Street Torrance, CA 90503	Well	No, recent addition of new extraction well for Goldsworthy expansion
Torrance	Descanso Park	2500 Descanso Way Torrance, CA 90504	Well	No, too far from plume
Torrance	Discovery Park	Ocean Avenue and 226th Street, Torrance, CA 90505	Well	No, too far from Centralized Treatment locations
Torrance	El Nido Park	18301 Kingsdale Avenue Redondo Beach, CA 90278	Well	No, too far from Centralized Treatment locations
Torrance	El Prado Park	El Prado Avenue Torrance, CA 90501	Well	No, too far from plume
Torrance	El Retiro Park	126 Vista del Parque Redondo Beach, CA 90277	Well	No, west of plume water
Torrance	Entradero Park	5500 Towers Street Torrance, CA 90503	Well	No, too far from Centralized Treatment locations
Torrance	Greenwood Park	1520 Greenwood Avenue Torrance, CA 90503	Well	No, just east of high salinity plume
Torrance	Guenser Park	17800 Gramercy Place Torrance, CA 90504	Well	No, not over plume
Torrance	Hickory Park	2850 232nd Street Torrance, CA 90503	Well	No, not over plume
Torrance	La Carretera Park	2040 186th Street Torrance, CA 90504	Well	No, northeast of plume
Torrance	Seaside Heroes Park	22851 Anza Avenue Torrance, CA 90505	Well	No, too far from Centralized Treatment locations
Torrance	La Paloma Park	Lomita Boulevard east of Anza, Torrance, CA 90505	Well	No, too far from Centralized Treatment locations
Torrance	La Romeria Park	19501 Inglewood Avenue Torrance, CA 90503	Well	No, too far from Centralized Treatment locations
Torrance	Lago Seco Park	3920 235th Street Torrance, CA 90505	Well	No, too far from Centralized Treatment locations
Torrance	Los Arboles Park	5101 Calle de Ricardo Torrance, CA 90505	Well	No, southwest of plume
Torrance	McMaster Park	3624 Artesia Boulevard Torrance, CA 90504	Well	No, too far from Centralized Treatment locations
Torrance	Miramar Park	201 Paseo de la Playa Redondo Beach, CA 90277	Well	No, far west of plume – on the beach
Torrance	Osage Park	17008 Osage Avenue Torrance, CA 90504	Well	No, north of plume
Torrance	Paradise Park	5006 Lee Street Torrance, CA 90503	Well	No, too far from Centralized Treatment locations
Torrance	Pequeno Park	Regina Avenue and 180th Street, Torrance, CA 90504	Well	No, not over an area of the plume with > 250 mg/L chloride

Table 3-1. Properties Identified by Stakeholder Group

Agency	Property Name	Property Address	Potential Property Use	Used in Project Development
Torrance	Pueblo Park	2252 Del Amo Boulevard Torrance, CA 90501	Well	No, not over the plume
Torrance	Riviera Park	Catalina Avenue and Palos Verdes Drive Redondo Beach, CA 90277	Well	No, far to the west of the plume area
Torrance	Sea-Aire Golf Course	22730 Lupine Drive Torrance, CA 90505	Well	No, not over an area of the plume with > 250 mg/L chloride
Torrance	Sunnyglen Park	5525 Del Amo Boulevard Torrance, CA 90503	Well	No, too far from Centralized Treatment locations
Torrance	Sur La Brea Park	23610 Cabrillo Avenue Torrance, CA 90501	Well	No, not over plume
Torrance	Torrance Park	2001 Santa Fe Avenue Torrance, CA 90501	Well	No, not over plume
Torrance	Victor Park	4727 Emerald Street Torrance, CA 90505	Well	No, not close to Centralized Treatment locations
Torrance	Walteria Park	3855 242nd Street Torrance, CA 90505	Well	No, not over the plume
Torrance	Wilson Park (Charles H.)	2200 Crenshaw Boulevard Torrance, CA 90501	Well	No, not over the plume
Torrance	Well No. 8	Abalone Avenue and W 223rd Street Torrance, CA 90401	Well	No, could not find water quality information
Torrance	Well No. 7	2223 Border Avenue Torrance, CA 90501	Well	No, chloride level less than 500 mg/L
Torrance	Madrona Marsh Center East	3201 Plaza del Amo Torrance, CA 90503	Well	Yes
Torrance	Madrona Marsh Center West	3201 Plaza del Amo Torrance, CA 90503	Well	Yes
Torrance	Madrona Marsh Sepulveda Madrona	Madrona Avenue and Sepulveda Boulevard Torrance, CA 90503	Well	Yes
Torrance	Madrona Avenue and Fashion Way	21405 Madrona Avenue Torrance, CA 90503	Well	Yes
Torrance	Del Amo Shopping Center Former Parking Lot 1	Madrona Avenue and Onrado Street Torrance, CA 90503	Well	Yes
Torrance	Del Amo Shopping Center Adjacent to Parking Lot 1	Madrona Avenue and Onrado Street Torrance, CA 90503	Well	Yes
Torrance	Orduna Well/Sepulveda 2	4555 Sepulveda Torrance, CA	Well	Yes
Torrance	Sepulveda and Maple Avenue	Sepulveda and Maple Avenue, Torrance, CA	Well	Yes
Torrance	Madrona Middle School	Madrona Avenue and Opal Street, Torrance, CA	Well	Yes
Torrance	First Christian Church	El Dorado and Maple Avenue, Torrance, CA	Well	Yes

Table 3-1. Properties Identified by Stakeholder Group

Agency	Property Name	Property Address	Potential Property Use	Used in Project Development
Torrance	Ocean Sump	21800 Talisman Street Torrance, CA	Well	No, too far from Centralized Treatment locations
Torrance	Del Amo Sump	21735 Madrona Avenue Torrance, CA	Well	Yes
Torrance	Torrance Police Station	3300 Civic Center Drive Torrance, CA	Well	Yes
Torrance	Sepulveda 1	Not available	Well	Yes
West Basin	Juanita McDonald Carson Regional Recycling Facility	21029 South Wilmington Avenue, Carson, CA	Well	No, not close to the plume

Note:

LACSD = Los Angeles County Sanitation Districts

3.2 Available Facilities

The following is a list of existing facilities suggested by the Stakeholder Group for consideration in project development:

- **Robert W. Goldsworthy Desalter.** The Goldsworthy Desalter is an existing brackish groundwater treatment facility owned by WRD and operated by the City of Torrance. The facility began operation in 2001 with a capacity of 2.5 million gallons per day (mgd). In 2018, the facility was expanded to 5.0 mgd, which is equivalent to 5,800 acre-feet per year (AFY) extracted and 4,500 AFY of potable water produced. This expansion represents the full build out of the facility. The location of the Goldsworthy Desalter is shown on Figure 3-1.
- **C. Marvin Brewer Desalter.** The Brewer Desalter is an existing brackish groundwater treatment facility owned by WBMWD and operated by Cal Water. The facility was built on a site owned by Cal Water and is located in the City of Torrance. The current estimated extraction capacity of the desalter is 900 gallons per minute (gpm) or roughly 1,500 AFY. The location of the Brewer Desalter is shown on Figure 3-1. Brewer is a small facility and adding a substantial amount of capacity would be equivalent to constructing a new facility. The possibility of expanding into an existing bus parking area between the Goldsworthy and Brewer Desalters had been raised at a Stakeholder Workshop; however, that site is federally owned and is thus not suitable for expansion or a new desalter.
- **Madrona Lateral.** The Madrona Lateral is an existing, partially unused, recycled water pipeline owned by WBMWD. Potential incorporation into the Project was suggested by Torrance (through which the pipeline is routed). WBMWD will further investigate the viability of using this pipeline in the Potential Projects. Location of the Madrona Lateral is shown on Figure 3-1.

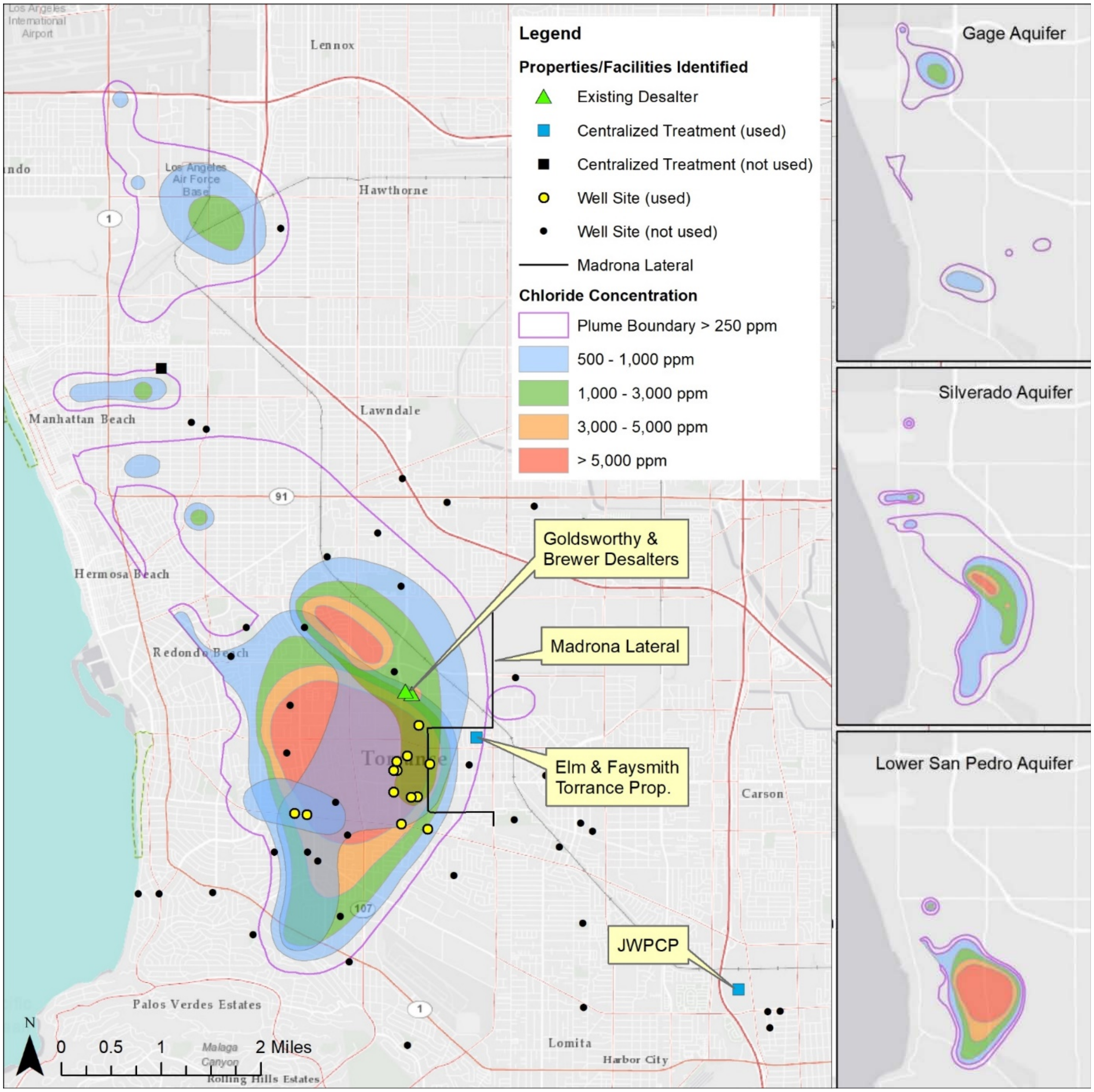

Figure 3-1. West Coast Basin Saline Plume and Existing Groundwater Desalters

3.3 Maximum Acceptable Volume of Product Water

Within the Stakeholder Group, there are six water purveyor agencies identified to serve the product water to customers. The purveyor agencies were asked to estimate the maximum volume of product water they would be willing to accept into their systems from the Program to offset the purchase of imported water, based on current and future demands. Table 3-2 summarizes the annual volume of product water each purveyor is willing to accept. To represent seasonal variations, demands were further broken down by monthly increments and is further discussed in Section 6.

The values shown in Table 3-2 are only estimates and may change as the project progresses. The actual volume that can be accepted will be dependent on the final delivery location, storage, and system hydraulics for each stakeholder.

Table 3-2. Maximum Acceptable Product Water Volume by Purveyor

Purveyor	Maximum Acceptable Product Water Amount (AFY)
Cal Water	9,500
GSWC	13,000
LADWP	10,000
City of Lomita	2,500
City of Manhattan Beach	3,620
City of Torrance	5,000
Note that West Basin does not have any water rights within the adjudication.	

3.4 Product Water Delivery Locations

To deliver the product water into the potable water distribution system, preferred potential delivery locations were identified by each purveyor. Existing and potential intertie locations were also identified as a potential for water "wheeling," where the potable water produced by the Program is delivered to one or more stakeholders and transferred to another stakeholder via piping intertie. Table 3-3 lists the potential delivery locations and interties. Where water wheeling was not possible due to limited distribution system capacity, intertie locations were also considered delivery locations.

Table 3-3. Potential Product Water Delivery Locations

Agencies	Location	Type
Torrance → Cal Water	• **Del Amo Boulevard and Maple Avenue** • Walnut and Middlebrook • **Sepulveda and Ellinwood**	Existing Emergency Connection
Torrance → Lomita	• **Arlington Avenue and 239th Street** • Pennsylvania Avenue and 240th Street	Existing Emergency Connection[1]
Lomita → LADWP	• Palos Verdes Drive (Pineknoll Avenue and Leesdale Avenue)	Existing Emergency Connection
Manhattan Beach ↔ Cal Water and El Segundo	• **Manhattan Beach Boulevard and Redondo Beach Boulevard**	Existing Emergency Connection
Golden State ↔ LADWP	• Century Boulevard and Wilton Place	Existing Emergency Connection[1]
Golden State ↔ Cal Water	• Victoria and Central	Existing Emergency Connection
Torrance → LADWP	• **Normandie Avenue and 190th Street** • Western Avenue and Sepulveda Boulevard • **Normandie Avenue and Del Amo Boulevard**	Potential Intertie
Torrance → Golden State	• **166th and Gramercy** • 164th and Gramercy	Potential Intertie
Torrance → Cal Water	• Madrona Avenue and Emerald Street	Potential Intertie
LADWP	• *Sepulveda and Normandie* • Torrance and Normandie	Potential Delivery Location
Torrance	• ***Elm and Faysmith Property***	Potential Delivery Location
Lomita	• *WB-7: Turrell Street and Walnut Street*	Potential Delivery Location

Table 3-3. Potential Product Water Delivery Locations

Agencies	Location	Type
Cal Water	• WB-29: Manhattan Beach and Redondo Street • *WB-2B: Manhattan Beach and Inglewood* • WB-5: Manhattan Beach and Redondo Beach • 511 S. Lucia Avenue • 1700 Rockefeller • Maple Avenue and Del Amo Boulevard	Potential Delivery Location
Manhattan Beach	• *Manhattan Beach and Redondo Ave*	Potential Delivery Location
Golden State	• *Hawthorne and Redondo Beach Blvd*	Potential Delivery Location

Notes:

Bolded locations indicate interties used in project development.

Italicized locations include delivery locations used in Projects 1 to 13

[1]There is some uncertainty regarding the existence of this connection

4. Approach to Project Development

This section describes the approach and key assumptions applied to develop a range of Potential Projects that meet the goals and objectives of the Program. Each Potential Project consists of combinations of options for each of the following project components:

- Brackish water extraction
- Brackish water treatment
- Conveyance of:
  - Brackish water to treatment
  - Treated product water to purveyors
- Brine disposal
- Groundwater replenishment volume

To establish the target capacities for each of these Project components, a range of extraction rates was identified, as described below.

4.1 Extraction Rates and Treatment Durations

Initial development of the Potential Projects considered the following three primary factors: the target plume volume, a range of extraction rates, and a project financing period of 30 years that establishes the project duration.

With the decision to target chloride concentrations greater than 500 mg/L, the approximate plume size was reduced from the original concept that would treat approximately 600,000 AF to a smaller, estimated plume volume of 375,000 AF.

A range of extraction rates was identified as described below. For costing purposes, extraction rates were varied to provide a range of anticipated treatment durations for the Program.. In addition, the operation of the existing Goldsworthy and Brewer Desalters, which each currently extract and treat water from the plume, will affect the extraction rate required for the new desalters. The bolded items describing this approach to developing the range of extraction rates and associated project durations are summarized in Table 4-1.

a. For the original 600,000 AF plume, treatment over the **30-year financing period** yielded an average annual extraction rate of **20,000 AFY**. This established the **maximum new desalter extraction rate** that is considered for project formulation.

b. Applying the 20,000 AFY annual extraction rate to the smaller 375,000-AF plume results in remediation of the plume within a **minimum duration of 20 years**. This treatment period is referred to as **the Minimum Treatment Duration** of the treatment plant operation and includes the desalination treatment process. Extraction of this target plume volume for treatment will be distributed among the three aquifers. See Figure 4-1.

The treatment plant is then assumed to continue "operation" for up to an additional **10 years** of the financing period. This is referred to as **the Additional Pumping Duration** and will not require operation of the desalination system. The extracted groundwater, no longer requiring chloride removal, would bypass the desalination process and be delivered directly to the distribution system, likely with minimal additional treatment such as chlorination and fluoridation. See Figure 4-2. Note that, although manganese is present in the groundwater, the graphs in the *Source Water Characterization TM* of this Program feasibility study indicates that the manganese levels have been decreasing over time and likely will be below California's secondary maximum contaminant level of 0.05 mg/L in the near future.

c. To establish the lower end of the extraction range, the smaller treatment of the 375,000-AF plume over the full 30-year financing period yields an average annual extraction rate of **12,500 AFY**.

d. With the existing desalters operating at their full design capacities, their total extraction rate will be approximately **7,300 AFY** (5,800 AFY from Goldsworthy and 1,500 AFY from Brewer) and will continue to operate at the current rate.

e. Thus, the upper end of the extraction range for the project development consists of the maximum new desalter extraction rate of 20,000 AFY plus the 7,300 AFY from the existing desalters, for a total of **27,300 AFY**. At this higher total extraction rate, the Minimum Treatment Duration is reduced to **14 years**, and the Additional Pumping Duration is thus extended to **16 years**.

f. And, on the lower end of the extraction range, with 7,300 AFY of extraction from the existing desalters, the 12,500 AFY average annual extraction over 30 years would be achieved with a small, new desalter of **5,200 AFY**.

Table 4-1. Projected Treatment Durations

Bullet ID	Plume Size (AF)	Plume Chloride Concentration (mg/L)	Project Duration (Years)	Total Extraction Rate: Existing + New Desalters (AFY)	Minimum Treatment Duration (Years)	Additional Pumping Duration (Years)
a	600,000	≥250 mg/L	30	20,000	30	---
b	375,000	≥500 mg/L	30	20,000	20	10
c	375,000	≥500 mg/L	30	12,500	30	---
d, e	375,000	≥500 mg/L	30	27,300 • 7,300 existing desalters • 20,000 new desalters	14	16
f	375,000	≥500 mg/L	30	12,500 • 7,300 existing desalters • 5.200 new desalters	30	---

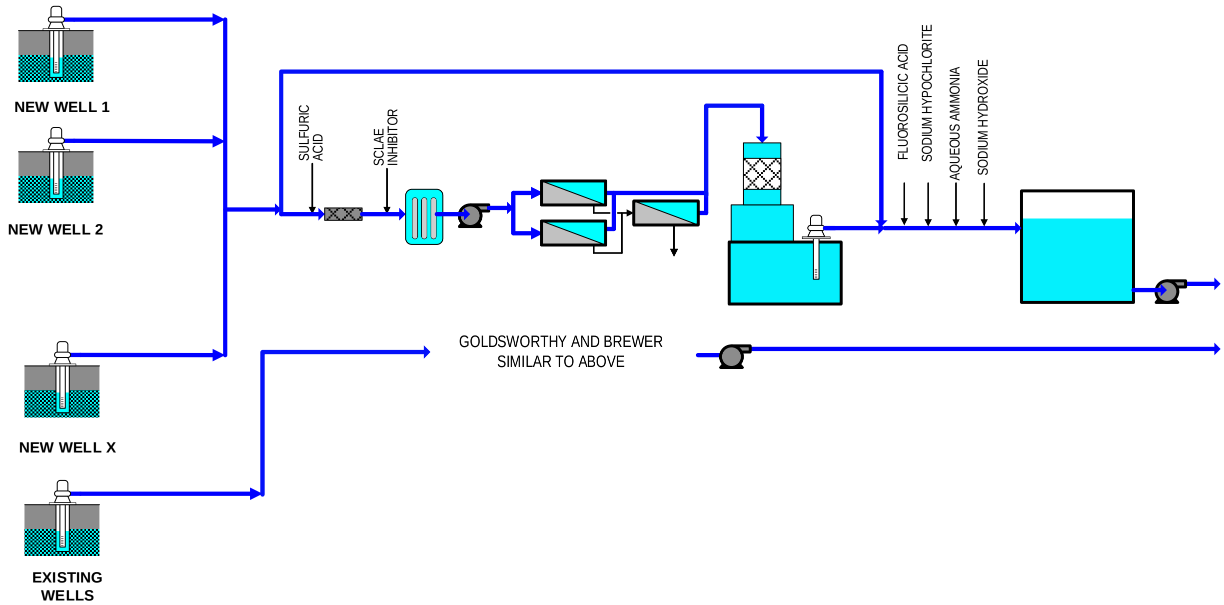

Figure 4-1. Plume Treatment Process Flow Diagram for Minimum Treatment Duration Phase

Once the extracted plume water contains less than 500 mg/L chloride ion, the treatment process would revert to what is shown on Figure 4-2. It is possible that additional treatment, such as manganese removal, may be required in subsequent phases of the Program. The treatment shown on Figure 4-2 is used for the initial screening of alternatives and is not the final treatment configuration.

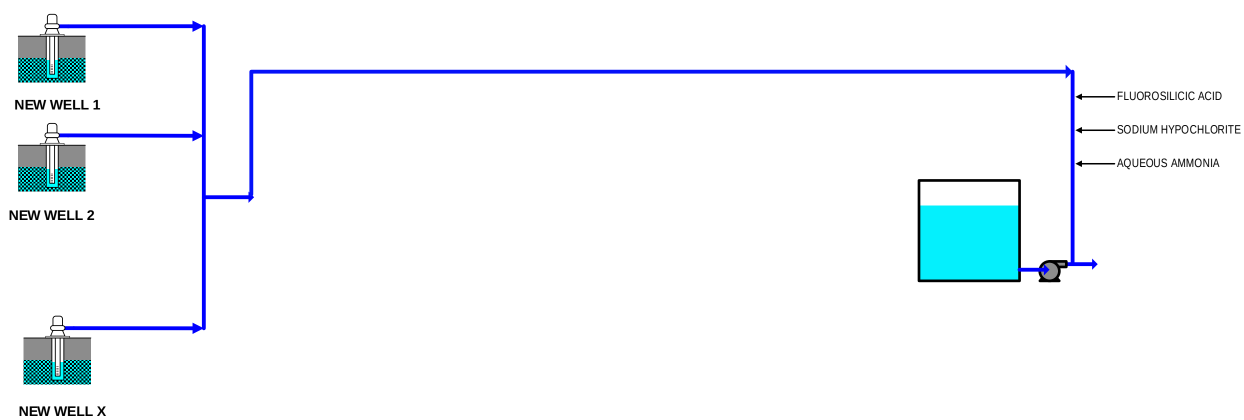

Figure 4-2. Plume Treatment Process Flow Diagram for Additional Pumping Duration Phase

4.2 Project Component and Delivery Volume Assumptions

In defining the initial facility and delivery requirements of the Potential Projects, several key assumptions were applied to the analysis and are summarized in Table 4-2. These assumptions will be revised and refined as the Potential Projects are further developed in later tasks of this Program.

Table 4-2. Project Component Assumptions

Component	Key Assumptions
Brackish Water Extraction	• Considers the use of 2 existing well • Well production rate of 2,000 AFY per well (existing and new) • Up to 10 production wells with 1 redundant well (11 wells total) for 20,000 AFY extraction
Brackish Water Conveyance	• New conveyance with the exception of the Madrona Lateral
Brackish Water Treatment	• Up to two centralized treatment facilities and/or up to 11 wellhead treatment systems
Product Water Conveyance	• Maximize use of existing infrastructure (including portions of Madrona Lateral) • Product water can be delivered through interties or preferred locations identified by purveyors; the impact of blending the product water with distribution system water should be addressed in the next phase of the Program • Considered new piping • Torrance's distribution system at Elm & Faysmith property has a capacity of 8,500 AFY (20-inch) • Intertie and pipe capacities were developed assuming a velocity of 7 fps
Brine Disposal	• Brine is discharged to the sanitary sewer • Additional brine disposal options, including separate brine line with connection to JWPCP tunnel/outfall, will be considered in subsequent screening
Groundwater Basin Replenishment	• Replenish 80 percent of extracted volume to the barrier • Replenishment cost of $339/AF with 3 percent annual escalation

4.3 Saline Plume Treatment

The groundwater treatment process required to desalinate the brackish plume water is depicted on Figure 4-1 and is similar to the processes currently used at the existing Goldsworthy and Brewer Desalters. Treatment consists of well water extraction, chemical adjustment with sulfuric acid and/or scale inhibitor (to prevent precipitation in the reverse osmosis [RO] process), 5-micron cartridge filtration, desalination via RO, air stripping, and post treatment chemical addition required to condition the water such that it is noncorrosive and suitable for public health, including chloramination, and fluoridation. It is anticipated that up to 5 percent of the extracted groundwater may be able to bypass the desalination system and blend with the treated water. This treatment process was assumed for all of the Projects. This treatment configuration was used for all Projects to allow for direct comparisons based on treated volumes. The final treatment process will be determined in later portions of the feasibility study.

5. Model Development

Two tools were utilized to develop and compare the Projects. The Jacobs' Conceptual and Parametric Engineering System (CPES) was used to develop construction costs for pipelines and treatment plants and annual operations costs for treatment plants. Voyage, a dynamic simulation software, was used to model both the water balance associated with each Project and the cost of each Project.

CPES is a tool that generates conceptual-level designs and cost estimates with minimal upfront information. The tool uses parametric engineering algorithms based on information from previous projects that have been successfully implemented. This eliminates the need for scaling factors and other rules of thumb typically used in early cost estimates and allows CPES to produce cost estimates with Class IV accuracy (+50 percent to -30 percent). Tables 5-1A and 5-1B include the costs generated by CPES that are used in the study. Costs are presented in 2019 dollars.

Table 5-1A. Pipeline Costs

Length, miles		0.19	0.38	1.00	2.00	3.00	5.50
Length, feet		1,000	2,000	5,280	10,560	15,840	29,040
Diameter, inch	4	$260,000	$870,000	$1,500,000	$2,600,000		
	6	$300,000	$970,000	$1,800,000	$3,100,000		
	8	$350,000	$1,100,000	$2,000,000	$3,700,000		$9,600,000
	12	$460,000	$1,300,000	$2,600,000	$4,800,000	$7,200,000	
	16	$560,000	$1,500,000	$3,100,000	$5,800,000	$8,800,000	$16,000,000
	24	$770,000	$1,900,000	$4,200,000	$8,000,000	$12,000,000	
	30	$1,000,000	$2,200,000	$5,100,000	$10,000,000	$14,800,000	
	36	$1,100,000	$2,500,000	$5,900,000	$11,400,000	$17,000,000	

Table 5-1B. Treatment Plant Costs

Feed Flow AFY	Feed Flow mgd	CAPEX Installed/plant ($)	OPEX Annual OPEX/plant ($)
2,000	1.8	36,100,000	1,600,000
3,333	3.0	40,000,000	2,000,000
4,000	3.6	43,000,000	2,300,000
5,000	4.5	46,000,000	2,650,000
6,667	6.0	53,000,000	3,450,000
10,000	8.9	68,000,000	5,200,000
12,500	11.2	75,000,000	5,700,000
20,000	17.9	95,000,000	8,400,000

Notes:

CAPEX = capital cost or expenditure
OPEX = operating cost or expenditure

For this task, it is assumed that the brine would be disposed of in the sanitary sewer. This will be studied further in subsequent study tasks. LACSD has developed a rate structure for the disposal of wastes into their distribution system. The rate structure includes both an initial connection fee and an annual surcharge, as follows (LACSD, 2019):

$$\text{Connection Fee} = R[(X * \text{Flow}/260) + (Y * \text{COD}/1.22) + (Z * \text{TSS}/0.59)]$$

Where:

- Flow in is gallons per day (gpd)
- R is the cost per capacity unit, $4,015
- X is capital cost factor (for an incremental expansion of the sewer system) for flow, 0.67
- Y is capital cost factor for COD, 0.13
- Z is capital cost factor for TSS, 0.2

- COD and TSS are "chemical oxygen demand" of the water and "total suspended solids," respectively, in units of 1,000 pounds per year (lb/year). For these, Jacobs assumed the following:
  - COD of 1 mg/L
  - TSS of 1 mg/L

And the annual surcharge =

(Volume * $746) + (COD * $131.90) + (TSS * $372.7) + ([2.5Log(P/Q) * $98.90 * P]

Where:

- V is the annual volume in millions of gallons
- P is the peak flow over 20 min in gpm, and
- Q is the average flow in gpm

The Voyage model was designed to assess the feasibility of each Project in terms of water use and to calculate quantities that would be used for estimating the cost of each Project. The water balance portion of the Voyage model considers not only the plume size and how long it takes to treat the plume at varying extraction rates, but also how much water is being lost during treatment; it also compares the delivered amount to the capacity available to each stakeholder. This analysis was conducted on a monthly basis to understand the seasonal variability, with assumptions for stakeholders that did not have monthly data available.

The water use portion of the model was also used to develop quantities that are required for calculating the costs of Projects, such as operating time for wells and treatment plants and amount of brine disposal required.

The following assumptions were used in the cost development:

- **Wells –** From a recent (2016) desalter expansion project in southern San Diego County (Sweetwater Authority Reynolds Plant), the average extraction well cost was $1.4 million for 1,750-AFY wells. For a 2,000-AFY extraction well, this is roughly equivalent to $2 million; thus $2 million was used as the new extraction well CAPEX. To operate the wells, an electrical cost of $0.105 per kilowatt hour (kWh) was used.
- **Treatment Plant –** RO treatment with 90 percent recovery. Analysis of the water quality data from the monitoring wells nearest to the new extraction well locations indicates that this is an appropriate recovery to use at this juncture of the Program. The CAPEX includes contractor markups, 30 percent contingency, and a location adjustment factor. The OPEX includes labor, chemicals, and energy, assuming $0.105/kWh for electricity. (The 90 percent recovery was subsequently changed to 85 percent when Task 1.E was completed.)
- **Piping –** High-density polyethylene (HDPE) standard dimension ratio (SDR) 17 (160 pounds per square inch [psi]) pressure piping with open cut installation. Includes contractor markups, 30 percent contingency, and location adjustment factor. For each Project, the lengths and diameters of piping were estimated based on the collection and delivery locations.
- **Brine Disposal** – For Projects that discharge brine to the sewer system, the connection fee and annual surcharge are based on the LACSD industrial wastewater ordinance computation, listed above.
- All CAPEX costs are marked up 2 percent for permitting, 2 percent for commissioning and startup, 8 percent for engineering and construction services, and 8 percent for engineering.

Table 5-2 shows an example of how the cost of water per AF delivered was calculated for Project 1, which produces a total of 18,000 AFY from the 20,000 AFY of extracted water (at a 90 percent recovery rate).

Table 5-2. Example Project Cost Calculation – Project 1: Spread Across Stakeholders with Two Wellhead Treatment Units

Component	Quantity	Unit Cost ($)	Capital Cost[g] ($)	Average Annual Cost ($)	Cost per AF Delivered[a, b] ($)
New Extraction Wells	9[f]	2,000,000 each	18,000,000		42
Energy for Wells	1163 kWh per day	0.11/kWh		1,100,000	64
Collection System Pipe[c]	1.06 miles of 24 inch	4,300,000/mile	4,600,000		11
	0.62 miles of 16 inch	3,400,000/mile	2,100,000		5
	0.25 miles of 12 inch	3,000,000/mile	800,000		2
	0.62 miles of 36 inch	6,100,000/mile	3,800,000		9
Elm and Faysmith Treatment Plant	16,000 AFY		85,000,000		197
Elm and Faysmith Plant OPEX/O&M	14 years of treatment	7,000,000/year		3,300,000	191
WHT	4,000 AFY		72,000,000		167
WHT OPEX/O&M	14 years of treatment	3,000,000/year		1,400,000	81
Brine Disposal Connection[d]	3	6,000,000 each	18,000,000		42
Brine Disposal Surcharge[d]	14 years of treatment	544,000/year		254,000	15
Conveyance Pipe to[c]					
Torrance	None		0		0
GSWC	3.8 miles of 16 inch	3,200,000/mile	12,000,000		28
Manhattan Beach	2.7 miles of 16 inch	2,900,000/mile	7,800,000		18
LADWP	3.1 miles of 12 inch	2,400,000/mile	7,500,000		18
Cal Water	2 miles of 16 inch	3,000,000/mile	6,000,000		14
Lomita	1.4 miles of 12 inch	3,000,000/mile	4,000,000		9
Shared Costs[d]	1	5,000,000 each	5,000,000		12
Replenishment[e]					538
Total[a,b]			**296,500,000**	**6,100,000**	**1,460**

[a] Assumes markups of 2 percent for permitting, 2 percent for commissioning and startup, 8 percent for engineering and construction services, and 8 percent for engineering. Applied to capital costs only.

[b] Assumes 350 days of operation per year for operational costs.

[c] Per mile cost varies by pipe diameter and length of pipe installed.

[d] Shared costs are the excavation costs for pipes that can share a trench.

[e] Replenishment cost represents the average cost over the 30-year planning period with 3 percent annual escalations and was added on a per-AF basis for all alternatives.

[f] Note that Project 1 includes the use of two existing wells: Sepulveda 1 and 2.

[g] Capital costs do not include additional costs for financing.

Note:

WHT = wellhead treatment

6. Projects and Evaluation Results

Projects were developed by combining options for collection, treatment, brine disposal, and delivery, which were described in Section 4. Projects were initially developed with a goal in mind, such as delivering water to all stakeholders taking advantage of existing infrastructure such as the Madrona Lateral. Variations on these Projects were developed by varying one or more project components, such as lower delivery volumes or different distribution piping configurations (e.g., use of interties or no interties). This is used to test the sensitivity of the Projects to changes in project configuration and aids in the development of the shortlist of Projects that will be developed further.

Table 6-1 lists the 29 Projects that were evaluated. For each Project, the table includes a brief description, the number of required extraction wells, type of treatment and capacity, the total new and existing extraction volumes, the amount of water delivered to each stakeholder on an annual average basis, and which brine disposal option is assumed. The following additional information was used in the model but is not reflected in Table 6-1:

- Detail on collection and distribution pipe size and length for each Project
- Monthly distributions of the demands and capacity for each stakeholder to accept water at specific connection points

A conceptual layout of the brackish water and product water pipe routing for Project No. 15 is shown on Figure 6-1. The Project utilizes interties for product piping location and includes the use of the Madrona Lateral.

Projects deliver water to stakeholders either by new piping, use of interties, primarily with Torrance, or both. Projects 1 to 13 use all new piping for product (potable) water distribution. Most of the other projects use interties or a combination of new piping and interties as described in Table 6-1. Product water delivered to stakeholders in new piping is 100 percent desalinated groundwater from the Project. Intertie water is a mixture of desalinated groundwater from the Project and other water in the Torrance distribution system.

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Table 6-1. List of Potential Projects

			Treatment Locations						Water Delivery Locations							Brine Disposal
	Potential Project - General Description	Extraction Wells	Elm and Faysmith (Torrance)	Wellhead (WHT)	Goldsworthy and Brewer	JWPCP	Total New Extraction, AFY	Total Existing Extraction (Goldsworthy and Brewer), AFY	Torrance	Golden State Water	Manhattan Beach	LADWP	Cal Water	Lomita	Total New Product Delivery, AFY	Sewer (SWR) or Brine Line (BL)
1	Spread Across Stakeholders (20,000 AFY)	8 new wells, 2 existing (WHT)	16,000	4,000	7,300	-	20,000	7,300	3,500	3,000	3,000	3,000	3,000	2,500	18,000	SWR
2		9 new wells, 1 existing (WHT)	18,000	2,000	7,300	-	20,000	7,300	3,500	3,000	3,000	3,000	3,000	2,500	18,000	SWR
3		10 new wells	20,000	-	7,300	-	20,000	7,300	3,500	3,000	3,000	3,000	3,000	2,500	18,000	SWR
4	Torrance, GSWC, LADWP (Highest Delivery), Lomita (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	2,500	-	8,000	-	2,500	18,000	SWR
5	Torrance, GSWC (Highest Delivery), LADWP (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	11,000	-	2,000	-	-	18,000	SWR
6	Torrance, GSWC (Highest Delivery), Manhattan (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	11,000	2,000	-	-	-	18,000	SWR
7	Torrance, GSWC, Cal Water (Highest Delivery) (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	5,500	-	-	7,500	-	18,000	SWR
8	Torrance, GSWC, LADWP (Highest Delivery) (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	5,000	-	8,000	-	-	18,000	SWR
9	Spread Across Stakeholders with 1 existing well (20,000 AFY)	9 new wells, 1 existing	20,000		7,300	-	20,000	7,300	3,500	3,000	3,000	3,000	3,000	2,500	18,000	SWR
10	All Wellhead with Distribution Piping (20,000 AFY)	8 new wells, 2 existing	-	20,000	7,300	-	20,000	7,300	5,000	11,000	2,000	-	-	-	18,000	SWR
11	Two Centralized Plants (20,000 AFY)	10 new wells	7,500	-	7,300	12,500	20,000	7,300	5,000	2,500	-	8,000		2,500	18,000	SWR
12	JWPCP (20,000 AFY)	10 new wells	-	-	7,300	20,000	20,000	7,300	5,000	2,500	-	8,000		2,500	18,000	BL
13	Torrance, GSWC, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	5,000	-	8,000	-	-	18,000	BL
14	Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	-	-	5,000	6,500	1,500	18,000	SWR
15	Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties and Madrona Lateral (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	-	-	5,000	6,500	1,500	18,000	SWR
16	Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties and Madrona Lateral (12,700 AFY)	8 new wells	12,700	-	7,300	-	12,700	7,300	4,000	-	-	3,000	4,060	1,000	12,060	SWR
17	Spread Across Stakeholders via Interties and Madrona Lateral (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	4,100	900	1,000	2,750	1,500	1,000	11,250	SWR
18	Spread Across Stakeholders via interties with New Pipeline to Manhattan Beach (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	4,100	900	1,000	2,750	1,500	1,000	11,250	SWR
19	Spread Across Stakeholders via interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (12,500 AFY)	10 new wells	10,500	2,000	7,300	-	12,500	7,300	4,100	900	1,000	2,750	1,500	1,000	11,250	SWR

Table 6-1. List of Potential Projects

			Treatment Locations						Water Delivery Locations							Brine Disposal
	Potential Project - General Description	Extraction Wells	Elm and Faysmith (Torrance)	Wellhead (WHT)	Goldsworthy and Brewer	JWPCP	Total New Extraction, AFY	Total Existing Extraction (Goldsworthy and Brewer), AFY	Torrance	Golden State Water	Manhattan Beach	LADWP	Cal Water	Lomita	Total New Product Delivery, AFY	Sewer (SWR) or Brine Line (BL)
20	Torrance, GSWC (Highest Delivery), Manhattan (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	3,000	6,250	2,000	-	-	-	11,250	SWR
21	Torrance (Highest Delivery), LADWP, Cal Water via interties (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	5,000	-	-	2,750	3,500	-	11,250	SWR
22	Torrance (Highest Delivery), GSWC, LADWP, Cal Water, Lomita via Interties (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	5,000	900	-	850	3,500	1,000	11,250	SWR
23	Torrance (Highest Delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	5,000	900	-	850	3,500	1,000	11,250	SWR
24	JWPCP (12,500 AFY)	7 new wells			7,300	12,500	12,500	7,300	5,000	-	-	5,250		1,000	11,250	BL
25	Torrance, GSWC, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (12,500 AFY)	7 new wells	12,500		7,300		12,500	7,300	3,000	3,000	-	5,250			11,250	BL
26	Torrance (Highest Delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral with 1 existing well (12,500 AFY)	6 new wells, 1 existing well	12,500		7,300		12,500	7,300	5,000	900	-	850	3,500	1,000	11,250	SWR
27	All Wellhead no New Distribution Piping (10,500 AFY)	7 new wells	-	10,500	7,300	-	10,500	7,300	5,000	900	1,000	1,000	800	750	9,450	SWR
28	Torrance (Highest Delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (5,200 AFY)	3 new wells	5,200	-	7,300	-	5,200	7,300	2,100	500	-	500	1,000	500	4,600	SWR
29	All Wellhead (5,200 AFY)	2 new wells, 1 existing	-	5,200	7,300	-	5,200	7,300	4,600	-	-	-	-	-	4,600	SWR

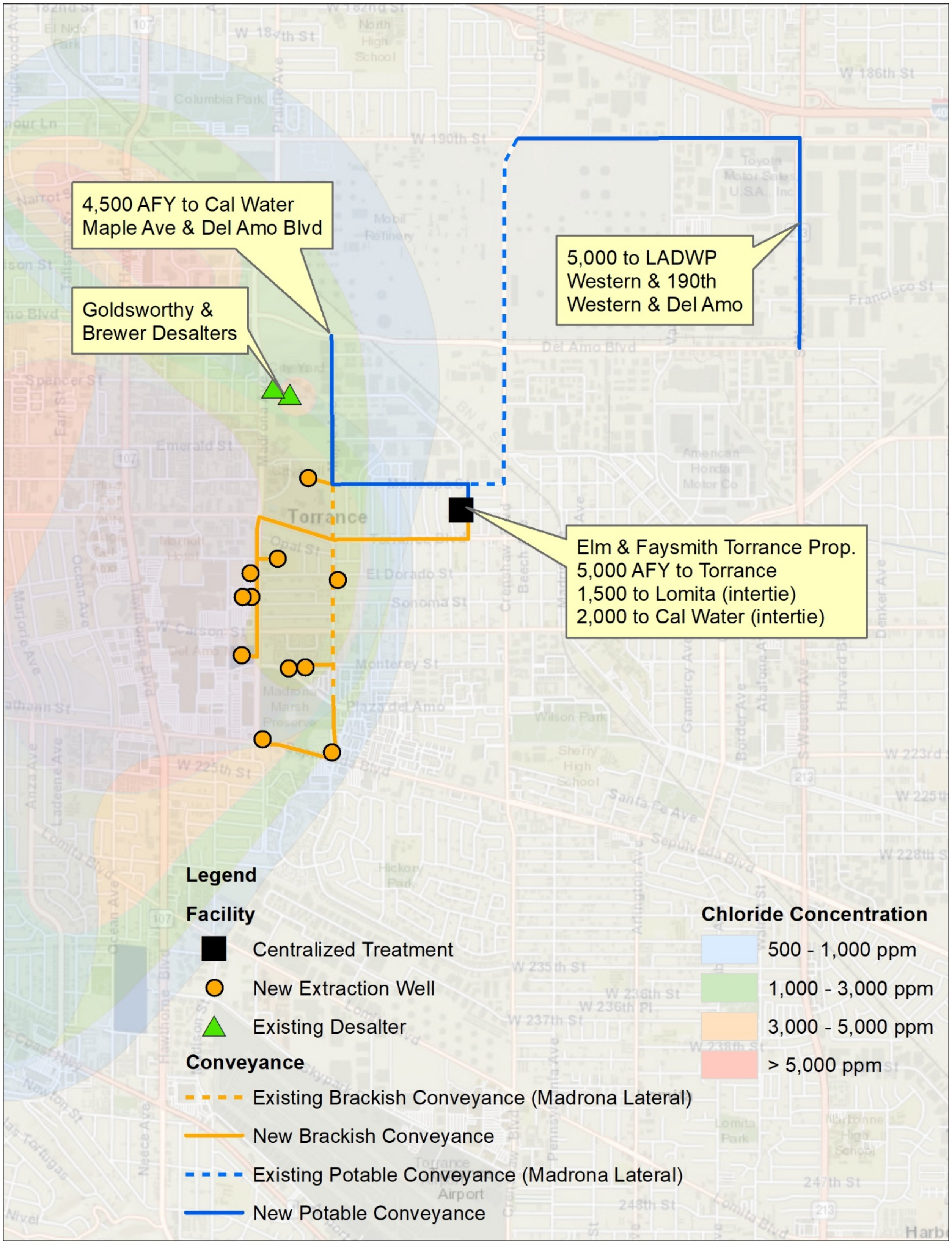

Figure 6-1. Conceptual Layout for Project No. 15

Table 6-2 summarizes the monthly demands for each of the stakeholders. Monthly demand data was only received from LADWP and Lomita. LADWP provided daily water use information for 2010 through June 2018. After discussions with LADWP, it was determined that data from 2015 at LA-05 and L-09 were most representative of the expected demands in the future that could be met by water from the desalter. The monthly and annual totals were calculated and used to determine the percentages for LADWP. Lomita published monthly water use totals for July 2012 through June 2015 in their 2015 Urban Water Management Plan. The percent of annual use was calculated for each month and then averaged across the years. For the other stakeholders, similar demand patterns were assumed based on the annual total water demand information provided in the Urban Water Management Plans for each stakeholder.

Table 6-2. Monthly Demand as Percent of Annual Average Demand

Month	Torrance (%)	Golden State Water (%)	Manhattan Beach (%)	LADWP (%)	Cal Water (%)	Lomita (%)
January	8.36	7.37	7.37	8.36	8.36	7.37
February	7.71	6.62	6.62	7.71	7.71	6.62
March	8.63	7.72	7.72	8.63	8.63	7.72
April	8.27	7.96	7.96	8.27	8.27	7.96
May	8.22	8.71	8.71	8.22	8.22	8.71
June	9.15	8.70	8.70	9.15	9.15	8.70
July	8.40	9.41	9.41	8.40	8.40	9.41
August	8.41	9.78	9.78	8.41	8.41	9.78
September	8.29	9.23	9.23	8.29	8.29	9.23
October	8.36	8.88	8.88	8.36	8.36	8.88
November	8.04	8.39	8.39	8.04	8.04	8.39
December	8.15	7.22	7.22	8.15	8.15	7.22

This information is relevant since one of the parameters tracked in the model is the total amount of water that is used by stakeholders on a monthly basis. A common theme among the Projects is that not all of the water produced by the desalter facility can be fully used by the stakeholders year-round, particularly in the winter months. However, the amount of water that is not used typically ranges from 1 to 6 percent of the produced volume. Additional analysis can be conducted to better define monthly demand patterns for each stakeholder and available capacity at the delivery locations to better understand the seasonal variations.

Table 6-3 compares the maximum annual water use in the model to the Stakeholders' adjudicated rights in the West Coast Basin. While individual water use may be above adjudicated rights, total water use is below the basin adjudication. This is common among all the Projects.

Table 6-3. Comparison of Maximum Annual Water Use Adjudicated Rights

Stakeholder	Maximum Annual Water Use (AFY)	Adjudicated Water Right for West Coast Basin (AFY)
Torrance	3,510	5,640
GSWC	3,007	7,502
Manhattan Beach	3,008	1,131
LADWP	3,007	1,503
Cal Water	3,008	4,070
Lomita	2,506	1,352
Total[a]	18,046	21,198

[a]The total water use exceeds the annual supply from the desalter and wellhead treatment systems (18,000 AFY) because the maximum annual water use for each stakeholder does not necessarily occur simultaneously.

Figure 6-2 shows the project costs grouped by volume extracted and ranked by cost per acre-foot delivered. In this figure, the costs for each project component (extraction, treatment, brine disposal, delivery, and replenishment) are included. The solid portions of the bars are all capital expenditures, while the hashed portions are related to operational costs. Presenting the costs in this way demonstrates which cost components are expected to be the largest investment, but also allows for understanding the difference in costs between Projects. For example, Projects that include wellhead treatment have higher treatment costs than using a centralized facility.

6.1 20,000 AFY New Extraction

Projects with 20,000 AFY of new extraction have a total plume extraction rate of 27,300 AFY (including the existing Goldsworthy and Brewer Desalters) and a minimum treatment duration of 14 years, followed by up to 16 years additional pumping without RO treatment. All Projects have a total delivery of 18,000 AFY of new desalination plume water to stakeholders.

Note that the capacities listed below are for the treatment plant brackish plume feedwater. The desalinated product water would be 90 percent of these values.

Project 1: Spread Across Stakeholders with Two Wellhead Treatments

This alternative assumes that all stakeholders receive water in roughly equal amounts. The extraction wells are located either near Elm and Faysmith or at the Sepulveda 1 and 2 locations. To convey brackish water from the extraction wells to the desalter, 2.6 miles of pipe between 12-inch- and 36-inch-diameter is required. The wells at Sepulveda 1 and 2 each have a treatment capacity of 2,000 AFY. The treatment systems at these wells are assumed to extract, treat, and then deliver water into the distribution system near the well. The treatment plant at Elm and Faysmith has a capacity of 16,000 AFY.

The costs for this Project total $570/AF for capital costs and $890/AF for operational costs.

Project 2: Spread Across Stakeholders with One Wellhead Treatment

Project 2 is the same as Project 1, but only uses the well at Sepulveda 2 for wellhead treatment. To obtain 20,000 AFY of new extraction, the number of new extraction wells is increased from 8 to 9. The additional new extraction well also requires an additional 0.3 mile of collection system piping.

The cost for this alternative is lower for both CAPEX and OPEX when compared to Project 1. Project 2 has a capital cost of $508/AF and OPEX cost of $862/AF. The primary difference in costs is attributable to a reduction in the treatment costs. The additional new well increased the piping and well CAPEX by about $6/AF total, but the treatment costs are decreased by about $95 for CAPEX and OPEX when one wellhead treatment unit is removed, due to economies of scale.

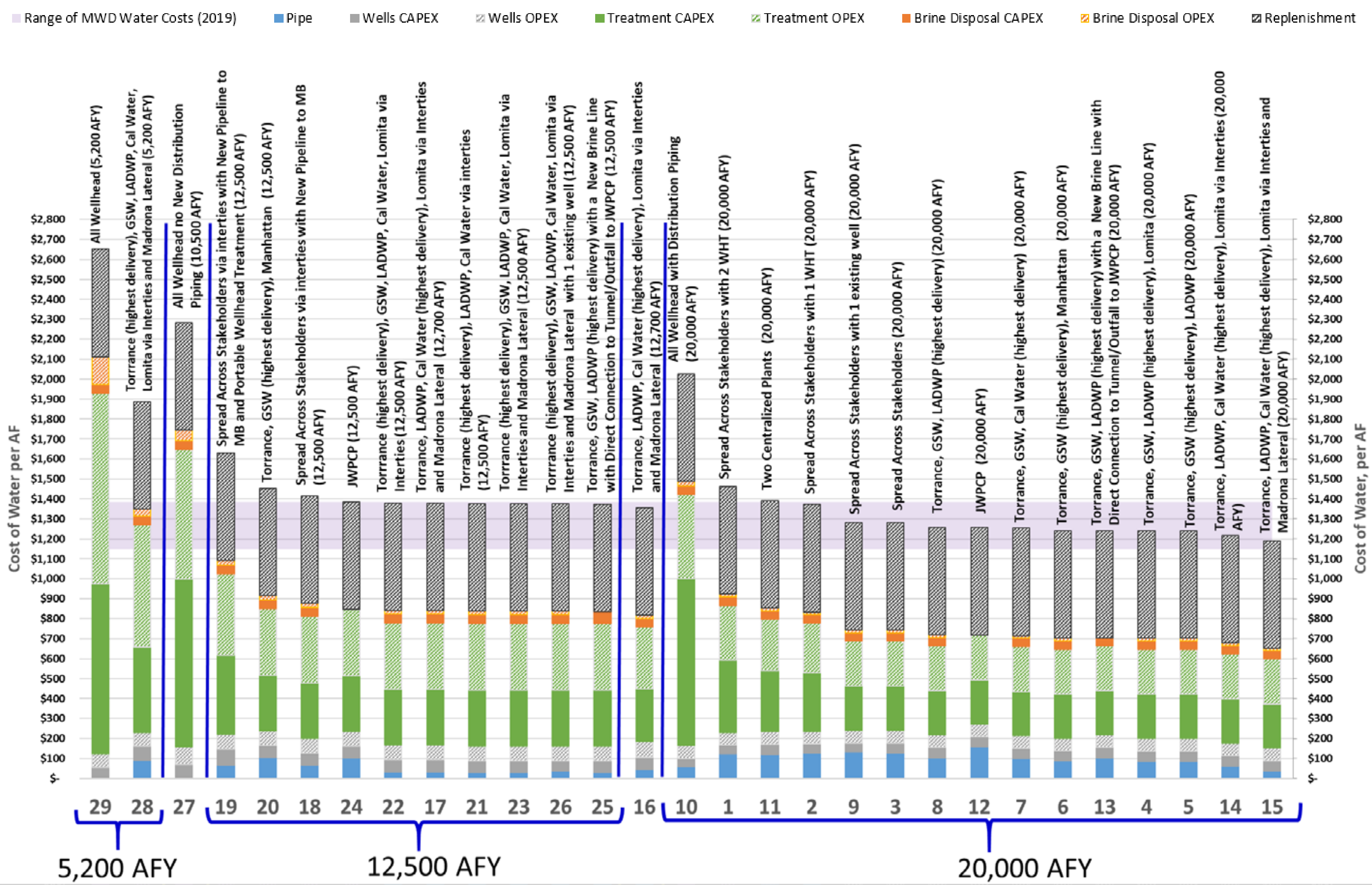

Figure 6-2. Estimated Project Costs per Acre-foot of Water Delivered

Project 3: Spread Across Stakeholders

Project 3 is the same as Project 1, but with all new extraction wells and no wellhead treatment. The new extraction wells add about 0.3 mile of collection system piping to get the water to Elm and Faysmith.

The cost for this alternative is lower for both CAPEX and OPEX than Projects 1 and 2. Project 3 has a capital cost of $440/AF and OPEX cost of $839/AF. The primary difference in costs is attributable to a reduction in the treatment costs, which are about $190/AF (CAPEX and OPEX) less than for Project 1.

Project 4: Torrance, GSWC, LADWP (Highest Delivery), Lomita

Project 4 delivers water to only some of the Program stakeholders to understand if there is any benefit to delivering larger amounts to some users. For this Project, the largest amount of water was delivered to LADWP, which was assumed to receive 8,000 AFY.

Like other 20,000-AFY Projects without wellhead treatment, this Project requires 10 new extraction wells and associated collection pipe to send the water to Elm and Faysmith for treatment. In these alternatives, because the desalter is located at Elm and Faysmith which is near a tie-in location for the Torrance system, Torrance always receives water and there is no required piping to deliver the water to the distribution system. The primary difference between this alternative and others like it is the amount of distribution piping required to deliver the water to the stakeholders:

- GSWC: 1.7 miles of 12-inch pipe
- LADWP: 2.5 miles of 30-inch and 0.6 miles of 24-inch pipe
- Lomita: 1.4 miles of 12-inch pipe

The costs for this Project total $399/AF for capital costs and $839/AF for operational costs.

Project 5: Torrance, GSWC (Highest Delivery), LADWP

For Project 5, only Torrance, GSWC, and LADWP receive water from the desalter. GSWC receives the largest amount at 11,000 AFY. This results in larger-diameter piping required to deliver the water to GSWC and smaller-diameter piping to deliver to LADWP, when compared to Project 4. The following are distribution pipe assumptions for this Project:

- GSWC: 1.7 miles of 30-inch pipe
- LADWP: 3.1 miles of 12-inch pipe

The costs for this Project total $399/AF for capital costs and $839/AF for operational costs, which is the same as Project 4. The difference in delivery piping diameters and lengths between the two Projects results in similar costs.

Project 6: Torrance, GSWC (Highest Delivery), Manhattan Beach

Project 6 is similar to Project 5, except that Manhattan Beach receives water instead of LADWP. Additional piping is required for GSWC in this delivery configuration because it does not have any shared piping with LADWP.

The delivery piping configuration for this Project includes the following:

- GSWC: 2.1 miles of 30-inch pipe
- Manhattan Beach: 2.7 miles of 12-inch pipe

The costs for this Project total $400/AF for capital costs and $839/AF for operational costs, which is $1/AF more than Projects 4 and 5. The difference in delivery piping diameters and lengths among the three Projects results in similar costs.

Project 7: Torrance, GSWC, Cal Water (Highest Delivery)

Project 7 is a variation of Projects 5 and 6, but with Cal Water receiving water instead of LADWP or Manhattan Beach. Cal Water is receiving the most water at 7,500 AFY.

The delivery piping configuration for this Project includes the following:

- GSWC: 3.8 miles of 24-inch pipe
- Manhattan Beach: 2.0 miles of 30-inch pipe

The capital cost associated with Project 7 is $413/AF, which is higher than for Projects 4 through 6. This is due to the difference in delivery piping; Project 7 requires both longer length and larger diameters. The OPEX cost, $839/AF, is the same as Projects 4 through 6.

Project 8: Torrance, GSWC, LADWP (Highest Delivery)

Project 8 is directly comparable to Project 5. For both Projects, water is being delivered to Torrance, GSWC, and LADWP, but in Project 8, LADWP is receiving the most water. This configuration requires the following new delivery piping:

- GSWC: 3.8 miles of 24-inch pipe
- LADWP: 3.1 miles of 24-inch pipe

The capital cost associated with Project 8 is $417/AF, which is higher than for Project 5. This is due to the difference in delivery piping for GSWC, which is longer but has a smaller diameter than Project 5 and a larger length of 24-inch pipe required for delivery to LADWP. The OPEX cost, $839/AF, is the same as Project 5.

Project 9: Spread Across Stakeholders with One Existing Well

Project 9 is a variation of Project 3, but instead of drilling all new extraction wells, the existing well at Sepulveda 2 is used to extract water, and new piping is added to connect it to the treatment system at Elm and Faysmith. This Project is used to understand the tradeoff between the cost of drilling a new well and using an existing one with potentially more collection system piping. For this Project, the collection system piping now includes an additional mile of collection system piping compared to Project 3.

Like Projects 1 through 3, all stakeholders receive water from the new desalter. The capital cost for this Project is $440/AF, which is similar to Project 3 and $68/AF less than Project 2. The cost difference between drilling a new well closer to the treatment system and using an existing well that requires additional collection system piping is very small. The operational cost, however, is $839/AF, which is the same for other Projects with this number of wells.

Project 10: All Wellhead Treatment with Distribution Piping

Wellhead treatment has potential benefits because the water is extracted, treated, and delivered at the well location. Ideally, there is no additional piping required beyond the very limited amount of piping needed to connect the well to the adjacent treatment system and the treatment system to the adjacent existing distribution lines. To explore the benefits of wellhead treatment, a Project that uses all wellhead treatment with a total extraction rate of 20,000 AFY was developed. However, there is not enough existing capacity in the distribution system near the proposed well locations, based on pipe size, to accept a total of 18,000 AFY. Therefore, new distribution piping is required.

For this Project, only Torrance, GSWC, and Manhattan Beach receive water due to their proximity to the wells. Piping is required for delivery to GSWC (2.1 miles of 30-inch pipe) and Manhattan Beach (2.7 miles of 12-inch pipe).

The capital cost for Project 10 is $978/AF and operational cost is $1,047/AF, making this one of the three most expensive Projects on a per-AF basis. The high costs are mostly associated with needing

10 separate wellhead treatment systems. Even though two of the wells used for wellhead treatment are existing, the savings from using these wells is not enough to offset the cost of treatment.

Project 11: Two Centralized Plants

Project 11 was developed to understand the potential benefits of using two smaller centralized treatment plants. The plants would be located in areas that would reduce the amount of distribution and/or collection piping. In addition, the JWPCP location was provided as a potential location for a desalter. Because there is an existing outfall at this plant to which the brine can be discharged, the brine disposal costs could be reduced. The amount of water delivered to the stakeholders is the same as in Project 4.

In this case, the treatment plant at Elm and Faysmith would have a total capacity of 7,500 AFY and deliver water to Torrance and GSWC. The second desalter at JWPCP would have a capacity of 12,500 AFY and deliver water to LADWP and Lomita. The location of the JWPCP requires that 3.4 miles of 36-inch pipe be constructed to convey the water from the extraction wells to the JWPCP.

For Project 11, the distribution piping for GSWC increases in length from 1.7 miles to 2.1 miles, maintaining the same diameter. For Lomita, the length of 12-inch distribution pipe decreases from 1.4 to 1.1 miles. The biggest difference, however, is in delivering to LADWP. In Project 4, a total of 3.1 miles of pipe is required and 2.5 miles of it is 30-inch pipe. For this Project, only 0.9 mile of 24-inch pipe is required.

The capital and operational costs associated with building and operating two treatment plants are higher than options with one centralized facility, which is to be expected. In this case, because the extraction wells are located in the heart of the plume and are not near the JWPCP, there is additional cost associated with the collection system. The savings in distribution piping do not offset this cost. The total capital cost for this Project is $519/AF and operational cost is $868/AF.

Project 12: JWPCP

Project 12 is in direct comparison to Projects 11 and 4. Instead of treatment at a centralized facility at Elm and Faysmith, all treatment would be located at JWPCP, taking advantage of the brine disposal facilities associated with this location. The tradeoff, however, is that additional collection and distribution piping is required.

A total of 5.53 miles of collection system piping, with diameters between 12 and 36 inches, would be required to convey the water from the extraction wells to the desalter at the JWPCP. Distribution piping would be required to deliver water to all the stakeholders, including Torrance:

- Torrance: 1.8 miles of 30-inch pipe
- GSWC: 5.0 miles of 12-inch pipe
- LADWP: 0.9 miles of 36-inch pipe
- Lomita: 1.1 miles of 12-inch pipe

Treatment at the JWPCP is within the LACSD sanitation system. Thus, compared to sewering the brine, there are some distinct advantages regarding brine disposal. First, it may be possible to connect the brine discharge to the JWPCP outfall where it would not require treatment by LACSD. Second, LACSD has incentive to reduce the salinity of the waters entering the JWPCP treatment plant and may be willing to offer incentives to the stakeholders even if the outfall connection is not viable. Further details on the brine disposal options related to treatment at the JWPCP will be developed later in the study in Task 1.D.

The cost of this Project is $429/AF for capital costs and $827/AF for operational costs. This Project has a higher capital cost than Project 4, primarily due to the cost of collection and distribution system piping. However, it has a lower operational cost because this Project assumes that there is no cost associated with brine disposal.

Project 13: Torrance, GSWC, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP

Project 13 is a variation of Project 8. The collection, treatment, and delivery systems are the same, except that a new brine line connection to the tunnel/outfall at the JWPCP is used for brine disposal instead of connecting to nearby sewers. The cost of the new brine line is estimated at $20 million.

The capital cost for this Project is $413/AF and operational cost is $827/AF. The capital cost is the same as Project 8 because the cost of the new brine line is about the same as the connection fees for the nearby sewer. However, the operational cost is lower because this Project still assumes that there is no annual fee for using the tunnel/outfall, but Project 8 assumes an annual surcharge for discharge to the sewer system.

Project 14: Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties

Project 14 focuses on delivering water to stakeholders that have existing interties and using these interties to deliver water to other stakeholders. This reduces the amount of new distribution piping that would need to be constructed. For Project 14, it is assumed that Torrance uses existing interties with Cal Water (2,000 AFY) and Lomita (1,500 AFY) to deliver water in excess of what Torrance can use. Cal Water can use more water than can be delivered via the intertie with Torrance, so a new 1.1 mile, 16-inch distribution pipe would still be needed. New piping is also still required to deliver water to LADWP.

In terms of capital costs, this Project is one of the lowest-cost Projects with 20,000 AFY of extraction at $375/AF. The operational costs are similar to other Projects that include one centralized desalter and brine disposal in a nearby sewer line.

Project 15: Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties, and Madrona Lateral

Project 15 is a version of Project 14 with one change – the Madrona Lateral is assumed to be available for collection of brackish water and delivery of treated water. This reduces the required collection system piping by about 1.1 miles and the distribution piping to LADWP by 1.6 miles. This results in a capital cost of $350/AF, which is $25/AF less than Project 14. The operational cost is $839/AF, which is the same as Project 14.

6.2 12,500 AFY to 12,700 AFY Extractions

This group of Projects has a total new extraction of between 12,500 AFY and 12,700 AFY. With the Goldsworthy and Brewer Desalters operating at full capacity (7,300 AFY), this will be a total treatment duration of 20 years, followed by pumping without RO treatment for 10 years. These Projects deliver between 11,250 and 12,060 AFY total to stakeholders.

The Projects in this group are typically variations of Projects with 20,000 AFY of new extraction described above.

Project 16: Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties and Madrona Lateral (12,700 AFY)

Project 16 is the same as Project 15, except that the new extraction is 12,700 AFY, for a total extraction of 20,000 AFY. The lower extraction rate results in an additional 5 years of treatment, which impacts the operational costs of the Project. However, the construction of a smaller desalter has a lower upfront capital investment.

For this Project, the capital cost is $412/AF and the operational cost is $944/AF. On a per-AF basis, this Project is more expensive than Project 15, which delivers more water to the stakeholders.

Project 17: Spread Across Stakeholders via Interties and Madrona Lateral (12,500 AFY)

Project 17 is similar to Project 3, which also delivers water to all stakeholders. However, this Project also takes advantage of interties and the Madrona Lateral to reduce the amount of new piping that would be needed. As a result, this Project has a capital cost of $415/AF, which is less than the capital cost of Project 3 ($440/AF). However, the extended treatment time increases the operational cost by about $125/AF.

Project 18: Spread Across Stakeholders via Interties with New Pipeline to Manhattan Beach (12,500 AFY)

In Project 17, an assumption was made that the interties between Torrance and Cal Water and between Cal Water and Manhattan Beach could be used to deliver water to Manhattan Beach. If this is not a valid assumption, additional piping would be needed to deliver water to Manhattan Beach. Project 18 assumes that new piping is required, and the intertie is not used. The additional piping increases the capital cost by $34/AF to $449/AF, and the operational cost stays the same as Project 17 ($964/AF).

Project 19: Spread Across Stakeholders via Interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (12,500 AFY)

Project 19 is a variation of Project 18 where most of the extraction wells are connected to the desalter at Elm and Faysmith, but a portable wellhead treatment unit is used for targeted treatment of areas outside of the main plume, particularly for the upper Gage aquifer. The concept is that the portable wellhead treatment unit, likely a containerized unit, would be placed at a location for treatment for a number of years (assumed to be less than 5 years), after which the chloride concentration of that particular well would decrease below 500 mg/L. At this point, the portable wellhead treatment unit would be relocated to a new area where a new well would be constructed, and the process would be repeated. This Project has potential benefits related to treating portions of the plume that would not be treated with other Projects. The capital cost associated with Project 19 is $586/AF, which reflects the cost of the additional wells (assumed four total) and the portable treatment unit, and the operational cost is $1,047/AF, which reflects the operation of two separate treatment systems.

Project 20: Torrance, GSWC (Highest Delivery), Manhattan Beach (12,500 AFY)

Project 20 is similar to Project 6, but with less water being delivered to Torrance and GSWC. With fewer extraction wells, the amount of collection system piping is reduced from 2.9 miles to 2.0 miles. For delivery, because there is less water being delivered to GSWC, smaller-diameter piping is required. However, even with these changes in capital expenditures, this Project is still more expensive on a per-AF basis than Project 6. Costs for Project 20 are estimated at $480/AF for capital cost and $964/AF for operational cost.

Project 21: Torrance (Highest Delivery), LADWP, Cal Water via Interties (12,500 AFY)

Project 21, as well as Projects 22 through 24, was designed to take full advantage of the existing infrastructure for water delivery. The only distribution piping that is required is 1.1 miles of 16-inch pipe to provide Cal Water with water in excess of the capacity of the intertie with Torrance (2,000 AFY).

The capital cost for this Project is estimated at $412/AF and operational cost at $964/AF.

Project 22: Torrance (Highest Delivery), GSWC, LADWP, Cal Water, and Lomita via Interties (12,500 AFY)

Project 22 is similar to Project 21 and takes advantage of existing interties. However, the collection system layout is different, and water is also delivered to Lomita and GSWC. Additional piping is required for this Project, so the capital cost is higher at $415/AF, but only by $3/AF. The operational cost is the same as other 12,500-AFY Projects with one centralized treatment plant ($964/AF).

Project 23: Torrance (Highest Delivery), GSWC, LADWP, Cal Water, Lomita via Interties, and Madrona Lateral (12,500 AFY)

This Project is a variation of Project 22 but uses portions of the Madrona Lateral for collection of brackish water. The reduction in piping offsets the cost of piping to Cal Water, and the capital cost is estimated at $412/AF. The operational cost is similar to the other Projects in this group at $964/AF.

Project 24: JWPCP (12,500 AFY)

Like Project 12, this Project examines the impact of building a centralized desalter at the JWPCP to take advantage of the tunnel/outfall system for brine disposal. With the reduced collection volumes, the amount of water that is sent to the stakeholders is also reduced. In this case, no water is delivered to GSWC, and the amount of water delivered to LADWP and Lomita is reduced.

Similar to Project 12, additional collection system piping is required to convey the brackish water to the desalter and piping is required to deliver water to Torrance. The capital cost for this Project is estimated at $441/AF and the operational cost is estimated at $945/AF.

Project 25: Torrance, GSWC, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (12,500 AFY)

Project 25 is a similar concept as Project 13 – constructing a new brine line to the tunnel/outfall at the JWPCP, but the volumes that are delivered to stakeholders are reduced. The construction of the brine line increases the capital costs when compared to Projects that discharge to the nearby sewer. However, operational costs are lower because it is assumed there is no annual fee to use the new brine line. The costs for Project 25 are estimated at $426/AF and $954/AF for capital and operational costs, respectively.

Project 26: Torrance (Highest Delivery), GSWC, LADWP, Cal Water, Lomita via Interties, and Madrona Lateral with One Existing Well (12,500 AFY)

Project 26 is a version of Project 23, but instead of all new extraction wells, it is assumed the existing well at Sepulveda 2 can be used. Additional piping is required to connect this well to the desalter at Elm and Faysmith, but that cost is offset by the cost savings in using an existing well. Project costs are estimated at $412/AF (capital) and $964/AF (operational), which is the same as several other Projects with 12,500 AFY of extraction.

6.3 Less than 12,500 AFY Extraction

Projects with less than 12,500 AFY of new extraction have a total plume extraction rate of 12,500 or 17,800 AFY. This is equivalent to a desalter treatment duration between 30 and 21 years, respectively. For Projects that have a desalter operation of 21 years, 9 years of pumping without RO treatment follows. These Projects have a delivery volume of 4,600 AFY or 9,450 AFY, respectively.

Project 27: All Wellhead No New Distribution Piping (10,500 AFY)

For Project 27, the amount of water delivered to the stakeholders is limited by the capacity of the distribution system at the wellhead treatment location. This Project assumes that the wells are located near the stakeholder's distribution system, or in the case of LADWP, has an intertie with another stakeholder than can be used to deliver the water. However, all stakeholders receive water with this Project.

Even without the cost of piping, the capital cost of this Project is estimated at $953/AF and operational cost at $1,332/AF. Treatment is the largest cost component of both capital and operational costs.

Project 28: Torrance (Highest Delivery), GSWC, LADWP, Cal Water, Lomita via Interties, and Madrona Lateral (5,200 AFY)

Project 28 is the same configuration as Project 23, but there is less volume extracted so fewer extraction wells are required and less water is delivered to the stakeholders. Project costs are approximately $635/AF for capital and $1,263/AF for operations. However, because this Project requires fewer wells and a smaller treatment system, it is one of the Projects with the lowest upfront capital expenditures.

Project 29: All Wellhead (5,200 AFY)

Project 29 is another Project with wellhead treatment and no new piping. Like Project 28, because there are fewer wells required, the upfront capital expenditure is low. However, costs on a per-AF basis are still higher than most Projects at $952/AF for CAPEX and $1,694/AF for OPEX costs.

7. Recommended Project Shortlist

A recommended shortlist of Projects to carry forward for further analysis in this study was developed from the 29 Projects evaluated in this analysis. The list was developed based on the information learned during the project evaluation and input from stakeholders when the results were presented at the second Stakeholder Workshop, held at WRD headquarters on November 14, 2018.

The following types of Projects were not selected to be carried forward:

- Projects with a mix of wellhead treatment and centralized treatment
- Most Projects that require *all* new piping to various combinations of stakeholders

Projects that were retained include Projects that have one or more of the following characteristics:

- Lowest overall CAPEX, which are typically Projects with 5,200 AF of extraction
- Can treat the entire plume, including the upper portion of the Gage plume
- Provide water to all stakeholders
- Could take advantage of the construction of a new brine line
- Use the existing interties
- Lowest overall cost per AF for 12,500 and 20,000 AFY extraction rates

Figure 7-1 shows the Projects that are recommended to be carried forward, along with the costs. When selecting Projects, importance was placed on selecting Projects that were not simply the lowest cost per AF but rather reflected a broader range of considerations. This list of Projects will be evaluated further in the next portion of the study, which will include a multi-objective decision analysis (MODA) process that looks at a variety of factors, such as how much of the produced water is used or how many of the stakeholders receive water. While project costs will be one of the evaluation criteria, selecting only low-cost Projects at this stage could bias the MODA toward those Projects and eliminate Projects that have other benefits not reflected in cost estimates.

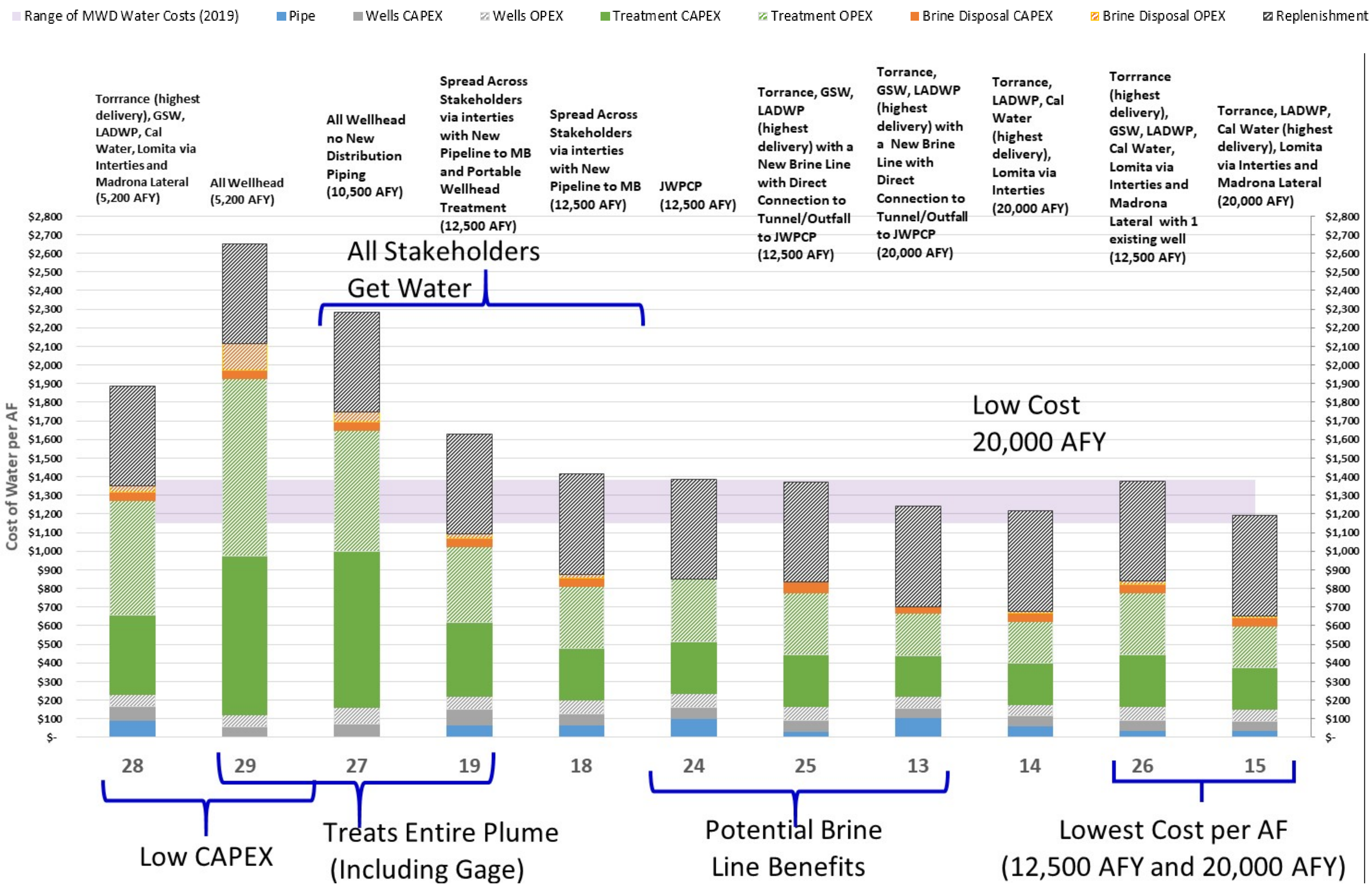

Figure 7-1. Recommended Shortlist of Projects

8. Next Steps

Further details of each of the 11 shortlisted Projects will be developed in subsequent study tasks with respect to the following:

- Brackish water extraction (Task 1.E)
- Brine waste discharge options (Task 1.F)
- Product water delivery (Task 1.G)
- Layout and design details (Task 1.H)

Subsequently, further quantitative (cost) refinement of the shortlisted Projects will be performed. In addition, a MODA analysis will rank each of the 11 shortlisted Projects (in Task 1.I) to determine which Projects will be evaluated further in the study in subsequent Tasks 2 through 8. The ranking will be based on the evaluation criteria that were established in the Program Context Technical Memorandum (dated September 24, 2018), and another criterion based on discussions with the stakeholders. The current list of evaluation criteria is provided in Table 8-1. The MODA analysis will have two steps:

1) Criteria Weighting – Used to assign relative value weights that represent the relative importance of each criterion across the range of Projects under consideration.

2) Project Scoring – Each Project will be evaluated as to how well it measures against the performance criteria. For example, Projects with an anticipated high level of permitting difficulty would score low in that category.

The Criteria Weighting and Project Scoring will be combined to create an Overall Score for each of the Projects. The first step in the MODA process will be to send out a weighting survey to the stakeholders for their input on the importance of the criteria. Table 8-1 is the weighting survey table that will be provided to the stakeholders.

Jacobs will prepare a TM (Conceptual System Design and Program Requirements [CSDPR]), that will include a summary of the Tasks 1.E through 1.I as well as the initial results of the Project Scoring. Stakeholders will be asked to review the findings and scoring results for discussion at the third Stakeholder Workshop.

Table 8-1. Weighting Survey for Multi-objective Decision Analysis to Select Final Projects for Further Evaluation

Evaluation Criteria	Description	Weight
Project Costs		
Project Implementation		
Permitting Difficulty	Measure of whether a project is expected to face permitting hurdles or will require significant time to acquire permits	
Ability to meet the Project Need, Purpose, and Objectives	The Project's primary purpose and objectives are as follows: • Treat and reclaim the saline plume trapped in the West Coast Basin. • Treat and reuse the extracted high-TDS water for beneficial use, including increasing local water supplies. • Increase usable storage capacity in the West Coast Basin. • Enhance the ability of the West Coast Basin to sustainably store and deliver water supplies, thereby reducing the region's reliance on imported water.	
Potential Project Phasing	Project can be expanded or relocated after a period of operation	
Beneficial Uses		
Beneficial Use	Measure of how much of the produced water is used by stakeholders	
Proximity to Other Contaminant Plumes	Location of extraction wells relative to other plumes, which may require additional treatment	
Greenhouse Gas (GHG) Emissions	Amount of GHG produced over project life (construction and operation)	
New Criteria		
Delivery of Water to All Stakeholders	Number of stakeholders that receive desalter product water	

9. Reference

Los Angeles County Sanitation Districts (LACSD). 2019. LACSD website. February. https://www.lacsd.org/wastewater/industrial_waste/iwpolicies/connection_fee_program.asp

4. Source Water Quality and Conveyance (Task 1.E)

Source Water Quality Characterization

Brackish Water Extraction Conveyance Piping Route Analysis

Technical Memorandum

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Subject	**Source Water Quality Characterization**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019

1. Introduction

In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, Lynwood and Lower San Pedro (LSP, equivalent to Sunnyside) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To more fully utilize the West Coast Basin, the Water Replenishment District of Southern California (WRD) has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. This Source Water Quality Characterization Technical Memorandum (TM) is one part of the overall Program Feasibility Study. The feasibility study will evaluate the following components: where to extract the plume water, where and how to treat the plume water, how to convey the treated potable water to the Program stakeholders, and how to manage the brine waste stream. The feasibility study includes the analysis of numerous "Projects," consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of the above components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed as dollars per acre-foot (AF) of treated water.

As a part of the Program, WRD has initiated a regional planning study to evaluate the feasibility of remediating the saline plume with seven additional stakeholders (known as the Stakeholder Group). The Stakeholder Group has expressed interest in treating the saline plume, receiving the treated water, or both, as part of the Program.

The members of the Stakeholder Group either pump, hold water rights, or have other key roles in supporting the basin operations. The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

Five of the Program stakeholders pump and sell potable water in the West Coast Basin. LADWP holds groundwater rights in the basin, but is not currently pumping, and serves City of Los Angeles customers overlying the basin. LADWP, WBMWD and the City of Torrance are also member of Metropolitan Water District of Southern California (MWD), and, as such, serve as providers of imported water purchased from MWD to cities and other retail water agencies. And both LADWP and WBMWD also supply recycled water for basin injection and artificial replenishment at two seawater intrusion barriers in the West Coast Basin.

The purpose of this TM is to characterize the source water quality of the water to be extracted for treatment. This TM is organized to include the following sections:

- Section 1 – Introduction
- Section 2 – Saline Plume, Monitoring, and Potential Extraction Wells
- Section 3 – Water Quality Data
- Section 4 – Approach to Assessing Water Quality of the Potential Future Extraction Wells
- Section 5 – Evaluation of Extraction Well Infrastructure for Potential Projects
- Section 6 – Results of Source Water Quality Evaluation
- Section 7 – Conclusions and Recommendations

As part of this feasibility study, a TM entitled *Potential Projects and Recommended Short List* recommended the Projects listed in Table 1-1 for further consideration. The shortlisted Projects vary with respect to desalter capacity and water delivery destination. However, the shortlisted Projects can be broadly grouped as follows:

- Eight Projects with centralized treatment at the Elm and Faysmith site. One of these Projects (No. 19 in Table 1-1) also includes a portable wellhead treatment unit that is designed to be used temporarily at different locations for treatment over the 30-year equipment life assumed in the Program.
- One project with centralized treatment at the Los Angeles County Sanitation Districts' (LACSD) Joint Water Pollution Control Plant (JWPCP).
- Two Projects with only wellhead treatment, where single wells would undergo onsite treatment at the well.

The *Brine Waste Discharge Evaluation* TM re-examines some of the assumptions that were used to generate the shortlist and presents information related to the brine management options for each of these recommended shortlisted Projects.

Table 1-1. Shortlisted Projects

Potential Project - General Description		Extraction Wells	Treatment Locations				Total New Extraction (AFY)	Total Existing Extraction (Goldsworthy and Brewer) (AFY)	Water Delivery Locations						Total New Product Delivery (AFY)	Brine Discharge
			Elm and Faysmith (Torrance)	Wellhead Treatment (WHT)	Goldsworthy and Brewer	JWPCP			Torrance	Golden State Water	Manhattan Beach	LADWP	Cal Water	Lomita		Sewer or Brine Line
13	Torrance, GSWC, LADWP (highest delivery) with a New Brine Line Having Direct Connection to Tunnel/Outfall to JWPCP (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	5,000	-	8,000	-	-	18,000	Brine Line
14	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	-	-	5,000	6,500	1,500	18,000	Sewer
15	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties and Madrona Lateral (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	-	-	5,000	6,500	1,500	18,000	Brine Line
18	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	4,100	900	1,000	2,750	1,500	1,000	11,250	Sewer
19	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (12,500 AFY)	10 new wells	10,500	2,000	7,300	-	12,500	7,300	4,100	900	1,000	2,750	1,500	1,000	11,250	Brine Line
24	LACSD JWPCP with Brine Connection to LACSD JWPCP Tunnel/Outfall (12,500 AFY)	7 new wells	-	-	7,300	12,500	12,500	7,300	5,000	-	-	5,250	-	1,000	11,250	Brine Line
25	Torrance, GSWC, LADWP (highest delivery) with a New Brine Line with Direct Connection to LACSD JWPCP Tunnel/Outfall (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	3,000	3,000	-	5,250	-	-	11,250	Brine Line
26	Torrance (highest delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral with one existing well (12,500 AFY)	6 new wells, 1 existing well (Sepulveda -2)	12,500	-	7,300	-	12,500	7,300	5,000	900	-	850	3,500	1,000	11,250	Sewer
27	All Wellhead No New Distribution Piping (10,500 AFY)	7 new wells	-	10,500	7,300	-	10,500	7,300	5,000	900	1,000	1,000	800	750	9,450	Sewer
28	Torrance (highest delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (5,200 AFY)	3 new wells	5,200	-	7,300	-	5,200	7,300	2,100	500	-	500	1,000	500	4,600	Sewer
29	All Wellhead (5,200 AFY)	2 new well, 1 existing (Sepulveda -2)	-	5,200	7,300	-	5,200	7,300	4,600	-	-	-	-	-	4,600	Sewer

Notes:

AFY = acre-feet per year

- = component not included in Project

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2. Saline Plume, Monitoring, and Potential Extraction Wells

2.1 Plume Location and Distribution

In the West Coast Basin, the saline plume consists of roughly 600,000 AF of water containing chloride concentrations above 250 milligrams per liter (mg/L). However, based upon input from the Stakeholder Group, the plume extraction and treatment will target the approximately 375,000 AF of saline plume water with concentrations of greater than or equal to 500 mg/L chloride.

Figure 2-1 shows an overlay of the saline plumes in the Gage, Silverado, and LSP aquifers. WRD estimated that the Silverado and LSP aquifers contain 94 percent of the saline plume volume (Table 2-1).

Table 2-1. Plume Volume Distribution among Aquifers

Aquifer	Plume Volume (AF)	Percent of Total Volume
Gage	22,000	6%
Silverado	113,000	30%
LSP	240,000	64%
Total	*375,000*	*100%*

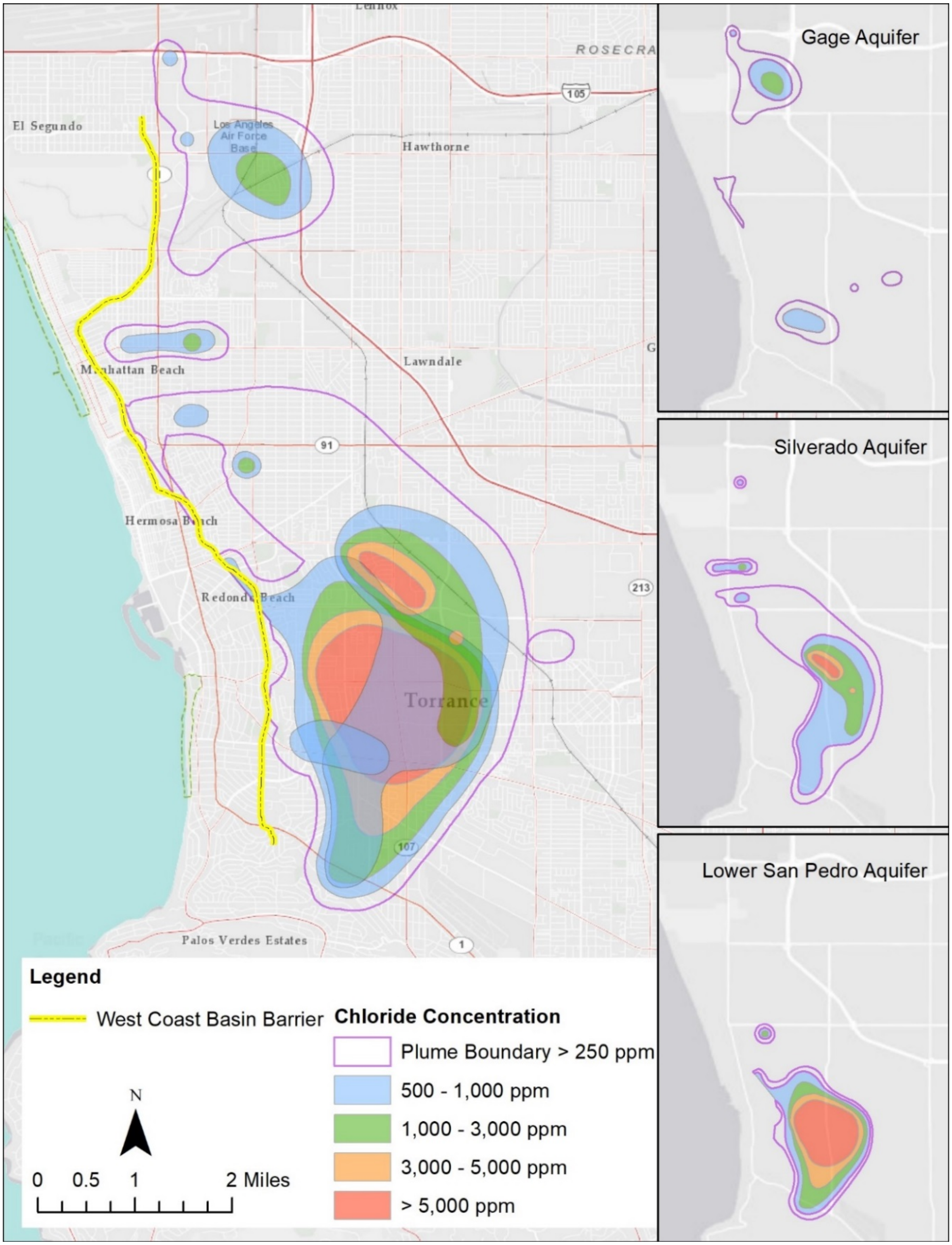
2.2 Well Locations

Figure 2-1 shows that most of the saline plume lies under Torrance's service area. Small patches of the plume exist between Hermosa Beach and El Segundo/Hawthorne. One of the Program's 11 shortlisted Projects does include treatment of these patches by a portable treatment system. However, the other 10 shortlisted Projects recognize that these patches contain insufficient plume volume to justify 2,000 AF per year extraction wells because such wells would extract all the high-salinity water in less than 5 years.

Potential sites for project component locations were solicited from the Stakeholder Group at the initiation of the feasibility study. As part of their response, the City of Torrance identified 10 properties to use for new extraction wells for this Program, with locations depicted as yellow dots with corresponding descriptions on Figure 2-2. These properties are located along the eastern edge of the saline plume in the LSP aquifer, near the site located between Elm and Faysmith Avenues in Torrance that is being considered for the treatment plant. The saline plume is slowly migrating eastward due to the barrier water injected near the Pacific Ocean coastline, and wells at these locations would extract water from the leading edge area of the plume. Extraction wells for the Program include new wells at these locations and the potential use of the existing Sepulveda 1 and Sepulveda 2 extraction wells. The existing Sepulveda wells were installed for another project years ago, but were never used. They are located on the southwestern section of the LSP plume as shown on Figure 2-2.

WRD has been assessing the groundwater quality of the West Coast Basin annually by monitoring and analyzing groundwater samples from its monitoring well network. The Regional Groundwater Monitoring Program provides basic information on groundwater monitoring wells (WRD, 2017). The location of the WRD multi-level nested monitoring wells near the Program area are shown on Figure 2-2 with "PM" designations. These include PM-1, PM-2, PM-4, PM-5, and PM-6 as Columbia, Police Station, Mariner, Columbia Park and Madrona Marsh monitoring wells, respectively. The new extraction wells for the Program are located between PM-2 (Police Station) and PM-6 (Madrona Marsh), and thus these two monitoring wells were used for the evaluation of source water quality for the new extraction wells. PM-2 and PM-6 are WRD monitoring wells used to monitor groundwater quality in the eastern portion of the saline plume area. Multi-level nested wells are screened in a portion of a specific aquifer, providing water quality and water level information for the specific zone (WRD, 2017).

Figures 2-3a and 2-3b show the well logs for the PM-2 and PM-6 monitoring wells, respectively. The PM-2 well is screened at four depth intervals, as shown on Figure 2-3a, and the PM-6 well is screened at six depth intervals, as shown on Figure 2-3b.



Note:

ppm = parts per million

Figure 2-1. Saline Plume in Aquifers: Gage, Silverado, and Lower San Pedro

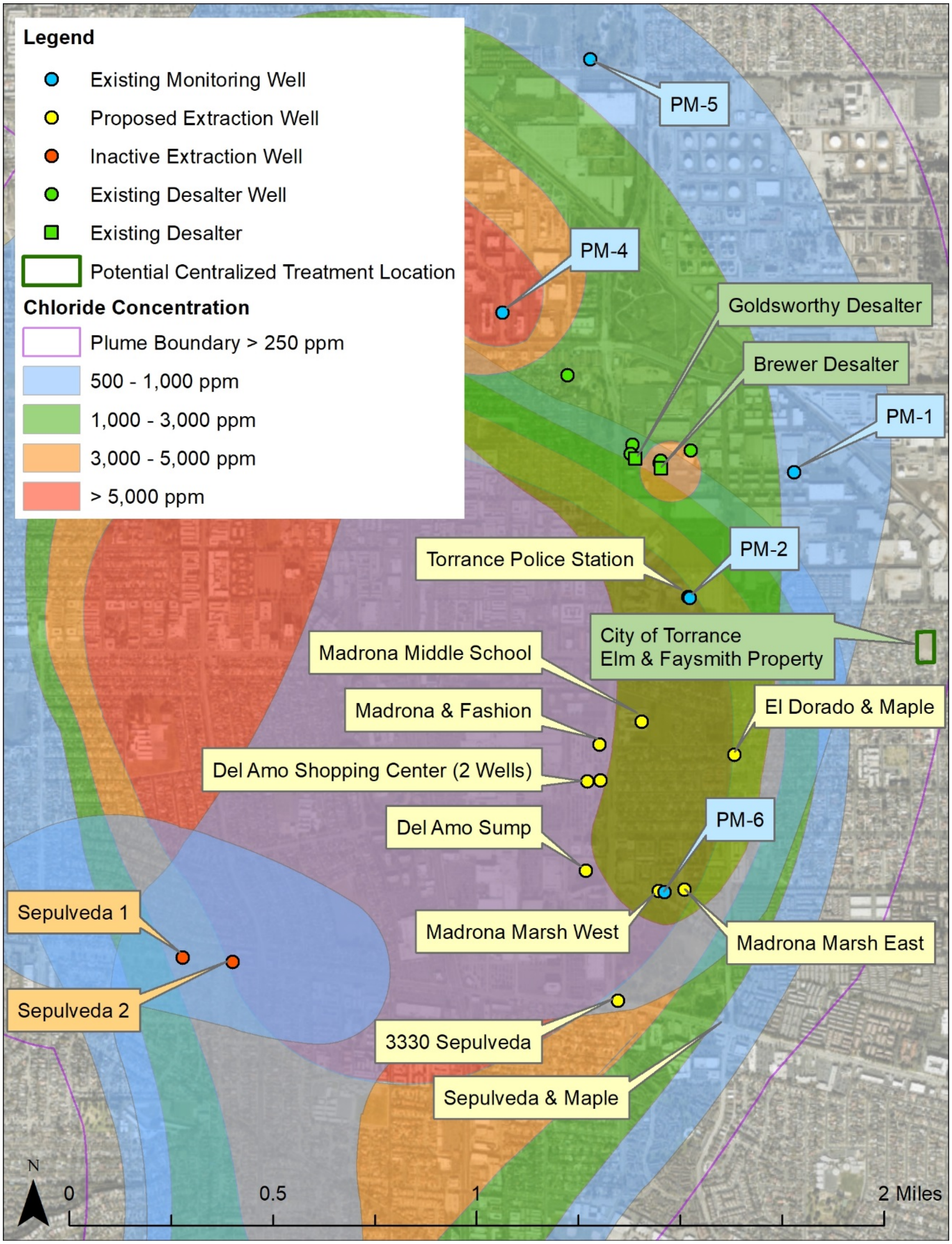
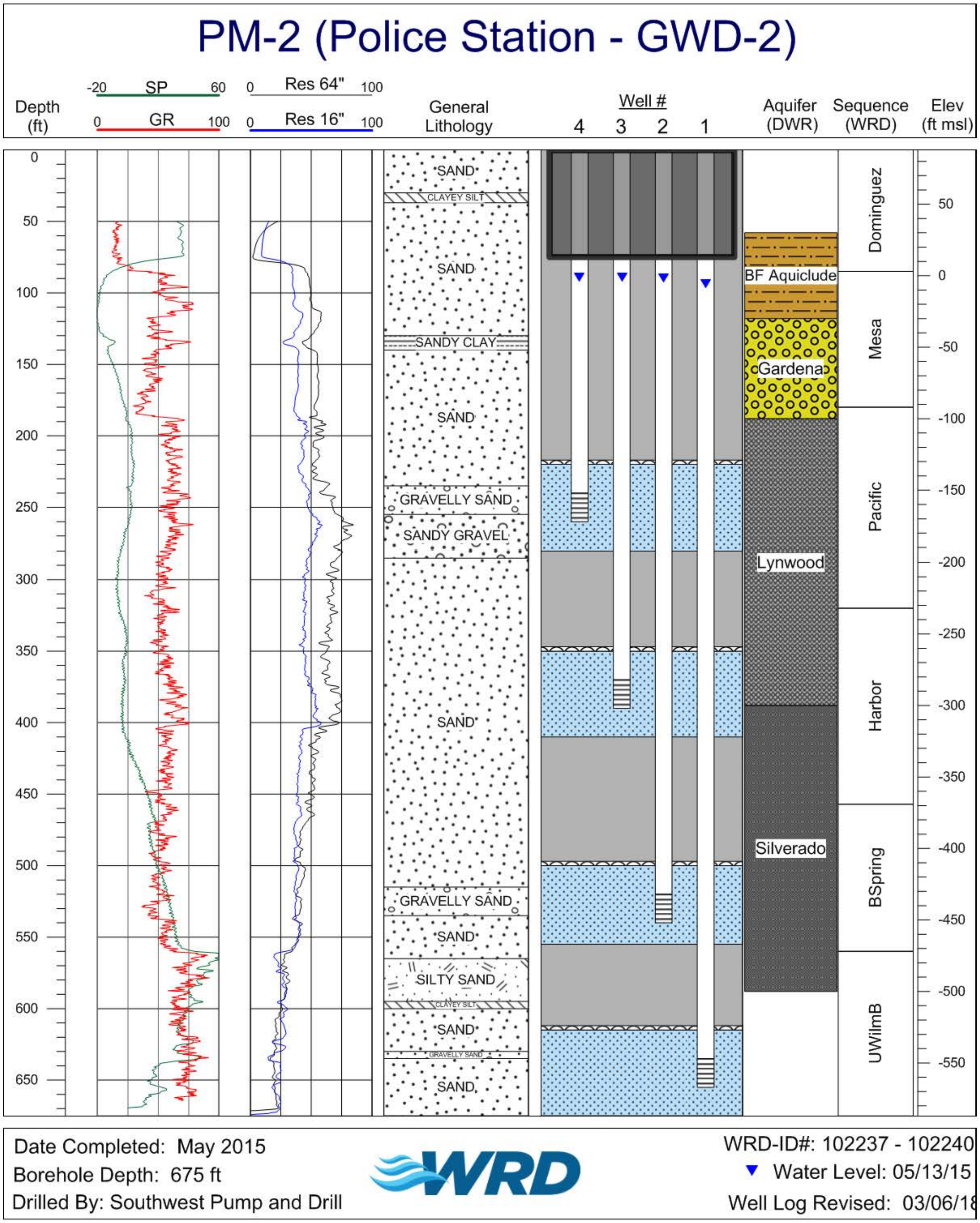
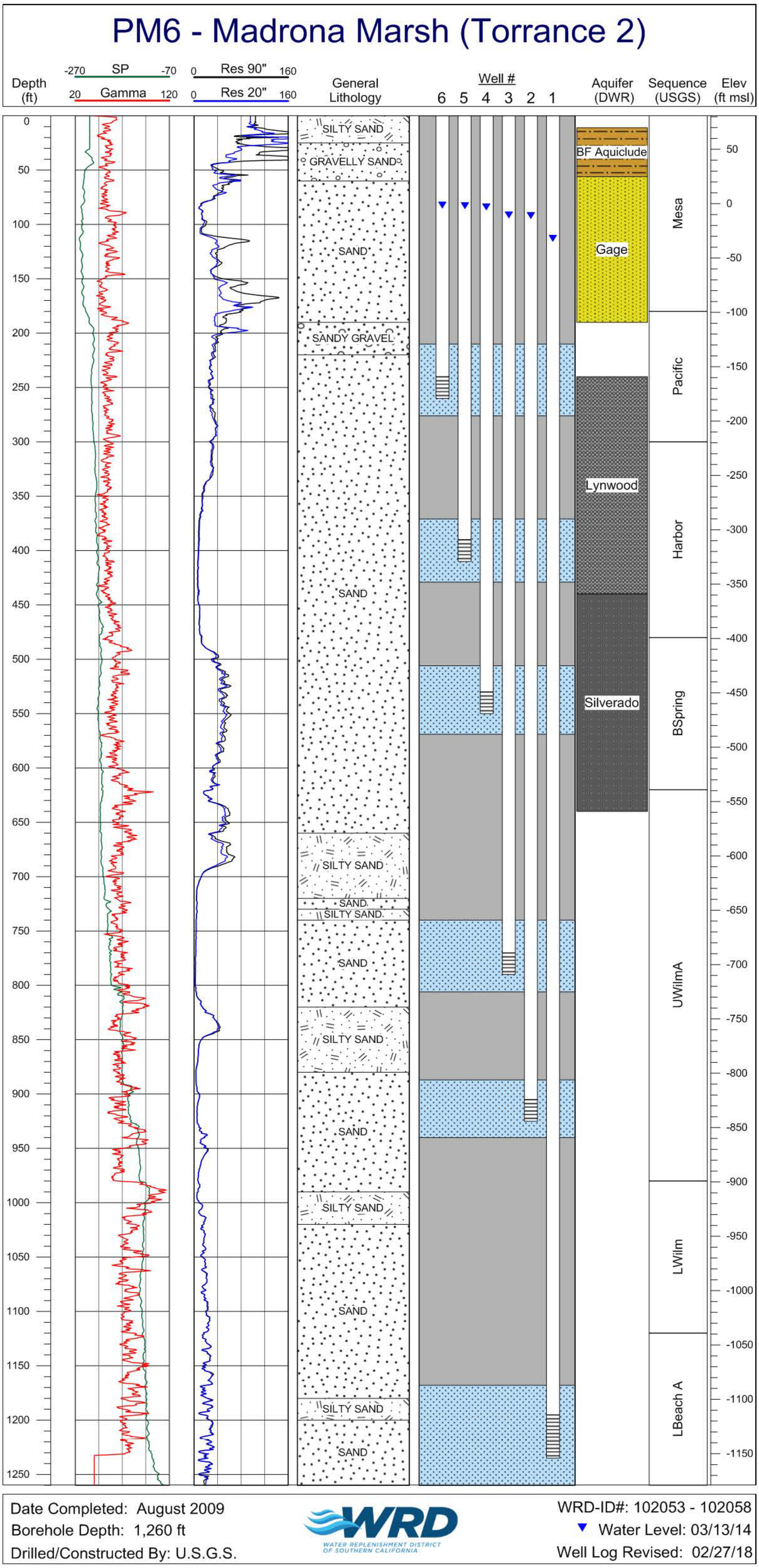


Figure 2-2. Regional Map with the Location of Monitoring Wells, Potential Extraction Wells, One Potential Treatment Plant Location (Elm & Faysmith Property) along with an Overlay of Saline Plumes in the Gage, Silverado, and Lower San Pedro Aquifers



Note: the LSP aquifer is below the Silverado aquifer.

Figure 2-3a. PM-2 Well Log



Note: the LSP aquifer is below the Silverado aquifer.

Figure 2-3b. PM-6 Well Log

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3. Water Quality Data

This section summarizes the water quality data collected from WRD's two monitoring wells of interest, PM-2 and PM-6 which, as demonstrated in Section 4 of this TM, becomes the basis of the estimated well water quality from the new extraction wells.

3.1 PM-2 (Police Station) Well

As shown on Figure 2-3a, PM-2 is a multi-level nested monitoring well, with four individual nested wells (zones) (labeled as wells 1 through 4 from deepest to shallowest) that are screened in various aquifers, at depths ranging from approximately 230 feet below ground surface (bgs) to 650 feet bgs, corresponding to elevations of approximately -160 feet relative to mean sea level (msl) to -560 feet msl. Figures 3-1 through 3-4 present temporal profiles of measured concentrations of eight key constituents for treatment consideration, alkalinity, barium, calcium, chloride, iron, manganese, sulfate, and TDS, for nested wells 1 through 4, respectively. For all four nested wells, only two measurements for all water quality parameters are available, one each from 2017 and 2018. Based on the data, the concentrations of the eight key constituents were similar to each other, providing confidence in the data. Unfortunately, long-term data from this monitoring well is not available to develop any temporal trends of parameter concentrations. Table 3-1 presents the minimum (min), maximum (max), and median of available data along with the screened interval elevations.

Table 3-1. Summary of Water Quality Parameters for the PM-2 Monitoring Well

Well ID	Screened Interval Elevation (feet msl)	Descriptive Statistics	Alkalinity (mg/L)	Barium (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Iron (mg/L)	Manganese (µg/L)	Sulfate (mg/L)	TDS (mg/L)
Police Station Well 4 (PM-2-4)	-150 to -170	Min	160	42	74	190	0.02	71	160	760
		Max	180	53	89	260	0.02	90	170	920
		Median	170	48	82	225	0.02	81	165	840
Police Station Well 3 (PM-2-3)	-280 to -300	Min	140	33	88	180	0.02	170	230	810
		Max	140	33	92	190	0.02	200	250	860
		Median	140	33	90	185	0.02	185	240	835
Police Station Well 2 (PM-2-2)	-430 to -450	Min	150	260	360	1,400	1.30	1,800	64	2,800
		Max	160	270	410	1,400	1.50	2,500	69	2,900
		Median	155	265	385	1,400	1.40	2,150	67	2,850
Police Station Well 1 (PM-2-1)	-550 to -570	Min	120	250	1,100	5,800	0.22	400	600	12,000
		Max	120	280	1,200	6,200	0.23	410	640	14,000
		Median	120	265	1,150	6,000	0.23	405	620	13,000

Notes:

µg/L = microgram(s) per liter

mg/L = milligram(s) per liter

Figure 3-5 presents the depth profile of median chloride and TDS concentrations for the PM-2 multi-level nested monitoring wells.

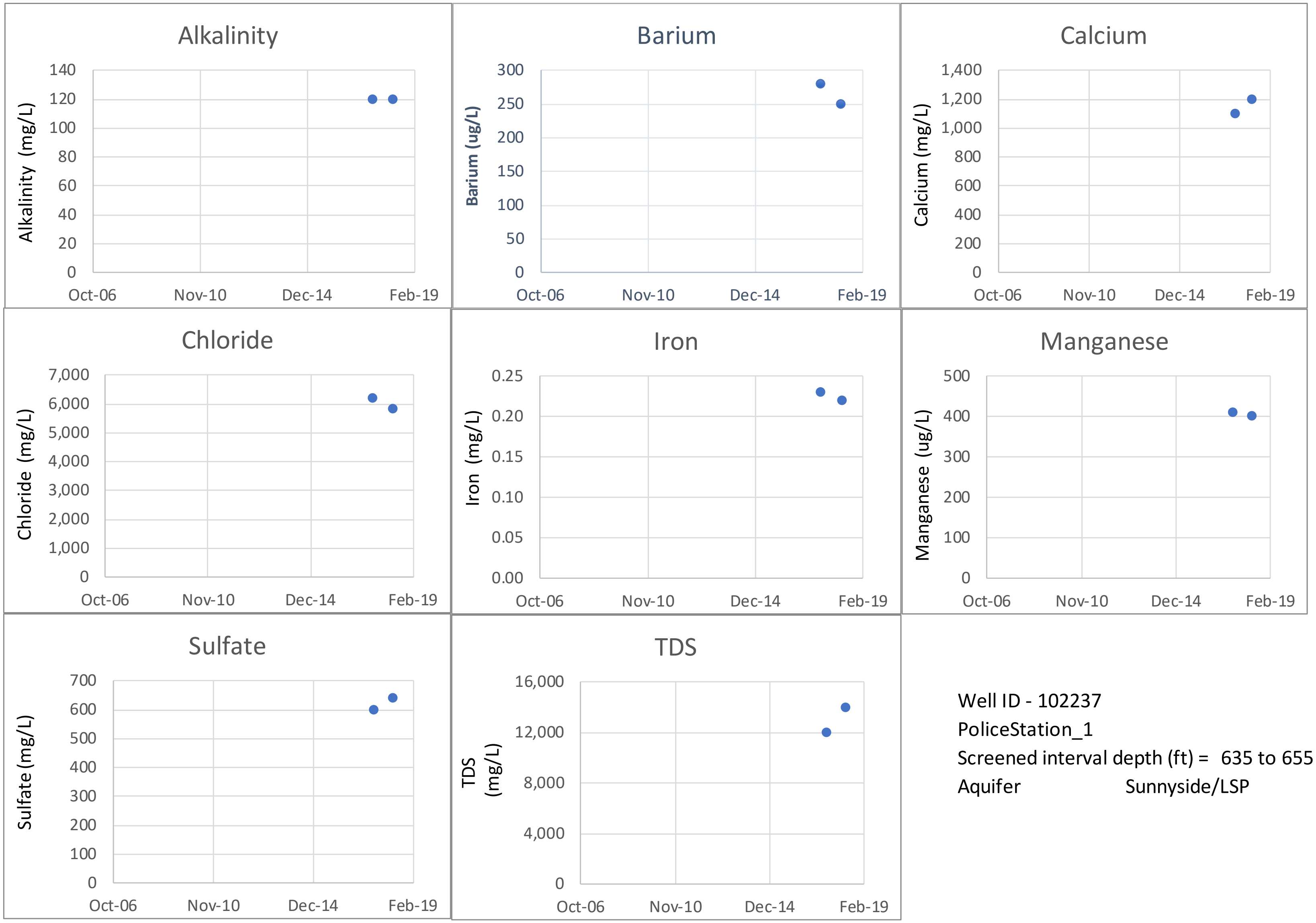


Figure 3-1. Water Quality of PM-2 (Police Station) at Well 1

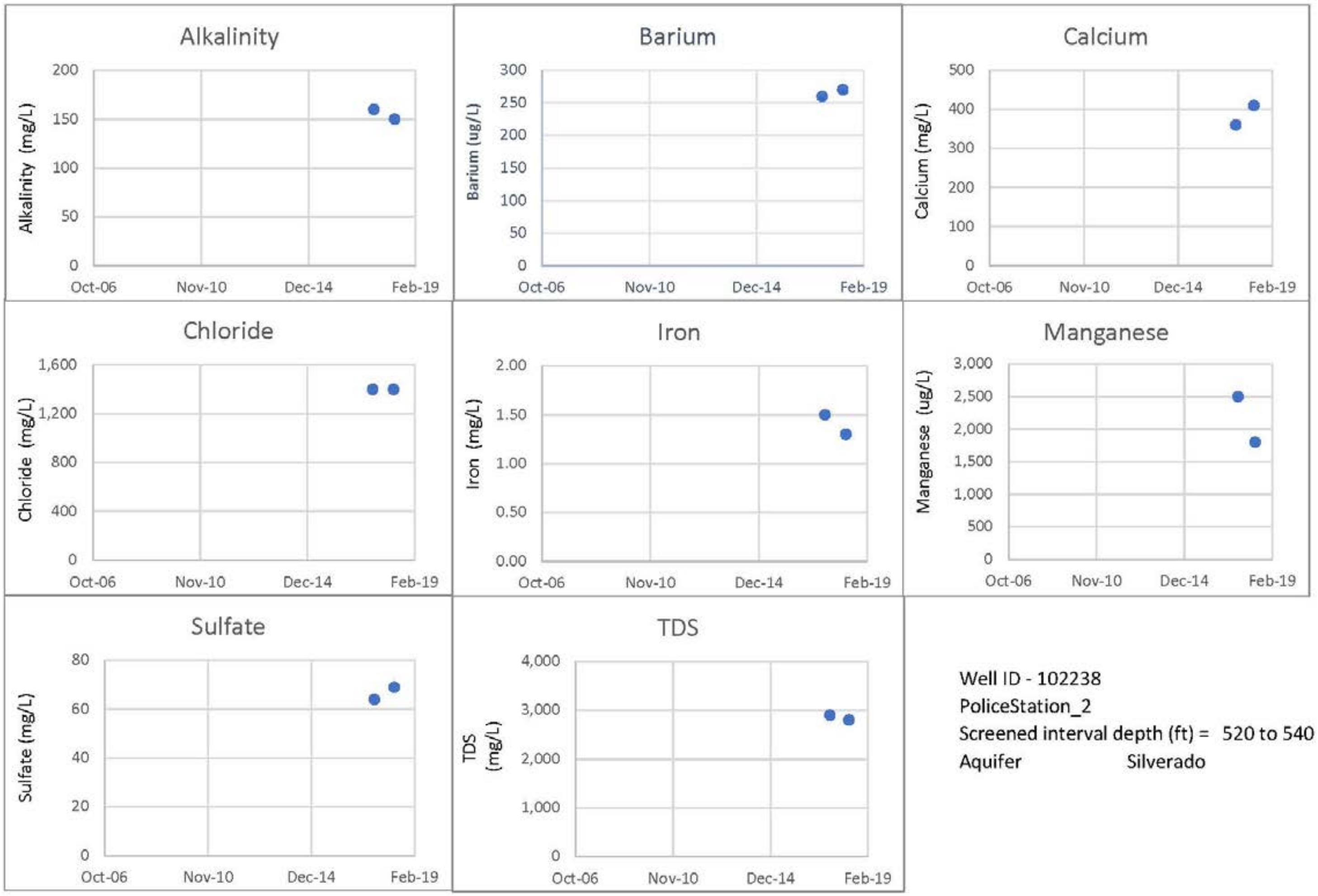


Figure 3-2. Water Quality of PM-2 (Police Station) at Well 2

Figure 3-3. Water Quality of PM-2 (Police Station) at Well 3

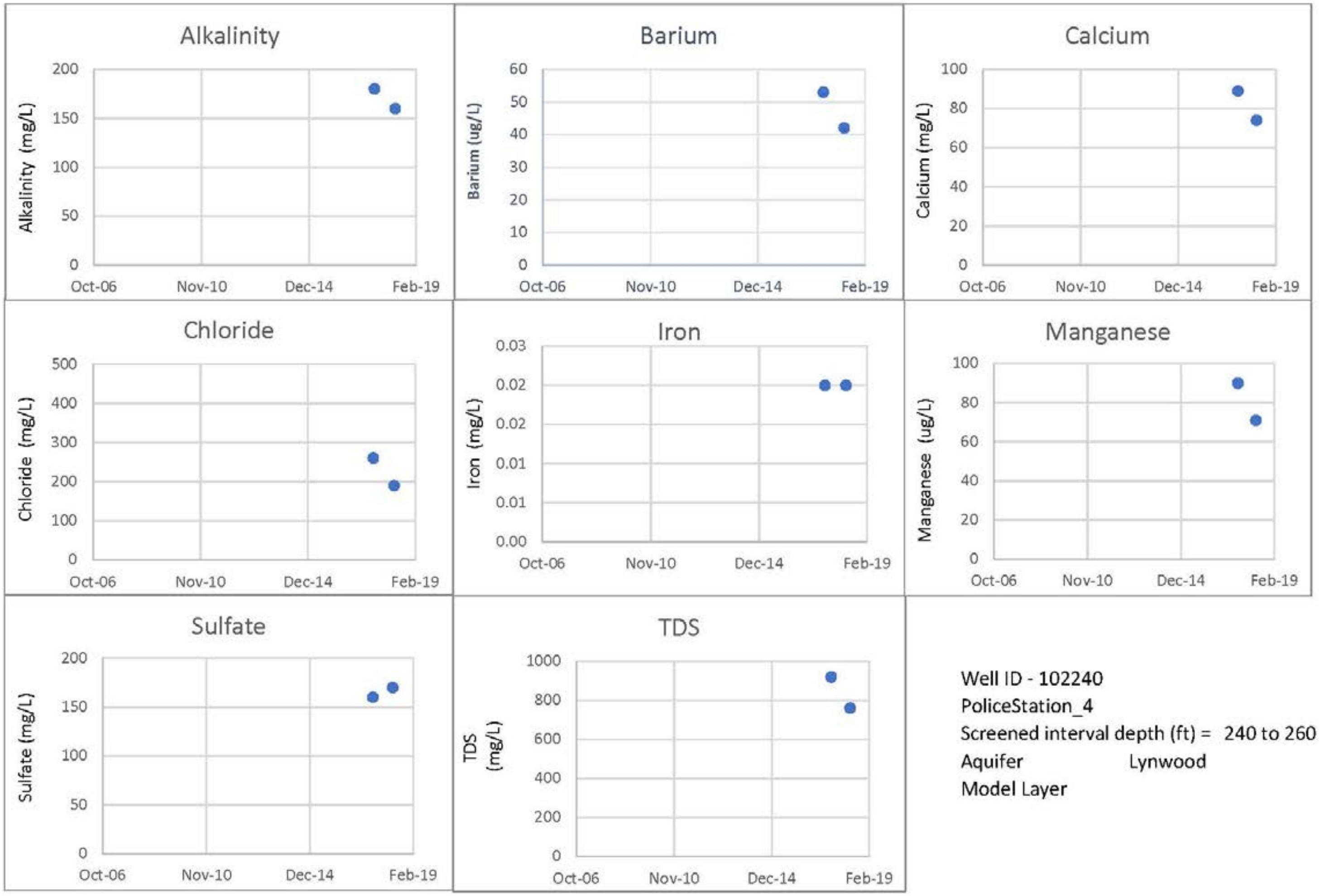
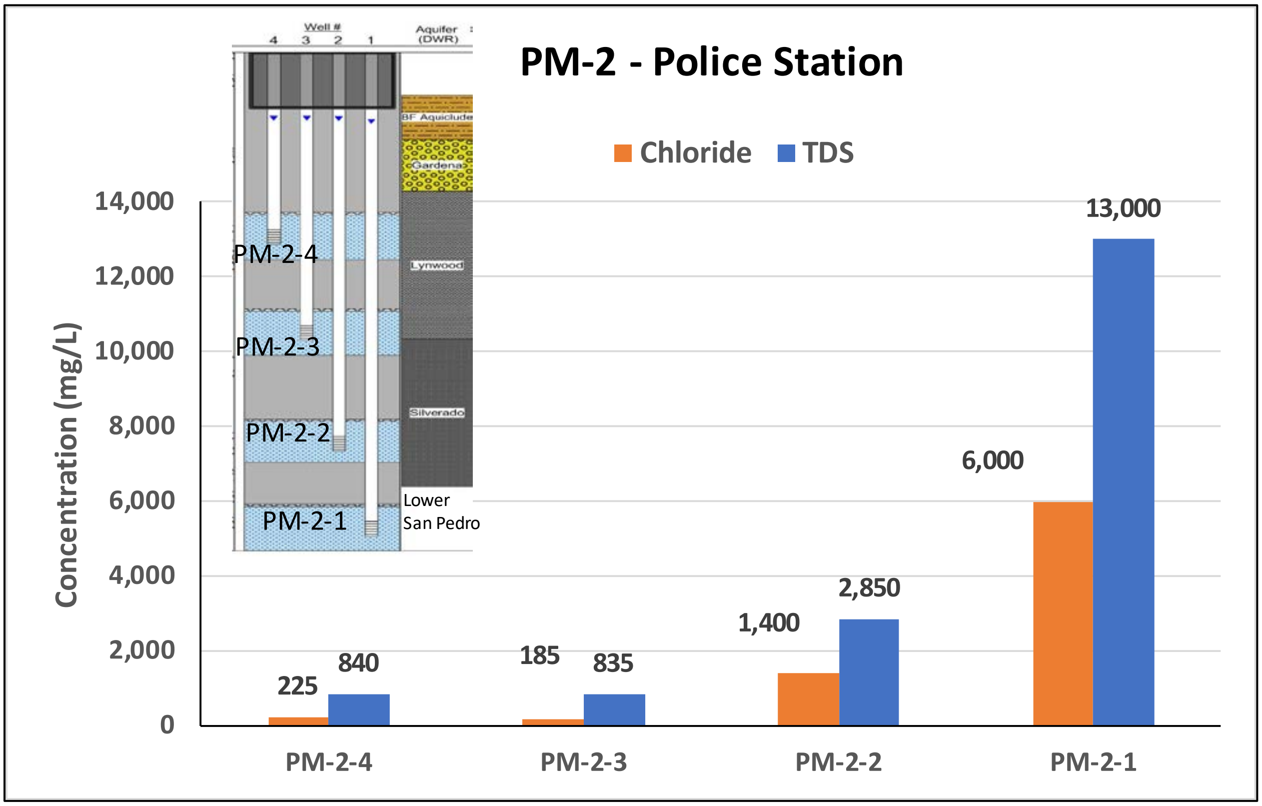


Figure 3-4. Water Quality of PM-2 (Police Station) at Well 4



Refer to Figure 4-5 for Gage/Gardenia/Lynwood Aquifer relationships.

Figure 3-5. Distribution of Median Chloride and TDS Concentrations among the PM-2 Multi-level Nested Monitoring Wells

3.2 PM-6 Well (Madrona Marsh)

As shown on Figure 2-3b, PM-6 is a multi-level nested monitoring well, with six individual nested wells (labeled as wells 1 through 6 from deepest to shallowest) that are screened in various aquifers, at depths varying from approximately 200 feet bgs to 1,200 feet bgs, corresponding to elevations of approximately -160 feet msl to -1,120 feet msl. Table 3-2 presents the minimum (min), maximum (max), and median concentrations of eight key constituents for treatment consideration, i.e., alkalinity, barium, calcium, chloride, iron, manganese, sulfate, and TDS for wells 1 through 6. For all six wells, data for these water quality parameters were available from 2009 through 2018. Figures 3-6 through 3-11 present temporal variations in measured concentrations for these constituents for wells 1 through 6, respectively.

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Table 3-2. Summary of Water Quality Parameters for the PM-6 Monitoring Well

Well ID	Screened Interval Elevation (feet msl)	Descriptive Statistics	Alkalinity (mg/L)	Barium (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Iron (mg/L)	Manganese (µg/L)	Sulfate (mg/L)	TDS (mg/L)
Madrona Marsh Well 6 (PM-6-6)	-160 to -180	Min	160	17	68	180	0.13	85	100	600
		Max	200	36	120	320	0.34	230	150	960
		Median	180	27	97	230	0.25	150	120	780
Madrona Marsh Well 5 (PM-6-5)	-310 to -330	Min	140	100	250	1,400	0.77	460	120	2,800
		Max	210	220	530	1,900	1.30	1,200	460	4,600
		Median	160	170	350	1,500	0.99	740	410	3,400
Madrona Marsh Well 4 (PM-6-4)	-450 to -470	Min	210	9	16	51	0.03	18	0.3	350
		Max	250	28	20	62	0.10	94	9.4	400
		Median	240	23	18	53	0.05	76	0.3	380
Madrona Marsh Well 3 (PM-6-3)	-690 to -710	Min	120	2,200	980	2,400	0.05	120	6.2	10,000
		Max	170	3,100	1,200	7,500	0.21	380	83	16,000
		Median	150	2,700	1,100	6,600	0.10	210	32	12,000
Madrona Marsh Well 2 (PM-6-2)	-825 to -845	Min	110	300	160	2,400	0.05	120	0.3	4,400
		Max	240	560	220	4,900	0.21	220	1.4	5,600
		Median	130	500	200	2,700	0.10	190	0.3	4,700
Madrona Marsh Well 1 (PM-6-1)	-1115 to -1155	Min	210	23	9	53	0.01	14	1.1	690
		Max	540	1,000	330	2,200	0.14	120	180	4,400
		Median	420	430	150	1,000	0.07	36	7	2,300

Based on Figures 3-6 through 3-11, a few water quality parameters appeared to have an increasing trend in concentration while a few other parameters showed a declining trend. A few parameters showed no increasing or decreasing trend. Such variabilities were observed throughout the wells at various depths. Provided below is a list of the temporal trend of measurements.

- For well 1 (Figure 3-6), an increasing trend for barium, calcium, chloride, and TDS, and a decreasing trend for alkalinity, is apparent. Sulfate concentrations were less variable, and no strong trend is apparent for iron and manganese.
- For well 2 (Figure 3-7), an increasing trend for calcium is apparent. Sulfate concentrations were less variable over the monitoring period. No strong trend is apparent for other constituents.
- For well 3 (Figure 3-8), a decreasing trend for manganese concentrations is apparent. No strong trend is apparent for other constituents.
- For well 4 (Figure 3-9), no trend is apparent for any of the constituents, except barium and manganese with some lower values during initial measurements than rest of the measurements.
- For well 5 (Figure 3-10), a decreasing trend for most of the constituents is apparent, except for sulfate, which shows an increasing trend.
- For well 6 (Figure 3-11), a decreasing trend is apparent for all the constituents except iron, which does not show a strong trend.
- Manganese concentrations are decreasing in all nested wells, either toward or achieving the primary maximum contaminant level value of 50 µg/L, with the exception of nested well 2. These data, combined with the treatment goals of this Program to treat the majority of the saline plume over a 30-year period, and the use of low-manganese injection water for replenishment, support the assumption that once the plume has been treated and the aquifers are restored to TDS/chloride concentrations below the secondary maximum contaminant levels, the extracted groundwater will no longer need treatment for manganese. If, at that time, it is found that additional manganese treatment is still required, the use of the existing reverse osmosis (RO) or other treatment, such as greensand, will be considered.

3.2.1 Depth Profile of Chloride Concentration for PM-6 Monitoring Well

Based on the temporal data presented on Figures 3-6 through 3-11, median chloride concentrations for all six wells were calculated and plotted to understand the depth profile of chloride in different aquifers/zones. Figure 3-12 presents the depth profile of chloride concentrations along with the maximum chloride concentrations for each zone for the PM-6 monitoring well for the period from 2009 through 2017. Well 6 is the shallowest well, which covers the Gage and Lynwood aquifers and Well 1 is in the Pico Formation (Figure 2-3b). Data points in the chart are the median chloride concentrations and the error bars represent the maximum chloride concentration from median values. Blue dotted line represents the reference chloride concentration level of 500 mg/L, which is the minimum threshold concentration for the desalter operations. For reference, the corresponding aquifer is also labeled on the figure. The highest chloride concentrations are in the LSP aquifer (PM-6, well 3). In the screened interval for the Silverado aquifer (PM-6, well 4), the chloride concentrations were the lowest with values ranging between 50 and 60 mg/L for data from 2009 through 2018. Chloride concentrations for the Gage aquifer were below 500 mg/L throughout the monitoring period.

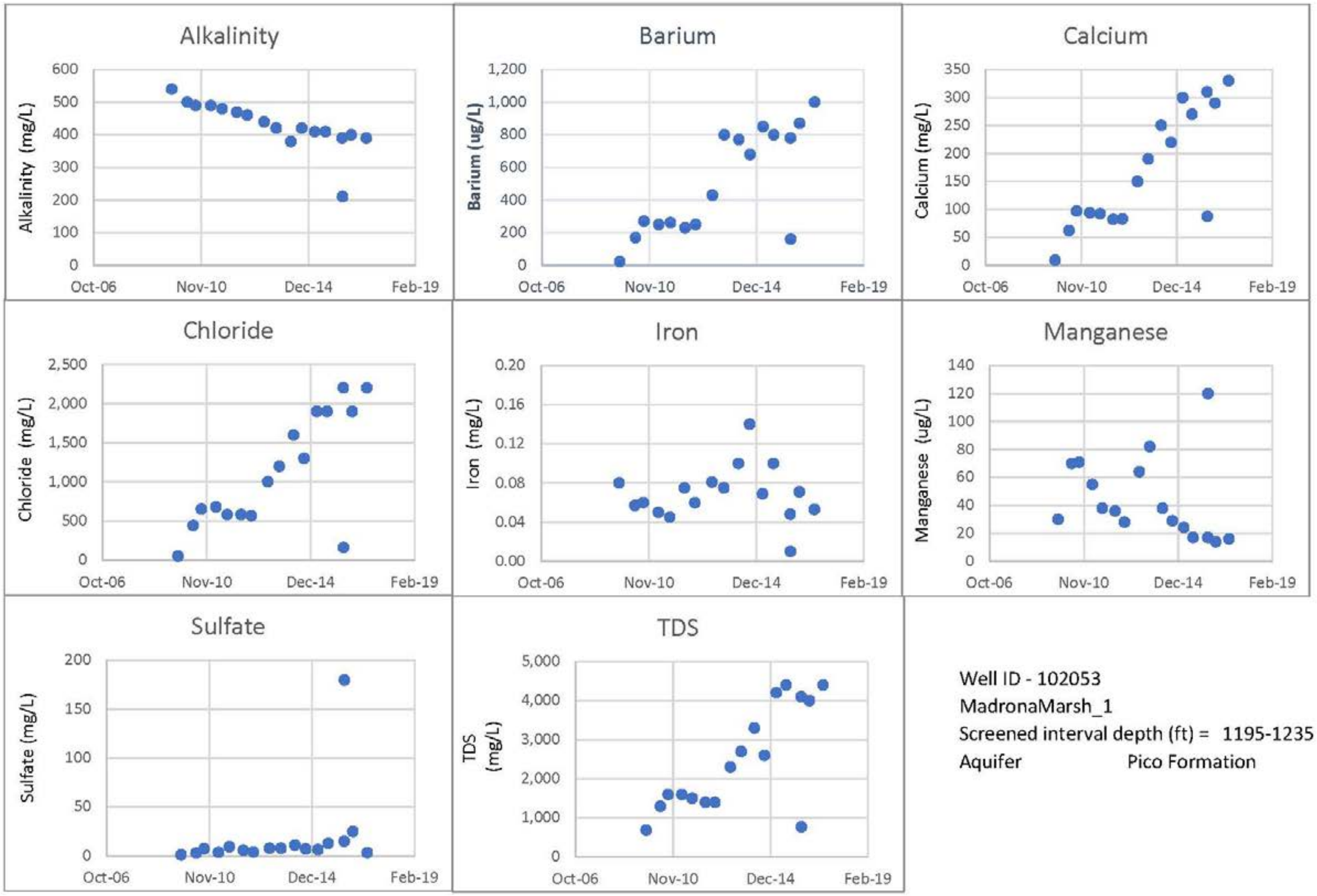


Figure 3-6. Water Quality of PM-6 (Madrona Marsh) at Well 1

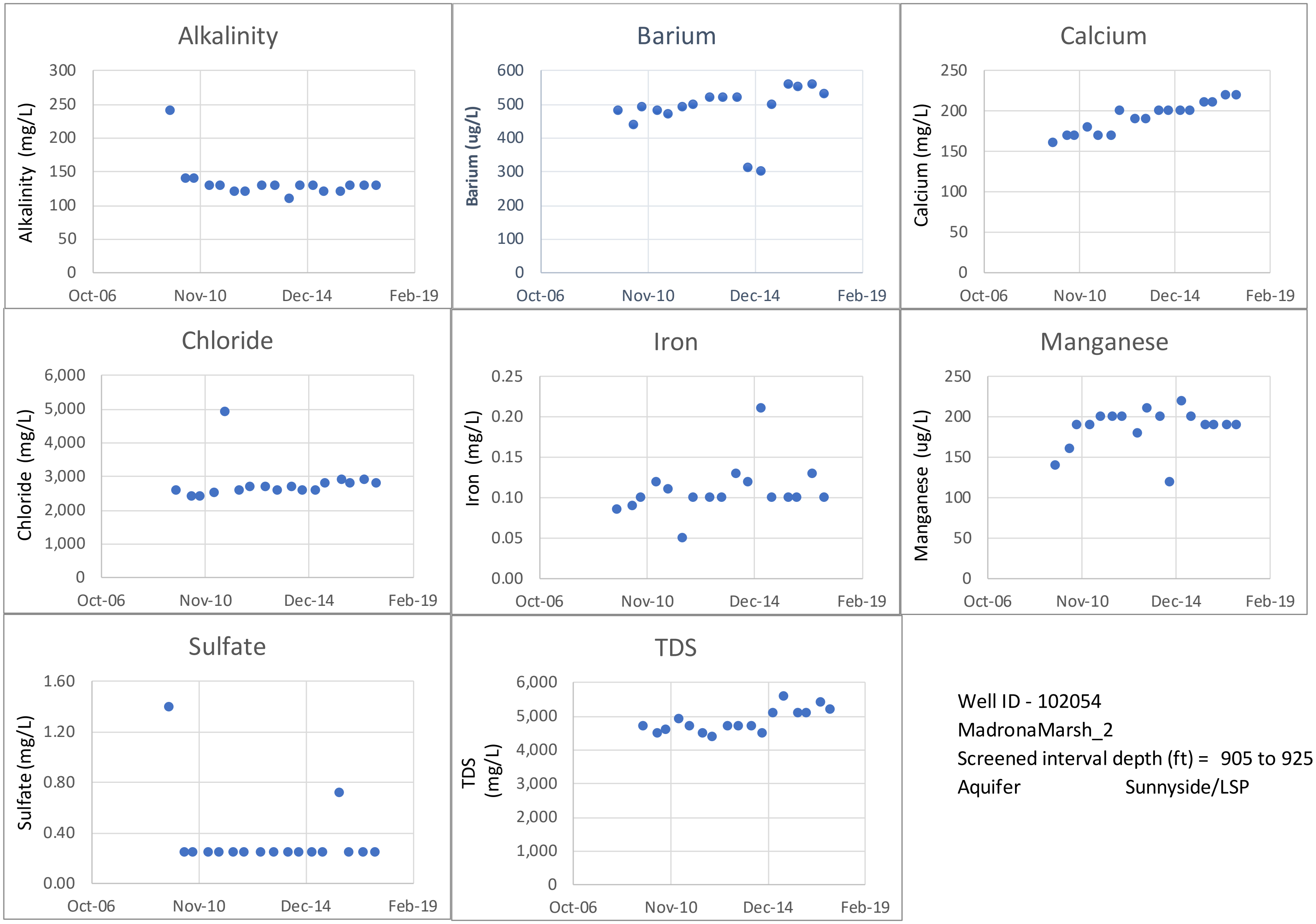


Figure 3-7. Water Quality of PM-6 (Madrona Marsh) at Well 2

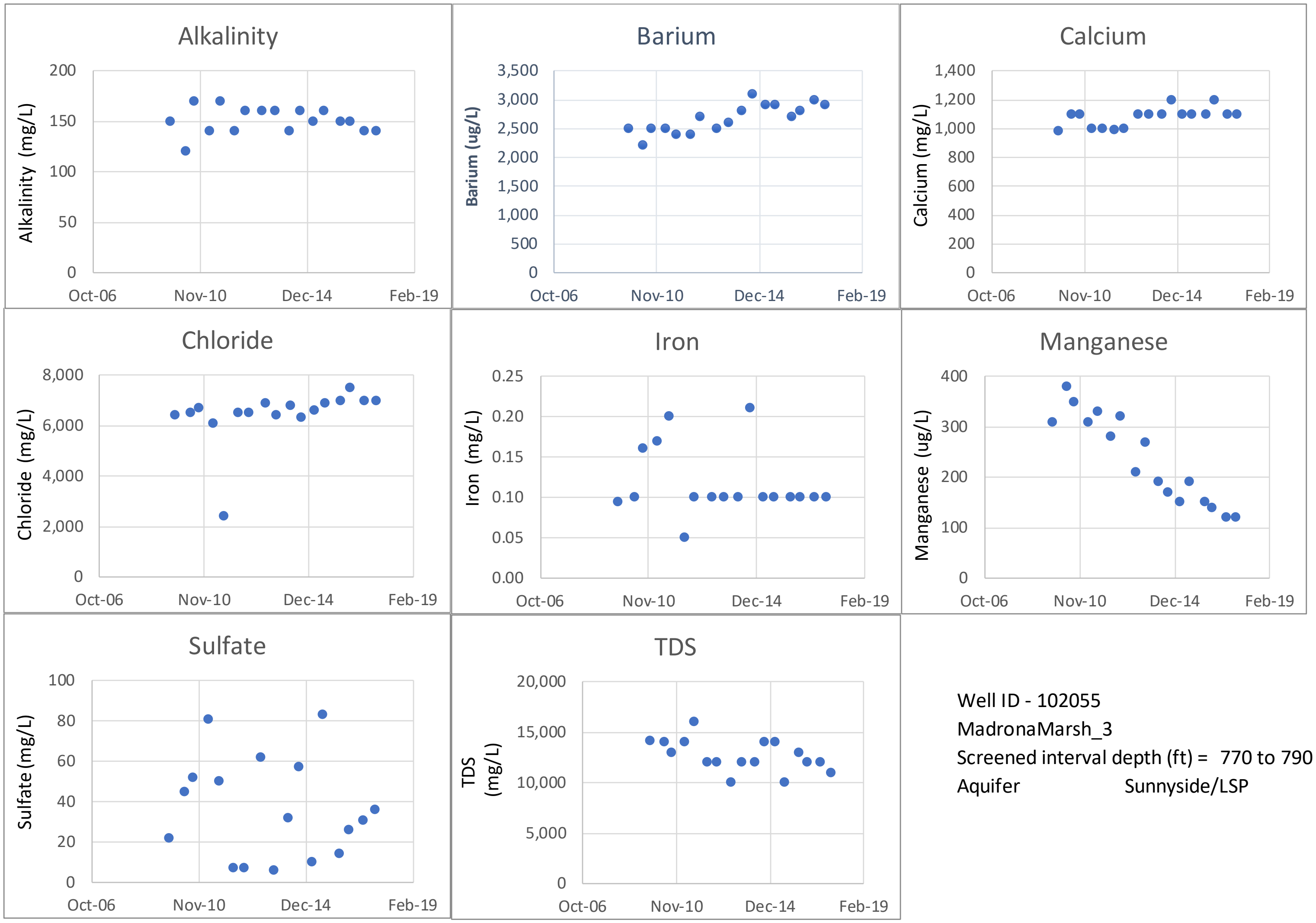


Figure 3-8. Water Quality of PM-6 (Madrona Marsh) at Well 3

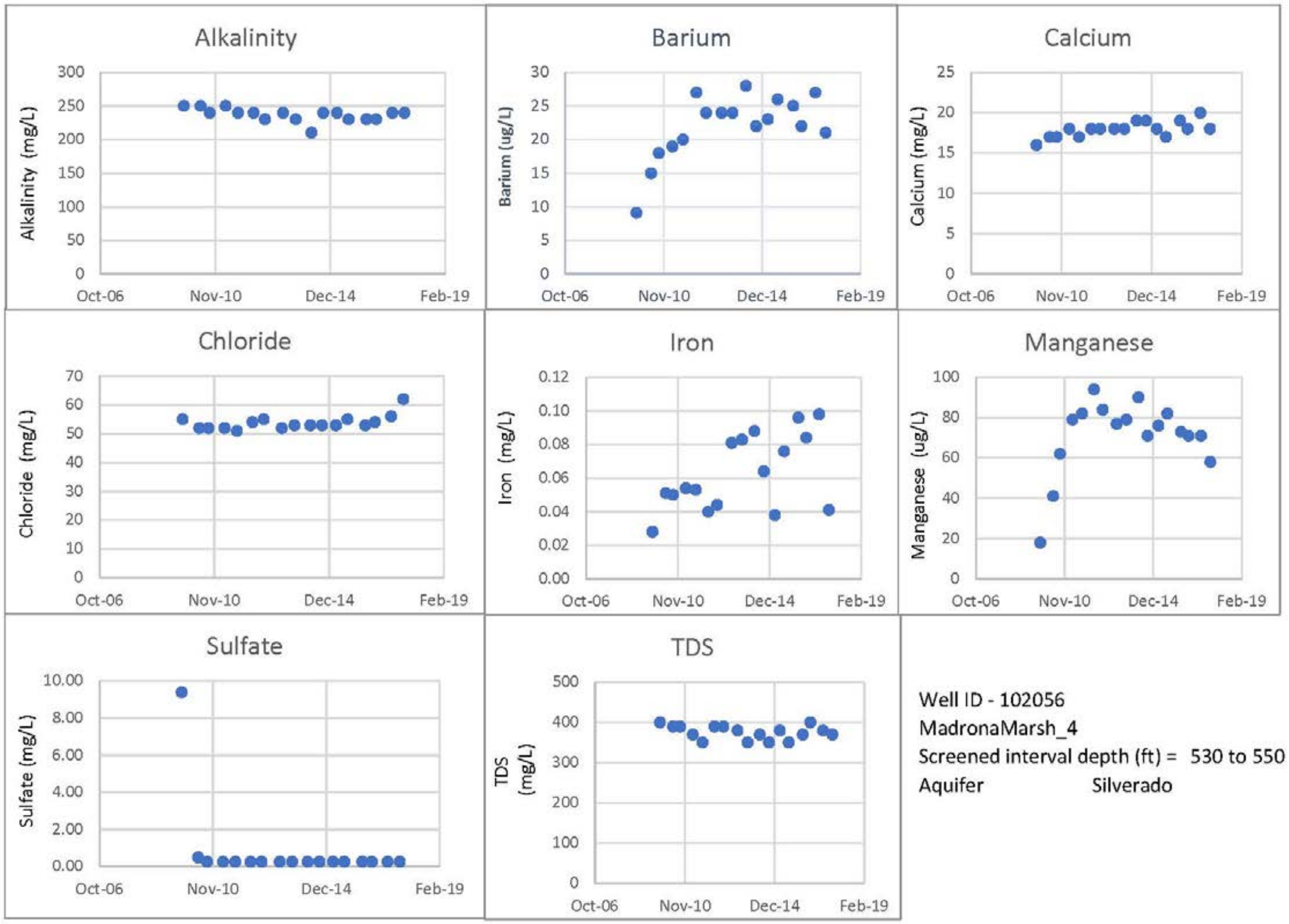


Figure 3-9. Water Quality of PM-6 (Madrona Marsh) at Well 4

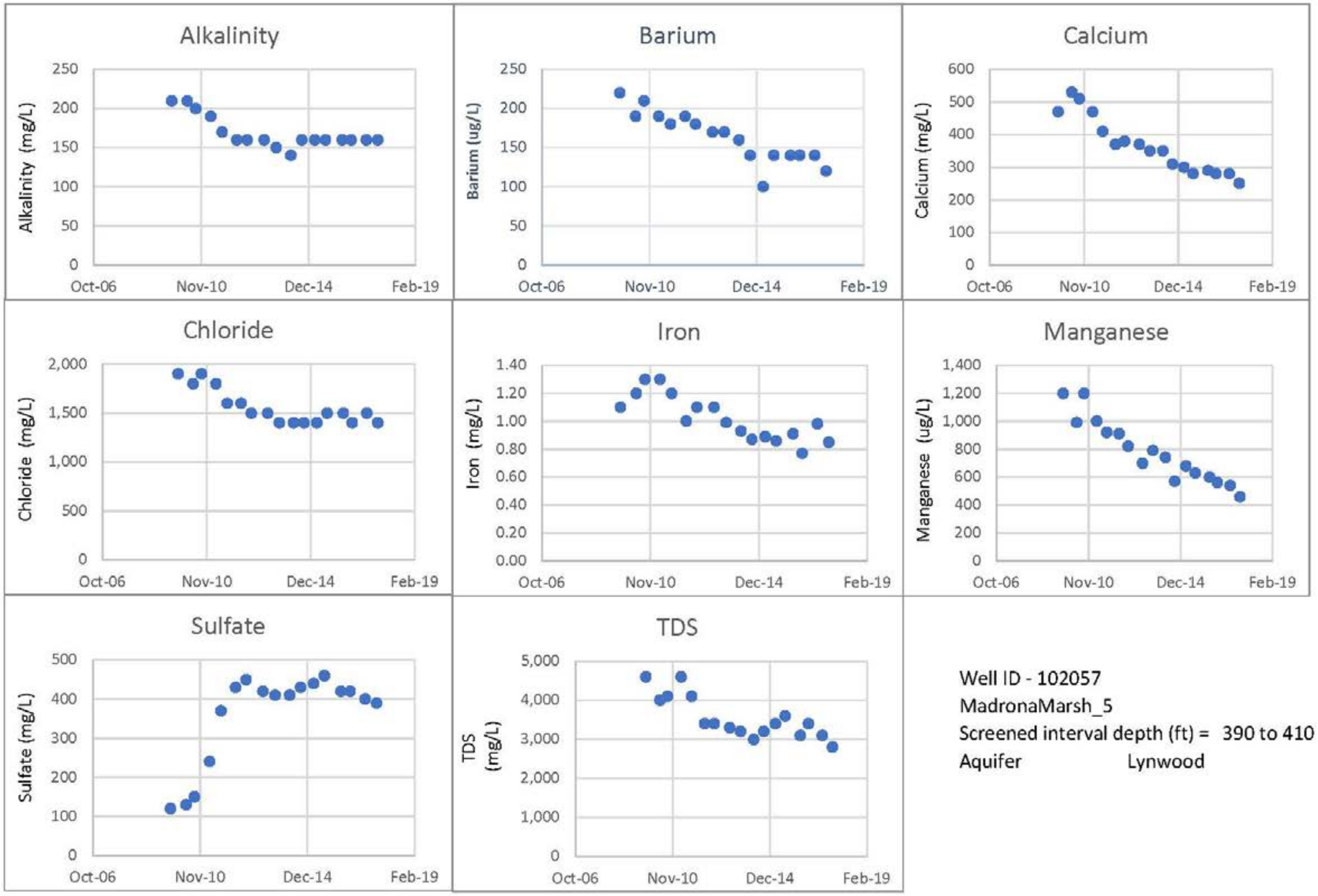
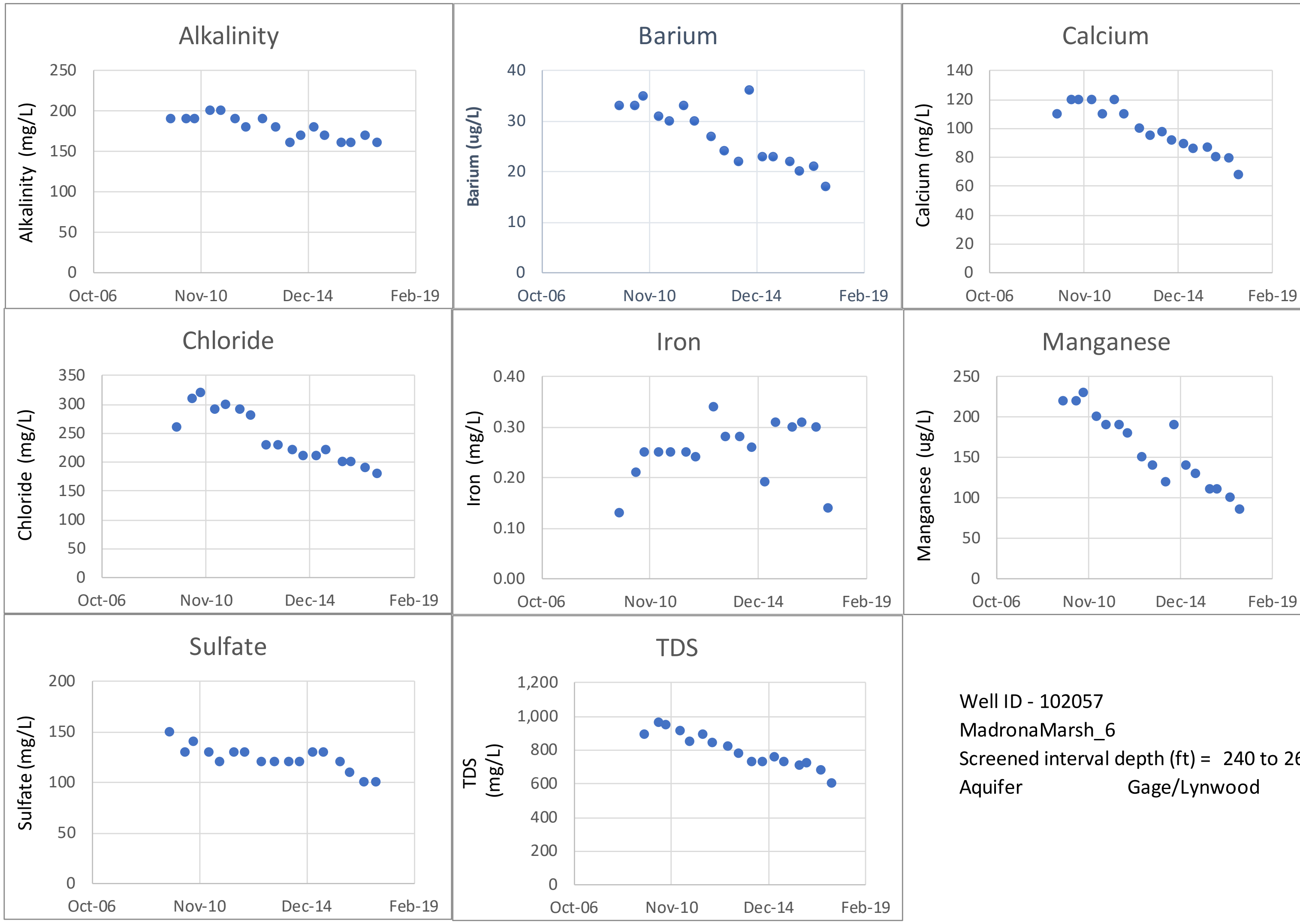


Figure 3-10. Water Quality of PM-6 (Madrona Marsh) at Well 5



Well ID - 102057
MadronaMarsh_6
Screened interval depth (ft) = 240 to 260
Aquifer Gage/Lynwood

Figure 3-11. Water Quality of PM-6 (Madrona Marsh) at Well 6

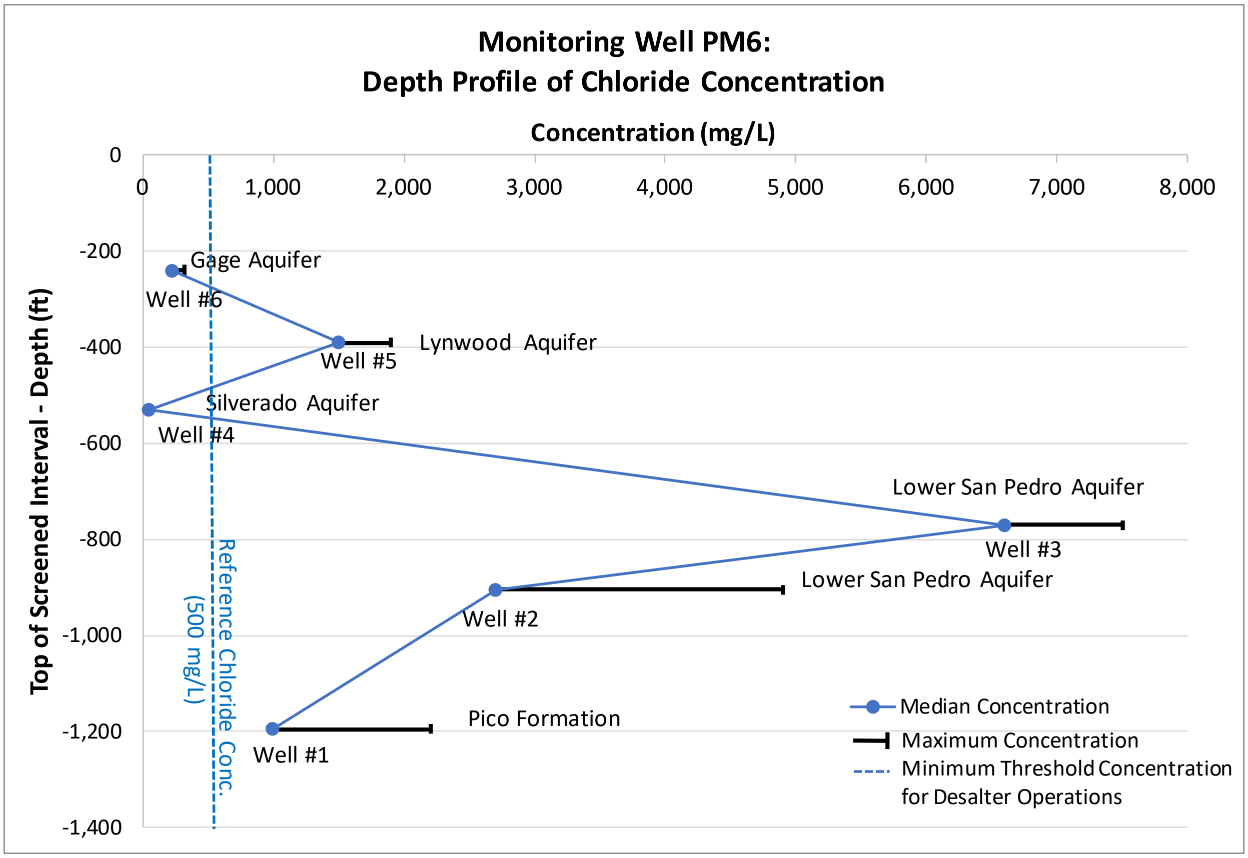


Figure 3-12. Depth Profile of Chloride Concentration for the PM-6 Monitoring Well

3.2.2 Chloride and TDS and Concentrations for the PM-6 Monitoring Wells

Figure 3-13 shows box and whisker plots of the median and the range of chloride and TDS concentrations for the multi-level nested Madrona Marsh well (PM-6). The spread of TDS and chloride concentrations are indicated in the box plot for each well. The boundary of the box closest to zero indicates the 25^{th} percentile, the line within the box marks the median concentration, and the boundary of the box farthest from zero indicates the 75^{th} percentile. Whiskers (error bars) above and below the box indicate the 90^{th} and 10^{th} percentiles of the data. The black filled circles above and below the whiskers indicate the outlier/maximum and outlier/minimum values, respectively. As seen in the depth profile for chloride on Figure 3-12, chloride concentrations were the highest in well 3 (i.e., in the LSP aquifer), followed by the concentration in well 2 (i.e., also in the LSP aquifer below well 3), and the lowest in well 4 (in the Silverado aquifer). The median chloride concentration in the Pico aquifer was above 500 mg/L. However, the concentrations in the Gage aquifer were below 500 mg/L. It can be noted that the chloride and TDS concentrations are relatively low in the upper three screened intervals, reach maximum concentration at PM-6-3 (i.e., well 3), and decrease at the lower depths. This concept is also noted in the depth profile of median chloride and TDS concentrations presented on Figure 3-14.

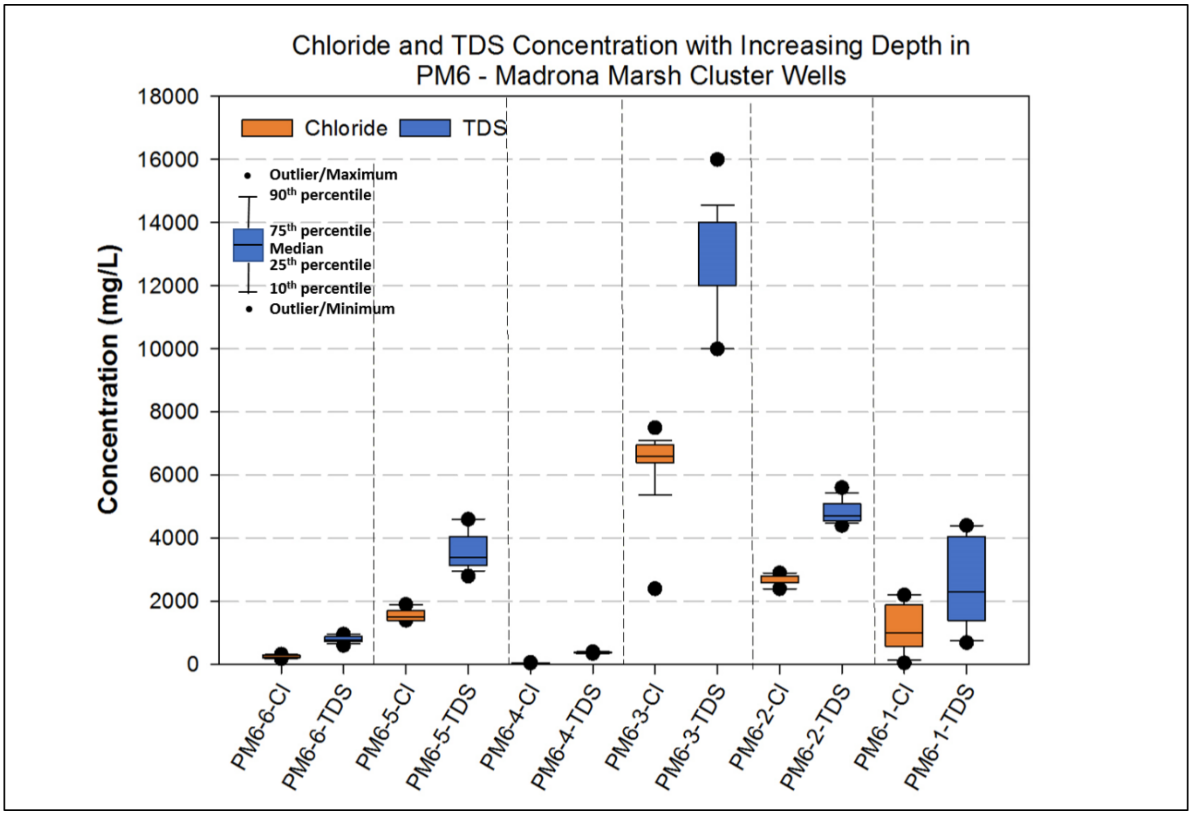
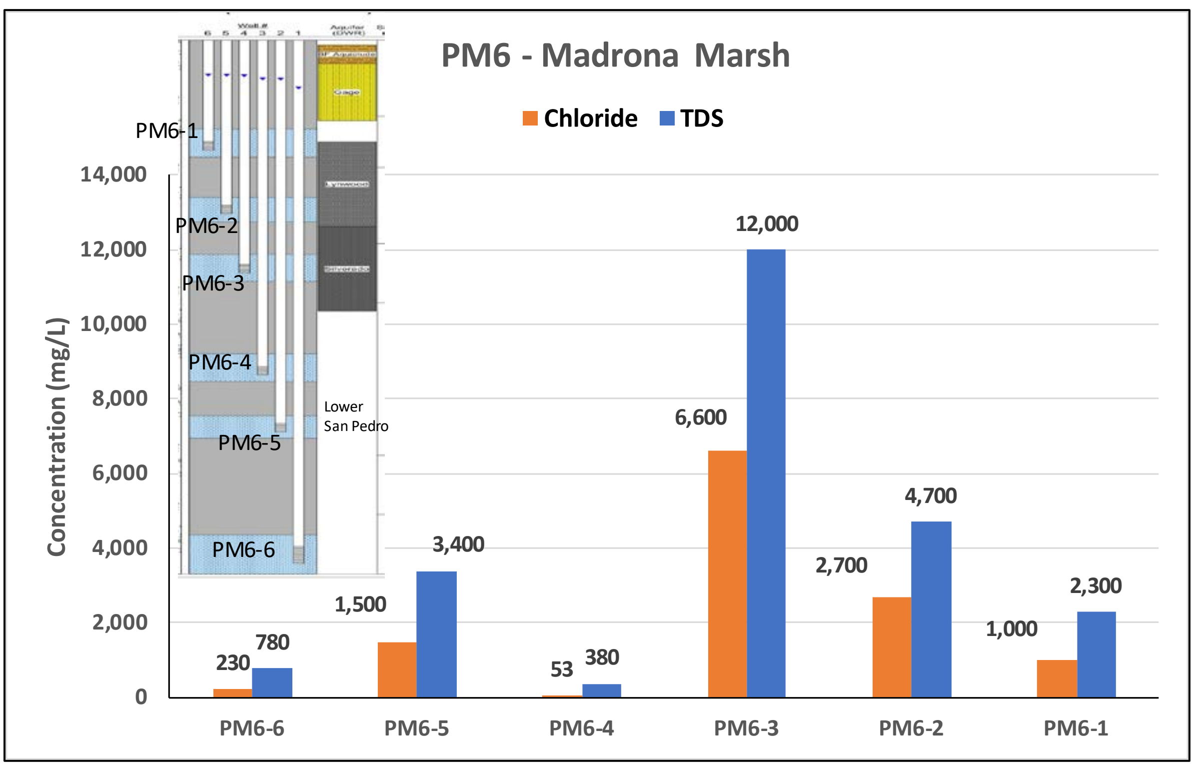


Figure 3-13. Chloride and TDS concentrations in the PM-6 (Madrona Marsh) Multi-level Nested Wells



Refer to Figure 4-5 for Gage/Gardenia/Lynwood Aquifer relationships.

Figure 3-14. Distribution of the Median Chloride and TDS Concentrations among the PM-6 Multi-level Nested Monitoring Wells

3.3 Existing Sepulveda Extraction Wells 1 and 2, PM-2, and PM-6 Multi-level Nested Monitoring Wells

Figures 3-15 and 3-16 show chloride and TDS concentrations in the Sepulveda 1 and 2 inactive extraction wells, PM-6 (Madrona Marsh multi-level nested monitoring wells), and PM-2 (Police Station multi-level nested monitoring wells), respectively. The following can be observed:

- Sepulveda wells 1 and 2 have chloride concentrations less than 2,000 mg/L.
- There was an initial increasing trend in concentration with depth and a decreasing trend at shallower depths for the PM-6 well.
- All three screened intervals above the deepest screened interval for the PM-2 well had relatively low chloride concentrations below 2,000 mg/L.
- PM-2, well 1 (PM-2-1) (i.e., the deepest screened interval) contained the maximum chloride concentrations, which were many times higher than those in the three shallower screened intervals.

The trends in TDS concentration are similar to those for chloride concentrations. The following can be observed from the plots:

- For the PM-6 well, there was an initial increasing trend in TDS concentration with increasing depth and a decreasing trend at lower depths.
- For the PM-2 well, all three screened intervals above the deepest screened interval had relatively low TDS concentrations below 3,000 mg/L.
- For the PM-6 well 3 (PM-6-3) and PM-2, well 1 (PM-2-1), between depths of 500 and 700 feet bgs indicate maximum TDS concentrations approaching or more than 14,000 mg/L.
- Sepulveda wells 1 and 2 had TDS concentrations less than 4,000 mg/L.

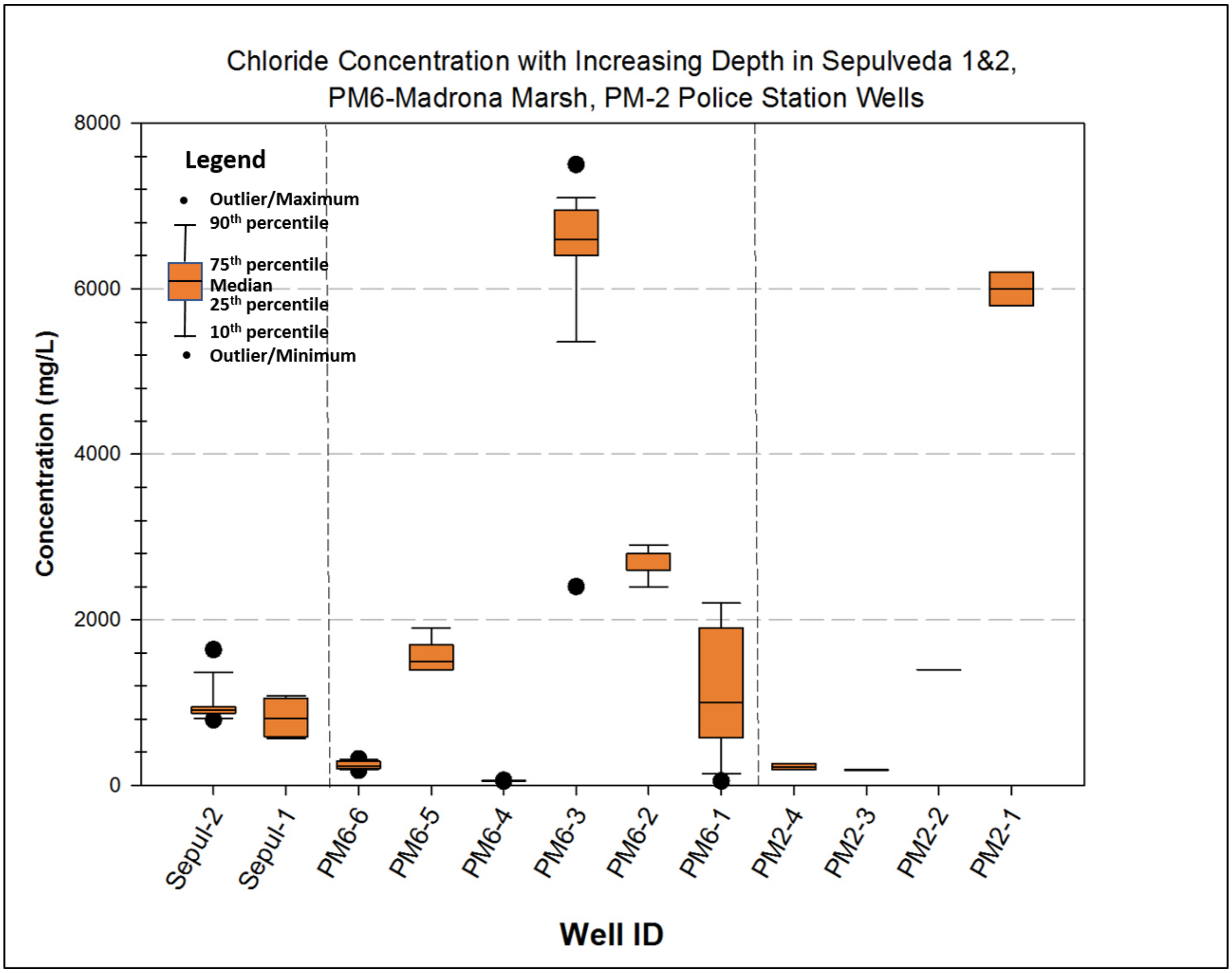


Figure 3-15. Chloride Concentrations in Sepulveda Wells 1 and 2, PM-6 (Madrona Marsh Multi-level Nested Wells), and PM-2 (Police Station Multi-level Nested Wells)

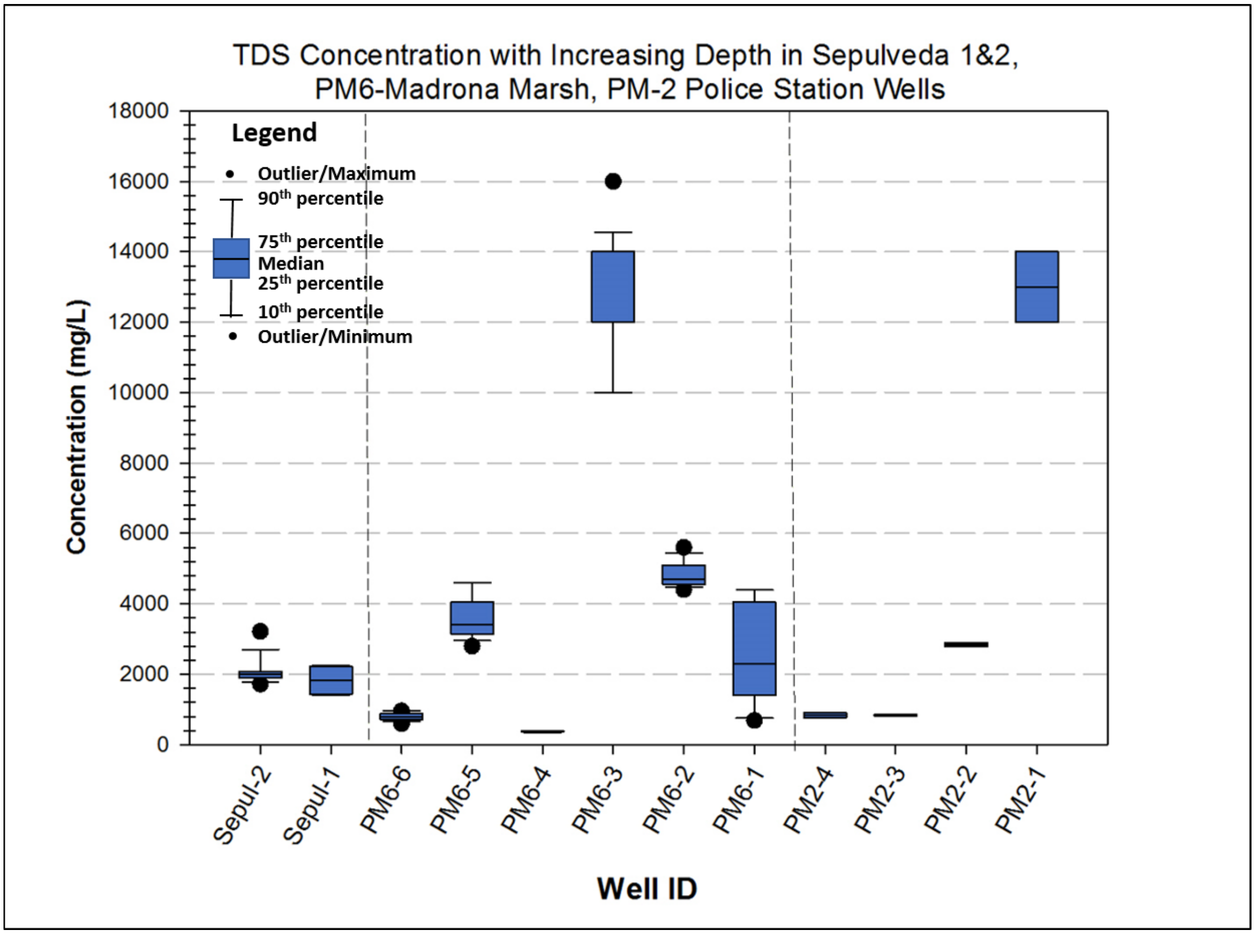


Figure 3-16. TDS Concentrations in Sepulveda Wells 1 and 2, PM-6 (Madrona Marsh Multi-level Nested Wells), and PM-2 (Police Station Multi-level Nested Wells)

4. Approach to Assessing Water Quality of the Potential Future Extraction Wells

The proposed Projects developed under this Program will use various combinations of extraction wells, such as the inactive Sepulveda wells, and new extraction wells. The combined blended water quality of these extraction wells is important for the design of the Project's treatment scheme. Key considerations for the extracted well water quality include:

- Percent flow contribution from each aquifer
- Number of extraction wells for each Project
- Thickness and hydraulic properties of the aquifers from which saline plume water will be extracted based on hydrogeologic cross sections through the proposed well locations
- Water quality of each aquifer and expected water quality from each well when pumping full capacity

Based on the information gathered and developed for these key components, this section presents the approach used for developing an average feed water quality for the Program's Potential Projects.

Monitoring data from the PM-2 and PM-6 wells were used to characterize the water quality of the brackish source water. It should be noted that the PM-2 and PM-6 wells are screened across a relatively small thickness of the aquifer (20-foot screened intervals) and pumped for sampling purposes at relatively low flow rates (2 to 4 gallons per minute [gpm]), which may not be representative of production well concentrations that draw water over a much broader thickness of the aquifer (100 feet plus screened intervals) at relatively higher flow rates (hundreds to thousands of gpm). Presented below are the steps taken to develop the water quality specifications for the proposed extraction wells and the resultant, averaged, feed water quality for the desalter.

4.1 Step 1 - Evaluation of Water Quality Data by Depth Based on PM-2 and PM-6 Data

This step involved assigning the water quality to the depths where the PM-6 and PM-2 wells are screened. Median chloride and TDS concentrations developed from the data (for the PM-2 and PM-6 monitoring wells as discussed in Section 3) were applied to the well-screened interval depths, shown in the well logs (Figures 2-3a and 2-3b). Figures 4-1 and 4-2 show the PM-2 and PM-6 well logs updated to show the median chloride and TDS concentrations for the various screened intervals from Tables 3-1 and 3-2. For the purposes of this feasibility study, it is assumed that the data gathered at these wells are representative of the water quality conditions of the saline plume that will be treated by the desalter.

4.2 Step 2 - Assessment of the U.S. Geological Survey Model Layers Relative to Depths of Water Quality Data

The well logs on Figures 2-3a and 2-3b do not identify the aquifers below the Silverado aquifer, where more than 60 percent of the saline plume volume resides (Table 2-1). Information presented in the U.S. Geological Survey (USGS) publication by Reichard et al. (2003) describing Los Angeles Basin (including the WCB) groundwater simulation model (USGS Model) was used to identify the aquifer systems (e.g., the Upper and the LSP), which contain various aquifers (e.g., Silverado and Sunnyside, not shown on Figures 4-1 and 4-2) and geologic formations (Figure 4-3). Figures 2-3a and 2-3b were updated to include the USGS model layers and aquifer system designations, as shown on Figures 4-1 and 4-2, respectively. In addition, the monitoring well water quality data assignments to model layers, USGS Model cross section were updated to include the USGS Model layer elevations relative to the PM-6 (Madrona Marsh) well lower screened intervals (Figure 4-4).

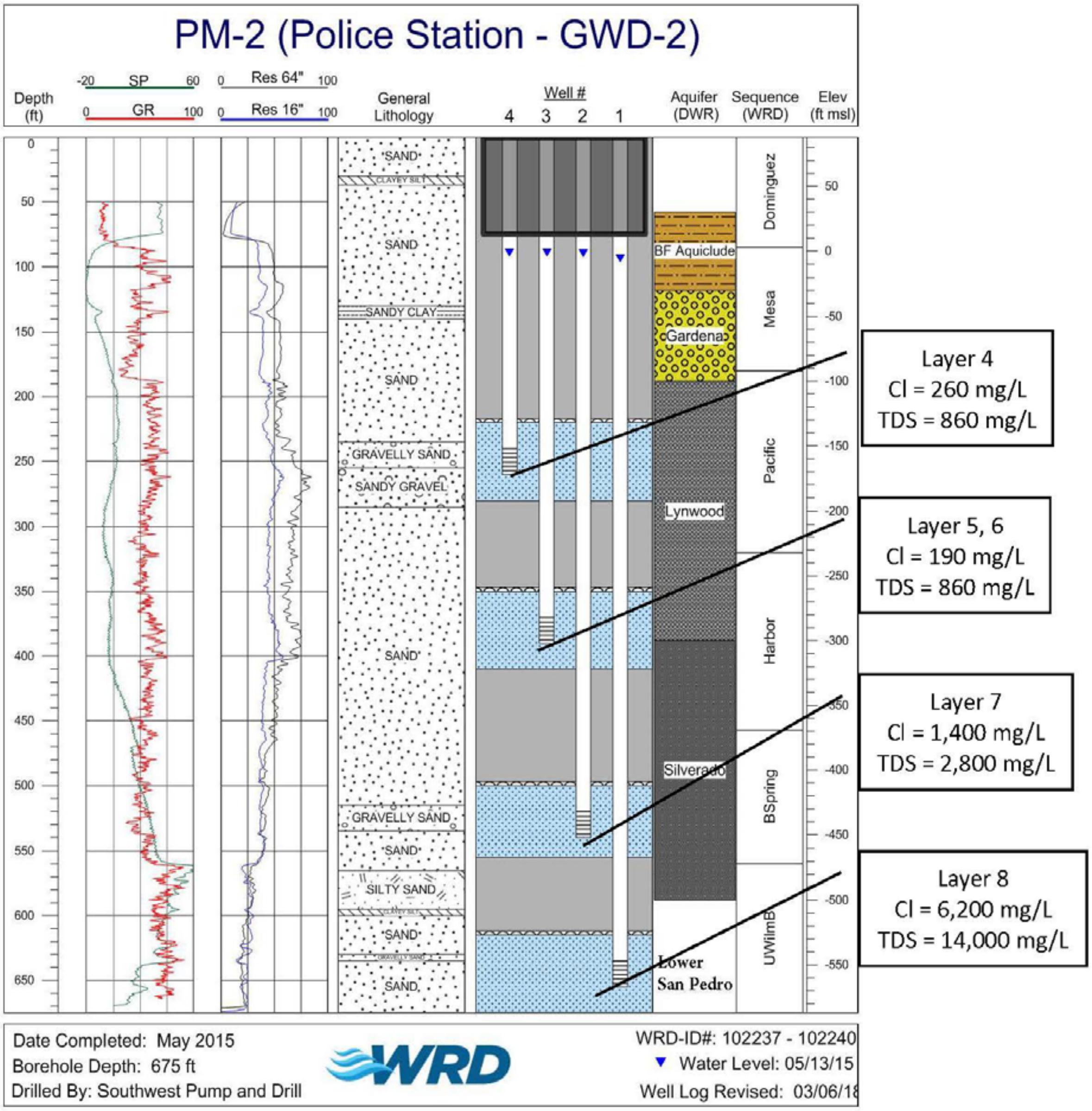


Figure 4-1. Median Chloride and TDS Concentrations for the PM-2 (Police Station) Multi-level Nested Well

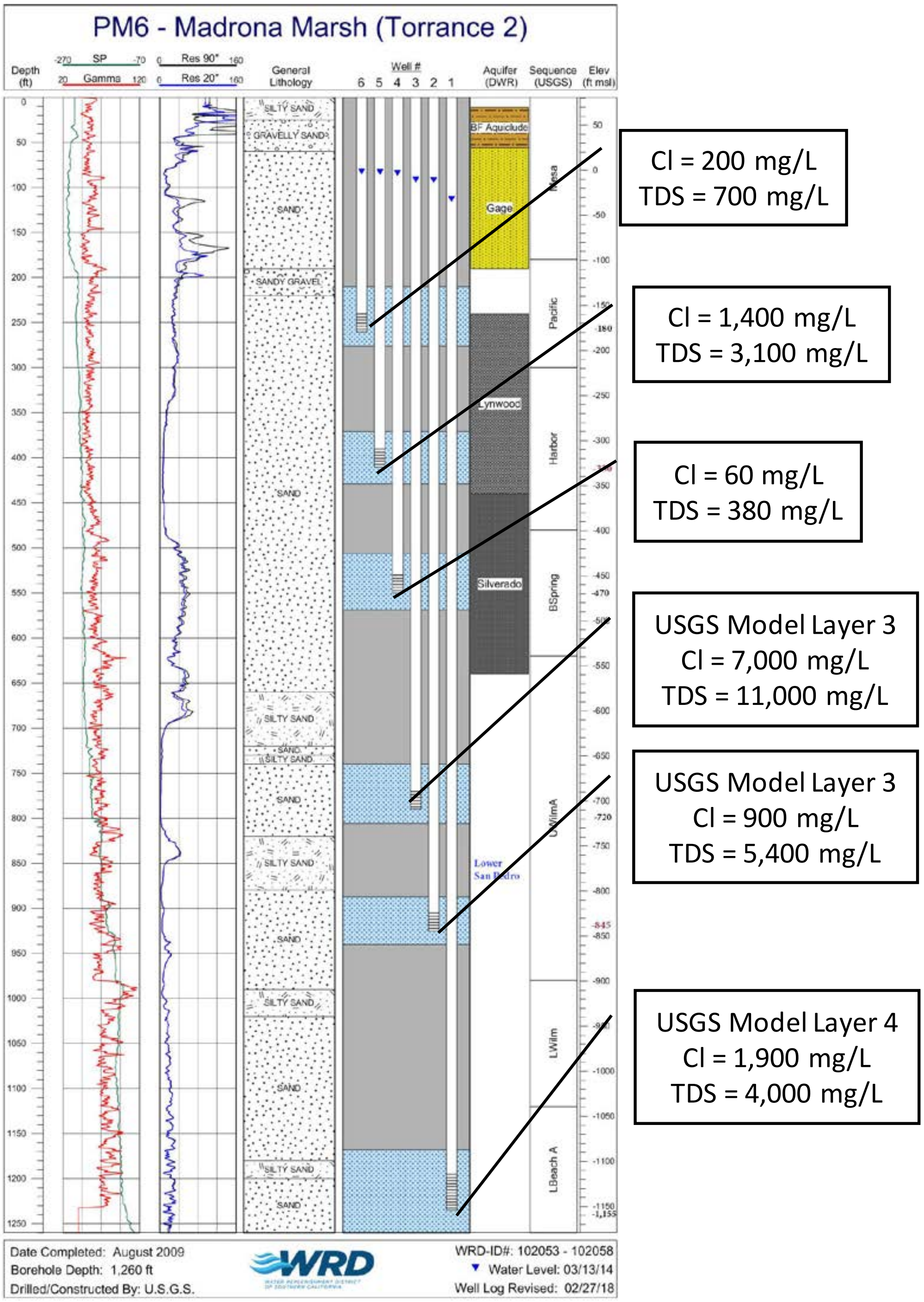


Figure 4-2. Median Chloride and TDS Concentrations for the PM-6 (Madrona Marsh) Multi-level Nested Well

AGE	FORMATION	AQUIFER	AQUIFER SYSTEMS	MODEL LAYER
HOLOCENE	ACTIVE DUNE SAND	SEMIPERCHED GASPUR	RECENT AQUIFER SYSTEM (Upper Aquifer Systems)	1
UPPER PLEISTOCENE	OLDER DUNE SAND *LAKEWOOD FORMATION* (California Dept. of Water Resources, 1961) *(UNNAMED UPPER PLEISTOCENE,* Poland and others 1956, 1959)	BALLONA EXPOSITION ARTESIA GARDENA GAGE (200 FOOT SAND)	Upper Aquifer Systems LAKEWOOD AQUIFER SYSTEM	2
LOWER PLEISTOCENE	*SAN PEDRO FORMATION*	HOLLYDALE JEFFERSON LYNWOOD (400 FOOT GRAVEL) SILVERADO	UPPER SAN PEDRO AQUIFER SYSTEM Lower Aquifer Systems	3
		SUNNYSIDE LOWER SAN PEDRO	LOWER SAN PEDRO AQUIFER SYSTEM (Lower Aquifer Systems)	4
UPPER PLIOCENE	*PICO FORMATION*		Pico unit	

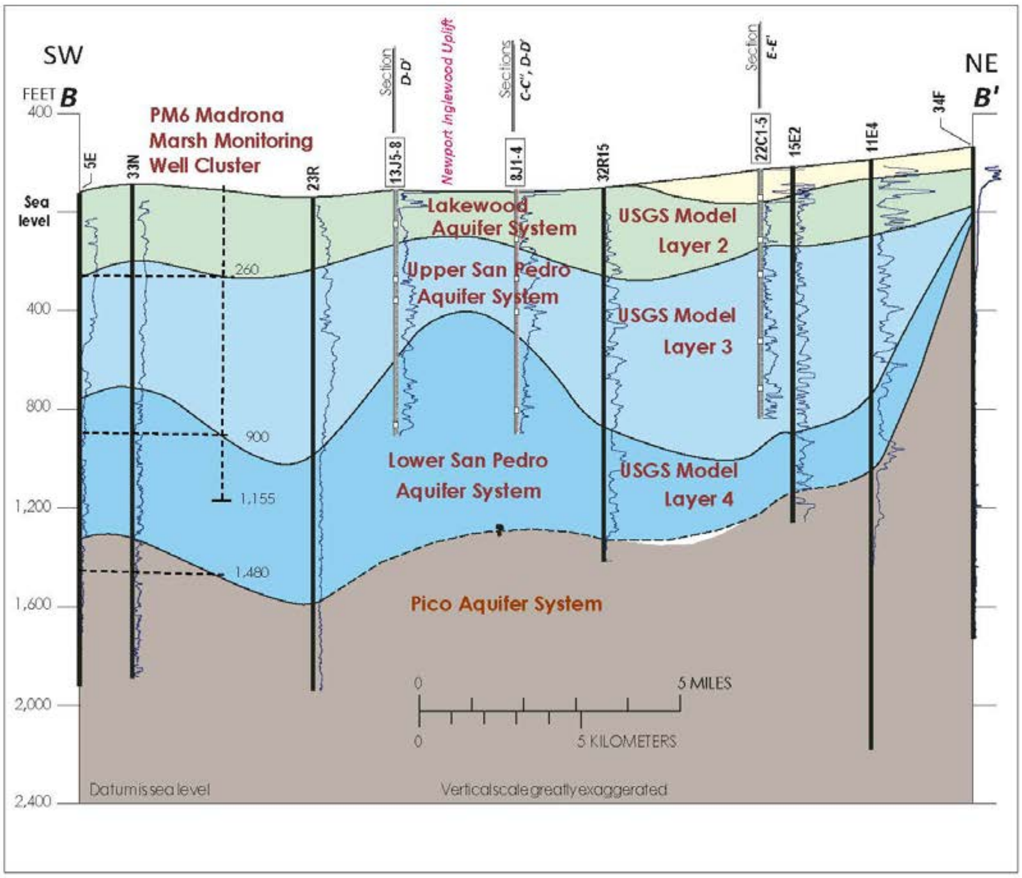
Modified from California Department of Water Resources, 1961; Ponti, 1989

EXPLANATION

Lower Aquifer Systems { Aquifer systems grouping for geochemical analysis

Source: Reichard et al. (2003)

Figure 4-3. Geologic Formations, Aquifers, Aquifer Systems, and USGS Model Layers



Note: updated Figure 4 from Reichard et al. (2003)

Figure 4-4. USGS Model Layers and SW-NE Cross Section of the PM-6 Monitoring Well

4.3 Step 3 - Evaluation of Hydraulic Properties of the USGS Model

The USGS Model layer assignments made in Step 3 were used to determine the flow contribution from various aquifer systems. Specifically, the model layer thicknesses and hydraulic conductivities were extracted from the USGS Model. Table 4-1 presents the top and bottom elevations for four USGS model layers, hydraulic conductivities, and the corresponding transmissivity values. The transmissivity for each layer was calculated by multiplying the hydraulic conductivity by the USGS Model layer thickness and assumed to be proportional to the amount of flow that could be produced by an extraction well screened across the corresponding USGS Model layer. This step was important to calculate an estimated blended wellhead concentration for each of the proposed extraction wells.

Application of the transmissivity values to each of the USGS model layers/aquifer zones was used to calculate the percent extraction from each layer for both the PM-2 and PM-6 monitoring well-screened depth intervals. For the PM-6 monitoring well, nested wells 6, 5, and 4 are screened in USGS Model Layer 3, while nested wells 3 and 2 are screened in USGS Model Layer 2 and well 1 is screened in the Pico Unit (Formation), below the bottom of the USGS Model (Figure 4-4). Similarly, for the PM-2 well, nested wells 4, 3, 2, and 1 are screened in Model Layer 3.

Table 4-1: USGS Model Layers Hydraulic Conductivity, Transmissivity, and Percent Extraction Data

Model Layer	Top Elevation[a] (feet msl)	Bottom Elevation (feet msl)	Depth-to-Bottom (feet bgs)	Saturated Thickness[b] (feet)	Hydraulic Conductivity (feet/day)	Transmissivity (ft^2/day)	Percent Transmissivity (%)	Transmissivity-Based Percent Extraction (%)	Adjusted Percent Extraction to Meet WRD Project Goals (%)
1. Vertical pumping allocation for PM-6 per model layer									
Layer 1[c]	115	105	10	0.0	NA				
Layer 2	105	-131	246	133	30.9	4,114	10	10	10
Layer 3	-131	-638	753	507	63.2	32,065	78	78	26
Layer 4	-638	-969	1,084	331	14.6	4,833	12	12	64
			Total	971	NA	41,012	100	100	100
2. Vertical pumping allocation for PM-2 per model layer									
Layer 1[c]	116	106	10	0.0	NA				
Layer 2	106	-131	247	133	37.2	4,953	13	13	13
Layer 3	-131	-613	6,454	482	60.4	29,110	75	75	23
Layer 4	-613	-979	1,095	366	13.0	4,743	12	12	64
			Total	981	NA	38,806	100	100	100

[a] The surface elevation at PM-6 from the well log is approximately 80 feet msl, which is approximately 35 feet lower than the top of Layer 1 elevation.

[b] Saturated thickness was calculated assuming water table elevation of 2 feet msl (estimated from monitoring report).

[c] Layer 1 is inactive in the model.

Note:

ft^2 = square feet

4.4 Step 4 - Assignment of Water Quality Data to the USGS Model Layers/Aquifer Systems

After assigning the flow contributions from each aquifer system based on the hydraulic properties of each USGS Model layer and associated well-screened intervals, the next step was to assign the water quality for each key water quality parameter. Median values of long-term data (spanning from 2009 through 2018) for the PM-6 monitoring well and median/average values of 2017 and 2018 data for the PM-2 monitoring well were used. After assigning the concentration values to each multi-level nested well in the respective USGS model layers, a flow-weighted average concentration for each well-screened interval was computed for both the PM-2 and PM-6 monitoring wells. The following assumptions were made for this analysis:

- For multiple nested wells that were screened within the same USGS Model layer, equal amounts of water will be drawn from each screened interval. For example, because all three PM-6 nested wells (6, 5, and 4) are screened in USGS Model Layer 3, it was assumed that a third of total flow amount will be extracted from each well (i.e., each screened interval).
- No water will be extracted from the Pico Formation because of anticipated low hydraulic conductivity and associated ability to produce water from a well, and overall economic and hydraulic feasibility of extractions from depths greater than 1,200 feet bgs.
- Based on the USGS Model layer transmissivities, approximately 75 percent of extraction was applied to the Silverado aquifer.

4.5 Step 5 - Evaluation of Saline Plume Target Extraction Depths Consistent with the WRD Project Objectives

Per Step 4, the natural soil properties dictate that Zone 3 from the Silverado layer will proportionally contribute the most water based on the hydraulic properties of the aquifer represented in USGS Model Layer 3 (i.e., high transmissivity). However, based on the WRD assessment, more than 60 percent of the saline plume is in the LSP aquifer (Table 2-1). Strategic extractions are thus needed to meet the goals of the project to remediate the majority of saline plume and the following modifications were made to the approach described in Step 4:

- For the PM-2 well, which is screened down to a depth of about 650 feet bgs, corresponding to an elevation of approximately -570 feet msl, the pumping was shifted from USGS Model Layer 3 based on the well screen elevation and USGS Model Layer 3 bottom elevation data representing the Silverado aquifer to Model Layer 4, representing the LSP aquifer and a deeper zone with higher chloride concentrations.
- While the calculated proportional flow based on transmissivity was 75 to 78 percent from the Silverado aquifer (USGS Model Layer 3) and relatively low salinity (Table 4-2), and only 12 percent from the LSP aquifer (USGS Model Layer 4) and relatively high salinity, the pumping was adjusted such that more than 60 percent of groundwater extractions were applied to the LSP aquifer to target pumping from the deeper zones of aquifers with higher chloride/TDS concentrations.

Based on these modifications, the extractions for the PM-6 monitoring well were adjusted to be 10 percent, 26 percent, and 64 percent from the Gage, Silverado, and LSP aquifers (USGS model layers 2, 3, and 4), respectively. Similarly, for the PM-2 monitoring well, the extractions were assumed to be 13 percent, 23 percent, and 64 percent from the Gage, Silverado, and LSP aquifers, respectively.

Eight of the potential new extraction wells are in the high chloride/TDS zones (Figure 2-2). However, two potential new extraction wells (i.e., wells with ID 3330 Sepulveda and ID Sepulveda & Maple on Figure 2-2) were located in the lower chloride zones (see the orange and the blue color bands for chloride concentrations on Figure 2-2). An average concentration of the band was applied as the chloride concentration for each of these two wells. For example, for the Sepulveda & Maple well, the range for the blue chloride concentration band on Figure 2-2 is 500 to 1,000 mg/L, so the average of 750 mg/L was applied to this well. Also, 100 percent of water extraction for these two wells was assumed to be from the higher chloride/TDS LSP aquifer.

4.6 Step 6 - Approach for Characterization of Source Water Quality

With the approach developed for the amount of water extracted from each aquifer (as discussed in Step 5), source water quality was characterized for chloride, TDS, and other six key water quality parameters (i.e., alkalinity, barium, calcium, manganese, iron, and sulfate). Before applying the median concentrations for calculating flow-weighted average concentrations, all non-detects in the data set were replaced with a concentration value equivalent to half of the detection limit reported in the data set. Note that the detection limit for some of the parameters varied over time, but the typical detection limits are listed in Table 5-1.

Because the flow-weighted average chloride concentration for the PM-2 and PM-6 monitoring wells was not significantly different, an average concentration of these two wells was assumed to represent the quality of the water extracted from the new extraction wells. The blended chloride concentration developed as the influent concentration to the Project's desalter was based on eight wells with the average chloride concentration of the PM-2 and PM-6 monitoring wells, the 3330 Sepulveda well with average chloride concentration of 4,000 mg/L (because it is located within the 3,000 to 5,000 mg/L chloride band; see orange band on Figure 2-2) and the Sepulveda & Maple well with an average chloride concentration of 750 mg/L (because it is located in the 500 to 1,000 mg/L; see blue band for chloride concentration on Figure 2-2). The approach applied for chloride was applied for TDS and the other six key water quality parameters to calculate the flow-weighted blended concentration from the 10 wells for the influent water quality to the treatment plant.

Using the approach as in Steps 5 and 6, flow-weighted concentrations for an additional 119 water quality parameters were calculated. Nested monitoring well data for the last 2 years was used for evaluating the blended source water quality for the new extraction wells.

5. Results of Source Water Quality Evaluation

Based on the approach presented in Section 4, a source water quality assessment was conducted for the Projects. Table 5-1 presents an average feed water quality for the new extraction wells that will feed 10 of the 11 shortlisted Projects listed in Table 1-1. Project 26 will have a blend of 6:1 of the new extraction well average quality: Sepulveda 2 (Table 1-1). Sepulveda 2 was included in Project 26 as it is the nearest existing extraction well over the plume that could be imported into the Program. The data for existing well Sepulveda 2 below was collected between 2000 and 2008. The extracted well water temperature is expected to be an average of 21.7 degrees Celsius (ºC) with min/max of 17/25ºC, based upon 2 years of data from the Goldsworthy Desalter, collected every 4 hours between spring 2010 and spring 2012.

Table 5-1. Average Desalter Feed Water Quality Concentration

Parameter	Concentration		Detection Limit	Units
	New Extraction Well Average	Sepulveda 2		
1,1,1,2-Tetrachloroethane	0.25	0.25	0.5	µg/L
1,1,1-Trichloroethane	0.25	0.25	0.5	µg/L
1,1,2,2-Tetrachloroethane	0.25	0.25	0.5	µg/L
1,1,2-Trichloroethane	0.25	0.25	0.5	µg/L
1,1-Dichloroethane	0.25	0.25	0.5	µg/L
1,1-Dichloroethylene	0.25	0.25	0.5	µg/L
1,1-Dichloropropene	0.25	0.25	0.5	µg/L
1,2,3-Trichlorobenzene	0.25	0.25	0.5	µg/L
1,2,3-Trichloropropane	0.25	0.25	0.5	µg/L
1,2,4-Trichlorobenzene	0.25	0.25	0.5	µg/L
1,2,4-Trimethylbenzene	0.25	0.25	0.5	µg/L

Table 5-1. Average Desalter Feed Water Quality Concentration

Parameter	Concentration		Detection Limit	Units
	New Extraction Well Average	Sepulveda 2		
1,2-Dichloroethane	0.25	0.25	0.5	µg/L
1,2-Dichloropropane	0.25	0.25	0.5	µg/L
1,3,5-Trimethylbenzene	0.25	0.25	0.5	µg/L
1,3-Dichlorobenzene	0.25	0.25	0.5	µg/L
1,3-Dichloropropane	0.25	0.25	0.5	µg/L
1,3-Dichloropropene (Total)	0.25	0.25	0.5	µg/L
1,4-Dioxane	0.39	1	1	µg/L
2,2-Dichloropropane	0.25	0.25	0.5	µg/L
2-Butanone (MEK)	2.5	0.25	5	µg/L
4-Methyl-2-Pentanone (MIBK)	2.5	0.25	5	µg/L
Alkalinity	142	150	2	mg/L
Aluminum	50.0	150	100	µg/L
Antimony	0.50	0.5	1	µg/L
Apparent Color	14	10	3	ACU
Arsenic	2.99	4.2	5	µg/L
Barium	872	120	2	µg/L
Benzene	0.25	0.25	0.5	µg/L
Beryllium	0.50	0.5	1	µg/L
Bicarbonate as HCO_3, calculated	170	180	2	mg/L
Boron	0.23	0.33	0.05	mg/L
Bromide	13,378	3,900	500	µg/L
Bromobenzene	0.25	0.25	0.5	µg/L
Bromochloromethane	0.25	0.25	0.5	µg/L
Bromodichloromethane	0.25	0.25	0.5	µg/L
Bromoethane	0.25	0.25	0.5	µg/L
Bromoform	0.25	0.25	0.5	µg/L
Bromomethane (Methyl Bromide)	0.25	0.25	0.5	µg/L
Cadmium	0.25	0.25	0.5	µg/L
Calcium	646	120	5	mg/L
Carbon Dioxide	6.33	2.3	2	mg/L
Carbon Disulfide	0.25	NS	0.5	µg/L
Carbon Tetrachloride	0.25	0.25	0.5	µg/L
Chloride	3,980	890	200	mg/L
Chlorobenzene	0.25	0.25	0.5	µg/L
Chlorodibromomethane	0.25	0.25	0.5	µg/L
Chloroethane	0.25	0.25	0.5	µg/L
Chloroform (Trichloromethane)	0.25	0.25	0.5	µg/L
Chloromethane (Methyl Chloride)	0.25	0.25	0.5	µg/L

Table 5-1. Average Desalter Feed Water Quality Concentration

Parameter	Concentration		Detection Limit	Units
	New Extraction Well Average	Sepulveda 2		
cis-1,2-Dichloroethylene	0.25	0.25	0.5	µg/L
cis-1,3-Dichloropropene	0.25	0.25	0.5	µg/L
Copper	4.2	16	10	µg/L
Dibromomethane	0.25	NS	0.5	µg/L
Dichlorodifluoromethane (Freon 12)	0.25	NS	0.5	µg/L
Di-Isopropyl Ether	1.50	1.5	3	µg/L
Ethyl Benzene	0.25	0.25	0.5	µg/L
Ethyl Tertiary Butyl Ether	1.5	1.5	3	µg/L
Field pH		NS	0.05	mg/L
Fluoride	0.16	0.19	0.5	µg/L
Fluorotrichloromethane (Freon11)	1.5	NS	3	mg/L
Hardness (Total, as $CaCO_3$)	3,073	550	0.5	µg/L
Hexachlorobutadiene	0.01	0.25	0.02	µg/L
Hexavalent Chromium (Cr VI)	0.05	NS	0.1	µg/L
Iodide	242	NS	1	µg/L
Iron	0.18	0.47	0.02	mg/L
Isopropylbenzene	0.25	0.25	0.5	µg/L
Lab pH	7.9	8.1	0.1	Units
Lab Turbidity	5.8	0.25	0.1	NTU
Langelier Index - 25 degree	1.1	0.93	-14	None
Lead	0.25	0.59	0.5	µg/L
m,p-Xylenes	0.25	0.25	0.5	µg/L
Magnesium	351	63	0.1	mg/L
Manganese	292	100	10	µg/L
Mercury	0.10	0.1	0.2	µg/L
Methane	7.0	NS	0.5	mg/L
Methyl Tert Butyl Ether (MTBE)	0.25	0.25	0.5	µg/L
Methylene Chloride	0.25	0.25	0.5	µg/L
Naphthalene	0.25	0.25	0.5	µg/L
n-Butylbenzene	12.5	0.25	25	µg/L
Nickel	3.2	6.4	0.62	mg/L
Nitrate (as N)	1.40	1.4	2.8	mg/L
Nitrate (as NO3)	0.31	0.31	0.62	mg/L
Nitrite, Nitrogen by IC	0.25	0.25	0.5	µg/L
n-Propylbenzene	0.25	0.25	0.5	µg/L
o-Chlorotoluene	0.25	0.25	0.5	µg/L
o-Dichlorobenzene (1,2-DCB)	0.50	0.25	0.5	µg/L
Odor	48.1	3	1	ton

Table 5-1. Average Desalter Feed Water Quality Concentration

Parameter	Concentration		Detection Limit	Units
	New Extraction Well Average	Sepulveda 2		
o-Xylene	0.25	0.25	0.5	µg/L
p-Chlorotoluene	0.25	0.25	0.5	µg/L
p-Dichlorobenzene	0.25	0.25	0.5	µg/L
Perchlorate	0.05	2	0.1	µg/L
p-Isopropyltoluene	0.50	0.25	1	mg/L
Potassium	64.7	15	0.1	µg/L
sec-Butylbenzene	0.25	0.25	0.5	µg/L
Selenium	32.1	8.1	25	µg/L
Silver	0.25	0.25	0.5	µg/L
Sodium	1,180	480	5	mg/L
Specific Conductance	11,191	2500	2	µmho/cm
Styrene	0.25	0.25	0.5	µg/L
Sulfate	223	230	25	mg/L
Surfactants	0.05	0.05	0.1	mg/L
tert-Butylbenzene	0.25	0.25	0.5	µg/L
Tertiary Amyl Methyl Ether	1.50	1.5	3	µg/L
Tertiary Butyl Alcohol	0.77	NS	2	µg/L
Tetrachloroethylene (PCE)	0.25	0.25	0.5	µg/L
Thallium	0.50	0.5	1	µg/L
Toluene	0.32	0.25	0.5	µg/L
Total Chromium	2.4	17	5	µg/L
TDS	7,679	1900	10	mg/L
Total Organic Carbon	1.0	2.1	0.3	mg/L
Total Trihalomethanes	0.25	0.25	0.5	µg/L
Total Xylenes	0.25	0.25	0.5	µg/L
trans-1,2-Dichloroethylene	0.25	0.25	0.5	µg/L
trans-1,3-Dichloropropene	0.25	0.25	0.5	µg/L
Trichloroethylene (TCE)	0.25	0.25	0.5	µg/L
Trichlorotrifluoroethane (Freon 113)	0.25	0.25	0.5	µg/L
Vinyl chloride (VC)	0.19	0.15	0.3	µg/L
Zinc	50	20	100	µg/L

Notes:

µmho/cm = microsiemen(s) per centimeter

ACU = apparent color units

HCO_3 = bicarbonate

MEK = methyl ethyl ketone

MIBK = methyl isobutyl ketone

NTU = nephelometric turbidity unit

NS = Not Sampled

6. Evaluation of Extraction Well Infrastructure for Potential Projects

Provided below is a summary of the types of wells and methodologies for the construction of new wells and/or retrofit of existing wells.

6.1 Construction and/or Retrofit Methodologies

Drilling of new extraction wells would likely be accomplished using the flooded-reverse circulation mud-rotary drilling method commonly used for installation of large water supply wells, as recently used for installation of the Delthorne Park and City Yard brackish groundwater supply wells for the Goldsworthy Desalter expansion and multi-level nested monitoring well PM-2 at the Torrance Police Department (CH2M, 2016). Designs of a new extraction wells for a given property location could include the following:

1) Single, 20-inch diameter, extraction wells installed at the identified accessible properties determined as part of this feasibility study and penetrating to the maximum target depth for extraction of the saline plume in the LSP aquifer. Typically, wells could be constructed of 316L stainless-steel ASTM A312/A312M blank casing and 316L stainless-steel wire-wrap screen and equipped with blank casing sections strategically placed between saline water production zones to allow for potential placement of inflatable packers to seal off the zones from one another and to focus flow into the well from one zone or the other, as recently used for installation of the Goldsworthy brackish groundwater supply wells (CH2M, 2016).

2) Smaller diameter, less-expensive wells installed as a well field, line of wells, or other configuration of wells screened across multiple target extraction zones and installed around the identified available and accessible properties determined as part of this feasibility study, but not limited to being within those property boundaries. These smaller wells could be advantageous because of the anticipated lower hydraulic conductivity of the LSP aquifer, as indicated by WRD and the USGS Model Layer 4 properties, that may limit the yield of a single larger-diameter wells to below the target extraction rate. Depending on site access, such wells could be installed in city streets, sidewalks, or green strips in between streets and sidewalks and penetrate to the maximum target depth for extraction of the saline plume in the LSP aquifer. Alternative drilling methods requiring a smaller footprint, relative to that required for the flooded-reverse circulation mud-rotary drilling method described above, could potentially be employed for these smaller-diameter wells to accommodate placement in city street and sidewalk areas. These smaller-diameter wells (e.g., 8- to 12-inch) could be constructed of polyvinyl chloride (PVC) casing and screen, or a combination of PVC casing and stainless-steel wire-wrapped screen, for example, at significantly less cost than larger-diameter wells constructed of stainless-steel casing. A group of these wells could effectively spread out the higher drawdown that a single larger-diameter well extracting from a lower-permeability aquifer and could offer operational advantages including the ability to extract more saline water from a larger area than a single well could accomplish.

3) Smaller diameter, less-expensive PVC wells installed in clusters, with each well screened across a single target extraction depth interval to target extraction in a zone of high salinity and constructed within the boundaries of the identified available and accessible properties determined as part of this feasibility study. Clusters of wells could enhance the flexibility in extraction options, by providing flexibility in the pumping rate applied to each target extraction depth interval in individual wells.

4) Existing wells, such as Sepulveda 1 and Sepulveda 2 wells could potentially be retrofitted by performing an inspection with a downhole video log to assess the condition of the well screen and casing before they are considered for retrofitting. Based on the condition of the well screen and casing, rehabilitation may be needed to clean the casing and the well screen to improve the hydraulic communication between the well and the aquifer to maximize well yield. Retrofitting would include equipping the wells with appropriately sized pumps, conveyance piping, and other infrastructure to connect these wells to a future treatment plant.

5) Horizontal wells could be considered, but preliminary evaluation suggests they would not be feasible for achieving the target extraction depths as deep as 900 feet bgs. Based on discussion with a directional drilling contractor, horizontal wells installed for groundwater remediation and water supply are drilled at an angle of approximately 18 degrees to horizontal ground surface, and approximately 3,000 feet of

drilling at this angle would be required to achieve a target extraction depth of 900 feet bgs. To date, horizontal wells of this nature have only been installed to depths of approximately 200 feet.

6) Existing wells such as the two inactive/abandoned wells, Sepulveda wells 1 and 2 shown on Figure 2-2, were evaluated for consideration as potential extraction wells for the removal of the saline water for some of the Potential Projects. After evaluations, the Sepulveda well 2 was considered as a potential extraction well for the Project because of its closer proximity to potential treatment sites.

7) New wells could be installed. Up to 10 new extraction wells have been identified to support the 11 shortlisted Projects identified in the Potential Projects and Recommended Short List TM. The location of these wells is shown on Figure 2-2.

7. Conclusions and Recommendations

The source water quality characterization presented in this TM is based on monitoring data collected from two multi-level nested monitoring wells PM-2 and PM-6, in the eastern portion of the saline plume area. The available water quality data for the PM-6 cluster monitoring well is for the period from 2009 through 2018; however, the water quality data for the PM-2 cluster well was only available for the last 2 years. The location of these two monitoring wells represent the leading edge of the plume area. Initiating the extraction of saline water from the leading edge of the plume helps with the containment of the plume; however, the mitigation of the impacts of extracting from various target depths in the saline aquifer requires careful planning.

The source water characterization presented in this TM is based on just the two multi-level nested monitoring wells (PM-2 and PM-6) located in the approximate 0.4-square-mile area of the leading edge of the saline plume, which may not reflect the water quality of the entire plume area of about 8 square miles. To move forward with full project implementation and drilling of numerous production wells and infrastructure, additional spatial and temporal water quality data should be obtained.

Moreover, the management of the plume and full extraction require greater understanding of the variability of water quality, spatially and with depth, in the various aquifer zones. Periodic tracking of the migration of the plume over time is recommended so that any negative impacts of remediation on the West Coast Basin can be avoided.

Based on discussion with WRD, it was learned that there is concern about the relatively low permeability of the LSP aquifer, where most of the saline plume resides, and the ability to pump large quantities of groundwater from that aquifer. In the course of performing the source water characterization, it was recognized that the PM-2 multi-level nested monitoring well at the northern end of the group of potential extraction wells (Figure 4-1) was completed to a much shallower depth (about 650 feet bgs, corresponding to an elevation of approximately -570 feet msl) relative to the PM-6 multi-level nested monitoring well completed in the southern portion of the group of potential extraction wells (Figure 2-2) to a much deeper depth (about 1,250 feet bgs, corresponding to an approximate elevation of -1,155 feet msl). Further evaluation of the PM-2 well, indicates that this location at the Torrance Police Department was considered as a location for a new desalter supply well for the Goldsworthy Desalter facility, but that results of pilot hole drilling and testing to a depth of about 650 feet bgs were determined not to be favorable for installing a new desalter supply well because it would not meet the target production rate and chloride level (CH2M, 2016). Thus, the potential extraction well location near the PM-2 well may require further consideration of whether these past findings render this location infeasible for a new extraction well. Furthermore, additional investigation should be considered for evaluating the depth distribution of the saline plume and the hydraulic properties of target extraction depths to confirm the ability of proposed extraction wells to meet target production rates from target high-salinity production zones.

In order to meet the Program objective of treating the plume, the acquisition of additional data and information is recommended. Spatial and temporal resolution of water quality characterization of the plume and hydraulic properties of the different target depth intervals will enable a better understanding of how much water can reasonably be pumped from depths. Table 7-1 provides a summary of data gaps and recommended areas of investigation, which may be necessary to efficiently operate the extraction facilities for the project.

Table 7-1. Key Data Gaps and Recommendations

Data Gaps/Unknowns	Recommendations
Spatial and temporal understanding of water quality of the entire plume area • Currently two multi-level nested monitoring wells (PM-2 and PM-6) are used for developing water quality specifications for the source water for the desalter	• Given the availability of data for only two multi-level nested monitoring wells in the area of potential new extraction wells (about 0.4 square miles) identified based on available, accessible properties near the leading edge of the saline plume, relative to the overall saline plume area (about 8 square miles), the water quality and hydraulic properties of the aquifers applied to the 10 extraction wells should be refined with more monitoring data. In particular, the area near the PM-2 multi-level nested monitoring well may not be suitable for achieving target production rates based on past investigation in this area (CH2M, 2016). • To characterize the water quality of the plume, installation of additional monitoring wells distributed over the entire plume area is recommended.
Water quality representation for all zones of aquifers	Well PM-2 is screened to a depth of 650 feet bgs; however, well PM-6 is screened over 1,200 feet bgs. To meet the objectives of the project to remediate the plume with more than 60 percent of volume in the LSP aquifer, water quality monitoring of the deeper aquifers is recommended. The selection of the well locations and screened intervals can be guided by the investigation and monitoring results.
Movement of plume	Although WRD has estimated that the plume is moving eastward at an average rate of 250 feet per year, a detailed flow and solute transport model of the area is recommended (CH2M and RMC, 2016). In order to mitigate the effect of drawdown in aquifers due to heavy pumping of saline water, a calibrated groundwater flow model and solute transport model can simulate future recharge and pumping effects, to guide project designs while minimizing any effects to the basin. Particle tracking simulations using a calibrated groundwater flow model are recommended to evaluate the portion of the saline plume captured by the proposed new extraction wells with depth and could also be used to estimate travel times from the hydraulically upgradient (western portion of the saline plumes) to reach the extraction wells and thereby provide a preliminary estimate of the time to clean up the saline plume.
Water yield from lower aquifers	The hydraulic conductivities of the LSP aquifer system are less than 15 feet per day. Based on these low conductivities, the production from deeper zones will be energy intensive and challenging. Strategies for pumping from deeper zones of high salinities may need to be adjusted over time to achieve the project goals.

The characterization of water quality for the plume presented in this deliverable is intended to be starting point for planning purposes. To move forward with full project implementation and drilling of numerous production wells and infrastructure is premature without obtaining more data as outlined in this TM. After more data are obtained and confidence strengthened in spatial and temporal variations in the saline plume, a phased approach of full project buildout and adjustments, as necessary, is recommended.

A detailed in-depth feasibility study of the Projects is recommended as a part of the long-term Program. Vertical profiling may also help with identification of zones for targeted saline plume remediation, in addition to understanding the effectiveness of remediation.

8. References

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Technical Memorandum

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Subject **Brackish Water Extraction Conveyance Piping Route Analysis**

Project Name Regional Brackish Water Reclamation Program Feasibility Study

Date May 7, 2019

1. Introduction

The Water Replenishment District of Southern California (WRD) is responsible for managing and replenishing both the West Coast and Central groundwater basins. In the West Coast Basin, a significant plume of saline groundwater with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, and Lower San Pedro (LSP) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To fully use the West Coast Basin, WRD has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. Program goals include treatment of the saline plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process. The Program will study the following components: where to extract the plume water, where and how to treat the plume water, how to convey the treated potable water to the Program stakeholders, and how to manage the brine waste stream. The Program includes the analysis of numerous "Projects," consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of the above components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed as dollars per acre foot (AF) of treated water.

As a part of the Program, WRD has initiated a regional planning study to evaluate the feasibility of remediating the saline plume with seven additional stakeholders (known as the Stakeholder Group). The Stakeholder Group has expressed interest in treating the saline plume, receiving the treated water, or both, as part of the Program. The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

As part of this feasibility study, a Technical Memorandum (TM) entitled *Source Water Quality Characterization* identified locations for new extraction wells that could be used to convey water to the proposed desalter facility (Project) at the Elm & Faysmith property in Torrance.

The purpose of this TM is to evaluate easements and jurisdictional rights associated with the proposed extraction wells and conveyance to the treatment facility. This TM is organized to include the following sections:

- Section 1 – Introduction
- Section 2 – Proposed Extraction Wells Property Ownership
- Section 3 – Proposed Conveyance Piping Routes
- Section 4 – Recommended Pipe Material
- Section 5 – Conclusions and Recommendations

2. Proposed Extraction Wells Property Ownership

The City of Torrance suggested 10 properties to use for extraction wells for the Program. The proposed extraction well locations are shown on Figure 2-1. Property ownership information is provided in Table 2-1. Based on ownership information provided by the Los Angeles County Office of the Assessor, it appears that easements may be required for extraction wells at the Del Amo Sump, Del Amo Shopping Center, Madrona & Fashion, and the Madrona Middle School as these properties are not owned by the City of Torrance.

Table 2-1. Proposed Extraction Wells Property Ownership

Proposed Extraction Well Location	Property Ownership Information[a]
3330 Sepulveda	Madrona Marsh Preserve, Assessor's ID No. 7359-002-903, owned by Torrance City
Sepulveda & Maple	Madrona Marsh Preserve, Assessor's ID No. 7359-002-903, owned by Torrance City
Madrona Marsh West (shown as Monterey Street on Figure 2-1)	Madrona Marsh Nature Center (3201 Plaza Del Amo), Assessor's ID No. 7359-030-900, owned by Torrance City
Madrona Marsh East (shown as 3201 Plaza Del Amo on Figure 2-1)	Madrona Marsh Nature Center (3201 Plaza Del Amo), Assessor's ID No. 7359-030-900, owned by Torrance City
Del Amo Sump (shown as 21735 Madrona Avenue on Figure 2-1)	Assessor's ID No. 7366-019-086, owned by Torrance Company (Property type is listed as vacant land and assessed value is listed as $21,324)
Del Amo Shopping Center (2 wells)	21515 Madrona Avenue, Assessor's ID No. 7366-019-051, owned by Madrona F and F LLC (Property type is listed as vacant land and assessed value is listed as $5,700,364)
Madrona & Fashion	21405 Madrona Avenue, Assessor's ID No. 7366-019-146, owned by Madrona F and F LLC (Property type is listed as commercial/industrial and assessed value is listed as $16,121,804)
Madrona Middle School (shown as Madrona Avenue and Opal Street on Figure 2-1)	Madrona Middle School (21364 Madrona Avenue), Assessor's ID No. 7362-004-900, owned by Torrance Unified School District
El Dorado & Maple	Maple Sump, Assessor's ID No. 7362-003-900, owned by Torrance City S by S
Torrance Police Station	3300 Civic Center Drive, Assessor's ID No. 7353-001-914, owned by the Torrance City

[a] Source: Los Angeles County Office of the Assessor (maps.assessor.lacounty.gov)

Aerial image © Google Earth Pro, 2018. Modified by Jacobs, 2019.

Figure Legend:

- New Extraction Well Location
- Extraction Well Piping
- Existing Flood Hazard Location
- Existing CalTrans Rail Location
- Existing Hazardous Liquid Pipelines
- Existing Water Pipelines

Figure 2-1
Vicinity Map
WRD EXTRACTION WELL PIPING
Torrance, California

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3. Proposed Conveyance Piping Routes

This section summarizes the proposed conveyance piping routes from the extraction wells to the proposed desalter facility at the City of Torrance Elm & Faysmith property. For this feasibility study, a desktop analysis was performed using available aerial images from Google Earth and data from the Los Angeles County Geographic Information System (GIS) Data Portal. Field investigations were not performed. Also, no existing utility data or geotechnical data were obtained for any of the alignments, other than available GIS data. There are other possible piping configurations and routes, but in general, the pipes were located on streets with a wide right-of-way (ROW) and adjacent to the proposed extraction wells.

Table 3-1 lists the preliminary pipe size, length, and route from each extraction well to the desalter facility. Also listed is available information regarding the route including the type of construction anticipated. A map of the proposed routes is included on Figure 2-1.

Table 3-1. Proposed Conveyance Piping Routes

Potential Extraction Well Location	Pipe Size (inches)[a]	Pipe Length (feet)[b]	Pipe Route	Comments
3330 Sepulveda	12	1,300	East along Sepulveda Boulevard (approximate 130-foot ROW) near Madrona Avenue intersection to Maple Avenue intersection	Sepulveda Boulevard is a City street with three lanes in the east direction and four lanes in the west direction, with signalized intersections. There is a sidewalk on the north side of Sepulveda Boulevard along the Madrona Marsh Preserve property where the pipe could potentially be located, pending utility investigations. It is anticipated that the pipe can be installed with open-cut construction methods.
Sepulveda & Maple	16	1,155	North along Maple Avenue (approximate 86-foot ROW) at Sepulveda Boulevard intersection to Plaza Del Amo intersection	Maple Avenue is a City street with two lanes in each direction with signalized intersections in this segment. It is anticipated that the pipe can be installed with open-cut construction methods.
Madrona Marsh West (shown as Monterey Street on Figure 2-1)	16	585	East along Plaza Del Amo (approximate 86-foot ROW) at Madrona Avenue intersection to Maple Avenue intersection	Plaza Del Amo is a City street with two lanes in each direction with signalized intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
Madrona Marsh East (shown as 3201 Plaza Del Amo on Figure 2-1)	16	1,285	East along Plaza Del Amo (approximate 86-foot ROW) at Madrona Avenue intersection to Maple Avenue intersection	Plaza Del Amo is a City street with two lanes in each direction with signalized intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
Del Amo Sump (shown as 21735 Madrona Avenue on Figure 2-1)	12	450	South along Madrona Avenue (approximate 115-foot ROW) from Del Amo Sump property to Plazo Del Amo	Madrona Avenue is a City street with three lanes in each direction and a center median/turn lane, with signalized intersections in this segment. It is anticipated that the pipe can be installed with open-cut construction methods.
N/A	24	2,610	North along Maple Avenue (approximate 86-foot to 60-foot ROW) from Plaza Del Amo intersection to El Dorado Street intersection	Maple Avenue is a City street with one lane in each direction with traffic signals at major intersections and stop signs at minor intersections. It is anticipated that the pipe can be installed with open-cut construction methods.

Table 3-1. Proposed Conveyance Piping Routes

Potential Extraction Well Location	Pipe Size (inches)[a]	Pipe Length (feet)[b]	Pipe Route	Comments
Del Amo Shopping Center (2 wells)	16	1,015	North along Madrona Avenue (approximate 115-foot ROW) from Del Amo Shopping Center property to Fashion Way intersection	Madrona Avenue is a City street with three lanes in each direction and a center median/turn lane, with traffic signals at major intersections and stop signs at minor intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
Madrona & Fashion	24	575	North along Madrona Avenue (approximate 115-foot ROW) from Fashion Way to Madrona Middle School well	Madrona Avenue is a City street with three lanes in each direction and a center median/turn lane, with traffic signals at major intersections and stop signs at minor intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
Madrona Middle School (shown as Madrona Avenue and Opal Street on Figure 2-1)	24	1,845	North along Madrona Avenue (approximate 115-foot ROW) from well location to Torrance Boulevard, and then east along Torrance Boulevard (approximate 130-foot ROW) to Maple Avenue intersection	Madrona Avenue is a City street with three lanes in each direction and a center median/turn lane, and Torrance Boulevard is a City street with three lanes in the west bound direction and two lanes in the east bound direction. Madrona Avenue has traffic signals at major intersections and stop signs at minor intersections. Torrance Boulevard has signalized intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
El Dorado & Maple	24	725	North along Maple Avenue (approximate 60-foot ROW) from El Dorado Street intersection to Torrance Boulevard intersection	Maple Avenue is a City street with one lane in each direction with traffic signals at major intersections and stop signs at minor intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
Torrance Police Station	12	2,350	East along Civic Center Drive (approximate 60-foot ROW) from Torrance Police Station to Maple Avenue intersection, and then south along Maple Avenue (approximate 74-foot ROW) to Torrance Boulevard intersection	Civic Center Drive is a City street with one lane in each direction, and Maple Avenue is a City street with two lanes in each direction. Civic Center Drive has stop signs at intersections. Maple Avenue has traffic signals at major intersections and stop signs at minor intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
N/A	36	3,270	East along Torrance Boulevard (approximate 130-foot ROW) from Maple Avenue intersection to Elm Avenue intersection, and then north on Elm Avenue (approximate 60-foot ROW) to the proposed desalter facility at the Elm & Faysmith property	Torrance Boulevard is a City street with two lanes in each direction and a center/turn lane, and Elm Avenue is a City residential street with one lane in each direction. Torrance Boulevard has traffic signals at major intersections and stop signs at minor intersections. Elm Avenue has stop signs at intersections. It is anticipated that the pipe can be installed with open-cut construction methods.

[a] Approximate pipe size for feasibility study, to be confirmed with hydraulic modeling during design

[b] Approximate pipe length based on desktop analysis

Note: N/A = not available/not applicable

4. Recommended Pipe Material

The pipe diameters will vary between 12 inches and 36 inches. The assumed pipe pressure is between 60 and 100 pounds per square inch (psi).

Key properties for consideration of satisfactory pipe materials include internal and external corrosion resistance, cost, constructability, and thrust restraint methodology. For the saline well water, polyvinyl chloride (PVC) and high-density polyethylene (HDPE) are acceptable pipe materials for the required pipe diameters. Both materials have good internal and external corrosion resistance for conveyance of the brine and protection from corrosive soils. The main advantage of HDPE is that the joints are fused and fully restrained, and mechanical thrust restraint or thrust blocks are not required. PVC pipe requires the use of thrust blocks or mechanical thrust restraint. It is anticipated that the pipe routes will be crowded with existing utilities, so thrust blocks are not recommended, and a mechanical thrust restraint system would be required. Also, ductile iron (DI) fittings are commonly used with PVC pipe at bends. The DI bends would require internal and external corrosion protection. The installed cost is anticipated to be similar for both types of pipe. For this project, HDPE pipe is recommended.

The recommended minimum pipe class is HDPE PE 4710, DR 17. This will need to be confirmed during design based on hydraulic and surge modeling.

5. Conclusions and Recommendations

Easements will be required for some of the extraction wells that are not located on City of Torrance property. All conveyance piping from the extraction wells to the proposed desalter facility will be located in City street ROW and no easements are required to be obtained for the pipelines. For the conveyance piping, geotechnical, survey, and utility investigations will need to be performed during design, and the exact route in the City ROW will need to be determined in order to minimize utility conflicts and traffic disruption. When possible, the pipelines should be located outside of the pavement area. Additional information on the well site locations will developed during the next phase of the feasibility study.

6. References

Los Angeles County Assessor. 2019. https://assessor.lacounty.gov/

Los Angeles County GIS Data Portal. 2019. https://egis3.lacounty.gov/dataportal/

5. Brine Waste Management (Task 1.F)

Brine Waste Discharge Evaluation

Dedicated Brine Line Route Analysis

JACOBS

Technical Memorandum

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Subject	**Brine Waste Discharge Evaluation**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019

1. Introduction

In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, and Lower San Pedro aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To more fully utilize the West Coast Basin, the Water Replenishment District of Southern California (WRD) has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. Program goals include treating the plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process. The Program will study the following components: where to extract the plume water, where and how to treat the plume water, how to convey the treated potable water to the Program stakeholders, and how to manage the brine waste stream. The Program includes the analysis of numerous different “Projects,” consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of the above components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed in dollars per acre foot (AF) of treated water.

This technical memorandum (TM) re-examines some of the assumptions used to generate the shortlist of Projects and presents information related to the brine management options for each of these recommended shortlisted Projects.

The costs presented are Class IV cost estimates with accuracies of +50 percent to -30 percent of actual Project cost. The costs included in this TM for the zero-liquid discharge, deep well injection, and ocean outfall options (for brine discharge) are based on the thorough and comprehensive southern California reuse and brine study (Reclamation, 2009). The Reclamation study was a collaboration between the United States Bureau of Reclamation (USBR) and 14 local and state agency partners including the Los Angeles County Sanitation Districts (LACSD), LADWP and Metropolitan Water District (MWD). Estimated costs generated in the Reclamation study were escalated by 2 percent per year and reported in 2019 dollars. Additional costs for pipelines, pump stations, and other infrastructure were developed using Jacobs’ Cost Parametric Engineering System tool and presented in 2019 dollars.

2. Assumptions

2.1 Brine Processing Options

The far-right column of Table 1-1 indicates that the brine discharge for each of the recommended Projects was either via discharge to the LACSD Joint Water Pollution Control Plant (JWPCP) influent (sewer) or via a new, dedicated brine line (DBL) with a direct connection to the LACSD JWPCP effluent tunnel/outfall system. This TM will explore several additional options for brine discharge, including the following:

- Connection into the LACSD sewer collection system

- Zero-liquid discharge (ZLD)
- Deep Well Injection (DWI)
- Construction of a DBL and connection into the LACSD JWPCP ocean discharge tunnel/outfall system
- Construction of a DBL and connection into the Los Angeles Sanitation & Environment (LASAN) - Hyperion outfall system
- Construction of a new ocean outfall and discharge structure
- Trucking the brine to the JWPCP

Table 1-1. Shortlisted Projects

Potential Project - General Description		Extraction Wells	Treatment Locations				Total New Extraction (AFY)	Total Existing Extraction (Goldsworthy and Brewer) (AFY)	Water Delivery Locations						Total New Product Delivery (AFY)	Brine Discharge
			Elm and Faysmith (Torrance)	Wellhead Treatment (WHT)	Goldsworthy and Brewer	JWPCP			Torrance	Golden State Water	Manhattan Beach	LADWP	Cal Water	Lomita		Sewer or Brine Line to LACSD - JWPCP
13	Torrance, GSWC, LADWP (highest delivery) with a New Brine Line Having Direct Connection to Tunnel/Outfall to JWPCP (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	5,000	-	8,000	-	-	18,000	Brine Line
14	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	-	-	5,000	6,500	1,500	18,000	Sewer
15	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties and Madrona Lateral (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	-	-	5,000	6,500	1,500	18,000	Brine Line
18	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	4,100	900	1,000	2,750	1,500	1,000	11,250	Sewer
19	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (12,500 AFY)	10 new wells	10,500	2,000	7,300	-	12,500	7,300	4,100	900	1,000	2,750	1,500	1,000	11,250	Brine Line
24	LACSD JWPCP with Brine Connection to LACSD JWPCP Tunnel/Outfall (12,500 AFY)	7 new wells	-	-	7,300	12,500	12,500	7,300	5,000	-	-	5,250	-	1,000	11,250	Brine Line
25	Torrance, GSWC, LADWP (highest delivery) with a New Brine Line with Direct Connection to LACSD JWPCP Tunnel/Outfall (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	3,000	3,000	-	5,250	-	-	11,250	Brine Line
26	Torrance (highest delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral with one existing well (12,500 AFY)	6 new wells, 1 existing well	12,500	-	7,300	-	12,500	7,300	5,000	900	-	850	3,500	1,000	11,250	Sewer
27	All Wellhead No New Distribution Piping (10,500 AFY)	7 new wells	-	10,500	7,300	-	10,500	7,300	5,000	900	1,000	1,000	800	750	9,450	Sewer
28	Torrance (highest delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (5,200 AFY)	3 new wells	5,200	-	7,300	-	5,200	7,300	2,100	500	-	500	1,000	500	4,600	Sewer
29	All Wellhead (5,200 AFY)	2 new wells, 1 existing	-	5,200	7,300	-	5,200	7,300	4,600	-	-	-	-	-	4,600	Sewer

Notes:

AFY = acre-feet per year

- = component not included in Project

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2.2 Desalter Feed Water Quality and Treatment Recovery

The water quality of the saline plume required quality characterization in order to determine how the plume is to be treated. The recommended Project shortlist was generated prior to performing a full analysis of the expected feed water quality. The monitoring well water quality at different depths has now been examined near the location where the new extraction wells will be installed. This examination, in combination with the soil transmissivity at each depth, results in the expected desalter feed water quality shown in Table 2-1. Further details on how this water quality was derived can be found in the Brackish Water Extraction Evaluation TM.

Table 2-1. Expected Desalter Feed Water Quality

Constituent	Quantity	Unit
15-minute Silt Density Index	< 4	NA
Turbidity	< 1	NTU
Calcium	646	mg/L
Magnesium	351	mg/L
Sodium	1181	mg/L
Potassium	65	mg/L
Barium	0.82	mg/L
Bicarbonate	171	mg/L
Sulfate	224	mg/L
Chloride	3980	mg/L
Fluoride	0.16	mg/L
Nitrate	1.4	mg/L
Silica	28	mg/L
Boron	0.23	mg/L
Iron	0.18	mg/L
Manganese	0.29	mg/L
Arsenic	3.0	µg/L
Nickel	3.2	mg/L
Selenium	32	µg/L
Methane	7.0	mg/L
TDS	6580	mg/L

Notes:

Monitoring well data do not include strontium or silica. Silica at a concentration of 28 mg/L was based on the Goldsworthy Desalter feed water.

NA = not applicable

NTU = Nephelometric Turbidity Unit

mg/L = milligram(s) per liter

µg/L = microgram(s) per liter

2.2.1 Recovery – Quantity of Waste Generated

The optimum treatment process will be studied in a future phase of this Program. For the purposes of brine discharge, and based upon the feed water quality listed in Table 2-1, the following describes the prototypical treatment process and potential recovery (product water divided by treatment plant feed water) rates:

- The treatment process is assumed to include cartridge filtration and pretreatment chemical addition, including acid and antiscalant, reverse osmosis (RO), and air stripping and then remineralization, with approximately 1 percent of the extracted well water bypassing the RO process and blending with the RO permeate. The 1 percent bypass is beneficial in reducing the amount of remineralization chemicals necessary to stabilize the treated water and protect the distribution system. The bypass must be less than 2 percent of the total treated water in order for the treated water to reliably meet water quality goals, including manganese, and comply with California and Federal Primary and Secondary Drinking Water Standards.
- The only substantial wastes generated will be the RO brine, and, to a lesser extent, water from rinsing the RO trains when shutdowns occur. The RO cleaning frequency is expected to be infrequent and will only generate a small amount of waste. RO clean-in-place (CIP) solutions will be neutralized onsite, and if permissible, slowly metered into and mixed with the RO brine in order to minimize changes in brine composition.
- Antiscalant projections indicate that the maximum recovery that conventional RO can achieve is 85 percent, limited primarily by silica and barium sulfate.
- Closed-circuit reverse osmosis (CCRO) was analyzed as a method of increasing the recovery past 85 percent. Discussions with Desalitech revealed that they do not have enough data on barium sulfate at this point, but they were comfortable with an overall recovery of 90 percent based upon silica alone. However, the savings in brine discharge costs were less than the additional capital expenditure (CAPEX) and operations and maintenance (O&M) costs, due primarily to the extra energy cost, with the addition of CCRO.

The analysis included in Section 3.1.1.2 indicates that the economics favor maintaining conventional RO at its maximum recovery over adding CCRO as a secondary RO process. Thus:

- The amount of waste generated by the 85 percent recovery treatment process is assumed to be 15 percent of the feed water to the plant.

A preliminary mass balance of the 12,500-AFY feed water treatment process is displayed in Table 2-2 and indicates the following:

- Approximately 1,146 gallons per minute (gpm) of continuously produced brine for discharge (The 1,175 gpm [shown in the sample calculation provided in Section 3.1.1.2] includes periodic shutdown and startup flushes of the RO trains as well as neutralized CIP solutions).
- Approximately 1 percent of the extracted well water can bypass the RO process.

2.2.2 Quality of Waste

The Projects will produce a continuous brine waste having maximum constituent concentrations as indicated in the “Rowc” column (Brine) of Table 2-2. On average, these values will likely be diluted by 2 to 3 percent, with RO startup and shutdown rinse waters that consist of well water and RO permeate, respectively. The brine will be supersaturated in barium sulfate, silica, and other sparingly soluble salts. These salts are maintained in solution by the presence of the antiscalant continuously dosed in the RO feed; however, their effectiveness is limited in time, typically on the order of 24 hours. Thus, discharge methods that do not include dilution of the brine with another water source, such as sewering, within this period of time or less run the risk of producing scale (solids) in the discharge system, or in the case of DWI, in the well or receiving zone.

Table 2-2. Preliminary 12,500-AFY Centralized Desalter Mass Balance

Mass Balance - WRD FS			
Primary RO recovery: 85%	Based upon 5-year membrane age		
CCRO Recovery: 0%			
Overall Recovery: 85%		Arsenic Rejection: 90%	
Bypass (gpm): 100		Selenium Rejection: 96%	
Permeate Quality FOS: 1.3	CPA6LD ->CPA5LD	Arsenite Rejection: 82%	
		Arsenate Rejection: 98.5%	

Parameter	RW Well Feed	RO System: ROf Feed to RO	RO System: ROwc RO Concentrate	RO System: ROp RO Permeate	RO System: ROp RO Permeate (with FOS)	Decarbonated ROp	Bypass RO Bypass	Blend	Fp Final
Flow (mgd)	11.1	11.0	1.6	9.3	9.3	9.3	0.14	9.5	**9.5**
(gpm)	7,743	7,643	1,146	6,497	6,497	6,497	100	6,592	**6,592**
(AFY)	12,490	12,328	1,849	10,479	10,479	10,479	161	10,640	**10,640**
Calcium (mg/L)	646	646	4,279	4.8	6.2	6.2	646	16	**16**
Magnesium (mg/L)	351	351	2,325	2.6	3.4	3.4	351	8.7	**8.7**
Sodium (mg/L)	1,181	1,181	7,636	41.8	54.3	54.3	1,181	71	**104**
Potassium (mg/L)	65	65	417	2.9	3.8	3.8	65.0	4.7	**4.7**
Ammonia (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Barium (mg/L)	0.82	0.8	5.4	0.006	0.01	0.01	0.82	0.02	**0.02**
Bicarbonate (mg/L)	171	163	1,052	5.8	5.8	5.8	171	8.3	**100**
Sulfate (mg/L)	224	224	1,487	1.1	1.4	1.4	224	4.8	**4.8**
Chloride (mg/L)	3,980	3,985	26,119	79	102	102	3,980	161	**161**
Fluoride (mg/L)	0.16	0.2	1.0	0.01	0.0	0.0	0.2	0.0	**0.0**
Nitrate (mg/L)	1.40	1.4	8.7	0.1	0.2	0.2	1.4	0.2	**0.2**
Silica (mg/L)	28	28.0	184	0.5	0.7	0.7	28.0	1.1	**1.1**
Boron	0.23	0.2	0.7	0.15	0.21	0.21	0.23	0.21	**0.21**
Iron (mg/L)	0.18	0.18	1.2	0.001	0.001	0.001	0.180	0.004	**0.004**
Manganese (mg/L)	0.29	0.29	1.9	0.002	0.003	0.003	0.290	0.01	**0.01**
Nickel (µg/L)	3.2	3.2	21.2	0.02	0.03	0.03	3.2	0.08	**0.08**
Arsenic (µg/L)	3.0	3.0	19.0	0.2	0.2	0.2	3.0	0.3	**0.3**
Selenium (µg/L)	32	32	210.6	0.5	0.6	0.6	32.0	1.1	**1.1**
Methane (mg/L)	7.0	7.0	7.0	7.0	7.0	0.07	7.0	0.2	**0.2**
TDS (reported)	7,694	7,694							
TDS (calculated)	6,580	6,580	43,094	136	176	176	6,580	273	**361**
pH	7.9	7.5	8.3	6.0	6.0	6.1	7.9	6.2	**8.4**
Temperature (°F)	71	71	71	71	71	71	71	71	**71**
CO_2 (mg/L)	3.1	9.1	9.1	9.1	9.1	8.0	3.1	7.9	**0.7**
LSI	1.3	0.9	3.2	-4.0	-3.9	-3.8	1.3	-3.1	**0.1**

Notes:

µg/L = microgram(s) per liter
°F = degree(s) Fahrenheit
CO_2 = carbon dioxide
CPA = Composite Polyamide
FOS = factor of safety
Fp = finished product water
FS = feasibility study
LSI = Langelier saturation index
MCL = maximum contaminant level
mgd = million gallon(s) per day
ROf = reverse osmosis feed
ROp = reverse osmosis permeate
Rowc = reverse osmosis concentrate or brine
RW = raw water (well feed)

3. Brine Management Options

3.1 Connection into the Los Angeles County Sanitation Districts Sewer Collection System

The existing Goldsworthy Desalter in Torrance uses a connection to the LACSD collection system for brine discharge; thus, this is a well-established method of brine discharge for WRD. In addition, the Brewer Desalter operated by the West Basin Municipal Water District (WBMWD) also discharges its brine into the LACSD collection system. The collection system discharges into the JWPCP treatment facility.

3.1.1 Water Quality Limitations

Table 3-1 displays the current water quality limits set forth by LACSD for discharge to their sewer system.

None of the limits are expected to be problematic for any potential Project. However, the Project levels of cyanide and dissolved sulfide in the feed water are unknown because the monitoring wells have not been tested for these constituents, so levels of these two constituents would need to be confirmed in future phases of the Program.

Table 3-1. Water Quality Limitations for Discharge to LACSD Sewer

Constituent	Quantity	Estimated Project Brine Concentration	Unit
Arsenic	3	0.02	mg/L
Cadmium	15	< 0.01[a]	mg/L
Total Chromium	10	--[b]	mg/L
Copper	15	< 0.15[a]	mg/L
Cyanide (total)	10	NA[b]	mg/L
Lead	40	< 0.01[a]	mg/L
Mercury	2	< 0.002[a]	mg/L
Nickel	12	< 0.041	mg/L
Silver	5	< 0.01[a]	mg/L
Sulfide (dissolved)	0.1	--[b]	mg/L
Zinc	25	< 1[a]	mg/L
pH	> 6.0	7.8	NA
TICH	None	None	mg/L

[a] Pertinent monitoring well concentrations for these constituents are below the method detection limit.

[b] No pertinent monitoring well data are available for these constituents.

Note:

TICH = total identifiable chlorinated hydrocarbons

3.1.2 Economics

Brine discharge into the LACSD sewer would not require substantial additional infrastructure for the Projects. Each Project includes a treatment location, whether centralized or at a wellhead, that is in an urban area and thus close to a sewer connection, so minimal piping will be required to sewer the brine. Further, no additional pumping would be required because the secondary RO brine would have enough pressure to reach the sewer line.

The costs involved in sewering the brine include the one-time connection/capacity fee for a new discharge into LACSD's sewer system and an annual surcharge that funds LACSD treatment requirements . Each of these costs is based on flow rates and the levels of chemical oxygen demand (COD) and total suspended solids (TSS) in the brine, as shown in the following equations (LACSD, 2019).

$$\text{Connection Fee} = R[(X * \text{Flow}/260) + (Y * \text{COD}/1.22) + (Z * \text{TSS}/0.59)]$$

$$\text{Annual Surcharge} = (\text{Volume} * \$746) + (\text{COD} * \$131.90) + (\text{SS} * \$372.7) + ([2.5\text{Log}(P/Q) * \$98.90 * P]$$

Where:

V = Annual volume in millions of gallons

P = Peak flow over 20 minutes in gpm

Q = Average flow in gpm

Flow = Average flow in gallons per day

COD = Annual COD in 1,000 pounds (lb)/year

TSS = Annual TSS in 1,000 lb/year

R = 4015

X = 0.67

Y = 0.13

Z = 0.12

Although there are no data on TSS or COD in the monitoring wells, groundwater typically has low levels of each of these constituents. It is assumed that the desalter brine effluent would contain a maximum of 1 mg/L of each, as shown in the following sample calculation.

Sample Calculation for 12,500-AFY Feed Projects (Nos. 18, 24, 25, 26 in Table 1-1)

Assume the treatment plant operates at maximum capacity, the brine flow is fairly steady (peak = average flow + 200 gpm for RO rinse), the recovery is 85 percent, and the COD and TSS of the brine effluent are each 1 mg/L.

- Flow = 12,500 AFY * 325,851 gal/AF * 1 Y/365 days* 1 day/1440 min* (1-85 percent Recovery) = 1,175 gpm
- COD = TSS = 1 mg/L * 3.78 L/gal * 1146 gpm * 1 kg/10^6 mg * 2.2 lb/kg * 1/1000 * 1440 min/day * 365 days/year = 5.0
- Connection Fee = 4015*[(0.67*1146*1440/260) + (0.13*5/1.22) + (0.12*5/0.59)] = **$17,500,000**
- Annual Surcharge = ((542*1440*365)/1000000*$746) + (2.7*$131.90) + (2.7*$372.7) + ([2.5Log(742/542)*$98.90 *742 = **$490,000 per year**

Notes:

gal = gallon(s)

kg = kilogram

lb/kg = pound(s) per kilogram

mg = milligram

min = minute(s)

Is CCRO as a secondary RO treatment process economically justifiable?

Due to the high salinity of the water, no.

The addition of CCRO as a secondary treatment process (i.e., treating the brine from the primary RO treatment process) may increase the overall recovery from 85 to 90 percent, resulting in a reduced connection fee and annual surcharge for brine discharge to sewer. However, the CCRO system itself will include additional capital costs, increases in membrane replacement and maintenance costs, as well as more energy and chemical use. Table 3-2 provides cost information for incorporating a secondary RO system. The following analysis is specific to the 12,500-AFY (feed) Projects but is considered scalable to all Projects.

Analysis

- Typically, the primary (conventional) RO system will operate at a substantially lower recovery rate than maximum, to ensure that no precipitation of sparingly soluble salts occurs before the secondary RO process. Therefore, if the primary RO operates at 75 percent recovery, the secondary RO will operate at 60 percent recovery and will treat a feed flow of 2.8 million gallons per day (mgd).
- At $450 per RO membrane, the annual membrane replacement cost for the secondary RO inclusion would be approximately $8,100. Fewer membranes would be required in the primary RO system if a secondary RO system were used, and this has been included in the $8,100.
- At $0.105 per kilowatt-hour (kWh), the annual additional energy consumption of the secondary RO would be approximately $270,000.
- Based on cleaning frequencies of primary RO trains every 6 months and secondary RO trains every 90 days, the additional annual cleaning chemical consumption would be approximately $38,000 with the secondary RO system.

Table 3-2. Economics of Adding a Secondary RO System

Constituent	Overall Recovery	LACSD Connection Fee	Secondary RO CAPEX	LACSD Annual Surcharge	Secondary RO Annual OPEX
Primary RO only	85 percent	$17,500,000	--	$490,000	--
Primary feeding secondary RO	90 percent	$11,600,000	$4,000,000	$330,000	$320,000

Notes:

Secondary RO addition results in a smaller primary RO system. Costs related to secondary RO listed are secondary RO costs minus the difference in primary RO costs.

CAPEX = capital expenditure

OPEX = operational expenditure

-- = not applicable

3.1.3 Other Factors to Consider

LACSD has indicated they are evaluating the conditions and charges for brine discharge to their collection system in consideration of water quality impacts on the proposed MWD/LACSD Advanced Water Treatment (AWT) Facility at the JWPCP. The new requirements may include a cost component for the mass of brine salinity, likely in mg/L of TDS in the above surcharge formula as well as in the connection fee formula to account for treatment of the brine. This will likely increase the cost for sewer disposal for RO brines.

3.2 Zero-liquid Discharge

The most established technology for ZLD consists of RO brine treated by a brine concentration (using an evaporator) and crystallization system. The evaporator would treat the brine from the RO system containing roughly 43,000 mg/L of TDS by concentrating the brine to a 200,000- to 300,000-mg/L TDS stream that would enter the crystallizer. The crystallizer discharge would be solid salt requiring landfilling. A benefit of these processes is that the recovered distillates from both the evaporator and the crystallizer are high quality and appropriate for potable use, resulting in a 99 percent+ recovery system. This would result in a decrease in the capacities and costs of both the RO system, although additional post-treatment chemical use would be required. However, these cost savings are outweighed by the costs of the combined evaporator and crystallization system, as explained in Sections 3.2.1 and 3.2.2.

3.2.1 Economics

The combined evaporator and crystallizer system, operating on the approximately 1,175-gpm of brine (12,500-AFY feed centralized desalter) would have a capital cost of approximately $35,000,000. Assuming $0.105 per kWh, the annual OPEX of the evaporator and crystallizer system would be approximately $8,700,000, including energy, chemicals, parts, maintenance, and labor.

3.2.2 Other Factors to Consider

Evaporators and crystallizers are highly energy intensive, complex to operate, and would require additional operator involvement, all included in the costs presented in Section 3.2.2. In addition, the height of this equipment may represent a permitting issue.

3.3 Deep Well Injection

DWI has a proven but limited history in California; the Laguna County Sanitation District disposes of RO concentrate into a Class I injection well. The United States Environmental Protection Agency and the Regional Water Quality Control Boards (RWQCBs) stipulate that RO concentrate can be disposed of in either Class I or Class V injection wells. Class V injection wells are limited to waters with less than 10,000 mg/L of TDS, and the RO concentrate from the Projects under consideration will have an approximate TDS of 43,000 mg/L, so only Class I injection wells are applicable. Class I injection wells are used to inject either hazardous or nonhazardous waste into deep, confined rock formations below underground sources of drinking water. Class I injection wells must be in locations that are free from adverse geological features, including earthquake faults, and the wells must be continuously monitored for integrity.

Numerous oil and gas wells are within 2 miles of the Elm and Faysmith and JWPCP potential centralized treatment facilities. Injection of the RO brine into abandoned oil wells is an option if the wells comply with regulatory standards to protect the underground source of drinking water. This option of using abandoned oil wells would need to be further investigated. If new injection wells are constructed, the capital cost of the new well construction would be double the retrofit cost shown in Table 3-2.

3.3.1 Potential Problems

It is unlikely that the brine from the potential Projects could be disposed of via DWI without further treatment. The water will be supersaturated with barium sulfate and silica, and these will likely precipitate in the piping to the injection well and in the injection well formation. In addition, as shown in Table 2-2, the brine will have approximately 1.1 mg/L of iron, which could oxidize with exposure to air and precipitate. Jacobs designed another California groundwater desalter project in 2012 using injection wells for discharge of RO brine with approximately 2 mg/L of iron, and oxidation/media filtration was designed for iron removal prior to DWI. Unfortunately, the desalination portion of this project was eliminated, and the injection wells were never installed. Nonetheless, precipitation or iron oxidation would result in deposits in the brine effluent piping and could clog the injection well formation, leading to diminished injection capacity over time.

However, numerous successful DWI projects are in operation in Florida. Precipitation can be prevented in the piping if the wells are reasonably close, but the potential for precipitation in the receiving zone exists and requires a geochemical evaluation.

In addition, previous work by LACSD in Santa Clarita Valley has demonstrated that DWI would also require an active public outreach and education program. After numerous studies, DWI was recommended as the brine discharge option for the Santa Clarita Valley Sanitation District (SCVSD) Chloride Compliance Facilities Plan (LACSD, 2013) in Valencia, California. However, it was decided to truck the brine away in part because of public opposition to DWI.

3.3.2 Economics

Capital and O&M costs for DWI are site specific, and DWI is feasible only in certain conditions that have a confining layer and a porous injection zone capable of sustaining adequate injection rates. DWI requires further study and investigation to develop economic estimates that are comparable in accuracy to the other options included in this TM, including sewering and ZLD. The estimate presented here will help determine whether this DWI option is worth further consideration.

In a 2013 facilities plan for SVCSD's Chloride Compliance Program (LACSD, 2013), CAPEX for a 0.5-mgd DWI brine discharge project was estimated at $42,000,000. This project consisted of a pump station, a 2.5-mile-long, 8-inch-diameter pipeline to the DWI site, five new (not retrofitted) injection wells, injection pumps, chemical storage tanks, and electrical switchgear.

3.3.2.1 Assumptions

The estimate presented here includes a pump station to transfer the RO brine from the treatment plant to the injection wells and retrofitting the abandoned wells. The estimate assumes the following:

- No further treatment is required before injection (optimistic).
- Suitable abandoned oil and gas wells can be found within a few miles of the treatment facility.
- Sustainable injection rates of 80 gpm per injection well (similar to other California injection wells).

The estimated capital cost to dispose of 1,175 gpm of RO brine from a potential 12,500-AFY feed water flow desalter is presented in Table 3-3.

Table 3-3. Estimated Minimum CAPEX of Deep Well Injection of RO Brine from 12,500-AFY (feed flow) Project

Item	CAPEX
Submerged wet well and pump station	$3,000,000
2 miles of piping	$5,000,000
Retrofit of 16 abandoned oil and gas wells (1 spare)	$17,400,000
Total	**$25,400,000**

Operating costs for DWI include energy to inject the brine below the drinking water aquifer (more than 1,000 feet) and to cover maintenance and chemical costs. Annual operating costs for RO brine from 12,500-AFY (feed flow) Projects are estimated to be approximately $1,900,000.

3.4 Ocean Discharge

Ocean discharge includes options of either a new ocean outfall or a new DBL that would mix the brine with the waste water effluent from the JWPCP before ocean discharge. The economics of the new DBL, as discussed herein, have not been fully developed and would require negotiations between WRD and LACSD.

3.4.1 Using Existing Ocean Outfalls

The community's concerns will likely be expressed as basic questions: Why the need for a new outfall? What are the alternatives? The *California Ocean Plan* (SWRCB, 2015) is the principal document setting forth requirements and guidelines for siting an ocean outfall and standards for the effluent being discharged into the marine receiving waters through the outfall. Specific criteria are set forth in many sections of the *California Ocean Plan* for the discharge of brine from desalination facilities. While the brine to be generated from the proposed Projects is not generated from seawater desalination, it meets the intent of the *California Ocean Plan*. The *California Ocean Plan* states that the regional water board will require the permit applicant to examine a number of factors (III.M.2.b – p. 37) in determining the "best available site feasible" (SWRCB, 2015). For this discussion, chief among these factors is No. 6:

> *Analyze the presence of existing discharge infrastructure, and the availability of wastewater to dilute the facility's brine discharge.* (SWRCB, 2015)

Factor No. 6 leads to the consideration of both the Hyperion Water Reclamation Plant outfall and the outfall operated by LACSD for the JWPCP. Because WRD is already discharging the Goldsworthy brine to the LACSD system and ultimately to the ocean through their outfall, a rationale would need to be presented as to why this practice could not continue for this proposed project. Due to cost, it is almost certain that Hyperion or JWPCP wastewater effluent would not be conveyed to the site of a new outfall for the purpose of diluting the brine to be discharged. Encouragement to use existing wastewater outfalls is further emphasized in the *California Ocean Plan* on page 41:

> *The preferred technology for minimizing intake and mortality of all forms of marine life resulting from brine discharge is to commingle brine* with wastewater (e.g., agricultural, municipal, industrial, power plant cooling water, etc.) that would otherwise be discharged to the ocean.* (SWRCB, 2015)

These quotations from the *California Ocean Plan* are pertinent examples of the clear desire, if not directive, that brine should be commingled with wastewater and discharged to the ocean through a permitted and well-designed existing outfall system. The LACSD JWPCP and Hyperion outfall systems satisfy these criteria; however, Hyperion, run by the City of Los Angeles and not LACSD, is roughly double the distance to Elm and Faysmith compared to the JWPCP. Moreover, the existing Goldsworthy and Brewer desalter brines are routed to the LACSD JWPCP, thus encouraging DBL negotiations with LACSD for direct connection to the JWPCP tunnel and ocean outfall system, rather than with the City of Los Angeles concerning its Hyperion Water Reclamation Plant outfall.

3.4.2 DBL

The option of a DBL would consist of installing a pipeline that would convey the brine from the proposed Project desalter to one of the following: the LACSD JWPCP effluent tunnel, which connects to their network of ocean outfalls at Whites Point on the Palos Verdes peninsula, or to the existing outfall of the LASAN - Hyperion wastewater treatment plant. The high-salinity brine would be diluted by the much larger flow of the applicable wastewater effluents and would not require further treatment.

3.4.2.1 DBL to the JWPCP

LACSD will most likely institute a program to reduce the salinity of the JWPCP influent because of the proposed AWT Project at the JWPCP. As such, LACSD may be willing to work with WRD and the Stakeholder Group to provide DBL connection to the JWPCP outfall in lieu of accepting the brine via the sewer. There is a precedent for such a separate connection in the existing DBL from the West Basin Carson Regional Water Recycling Facility connection to the LACSD JWPCP effluent tunnel system. The details of this DBL discharge option would need to be worked out between LACSD and WRD. It may be in the best interests of both parties to install a new "regional" DBL that would collect the effluent from the existing Goldsworthy and Brewer desalters as well as the new Project. LACSD would achieve its objective of reducing the TDS/chlorides in its influent wastewater and the Brackish Water Recovery Project would achieve discharge cost certainty and control. Contractual details must be worked out with LACSD, but

LACSD has expressed a desire to work with the Project proponents to arrive at a satisfactory solution for all. If the regional brine line option is pursued, sizing the line to accept potential future desalter brines is recommended.

If water recycling via AWT at the JWPCP progresses as projected, brine flows from the JWPCP would increase, and less wastewater effluent would be available for dilution. LACSD is aware of this future condition and, along with MWD, is investigating the ramifications and potential mitigation measures. It is recommended that WRD collaborate with LACSD and MWD to ensure that a fit is considered for the new desalter Project. The potentially brine-dominated effluent could have negative ramifications on effluent compliance with receiving water quality limits. In recognition of the furtherance of water reuse (which clearly includes the JWPCP AWT and the Project), the *California Ocean Plan* has a provision that addresses potential Revision to Waste Discharge Requirements in Section III.G.2:

> 2. *Regional Water Boards may impose alternative less restrictive provisions than those contained within Table 1 of the Plan, provided an applicant can demonstrate that:*
>
>   a. *Reasonable control technologies (including source control, material substitution, treatment and dispersion) will not provide for complete compliance; or*
>
>   b. *Any less stringent provisions would encourage water reclamation.*
>   (SWRCB, 2015)

3.4.2.2 DBL to Hyperion

The WBMWD's Edward C. Little Water Recycling Facility (ECLWRF) currently sends its RO brine to the LASAN - Hyperion outfall, so the City of Los Angeles may be willing to accept the brine from the new Project as well. However, Hyperion is much further away from the Elm and Faysmith site; therefore, the pipeline project costs would be higher.

3.4.2.3 Economics

The economics of the new DBL option would likely include the cost of a pump station, the cost of the DBL itself, and the fees imposed by LACSD or LASAN for accepting the waste. At this time, the fees to be imposed by LACSD (JWPCP) and the City of Los Angeles (Hyperion) have not been established. Therefore, only the CAPEX costs of the new brine line options are presented.

For a 12,500-AFY (feed) centralized treatment Project at Elm and Faysmith, the estimated capital cost of a 4-mile-long, 12-inch-diameter high-density polyethylene (HDPE) pipeline to convey 1,175 gpm of RO brine to the JWPCP is approximately $7,400,000 (see Table 3-4). A brine collection system and pump system would be required to get the brine to the outfall of the JWPCP.

Table 3-4. Estimated CAPEX of a DBL from 12,500-AFY (feed flow) Project at Elm and Faysmith to the JWPCP Tunnel/Outfall

Item	CAPEX
Submerged wet well and pump station	$3,000,000
4 miles of 12-inch-diameter piping	$9,600,000
Total	**$12,600,000**

A regional DBL, intended for additional future wastes and the existing brines from the Goldsworthy and Brewer desalters, would be 1.5 miles longer and oversized for the potential future Projects. Assuming a 16-inch line, capable of approximately 3,000 gpm of flow, the brine line cost would be approximately $22,000,000, including brine collection and pump systems. Costs for the regional brine line are presented in Table 3-5.

Table 3-5. Estimated CAPEX of a DBL from the Brewer and Goldsworthy Desalters, Passing by Elm and Faysmith to the JWPCP Tunnel/Outfall

Item	CAPEX
Two submerged wet well and pump stations (one shared by Goldsworthy and Brewer and one at the new Project)	$6,000,000
5.5 miles of piping (1.5 miles of 12-inch followed by 4 miles of 16-inch)	$16,000,000
Total	**$22,000,000**

The distance from a centralized treatment plant at Elm and Faysmith to Hyperion is 11 miles. Costs are shown in Table 3-6.

Table 3-6. Estimated CAPEX of a DBL from 12,500-AFY (feed flow) Project at Elm and Faysmith to the Hyperion Outfall

Item	CAPEX
Submerged wet well and pump station	$3,000,000
11 miles of 12-inch-diameter piping	$24,000,000
Total	**$27,000,000**

The details of the operating costs (i.e., LACSD's charges for discharge) need to be worked out between WRD and LACSD. WBMWD's ECLWRF discharges its brine to the outfall of the Hyperion Water Reclamation Plant and we understand that Hyperion does not charge WBMWD for this arrangement. However, ECLWRF treats water that Hyperion would have discharged, so there is no additional salt or mass loading for the Hyperion discharge. For this Program, the DBL would collect additional salt from the ground, so there would be an additional mass loading on the outfalls. Thus, the economic situation for this Program is likely to be different from that of the Hyperion/WBMWD arrangement.

3.4.2.4 Other Factors to Consider

The DBL would likely contain supersaturated wastes and would be in danger of forming solids in the pipelines to the tunnel/outfalls. This situation could be mitigated by decreasing the recoveries of the RO treatment facilities feeding the brine line, although this solution would likely require the DBL piping size to be increased, at an additional cost. Precipitation would not be an issue at the centralized Project location at the JWPCP itself because there would be insufficient time for the precipitant to develop before being diluted with wastewater.

3.4.3 New Ocean Outfall

3.4.3.1 Permitting Requirements

The *California Ocean Plan* is the primary regulatory document used in setting forth criteria for permitting any discharge to the ocean. For the case of a brine discharge, it is clear in the *California Ocean Plan* that every effort must be made by the permit applicant to utilize existing ocean outfall structures and the dilution available in that discharge. Thus, before considering a new ocean outfall, the availability of existing outfall discharges must be pursued. Assuming existing outfall systems are unavailable for use, obtaining a permit to discharge any effluent, including brine concentrate via a new ocean outfall, is rigorous and is highly likely to require a comprehensive environmental impact report. In addition, the permanent discharge permit will typically not be issued until the Project is constructed and has passed concentrate quality tests to determine constituent concentrations. The permit application process would require the following:

- Outfall diffuser modeling
- Water quality modeling
- Sampling of anticipated flows

Permission for the construction of a new outfall, particularly in the environs of Santa Monica Bay, would require completion of extensive technical and environmental analyses, which would serve as the basis for applications to obtain construction and operation permits. Permits would need to be obtained from the following entities:

- California Coastal Commission
- California Department of Fish and Wildlife
- National Marine Service Fisheries
- RWQCB
- State Water Resources Control Board
- United States Army Corps of Engineers (USACE)
- United States Fish and Wildlife Service

A California Environmental Quality Act (CEQA) process must be initiated, and a USACE Section 404 permit would most likely be required. In addition, Section 7 of the Endangered Species Act would require consultation from the resource agencies on the CEQA documentation, and a National Pollutant Discharge Elimination System (NPDES) permit. Also, coordination with the State Lands Commission could be required for a lease of coastal lands under their ownership, as well as for any stream crossings. For a new outfall to be eligible to receive a permit from a RWQCB or the California Coastal Commission, it must be a sufficient distance from sensitive areas, including State Water Quality Protection Areas. In addition, the effluent must pass a bioassay test before an ocean discharge permit is issued.

The Coastal Zone Management Act requires all federal permittees that affect a state coastal zone to comply with state guidelines regarding coastal zone management. These guidelines could affect any ocean discharge requiring one or more federal permits.

Regulatory issues involved with discharging brine to surface waters, including the ocean, primarily involve obtaining an NPDES permit and any permits associated with conveyance to the discharge site. The quality and quantity of the brine will be required to obtain an NPDES permit. In addition, reporting guidelines to the regulating agency are to be determined prior to issuance of an NPDES permit. An NPDES permit will be issued only if requirements imposed by national and state authorities are satisfied.

One key issue associated with obtaining an NPDES permit is the ability to provide an adequate visual mixing zone for the concentrate to protect the marine habitat. NPDES limits on metals are often below drinking water quality levels because they are based on the *California Ocean Plan* (SWRCB, 2015). Table 3-7 indicates that the selenium concentration in the brine is the only constituent that is predicted to exceed the *California Ocean Plan* limits. Thus, the undiluted, unmixed discharge of the brine to the ocean would require a well-designed diffuser system on the end section of the outfall. For the new ocean outfall implemented as part of the recent Collogues Municipal Water District Salt Management Project, the RWQCB set a dilution ratio of 72 to 1, more than required to meet the *California Ocean Plan* targets, and required that the brine be commingled with wastewater.

Table 3-7. California Ocean Plan Discharge Water Quality Targets

Constituent	Ocean Plan Water Quality Targets	Estimated Project Brine Concentration	Unit
Ammonia-N	6,000	Na[a]	µg/L
Arsenic	80	19	µg/L
Cadmium	10	< 8[b]	µg/L
Cyanide	10	Na[a]	µg/L
Hexavalent Chromium	20	< 2[b]	µg/L
Copper	0.4	< 150[b]	µg/L
Mercury	0.4	< 3[b]	µg/L
Nickel	50	< 40[b]	µg/L
Selenium	150	210	µg/L
Silver	7	< 8[b]	µg/L

[a] Na = not available; no pertinent monitoring well data are available for these constituents.

[b] Pertinent monitoring well concentrations for these constituents are below the method detection limit.

Note:

Value in red exceeds *California Ocean Plan* limits.

In addition to undergoing the process for obtaining a permit, the proposal for locating an outfall in Santa Monica Bay would need to be carefully crafted such that it garners the support of a community that is environmentally sensitive and active. Their support will be critical before the CEQA and permitting processes can begin.

3.4.3.2 Economics

CAPEX for the 12,500-AFY (feed) flow centralized Projects at the Elm and Faysmith site would include at least 3.7 miles of new 12-inch-diameter HDPE pipeline to get to the ocean. The estimated CAPEX of a new dedicated ocean discharge for these Projects is presented in Table 3-8, and assumes an ocean outfall 4,500 feet long, equivalent to that at the end of the new Collogues Salinity Management Pipeline at Port Hueneme.

Table 3-8. Estimated CAPEX of New Ocean Discharge from 12,500-AFY (feed flow) Project at Elm and Faysmith

Item	CAPEX
Submerged wet well and pump station	$3,000,000
4 miles of 12-inch piping	$9,600,000
New ocean outfall (4,500 feet long, 12-inch-diameter)	$9,900,000
Total	**$22,500,000**

3.4.3.3 Operating Costs

Within the last 10 years, the Collogues Salinity Management Pipeline was constructed in Ventura County to convey wastes from both municipal wastewater treatment plants and multiple groundwater desalter (brines) to the ocean for discharge. Collogues maintains the pipeline and provided a detailed annual budget that was incorporated into Table 3-8.

Collogues did not quantify the labor involved in maintaining the pipeline but described the level of labor as extensive, including quarterly replacement of pressure control valves, meters, and air and vacuum valves. Quarterly replacement of these devices results from salt in the line that precipitates and clogs the rubber seals. Such frequent replacements are required as any air and vacuum relief valve water discharge, due to hardened seat, is considered a spill incident and must be reported to the RWQCB. Collogues explained that dewatering the pipe is another issue because the water cannot be discharged as waste, so Collogues had to add special blow offs to dewater the pipe to the ocean. Estimated annual O&M costs that the Project would incur for a new ocean outfall are estimated in Table 3-9.

Table 3-9. Annual Operations and Maintenance Costs of a New Ocean Discharge

Item	OPEX
Pump station energy (assumed 50 psig and $0.10 per kWh)	$30,000
Labor	$100,000
Supplies[a] (replacement valves and seals, leak response materials)	$15,000
Consultants[a]	$115,000
Sampling[a] (lab services, including permit analysis for metals, includes boat)	$335,000
Outside services[a] (sediment survey, annual dive survey)	$15,000
Annual SWRCB Discharge Permit[a]	$75,000
Annual Total	**$685,000**

[a] From Calleguas Municipal Water District 2017-2018 Budget

3.4.4 Trucking the Brine to the JWPCP

The SCVSD is in the process of implementing a Chloride Compliance Project to meet a California state mandate on chloride limits in the Santa Clarita Valley. This project will use RO on microfiltered municipal effluent, and there are no options for either sewering the brine or building a brine line to a nearby waste water treatment plant. After a 2013 Environmental Impact Report was challenged in court, trucking the brine to the JWPCP has proven to be the only publicly acceptable option for brine management for this project. As a result, the design of the Chloride Compliance Project has been modified to achieve a high recovery rate to reduce the volume of brine and thus the trucking and management cost.

Trucking the brine to the JWPCP is an option for the WRD Projects as well. However, as described in this Program's Task 1.H Treatment Memorandum, the additional treatment options for pushing the recovery higher than 85 percent cost more than the reduction in brine management costs via sewering or DBL. As a result, the Projects have a high volume of brine that needs to be managed for the trucking option.

The LACSD and SCVSD have yet to establish the cost that LACSD will charge for accepting the brine for the Chloride Compliance Project, but it could be as low as $0.01/gallon. At that price, the cost of disposal (not including trucking costs) of the 1,179 gpm of brine from a 12,500-AFY Project would be on the order of $6,000,000 per year, making this an expensive annual cost option. However, this option would require relatively little CAPEX.

4. Summary of Brine Management Option Costs for Shortlisted Projects and Recommendations

Table 4-1 displays the costs for the brine management options for all 11 shortlisted Projects. In summary, the following recommendations are made:

- For the centralized treatment facility option at the JWPCP, the brine discharge connection to the onsite JWPCP tunnel/outfall system has the lowest cost.
- For all other Projects, brine discharge via the LACSD system is the preferred option, either through discharge to the LACSD existing sewer collection system or via a DBL directly connected to the JWPCP tunnel and outfall system. The optimum choice requires further discussion with LACSD as to future economic parameters for receipt of brine in the JWPCP influent and requirements for the direct connection of the DBL to the effluent tunnel/outfall system.
- ZLD is the most expensive alternative, with extremely high energy use and OPEX. The use of ZLD in lieu of sewering the brine would result in an additional expense of approximately $380/AF of product water produced. Because of the economics, ZLD is not recommended for any Project and would be particularly unsuitable for wellhead treatment because either multiple sets of ZLD equipment would be required (one set for each treatment site), or additional infrastructure would be required to pump and pipe to a centralized ZLD facility.
- DWI is not worth further investigation for this Program. The costs presented, which would result in $70 to $100 additional per AF, are optimistic because they assume that existing abandoned oil wells can be identified and that no brine treatment before injection would be required.
- Trucking is an option but will likely be expensive due to the relatively high volume/flow. Other options, namely DBL and sewering, are substantially more economical.
- Permitting efforts associated with the installation of a new ocean discharge would be substantial if not insurmountable in consideration of the requirements of the *California Ocean Plan*.

5. References

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Los Angeles County Sanitation Districts (LACSD). 2013. *Santa Clarita Valley Sanitation District Chloride Compliance Facilities Plan and Environmental Impact Report*. October.

State Water Resources Control Board (SWRCB). 2015. *California Ocean Plan*.

Table 4-1. Brine Discharge Option Costs for Shortlisted Projects

Potential Project - General Description		Estimated Total Brine Flow, gpm	Sewer			Zero Liquid Discharge			Deep Well Injection (Using Existing Wells, no treatment)			New Brine Line to Outfall of JWPCP (Project only, not including Goldsworthy and Brewer)			New Brine Line to Outfall of Hyperion (Project only, not including Goldsworthy and Brewer)			New Ocean Discharge		
			Total CAPEX, $	Annual OPEX, $	Total $/AF product water	Total CAPEX, $	Annual OPEX, $	Total $/AF product water	Total CAPEX, $	Annual OPEX, $	Total $/AF product water	Total CAPEX, $	ASSUMED Annual OPEX, $	Total $/AF product water	Total CAPEX, $	ASSUMED Annual OPEX, $	Total $/AF product water	Total CAPEX, $	Annual OPEX, $	Total $/AF product water
13	Torrance, GSWC, LADWP (highest delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (20,000 AFY)	1880	28,000,000	760,000	96	48,200,000	14,200,000	895	35,900,000	3,050,000	240	14,600,000	??	??	32,000,000	??	??	25,600,000	705,000	88
14	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties (20,000 AFY)	1880	28,000,000	760,000	96	48,200,000	14,200,000	895	35,900,000	3,050,000	240	14,600,000	??	??	32,000,000	??	??	25,600,000	705,000	88
15	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties and Madrona Lateral (20,000 AFY)	1880	28,000,000	760,000	96	48,200,000	14,200,000	895	35,900,000	3,050,000	240	14,600,000	??	??	32,000,000	??	??	25,600,000	705,000	88
18	Spread Across Stakeholders via interties with New Pipeline to MB (12,500 AFY)	1175	17,500,000	490,000	97	35,300,000	8,700,000	894	25,400,000	1,900,000	249	12,600,000	??	??	27,000,000	??	??	22,500,000	685,000	130
19	Spread Across Stakeholders via interties with New Pipeline to MB and Portable Wellhead Treatment (12,500 AFY)	1175	17,500,000	490,000	97	Not Recommended							??	??		??	??		685,000	
24	JWPCP (12,500 AFY)	1175	17,500,000	490,000	97	35,300,000	8,700,000	894	25,400,000	1,900,000	249	0	??	??				27,300,000	685,000	144
25	Torrance, GSWC, LADWP (highest delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (12,500 AFY)	1175	17,500,000	490,000	97	35,300,000	8,700,000	894	25,400,000	1,900,000	249	12,600,000	??	??	27,000,000	??	??	22,500,000	685,000	130
26	Torrance (highest delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral with 1 existing well (12,500 AFY)	1175	17,500,000	490,000	97	35,300,000	8,700,000	894	25,400,000	1,900,000	249	12,600,000	??	??	27,000,000	??	??	22,500,000	685,000	130
27	All Wellhead no New Distribution Piping (10,500 AFY)	987 (165 at each well)	14,700,000	210,000	75	Not Recommended			14,600,000	1,600,000	225	18,600,000	??	??	33,000,000	??	??	25,200,000	685,000	164
28	Torrance (highest delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (5,200 AFY)	489	7,300,000	220,000	101	19,800,000	3,619,200	931	13,400,000	790,000	269	10,400,000	??	??	22,200,000	??	??	19,200,000	665,000	284
29	All Wellhead (5,200 AFY)	489 (165 at each well)	7,400,000	120,000	80	Note Recommended			11,000,000	790,000	252	11,900,000	??	??	23,700,000	??	??	20,700,000	665,000	295

Notes:

ZLD is not recommended for wellhead treatment Projects because multiple ZLD units would be required.

DWI costs are considered minimums and assume existing wells and no brine treatment.

Project 19 includes a portable wellhead treatment unit. Because of relocation, sewer is the only viable option.

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Subject	**Dedicated Brine Line Route Analysis**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019

1. Introduction

The Water Replenishment District of Southern California (WRD) is responsible for managing and replenishing both the West Coast and Central groundwater basins. In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, and Lower San Pedro aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To fully utilize the West Coast Basin, WRD has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. Program goals include treating the plume to produce potable water and discharge of waste streams generated (mostly high salinity brine) in the treatment process. The Program will study the following components: where to extract the plume water, where and how to treat the plume water, how to convey the treated potable water to the Program stakeholders, and how to manage the brine waste stream. The Program includes the analysis of numerous different “Projects,” consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of the above components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed in dollars per acre foot (AF) of treated water.

As a part of the Program, WRD has initiated a regional planning study to evaluate the feasibility of remediating the saline plume with seven additional stakeholders (known as the Stakeholder Group). The Stakeholder Group has expressed interest in treating the saline plume, receiving the treated water, or both, as part of the Program. The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

As part of this feasibility study, a Technical Memorandum (TM) entitled the *Brine Waste Discharge Evaluation* evaluated brine management options for the recommended shortlisted projects. One of the lowest cost options was a dedicated brine line from the proposed desalter facility (Project) at the Elm & Faysmith property in Torrance to the Los Angeles County Sanitation Districts (LACSD) Joint Water Pollution Control Plant (JWPCP).

The purpose of this TM is to evaluate the proposed route for the brine line, from the desalter facility to the JWPCP. This TM is organized to include the following sections:

- Section 1 – Introduction
- Section 2 – Proposed Brine Line Route
- Section 3 – Required Easements and Permits
- Section 4 – Recommended Pipe Material
- Section 5 – Conclusions and Recommendations

2. Proposed Brine Line Route

This section summarizes the proposed dedicated brine line route from the proposed desalter facility at the City of Torrance Elm & Faysmith property to the JWPCP. For this feasibility study, a desktop analysis was performed using available aerial images from Google Earth and data from the Los Angeles County Geographic Information System (GIS) Data Portal. Field investigations were not performed. Also, no existing utility data or geotechnical data were obtained for any of the alignments, other than available GIS data. There are numerous possible routes for the brine line, but in general, the pipeline was located on streets with a wide right-of-way (ROW), that had area available for easements for the Interstate 110 (I-110) crossing, and that minimized railroad and highway crossings.

Table 2-1 lists the preliminary pipe length and route, as was well as available information regarding the route including the type of construction anticipated. A map of the proposed routes is included on Figure 2-1. The brine line size is assumed to be 12 inches per the *Brine Waste Discharge Evaluation* TM.

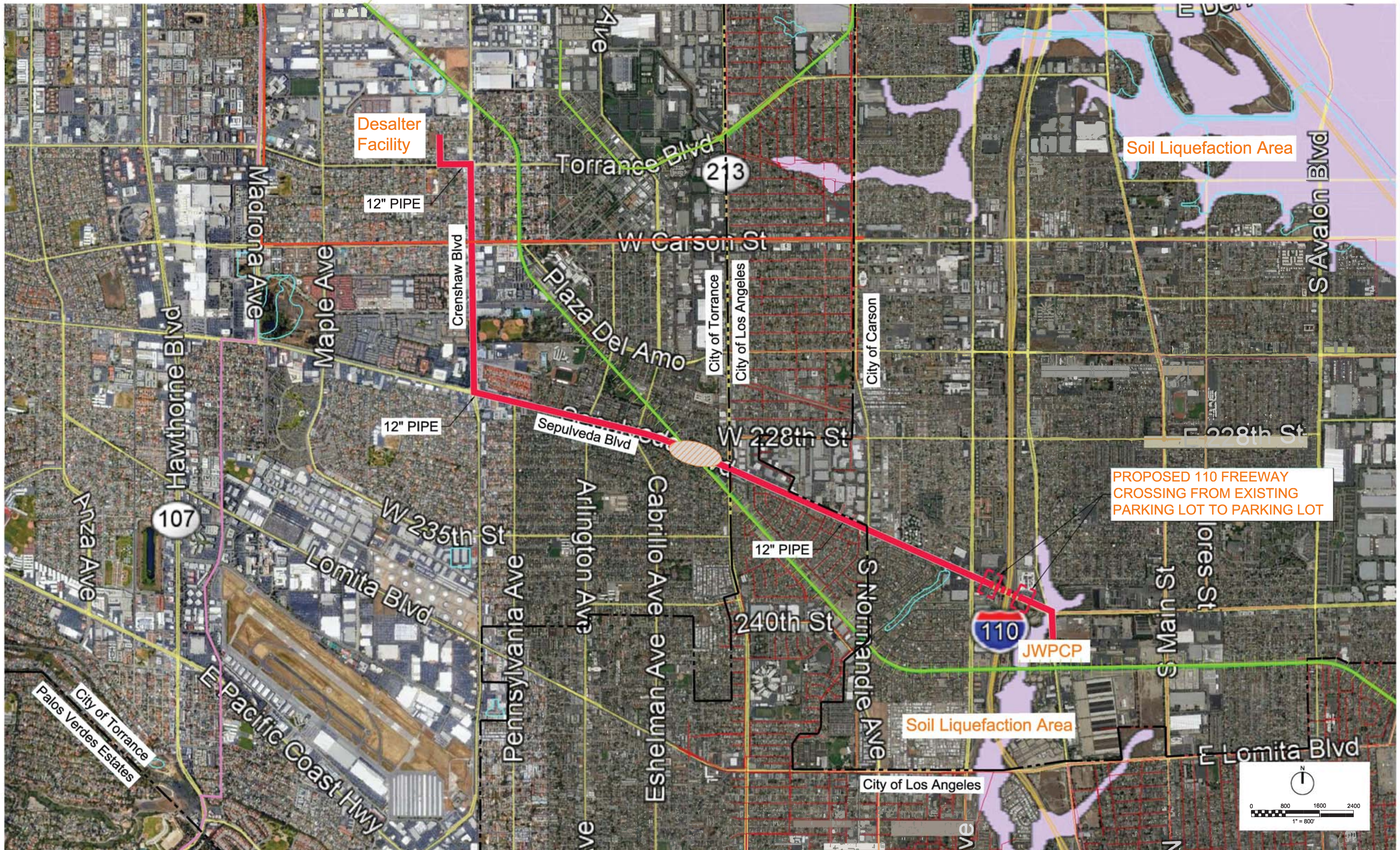
Table 2-1. Proposed Brine Line Route

Street	Pipe Length (feet)[a]	Pipe Route	Comments
Elm Avenue	585	South along Elm Avenue (60-foot ROW) from the proposed desalter facility at the Elm & Faysmith property to the Torrance Boulevard intersection	Elm Avenue is a residential street with one lane in each direction. Elm Avenue has stop signs at intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
Torrance Boulevard	780	East along Torrance Boulevard (110-foot ROW) from Elm Avenue intersection to Crenshaw Boulevard	Torrance Boulevard is a City street with two lanes in each direction and a center/turn lane, with traffic signals at major intersections and stop signs at minor intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
Crenshaw Boulevard	5,240	South along Crenshaw Boulevard (100-foot ROW) from Torrance Boulevard intersection to Sepulveda Boulevard intersection	Crenshaw Boulevard is a City street with three lanes in each direction and a center/turn lane, with traffic signals at major intersections and stop signs at minor intersections. It is anticipated that the pipe can be installed with open-cut construction methods.
Sepulveda Boulevard	12,890	East along Sepulveda Boulevard (104-foot ROW) from Crenshaw Boulevard intersection to east of I-110 crossing	Sepulveda Boulevard is a City street with three lanes in each direction with traffic signals at major intersections and stop signs at minor intersections. The alignment includes one railroad crossing and a crossing of State Route 213 (Western Avenue). It is anticipated that the pipe can be installed with open-cut construction methods, except at the railroad and State Route 213 crossings, which will require trenchless crossings.

Table 2-1. Proposed Brine Line Route

Street	Pipe Length (feet)[a]	Pipe Route	Comments
I-110 Crossing	1,400 (Tunnel is 200 to 700 feet depending on crossing location)	North from Sepulveda Boulevard through new easement (parking lot on the west side of I-110), east across I-110, southeast through new easement (parking lot on the east side of I-110), and then to Figueroa Street	Permanent and temporary construction easements will be required on the east and west side of I-110 near Sepulveda Boulevard. There are existing parking lots in this location where easements could be obtained. It is anticipated that the pipe can be installed with open-cut construction methods in the easements, except at the I-110 crossing, which will require a trenchless crossing.
Figueroa Street	750	South along Figueroa Street (100-foot ROW) from easement to Sepulveda Boulevard, and then across Sepulveda Boulevard to the JWPCP	Figueroa Street is a City street with two lanes in each direction, a center turning lane, and signalized intersections in this segment. At the intersection of Figueroa Street and Sepulveda Boulevard, the brine route crosses into liquefiable soils per LA County GIS data. It is anticipated that the pipe can be installed with open-cut construction methods.

[a] Approximate pipe length based on desktop analysis



Aerial image © Google Earth Pro, 2018. Modified by Jacobs, 2019.

Figure Legend:

- New Brine Pipe Rail Crossing
- Brine Piping
- Existing Flood Hazard Location
- Existing CalTrans Rail Location
- Existing Hazardous Liquid Pipelines
- Existing Water Pipelines
- Existing City of Los Angeles Sewer

Figure 2-1
Vicinity Map
WRD BRINE
WATER PIPING
Torrance, California

JACOBS

3. Required Easements and Permits

Required permanent and temporary construction easements for the dedicated brine line are listed in Table 3-1. The remaining pipeline segments will be constructed in the street ROW.

Table 3-1. Required Easements for Dedicated Brine Line

Easement Location	Property Ownership Information[a]
I-110 Crossing (West Side)	851 Sepulveda Boulevard, Torrance, CA 90502, Assessor's ID No. 7407-004-028, owned by Horton, Roy Tr. et al.; Roy Horton Family Trust Lessor Ralphs Grocery Company Lessee (Property type is listed as commercial/industrial, and assessed value is listed as $12,188,326)
I-110 Crossing (East Side)	23529 Figueroa Street, Carson, CA 90745, Assessor's ID No. 7330-006-001, owned by Greenberg, Michael Co. Tr.; Marjorie Greenberg Decd. Trust (Property type is listed as commercial/industrial, and assessed value is listed as $5,799,762)
I-110 Crossing (East Side) – Alternate Property	651 West Sepulveda Boulevard, Carson, CA 90745, Assessor's ID No. 7330-006-012, owned by Forward Win USA Inc. and Fig Street Properties (Property type is listed as commercial/industrial, and assessed value is listed as $30,910,133)

[a] Source: Los Angeles County Office of the Assessor (maps.assessor.lacounty.gov)

Required encroachment permits for highway and railroad crossings are listed in Table 3-2. This is not a comprehensive list of all permits required for the Project.

Table 3-2. Required Encroach Permits for Highway and Railroad Crossings

Proposed Crossing Location	Required Permit
Railroad Crossing at Sepulveda Boulevard near Walnut Street	Caltrans (District 7) Encroachment Permit
SR 213 Crossing at Sepulveda Boulevard	Caltrans (District 7) Encroachment Permit
I-110 Crossing at Sepulveda Boulevard	Caltrans (District 7) Encroachment Permit

4. Recommended Pipe Material

The 12-inch-diameter brine line will convey approximately 1,175 gallons per minute (gpm) per the Brine Waste Discharge Evaluation TM. The approximate length of the brine line, based on the desktop analysis, is 21,645 feet. Based on elevation data in Google Earth, there is approximately an 80-foot elevation drop between the desalter facility to the JWPCP. It is assumed that the brine discharge will be pressurized gravity or pumped.

Key properties for consideration of satisfactory pipe materials include internal and external corrosion resistance, cost, constructability, and thrust restraint methodology. For the high-salinity brine, polyvinyl chloride (PVC) and high-density polyethylene (HDPE) are acceptable pipe materials for the required pipe diameter. Both materials have good internal and external corrosion resistance for conveyance of the brine and protection from corrosive soils. The main advantage of HDPE is that the joints are fused and fully restrained, and mechanical thrust restraint or thrust blocks are not required. PVC pipe requires the use of thrust blocks or mechanical thrust restraint. It is anticipated that the pipe route will be crowded with existing utilities, so thrust blocks are not recommended, and a mechanical thrust restraint system would be required. Also, ductile iron (DI) fittings are commonly used with PVC pipe at bends. The DI bends would require internal and external corrosion protection. The installed cost is anticipated to be similar for both types of pipe. For this project, HDPE pipe is recommended.

The recommended minimum pipe class is HDPE PE 4710, DR 17. This will need to be confirmed during design based on hydraulic and surge modeling.

5. Conclusions and Recommendations

The proposed brine line from the proposed desalter facility to the JWPCP will be located in City street ROW. Trenchless crossings and permits are required at railroads and highways. Easements will also be required for the crossing of I-110. Geotechnical, survey, and utility investigations will need to be performed during design, and the exact route in the City ROW will need to be determined in order to minimize utility conflicts and traffic disruption. When possible, the pipelines should be located outside of the pavement area. Additional information on the well site locations will developed during the next phase of the feasibility study.

6. References

Los Angeles County Assessor website. April 2019. https://assessor.lacounty.gov/

Los Angeles County GIS Data Portal website. April 2019. https://egis3.lacounty.gov/dataportal/

6. Product Water Quality and Conveyance (Task 1.G)

Identification of Product Water Quality Specifications

Product Water Conveyance System Analysis

Technical Memorandum

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Subject	**Identification of Product Water Quality Specification**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019
Prepared by	Liana Olivas Fred Gerringer, D.Env., P.E., BCEE
Reviewed by	David Hokanson, Ph.D., P.E., BCEE Steve Alt, P.E. Judi Miller, P.E. Jim Lozier, P.E.

1. Introduction

Within the West Coast Basin, a plume of high total dissolved solids (TDS), approximately 375,000 acre-feet (AF) in size, has been entrapped due to seawater intrusion and the implementation of the West Coast Seawater Intrusion Barrier. The Water Replenishment District of Southern California (WRD) has initiated a Regional Brackish Water Reclamation Program to evaluate ways to remediate the basin. Regional planning efforts involve evaluating the feasibility of remediating the high TDS plume with a Stakeholder Group, which consists of WRD and seven agencies that pump and wholesale potable water within the basin. These stakeholders include the following:

1. City of Manhattan Beach
2. City of Lomita
3. City of Torrance
4. California Water Service (Cal Water)
5. Los Angeles Department of Water and Power (LADWP)
6. Golden State Water Company (GSW)
7. West Basin Municipal Water District (WBMWD)
8. WRD

The Program team is conducting a feasibility study, led by Jacobs, to evaluate potential siting and technologies for brackish water reclamation facilities within the plume, aiming toward maximum remediation benefit and the most efficient cost of water. Jacobs screened 29 potential Projects to develop a shortlist of 11 Projects, summarized in Table 1, that will undergo further consideration. The purpose of this technical memorandum is to communicate water quality goals that have been developed for the shortlisted Projects.

Table 1. Summary of Shortlisted Projects

Potential Project - General Description	Project No.	Water Delivered to Each Stakeholder (AFY)					
		City of Torrance	GSW	City of Manhattan Beach	LADWP	Cal Water	City of Lomita
Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties (20,000 AFY)	14	5,000	-	-	5,000	6,500	1,500
Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties and Madrona Lateral (20,000 AFY)	15	5,000	-	-	5,000	6,500	1,500
Torrance, GSW, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (20,000 AFY)	13	5,000	5,000	-	8,000	-	-
Torrance, GSW, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (12,500 AFY)	25	3,000	3,000	-	5,250	-	-
Torrance (Highest Delivery), GSW, LADWP, Cal Water, Lomita via Interties and Madrona Lateral with 1 Existing Well (12,500 AFY)	26	5,000	900	-	850	3,500	1,000
Torrance (Highest Delivery), GSW, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (5,200 AFY)	28	2,100	500	-	500	1,000	500
Spread Across Stakeholders via Interties with New Pipeline to Manhattan Beach (12,500 AFY)	18	4,100	900	1,000	2,750	1,500	1,000
Spread Across Stakeholders via Interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (12,500 AFY)	19	4,100	900	1,000	2,750	1,500	1,000
All Wellhead No New Distribution Piping (10,500 AFY)	27	5,000	900	1,000	1,000	800	750
All Wellhead (5,200 AFY)	29	4,600	-	-	-	-	-
JWPCP (12,500 AFY)	24	5,000	-	-	5,250	-	1,000

Notes:

- = not applicable

AFY = acre-feet per year

JWPCP = Joint Water Pollution Control Plant

1.1 Approach

Trussell Technologies has developed finished water quality goals for the 11 shortlisted Projects based on the existing potable water quality in the distribution system. The 11 shortlisted Projects listed in Table 1 propose various methods to distribute the remediated brackish groundwater across the West Coast Basin. Each Project plans to feed demineralized water to up to six stakeholders listed in Table 2, each with its own specific set of water quality characteristics. Additionally, each stakeholder receives potable water from different sources, such as local groundwater and/or water purchased from the Metropolitan Water District of Southern California (MWD). These blends are unique to each stakeholder and vary seasonally. The most recent known blend of waters of each stakeholder is shown in Table 2. Based on the known blend ratios of Manhattan Beach and LADWP, it was assumed that purchased MWD surface water was also the dominant source of drinking water for the City of Lomita, Cal Water, and GSW. LADWP's largest potable water source is the Los Angeles Aqueduct Filtration Plant (LAAFP), shown in bold along with the other dominant source waters in Table 2.

Table 2. Blend Ratios of Each Stakeholder

Stakeholder		Potable Water Source	Blend Ratio
1	City of Manhattan Beach	Local Groundwater	10%
		Purchased MWD Surface Water	90%
2	City of Lomita	Local Groundwater	-
		Purchased MWD Surface Water	-
3	City of Torrance	Local Groundwater	20%
		Purchased MWD Surface Water	80%
4	Cal Water	Local Groundwater	-
		Purchased MWD Surface Water	-
5	LADWP	Los Angeles Aqueduct Filtration Plant	73%
		Local Groundwater	3%
		Purchased MWD Surface Water	22%
6	GSW	Local Groundwater	-
		Purchased MWD Surface Water	-

Water quality goals were established based on the needs of each individual system and were considered independent of each other. The product water quality goals were developed based on the amount of data available in the water quality reports, typically an average and a range. The goals may be refined should additional data become available.

Initially, separate product water quality goals were established for the six receiving stakeholders, such that each shortlisted Project would aim to treat the new groundwater to match the existing water quality of each of the stakeholders that it serves. As the development of the product water quality goals progressed, it was determined that it would be more cost effective and still protective of the distribution systems to establish one common set of water quality targets for all six stakeholders receiving water from the Project. The remaining goal is to produce water quality that is as similar as possible to the water that currently exists in the distribution system. This will allow for the most compatibility and would minimize the risk for issues such as corrosion, breakpoint chlorination, and disinfection byproduct (DBP) formation.

The following water quality parameters were considered pertinent to ensure compatibility with the receiving stakeholder potable water: disinfectant type/dose, corrosion control mode (e.g., calcium carbonate control vs. phosphate inhibitor control), Langelier Saturation Index (LSI), fluoride dosage, and TDS.

2. Product Water Quality Goals

The annual water quality reports of each stakeholder that were available from 2013 to 2017 were used to establish existing potable water characteristics in the distribution system based on 5 years of data. A list of the reports that were obtained for data collection can be found in Appendix A. Annual water quality reports outline measured water quality parameters present within the distribution system or from the source waters. The six stakeholders receiving water reported disinfectant residual present within the distribution system itself, while the rest of the water quality parameters of interest were measured from the potable water sources (e.g., groundwater or purchased MWD water).

2.1 Disinfectant Residual

Annual average chlorine residuals were identified for each stakeholder and can be found in Appendix A. Chloramines are used as a disinfectant within the distribution systems of all six stakeholders, the range of which is shown in Table 3.

Table 3. Existing Water Quality Goals for Disinfectant Residual

	Stakeholder	Disinfectant	Existing Residual (mg/L)
1	Manhattan Beach	Chloramines	0.5 to 1.3
2	City of Lomita	Chloramines	1.8 to 2.5
3	City of Torrance	Chloramines	1.4 to 1.6
4	Cal Water	Chloramines	1.6 to 1.8
5	LADWP	Chloramines	1.6 to 2.0
6	GSW	Chloramines	1.7 to 1.9

It is recommended that chloramines also be used as the disinfectant for treated water produced by the shortlisted Projects because the introduction of free chlorine could pose the potential for breakpoint chlorination when the treated and potable waters are blended. Furthermore, adding treated groundwater with a free chlorine residual to a distribution system that is dominated by chloraminated surface water with a higher total organic carbon concentration could increase the formation of DBPs, such as trihalomethanes or haloacetic acids. Maintaining a chloramine residual in the treated groundwater instead of a free chlorine residual would negate this risk. It is recommended that the selected Projects target a chloramine residual of 2.5 mg/L for all stakeholders, matching the highest observed chloramine residual among the six stakeholders listed in Table 3.

2.2 Corrosion Control with Langelier Saturation Index

The corrosion control method is the approach that a stakeholder uses to prevent corrosion of the distribution pipelines and consumer plumbing. Types of corrosion control being applied in the areas to be served include phosphate control, where phosphate acts as a corrosion inhibitor, and LSI control, or control of calcium carbonate ($CaCO_3$) saturation. LADWP's 2017 Drinking Water Quality Report suggests that corrosion control via zinc orthophosphate dosing will be expanded to their entire service area by 2020 (LADWP, 2017). The remaining five stakeholders to receive water (City of Manhattan Beach, City of Lomita, City of Torrance, Cal Water, and GSW) solely rely on LSI control. Because 10 of the 11 shortlisted Projects feed the LADWP system and at least one other stakeholder's system, a decision on LSI or orthophosphate corrosion control must be made.

Based on traditional practice for the use of phosphate, a high pH resulting from corrosion control with LSI may reduce the effectiveness of orthophosphate, which is traditionally thought to perform optimally at a pH of less than 8. There is also the question of whether stakeholders other than LADWP will be comfortable with orthophosphate entering their distribution systems. Because the goal is to have one water quality going to all stakeholders receiving water from that Project, it is recommended that the Project use an LSI goal as the corrosion control method. This approach complies with the goal of matching the water quality of the demineralized water to that of the majority of water that exists in the distribution system, to the extent possible.

Purchased MWD surface water is used as a potable water source for the six stakeholders. Each year, MWD's water treatment plants (WTPs) report their annual average LSI values in MWD's annual water quality report. Weymouth WTP, Diemer WTP, and Jensen WTP provide water to the Los Angeles area. The LSI values reported by these three plants from 2013 to 2017 were used to develop an LSI range for all of the stakeholder-purchased MWD surface water. If the LSI was not reported, it was calculated based on calcium, alkalinity, pH, TDS, and temperature data from each stakeholder's available water quality reports (see Appendix A). The LSI was calculated for each stakeholder's local groundwater as well as water delivered from LAAFP. The existing LSI range for each stakeholder's potable water sources are shown in Table 4.

Table 4. LSI Ranges Present in Source Water

	Stakeholder	Potable Water Source	Existing LSI Range
1	City of Manhattan Beach	Local Groundwater	0.04 to 0.41
		Purchased MWD Surface Water	0.20 to 0.62
2	City of Lomita	Local Groundwater	-0.21 to 0.74
		Purchased MWD Surface Water	0.20 to 0.62
3	City of Torrance	Local Groundwater	-0.07 to 0.23
		Purchased MWD Surface Water	0.20 to 0.62
4	Cal Water	Local Groundwater	-0.25
		Purchased MWD Surface Water	0.20 to 0.62
5	LADWP	Los Angeles Aqueduct Filtration Plant	-1.05 to (-0.77)[a]
		Local Groundwater	-0.47 to (-0.16)
		Purchased MWD Surface Water	0.20 to 0.62
6	GSW	Local Groundwater	0.03 to 0.23
		Purchased MWD Surface Water	0.20 to 0.62

[a] LADWP has a lower LSI range because they currently use phosphate control as an alternative to LSI control.

The LSI ranges of the various source waters of the stakeholders do not always overlap. To address this issue, the approach for developing the LSI goals was to target the LSI range of the dominant source water in the distribution system of each stakeholder. However, the stakeholders' two major potable water providers, MWD and LAAFP, have conflicting LSI ranges (0.2 to 0.62 and -1.05 to -0.77, respectively). LAAFP waters have a negative LSI because orthophosphate is used as the corrosion control method, while MWD maintains a positive LSI to prevent corrosion. Table 1 shows that, although LADWP is a recipient of water in 10 of the 11 Projects, LADWP would not be the majority recipient of the demineralized product water for any of these Projects. Considering the decision to have one product water quality goal for all stakeholders and the fact that LADWP incorporates MWD water with a higher LSI into its distribution system, the LSI target of the shortlisted Projects has been set to match MWD's LSI range of 0.2 to 0.62.

Adjustment of calcium carbonate solubility via the LSI is the most widely used corrosion control practice, and it has been shown to be successful in demonstration-scale testing with desalted waters conducted in Tampa, Carlsbad, Monterey, Long Beach, and West Basin. According to Wilczak (2010), the concept that $CaCO_3$ can act as a corrosion inhibitor comes from the observation that certain hard groundwaters that have a chemistry suitable for forming a $CaCO_3$ film (scaling water) do not result in red water, while others that cannot form a film are more often associated with red water problems. Corrosion was originally thought to be less pronounced in scaling waters because of the protective $CaCO_3$ layer. However, no studies at the time examined the degree to which $CaCO_3$ formed on the water pipe or the degree to which such films, once formed, would protect the pipe from corrosion. Historically, LSI was adopted as an important corrosion control parameter because the idea of a protective $CaCO_3$ scale was widely accepted, it was developed using fundamental chemistry, it was easily implemented, and it was closely tied to pH, which is now understood to be a master index governing the solubility of most metal scales (Wilczak, 2010).

Studies conducted since that time show little evidence of the role of a protective calcium carbonate scale, and the method is not supported in the most recent U.S. Environmental Protection Agency (EPA) Guidance on corrosion control. As a result, success with the LSI method is apparently not so much a result of the degree of calcium carbonate saturation itself as it is to achievement conditions common to such waters (significant alkalinity, significant calcium hardness, and alkaline pH). To achieve these similar conditions, the following targets are recommended to achieve a positive LSI:

- Alkalinity = 70 mg/L as $CaCO_3$
- pH = 8 to 8.5
- Ca-hardness = 40 mg/L as $CaCO_3$

Achieving the conditions listed above is difficult to do in a desalted water without using lime. LSI can also be increased by raising the pH via sodium hydroxide addition. While dosing sodium hydroxide may increase $CaCO_3$ saturation, this strategy is not recommended because it relies on a much higher pH in the finished water and will not reach the recommended alkalinity and hardness. A combination of sodium hydroxide, carbon dioxide, and calcium chloride will enable the alkalinity, pH, and calcium hardness targets to be achieved. Lime and carbon dioxide can also be used, but lime presents the possibility of turbidity problems in the finished water. While water quality and treatment projections suggest calcium addition might not be required to achieve the calcium hardness target, it is recommended that the capability of adding calcium be included in case the actual water quality differs from expectations and to provide the flexibility of increasing the calcium target, if necessary.

2.3 Fluoride

MWD and LAAFP add fluoride to their water to promote oral health, and Torrance adds fluoride to both its groundwater and supplies produced from the Goldsworthy Desalter. In addition, each stakeholder’s treated groundwater also contains fluoride, either through chemical addition in the treatment process or natural deposits from the soil. The existing fluoride range for each stakeholder’s potable water sources are shown in Table 5.

Table 5. LSI Ranges Present in Source Water

Stakeholder		Potable Water Source	Existing Fluoride Range (mg/L)
1	City of Manhattan Beach	Local Groundwater	0.20 to 0.35
		Purchased MWD Surface Water	0.7 to 0.9
2	City of Lomita	Local Groundwater	0.34 to 0.39
		Purchased MWD Surface Water	0.7 to 0.9
3	City of Torrance	Local Groundwater	0.19 to 0.27
		Purchased MWD Surface Water	0.7 to 0.9
4	Cal Water	Local Groundwater	0.29 to 0.60
		Purchased MWD Surface Water	0.7 to 0.9
5	LADWP	LAAFP	0.6 to 0.8
		Local Groundwater	0.5 to 0.8
		Purchased MWD Surface Water	0.7 to 0.9
6	GSW	Local Groundwater	0.69 to 0.78
		Purchased MWD Surface Water	0.7 to 0.9

Similar to the existing LSI ranges, the existing fluoride ranges for the various source waters are not compatible for every stakeholder. Therefore, it is recommended that the fluoride range of the source which supplies a majority of each stakeholder's potable water be targeted. It is recommended that the Projects target a fluoride range of 0.7 to 0.8 mg/L to fall within the range of both major water suppliers (MWD and LAAFP).

2.4 Total Dissolved Solids

It is recommended that the Projects target a TDS goal below 500 mg/L because this is the secondary maximum contaminant level set by the EPA.

2.5 Finalized Product Water Quality Goals

Table 6 provides an outline of all product water quality goals, including chloramine residual, LSI target range, fluoride dose, and TDS.

Table 6. Recommended Product Water Quality Goals Leaving the Project Treatment Plant

Chloramine Residual (mg/L as Cl_2)	LSI Range	pH Range	Alkalinity (mg/L as $CaCO_3$)	Calcium Hardness (mg/L as $CaCO_3$)	Fluoride Dose (mg/L)	TDS (mg/L)
2.5	0.2 to 0.62	8 to 8.5	70	40	0.7 to 0.8	< 500

3. Conclusion

Product water quality goals, including disinfectant residual, LSI, pH, alkalinity, hardness, fluoride dose, and TDS, are outlined in Table 6. It is recommended that all of the shortlisted Projects target these water quality goals, which are based on the water quality characteristics of the existing dominant water supply within the distribution system.

It is recommended that the Projects maintain a disinfectant residual of chloramines to match the practices of the six stakeholders that might receive water. A target residual of 2.5 mg/L is recommended. LSI goals can be met via pH, alkalinity, and hardness adjustment with a goal of achieving an LSI between 0.2 and 0.62. Other recommendations include adding fluoride for oral health at a dose of 0.7 to 0.8 mg/L and targeting a TDS below 500 mg/L. Lastly, pH control should be monitored downstream of all chemical addition, especially fluorosilicic acid, to ensure that the pH of the water entering the distribution system is within the desired range.

A list of annual water quality reports used for this analysis, along with annual data on chloramine residual, calcium, alkalinity, pH, TDS, temperature, LSI, and fluoride can be found in Appendix A.

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Appendix A
Existing Water Quality Data

Table A1. Water Quality Reports Used for Analysis

Stakeholder	Annual Water Quality Reports Available for Analysis
City of Manhattan Beach	2013, 2014, 2015, 2016, 2017
City of Lomita	2013, 2014, 2015, 2016, 2017
City of Torrance	2013, 2014, 2015, 2016, 2017
Cal Water	2014, 2015, 2016, 2017
LADWP	2013, 2015, 2016, 2017
GSW	2015, 2017

Notes:

Cal Water = California Water Service

GSW = Golden State Water

LADWP = Los Angeles Department of Water and Power

Table A2. Existing Disinfection Residual Data for the Six Stakeholders

Stakeholder	Year	Disinfectant	Total Chloramine Residual (mg/L)
City of Manhattan Beach	2013	Chloramines	1.20
	2014	Chloramines	1.20
	2015	Chloramines	1.20
	2016	Chloramines	0.50
	2017	Chloramines	1.30
	Average:	Chloramines	1.08
City of Lomita	2013	Chloramines	2.13
	2014	Chloramines	2.00
	2015	Chloramines	1.92
	2016	Chloramines	1.82
	2017	Chloramines	2.46
	Average:	Chloramines	2.07
City of Torrance	2013	Chloramines	1.50
	2014	Chloramines	1.60
	2015	Chloramines	1.40
	2016	Chloramines	1.50
	2017	Chloramines	1.40
	Average:	Chloramines	1.48
Cal Water (East LA District)	2013		
	2014	Chloramines	1.80
	2015	Chloramines	1.60
	2016		
	2017	Chloramines	1.72
	Average:	Chloramines	1.71
LADWP	2013	Chloramines	1.60
	2014		
	2015		
	2016		
	2017	Chloramines	2.00
	Average:	Chloramines	1.80
GSW	2013		
	2014		
	2015	Chloramines	1.70
	2016		
	2017	Chloramines	1.90
	Average:	Chloramines	1.80

Notes:

LA = Los Angeles

mg/L = milligram(s) per liter

Table A3. Existing LSI Water Quality Data for the Six Stakeholders' Source Waters

Plant	Year	Water Quality Parameter (Annual Averages)					
		Ca (mg/L)	Alk (mg/L)	pH	TDS (mg/L)	Temp (°C)	LSI
Weymouth Treatment Plant	2012-2013	54	103	8.08	497	19	0.35
	2013-2014	67	118	8.08	565	20	0.5
	2014-2015	75	128	8.06	628	21	0.56
	2015-2016	76	121	8.08	648	20	0.53
	2016-2017	49	86	8.29	452	20	0.36
	Average:	64	111	8.12	558	20	0.46
Diemer Treatment Plant	2012-2013	54	104	8.10	496	20	0.39
	2013-2014	68	117	8.10	568	22	0.55
	2014-2015	76	126	8.09	632	24	0.62
	2015-2016	74	122	8.10	648	21	0.59
	2016-2017	51	89	8.27	468	22	0.41
	Average:	65	112	8.13	562	22	0.51
Jensen Treatment Plant	2012-2013	23	82	8.31	270	19	0.2
	2013-2014	26	86	8.26	308	20	0.21
	2014-2015	34	90	8.16	378	20	0.22
	2015-2016	35	94	8.30	415	20	0.39
	2016-2017	29	89	8.29	374	19	0.28
	Average:	29	88	8.26	349	20	0.26
City of Manhattan Beach Local Groundwater	2013	105	215	7.6	745	20[a]	0.04
	2014	105	215	7.6	745	20[a]	0.04
	2015	111	200	8.00	890	20[a]	0.41
	2016	111	200	8.00	890	20[a]	0.41
	2017	111	200	8.00	890	20[a]	0.41
	Average:	111	200	8.00	890	20[a]	0.26
City of Lomita Local Groundwater	2013	90	303	7.27	770	20[a]	-0.21
	2014	79	303	7.74	685	20[a]	0.21
	2015	78	303	7.80	690	20[a]	0.27
	2016	86	390	8.00	682	20[a]	0.62
	2017	86	390	8.10	583	20[a]	0.74
	Average:	84	338	7.78	682	20[a]	0.33
City of Torrance Local Groundwater	2013	112	155	7.80	602	20[a]	0.15
	2014	99	161	7.80	467	20[a]	0.14
	2015	109	156	7.60	660	20[a]	-0.07
	2016	102	193	7.80	491	20[a]	0.23
	2017				557		
	Average:	105	166	7.75	555	20[a]	0.11

Table A3. Existing LSI Water Quality Data for the Six Stakeholders' Source Waters

Plant	Year	Water Quality Parameter (Annual Averages)					
		Ca (mg/L)	Alk (mg/L)	pH	TDS (mg/L)	Temp (°C)	LSI
Cal Water Local Groundwater (East LA District)	2013						
	2014	84		7.60	524		
	2015	83		7.40	524		
	2016	67		7.40	495		
	2017	69	190	7.50	482	20[a]	-0.25
	Average:	76	190	7.48	506	20[a]	-0.23
LADWP Local Groundwater	2013	122	52	7.60	399	18	-0.47
	2014						
	2015	77	162	7.60	489	20	-0.17
	2016	78	166	7.60	520	20	-0.16
	2017	27	105	7.90	216	19	-0.46
	Average:	76	121	7.68	406	19	-0.21
GSW Local Groundwater	2013						
	2014						
	2015	53	180	8.10	410	20[a]	0.23
	2016						
	2017	49	146	8.00	351	21	0.03
	Average:	51	163	8.05	381	20	0.13
Los Angeles Aqueduct	2013	24	87	7.50	276	16	-1.05
	2014						
	2015	36	93	7.50	350	18	-0.84
	2016	31	100	7.60	335	18	-0.77
	2017	24	105	7.60	208	18	-0.82
	Average:	29	96	7.55	292	18	-0.86

[a]A temperature of 20°C was assumed for scenarios in which temperature was the only missing parameter for LSI calculation.

Notes:

Alk = alkalinity

°C = degree(s) Celsius

Ca = calcium

LSI = Langelier Saturation Index

TDS = total dissolved solids

Table A4. Existing Fluoride Data for the Six Stakeholders' Source Waters

Plant	Fiscal Year	Fluoride (mg/L)		Plant	Fiscal Year	Fluoride (mg/L)
Weymouth Treatment Plant	2012-2013	0.90		Torrance	2013	0.27
	2013-2014	0.80			2014	0.19
	2014-2015	0.90			2015	0.20
	2015-2016	0.80			2016	0.24
	2016-2017	0.70			2017	0.27
	Average:	0.82			Average:	0.23
Diemer Treatment Plant	2012-2013	0.90		Cal Water (East LA District)	2013	0.60
	2013-2014	0.90			2014	0.60
	2014-2015	0.90			2015	0.50
	2015-2016	0.80			2016	0.30
	2016-2017	0.80			2017	0.29
	Average:	0.86			Average:	0.46
Jensen Treatment Plant	2012-2013	0.80		LADWP	2013	0.50
	2013-2014	0.80			2014	
	2014-2015	0.80			2015	0.80
	2015-2016	0.70			2016	0.70
	2016-2017	0.70			2017	0.80
	Average:	0.76			Average:	0.70
Manhattan Beach	2013	0.30		GSW	2013	
	2014	0.35			2014	
	2015	0.24			2015	0.78
	2016	0.20			2016	
	2017	0.24			2017	0.69
	Average:	0.27			Average:	0.74
Lomita	2013	0.34		LADWP – Los Angeles Aqueduct	2013	0.60
	2014	0.34			2014	
	2015	0.34			2015	0.80
	2016	0.39			2016	0.80
	2017	0.39			2017	0.80
	Average:	0.36			Average:	0.75

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Technical Memorandum

Subject	**Product Water Conveyance System Analysis**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019
Prepared by	Jon Ganz, P.E. (Brown and Caldwell)
Reviewed by	Mark Briggs, P.E. (Brown and Caldwell) Andrew Fugal, P.E. (Brown and Caldwell)
Reference	152586.001

1. Introduction/Purpose

1.1 Introduction

This Technical Memorandum (TM) presents the findings of a distribution system analysis performed for shortlisted potential Projects that would deliver treated potable water from a new brackish water reclamation facility to potential stakeholders. The analysis includes the following scope elements:

- Pipeline alignment routing
- Hydraulic sizing of new distribution system piping
- Preliminary pipeline material and class selection
- High-level pipeline corrosion analysis
- Proposed connection points
- Blending requirements (to meet local retailers' product water quality requirements)
- Storage requirements
- Right-of-way (ROW) and easement acquisition
- Permitting and approvals
- State Water Resources Control Board Division of Drinking Water (DDW) requirements
- Distribution system power requirements
- Implementation schedule and cost estimate for proposed alternative

1.2 Background

The Water Replenishment District of Southern California (WRD) is responsible for managing and replenishing both the West Coast and Central groundwater basins. In the West Coast Basin, a significant saline plume of groundwater with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, Lynwood, and Lower San Pedro (LSP, equivalent to Sunnyside) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To fully utilize the West Coast Basin, WRD has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. Program goals include treating the plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process. The Program will study the following components: where to extract the plume water, where and how to treat the plume water, how to convey the treated potable water to the Program Stakeholders, and how to manage the brine waste stream. The Program includes the analysis of numerous different "Projects," consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of the above components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed in dollars per acre foot (AF) of treated water.

As a part of the Program, WRD has initiated a regional planning study to evaluate the feasibility of remediating the saline plume with seven additional Stakeholders (known as the Stakeholder Group). The Stakeholders have expressed interest in either treating the saline plume, receiving the treated water, or both, as part of the Program. The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance (Torrance)
- City of Manhattan Beach (MB)
- City of Lomita (Lomita)
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

2. Previous Assumptions

2.1 Potential Projects

Following several Stakeholder Group meetings, six potential Projects were shortlisted for further consideration. All potential Projects site a new brackish water reclamation facility on property owned by the City of Torrance at Elm Avenue and Sierra Street and would distribute treated potable water across the various Stakeholders. These Projects and water delivery allocations are summarized in Table 2-1.

Table 2-1. Potential Projects

No.	Potential Projects and Total Feed Water Capacity	Water Delivery (AFY)						Total Product Water Delivery (AFY)
		Torrance	GSWC	MB	LADWP	Cal Water	Lomita	
1	New Pipeline to MB (12,500 AFY)	3,872	850	944	2,597	1,417	944	10,625
2	New Pipeline to MB and Portable Wellhead Treatment (12,500 AFY)	3,872	850	944	2,597	1,417	944	10,625
3	New Pipeline to MB (16,000 AFY)	3,900	900	1,700	2,900	2,900	1,300	13,600
4	New Pipeline to MB and Portable Wellhead Treatment (16,000 AFY)	3,900	900	1,700	2,900	2,900	1,300	13,600
5	New Pipeline to MB (20,000 AFY)	4,500	900	1,700	4,200	4,200	1,500	17,000
6	New Pipeline to MB and Portable Wellhead Treatment (20,000 AFY)	4,500	900	1,700	4,200	4,200	1,500	17,000

Note:
AFY = acre-feet per year

All shortlisted projects in Table 2-1 share the following two common distribution system elements:

1. An inter-tie between the proposed brackish water reclamation plant and the City of Torrance distribution system at the intersection of Elm Avenue and Sierra Street, with point of connection (POC) at a blind flange on the City's existing 18-inch-diameter cast iron pipe water line – All flows, ***excluding*** those to MB, would be conveyed to the other Stakeholders through the existing City of Torrance distribution system.[1]
2. A new pipeline with POC/termination at Manhattan Beach Boulevard and North Redondo Avenue in the City of Manhattan Beach – As indicated in Table 2-1, the flows to be conveyed by this new pipeline would be either 944 or 1,700 AFY, depending on which of the six potential projects is selected.

2.2 Product Water Quality (PWQ) Specifications

As part of this Program, finished PWQ specifications were developed. Initially, PWQ specifications were established based on the needs of each individual Stakeholder system and were considered independent from one another. However, as development of the PWQ specifications progressed, it was determined that a more cost-effective approach would be to establish one common set of PWQ specifications that would be protective of all Stakeholders. The development of these PWQ specifications is summarized in a separate TM, *Identification of Product Water Quality Specifications*, prepared by Trussell Technologies, Inc. in coordination with Jacobs.

The pertinent PWQ parameters established in this TM are summarized in Table 2-2.

Table 2-2. Recommended PWQ Specifications for Proposed Brackish Water Reclamation Plant

Chloramine Residual (mg/L as Cl2)	LSI Range	pH Range	Alkalinity (mg/L as $CaCO_3$)	Calcium Hardness (mg/L as $CaCO_3$)	Fluoride Dose (mg/L)	TDS (mg/L)
2.5	0.2 – 0.62	8.0 – 8.5	70	40	0.7 – 0.8	<500

Notes:
CaCO3 = calcium carbonate
Cl2 = chlorine
LSI = Langelier Saturation Index
mg/L = milligrams per liter

3. Alternatives Analysis

3.1 Alignment Selection

As identified in Section 2.1, all shortlisted projects share two common distribution system elements. The first is an inter-tie between the proposed brackish water reclamation plant and the City of Torrance distribution system, which would be made to the City's existing 18-inch-diameter water line located immediately adjacent to the site of the proposed plant. The second is a new pipeline with POC/termination at Manhattan Beach Boulevard and North Redondo Avenue in the City of Manhattan Beach.

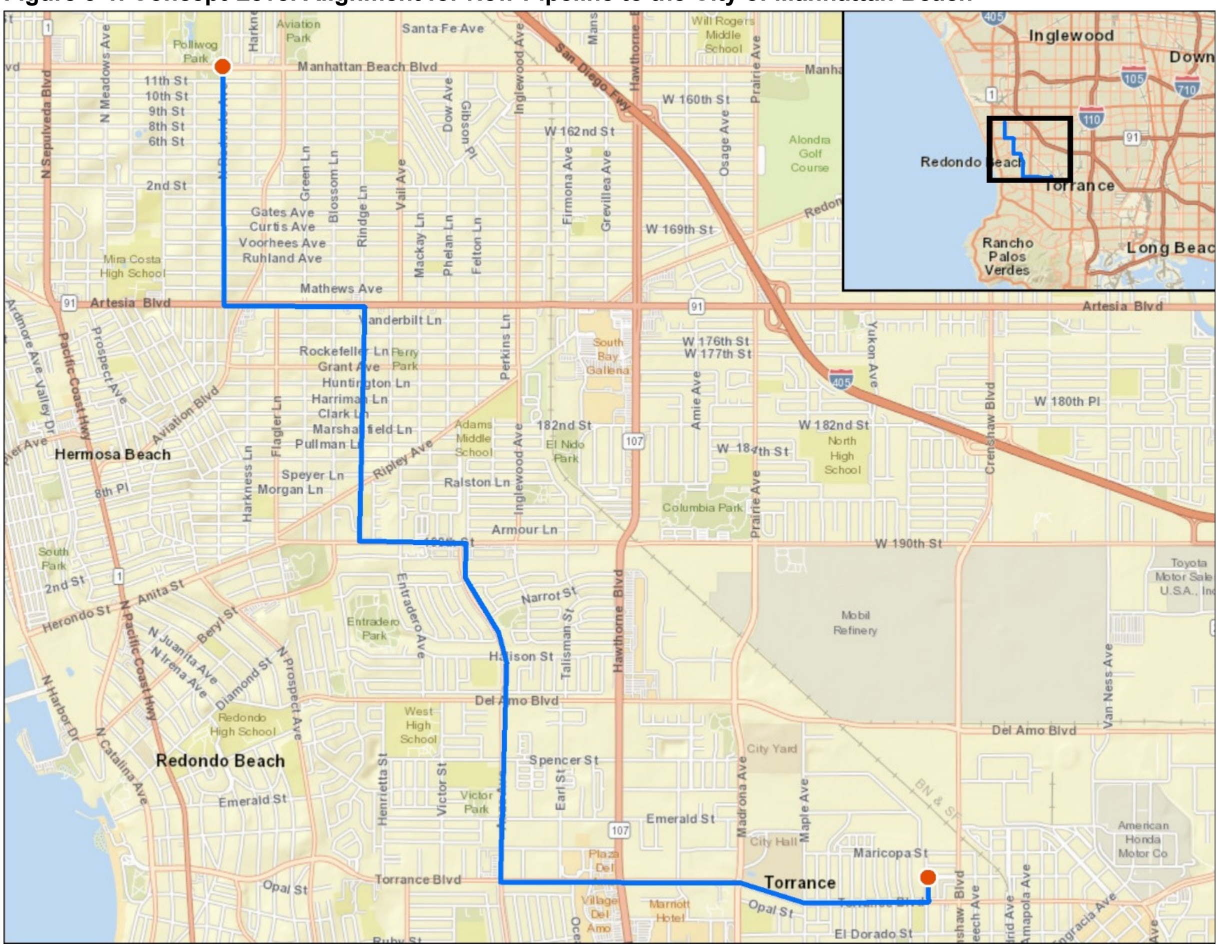
[1] The identification and sizing of POCs between the City of Torrance's system and the other Stakeholders' systems is not addressed in this TM. In addition, it is assumed that the City of Torrance has verified, or will verify, that there is sufficient capacity in its distribution system to convey the additional flows identified in Table 2-1

For the purpose of this study, a concept-level alignment for the new pipeline was identified between the proposed brackish water reclamation plant and the MB POC/termination point. This alignment would serve for either flow scenario – 944 AFY or 1,700 AFY. In determining this alignment, the following criteria were followed:

- Alignment to be within existing public ROW, where feasible, to minimize or avoid the need to acquire temporary construction or permanent easements
- Avoid crossing freeways and railroads, where feasible

Based on the above criteria, a possible alignment was identified. This concept-level alignment extends from the proposed brackish water reclamation facility south along Elm Avenue to Torrance Boulevard, then west to Anza Avenue, then north to West 190th Street, then west to Rindge Lane, then north to Artesia Boulevard, then west to South Redondo Avenue, then north to Manhattan Beach Boulevard until the intersection with North Redondo Avenue, where connection to the City of Manhattan Beach distribution system would be required. As shown on Figure 3-1, the proposed alignment is approximately 6.5 miles in length and extends wholly within public ROW within the Cities of Torrance and Manhattan Beach.

Figure 3-1. Concept-Level Alignment for New Pipeline to the City of Manhattan Beach



This alignment was driven in its entirety and is considered feasible. As the project evolves to the preliminary engineering phase, refinements to the alignment should be considered to avoid or minimize potential constructability issues (e.g., traffic conditions, heavily congested utility substructure, overhead electrical lines, excavation moratoriums, etc.) identified during a more detailed investigation. Regardless, the overall length of the proposed pipeline should not vary significantly as a result of these refinements.

3.2 Sizing

A hydraulic model was developed to determine the optimal size of the new pipeline under the two flow conditions identified for the potential projects – 944 AFY and 1,700 AFY. Key hydraulic parameters and boundary conditions assumed in developing the model include:

- Design flow rates are constant and follow same alignment described in Section 3.1
  - Q_1 = 944 AFY (585 gallons per minute [gpm])
  - Q_2 = 1,700 AFY (1,054 gpm)
- Discharge pressure required at connection with MB distribution system is 90 pounds per square inch (psi)
- Pipe roughness coefficient, C factor, is 130
- Velocity
  - Minimum: 2 feet per second (fps)
  - Maximum: 6 fps
- Ground elevations from the U.S. Geological Survey (USGS) 1-meter National Elevation Dataset for concept-level alignment used
- The ground elevations were assumed for the pipeline

Detailed model results for both flow scenarios across various pipe sizes are summarized in Table 3-1 and are shown graphically in Figures 3-2, 3-3, and 3-4. The required pressure indicated in Table 3-1 for a given scenario is the pressure at the brackish water reclamation plant, to be provided by a separate water pump station, required to deliver the target 90 psi at the MB POC.

Table 3-1. Hydraulic Model Results

Scenarios	Flow (AFY)	Flow (gpm)	Target Pressure at MB (psi)	8-inch		10-inch		12-inch	
				Required Pressure (psi)	Velocity (fps)	Required Pressure (psi)	Velocity (fps)	Required Pressure (psi)	Velocity (fps)
Scenario 1	944	585	90	184	3.7	119	2.4	100	1.7
Scenario 2	1,700	1,054	90	378	6.7	185	4.3	126	3.0

Cells shaded in gray lie outside of the defined velocity range

Figure 3-2. Hydraulic Grade Lines for 8-Inch Diameter Pipe

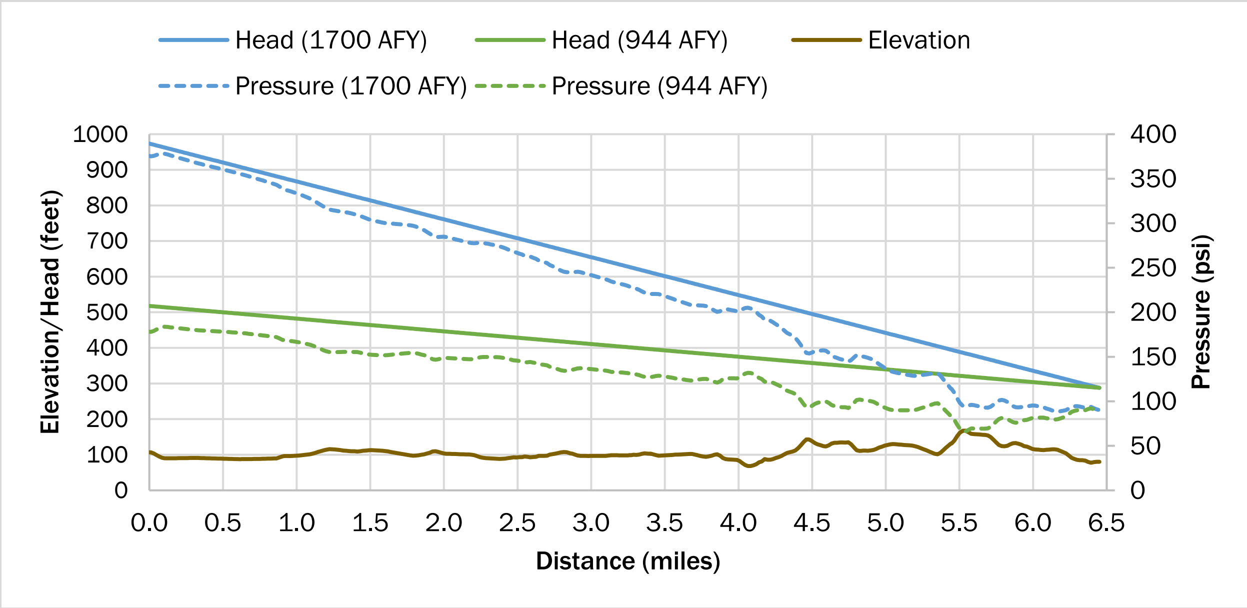


Figure 3-3. Hydraulic Grade Lines for 10-Inch Diameter Pipe

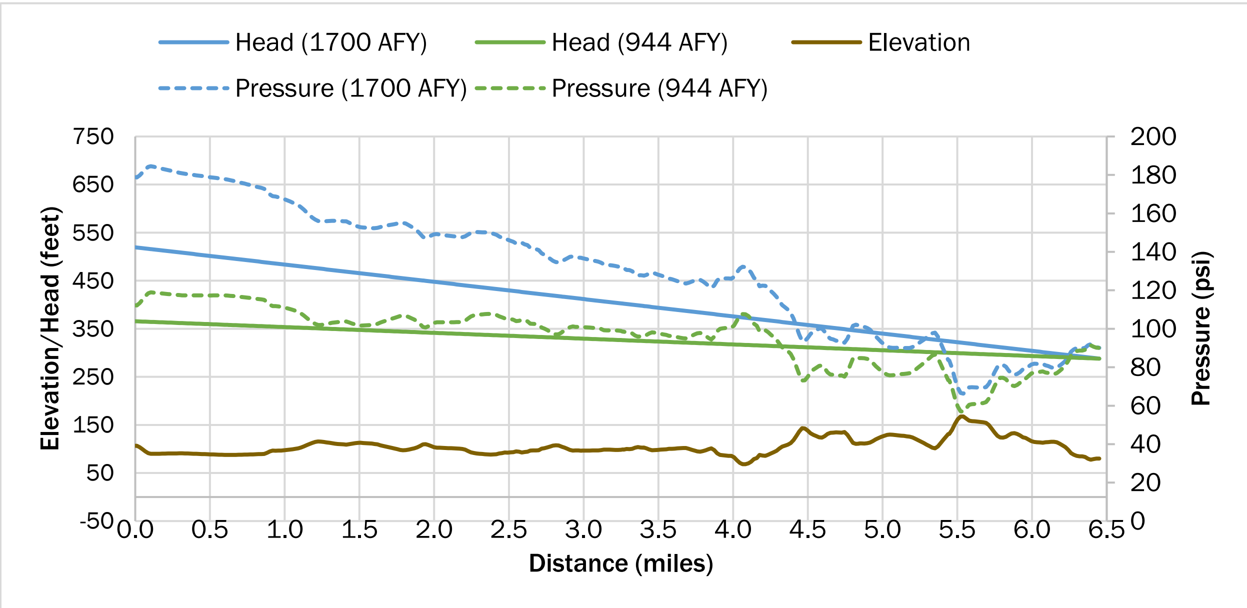
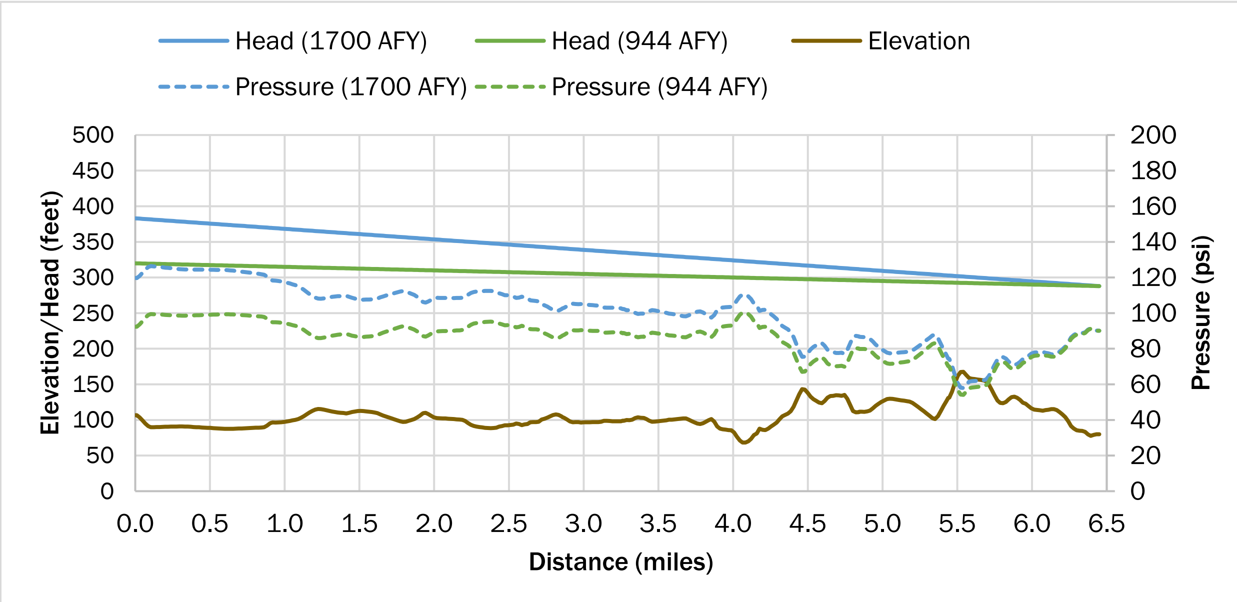


Figure 3-4. Hydraulic Grade Lines for 12-Inch Diameter Pipe



To minimize pumping costs at the new water pump station, the optimal pipe sizes for the new pipeline are as follows:

- Scenario 1 (944 AFY): 10-inch diameter
- Scenario 2 (1,700 AFY):12-inch diameter

3.3 Pipe Material and Corrosion Analysis

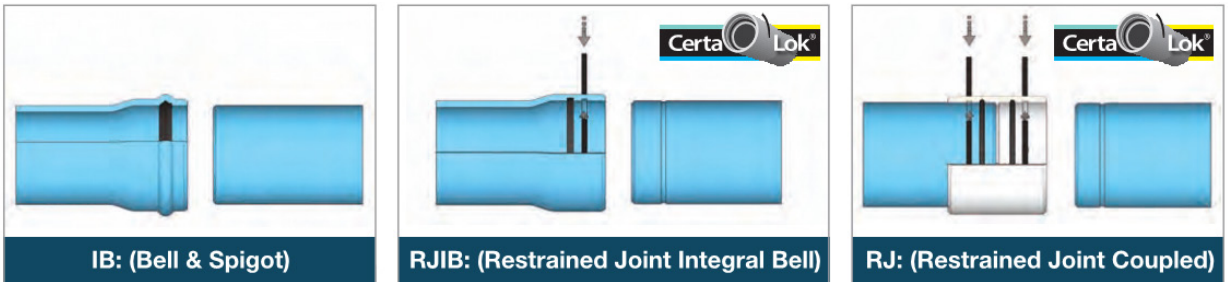
Pipe materials considered for the new pipeline include:

- Polyvinyl Chloride (PVC)
- High-Density Polyethylene Pipe (HDPE)
- Ductile Iron Pipe (DIP)
- Welded Steel Pipe (WSP)

3.3.1 Polyvinyl Chloride (PVC) Pipe

PVC pressure pipe is a flexible pipe available in standard diameters and wall thicknesses and is manufactured and designed per American Water Works Association (AWWA) C900 and AWWA M23. Fittings and bends would be DIP per AWWA C-110. Watertight pressure joints are typically provided by bell-and-spigot-style joints with mechanical thrust restraint or thrust blocks (where required) or butt-fusion joints (Fusible PVC®). PVC pipe is also available with several types of restrained joint systems for trenchless installation and restraint without additional hardware. These systems include internally restrained gasketed joints, pin-and-groove gasketed joints, spline lock gasketed joints, and butt-fused joints. See Figure 3-5 for AWWA C900 PVC pipe joint types.

Figure 3-5. AWWA C900 PVC Pipe



Source: North American Pipe Corporation

PVC pipe does not corrode internally or externally, eliminating the need for corrosion protection. Corrosion protection or resistance is required for restraint devices and appurtenances if further evaluation identifies the need for corrosion mitigation. There are multiple vendors of traditional PVC pipe that serve Southern California.

3.3.2 High-Density Polyethylene Pipe (HDPE)

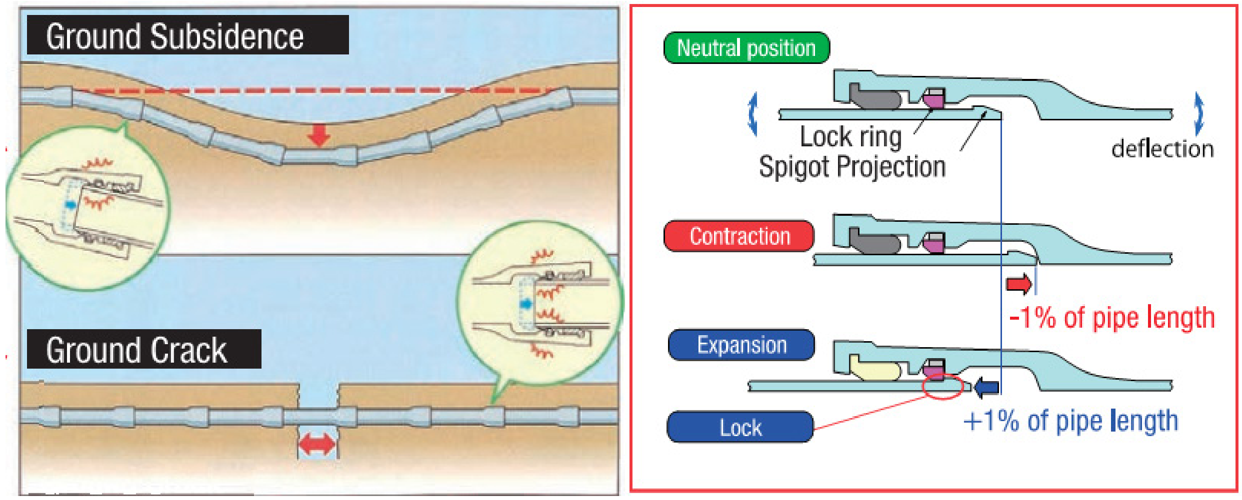
HDPE is a flexible plastic pipe that can resist chemical and corrosion degradation. Standard HDPE, from 4-inch through 65-inch diameter, is manufactured and designed in accordance with AWWA C-906 and AWWA M55, respectively. HDPE can be joined together by a number of methods including thermal heat fusion, electrofusion, and the use of mechanical fittings. The main advantages of HDPE over ferrous piping include its corrosion-resistant nature and its smooth interior, resulting in lower friction head losses. In addition, when fused joints are used, they are considered to be self-restraining, which can minimize or eliminate the need for thrust restraints and thrust blocks.

Though it has a number of advantages, HDPE is potentially susceptible to degradation in the presence of potable water disinfectants. The severity of the degradation varies and is dependent on a number of factors, which should be evaluated during the preliminary engineering phase. For additional information, refer to TN-44, “Long Term Resistance of AWWA C906 Polyethylene (PE) Pipe to Potable Water Disinfectants”, prepared by the Plastics Pipe Institute (https://plasticpipe.org/pdf/tn44.pdf).

3.3.3 Ductile Iron Pipe (DIP)

DIP with an NSF/American National Standards Institute (ANSI) 61 lining and external corrosion protection would be suitable for the new pipeline in areas where shallow cover or resistance to ground movement is required. Standard DIP is manufactured and designed in accordance with AWWA C-151 and AWWA C-150, respectively, and typically has thicker wall sections than PVC or WSP. Joints would be push-on, mechanical joint and restrained designs (e.g., US PIPE and McWane Ductile TR-FLEX) conforming to AWWA C-111 and C-110, respectively, Earthquake-Resistant DIP (ERDIP) joints and fittings are also available. ERDIP joints provide a unique bell-and-spigot joint design that allows each joint to expand or contract up to 1 percent of the standard pipe length and allows up to 5 degrees of deflection in this diameter range. A locking mechanism composed of a locking ring and spigot projection eliminate the possibility of the joint pulling apart during expansion. See Figure 3-6 for an illustration of ERDIP joints and movement during an earthquake. This wide range of movement at the joint allows the pipeline system to move with the ground during an earthquake and reduces the potential for damage. Although the alignment does not cross an active fault zone, liquefaction and lateral spreading may be of concern given the proximity to the coastline and where shallow cover may be desired.

Figure 3-6. ERDIP Movement During an Earthquake



Source: Kubota Corporation

Corrosion protection for DIP is needed and is typically provided by polybags (as recommended by the Ductile Iron Pipe Research Association [DIPRA]); bonding of joints to allow monitoring of electrical continuity; and protective cement mortar, polyurethane, or other manufacturer recommended coatings. Polybags are not recommended in areas of high, salty groundwater.

3.3.4 Welded Steel Pipe (WSP)

WSP is a flexible pipe available in a wide variety of diameters, linings and coatings, yield strengths, and wall thicknesses. WSP is fabricated and designed in accordance with AWWA C-200 and, AWWA M-11, respectively. Watertight pressure joints are typically provided by bell-and-spigot style joints or welded single-lap, double-lap, or butt-welded joints where thrust restraint, axial loading, or seismic restraint is required. The design of steel pipe considers the wall thickness required for welding, handling, internal pressure, external loading, and installation. WSP is typically considered in areas with higher pressure requirements.

In corrosive environments, several protection strategies can be employed for WSP, including bonding of the joints to allow monitoring of electrical continuity, use of mortar lining and coating, dielectric tape wrap, installation of impressed current systems, or sacrificial anode beds.

3.3.5 Preliminary Pipe Material and Class

For the purpose of developing an implementation schedule and budgetary cost, C900 PVC pipe rated for a nominal pressure of 165 psi (DR25), with traditional bell-and-spigot gasketed joints and mechanical restraint devices, will be used. However, as indicated above, there are benefits that could be realized, such as lower cost and installation flexibility, that HDPE offers, should further evaluation deem it appropriate for the intended service.

3.4 Blending Requirements

As indicated in Section 2.2, one common set of PWQ specifications has been established for potable water produced by the proposed brackish water reclamation plant. The goal of this approach is to produce potable water that is protective of all Stakeholder distribution systems, allowing for the highest level of compatibility and minimizing risks for issues such as corrosion, breakpoint chlorination and disinfection byproduct formation.

Based on the Program approach to PWQ specifications, as detailed in the separate TM by Trussell Technologies, Inc. in coordination with Jacobs, additional blending to meet Stakeholders' existing PWQ requirements is not anticipated to be required. If there are changes in this approach or to Stakeholder PWQ requirements, the need for blending prior to discharge to a given Stakeholder's distribution system should be re-evaluated.

3.5 Storage Requirements

Water storage typically serves the following objectives for a distribution system:

- Allows balanced flow through pipelines and serves as a buffer between the source and the treatment plant or distribution system
- Supplies water during peak demand periods
- Maintains pressure in the distribution system
- Minimizes interruptions of supply water due to power outages, repair of pumps, failures of mains, pumps, or other plant or well equipment
- Provides an emergency supply for fire protection

As indicated above, the proposed brackish water reclamation facility is intended to provide a constant supply of treated potable water, at either 944 AFY or 1,700 AFY, when operating. It is intended as a supplementary source and, in all cases, is augmenting the available supply for an existing distribution system. Based on the information available at the time of this TM, it is assumed that the existing distribution systems have sufficient supply for fire protection and will not need to rely on this supplementary source for this purpose.

Based on the above, water storage is not considered necessary. However, if water storage would facilitate or otherwise support anticipated operations at the brackish water reclamation facility, then siting at the proposed brackish water reclamation plant location should be considered.

3.6 ROW and Easement Acquisition

As indicated in Section 3.1, the concept-level alignment is located wholly within public ROW to minimize or avoid the need to acquire temporary construction or permanent easements. As the project evolves to the preliminary engineering phase, the actual pipeline corridor will be selected, and a determination made regarding whether any temporary construction easements are required to accommodate construction along boundaries between public ROW and private property parcels.

3.7 Permitting and Approvals

Several permits and approvals have been identified as necessary for project construction, as well as for geotechnical work and utility potholing. Table 3-2 identifies anticipated permits and approvals, and agencies with jurisdiction.

Table 3-2. Summary of Anticipated Permits and Approvals

Agency	Permit/Approval
Lead Agency (TBD)	California Environmental Quality Act (CEQA) Approval
City of Torrance	Encroachment / Traffic Control
City of Manhattan Beach	Encroachment / Traffic Control
California Department of Transportation • Artesia Boulevard (State Route [SR] 91) • Hawthorne Boulevard (SR 107)	Encroachment / Traffic Control
Division of Drinking Water (DDW), State Water Resources Control Board	Approval for Alternative to Separation Requirements

3.7.1 California Environmental Quality Act (CEQA)

CEQA approval typically includes development of a biological technical report, cultural resources report, noise study, and air quality study. This project can potentially qualify for one of several Categorical Exemptions identified in CEQA for repair and/or replacement of existing utilities (e.g., Sections 15301 and 15302). Regardless, it is recommended to prepare an Initial Study (IS) or Mitigated Negative Declaration (MND). This approach is considered more transparent, more usable by the local and state responsible or trustee agencies, and less subject to litigation.

The prepared IS/MND would be based on the biological and cultural technical reports prepared for this project, as well as other technical analyses for construction noise and air quality. A lead agency must be determined for the CEQA process to move forward.

3.7.2 City of Torrance

Excluding those portions identified in Section 3.7.4, the portion of alignment along Elm Avenue, Torrance Boulevard, Anza Avenue and West 190th Street falls within City of Torrance ROW jurisdiction. Since the boundary between the Cities of Torrance and Manhattan Beach extends along West 190th Street, a determination over jurisdiction will depend on the selection of the final alignment. Any work performed in the ROW requires prior approval with an encroachment permit. Application packages are to be submitted to the City of Torrance's Community Development Department at the following address:

City of Torrance, Community Development Department
Attn: Permit Section
3031 Torrance Boulevard
Torrance, CA 90503
310.618.589

The encroachment application package, at minimum, requires the following information:

- Encroachment application
- Plans, including traffic management plans

The encroachment application package will be reviewed by the City of Torrance Permit Section, as well as the City Engineer. Once the request for encroachment is approved, a non-refundable administrative fee and a bond must be paid before a permit will be issued.

3.7.3 City of Manhattan Beach

Excluding those portions identified in Section 3.7.4, the portion of alignment along West 190th Street, Rindge Lane, Redondo Avenue and Manhattan Beach Boulevard falls within City of Manhattan Beach ROW jurisdiction. Since the boundary between the Cities of Torrance and Manhattan Beach extends along West 190th Street, a determination over jurisdiction will depend on the selection of the final alignment. Any work performed in the ROW requires prior approval with a ROW permit. Application packages are to be submitted to the City of Manhattan Beach's Community Development Department at the following address:

City of Manhattan Beach, Community Development Department
1400 Highland Avenue
Manhattan Beach, CA 90266-4795
310.802.5500

The ROW application package, at minimum, requires the following information:

- ROW application
- Plans, including traffic management plans

The ROW package will be reviewed by the City of Manhattan Beach ROW Permitting Section, as well as the City Engineer. Once the application is approved, a non-refundable administrative fee and a bond must be paid before a permit will be issued.

3.7.4 California Department of Transportation (Caltrans)

Caltrans has jurisdiction over the state highway or State Route (SR) system, which includes Artesia Boulevard (SR 91) and Hawthorne Boulevard (SR 107). An encroachment permit must be obtained for all proposed activities within, under, or over Caltrans ROW. For work in the proposed area, applicants must complete a standard encroachment permit application, attach supporting documentation, and submit to the District 7 Encroachment Permits Office at the address below:

Caltrans District 7
100 South Main Street, Suite 100
Los Angeles, CA 90012
213.897.3631

The encroachment permit package requires, at minimum, the following information:

- Encroachment application
- Plans, including traffic management plans
- Environmental documentation
- Letter of Authorization

The permit fee will depend on the amount of staff hours required to review and inspect project work. A deposit may be required at the time of submission. Once Caltrans has deemed the submittal package complete, it will either approve or deny the permit within 60 days.

3.7.5 Division of Drinking Water (DDW) Requirements

Guidance criteria for the separation of new water mains and non-potable pipelines, established under Title 22 of the California Code of Regulations and enforced by the DDW, need to be considered when selecting the final pipeline alignment. The separation criteria to be used are summarized as follows:

- 4 feet horizontally and 1 foot vertically from potable and recycled water lines (edge to edge)
- 10 feet horizontally and 1 foot vertically above wastewater (including brine) lines (edge to edge)

In areas where these criteria cannot be met, approval will need to be obtained from DDW to use alternative criteria for construction. It is the responsibility of the water system proposing an alternative to demonstrate that its proposed construction will have at least the “same level of protection to public health” as the minimum separation distances prescribed in the regulations.

3.8 Power Requirements

As indicated in Section 3.2, a separate water pump station will be required to deliver the target 90 psi at the MB POC and would be located at the brackish water reclamation plant site. Based on flow and pressure requirements defined in Section 3.2, the pump design criteria for the two flow scenarios are as summarized in Table 3-3.

Table 3-3. Pump Station Design Criteria

Scenarios	Flow (AFY)	Flow (gpm)	Pressure (psi)	Pressure (ft)	Required Horsepower (hp)	Electrical Requirements	Annual Power Cost[a]
Scenario 1	944	585	119	274	60	3-phase, 460V, 60 Hz	$40,000
Scenario 2	1,700	1,054	126	291	125	3-phase, 460V, 60 Hz	$76,000

Notes:

[a] Assumes constant operation at design flow, 24 hours a day, 7 days a week.

hp = horsepower

V = volt(s)

Hz = hertz

The anticipated motor sizes listed in the above table are based on one pump providing the design flow at the required pressure. The ultimate configuration could utilize multiple, smaller pumps, depending on ultimate operating parameters for the proposed brackish water reclamation plant. In addition, full standby pumping capability is recommended for the ultimate configuration.

In Table 3-3, the required horsepower was calculated using the Equation 3-1:

$$HP = {}^{Q\,x\,P}\!/_{(1{,}714\mu_e)} \qquad \text{Eqn 3-1}$$

where, HP = horsepower

Q = flow rate, gpm

P = pressure, psi

μ_e = total pump efficiency

= 70%

In Table 3-3, estimated power costs were calculated using the Equation 3-2:

$$C = {}^{0.746Qhc}\!/_{(3{,}960\mu_e)} \qquad \text{Eqn 3-2}$$

where, C = cost per hour

Q = flow rate, gpm

h = head, feet

c = unit cost of power per kilowatt hour (kWH)

= $0.105 per kWH

μ_e = total pump efficiency

= 70%

4. Implementation and Cost

4.1 Implementation Schedule

Since there are relatively few jurisdictions from which permits will be required, it is recommended that the new pipeline be packaged as a single contract, separate from the brackish water reclamation plant. However, design and construction of the new pipeline should be coordinated with that of the plant.

The new pipeline is anticipated to be constructed primarily by open-cut construction methods with a recommended minimum depth of cover of 5 feet. Trenchless construction would be used to avoid utility conflicts and to minimize traffic impacts at intersections. Based on the range of feasible pipe sizes, applicable trenchless methods include traditional jack-and-bore/auger boring and horizontal directional drilling. Small-diameter microtunneling is typically used for pipe greater than 24 inches in diameter and is not considered applicable.

For schedule and cost purposes, open-cut construction is assumed to be used for 90 percent of the total project length and trenchless construction for the remaining 10 percent. Based on the above breakdown, the construction duration for the new pipeline is estimated to be 18 months.

Because pipeline construction will extend over more than one year, project phasing must consider any local agency moratoriums, including summer season and holiday shopping construction moratoriums in popular tourist and retail shopping areas.

4.2 Opinion of Probable Construction Cost

An Opinion of Probable Construction Cost (OPCC) for the new pipeline was developed for both flow scenarios: 944 AFY and 1,700 AFY. These OPCCs reflect the recommended pipe sizing and material, as well as anticipated construction methods discussed in this TM. They have been prepared as a Class 4 cost estimate, in accordance with the Association for the Advancement of Cost Engineering (AACE) International's definitions of the five "class estimates" in AACE International Recommended Practice No. 18R-97. The expected accuracy of a Class 4 cost estimate is +50 percent to -30 percent. The cost estimates are based on similar projects and include the following factors:

- The costs for pipeline construction were based on the following average unit costs:
  - Open-cut construction: $20 per inch-diameter per linear foot
  - Trenchless construction: $50 per inch-diameter per linear foot
- An additional 30 percent of the subtotal direct cost was included as a contingency allowance for additional items that may be identified during detailed design
- An additional 10 percent of the subtotal direct cost was included for general conditions

- An additional 15 percent of the total direct cost was included for general contractor overhead and profit
- An additional 2 percent of the total direct cost was included for bonds and insurance
- Sales tax was included and based on 50 percent of the total direct cost

The OPCCs for both flow scenarios are included in Table 4-1.

Table 4-1. Summary of Construction Cost Estimates

Scenarios	Construction Cost Estimate[a]
Scenario 1 – 944 AFY	$13.4 M
Scenario 2 – 1,700 AFY	$16.1 M

[a] Includes construction costs only, in 2019 dollars.

7. Evaluation of Alternatives and Treatment Technologies (Task 1.H)

Technical Memorandum

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Subject	**Evaluation of Alternatives and Treatment Technologies**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019
Prepared by	Liana Olivas David Hokanson, Ph.D., P.E., BCEE Steve Alt, P.E.
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1. Introduction

Due to seawater intrusion and the implementation of the West Coast Seawater Intrusion Barrier, a plume of high concentrations of total dissolved solids (TDS), approximately 375,000 acre-feet (AF) in size, has been entrapped within the West Coast Basin. To tackle this issue, the Water Replenishment District of Southern California (WRD) has initiated a Regional Brackish Water Reclamation Program (Program), which will evaluate ways to remediate the high TDS plume.

The Program includes a feasibility study, led by Jacobs, which will evaluate potential siting and technologies for the brackish water reclamation facilities within the plume. Jacobs has designed a conventional two-stage reverse osmosis (RO) treatment system as the baseline for remediating the brackish groundwater. The mass balance for a 12,500-acre-foot-per-year (AFY) project using this baseline treatment is presented in Table 1, and a process flow diagram of the baseline RO system is shown on Figure 1. Because of limited information and the lack of strontium data, a full water quality assessment is recommended as the project moves forward. The purpose of this technical memorandum (TM) is to communicate the alternate treatment technologies that were evaluated by Trussell Technologies with the goal of minimizing waste flow and cost.

1.1 Baseline Process

Finished potable water quality goals, established in the previous Task 1.G Product Water Quality of this Program, include the following:

1. TDS less than 500 milligrams per liter (mg/L)
2. Approximately 2.5 mg/L chloramine residual
3. pH between 8 and 8.5
4. Fluoride of 0.7 to 0.8 mg/L
5. 40 mg/L (as calcium carbonate [$CaCO_3$]) of calcium hardness
6. 70 mg/L (as $CaCO_3$) of alkalinity
7. Langelier Saturation Index (LSI) 0.2 to 0.62

The baseline treatment process includes direct well water feed to 5-micron cartridge filtration, hydrochloric acid, and antiscalant dosing as pretreatment to conventional RO. The RO permeate is pumped to an air stripper for removal of methane and carbon dioxide. Remineralization chemicals are then added to the stripped permeate to achieve the LSI, pH, fluoride, chloramine, and alkalinity targets listed above. A process flow diagram of the baseline treatment for the 12,500-AFY Project is included on Figure 1.

The conventional RO process includes a recovery (product water flow divided by feed water flow) of 85 percent, limited by the scaling potential of barium sulfate and silica, the maximum achievable with the latest antiscalant chemicals (approximately 3.4 mg/L of Avista Vitec 4000; see Appendix A). A slight pH depression with 5 to 10 mg/L hydrochloric acid may be required to meet this recovery by inhibiting calcium carbonate scaling. Maximizing the recovery will minimize the brine volume and thus the brine disposal costs. In addition, according to the Hydranautics IMS projection in Appendix A, the baseline process includes the use of high-rejection brackish RO membranes to reduce the salinity of the well water from approximately 6,500 mg/L of TDS down to a projected value of approximately 140 mg/L. Assuming a 30 percent permeate quality factor of safety, the RO product TDS will approach 176 mg/L.

To minimize the amount of remineralization chemicals, a small RO bypass flow of raw well water will blend with the RO permeate to achieve the calcium hardness target in the finished water. The following remineralization/post-treatment chemicals will be added to the blended water to achieve a finished potable product water:

- 3.5 mg/L of sodium hypochlorite
- 1.2 mg/L of ammonium hydroxide
- 1 mg/L of fluorosilicic acid
- 47 mg/L of carbon dioxide
- Approximately 50 mg/L of sodium hydroxide

The finished water will have a TDS of approximately 360 mg/L. The mass balance in Table 1 indicates that the baseline process will meet the U.S. National and California requirements for drinking water. The pertinent maximum contaminant limits (MCLs) are listed with the following color code in this table: black = U.S. National primary drinking water MCL, purple = U.S. National secondary drinking water MCL, green = California MCL or notification limit.

A 1-hour clearwell onsite is recommended as a buffer for temporary equipment shutdowns. The layout of the 20,000-AFY (feed flow) baseline process option placed onto the 1 acre of available space at the Elm and Faysmith site is included in Appendix B. The layout fits on 1 acre with little room to spare for additional equipment; therefore, footprint is a consideration in the evaluation of alternate treatment technologies. A 12,500-AFY baseline RO footprint would be equivalent to the 20,0000-AFY minus one RO train and feed pump, one cartridge filter, one air stripper, and a clearwell diameter reduction of 10 feet.

The following baseline conventional RO design aspects are noteworthy:

1. 85 percent recovery of well water with 6,500 mg/L TDS results in a brine with a salinity of 43,000 mg/L.
2. Because of the relatively high osmotic pressure associated with the high feed water and especially brine salinity, the two-stage conventional RO requires flux (flow) balancing between the first and second RO stages. This consists of the following:
   a. The use of a turbocharger that uses the brine energy (pressure) to boost the feed pressure of the second RO stage.
   b. The use of a tighter RO membrane in the first stage and a slightly looser RO membrane in the second stage, which encourages a higher flux in the second stage.
3. The feed and the interstage pressures of the RO are anticipated to be approximately 405 and 530 pounds per square inch gauge (psig), respectively, with aged membranes at the coldest anticipated water temperature of 17 degrees Celsius (°C). These pressures leave an adequate fouling range of 600 psig, which is the maximum recommended for brackish RO membranes.
4. High-rejection brackish RO membranes are required in this application because energy saving brackish RO membranes would produce RO product water TDS of 475 mg/L, which, in combination with the required remineralization chemicals, would exceed the 500 mg/L TDS goal.

Table 1. Mass Balance of Baseline 12,500-AFY Project Two-stage Conventional RO

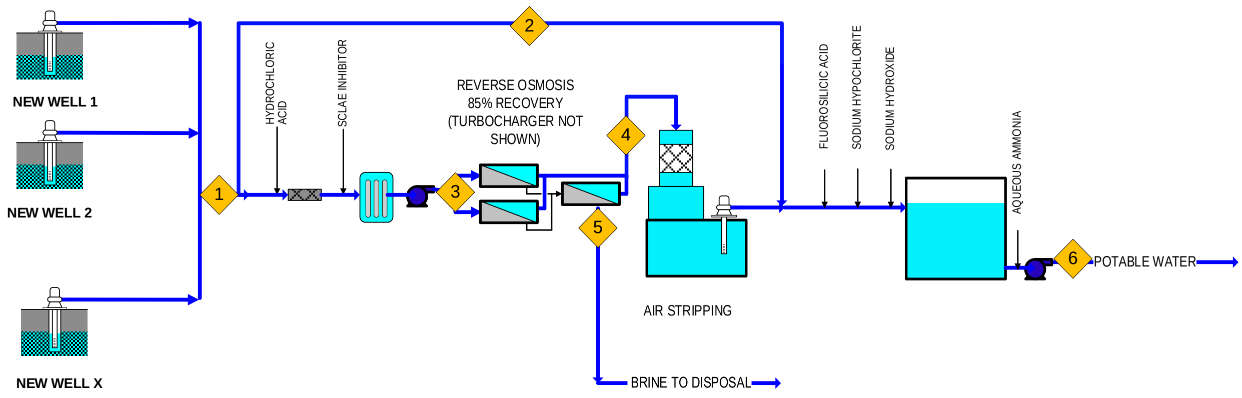
Mass Balance - WRD FS

Primary RO recovery:	85%	Based upon 5-year membrane age		
CCRO Recovery:	0%			
Overall Recovery:	85%		Arsenic Rejection:	90%
Bypass (gpm):	100		Selenium Rejection:	96%
Permeate Quality FOS:	1.3	CPA6LD ->CPA5LD	Arsenite Rejection:	82%
			Arsenate Rejection:	98.5%

		RO System								
Parameter	RW Well Feed	ROf Feed to RO	ROwc RO Concentrate	ROp RO Permeate	ROp RO Permeate (with FOS)	Decarbonated ROp	Bypass RO Bypass	Blend	Fp Final	MCL
Flow (mgd)	11.1	11.0	1.6	9.3	9.3	9.3	0.14	9.5	**9.5**	--
(gpm)	7,743	7,643	1,146	6,497	6,497	6,497	100	6,592	**6,592**	--
(AFY)	12,490	12,328	1,849	10,479	10,479	10,479	161	10,640	**10,640**	--
Calcium (mg/L)	646	646	4,279	4.8	6.2	6.2	646	16	**16**	--
Magnesium (mg/L)	351	351	2,325	2.6	3.4	3.4	351	8.7	**8.7**	--
Sodium (mg/L)	1,181	1,181	7,636	41.8	54.3	54.3	1,181	71	**104**	--
Potassium (mg/L)	65	65	417	2.9	3.8	3.8	65.0	4.7	**4.7**	--
Ammonia (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	--
Barium (mg/L)	0.82	0.8	5.4	0.006	0.01	0.01	0.82	0.02	**0.02**	2
Bicarbonate (mg/L)	171	163	1,052	5.8	5.8	5.8	171	8.3	**100**	--
Sulfate (mg/L)	224	224	1,487	1.1	1.4	1.4	224	4.8	**4.8**	250
Chloride (mg/L)	3,980	3,985	26,119	79	102	102	3,980	161	**161**	250
Fluoride (mg/L)	0.16	0.2	1.0	0.01	0.0	0.0	0.2	0.0	**0.0**	2
Nitrate (mg/L)	1.40	1.4	8.7	0.1	0.2	0.2	1.4	0.2	**0.2**	10
Silica (mg/L)	28	28.0	184	0.5	0.7	0.7	28.0	1.1	**1.1**	--
Boron	0.23	0.2	0.7	0.15	0.21	0.21	0.23	0.21	**0.21**	1
Iron (mg/L)	0.18	0.18	1.2	0.001	0.001	0.001	0.180	0.004	**0.004**	0.3
Manganese (mg/L)	0.29	0.29	1.9	0.002	0.003	0.003	0.290	0.01	**0.01**	0.05
Nickel (µg/L)	3.2	3.2	21.2	0.02	0.03	0.03	3.2	0.08	**0.08**	100
Arsenic (µg/L)	3.0	3.0	19.0	0.2	0.2	0.2	3.0	0.3	**0.3**	10
Selenium (µg/L)	32	32	210.6	0.5	0.6	0.6	32.0	1.1	**1.1**	50
Methane (mg/L)	7.0	7.0	7.0	7.0	7.0	0.07	7.0	0.2	**0.2**	--
TDS (reported)	7,694	7,694								
TDS (calculated)	6,580	6,580	43,094	136	176	176	6,580	273	**361**	500
pH	7.9	7.5	8.3	6.0	6.0	6.1	7.9	6.2	**8.4**	6.5-8.5
Temperature (°F)	71	71	71	71	71	71	71	71	**71**	--
CO_2 (mg/L)	3.1	9.1	9.1	9.1	9.1	8.0	3.1	7.9	**0.7**	--
LSI	1.3	0.9	3.2	-4.0	-3.9	-3.8	1.3	-3.1	**0.1**	--

Notes:
The pertinent drinking water MCLs are listed with the following color codes:
black = EPA primary MCL
purple = EPA secondary MCL
green = California MCL or notification level

µg/L = microgram(s) per liter
°F = degree(s) Fahrenheit
CCRO =closed-circuit reverse osmosis
CO_2 = carbon dioxide
CPA = Composite Polyamide
FOS = factor of safety
Fp = finished product water
FS = feasibility study
LSI = Langelier saturation index
MCL = maximum contaminant level
mgd = million gallon(s) per day
ROf = reverse osmosis feed
ROp = reverse osmosis permeate
Rowc = reverse osmosis concentrate or brine
RW = raw water (well feed)



Stream #	1	2	3	4	5	6
Flow, AFY	12489	161	12327	10478	1849	10640
Flow, gpm	7743	100	7643	6497	1146	6597
TDS, mg/L	6580	6580	6580	140	43073	350
Pressure, psig	60	60	375	10	0	100

Figure 1. Process Flow Diagram of Baseline Two-stage RO System

1.1.1 Baseline Process Economics

The treatment and brine disposal costs of the centralized 12,500-AFY and 20,000-AFY baseline RO processes are listed in Table 2. Energy cost was assumed to be $0.105 per kilowatt hour (kWh). The cost estimates were developed in light of the following:

- Cost estimates do not include Capital expenditure (CAPEX) financing because that will be investigated in future Task 7 of this Program.
- Cost estimates are Class IV cost estimates with accuracies of +50 percent to -30 percent of actual project cost.

Table 2. Baseline Conventional RO Process Economics

Feed Flow (AFY)	CAPEX[a]		Annual OPEX		
	Treatment Plant	LACSD Sewer Connection Fee	Treatment Plant Power	Treatment Plant Chemicals[b]	LACSD Annual Surcharge (Brine)
12,500	$62,000,000	$17,500,000	$2,600,000	$2,200,000	$480,000
20,000	$82,000,000	$28,000,000	$4,050,000	$3,450,000	$740,000

[a] Installed costs include permitting, engineering, and construction.

[b.] Includes energy, chemicals, labor, membrane and other replacements

Notes:

LACSD = Los Angeles County Sanitation Districts

OPEX = operational expenditure

1.2 Approach

Based on the provided material, Trussell Technologies evaluated the following treatment technologies as potential alternates or additions to the baseline conventional RO:

1. Conventional nanofiltration
2. Separate final RO/nanofiltration stage
3. Closed-circuit RO (CCRO)
4. Traditional High Efficiency RO (HERO)

5. Modified HERO
6. Ion exchange
7. Electrodialysis reversal
8. Interstage lime softening (pellet reactor)

2. Evaluation of Alternate Treatment Technologies

The treatment technologies listed above were evaluated based on technology suitability for the treatment, cost, and spatial limitations. A description of each technology and the reasons for ruling each out is provided in this section. The technology options are summarized in Table 9 of Section 3 of this TM.

2.1 Conventional Nanofiltration

Nanofiltration membranes were developed as a softening process. Nanofiltration membranes are porous (approximately 2-nanometer pore diameter) and can reject particles as small as 0.001 to 1 nanometer. A summary of the constituents rejected by nanofiltration membranes is shown on Figure 2.

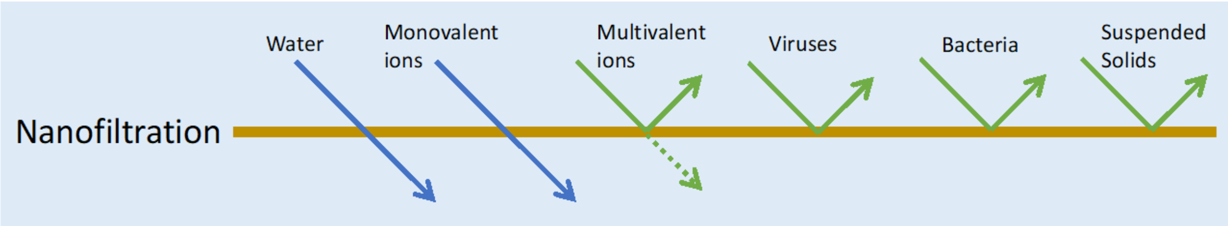


Figure 2. Constituents Rejected by Nanofiltration

Nanofiltration membranes have lower pressure requirements than conventional RO. They are used for the removal of divalent cations, disinfectant byproduct precursors, natural organic matter, and sizable amounts of other constituents. They reject monovalent ions far less effectively than divalent cations, which are completely removed on the porous, negatively charged membranes. For example, chloride and sodium rejection are 40 to 75 percent and 50 to 75 percent, respectively. In addition, nanofiltration does not reject uncharged ions like silica with the same efficiency as multivalent ions.

Given its ineffectiveness at rejecting chloride and sodium and their high concentrations in both the well feed water and the baseline RO concentrate, nanofiltration is unsuitable for use as either a replacement for the baseline RO or treatment of the baseline RO concentrate. Appendix C includes a projection with NF 90 membranes, and the product water TDS of the nanofiltration permeate is 888 mg/L, well above the treatment goal.

2.2 Single-stage RO System Treating Baseline Two-stage RO Concentrate

Overall water recovery could be increased by adding an additional single-stage RO system that would treat the concentrate from the baseline two-stage RO system designed by Jacobs. This approach provides the benefit of isolating the extra operations and maintenance that would be required to operate at higher recovery to a system that is separated from the primary two-stage RO system.

Hydranautics model, Integrated Membranes Solutions Design Software (2016), was used to model the performance of the final one-stage RO system. The model used the following RO membrane assumptions from the Hydranautics model of the primary RO (Appendix A):

- Element age 5 years
- Flux decline percent, per year 5
- Fouling factor 0.77
- Salt passage increase, per year 7 percent
- Number of pressure vessels: 38
- Number of elements per vessel: 7

The Hydranautics model predicted a 20 percent recovery of the concentrate leaving the baseline two-stage RO system, yielding an overall RO recovery of 88 percent. Barium sulfate and silicon dioxide saturations limited the recovery of the system. The model resulted in a low flux of 3 gallons per square-foot per day (gfd), which is likely a result of the small difference (5 pounds per square inch) between the concentrate pressure and concentrate osmotic pressure. Acid dosing can lower the LSI below 2.5, but other scalants, such as barium sulfate and silica, exhibit high concentrate saturations: 11,381 percent and 186 percent, respectively. Complete model results can be found in Appendix D.

Scaling would be a problem with this “sacrificial” third stage. Avista Advisor was used to evaluate antiscalant effectiveness under the conditions modeled above, and it could not identify an Avista Technologies antiscalant that would be capable of controlling scale formation. It is likely that other commercial antiscalants also would be unable to prevent scaling under these conditions. Therefore, membrane scaling would be expected to pose an insurmountable challenge, and the membranes would require frequent replacement. The exact scaling frequency is difficult to quantitate, but third-stage membrane replacement annually is a possibility.

This approach is uneconomical when compared to the baseline. The modeled membrane flux is low, which would result in a high capital cost for a relatively small increase in water production. Assuming that these membranes would need to be replaced annually because of scaling, the membrane replacement cost would add $140,000/$220,000 to the annual OPEX cost with a benefit of only a 230- /240-gallon-per-minute reduction in brine flow for the 12,500-AFY/20,000-AFY projects. This is substantially more than the annual cost savings in sewer disposal of $90,000/$145,000.

2.3 Closed-circuit Reverse Osmosis

CCRO is a proprietary process from Desalitech that operates between two main modes, shown on Figures 3 and 4. In the closed-circuit mode, a high-pressure pump maintains a flux set point, and a pump recirculates the feed concentrate across the membranes at high crossflow velocities. During the closed-circuit mode, the system operates at 100 percent recovery (i.e., feed flow and permeate flow are equal). Pressure gradually increases as the salt concentration in the system increases over the length of the cycle. The closed-circuit mode ends, and the flush mode initiates, once the batch of feed concentrate reaches a certain salt concentration, or a desired volume of permeate is produced. The second mode flushes out the system by stopping the recirculation pump, opening a brine flush valve, and displacing the high concentrate brine with a high-rate plug-flow pulse of feed water. Because this system processes most of the influent water in batches, CCRO is often referred to as a semi-batch process as opposed to a traditional plug-flow process.

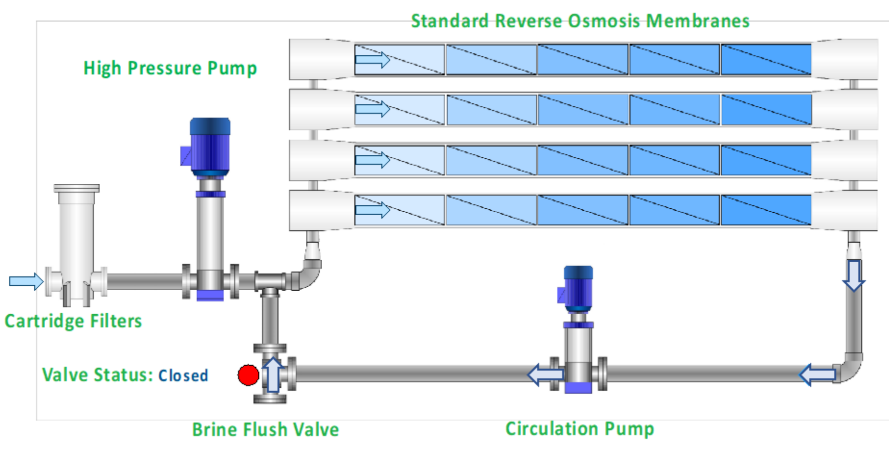


Figure 3. CCRO in Closed-circuit Mode

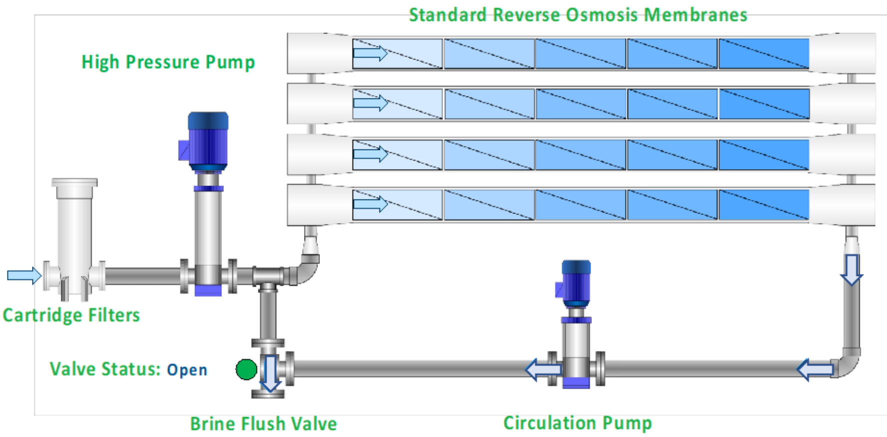


Figure 4. CCRO in Flushing Mode

CCRO has the potential to increase overall recovery, be fully automated, and be adaptable to different permeate/concentrate requirements. CCRO can either be implemented as the primary RO system or as a final RO stage (i.e., treating primary RO concentrate).

If CCRO were used to treat primary RO concentrate, it would allow the upstream RO system to operate with a less aggressive recovery (e.g., 75 percent recovery versus 85 percent recovery). Experience at Padre Dam and San Diego shows that a lower recovery can extend the time between chemical cleanings. If used as the primary RO, CCRO may achieve a higher recovery than the baseline two-stage RO system.

CCRO is promoted as being more tolerant of silica scaling because it only reaches the maximum concentration for a short period during each cycle. Past testing at the Padre Dam Municipal Water District (Padre Dam) advanced water purification demonstration facility suggests that CCRO is capable of treating elevated silica levels (Idica, 2017). Padre Dam was able to achieve stable 96 percent overall recovery from its demonstration scale RO system, using the CCRO system to treat RO concentrate. The primary RO system operated at a recovery of 75 percent during the testing, and the CCRO system treated the primary RO system concentrate with a recovery of 75 to 80 percent. In the absence of comparable brackish groundwater data,[1] silica concentrations entering the Padre Dam CCRO system are shown on Figure 5 and ranged from 20 to 75 mg/L. Silica saturations were calculated for the testing and are shown on Figure 6. These silica levels in the RO concentrate ranged from between 100 and 200 percent of saturation for the 95 and 96 percent overall recovery levels. A scale inhibitor was present in the CCRO feed to inhibit silica precipitation.

[1] For purposes of estimation only, silica fouling experience may be different between groundwater and recycled water.

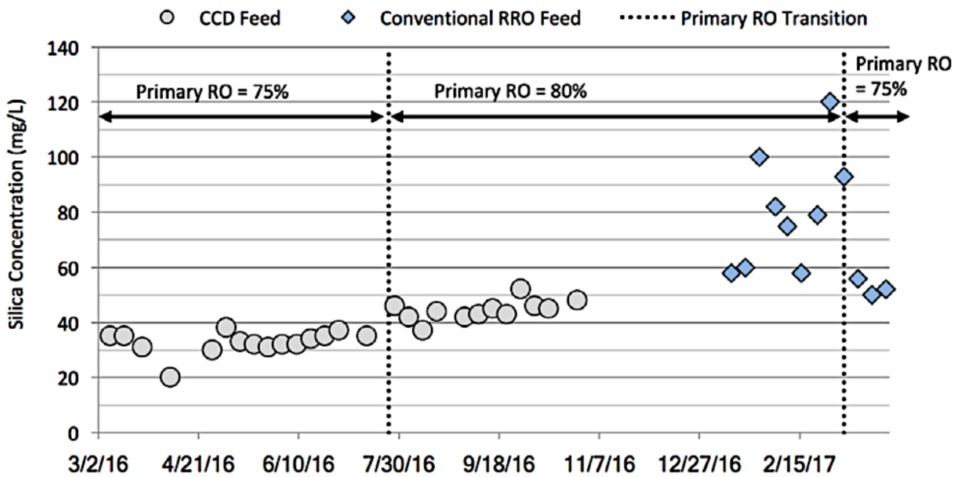


Figure 5. Silica Levels Feeding CCRO System at Padre Dam

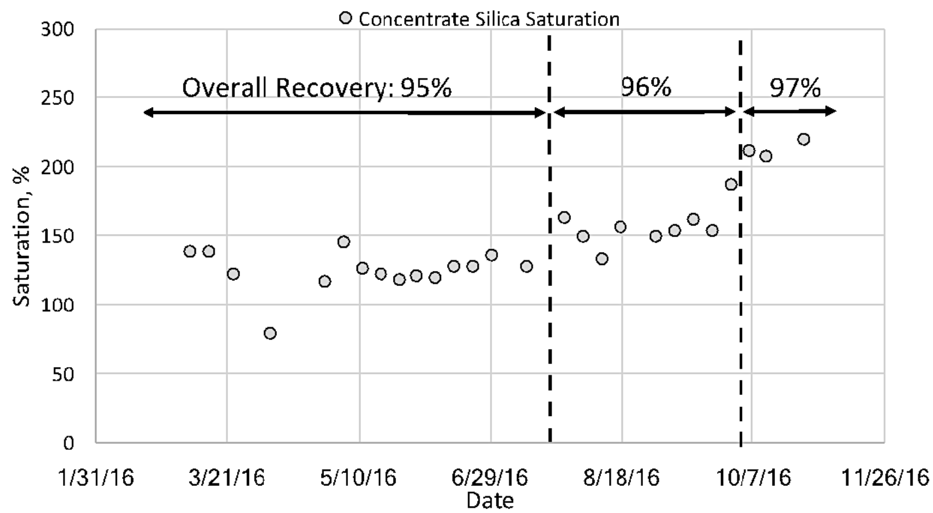


Figure 6. Estimated Silica Saturations in Padre Dam CCRO Concentrate

With the RO feedwater silica concentration estimated to be 28 mg/L, the silica saturation at 85 percent recovery is expected to be approximately 187 mg/L, which is about the limit of what conventional RO systems can handle at neutral pH with the latest antiscalants. The testing at Padre Dam suggests that the CCRO system may be able to treat slightly higher silica saturations. To significantly increase recovery beyond 85 percent, the CCRO system would have to handle silica saturations greater than 200 mg/L. If antiscalants can be found that will allow a conventional two-stage RO to successfully operate at 200 mg/L, then it stands to reason that a CCRO system will successfully operate at a higher level. One of the Desalitech case studies (a paper plant using an Arizona brackish groundwater source high in silica) shows the plant was able to increase its normal operating recovery from 73 percent to 90 percent, increasing its stable silica level by 80 percent to approximately 300 mg/L (Gunderson, 2016). A similar increase in this project would enhance recovery from 85 percent to 92 percent.

However, the economics of using CCRO as a secondary treatment process (i.e., treating the brine of the conventional RO) are not favorable and were presented in the Task 1.F Brine Discharge Evaluation TM of this Program. The additional CAPEX and OPEX (primarily energy) involved with adding CCRO as a secondary treatment system are more expensive than the brine discharge cost savings. Table 3 presents the economics of adding a secondary RO system. Additional details are presented in the Brine Discharge Evaluation TM.

Table 3. Economics of Adding a Secondary RO System to the 12,500-AFY Project Option

Constituent	Overall Recovery	LACSD Connection Fee	Secondary RO CAPEX	LACSD Annual Surcharge	Secondary RO Annual OPEX
Primary RO only- Baseline Conventional RO	85 percent	$17,500,000	--	$490,000	--
Primary feeding secondary CCRO	90 percent	$11,600,000	$4,000,000	$330,000	$320,000

Notes:

Values in the table are scalable to the 20,000-AFY option.

Secondary RO addition results in a smaller primary RO system. Costs related to secondary RO listed are secondary RO costs minus the difference in primary RO costs.

-- = not applicable

The addition of any secondary process creates footprint issues. The Twentynine Palms groundwater desalter currently in construction includes a 1,000-square-foot (ft^2) footprint for the break tank and CCRO train to treat 0.8 million gallons per day (mgd). For the WRD 20,000-AFY Project, the estimated additional footprint necessary for the CCRO secondary treatment of approximately 4.5 mgd would be about 3,000 ft^2. Examination of Appendix B indicates that the Elm and Faysmith 1-acre site with the baseline process equipment has insufficient room for the additional secondary CCRO equipment. Therefore, CCRO as a secondary treatment process addition is rejected based upon both economics and footprint/area required.

Desalitech modeled the proposed primary process at 90 percent recovery using Avista Advisor. Results, which are provided in Appendix E, used Avista Technologies' silica/sulfate specific antiscalant, Vitec 7400, and was able to keep silica at roughly 115 percent saturation and calcium carbonate below 80 percent saturation. CCRO can reach silica saturations above 100 percent because the short duration of exposure at these saturation levels does not allow time for scale formation. These model results suggest that CCRO can potentially operate at 90 percent recovery, with the right antiscalant. CCRO may be a viable option for WRD if it is considered as the primary RO system, although pilot testing to demonstrate its maximum sustainable recovery would be recommended.

Assuming 90 percent recovery could be achieved, a Lanxess LewaPlus CCRO projection, included in Appendix E, indicates that the energy use for the CCRO would be substantially higher than conventional RO. A seawater membrane would be required for the CCRO process because it exceeds the 600 psig feed pressure limit for brackish RO membranes. The CCRO projection is predicting 6.5 kWh per 1,000 gallons, whereas the Hydranautics and Lanxess LewaPlus conventional RO projections are predicting approximately 4 kwh per 1,000 gallons produced. The difference at $0.105/kWh is approximately $1.4 million dollars per year in additional energy at 20,000 AFY. Because this additional energy cost is more than the entire LACSD annual surcharge for the brine disposal, CCRO as a primary process would be more expensive than the baseline.

CCRO has not been used as the primary RO system for municipal applications, so further investigation will be necessary if this option is chosen. CCRO has been part of recent pilot testing of brackish groundwater treatment at Eastern Municipal Water District and the City of Oceanside, but the results of those studies are not yet available.

2.4 Ion Exchange

Conventional ion exchange involves exchange of an ion in the aqueous phase for an ion in the resin phase. Ion exchange resins are typically synthetic organic polymers cross-linked with divinylbenzene. In ion exchange, the resin phase consists of a presaturant ion associated with the functional groups on the resin.

As an example, consider the exchange of sodium onto a strong acid cation (SAC) exchange resin presaturated with hydrogen:

$$\bar{R} - H^{+} + Na^{+} \leftrightarrow \bar{R} - Na^{+} + H^{+}$$

and the exchange of sulfate onto a strong base anion (SBA) exchange resin presaturated with hydroxide:

$$\bar{R} - OH^{-} + SO_4^{2-} \leftrightarrow \bar{R} - SO_4^{2-} + OH^{-}$$

While it is common to use sodium and chloride as the presaturant ions (common ion exchange softeners do this with strong acid resins, for example), it is not feasible to do so for this application. This is because sodium and chloride ions must be removed, which is not possible when sodium and chloride are used as presaturant ions. In this case, hydrogen and hydroxide are chosen as presaturant ions because cation-exchange resins in the hydrogen form and anion-exchange resins in the hydroxide form, respectively, will remove sodium and chloride, respectively.

After the SAC resin is exhausted and sodium ions breakthrough the column at levels above the treatment target, it is necessary to regenerate the resin for continued use. This is typically accomplished by adding an excess amount of acid regenerant solution in the case of a resin presaturated with hydrogen ion (about 2 to 3 times stoichiometric requirements) (Dow Chemical, 2019). For the exchange reaction shown above, the regeneration can be accomplished by adding hydrochloric acid (HCl), as shown in the following reaction:

$$\bar{R} - Na^{+} + HCl \leftrightarrow \bar{R} - H^{+} + NaCl$$

For an SBA exchange resin, the regeneration step is often carried out using sodium hydroxide (NaOH) as shown in the following reaction for the case shown above:

$$\bar{R} - SO_4^{2-} + 2\ NaOH \leftrightarrow \bar{R} - OH^{-} + Na_2SO_4$$

A schematic of a strong acid cation-exchange resin showing downflow operation with concurrent regeneration is shown on Figure 7(a). A schematic of a strong base anion-exchange resin showing downflow operation with concurrent regeneration is shown on Figure 7(b).

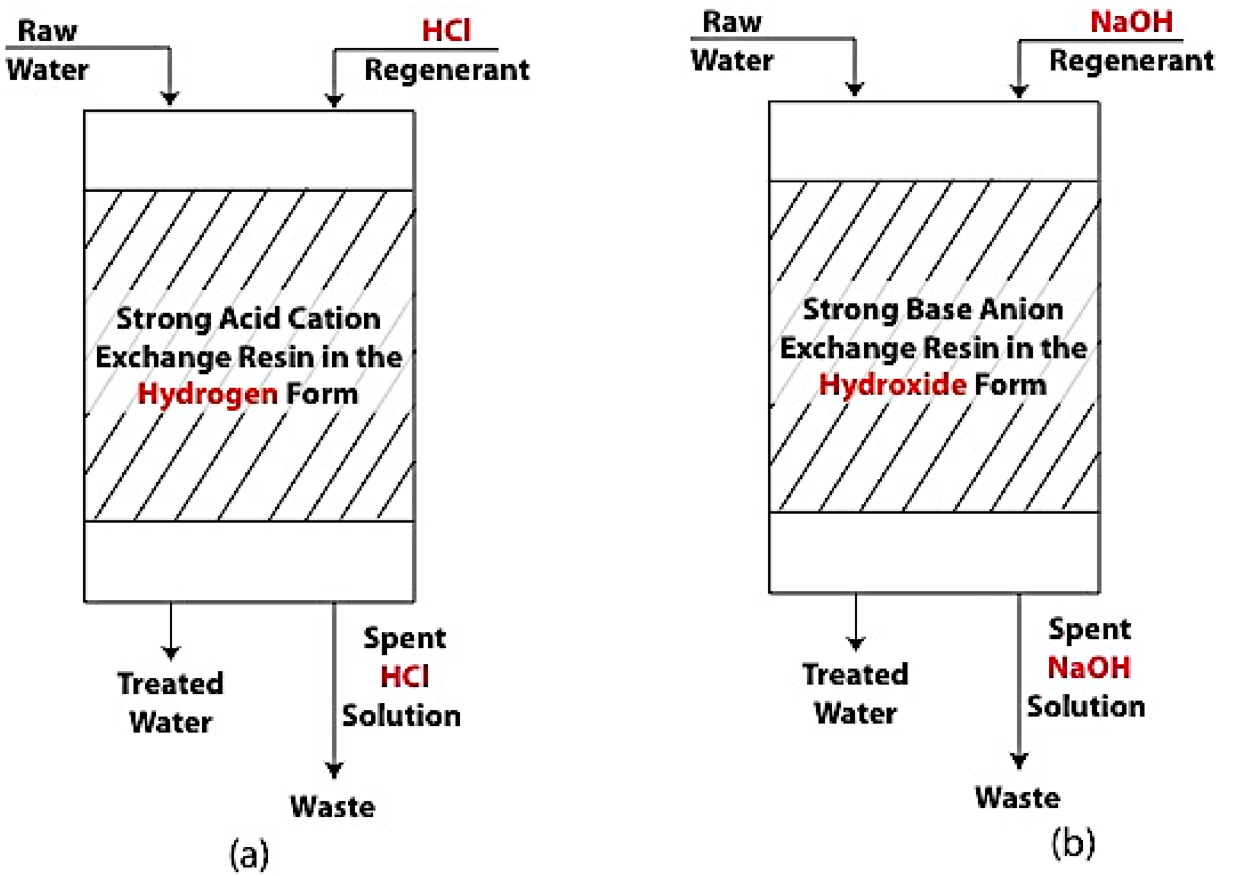


Figure 7a and 7b. Conventional Ion Exchange Treatment Process

Notes: (a) SAC exchange resin in the hydrogen form and concurrent regeneration with hydrochloric acid. (b) SBA exchange resin in the hydroxide form and concurrent regeneration with sodium hydroxide.

Based upon the recommendation in the Dow Chemical Different Chemical Efficiencies for Different Resin Configurations (Dow Chemical, 2019), the best-case amount of HCl and NaOH required for SAC->SBA deionization regeneration would be 2 stoichiometric equivalents of HCl per cation equivalent and 1.5 stoichiometric equivalents of NaOH per anion. Based on information in Table 4, the chemical regeneration for this application would require 228 milliequivalents per liter (meq/L) or 8,337 mg/L of HCl, and 179 meq/L or 7,146 mg/L of NaOH dosed continuously. At $510 per dry ton of HCl and $530 per dry ton of NaOH, this translates to chemical costs of approximately $200 million annually for 20,000 AFY, and $130 million annually for 12,500 AFY, assuming 94 percent treatment and 6 percent ion exchange bypass.

Therefore, demineralization via ion exchange is ruled out because of economics and because the chemical consumption is hundreds of thousands of gallons per day at either 20,000 AFY or 12,500 AFY, which is unrealistic from a storage and delivery standpoint.

Table 4. Demineralization via Ion Exchange Regenerant Calculations – Feed Water

Ion	Feed Water, mg/L	Feed Water meq/L
K	65	1.7
Na	1181	51.3
Mg	351	28.9
Ca	646	32.3
Ba	0.82	0.01
	Total Cation	**114.2**
HCO_3	171	
NO_3	1.4	
Cl	3980	
F	0.16	
SO_4	224	
	Total Anions	**119.2**

Notes:
Ba = barium
Ca = calcium
Cl = chlorine
F = fluorine
HCO_3 = bicarbonate
K = potassium
Mg = magnesium
Na = sodium
NO_3 = nitrate
SO_4 = sulfate

Mixed bed ion exchange may be more effective than SAC and SBA ion exchange in series. Mixed bed ion exchange consists of mixing SAC exchange resin and SBA exchange resins in the same fixed bed. The process has an advantage in that it removes silica, but the regeneration of a mixed bed process is substantially more complex (SAC and SBA resins must be separated prior to regeneration and then remixed for operation). The process does not resolve the problem of rapid exhaustion from high influent TDS and would still cost substantially more than the baseline process.

2.5 Traditional HERO

HERO is a technology that operates at a high pH regime to optimize scalant rejection. Two permutations of HERO were considered for this Project. The first is termed traditional HERO and consists of a weak acid cation-exchange resin in the process train. The second is termed Modified HERO and replaces the weak acid cation-exchange resin with a strong acid cation-exchange resin in the process train. This section discusses traditional HERO. Modified HERO will be discussed in Section 2.6.

Traditional HERO includes weak acid cation (WAC) exchange followed by carbon dioxide stripping followed by RO along with the addition of chemicals to meet process goals. A schematic of the traditional HERO process is shown on Figure 8.

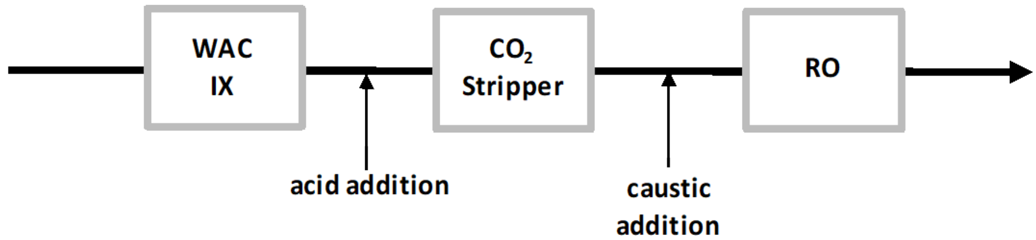


Figure 8. Simplified Schematic of the HERO Process

WAC exchange removes the hardness in the water it is treating, replacing it with acid until either the hardness or the alkalinity is removed. If the hardness is less than the alkalinity, then extra acid is added to remove the remaining alkalinity (Figure 8). The water is then treated by a stripper to remove carbon dioxide, such that the buffer capacity of the water is reduced, and less caustic addition is needed to raise pH to 11.5 or above upstream from the RO, which is designed to remove ionized silica at the elevated pH. WAC stops removing hardness once the alkalinity is removed; hence, if the feed water contains much more hardness than alkalinity, the WAC does not work, and hardness remains in the WAC effluent.

There are several reasons why the traditional HERO process is unsuitable as a primary process or for treatment of primary RO concentrate where the RO portion of HERO serves as the secondary RO. The most important is that, in this case, the hardness is higher than the alkalinity, which will leave hardness in the WAC effluent that will foul the membrane in the RO step of the process. Also, the weak acid resin is expensive. Regeneration with sulfuric acid can be problematic because calcium sulfate precipitates during regeneration. For this reason, regeneration requires the use of hydrochloric acid. Examination of Table 4 reveals that the calcium and magnesium hardness is approximately 55 percent of the total cations in the feed water. Therefore, even though WAC regeneration is much more efficient than SAC regeneration, the amount of acid required for WAC regeneration is still enormous, approximately 90,000 gallons of 32 percent HCl per day for 20,000 AFY, 60,000 gallons per month at 12,500 AFY, with a cost on the order of $25 million/$37.5 million annually for 20,000 AFY/12,500 AFY.

Given that traditional HERO will not work for this application (even if it did work, it is substantially more expensive than the baseline RO), it is eliminated from consideration. A Modified HERO process may be considered that uses SAC exchange, either to polish the WAC effluent or to be used in place of the WAC altogether. Section 2.6 considers SAC exchange in the HERO process train in place of weak base cation exchange.

2.6 Modified HERO

The Modified HERO process could work to further treat the primary RO concentrate, or it could be used as the primary RO treatment process. Modified HERO will first be considered for treatment of the RO concentrate of the primary, two-stage RO process. The treatment train in that configuration is shown on Figure 9 and consists of the following unit processes:

1. Primary RO
2. Air stripper
3. SAC ion exchange
4. HERO

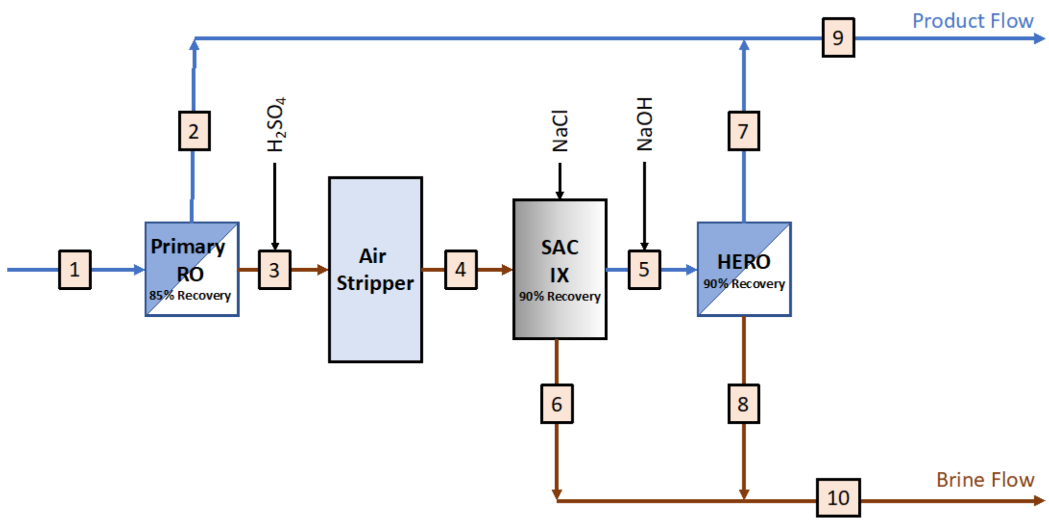


Figure 9. Process Flow Diagram of Baseline RO System Followed by Modified HERO

The Modified HERO process begins with the baseline RO system operating at 85 percent recovery. The RO concentrate is dosed with sulfuric acid, which lowers the pH and removes alkalinity. The dose of sulfuric acid should be equivalent to the alkalinity of the concentrate, which was calculated to be 740 mg/L as $CaCO_3$ based on the bicarbonate reported in the conventional RO mass balance. Adding 740 mg/L sulfuric acid would bring the pH of the concentrate down to approximately 3.3. The concentrate then continues to an air stripper, which should remove 95 percent of carbon dioxide (CO_2) and bring the pH up to approximately 4.5.

Next, the water passes through an ion exchange unit, which uses SAC in the sodium form to remove the hardness from the concentrate and reduce scaling in the final RO process. Because the ion exchange feed is higher in hardness than alkalinity, SAC is preferred over WAC (used in traditional HERO) because it would continue to remove hardness even after alkalinity is removed. The SAC exchanger requires two equivalents of sodium chloride (NaCl) per equivalent of hardness removed to regenerate the resin bed. This is equivalent to a constant dose of 30,000 mg/L of NaCl for regeneration. Feeding the regenerant in the opposite direction of the service flow (counterflow) will yield higher efficiency in salt use. The ion exchange is expected to yield a 90 percent recovery, considering that water from the RO permeate (either from the primary RO or the HERO process) would be removed from the product flow and used to make up the regenerant. It was assumed that no significant pH change would occur through the ion exchange.

After SAC, the water is dosed with 110 mg/L of NaOH to increase the pH to approximately 11.5. The high pH increases the solubility of silica, improving its rejection and allowing a higher recovery than when RO operates in a typical pH range of 6.5 to 7. Assuming it can reach the silica levels achieved in the LACSD design for Santa Clarita[2], the Modified HERO process is expected to yield a 90 percent recovery. The Modified HERO concentrate cannot be combined with the ion exchange brine because they are incompatible (i.e., will form calcium silicate), so one of the two waste streams must be hauled away while the other can be sent to the sewer. The Modified HERO permeate is combined with the primary RO permeate, resulting in an overall recovery of 97.2 percent.

The flow rates of the streams labeled on Figure 9 are shown in Table 5, and the chemical doses are shown in Table 6. The NaCl dose for regenerating the ion exchange (Table 6) is equivalent to a continuous dose, although in application, the resin bed would be regenerated in pulses that last for about 1 hour after 4 to 12 hours of operation.

[2] This would require confirmation because silica behavior in brackish groundwater and recycled water desalination may not be comparable.

Table 5. Expected Flow Rates for Baseline RO System Followed by Modified HERO

Stream No.	Stream Description	Flow (AFY)	Flow (mgd)
1	Influent	20,000	17.85
2	Primary RO Permeate	17,000	15.18
3	Primary RO Concentrate	3,000	2.68
4	Air Stripper Effluent	3,000	2.68
5	SAC Ion Exchange Permeate	2,700	2.41
6	SAC Ion Exchange Concentrate	300	0.27
7	HERO Permeate	2,430	2.17
8	HERO Concentrate	270	0.24
9	Combined Product Water	19,430	17.35
10	Combined Brine	570	0.51

Table 6. Recommended Chemical Doses for Baseline RO System Followed by Modified HERO

Chemical Name	Chemical Formula	Dose (mg/L)	Annual Chemical Cost for 12,500 AFY/20,000 AFY	Purpose
Sulfuric Acid	H_2SO_4	740	$370,000/$590,000	Lower pH and remove alkalinity of primary RO concentrate
Sodium Chloride	NaCl	30,000	$10.2 million/$16.3 million	Regenerate ion exchange
Sodium Hydroxide	NaOH	110	$130,000/$200,000	Raise pH of HERO feed

The Modified HERO process could also be applied directly to the well water. Doing so would require less additional footprint and infrastructure while still providing improved product water recovery. A process flow diagram of this system is shown on Figure 10, with corresponding flows and chemical doses shown in Table 7 and Table 8, respectively. The processes shown on Figure 10 are similar to those explained earlier in this section. Key differences include a SAC ion exchange recovery of 99 percent rather than 90 percent, a pH target of 11.0 instead of 11.5 when dosing sodium hydroxide, and a HERO process water recovery of 97 percent rather than 90 percent. Although the chemical doses are lower than they are for treating RO concentrate (Table 6), the total chemical volumes will be similar because the flow being treated in this situation is much higher. Making similar assumptions as those described for treatment of the RO concentrate, the overall process should achieve a recovery of approximately 96 percent.

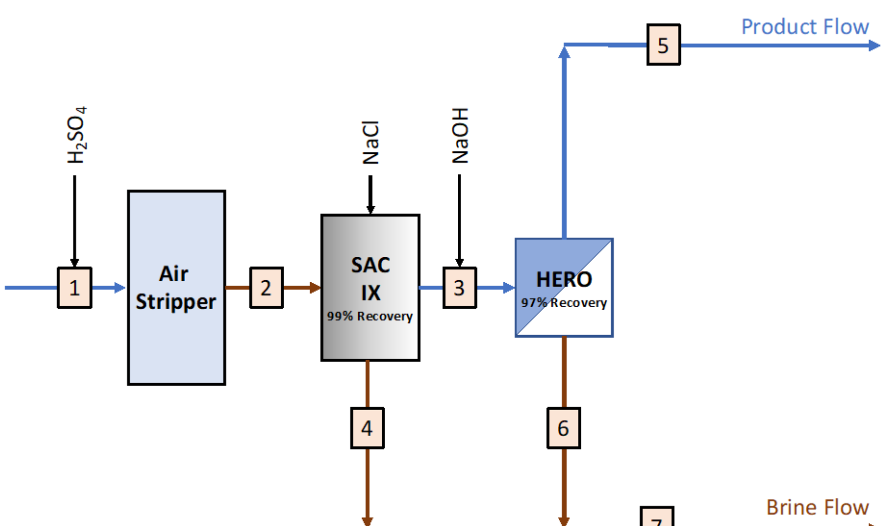


Figure 10. Process Flow Diagram of Modified HERO as Sole RO Treatment

Table 7. Expected Flow Rates for Modified HERO as Sole RO Treatment

Stream No.	Stream Description	Flow (AFY)	Flow (mgd)
1	Influent	20,000	17.85
2	Air Stripper Effluent	20,000	17.85
3	SAC Ion Exchange Permeate	19,780	17.65
4	SAC Ion Exchange Concentrate	220	0.20
5	HERO Permeate	19,226	17.16
6	HERO Concentrate	774	0.69
7	Combined Concentrate	994	0.89

Table 8. Recommended Chemical Doses for Modified HERO as Sole RO Treatment

Chemical Name	Chemical Formula	Dose (mg/L)	Annual Chemical Cost for 12,500 AFY/20,000 AFY	Purpose
Sulfuric Acid	H_2SO_4	140	$450,000/$720,000	Lower pH and remove alkalinity of primary RO concentrate
Sodium Chloride	NaCl	4,500	$11.3 million/$18.2 million	Regenerate ion exchange
Sodium Hydroxide	NaOH	100	$850,000/$1.3 million	Raise pH of HERO feed

Based on these two evaluations, either Modified HERO process would improve product water recovery. However, the chemical costs of each of the HERO processes alone are substantially more than the OPEX costs for the baseline RO process; thus, these treatment processes are eliminated because of poor economics. Additionally, a concentration of TDS exceeding 100,000 mg/L would require an infeasibly high RO feed pressure to overcome the osmotic pressure. Therefore, HERO is not recommended as an alternative treatment system for the Project.

2.7 Electrodialysis Reversal

The electrodialysis (ED) process moves dissolved salt ions through an electrodialysis stack consisting of alternating layers of cationic and anionic flat sheet membranes by application of an electric potential. Positive ions are attracted to the negative electrode, for example. The ED process creates alternating channels of desalted product water and concentrated reject water. Electrodialysis reversal (EDR) is a modification of the ED process that reverses the polarity of the applied electrical potential on the stack three to four times per hour. The reversal of polarity is intended to minimize the effects of scaling and fouling by converting product channels into concentrate channels. A schematic of the process is shown on Figure 11.

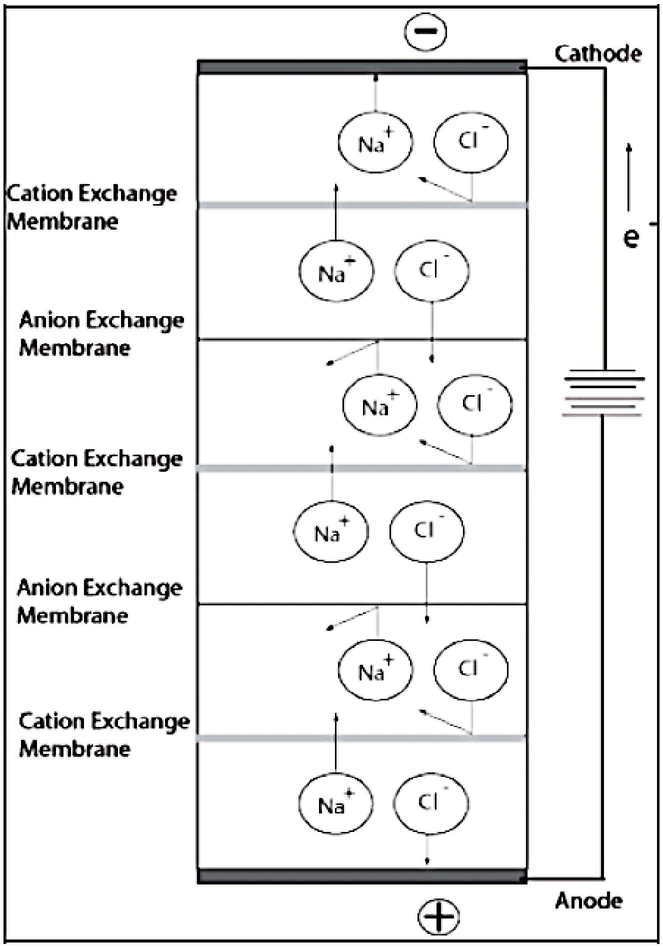


Figure 11. Schematic of Electrodialysis

All cations attempt to migrate to the cathode and all anions attempt to migrate to the anode. Only cations pass through cation-exchange membranes, and only anions pass through anion-exchange membranes. The net effect is the removal of salt from every other cell. In EDR, the polarities are regularly reversed, dislodging deposits on the membrane surface.

Advantages of EDR compared to RO include reduced chemical requirements, relatively lower scaling potential, and longer membrane life. However, this technology also has significant disadvantages. For example, EDR is effectively a proprietary process, where membranes, electrodes, and spacers must be purchased from one supplier: Suez. EDR is also less effective at removing TDS than RO. A study comparing the feasibility of ED and RO processes concluded that RO was more economical when the TDS exceeded 5,000 mg/L (Al-Karaghouli, 2013), and the groundwater TDS is expected to be much higher than that (Table 1). When considering all the factors discussed above, EDR is neither a good substitute for the primary RO process nor a viable approach for increasing recovery by treating the RO concentrate.

2.8 Interstage Lime Softening (Pellet Reactor)

The pellet reactor, in its first form, was promoted by the Permutit Company in the 1960s through the 1970s under the name “Spiractor.” In the 1970s, the Dutch developed the process further and now the reactors are quite popular in Europe. In a pellet reactor, softening is accomplished in an upflow fluidized bed of $CaCO_3$ crystals. A schematic of a pellet reactor is shown on Figure 12. If used at the desalter, its purpose would be to remove $CaCO_3$ from the primary RO concentrate, thereby enabling higher recovery to be achieved by a subsequent RO system.

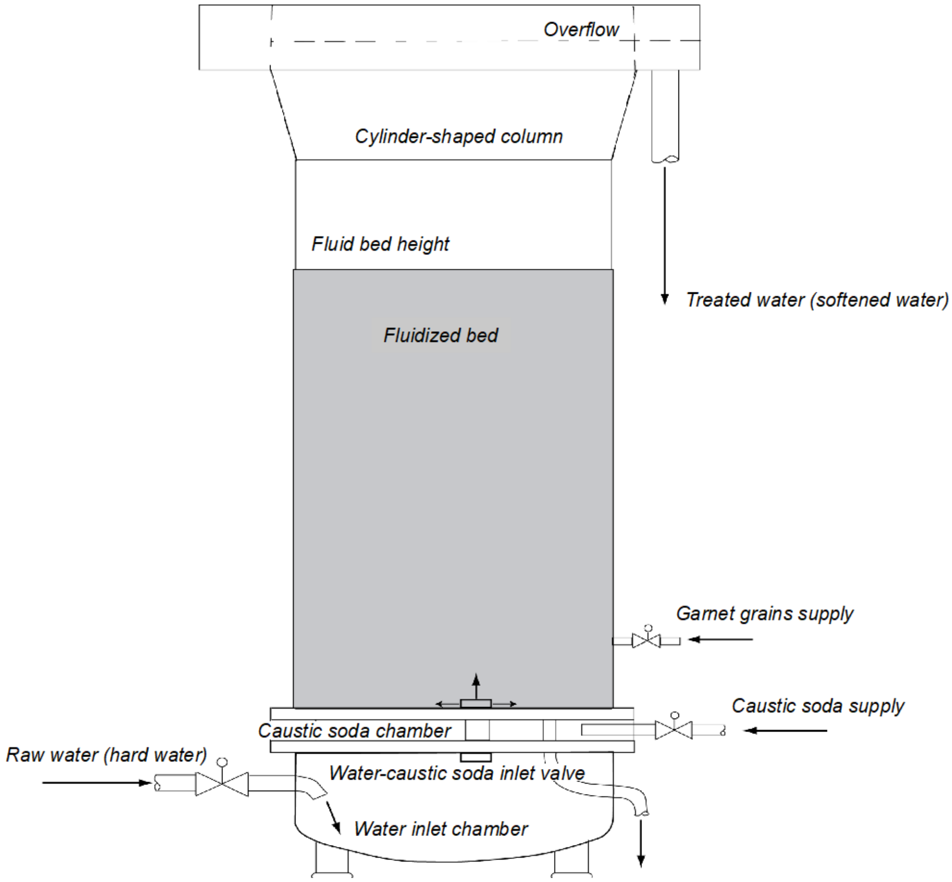


Figure 12. Schematic of a Pellet Reactor

This treatment process includes adding a base (usually NaOH) ahead of the reactor to convert alkalinity to carbonate, removing all of the calcium hardness as shown in the following equation:

$$NaOH + Ca(HCO_3)_2 \rightarrow CaCO_3 \downarrow + NaHCO_3 + H_2O$$

The nature of the precipitate is an advantage of the process. Because pH is kept relatively low, magnesium does not precipitate; rather, $CaCO_3$ crystallizes on the surface of the suspended material in the reactor, forming large "beads" of nearly pure $CaCO_3$. When solids must be withdrawn from the reactor, a port is opened, and a portion of the beads exits the reactor onto a surface where they quickly drain. The final product is basically "sand" composed of $CaCO_3$.

A pellet reactor was implemented at the Chino II groundwater desalter to treat 3.3 mgd of conventional RO brine, and the process at Chino II is similar to what would be required for this Program. The pellet reactor is followed by media filters to protect the downstream secondary conventional RO process. The media filter backwash waste is collected in a washwater tank and pumped to a clarifier. In addition to this equipment, a sand silo, sand washing equipment, a pellet storage area, and additional chemical storage and dosing are also included, as indicated in Appendix F. The footprint required for all of this equipment at Chino II is 240 by 40 feet (9,600 ft^2). For the WRD Program, the 12,500-AFY and 20,000-AFY Projects would produce baseline RO brines of 1.7 mgd and 2.6 mgd, respectively, and would require roughly 6,000 ft^2 and 8,000 ft^2, respectively, for the pellet reactor/secondary RO process. In accordance with Appendix B, the Elm and Faysmith 1-acre site does not have enough area to accommodate this additional equipment.

Even if footprint were available, the disadvantage of the process is that it sometimes produces turbid product water that requires further filtration. This turbidity is thought to be the result of spontaneous crystallization of $CaCO_3$ that occurs when the treatment chemicals are first introduced into the water.

Some of the fine crystals formed early in the process are not easily removed later. Even where calcium is concerned, the process does not remove permanent hardness (calcium hardness in excess of the alkalinity), although some new designs have been developed to address this issue.

Furthermore, regarding the process chemistry, the disadvantage of using a pellet reactor in this project is that it does not remove silica, which is the scalant that limits water recovery through RO processes. This problem could be resolved by increasing the pH in the pellet reactor high enough to precipitate magnesium hydroxide, which removes silica by adsorbing it to the magnesium hydroxide floc. This floc can be removed from the pellet reactor effluent by a solids contact reactor. Although effective, this increases costs and solids production. Because the calcium hardness in the RO concentrate exceeds the alkalinity, and silica removal would be expensive, a pellet reactor is not recommended for use in this project. While this focus was considering the use of a pellet reactor to treat the primary RO concentrate, the conclusion would be the same if it was treating the groundwater before RO because silica would still be the limiting scalant. Therefore, the pellet reactor is not suitable for the WRD Program.

3. Conclusion

Out of the eight treatment technologies that were evaluated as potential alternatives or supplements to the primary RO to increase the recovery and/or improve the process economics, none achieve the treatment goals at a cheaper cost within the available footprint. Table 9 indicates the reason that the treatment processes were eliminated.

Table 9. Summary of Alternate Treatment Technologies to the Baseline Conventional RO

Treatment Technology	Primary Treatment or Secondary Treatment (Primary RO Brine)	Issue or Fatal Flaw[a]	Comment
Nanofiltration	Primary	Will not produce potable water quality	High-rejection brackish RO required to meet TDS < 500 mg/L
Sacrificial Third RO Stage	Secondary	Uneconomical	
CCRO	Primary	Uneconomical	Proprietary system, and no major municipal systems as stand-alone primary treatment
CCRO	Secondary	Uneconomical	Proprietary system
Ion Exchange	Primary	Uneconomical	Chemical regeneration costs alone are substantially more expensive than total baseline RO OPEX
Traditional HERO	Primary	Downstream RO scaling, uneconomical	Chemical regeneration costs alone are more expensive than total baseline RO OPEX
Modified HERO	Primary or Secondary	Uneconomical	Chemical regeneration costs alone are more expensive than total baseline RO OPEX
EDR	Primary	Uneconomical	
Pellet Reactor	Secondary	Footprint	

[a] Uneconomical = baseline RO is cheaper

Modeling of the baseline two-stage RO system suggests that a proper design and an effective antiscalant should be able to achieve a recovery of 85 percent. Considering the high TDS in the RO feed, there is a risk that the RO membranes will require a high cleaning frequency that could reduce their longevity. Work by Trussell Technologies at Padre Dam and San Diego has demonstrated, for recycled water, that providing post-treatment (e.g., third-stage RO, CCRO, or HERO) while reducing the recovery of the primary two-stage RO significantly decreased cleaning frequencies, thereby extending membrane life and reducing maintenance costs. However, this work, which was done with recycled water, cannot be relied on to produce reliable quantitative estimates of the savings for this brackish groundwater project. Consequently, it is recommended that the facility be designed with a layout that would allow provision for post-treatment to be added in the future, should its benefits be demonstrated.

4. References

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Appendix A
Baseline RO Model Reports

Appendix A. Baseline RO Model Reports

Three model reports for the baseline process, including conventional two-stage RO, are attached, as follows:

1. The Hydranautics Integrated Membranes Solutions Design Software (2018) RO Simulation
2. The Avista Advisor Ci (Version 4.5.7) antiscalant simulation
3. The Tetra Tech RTW model of remineralization

The RTW Model

Ver. 4.0 ID:

STEP 1: Enter initial water characteristics.

Measured TDS	273	mg/L
Measured temperature	21	deg C
Measured pH	6.2	
Measured alk, as CaCO3	7.1	mg/L
Measured Ca, as CaCO3	40	mg/L
Measured Cl	161	mg/L
Measured SO4	4.8	mg/L

For CT and TTHM functions enter current:

Treated water pH		
Chlorine residual		mg/L
Chlorine or hypochlorite dose as chlorine equivalent		mg/L

STEP 2: Enter amount of each chemical to be added (expressed as 100% chemical). Press Ctrl+C to select chemicals for this list.

Alum *14H2O	0	mg/L
Carbon dioxide	47	mg/L
Caustic soda	51	mg/L
Ferric chloride (anhydrous)	0	mg/L
Ferrous sulfate *7H2O	0	mg/L
Hydrochloric acid	0	mg/L
Hydrofluosilicic acid	1	mg/L
Lime (slaked)	0	mg/L
Soda ash	0	mg/L
Sodium hypochlorite	3.5	mg/L

STEP 3: Adjust at Step 2 until interim water characteristics meet your criteria.

Theoretical interim water characteristics			Desired	Theoretical interim water characteristics			Desired
Interim alkalinity	71	mg/L	> 40 mg/L	Interim pH	8.59		6.8-9.3
Interim Ca, as CaCO3	40	mg/L	> 40 mg/L	Precipitation potential	1.96	mg/L	4-10 mg/L
Alk/(Cl+SO4)	0.4		> 5.0	Langelier index	0.29		>0

Press PAGE DOWN for additional initial, interim and final water characteristics if desired.

Calculated initial water characteristics

Initial acidity	25	mg/L
Initial Ca sat, as CaCO3	50367	mg/L
Initial DIC, as CaCO3	32	mg/L

Theoretical interim water characteristics

Interim acidity	68	mg/L
Interim Ca sat, as CaCO3	22	mg/L
Ryznar index	8.01	
Interim DIC, as CaCO3	139	mg/L
Aggressiveness Index	12.04	

Theoretical final water characteristics after CaCO3 precipitation

Final alkalinity	69	mg/L
Final Ca	38	mg/L
Final acidity	68	mg/L
Final pH	8.35	
Final DIC, as CaCO3	138	mg/L

Press PAGE UP to review measured initial water characteristics, chemical addition quantities and additional interim water characteristics.

CT and TTHM Results

Required chlorine residual to maintain current level of giardia inactivation	N/A	mg/L
Estimated maximum total trihalomethane concentration change from current level	N/A	%

AdvisorCi™

Technical Summary

Project: Unknown

Recovery: 86%	Date: 12-Feb-19
Customer:	Prepared by: Steve Alt
Engineer:	Water Analysis date: 08-Feb-19

Water Chemistry

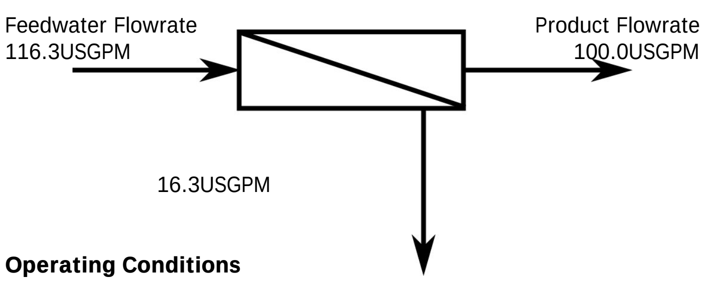
Ion	Entered Feed	Adjusted Feed	Calculated Concentrate
Sodium	1181.00	1309.02	9208.94
Potassium	65.00	65.00	453.05
Calcium	646.00	646.00	4574.60
Magnesium	351.00	351.00	2485.58
Iron	0.18	0.18	1.23
Manganese	0.29	0.29	1.97
Barium	0.82	0.82	5.82
Strontium	0.00	0.00	0.00
Aluminium	0.05	0.05	0.34
Ammonium	0.00	0.00	0.00
Anions			
Chloride	3980.00	4000.20	28207.24
Sulfate	224.00	224.00	1592.48
Bicarbonate	171.00	133.45	1096.26
Carbonate	0.00	0.46	99.80
Nitrate	1.40	1.40	9.27
Fluoride	0.16	0.16	1.11
Phosphate	0.00	0.00	0.00
Silica	28.00	28.00	198.90
Carbon Dioxide	0.00	50.56	28.97
TDS		6776.92	47965.57

Scaling Potential

Saturation Level	Entered Feed	Adjusted Feed	Calculated Concentrate
CCPP	35.80	-20.62	746.74mg/l
Calcium Sulfate $CaSO_4$	0.09	0.09	1.04x
Barium Sulfate $BaSO_4$	11.12	11.09	94.10x
Strontium Sulfate $SrSO_4$	0.00	0.00	0.00x
Calcium Phosphate	0.00	0.00	0.00x
Calcium Fluoride CaF_2	0.00	0.00	0.01x
Silica SiO_2	0.29	0.29	2.23x
Magnesium Hydroxide $Mg(OH)_2$	0.00	0.00	0.00x
Saturation Indices			
Langelier Saturation Index (LSI)	0.90	-0.21	2.41
Stiff and Davis Index (S&DI)	0.75	-0.36	1.72
System Parameters			
pH	7.90	6.90	7.88
Ionic Strength	0.15	0.15	1.11
Temperature (deg.C)	18.00	18.00	18.00

System Details

Used in Dosage and Feed Rate Calculations



Operating Conditions

% Recovery	**86**
Hours per Day	**24**
Days per Week	**7**
Weeks per Year	**52**
Load Factor	**100.0%**

Antiscalant Details

Antiscalant Selected	Vitec 4000
Dosage	3.37mg/l
Usage	4.70 lb per day.
Dosed Strength	100%
Pump Rate	0.50USGPD 1.31ml/min

There is one dosing pump and chemical tank per membrane train.
With 1 train, each pump will deliver 0.50USGPD

pH Correction

Chemical choice	Hydrochloric acid
Dosage:	19.5mg/l 100% HCl
Delivered Concentration:	36% HCl
Usage	75.43 lb per day.
Site Dilution:	100%
Pump Rate	7.65USGPD 20.13ml/min

There is one dosing pump and chemical tank per membrane train.
With 1 trains, each pump will deliver 7.65USGPD

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Avista TECHNOLOGIES

AdvisorCi™

Executive Summary

Project: Unknown

Recovery: 86%
Customer:
Engineer:

Date: 12-Feb-19
Prepared by: Steve Alt
Water Analysis date: 08-Feb-19

Membrane and Water Type

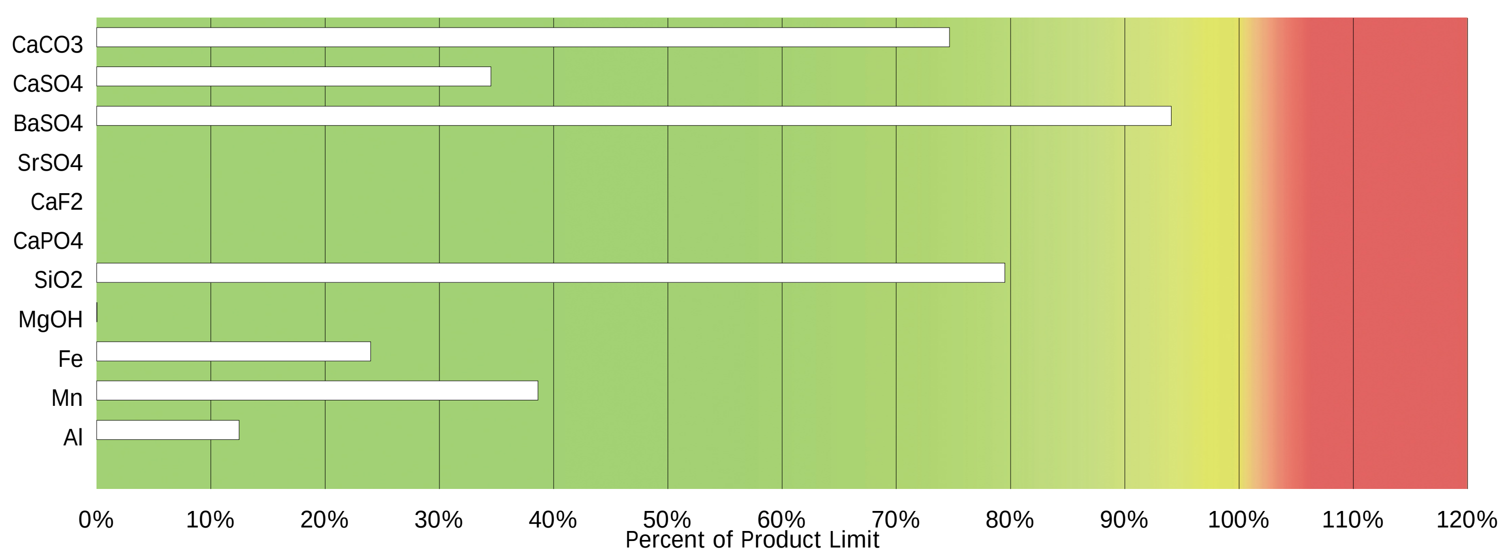
Feed Source:	**Unknown**
Membrane Manufacturer:	**Default**
Membrane Type:	**High Rej Brackish**

Antiscalant Recommendations

Recommended Product	Recommended Dosage	System Recovery
Vitec 4000	**3.37mg/l**	**86%**

Dosed Strength	Usage Per Day	pH Correction
100%	**4.70 lb**	**Hydrochloric acid**
		19.5mg/l

Saturation Indicies



While every effort has been made to ensure the accuracy of this program, no warranty, expressed or implied, is givenas actual application of the products is outside the control of Avista Technologies.

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Avista TECHNOLOGIES

AdvisorCi Version 4.5.7 Ci Engine version 180426 Antiscalant data file 1

Permeate Throttling (Variable), Turbo(75.6 %)

Project name	WRD GW FS		
Calculated by	S. Alt	Permeate flow/train	6588.00 gpm
HP Pump flow	7750.59 gpm	Raw water flow/train	7750.59 gpm
Feed pressure	375.4 psi	Permeate recovery	85.00 %
Feed temperature	21.5 °C(70.7°F)	Element age	5.0 years
Feed water pH	7.50	Flux decline %, per year	5.0
Chem dose, mg/l, 100 %	4.0 HCl	Fouling factor	0.77
Turbine exhaust pressure	4.35 psi	SP increase, per year	7.0 %
Turbo boost pressure	140.07 psi	Inter-stage pipe loss	3.000 psi
Specific energy	3.99 kwh/kgal		
Pass NDP	251.9 psi		
Average flux rate	14.6 gfd		
		Feed type	Brackish Well Non-Fouling

Pass - Stage	Perm. Flow gpm	Flow / Vessel Feed gpm	Flow / Vessel Conc gpm	Flux gfd	DP psi	Flux Max gfd	Beta	Stagewise Pressure Perm. psi	Stagewise Pressure Boost psi	Stagewise Pressure Conc psi	Perm. TDS mg/l	Element Type	Element Quantity	PV# x Elem #
1-1	4724.3	49.7	19.4	15.6	14.4	18.9	1.06	5	0	361	64.5	CPA6-LD	1092	156 x 7M
1-2	1869.6	39.8	15.2	12.7	9	23.8	1.18	5	140.1	489.1	328	CPA5-LD	532	76 x 7M

Ion (mg/l)	Raw Water	Feed Water	Permeate Water	Concentrate 1	Concentrate 2
Hardness, as CaCO3	3053.53	3053.53	22.813	20331.7	20331.7
Ca	646.00	646.00	4.826	1651.0	4301.4
Mg	351.00	351.00	2.622	897.1	2337.1
Na	1181.00	1181.00	41.766	2994.4	7676.0
K	65.00	65.00	2.861	164.4	419.3
NH4	0.00	0.00	0.000	0.0	0.0
Ba	0.820	0.820	0.006	2.1	5.5
Sr	0.000	0.000	0.000	0.0	0.0
Fe	0.200	0.200	0.001	0.5	1.3
Mn	0.300	0.300	0.002	0.8	2.0
Ni	3.200	3.200	0.024	8.2	21.3
H	0.00	0.00	0.001	0.0	0.0
CO3	1.84	0.71	0.001	5.9	49.1
HCO3	171.00	166.64	6.987	418.0	1039.3
SO4	224.00	224.00	1.107	572.9	1494.7
Cl	3980.00	3983.88	78.210	10146.8	26250.5
F	0.16	0.16	0.006	0.4	1.0
NO3	1.40	1.40	0.137	3.5	8.6
PO4	0.00	0.00	0.000	0.0	0.0
OH	0.00	0.00	0.000	0.0	0.0
SiO2	28.00	28.00	0.598	71.3	184.2
B	0.23	0.23	0.147	0.4	0.7
CO2	2.74	6.72	6.72	6.72	6.72
TDS	**6654.15**	**6652.54**	**139.30**	**16937.64**	**43791.99**
pH	**7.90**	**7.50**	**6.22**	**7.86**	**8.21**

Saturations	**Raw Water**	**Feed Water**	**Concentrate**	**Limits**
CaSO4 / ksp * 100, %	9	9	95	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	1018	1018	8917	10000
SiO2 saturation, %	22	23	130	140
CaF2 / ksp * 100, %	1	1	234	50000
Ca3(PO4)2 saturation index	0.0	0.0	0.0	2.4
CCPP, mg/l	54.14	47.35	687.89	
Langelier saturation index	1.20	0.79	3.04	2.5
Ionic strength	0.15	0.15	0.99	
Osmotic pressure, psi	66.3	66.3	435.6	

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Permeate Throttling (Variable), Turbo(75.6 %)

Project name WRD GW FS

Calculated by	S. Alt		Permeate flow/train	6588.00 gpm
HP Pump flow	7750.59	gpm	Raw water flow/train	7750.59 gpm
Feed pressure	375.4	psi	Permeate recovery	85.00 %
Feed temperature	21.5	°C(70.7°F)	Element age	5.0 years
Feed water pH	7.50		Flux decline %, per year	5.0
Chem dose, mg/l, 100 %	4.0	HCl	Fouling factor	0.77
Turbine exhaust pressure	4.35	psi	SP increase, per year	7.0 %
Turbo boost pressure	140.07	psi	Inter-stage pipe loss	3.000 psi
Specific energy	3.99	kwh/kgal		
Pass NDP	251.9	psi		
Average flux rate	14.6	gfd		

Feed type Brackish Well Non-Fouling

Pass - Stage	Perm. Flow gpm	Flow / Vessel Feed gpm	Flow / Vessel Conc gpm	Flux gfd	DP psi	Flux Max gfd	Beta	Stagewise Pressure Perm. psi	Stagewise Pressure Boost psi	Stagewise Pressure Conc psi	Perm. TDS mg/l	Element Type	Element Quantity	PV# x Elem #
1-1	4724.3	49.7	19.4	15.6	14.4	18.9	1.06	5	0	361	64.5	CPA6-LD	1092	156 x 7M
1-2	1869.6	39.8	15.2	12.7	9	23.8	1.18	5	140.1	489.1	328	CPA5-LD	532	76 x 7M

Pass - Stage	Element no.	Feed Pressure psi	Pressure Drop psi	Conc Osmo. psi	NDP psi	Permeate Water Flow gpm	Permeate Water Flux gfd	Beta	TDS	Ca	Mg	Na	Cl
									Permeate (Passwise cumulative)				
1-1	1	375.4	3.29	74	300.9	5.2	18.9	1.04	35	1.203	0.654	10.534	19.593
1-1	2	372.1	2.8	83.3	287.4	5	17.9	1.04	38.1	1.31	0.712	11.469	21.336
1-1	3	369.3	2.36	94.5	274.8	4.7	16.9	1.05	41.7	1.433	0.779	12.536	23.329
1-1	4	366.9	1.97	108.2	260.4	4.4	15.9	1.05	45.9	1.578	0.857	13.797	25.684
1-1	5	365	1.62	124.8	243.6	4.1	14.6	1.05	50.9	1.752	0.952	15.309	28.509
1-1	6	363.3	1.32	144.8	224	3.7	13.2	1.05	57	1.963	1.066	17.14	31.931
1-1	7	362	1.07	168.6	201	3.2	11.6	1.06	64.5	2.22	1.206	19.373	36.11
1-2	1	498	2.31	201.9	307.6	6.6	23.8	1.18	68.3	2.355	1.28	20.53	38.288
1-2	2	495.7	1.75	242.2	269.3	5.6	20	1.1	74.4	2.565	1.394	22.335	41.679
1-2	3	494	1.39	287.6	224.6	4.4	15.9	1.17	82.8	2.857	1.553	24.851	46.404
1-2	4	492.6	1.11	334.2	177.4	3.3	11.8	1.15	93.6	3.236	1.758	28.105	52.516
1-2	5	491.5	0.91	376.4	132	2.3	8.2	1.11	106.9	3.697	2.009	32.074	59.974
1-2	6	490.6	0.79	410.5	93	1.5	5.4	1.08	122.2	4.231	2.299	36.661	68.6
1-2	7	489.8	0.71	435.5	62.9	1	3.5	1.06	139.2	4.822	2.62	41.729	78.139

Permeate Throttling (Variable), Turbo(75.6 %)

Project name WRD GW FS

Calculated by	S. Alt		Permeate flow/train	6588.00	gpm
HP Pump flow	7750.59	gpm	Raw water flow/train	7750.59	gpm
Feed pressure	375.4	psi	Permeate recovery	85.00	%
Feed temperature	21.5	°C(70.7°F)	Element age	5.0	years
Feed water pH	7.50		Flux decline %, per year	5.0	
Chem dose, mg/l, 100 %	4.0	HCl	Fouling factor	0.77	
Turbine exhaust pressure	4.35	psi	SP increase, per year	7.0	%
Turbo boost pressure	140.07	psi	Inter-stage pipe loss	3.000	psi
Specific energy	3.99	kwh/kgal			
Pass NDP	251.9	psi			
Average flux rate	14.6	gfd			
			Feed type	Brackish Well Non-Fouling	

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

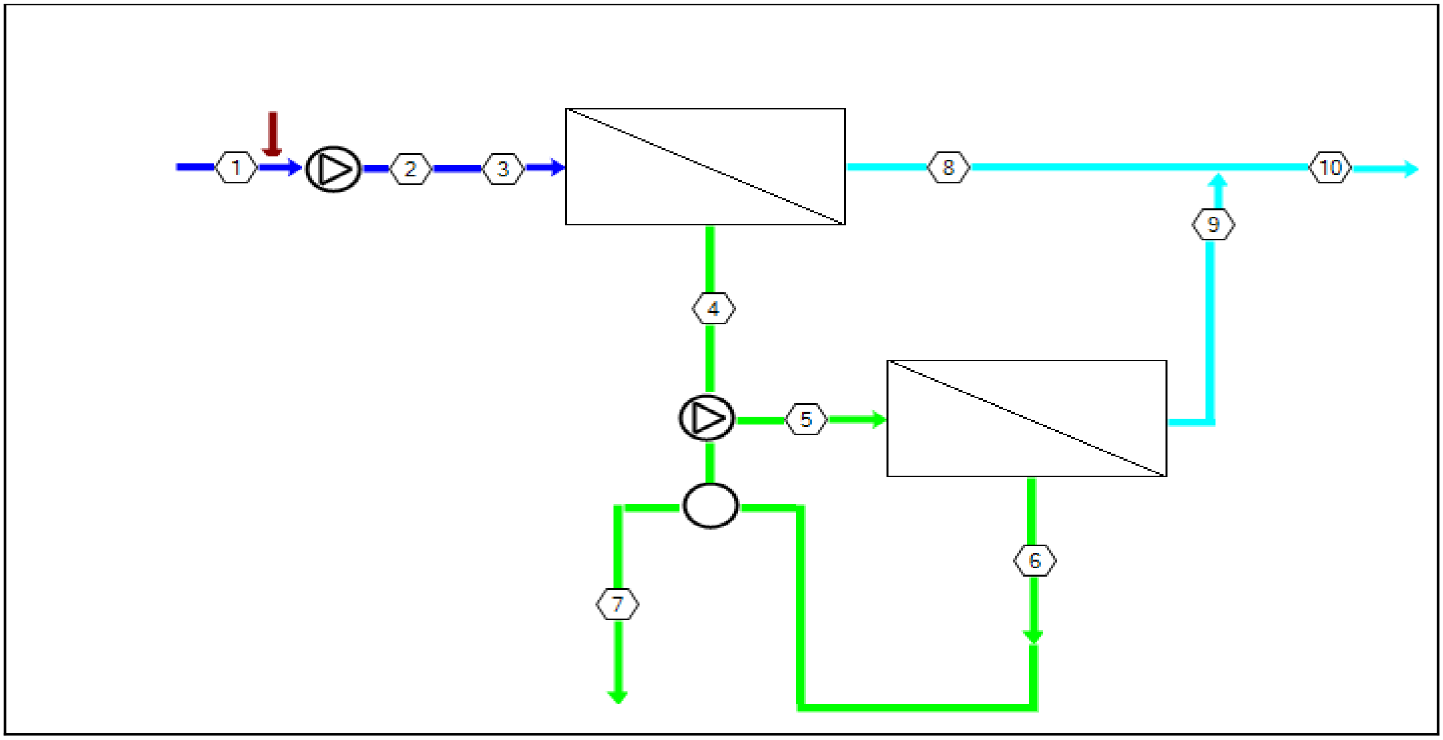
Concentrate Langelier saturation index (3.0) is higher than limit (2.5).

The above saturations limits only apply when using effective scale inhibitor or dispersant. Without scale inhibitor or dispersant, the saturation and precipitation limit of the contaminant should not exceed its solubility in solution.

Permeate Throttling (Variable), Turbo(75.6 %)

Project name WRD GW FS

Temperature : 21.5 °C Element age, P1 : 5.0 years



Stream No.	Flow (gpm)	Pressure (psi)	TDS (mg/l)	pH	Econd (µs/cm)
1	7751	0	6654	7.90	11979
2	7751	375	6653	7.50	11981
3	7751	375	6653	7.50	11981
4	3026	361	16938	7.86	28567
5	3026	498	16938	7.86	28567
6	1157	489	43792	8.21	69854
7	1157	4.35	43792	8.21	69854
8	4724	5.00	64.5	5.90	138
9	1870	5.00	328	6.58	701
10	6588	5.00	139	6.22	298

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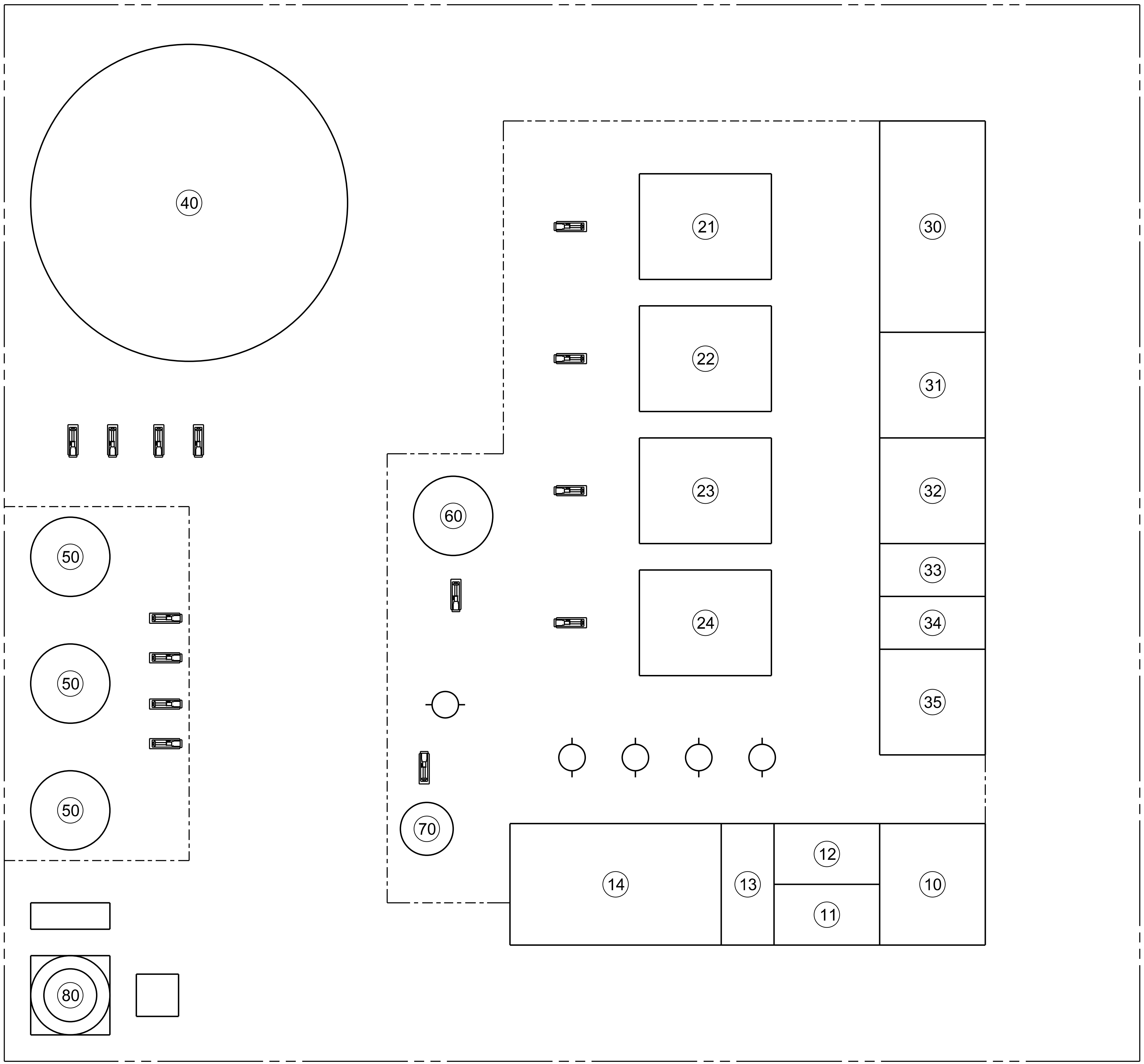
Appendix B
20,000-AFY Baseline Process Layout on 1-acre Site



FACILITY LEGEND

XX	FACILITY LEGEND
10	CONTROL ROOM
11	RESTROOM / SHOWER
12	LAB
13	TELECOM / SERVER
14	ELECTRICAL
21	REVERSE OSMOSIS 1
22	REVERSE OSMOSIS 2
23	REVERSE OSMOSIS 3
24	REVERSE OSMOSIS 4
30	NaOH STORAGE AND FEED
31	NaOCl STORAGE AND FEED
32	NH4OH STORAGE AND FEED
33	FSA STORAGE AND FEED
34	TI STORAGE AND FEED
35	HCl STORAGE AND FEED
40	CLEARWELL (1 HR)
50	A.S. UNITS
60	NEUTRALIZATION
70	CIP
80	CARBON DIOXIDE

N

0 10 20 30

1"=10'

NO.	DATE	REVISION	BY	APVD

DSGN S ALT DR L BENTHIN CHK APVD

Project Description
Project Location
Client Name
Client Location

JACOBS

CIVIL

OVERALL SITE PLAN

VERIFY SCALE

BAR IS ONE INCH ON ORIGINAL DRAWING.

0 1"

DATE

PROJ

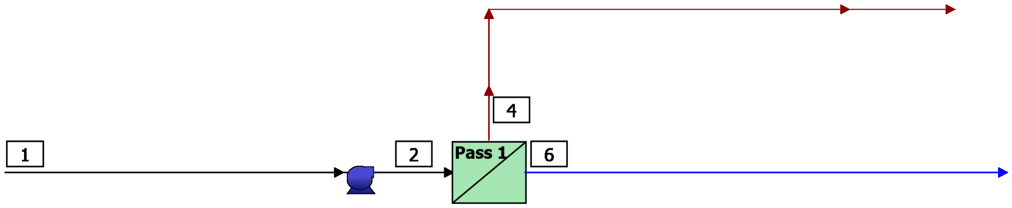
DWG 05-C-2000

SHEET of

Appendix C
Nanofiltration Projection

RO Summary Report

RO System Flow Diagram



#	Description	Flow (gpm)	TDS (mg/L)	Pressure (psi)
1	Raw Feed to Pump	7,755	6,784	0.0
2	Net Feed to Pass 1	7,750	6,788	193.7
4	Total Concentrate from Pass 1	1,165	41,166	369.2
6	Total Permeate from Pass 1	6,588	698.4	5.0

RO System Overview

Total # of Trains	1	Online =	1	Standby =	0	RO Recovery	85.0 %
System Flow Rate	(gpm)	Net Feed =	7,755	Net Product =	6,588		

Pass		Pass 1
Stream Name		Stream 1
Water Type		Well Water (SDI < 3)
Number of Elements		1624
Total Active Area	(m^2)	60350
Feed Flow per Pass	(gpm)	7,750
Feed TDS[a]	(mg/L)	6,788
Feed Pressure	(psi)	193.7
Flow Factor		0.85
Permeate Flow per Pass	(gpm)	6,588
Pass Average flux	(gfd)	14.6
Permeate TDS[a]	(mg/L)	698.4
Pass Recovery		85.0 %
Average NDP	(psi)	84
Specific Energy	(kWh/m^3)	0.77
Temperature	(°C)	21.5
pH		7.9
Chemical Dose		
RO System Recovery		85.0 %
Net RO System Recovery		85.0%

Footnotes:

[a]Total Dissolved Solids includes ions, SiO_2 and $B(OH)_3$. It does not include NH_3 and CO_2

RO Flow Table (Stage Level) - Pass 1

Stage	Elements	#PV	#Els per PV	Feed				Concentrate			Permeate			
				Feed Flow	Recirc Flow	Feed Press	Boost Press	Conc Flow	Conc Press	Press Drop	Perm Flow	Avg Flux	Perm Press	Perm TDS
			PV	(gpm)	(gpm)	(psi)	(psi)	(gpm)	(psi)	(psi)	(gpm)	(gfd)	(psi)	(mg/L)
1	NF90-400/34i	156	7	7,750	0.00	189.2	0.0	3,099	179.1	10.1	4,654	15.3	5.0	445.7
2	NF90-400/34i	76	7	3,097	0.00	376.2	200.0	1,165	369.2	7.0	1,934	13.1	5.0	1,306

RO Solute Concentrations - Pass 1

Concentrations (mg/L as ion)						
	Feed	Concentrate		Permeate		
		Stage1	Stage2	Stage1	Stage2	Total
NH_4^+	0.00	0.00	0.00	0.00	0.00	0.00
K^+	65.00	153.4	378.4	6.17	17.80	9.58
Na^+	1,312	3,102	7,669	121.2	350.2	188.5
Mg^{+2}	351.0	857.9	2,213	13.56	41.19	21.67
Ca^{+2}	646.0	1,580	4,080	24.25	73.86	38.82
Sr^{+2}	0.00	0.00	0.00	0.00	0.00	0.00
Ba^{+2}	0.82	2.01	5.18	0.03	0.09	0.05
CO_3^{-2}	3.47	13.69	53.82	0.00	0.01	0.00
HCO_3^-	171.0	407.2	1,013	7.09	21.45	11.31
NO_3^-	1.40	2.80	5.70	0.47	1.05	0.64
Cl^-	3,980	9,556	24,111	268.3	786.5	420.4
F^-	0.16	0.37	0.91	0.02	0.05	0.03
SO_4^{-2}	224.0	555.7	1,461	3.22	10.02	5.22
SiO_2	28.00	67.98	173.8	1.39	4.20	2.21
Boron	0.00	0.00	0.00	0.00	0.00	0.00
CO_2	1.87	4.49	13.39	2.45	6.42	3.62
TDS[a]	6,784	16,300	41,166	445.7	1,306	698.4
pH	7.9	7.8	7.6	6.6	6.6	6.6

Footnotes:

[a]Total Dissolved Solids includes ions, SiO_2 and $B(OH)_3$. It does not include NH_3 and CO_2

RO Design Warnings

Design Warning		Limit	Value	Pass	Stage	Element	Product
Permeate Flow Rate > Maximum Limit	(gpm)	6.31	7.14	1	1	1	NF90-400/34i
Permeate Flow Rate > Maximum Limit	(gpm)	6.31	8.17	1	2	1	NF90-400/34i
Element Recovery > Maximum Limit	(%)	19.0	20.1	1	2	1	NF90-400/34i

RO Flow Table (Element Level) - Pass 1

Stage	Element	Element Name	Recovery (%)	Feed Flow (gpm)	Feed Press (psi)	Feed TDS (mg/L)	Conc Flow (gpm)	Perm Flow (gpm)	Perm Flux (gfd)	Perm TDS (mg/L)
1	1	NF90-400/34i	14.4	49.7	189.2	6,788	42.6	7.14	25.7	196.2
1	2	NF90-400/34i	14.2	42.6	186.8	7,893	36.5	6.06	21.8	260.5
1	3	NF90-400/34i	13.7	36.5	184.9	9,159	31.5	5.01	18.0	350.9
1	4	NF90-400/34i	12.8	31.5	183.3	10,560	27.5	4.04	14.5	478.4
1	5	NF90-400/34i	11.6	27.5	182.0	12,041	24.3	3.18	11.5	655.6
1	6	NF90-400/34i	10.2	24.3	180.9	13,533	21.8	2.48	8.9	895.2
1	7	NF90-400/34i	8.8	21.8	179.9	14,968	19.9	1.93	6.9	1,206
2	1	NF90-400/34i	20.1	40.8	376.2	16,310	32.6	8.17	29.4	461.1
2	2	NF90-400/34i	18.2	32.6	374.4	20,279	26.7	5.94	21.4	717.3
2	3	NF90-400/34i	15.5	26.7	373.1	24,628	22.5	4.13	14.9	1,128
2	4	NF90-400/34i	12.5	22.5	372.0	28,926	19.7	2.82	10.1	1,755
2	5	NF90-400/34i	9.9	19.7	371.2	32,797	17.8	1.94	7.0	2,635
2	6	NF90-400/34i	7.9	17.8	370.4	36,086	16.4	1.40	5.0	3,737
2	7	NF90-400/34i	6.5	16.4	369.8	38,836	15.3	1.06	3.8	4,974

Footnotes:

[a]Total Dissolved Solids includes ions, SiO_2 and $B(OH)_3$. It does not include NH_3 and CO_2

RO Solubility Warnings

Warning	Pass No
Stiff & Davis Stability Index > 0	1
$BaSO_4$ (% saturation) > 100	1
SiO_2 (% saturation) > 100	1
Anti-scalants may be required. Consult your anti-scalant manufacturer for dosing and maximum allowable system recovery.	1

RO Chemical Adjustments

	Pass 1 Feed	RO 1st Pass Conc
pH	7.9	7.6
Langelier Saturation Index	1.2	2.4
Stiff & Davis Stability Index	0.8	1.4
TDS[a] (mg/l)	6,784	41,166
Ionic Strength (molal)	0.15	0.98
HCO_3^- (mg/L)	171.0	1,013
CO_2 (mg/l)	1.87	13.39
CO_3^{-2} (mg/L)	3.47	53.82
$CaSO_4$ (% saturation)	9.7	91.6
$BaSO_4$ (% saturation)	990.7	7,926
$SrSO_4$ (% saturation)	0.0	0.0
CaF_2 (% saturation)	0.6	70.9
SiO_2 (% saturation)	22.9	147.3
$Mg(OH)_2$ (% saturation)	0.1	0.2

Footnotes:

[a]Total Dissolved Solids includes ions, SiO_2 and $B(OH)_3$. It does not include NH_3 and CO_2

Appendix D
Final Single-stage RO Modeling Results

Appendix D. Final Single-stage RO Modeling Results

As described in Section 2.2, a single-stage RO system, which would treat the concentrate leaving the baseline RO system, was modeled using the Hydranautics model, Integrated Membranes Solutions Design Software (2016).

Nitto HYDRANAUTICS Nitto Group Company

Basic Design

Project name	WRD - 3rd Stage - 2.28.19		Page : 1/4
Calculated by	Liana Olivas	Permeate flow	230.00 gpm
HP Pump flow	1150.00 gpm	Raw water flow	1150.00 gpm
Feed pressure	539.0 psi	Permeate recovery	20.00 %
Feed temperature	21.7 °C(71.0°F)	Element age	5.0 years
Feed water pH	7.50	Flux decline %, per year	5.0
Chem dose, mg/l, 100 %	6.6 HCl	Fouling factor	0.77
Specific energy	25.59 kwh/kgal	SP increase, per year	7.0 %
Pass NDP	78.7 psi		
Average flux rate	3.11 gfd		
		Feed type	Sea Well Conventional

Pass - Stage	Perm. Flow gpm	Flow / Vessel Feed gpm	Flow / Vessel Conc gpm	Flux gfd	DP psi	Flux Max gfd	Beta	Stagewise Pressure Perm. psi	Stagewise Pressure Boost psi	Stagewise Pressure Conc psi	Perm. TDS mg/l	Element Type	Element Quantity	PV# x Elem #
1-1	229.8	30.3	24.2	3.1	8.2	6.8	1.06	0	0	530.8	2156.6	CPA5-LD	266	38 x 7

Ion (mg/l)	Raw Water	Feed Water	Permeate Water	Concentrate 1
Hardness, as CaCO3	20226.19	20226.19	359.711	25187.1
Ca	4279.00	4279.00	76.099	5328.5
Mg	2325.00	2325.00	41.349	2895.3
Na	7636.00	7636.00	647.575	9381.1
K	417.00	417.00	44.113	510.1
NH4	0.00	0.00	0.000	0.0
Ba	5.400	5.400	0.096	6.7
Sr	0.000	0.000	0.000	0.0
CO3	63.60	32.63	0.071	55.7
HCO3	904.00	924.82	92.854	1117.6
SO4	1487.00	1487.00	17.431	1854.0
Cl	26205.00	26211.43	1224.835	32450.9
F	1.00	1.00	0.093	1.2
NO3	8.70	8.70	2.074	10.4
PO4	0.00	0.00	0.000	0.0
SiO2	184.00	184.00	9.361	227.6
B	0.70	0.70	0.692	0.7
CO2	7.42	15.15	15.15	15.15
TDS	**43516.40**	**43512.70**	**2156.65**	**53839.82**
pH	**7.80**	**7.50**	**6.94**	**7.53**

Saturations	**Raw Water**	**Feed Water**	**Concentrate**	**Limits**
CaSO4 / ksp * 100, %	95	95	125	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	8813	8819	11381	10000
SiO2 saturation, %	144	151	186	140
CaF2 / ksp * 100, %	216	216	484	50000
Ca3(PO4)2 saturation index	0.0	0.0	0.0	2.4
Langelier saturation index	2.57	2.28	2.48	2.5
Ionic strength	0.99	0.99	1.22	
Osmotic pressure, psi	433.4	433.5	536.0	

Basic Design

Project name	WRD - 3rd Stage - 2.28.19			Page : 2/4
Calculated by	Liana Olivas		Permeate flow	230.00 gpm
HP Pump flow		1150.00 gpm	Raw water flow	1150.00 gpm
Feed pressure		539.0 psi	Permeate recovery	20.00 %
Feed temperature		21.7 °C(71.0°F)	Element age	5.0 years
Feed water pH		7.50	Flux decline %, per year	5.0
Chem dose, mg/l, 100 %		6.6 HCl	Fouling factor	0.77
Specific energy		25.59 kwh/kgal	SP increase, per year	7.0 %
Pass NDP		78.7 psi		
Average flux rate		3.11 gfd		
			Feed type	Sea Well Conventional

Pass - Stage	Perm. Flow	Flow / Vessel Feed	Flow / Vessel Conc	Flux	DP	Flux Max	Beta	Stagewise Pressure Perm.	Stagewise Pressure Boost	Stagewise Pressure Conc	Perm. TDS	Element Type	Element Quantity	PV# x Elem #
	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l			
1-1	229.8	30.3	24.2	3.1	8.2	6.8	1.06	0	0	530.8	2156.6	CPA5-LD	266	38 x 7

Pass - Stage	Element no.	Feed Pressure	Pressure Drop	Conc Osmo.	NDP	Permeate Water Flow	Permeate Water Flux	Beta	Permeate (Passwise cumulative) TDS	Ca	Mg	Na	Cl
		psi	psi	psi	psi	gpm	gfd						
1-1	1	539	1.36	461.5	127.1	1.9	6.8	1.06	888.9	31.253	16.981	267.264	504.09
1-1	2	537.7	1.26	479	75.9	1.1	3.9	1.04	1162.7	40.902	22.224	349.587	659.568
1-1	3	536.4	1.2	494.3	64.6	0.9	3.2	1.03	1370	48.221	26.201	411.824	777.329
1-1	4	535.2	1.15	507.4	54.3	0.7	2.6	1.03	1564.8	55.109	29.944	470.258	888.05
1-1	5	534	1.11	518.5	45.4	0.6	2.1	1.02	1759.1	61.992	33.683	528.518	998.576
1-1	6	532.9	1.08	527.9	38.1	0.5	1.7	1.02	1956.2	68.982	37.481	587.57	1110.734
1-1	7	531.9	1.05	535.7	32.2	0.4	1.4	1.01	2156.7	76.099	41.349	647.575	1224.835

Basic Design

Project name	WRD - 3rd Stage - 2.28.19				
Calculated by	Liana Olivas		Permeate flow	230.00	gpm
HP Pump flow	1150.00	gpm	Raw water flow	1150.00	gpm
Feed pressure	539.0	psi	Permeate recovery	20.00	%
Feed temperature	21.7	°C(71.0°F)	Element age	5.0	years
Feed water pH	7.50		Flux decline %, per year	5.0	
Chem dose, mg/l, 100 %	6.6	HCl	Fouling factor	0.77	
Specific energy	25.59	kwh/kgal	SP increase, per year	7.0	%
Pass NDP	78.7	psi			
Average flux rate	3.11	gfd			
			Feed type	Sea Well Conventional	

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

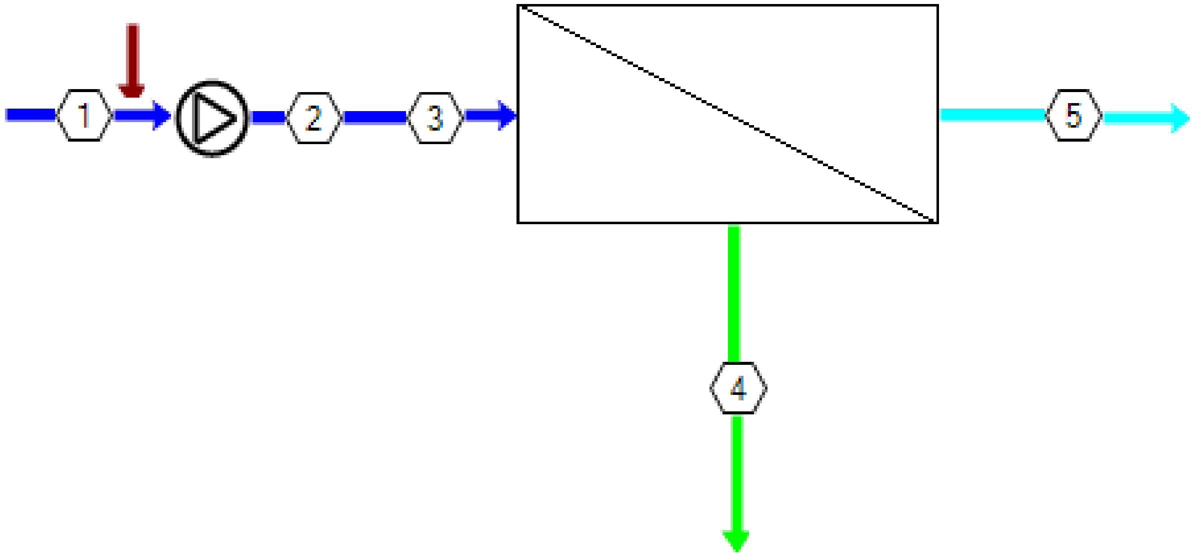
The difference between conc. pressure and conc. osmotic pressure is less than 5 psi.

Concentrate saturation of $BaSO_4$ (11381.24 %) is higher than limit 10000 %.
Concentrate saturation of SiO_2 (186.29 %) is higher than limit 140 %.

Basic Design

Project name WRD - 3rd Stage - 2.28.19

Temperature : 71.0 °F Element age, P1 : 5.0 years



Stream No.	Flow (gpm)	Pressure (psi)	TDS	pH	B
1	1150	0	43516	7.80	0.700
2	1150	539	43513	7.50	0.700
3	1150	539	43513	7.50	0.700
4	920	531	53840	7.53	0.702
5	230	0	2157	6.94	0.692

Appendix E
CCRO Modeling Results

Appendix E. CCRO Modeling Results

As described in Section 2.3, Desalitech provided antiscalant projections with Avista's model, Advisor^{TM} Ci (Version 4.6.0). The model was based on a silica saturation of 115 percent and an overall recovery of 90 percent. In addition, a CCRO projection was performed on Lanxess LewaPlus software.

AdvisorCi™

Technical Summary

Project: Unknown

Recovery: 90%
Customer:
Engineer:

Date: 13-Mar-19
Prepared by: Michael Boyd
Water Analysis date: 13-Mar-19

Water Chemistry

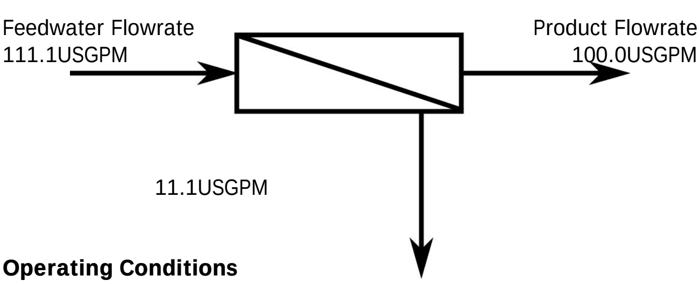
Ion	Entered Feed	Adjusted Feed	Calculated Concentrate
Sodium	1181.00	1309.02	12892.51
Potassium	65.00	65.00	634.27
Calcium	646.00	646.00	6404.44
Magnesium	351.00	351.00	3479.81
Iron	0.18	0.18	1.73
Manganese	0.29	0.29	2.75
Barium	0.82	0.82	8.15
Strontium	0.00	0.00	0.00
Aluminium	0.05	0.05	0.48
Ammonium	0.00	0.00	0.00
Anions			
Chloride	3980.00	3980.00	39298.52
Sulfate	224.00	269.73	2672.92
Bicarbonate	171.00	106.93	1016.46
Carbonate	0.00	0.18	80.03
Nitrate	1.40	1.40	12.97
Fluoride	0.16	0.16	1.56
Phosphate	0.00	0.00	0.00
Silica	28.00	28.00	278.46
Carbon Dioxide	0.00	62.84	40.44
TDS		6776.92	66825.52

Scaling Potential

Saturation Level	Entered Feed	Adjusted Feed	Calculated Concentrate
CCPP	35.01	-41.66	785.33mg/l
Calcium Sulfate CaSO4	0.09	0.11	1.88x
Barium Sulfate BaSO4	11.12	13.25	147.88x
Strontium Sulfate SrSO4	0.00	0.00	0.00x
Calcium Phosphate	0.00	0.00	0.00x
Calcium Fluoride CaF2	0.00	0.00	0.01x
Silica SiO2	0.29	0.29	3.26x
Magnesium Hydroxide Mg(OH)2	0.00	0.00	0.00x
Saturation Indices			
Langelier Saturation Index (LSI)	0.90	-0.59	2.43
Stiff and Davis Index (S&DI)	0.75	-0.74	1.70
System Parameters			
pH	7.90	6.60	7.73
Ionic Strength	0.15	0.15	1.57
Temperature (deg.C)	18.00	18.00	18.00

System Details

Used in Dosage and Feed Rate Calculations



Operating Conditions

% Recovery	**90**
Hours per Day	**24**
Days per Week	**7**
Weeks per Year	**52**
Load Factor	**100.0%**

Antiscalant Details

Antiscalant Selected	Vitec 7400
Dosage	XX mg/l
Usage	0.00 lb per day.
Dosed Strength	100%
Pump Rate	0.00USGPD 0.00ml/min

There is one dosing pump and chemical tank per membrane train.
With 1 train, each pump will deliver 0.00USGPD

pH Correction

Chemical choice	Sulfuric acid
Dosage:	43.9mg/l 100% H2SO4
Delivered Concentration:	98% H2SO4
Usage	59.68 lb per day.
Site Dilution:	100%
Pump Rate	3.91USGPD 10.29ml/min

There is one dosing pump and chemical tank per membrane train.
With 1 trains, each pump will deliver 3.91USGPD

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Avista TECHNOLOGIES

AdvisorCi Version 4.6.0 Ci Engine version 1811102 Antiscalant data file 3

AdvisorCi™

Executive Summary

Project: Unknown

Recovery: 90%	Date: 13-Mar-19
Customer:	Prepared by: Michael Boyd
Engineer:	Water Analysis date: 13-Mar-19

Membrane and Water Type

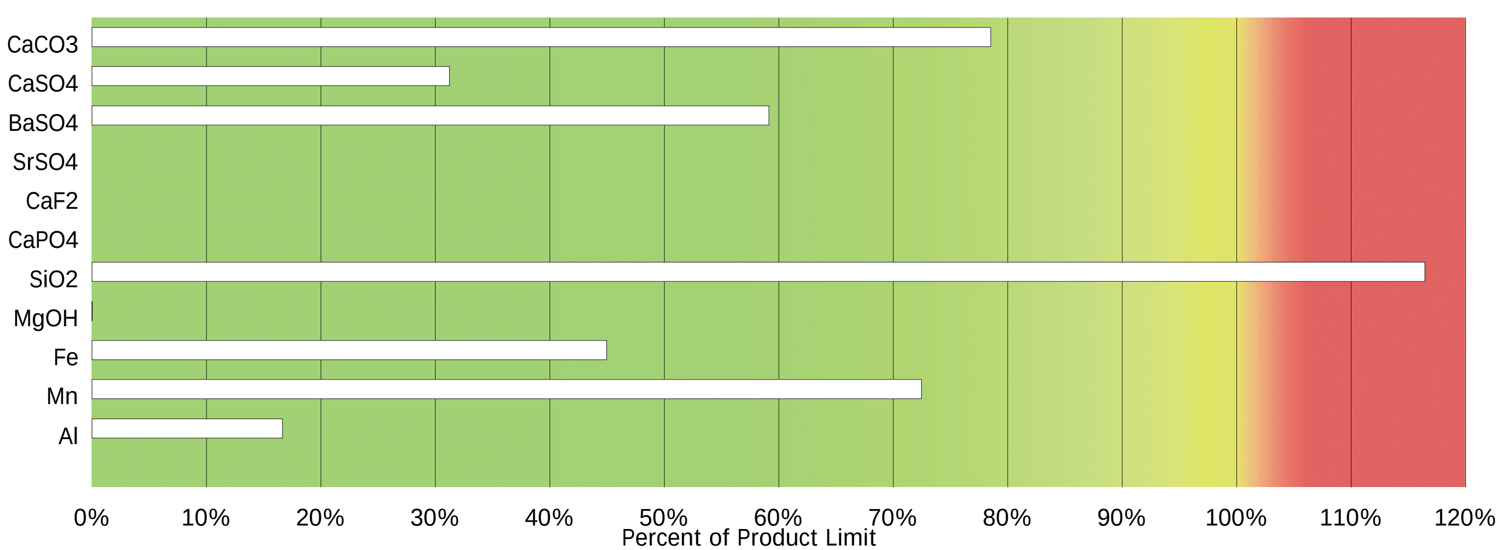
Feed Source:	**Unknown**
Membrane Manufacturer:	**Default**
Membrane Type:	**High Rej Brackish**

Antiscalant Recommendations

Recommended Product	Recommended Dosage	System Recovery
Vitec 7400	**XX mg/l**	**90%**

Dosed Strength	Usage Per Day	pH Correction
100%	**0.00 lb**	**Sulfuric acid**
		43.9mg/l

Saturation Indicies



While every effort has been made to ensure the accuracy of this program, no warranty, expressed or implied, is givenas actual application of the products is outside the control of Avista Technologies.

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Avista TECHNOLOGIES

General specification

Project description			
Project No.:	32	Date:	2019-04-19
Project title:	WRD GW FS CCRO		
Project subtitle:			
Remarks:			
Customer			
Name:		Phone:	
Location:		Fax:	
Contact:		Mail:	
Designer			
Name:	Jacobs	Phone:	
Location:		Fax:	
Contact:	Steve Alt	Mail:	steve.alt@jacobs.com

Water analysis of feed Date of sampling: 2019-04-19

Water source:			
Water type:		Country: United States	
Source flow rate:	7750.00 [gpm]		

Cations	Original Unit	[mg/l]	[gr $CaCO_3$/gal]	Anions	Original Unit	[mg/l]	[gr $CaCO_3$/gal]
Na	1181.00000 [mg/l]	1181.00000	149.72358	Cl	3980.00000 [mg/l]	3980.00000	327.22473
Ca	646.00000 [mg/l]	646.00000	93.95374	SO_4	224.00000 [mg/l]	224.00000	13.59298
Mg	351.00000 [mg/l]	351.00000	84.13037	CO_3	1.85576 [mg/l]	1.85576	0.18029
K	65.00000 [mg/l]	65.00000	4.84525	HCO_3	171.00000 [mg/l]	171.00000	8.16776
Sr	0.00000 [mg/l]	0.00000	0.00000	NO_3	1.40000 [mg/l]	1.40000	0.06581
Ba	0.82000 [mg/l]	0.82000	0.03480	F	0.16000 [mg/l]	0.16000	0.02454
NH_4	0.00000 [mg/l]	0.00000	0.00000	SiO_2	28.00000 [mg/l]	28.00000	1.35834
Fe(II)	0.20000 [mg/l]	0.20000	0.02088	B	0.23000 [mg/l]	0.23000	0.06201
Mn	0.30000 [mg/l]	0.30000	0.03183	PO_4	0.00000 [mg/l]	0.00000	0.00000
Al	0.00000 [mg/l]	0.00000	0.00000	Br	0.00000 [mg/l]	0.00000	0.00000
				As(III)	0.00000 [mg/l]	0.00000	0.00000
				As(V)	0.00000 [mg/l]	0.00000	0.00000
H+		0.00001	0.00004	OH-		0.02559	0.00438
Sum C			332.74046	Sum A			349.25612
+ Na		130.30743	16.51998	+ Cl		0.00000	0.00000

Others

Temperature	70.70 [°F]	Turbidity	0.00 [NTU]	Fe (total)	0.00 [ppm]
pH	7.90	SDI	0.00	Free chlorine	0.00 [ppm]
CO_2	2.74 [mg/l]	TSS	0.00 [ppm]	H_2S	0.00 [ppm]
		TOC	0.00 [ppm]		

Summary

TDS	6781.27 [ppm]
Conductivity	11030.91 [µS/cm]
Osmotic pressure	66.68 [psi]
Ionic strength	0.150

Comments

Notes and warning messages

- Design: Saturation values exceeded. Adjust feed water pH or use a scaling inhibitor.

System parameters

Water type	
Temperature	70.70 [°F]
Recovery	90.00 [%]
Feed flow	7750.00 [gpm]
Feed flow to stage 1	7750.00 [gpm]
Permeate flow	6975.00 [gpm]
System permeate flow	6975.00 [gpm]

pH adjustment

pH	7.50
Chemical	HCl
Dosing (100%)	4.01 [mg/l]

Membrane parameters

Default membrane age	5.00 [a]
Average membrane age	5.00 [a]
Flux decline ratio	5.00 [%]
Salt passage increase	7.00 [%/a]
Average permeate flux	14.59 [gfd]
Permeate salinity	79.55 [mg/l]
Permeate conductivity	148.93 [µS/cm]

System configuration

Pass	1 / 1
Number of vessels / elements	344 / 1720
Vessel length / Elements per vessel	6 / 5
System volume	11671.64 [gal]
Permeate volume (per batch)	105044.80 [gal]
Element type	RO S400 HF
Permeate blending	No
Permeate recirculation	No

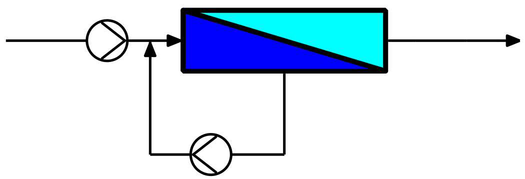
Closed circuit details

Entire sequence time	15.06 [min]
Total cycles	10.00
CC fraction of sequence	89.36 [%]
PF fraction of sequence	10.64 [%]

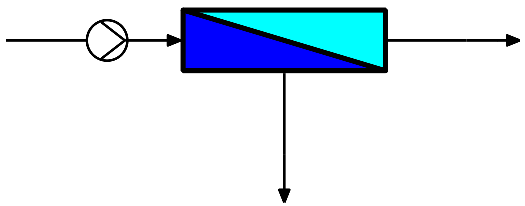
CC recovery	49.30 [%]
PF recovery	20.00 [%]
PF flow increase	20.00 [%]
Extra volume in piping	5.00 [%]

Design of pass 1

Mode CC



Mode PF



	Feed			**Concentrate**			Recirculation	**Permeate**			
	Flow	per vessel	Pressure	Flow	per vessel	Pressure	Flow	Flow	Flux	Pressure	TDS
Mode	[gpm]	[gpm]	[psi]	[gpm]	[gpm]	[psi]	[gpm]	[gpm]	[gfd]	[psi]	[mg/l]
CC1	15393.90	44.75	440.82	0.00	22.69	426.71	7805.37	7588.54	15.87	0.00	27.68
CC9	15393.92	44.75	924.19	0.00	22.69	910.89	7805.35	7588.55	15.87	0.00	126.00
PF	9106.25	26.47	269.38	7285.00	21.18	260.38	0.00	1821.25	3.81	0.00	188.62

Composition and scaling of pass 1

Composition		Feed Raw water	Feed Treated	Feed Blended	Concentrate	Permeate Average	Permeate Final Average
Ions		[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]
Na		1311.307	1311.307	1311.307	12955.896	22.117	22.117
Ca		646.000	646.000	646.000	6432.772	3.833	3.833
Mg		351.000	351.000	351.000	3495.206	2.082	2.082
K		65.000	65.000	65.000	638.356	1.638	1.638
Sr		0.000	0.000	0.000	0.000	0.000	0.000
Ba		0.820	0.820	0.820	8.170	0.004	0.004
NH_4		0.000	0.000	0.000	0.000	0.000	0.000
Fe(II)		0.200	0.200	0.200	1.995	0.001	0.001
Mn		0.300	0.300	0.300	2.993	0.001	0.001
Al		0.000	0.000	0.000	0.000	0.000	0.000
Cl		3980.000	3983.899	3983.899	39361.468	46.871	46.871
SO_4		224.000	224.000	224.000	2234.600	0.530	0.530
CO_3		1.856	0.720	0.720	122.050	0.000	0.000
HCO_3		171.000	166.655	166.655	1533.353	1.904	1.904
NO_3		1.400	1.400	1.400	12.725	0.125	0.125
F		0.160	0.160	0.160	1.577	0.002	0.002
SiO_2		28.000	28.000	28.000	276.923	0.356	0.356
B		0.230	0.230	0.230	1.558	0.085	0.085
PO_4		0.000	0.000	0.000	0.000	0.000	0.000
Br		0.000	0.000	0.000	0.000	0.000	0.000
As(III)		0.000	0.000	0.000	0.000	0.000	0.000
As(V)		0.000	0.000	0.000	0.000	0.000	0.000
CO_2		2.740	6.707	6.707	6.707	6.707	6.707
TDS	[mg/l]	6781.273	6779.691	6779.691	67079.561	79.550	79.550
pH		7.900	7.500	7.500	8.363	5.665	5.665
Conductivity	[µS/cm]	11030.913	11032.567	11032.567	98686.197	148.935	148.935
Osmotic pressure	[psi]	66.678	66.627	66.627	659.525	0.962	0.962
LSI		1.151	0.740	0.740	3.514	-4.695	-4.695

Scaling		Feed water
$CaSO_4$	[% Sat.]	8.74
$BaSO_4$	[% Sat.]	1007.54
$SrSO_4$	[% Sat.]	0.00
SiO_2	[% Sat.]	25.93
CaF_2	[% Sat.]	2.35
$Ca_3(PO_4)_2$		0.00
LSI		0.74
SDSI		0.37

Scaling		Concentrate
$CaSO_4$	[% Sat.]	155.25
$BaSO_4$	[% Sat.]	16328.88
$SrSO_4$	[% Sat.]	0.00
SiO_2	[% Sat.]	182.02
CaF_2	[% Sat.]	4087.86
$Ca_3(PO_4)_2$		0.00
LSI		3.51
SDSI		2.50

Scaling	Permeate
LSI	-4.69
RI	15.05
CCPP	-17.42

Cycle details for pass 1

		CC1		CC9		PF	
Composition		**Concentrate**	**Permeate**	**Concentrate**	**Permeate**	**Concentrate**	**Permeate**
Ions		[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]	[mg/l]
Na		2903.494	7.697	12955.896	35.032	1634.758	52.424
Ca		1433.739	1.329	6432.772	6.083	806.745	9.089
Mg		779.013	0.722	3495.206	3.305	438.340	4.939
K		143.663	0.572	638.356	2.591	80.925	3.881
Sr		0.000	0.000	0.000	0.000	0.000	0.000
Ba		1.820	0.001	8.170	0.007	1.024	0.010
NH_4		0.000	0.000	0.000	0.000	0.000	0.000
Fe(II)		0.444	0.000	1.995	0.001	0.250	0.002
Mn		0.666	0.000	2.993	0.002	0.375	0.002
Al		0.000	0.000	0.000	0.000	0.000	0.000
Cl		8821.142	16.287	39361.468	74.305	4966.578	111.093
SO_4		497.418	0.183	2234.600	0.843	279.850	1.258
CO_3		4.425	0.000	122.050	0.000	1.196	0.000
HCO_3		366.339	0.679	1533.353	2.966	207.546	4.547
NO_3		3.022	0.045	12.725	0.194	1.713	0.295
F		0.354	0.001	1.577	0.004	0.199	0.005
SiO_2		62.016	0.124	276.923	0.557	34.914	0.852
B		0.441	0.041	1.558	0.110	0.257	0.221
PO_4		0.000	0.000	0.000	0.000	0.000	0.000
Br		0.000	0.000	0.000	0.000	0.000	0.000
As(III)		0.000	0.000	0.000	0.000	0.000	0.000
As(V)		0.000	0.000	0.000	0.000	0.000	0.000
CO_2		6.707	6.707	6.707	6.707	6.707	6.707
TDS	[mg/l]	15017.996	27.683	67079.561	125.998	8454.671	188.619
pH		7.807	5.225	8.363	5.853	7.585	6.033
Conductivity	[µS/cm]	23619.137	55.278	98686.197	231.587	13630.938	341.012
Osmotic pressure	[psi]	142.670	0.338	659.525	1.515	82.213	2.255
LSI		1.718	-6.382	3.514	-4.072	1.012	-3.500

Element details for pass 1 (1 / 3)

						Permeate			Concentrate		Feed	
Cycle		Element	Age	Recovery	Beta	Flux	Flow	TDS	Flow	TDS	Flow	TDS
	#		[a]	[%]		[gfd]	[gpm]	[mg/l]	[gpm]	[mg/l]	[gpm]	[mg/l]
PF	1	RO S400 HF	5.0	4.54	1.04	4.33	1.20	61.84	25.27	7099.19	26.47	6779.69
PF	2	RO S400 HF	5.0	4.47	1.03	4.06	1.13	68.79	24.14	7428.05	25.27	7099.19
PF	3	RO S400 HF	5.0	4.38	1.03	3.81	1.06	76.70	23.08	7764.83	24.14	7428.05
PF	4	RO S400 HF	5.0	4.28	1.03	3.55	0.99	85.74	22.09	8107.74	23.08	7764.83
PF	5	RO S400 HF	5.0	4.15	1.03	3.30	0.92	96.08	21.18	8454.67	22.09	8107.74
CC1	1	RO S400 HF	5.0	11.03	1.09	17.76	4.94	18.49	39.81	8572.42	44.75	7628.98
CC1	2	RO S400 HF	5.0	11.83	1.10	16.94	4.71	21.98	35.10	9719.39	39.81	8572.42
CC1	3	RO S400 HF	5.0	12.68	1.11	16.02	4.45	26.63	30.65	11127.20	35.10	9719.39
CC1	4	RO S400 HF	5.0	13.56	1.12	14.95	4.16	33.01	26.50	12866.75	30.65	11127.20
CC1	5	RO S400 HF	5.0	14.37	1.12	13.70	3.81	42.07	22.69	15018.00	26.50	12866.75
CC2	1	RO S400 HF	5.0	11.44	1.10	18.42	5.12	25.59	39.63	12368.63	44.75	10956.87
CC2	2	RO S400 HF	5.0	12.14	1.10	17.31	4.81	30.98	34.82	14073.27	39.63	12368.63
CC2	3	RO S400 HF	5.0	12.81	1.11	16.05	4.46	38.30	30.36	16135.68	34.82	14073.27
CC2	4	RO S400 HF	5.0	13.38	1.11	14.61	4.06	48.52	26.30	18619.89	30.36	16135.68
CC2	5	RO S400 HF	5.0	13.72	1.12	12.98	3.61	63.20	22.69	21569.12	26.30	18619.89
CC3	1	RO S400 HF	5.0	11.85	1.10	19.08	5.30	32.22	39.45	16193.82	44.75	14278.59
CC3	2	RO S400 HF	5.0	12.45	1.10	17.67	4.91	39.73	34.54	18490.26	39.45	16193.82
CC3	3	RO S400 HF	5.0	12.93	1.11	16.06	4.46	50.12	30.07	21227.75	34.54	18490.26
CC3	4	RO S400 HF	5.0	13.18	1.11	14.26	3.96	64.88	26.11	24441.15	30.07	21227.75
CC3	5	RO S400 HF	5.0	13.09	1.11	12.29	3.42	86.33	22.69	28108.05	26.11	24441.15

Element details for pass 1 (2 / 3)

Cycle	#	Element	Age [a]	Recovery [%]	Beta	Permeate Flux [gfd]	Permeate Flow [gpm]	Permeate TDS [mg/l]	Concentrate Flow [gpm]	Concentrate TDS [mg/l]	Feed Flow [gpm]	Feed TDS [mg/l]
CC4	1	RO S400 HF	5.0	12.27	1.10	19.76	5.49	38.43	39.26	20049.61	44.75	17594.12
CC4	2	RO S400 HF	5.0	12.75	1.11	18.01	5.01	48.27	34.25	22972.58	39.26	20049.61
CC4	3	RO S400 HF	5.0	13.03	1.11	16.05	4.46	62.15	29.79	26403.62	34.25	22972.58
CC4	4	RO S400 HF	5.0	12.97	1.11	13.91	3.86	82.22	25.93	30327.07	29.79	26403.62
CC4	5	RO S400 HF	5.0	12.48	1.10	11.64	3.24	111.84	22.69	34634.64	25.93	30327.07
CC5	1	RO S400 HF	5.0	12.70	1.11	20.45	5.68	44.26	39.07	23937.82	44.75	20903.41
CC5	2	RO S400 HF	5.0	13.05	1.11	18.35	5.10	56.64	33.97	27522.69	39.07	23937.82
CC5	3	RO S400 HF	5.0	13.11	1.11	16.02	4.45	74.50	29.51	31663.63	33.97	27522.69
CC5	4	RO S400 HF	5.0	12.75	1.11	13.54	3.76	100.75	25.75	36274.32	29.51	31663.63
CC5	5	RO S400 HF	5.0	11.89	1.10	11.01	3.06	139.87	22.69	41148.77	25.75	36274.32
CC6	1	RO S400 HF	5.0	13.14	1.11	21.16	5.88	49.72	38.87	27860.55	44.75	24206.42
CC6	2	RO S400 HF	5.0	13.35	1.11	18.67	5.19	64.93	33.68	32143.38	38.87	27860.55
CC6	3	RO S400 HF	5.0	13.18	1.11	15.97	4.44	87.23	29.24	37008.23	33.68	32143.38
CC6	4	RO S400 HF	5.0	12.51	1.11	13.16	3.66	120.51	25.58	42279.81	29.24	37008.23
CC6	5	RO S400 HF	5.0	11.31	1.09	10.41	2.89	170.70	22.69	47650.43	25.58	42279.81
CC7	1	RO S400 HF	5.0	13.59	1.12	21.88	6.08	54.89	38.67	31820.16	44.75	27503.11
CC7	2	RO S400 HF	5.0	13.65	1.12	18.99	5.28	73.13	33.39	36837.72	38.67	31820.16
CC7	3	RO S400 HF	5.0	13.23	1.11	15.89	4.42	100.37	28.97	42437.84	33.39	36837.72
CC7	4	RO S400 HF	5.0	12.25	1.10	12.77	3.55	141.65	25.42	48340.44	28.97	42437.84
CC7	5	RO S400 HF	5.0	10.75	1.09	9.84	2.73	204.64	22.69	54139.49	25.42	48340.44

Element details for pass 1 (3 / 3)

						Permeate			Concentrate		Feed	
Cycle		**Element**	**Age**	**Recovery**	**Beta**	**Flux**	**Flow**	**TDS**	**Flow**	**TDS**	**Flow**	**TDS**
	#		[a]	[%]		[gfd]	[gpm]	[mg/l]	[gpm]	[mg/l]	[gpm]	[mg/l]
CC8	1	RO S400 HF	5.0	14.06	1.12	22.63	6.29	59.76	38.46	35819.38	44.75	30793.41
CC8	2	RO S400 HF	5.0	13.94	1.12	19.29	5.36	81.26	33.10	41609.22	38.46	35819.38
CC8	3	RO S400 HF	5.0	13.26	1.11	15.79	4.39	113.98	28.71	47953.10	33.10	41609.22
CC8	4	RO S400 HF	5.0	11.97	1.10	12.37	3.44	164.32	25.27	54453.18	28.71	47953.10
CC8	5	RO S400 HF	5.0	10.21	1.08	9.28	2.58	242.06	22.69	60615.85	25.27	54453.18
CC9	1	RO S400 HF	5.0	14.54	1.12	23.40	6.50	64.33	38.25	39861.68	44.75	34077.31
CC9	2	RO S400 HF	5.0	14.24	1.12	19.59	5.44	89.36	32.80	46462.31	38.25	39861.68
CC9	3	RO S400 HF	5.0	13.28	1.11	15.67	4.36	128.13	28.45	53555.34	32.80	46462.31
CC9	4	RO S400 HF	5.0	11.69	1.10	11.96	3.32	188.75	25.12	60615.75	28.45	53555.34
CC9	5	RO S400 HF	5.0	9.68	1.08	8.75	2.43	283.39	22.69	67079.56	25.12	60615.75

System power consumption

System capacity	10043999.1 [gpd]	Total electric power	3681.14 [hp]
System recovery	90.0 [%]	Specific power consumption	6.56 [kWh/kgal]

Power consumption in pass 1

High pressure pump	
Pump flow	7588.54 [gpm]
Pump suction pressure	7.25 [psi]
Required feed pressure	682.51 [psi]
Additional pump pressure	7.25 [psi]
Pump discharge pressure	689.76 [psi]
Pump efficiency	84.00 [%]
Motor efficiency	94.00 [%]
Motor power	5179.11 [hp]

Recirculation pump	
Pump flow	7805.36 [gpm]
Booster pressure	13.70 [psi]
Booster efficiency	84.00 [%]
Motor efficiency	94.00 [%]
Motor power	70.58 [hp]

Disclaimer

This LewaPlus software program is used for the dimensioning and calculation of Ion Exchange resin and Reverse Osmosis (hereafter RO) membrane systems applied in water treatment applications.

Within this program, Lanxess makes available to the system designer certain know-how concerning the design and operation of specific Lanxess engineered ion exchange products (in unique system configurations such as fluidized bed, lift bed, multistep- and rinse bed technologies) as well as other existing ion exchange technologies. In addition, Lanxess makes available to the system designer certain information about the design and operation of RO membrane systems, including scaling calculations, chemical and energy costs projections, and capital and operating cost projections based on the pretreatment of the feed water, and design decisions made by the designer.

This know-how is given in good faith but without warranty, Our advice does not release you from the obligation to verify the information currently provided - especially that contained in our safety data and technical information sheets - and to test our products as to their suitability for the intended processes and uses. The application, use and processing of our products and the products manufactured by you on the basis of our technical advice are beyond our control and, therefore, entirely your own responsibility.

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Note:
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Appendix F
Chino II Pellet Reactor Process Flow Diagram and Layout

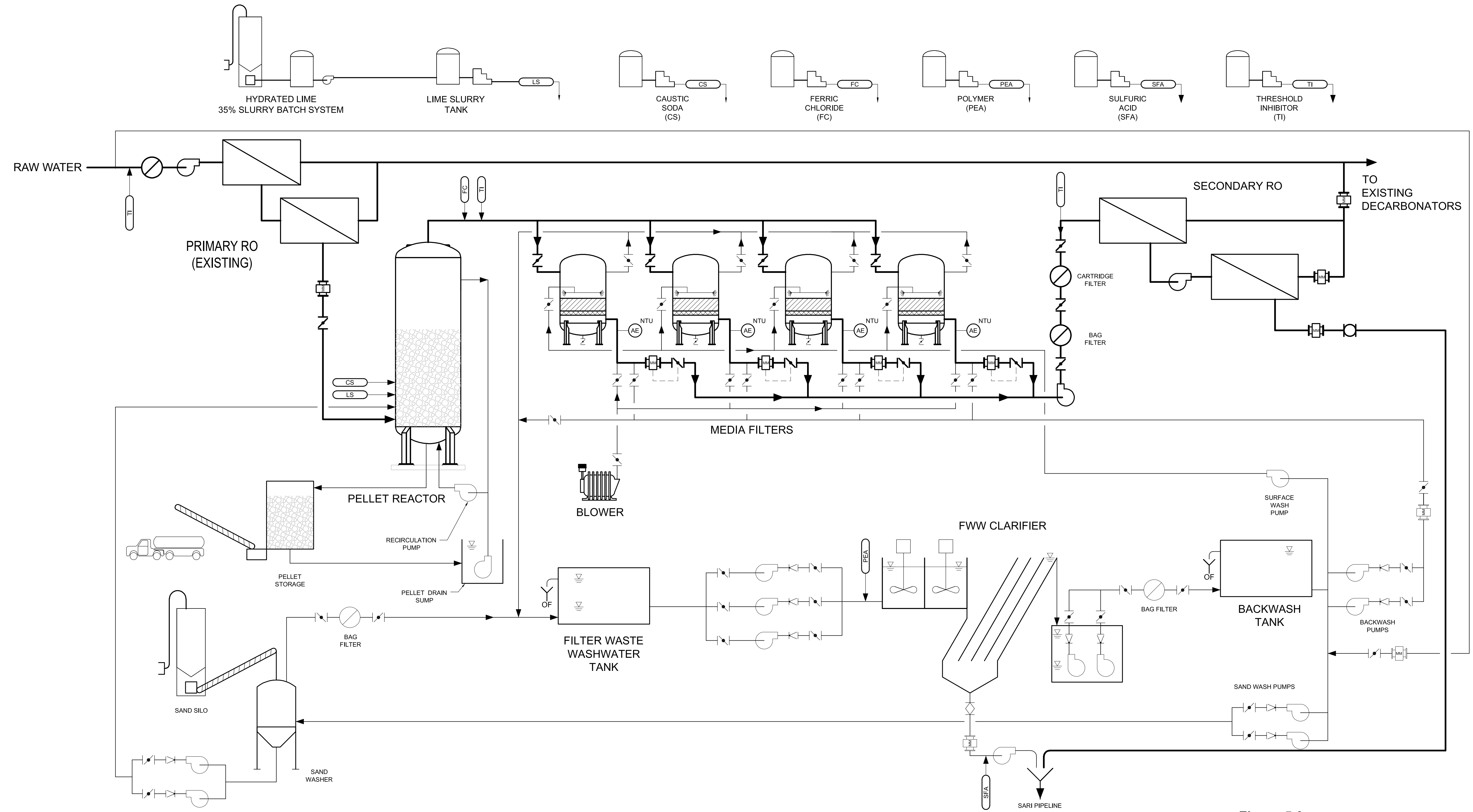

Figure 5.3
Chino Desalter Concentrate Reduction Schematic
CHINO DESALTER PHASE 3 PDR
JCSD/ONTARIO/WMWD

carollo
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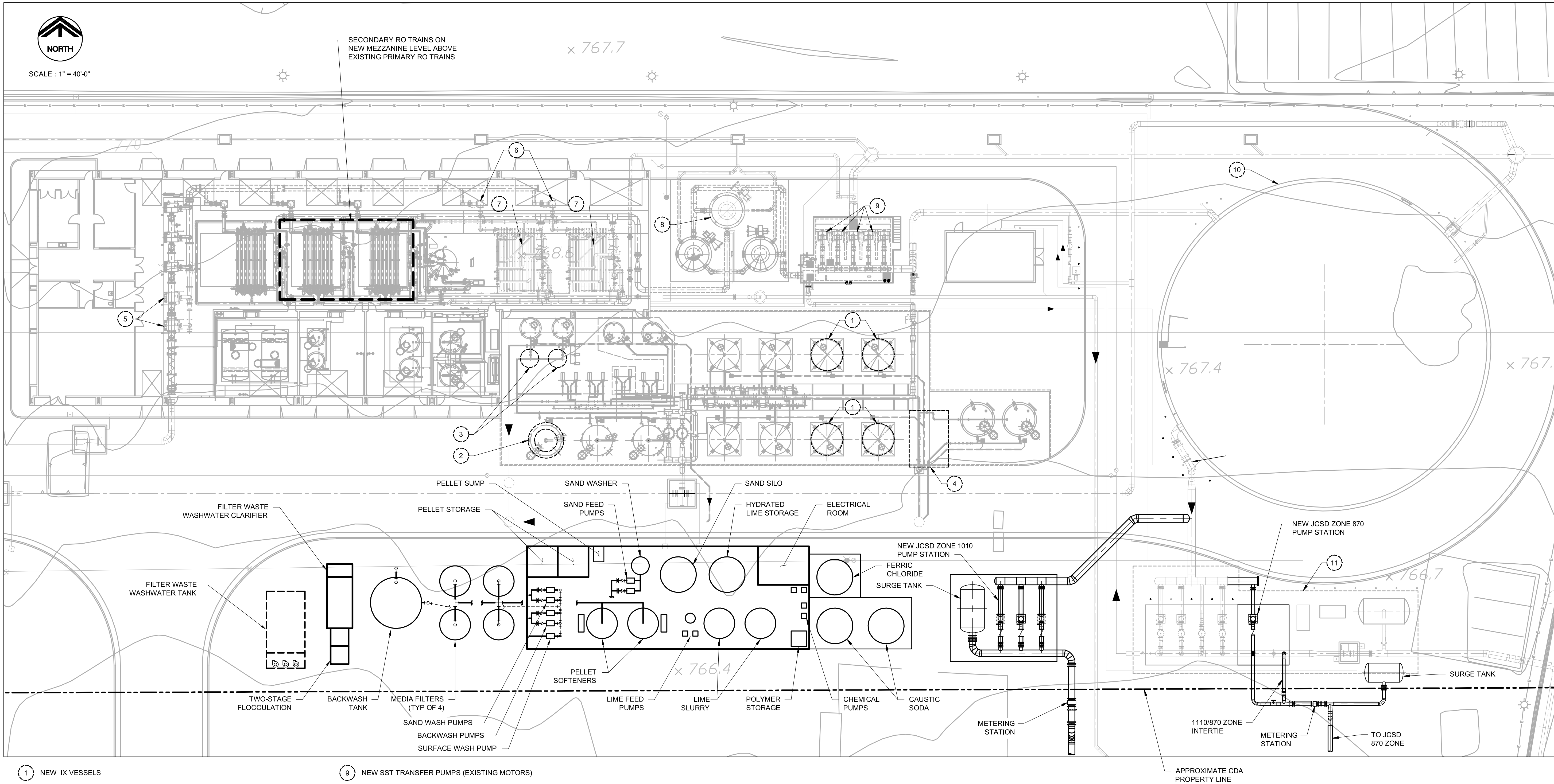

1 NEW IX VESSELS
2 NEW SALT STORAGE TANK
3 NEW SOFTENED WATER STORAGE TANKS
4 NEW BAG FILTERS (CONFIGURATION BY HUNGERFORD AND TERRY)
5 NEW CATRIDGE FILTERS
6 NEW RO FEED PUMPS
7 NEW RO TRAINS
8 NEW DECARBONATOR
9 NEW SST TRANSFER PUMPS (EXISTING MOTORS)
10 3 MG CLEARWELL
11 EXISTING PRODUCT WATER PUMP STATION

Figure 5.5
CHINO II CONCENTRATE REDUCTION SITE PLAN
CHINO DESALTER PHASE 3 PDR
JCSD/ONTARIO/WMWD

8. Potential Project Screening (Task 1.I)

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Technical Memorandum

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Subject	**Potential Project Screening**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 7, 2019

1. Introduction

In the West Coast Basin (basin), a significant plume of saline groundwater (saline plume) with elevated total dissolved solids has been trapped in the Gage, Silverado, Lynwood, and Lower San Pedro (LSP, equivalent to Sunnyside) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To more fully utilize the West Coast Basin, the Water Replenishment District of Southern California (WRD) has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume in the West Coast Basin. Program goals include treating the plume to produce potable water, and disposal of any waste streams generated (mostly high-salinity brine) in the treatment process. The Program will study the following components: where to extract the plume water, where and how to treat the plume water, how to convey the treated potable water to the Program stakeholders, and how to manage the brine waste stream. The Program includes the analysis of numerous different "Projects" or combination of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of the above components as well as the cost of the water necessary to replenish the high-salinity plume water extracted, expressed as U.S. dollars per acre-foot (AF) of treated water.

The Feasibility Study will consist of the evaluation of several project component configurations. The timeframe for reclamation of the entire plume will be targeted to match a 30-year financing period. The Program's first technical memorandum (TM), titled Program Context, was finalized on September 24, 2018, and described the Program's purpose, need, and objectives; supply and demand within the West Coast Basin; and project options and evaluation criteria for subsequent project development. The third TM, Potential Projects and Recommended Shortlist*,* described the development and screening of the master list of Projects and proposed 11 Projects to move forward through a multi-objective decision analysis (MODA) process to guide the selection of the final, Preferred Projects that will undergo further evaluation.

This TM describes the screening of the shortlisted Projects using decision science (MODA) and recommends Projects to move forward to the next phase of work. This TM is organized to include the following:

- Section 1 – Introduction
- Section 2 – Shortlist of Potential Projects
- Section 3 – Overview of MODA Process
- Section 4 – Criteria and Weighting
- Section 5 – Project Scoring
- Section 6 – MODA Analysis Results
- Section 7 – Next Steps
- Section 8 – References

2. Shortlist of Potential Projects

One of the first tasks in the Feasibility Study was to define Potential Projects to remediate the plume and beneficially use the treated water. A total of 29 Projects was developed by combining options for collection, treatment, product water delivery, and brine disposal based on information gathered from the stakeholders. The Potential Projects and their preliminary costs were reviewed with the stakeholders at Workshop 2 held at WRD headquarters on November 14, 2018, and the initial list of Projects was narrowed down to a shortlist of 11 projects to carry forward to the MODA evaluation. These projects are summarized in Table 2-1.

When selecting Projects, the stakeholders placed importance not simply on the lowest unit cost but on a broad range of considerations. Retained Projects have one or more of the following characteristics:

- Have the lowest overall capital expenditure, which are typically Projects with the lowest volume of extraction (5,200 acre-feet per year [AFY])
- Can treat the entire plume, including the northern portion of the Gage plume
- Provide water to all stakeholders
- Could take advantage of the construction of a new brine line
- Use the existing Torrance distribution system and its existing interties with other stakeholders for product water delivery to their potable water systems
- Have the lowest overall unit costs ($/AF) for the 12,500- and 20,000-AFY extraction rates

2.1 Project Refinement

The 11 shortlisted Projects underwent further refinement to narrow the uncertainty associated with some of the assumptions used in the screening process. Further refinements included the following:

- **Cost Sensitivity to All New Piping** – The costs for the shortlisted projects were calculated assuming either all new piping for delivery of the product water or use of existing piping only, primarily the existing Torrance distribution system (where feasible) for delivery of product water. Overall, the cost difference between these two options was less than $125/AF and, on average, was less than $75/AF.
- **Brackish Water Extraction** – Evaluation of the source water quality of the water to be extracted for treatment. The following conclusions were reached:
  - The evaluation revealed that more of the groundwater needed to be extracted from the highest salinity aquifer, which is the LSP. This resulted in an increase in the cost of treatment for all of the Projects (relative to the preliminary costs developed for Project shortlisting). However, projects extracting water using the existing Sepulveda wells were affected somewhat less than the other Projects because their salinity is lower than that expected from the new extraction wells.
  - In addition, it became evident that the Projects extracting less water, including those extracting 12,500 and 5,200 AFY, could benefit by having new extraction wells placed in areas that were less likely to be close to groundwater contaminant plumes.
  - Only the single Project that includes the portable wellhead treatment component is able to remediate the smaller, high-salinity plume locations. Thus, this Project is the only one characterized as able to “remediate the entire plume.”
- **Brine Disposal Options** – The evaluation of the brine management options concluded the following:
  - Two options were worth future consideration. The first option, discharge of the brine to a sanitary sewer, does not provide much of a Project differentiator because all of the treatment locations, including the potential locations for the portable wellhead treatment unit, are in urban locations near existing sewer lines. The second option is the construction of a new dedicated brine line to the effluent outfall systems of either the Los Angeles County Sanitation Districts Joint Water Pollution Control Plant (JWPCP) in Carson, or the City of Los Angeles’ Hyperion Water

Reclamation Plant (WRP) in El Segundo. This option would favor Projects where all of the treatment is provided at a single location.

- Projects using sewers for brine management would be easier to permit than those using the dedicated brine line.
- Projects using the new, dedicated brine line would not be able to be relocated and thus scored lower on potential project phasing.

- **Product Water Quality** – The assessment of product water quality does not affect the MODA evaluation.
- **Brackish Water Facility Design and Layout –** Design and layout of the facilities revealed the following:
  - Placing a 20,000-AFY Project at the 1-acre Elm and Faysmith site resulted in a tight fit, with no room for plant expansion and limited space around equipment. Therefore, a penalty was assessed for Projects of this capacity at this location.
  - Regarding permitting, Projects with multiple treatment locations, including wellhead treatment, were deemed to require more permits than a single, centralized facility.
  - The Project with the portable wellhead treatment facility was rewarded because of its flexibility in potential project phasing—specifically, its ability to be relocated.
  - Greenhouse gas (GHG) emissions are lower on a per unit of water produced basis for Projects of larger capacity, primarily because of higher motor efficiencies.

Table 2-1 also includes the overall project costs and unit costs per AF delivered for the shortlisted Projects, including the refinements above.

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Table 2-1. List of Potential Projects

	Potential Project - General Description	Extraction Wells	Treatment Locations				Total New Extraction, AFY	Total Existing Extraction (Goldsworthy and Brewer), AFY	Water Delivery Locations						Total New Product Delivery, AFY	Brine Disposal	Cost per AF Delivered
			Elm and Faysmith (Torrance)	Wellhead (WHT)	Goldsworthy and Brewer	JWPCP			Torrance	Golden State Water	MB	LADWP	Cal Water	Lomita		Sewer (SWR) or Brine Line (BL)	
13	Torrance, GSWC, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	5,000	-	8,000	-	-	18,000	BL	$1,397
14	Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	-	-	5,000	6,500	1,500	18,000	SWR	$1,403
15	Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties and Madrona Lateral (20,000 AFY)	10 new wells	20,000	-	7,300	-	20,000	7,300	5,000	-	-	5,000	6,500	1,500	18,000	SWR	$1,376
18	Spread Across Stakeholders via Interties with New Pipeline to MB (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	4,100	900	1,000	2,750	1,500	1,000	11,250	SWR	$1,629
19	Spread across Stakeholders via interties with New Pipeline to MB and Portable Wellhead Treatment (12,500 AFY)	10 new wells	10,500	2,000	7,300	-	12,500	7,300	4,100	900	1,000	2,750	1,500	1,000	11,250	SWR	$1,851
24	JWPCP (12,500 AFY)	7 new wells			7,300	12,500	12,500	7,300	5,000	-	-	5,250		1,000	11,250	BL	$1,512
25	Torrance, GSWC, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (12,500 AFY)	7 new wells	12,500		7,300		12,500	7,300	3,000	3,000	-	5,250			11,250	BL	$1,557
26	Torrance (Highest Delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral with One Existing Well (12,500 AFY)	6 new wells, 1 existing well	12,500		7,300		12,500	7,300	5,000	900	-	850	3,500	1,000	11,250	SWR	$1,590
27	All Wellheads, No New Distribution Piping (10,500 AFY)	7 new wells	-	10,500	7,300	-	10,500	7,300	5,000	900	1,000	1,000	800	750	9,450	SWR	$2,487
28	Torrance (Highest Delivery), GSWC, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (5,200 AFY)	3 new wells	5,200	-	7,300	-	5,200	7,300	2,100	500	-	500	1,000	500	4,600	SWR	$2,289
29	All Wellhead (5,200 AFY)	2 new wells, 1 existing	-	5,200	7,300	-	5,200	7,300	4,600	-	-	-	-	-	4,600	SWR	$2,868

Notes:

- = not applicable

MB = Manhattan Beach

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3. Overview of Multi-Objective Decision Analysis Process

MODA is a decision science evaluation method used to aid in decision making while considering several, possibly conflicting, criteria. MODA follows four general steps:

1) **Frame the decision and define evaluation criteria and measurement scales** – The evaluation criteria and their measurements were established in the Program Context TM (dated September 24, 2018); an additional criterion was added based on discussions with the stakeholders.
2) **Develop relative criteria weights** – A weighting survey was submitted to all of the Program stakeholders, and responses were received from all stakeholders. The individual weighting scores, along with average scores, is used to develop the ranking.
3) **Measure how well each Project meets each criterion** – A strawman Project scoring is included in this TM and was reviewed at stakeholder Workshop 3, held on March 20, 2019.
4) **Calculate MODA scores, evaluate trade-offs, and rank projects** – The criteria weighting and Project scoring are combined to create an overall score for each of the Projects. These MODA scores represent the overall benefits of the project and are plotted against the cost of each Project.

4. Criteria and Weighting

Table 4-1 presents the evaluation criteria that are used in this analysis as well a description of how Projects are measured against the criteria. Criterion No. 7 was added based on feedback from the stakeholders during Workshop 2.

Table 4-1. Evaluation Criteria

No.	Performance Measure	Measure	Range of Performance Spectrum	
			Minimum Score	Maximum Score
1	Beneficial Use	$\frac{\text{AF Delivered}}{\text{AF Produced}}$	All remediated water is reinjected into basin.	All remediated water is delivered to distribution system.
2	Proximity to Other Contaminant Plumes	Distance	Extraction well(s) requires treatment for additional contaminants.	No additional treatment is required for other contaminants.
3	Permitting Difficulty	Scalable	Project has permitting hurdles that could lead to schedule delays.	Project is permittable and the permitting process is not expected to cause delay.
4	Ability to Meet the Project Need, Purpose, and Objectives	Scalable	Project does not meet the project need, purpose, and objectives.	Project meets the project need, purpose, and objectives.
5	Potential Project Phasing	Scalable	Project cannot be expanded or relocated.	Potential for project to be expanded or relocated after a period of operation.
6	GHG Emissions	Scalable	High GHG emissions.	Low GHG emissions.
7	Delivery of Water to All Stakeholders	Number	Three or fewer stakeholders get water.	Six stakeholders get water.

A weighting survey of these criteria was submitted to stakeholders. The stakeholders were asked to provide weights for each criterion; higher weighted scores indicate that a criterion is more important to a stakeholder than a criterion with a lower score.

One of the stakeholders provided some comments on the criteria that are captured here for further clarification and response:

1) For Criterion No. 1, consider other beneficial uses, such as barrier injection, reinjection, and blending in recycled water pipeline.
2) Extraction wells constructed in the Gage aquifer could encounter contaminants other than salt.

3) Criterion No. 7 should be rephrased as follows: “Project is flexible so that all stakeholders have the potential to take water, if desired.”
4) Suggested new criterion: Ownership of Infrastructure – Ability to own part of the infrastructure being installed.
5) Suggested new criterion: Water Quality – Quality of the water being received/delivered.

Comment 1 was addressed by explaining how this criterion was applied to the Project scoring. The use would be considered beneficial if water were delivered to the stakeholders without requirements about how the stakeholders use the water. This criterion scored equally for all Projects because, in general, the Projects were designed to deliver the amount of water that the stakeholders indicated they could take. This criterion was originally established to reflect potential seasonal variability in demands that could limit the delivery of the Project’s product water to the stakeholders. Because monthly demands did not vary significantly, this criterion became a non-differentiator.

Regarding Comment 2, historical data from the existing monitoring wells were reviewed to identify contaminants in the Gage aquifer. Monitoring well “Hawthorne” is located inside one of the larger, upper Gage aquifer plumes. Its historical data revealed that, in addition to salt, the extracted well water contained elevated levels of manganese and trichloroethene at levels above the maximum contaminant limit for drinking water. However, the planned treatment of conventional reverse osmosis followed by air stripping will reduce each to acceptable levels for potable use.

Regarding Comment 5, the expected product water quality from all projects is expected to be similar and not a differentiator.

Comments 3 and 4 were not directly addressed at this time. However, the implications of these comments (i.e., not requiring stakeholders to take product water and considering that stakeholders may want to own portions of the infrastructure) will be considered in future phases of this Program.

Table 4-2 summarizes the criteria weightings received from each stakeholder. The shading indicates the relative ranking of the criterion among the stakeholders. The highest weighted criteria are shaded a darker green, and the lowest weighted criteria shaded pink; the other shades of green, orange and yellow indicated intermediate ratings. For all stakeholders, the proximity of the extraction system to other contaminant plumes had the highest weighting. The average weights were used in calculating the MODA scores for the Projects.

Table 4-2. Evaluation Criteria Weighting

Criteria	Stakeholder A	Stakeholder B[a]	Stakeholder C	Stakeholder D	Stakeholder E	Stakeholder F	Stakeholder G	Average
Permitting Difficulty	15	5.9	10	7.5	15	19	10	11.8
Ability to meet the Project Need, Purpose, and Objectives	60	35.3	25	30	29	19	30	32.6
Potential Project Phasing	5	5.9	15	10	10	16	10	10.3
Beneficial Use	5	17.6	20	30	18	8	20	16.9
Proximity to Other Contaminant Plumes	5	17.6	5	5	23	16	20	13.1
GHG Emissions	5	5.9	15	10	5	3	0	6.3
Delivery of Water to All Stakeholders	5	11.8	10	7.5	0	19	10	9.0

Notes:

[a]The weighting for Stakeholder B was normalized to total 100.

5. Project Scoring

Table 5-1 presents the scoring guidelines for each of the criteria. Higher scores indicate that the Project performs well against the criterion. Some of the criteria are quantitative: beneficial use, proximity to other plumes, delivery of water to stakeholders. Other criteria are qualitative, and scoring of these criteria was based on professional judgment of the Jacobs engineering team that scored the Projects.

Table 5-2. Evaluation Criteria Scoring Ranges

Criteria	Measurement Scale	Definition of a 1	Definition of a 3	Definition of a 5
Permitting Difficulty	Scalable	Project has permitting hurdles that could lead to schedule delays.	Portions of the project have permitting hurdles.	Project is permittable and the permitting process is not expected to cause delay.
Ability to Meet the Project Need, Purpose, and Objectives	Scalable	Project does not meet the project need, purpose, and objectives.	Project meets one of the project need, purpose, or objectives.	Project meets the project need, purpose, and objectives.
Potential Project Phasing	Scalable	Project cannot be expanded or relocated.	N/A	Potential for project to be expanded or relocated after a period of operation.
Beneficial Use	AF Delivered/ AF Produced	All remediated water is reinjected into basin.	Half of the remediated water is reinjected into the basin.	All remediated water is delivered to distribution system.
Proximity to Other Contaminant Plumes	Distance	Extraction well requires treatment for additional contaminants.	N/A	No additional treatment is required for other contaminants.
GHG Emissions	Scalable	High GHG emissions.	Midrange GHG emissions.	Low GHG emissions.
Delivery of Water to All Stakeholders	Number	Less than three stakeholders get water.	Three, four, or five stakeholders get water.	Six stakeholders get water.

Each of the shortlisted projects was scored by members of the Jacobs team as a starting point for discussion with the larger Stakeholder Group. Table 5-2 shows the results of that scoring.

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Table 5-2. Jacobs Strawman Scoring

Potential Projects			13	14	15	18	19	24	25	26	27	28	29
General Description			Torrance, GSW, LADWP (highest delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties and Madrona Lateral (20,000	Spread Across Stakeholders via interties with New Pipeline to MB (12,500	Spread Across Stakeholders via interties with New Pipeline to MB and Portable Wellhead Treatment (12,500 AFY)	JWPCP (12,500 AFY)	Torrance, GSW, LADWP (highest delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP	Torrance (highest delivery), GSW, LADWP, Cal Water, Lomita via Interties and Madrona Lateral with one existing well (12,500 AFY)	All Wellhead no New Distribution Piping	Torrance (highest delivery), GSW, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (5,200 AFY)	All Wellhead (5,200 AFY)
Permitting Difficulty	**Definition of a 1**	Project has permitting hurdles that could lead to schedule delays.	3	5	5	5	4	5	3	5	4	5	4
	Definition of a 3	Portions of the project have permitting hurdles.											
	Definition of a 5	Project is permittable and the permitting process is not expected to cause delay.											
Ability to meet the Project Need, Purpose, and Objectives	**Definition of a 1**	Project does not meet the project need, purpose, and objectives.	2	2	2	3	5	3	3	3	2	3	2
	Definition of a 3	Project meets one of the project need, purpose, or objectives.											
	Definition of a 5	Project meets the project need, purpose, and objectives.											
Potential Project Phasing	**Definition of a 1**	Project cannot be expanded or relocated.	1	2	2	2	5	1	1	2	3	2	3
	Definition of a 3	Project can be expanded or relocated, but complex.											
	Definition of a 5	Potential for project to be expanded or relocated after a period of operation.											
Beneficial use	**Definition of a 1**	All remediated water is reinjected into basin.	5	5	5	5	5	5	5	5	5	5	5
	Definition of a 3	Half of the remediated water is reinjected into the basin.											
	Definition of a 5	All remediated water is delivered to distribution system.											
Proximity to Other Contaminant Plumes	**Definition of a 1**	Extraction well(s) requires treatment for additional contaminants.	3	3	3	4	2	4	4	4	4	4	4
	Definition of a 3	May require treatment for other contaminants.											
	Definition of a 5	No additional treatment is required for other contaminants.											
GHG Emissions	**Definition of a 1**	High GHG emissions.	2	2	2	1	3	1	1	4	1	1	4
	Definition of a 3	Midrange GHG emissions.											
	Definition of a 5	Low GHG emissions.											
Delivery of Water to All Stakeholders	**Definition of a 1**	Three or fewer stakeholders get water delivered to their system.	1	3	3	5	5	1	1	3	5	3	1
	Definition of a 3	Four or five stakeholders get water delivered to their system.											
	Definition of a 5	Six stakeholders get water delivered to their system.											

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The logic applied in scoring the Projects is explained below:

- **Permitting Difficulty:** Projects that include a direct brine line connection to the JWPCP or Hyperion WRP outfall systems will be more difficult to permit because of long pipe lengths that could cross several jurisdictions. Similarly, Projects with multiple treatment locations would also require more than one permit for the multiple pipelines.
- **Ability to Meet the Project Need, Purpose, and Objectives:** Only Projects that treat all of the plume, including the northern Gage plume, can receive the highest score for this criterion. Projects that include treatment units for 20,000 AFY or wellhead treatment are penalized because of limited space for operators, which may make the plant more difficult to operate, thus reducing the ability to meet the project need.
- **Potential Project Phasing:** Projects with portable wellhead treatment can be easily relocated once the targeted portion of the plume is remediated, unlike a centralized treatment plant. A new connection to the existing sewer system is also easier to implement, and lends itself to phasing more than a new dedicated brine line does.
- **Beneficial Use:** The Projects all perform similarly for this criterion, and all Projects were given the highest score.
- **Proximity to Other Contaminant Plumes:** Proximity in this case is a surrogate for “likelihood to encounter other contaminants.” Project 19 that includes portable wellhead treatment treats more of the plume (i.e., smaller, isolated high-chloride plumes, including those in the northern Gage aquifer), so there is a greater chance of encountering a contaminant plume. Projects that pump at higher rates are more likely to cause local effects that may draw in a plume. No project received the highest score because of uncertainty associated with this criterion.
- **GHG Emissions:** The Projects that include use of the existing Sepulveda wells as well as portable wellhead treatment treat different source water quality than is extracted from the other wells, resulting in fewer GHG emissions and, therefore, higher scores. In addition, larger projects get higher scores because they are more efficient.
- **Delivery of Water to All Stakeholders:** This criterion is measured based on the number of Program stakeholders that receive water from the Project.

6. MODA Results

MODA combines the stakeholder weightings and Project scoring to create MODA scores that can be used to compare the Projects. For the results shown below, the average of the stakeholder weighting and the strawman Project scoring conducted by Jacobs were used to calculate the MODA scores.

Figure 6-1 shows the MODA scores for each Project, with bars to indicate the relative score for each of the criteria. A higher MODA score indicates a Project that performs more favorably against the criteria. For Projects that scored 1 for a criterion, which was the lowest score possible, the calculated MODA score is a zero because the scores are relative to the lowest possible score. For example, Project 13 received a score of 1 for Delivery of Water to All Stakeholders because it only delivers water to three stakeholders, so its MODA score is 0 for that criterion.

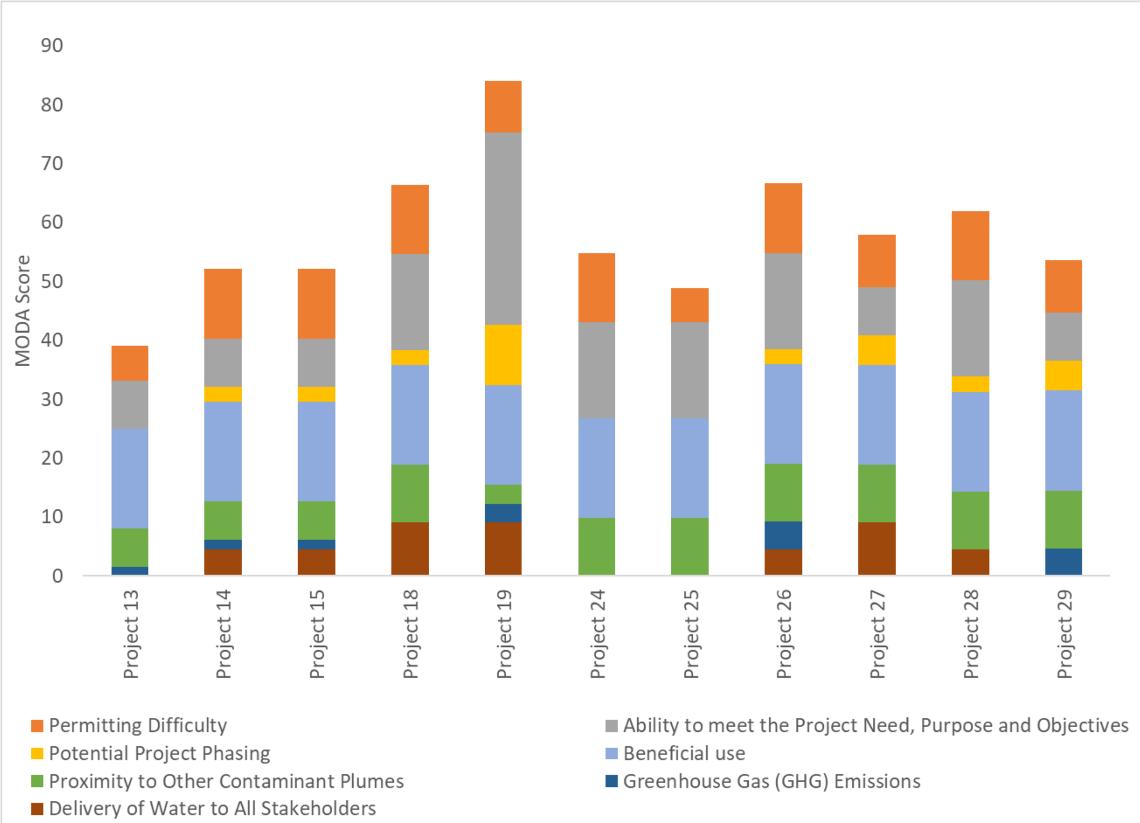

Figure 6-1. MODA Results for Average Weighting

Figure 6-2 shows the calculated MODA scores using the weightings of each individual stakeholder. Figure 6-2 shows the range of MODA scores reflecting the preferences of each stakeholder. Some Projects, such as Projects 25 and 27, have a wide range of calculated MODA scores, while others, like Project 26, have a much smaller range, indicating greater agreement among the stakeholders.

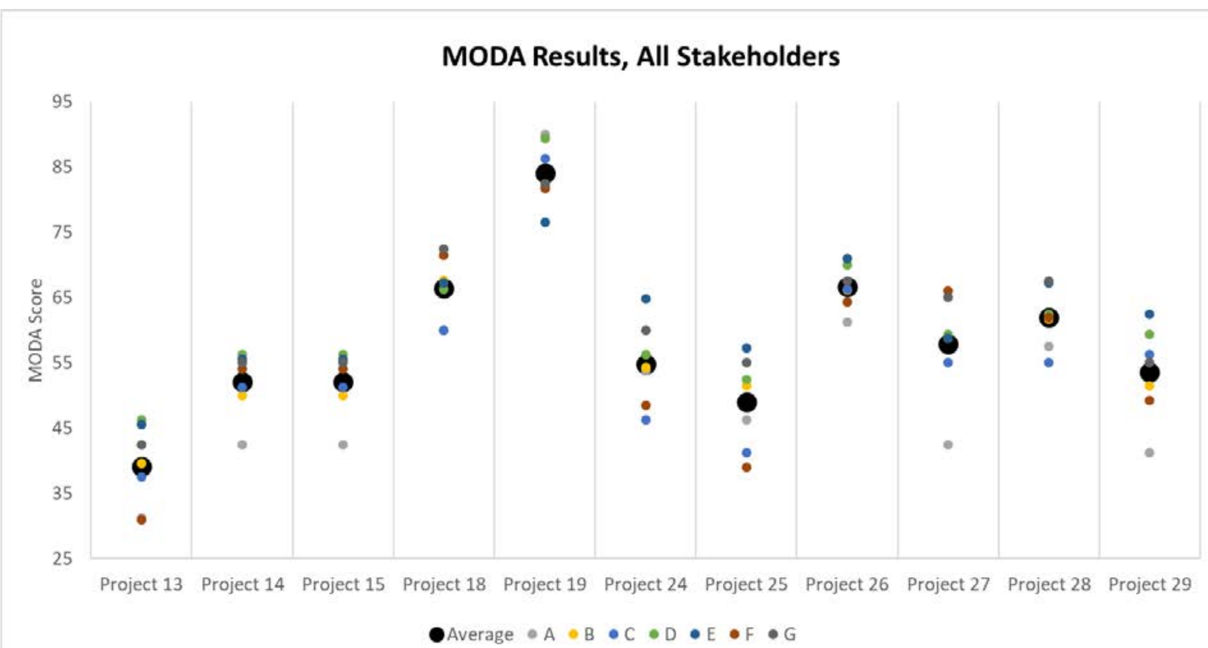

Figure 6-2. MODA Scores for Each Stakeholder

While there are some projects with a wide range of calculated scores, switching to any individual stakeholder's score generally only produces minor changes in Project ranking (shifting in ranking of one place), as shown in Table 6-1.

In Table 6-1, a lower number indicates a higher and more favorable rank. The green shading indicates that a Project would have moved up two or more places in ranking with that stakeholder's weighting, relative to the average. Pink cells indicate that the Project would have moved down two or more places relative to the average. Projects 19 and 13 do not change in rank, regardless of stakeholder weighting. Project 25, which has the largest range of MODA scores, is sensitive to the weighting used.

Table 6-1. Relative Project Rankings for Each Stakeholder

Project		Average	Stakeholder						
			A	B	C	D	E	F	G
Project 13	Torrance, GSW, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (20,000 AFY)	11	11	11	11	11	11	11	11
Project 14	Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties (20,000 AFY)	8	7	9	7	7	9	6	7
Project 15	Torrance, LADWP, Cal Water (Highest Delivery), Lomita via Interties and Madrona Lateral (20,000 AFY)	8	7	9	7	7	9	6	7
Project 18	Spread Across Stakeholders via Interties with New Pipeline to MB (12,500 AFY)	3	3	2	3	3	3	2	2
Project 19	Spread Across Stakeholders via Interties with New Pipeline to MB and Portable Wellhead Treatment (12,500 AFY)	1	1	1	1	1	1	1	1
Project 24	JWPCP (12,500 AFY)	6	5	6	9	7	5	9	6
Project 25	Torrance, GSW, LADWP (Highest Delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (12,500 AFY)	10	6	8	10	10	8	10	7
Project 26	Torrance (Highest Delivery), GSW, LADWP, Cal Water, Lomita via Interties and Madrona Lateral with One Existing Well (12,500 AFY)	2	2	3	2	2	2	4	3
Project 27	All Wellhead No New Distribution Piping (10,500 AFY)	5	7	5	5	5	7	3	5
Project 28	Torrance (Highest Delivery), GSW, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (5,200 AFY)	4	4	4	5	4	3	5	3
Project 29	All Wellhead (5,200 AFY)	7	10	7	4	5	6	8	7

A similar exercise comparing project ranking was performed for changes in scoring. In this case, the projects were scored equally for a single criterion, and the ranking was recalculated. The green shaded cells indicate that the ranking increased by two or more places, relative to Jacobs' Strawman Scoring, when the projects were all scored equally for that criterion. Pink cells indicate a decrease in rank by two or more places. Many of the projects are not sensitive to changes in scores, such as Projects 13, 18, 19, 26, and 28. Project 29 is sensitive to scoring, but the change in scoring generally resulted in a decrease in rank.

Table 6-2. Relative Project Rankings for Equal Scoring of Each Criterion

Project		Jacobs Strawman Scoring	Criterion 1: Permitting Difficulty	2: Ability to meet the Project Need, Purpose and Objectives	3: Potential Project Phasing	4: Beneficial use	5: Proximity to Other Contaminant Plumes	6: GHG (GHG) Emissions	7: Delivery of Water to All Stakeholders
Project 13	Torrance, GSW, LADWP (highest delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (20,000 AFY)	11	11	11	11	11	11	11	11
Project 14	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties (20,000 AFY)	8	9	7	7	8	6	7	9
Project 15	Torrance, LADWP, Cal Water (highest delivery), Lomita via Interties and Madrona Lateral (20,000 AFY)	8	9	7	7	8	6	7	9
Project 18	Spread across Stakeholders via interties with New Pipeline to MB (12,500 AFY)	3	3	3	3	3	3	2	3
Project 19	Spread across Stakeholders via interties with New Pipeline to MB and Portable Wellhead Treatment (12,500 AFY)	1	1	1	1	1	1	1	1
Project 24	JWPCP (12,500 AFY)	6	7	9	5	6	8	6	5
Project 25	Torrance, GSW, LADWP (highest delivery) with a New Brine Line with Direct Connection to Tunnel/Outfall to JWPCP (12,500 AFY)	10	7	10	9	10	10	9	7
Project 26	Torrance (highest delivery), GSW, LADWP, Cal Water, Lomita via Interties and Madrona Lateral with 1 existing well (12,500 AFY)	2	2	2	2	2	2	3	2
Project 27	All Wellhead No New Distribution Piping (10,500 AFY)	5	5	4	6	5	5	5	8
Project 28	Torrance (highest delivery), GSW, LADWP, Cal Water, Lomita via Interties and Madrona Lateral (5,200 AFY)	4	4	5	4	4	4	3	3
Project 29	All Wellhead (5,200 AFY)	7	5	6	10	7	9	10	6

Figure 6-3 plots the MODA score for each Project against the calculated cost of water per AF delivered. The costs shown on Figure 6-3 are updated based on the Project Refinement work (Section 2.1), which generally increased costs relative to the costs provided in the Potential Projects and Recommended Short List TM. The costs shown do not include Project financing, which will be addressed in a subsequent task of the Feasibility Study.

Figure 6-3 is used to understand the trade-off in MODA scores relative to cost. Projects 27, 28, and 29 have the highest unit costs because of the size and number of treatment plants required. These Projects have midrange MODA scores. The similar or better MODA scores could be achieved from Projects that are $500/AF to $1,000/AF less expensive. Given their high cost relative to their MODA benefit scores, these Projects are eliminated from further consideration.

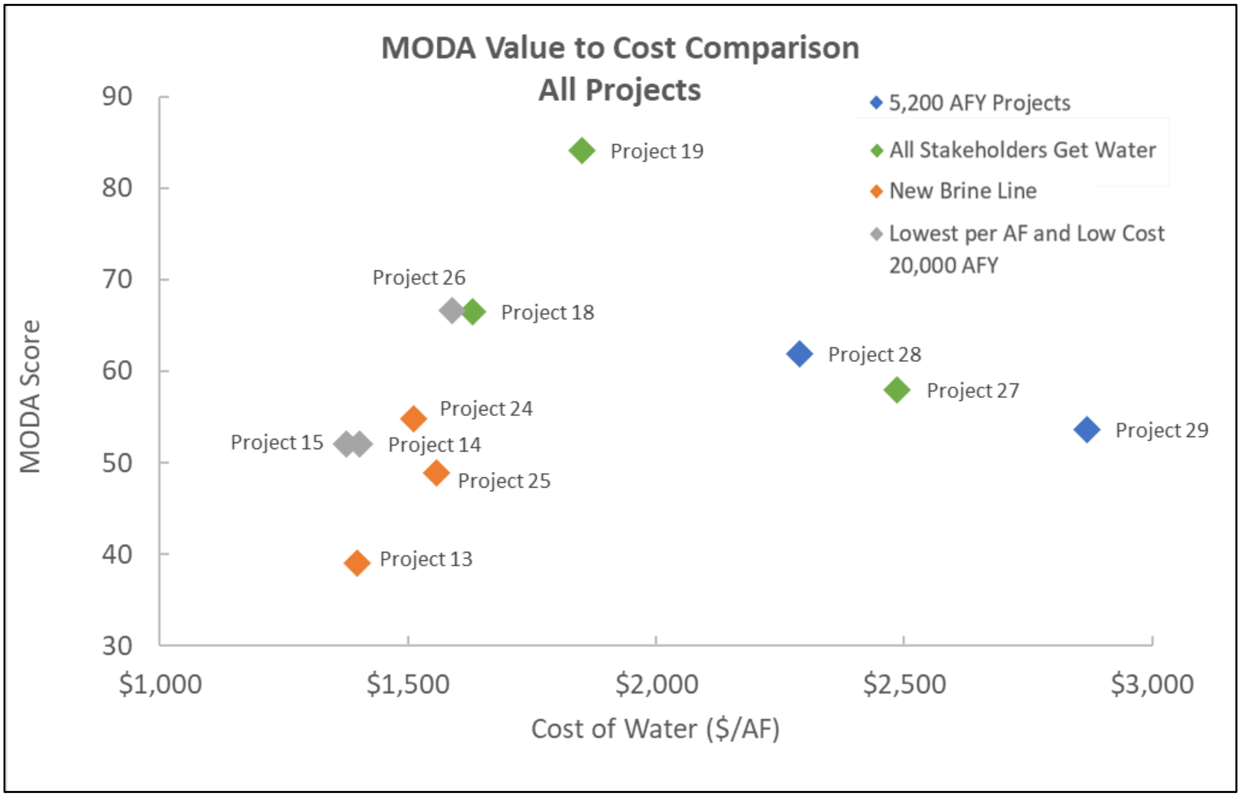

Figure 6-3. MODA Scores and Project Costs

Projects 18 and 26 are worthy of further consideration because of the relative similarity between their MODA scores and costs, and the insensitivity to changes in weights or scoring. Project 26, which had the lowest per AF cost of all of the 12,500-AF extraction projects in the initial project screening, could be reconfigured to deliver water to all stakeholders, but then Project 26 would look similar to Project 18. Therefore, carrying only one of these Projects forward is recommended.

Maintaining a 20,000-AFY Project is desirable because those projects generally have the lowest cost per AF delivered. Projects 14 and 15 extract 20,000 AFY and have similar MODA scores. The primary difference between these projects is the use of the Madrona Lateral in Project 15, which reduces costs because it takes advantage of existing infrastructure. However, the availability of the Madrona Lateral for use in this Program is unknown because of several factors. Therefore, Project 14 is favored over Project 15. However, if the Madrona Lateral becomes available for use, it would decrease costs for any project that could use the Madrona Lateral.

7. Recommendations and Next Steps

Projects 27, 28, and 29 have costs that exceed $2,000 per AF of delivered water and will be eliminated from further consideration.

The following Preferred Projects will be carried forward for further analysis:

- **Project 19 –** 12,500-AFY extraction with portable wellhead treatment (to target all portions of the plume) and delivery to all stakeholders
- **Project 18 –** 12,500-AFY extraction and delivery to all stakeholders
- **Project 14 –** 20,000-AFY extraction that delivers water to four stakeholders

During Workshop 3 in which these MODA results were presented and discussed, the following adjustments and additions were requested:

- Develop an “add-on” cost for portable wellhead treatment that allows any Project to target all portions of the plume, if desired.
- Develop an “add-on” cost for using a direct brine line to the JWPCP or Hyperion WRP outfall systems.
- Modify Project 14 such that it delivers water to all stakeholders.
- Evaluate Projects for a range of extraction volumes from 12,500 AFY and 20,000 AFY. This should provide information on how changes in extraction volumes will affect project costs.

Based on the recommendations presented in Workshop 3 and the variations discussed above, there are six Preferred Projects that will be carried forward in the Feasibility Study. The characteristics of these Projects are shown in Table 7-1.

Table 7-1. List of Preferred Projects for Further Evaluation

	Potential Project - General Description	Extraction Wells	Treatment Locations				Total New Extraction, AFY	Total Existing Extraction (Goldsworthy and Brewer), AFY	Water Delivery Locations						Total New Product Delivery, AFY
			Elm and Faysmith (Torrance)	Wellhead (WHT)	Goldsworthy and Brewer	JWPCP			Torrance	Golden State Water	MB	LADWP	Cal Water	Lomita	
18	Spread across Stakeholders via interties with New Pipeline to MB (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	3,872	850	944	2,597	1,417	944	10,625
19	Spread across Stakeholders via interties with New Pipeline to MB and Portable Wellhead Treatment (12,500 AFY)	10 new wells	10,500	2,000	7,300	-	12,500	7,300	3,872	850	944	2,597	1,417	944	10,625
41	Spread across Stakeholders via interties with New Pipeline to MB (16,000 AFY)	9 new wells	16,500	-	7,300	-	16,000	7,300	3,900	900	1,700	2,900	2,900	1,300	13,600
42	Spread across Stakeholders via interties with New Pipeline to MB and Portable Wellhead Treatment (16,000 AFY)	12 new wells	14,500	2,000	7,300	-	16,000	7,300	3,900	900	1,700	2,900	2,900	1,300	13,600
43	Spread across Stakeholders via interties with New Pipeline to MB (20,000 AFY)	11 new wells	20,000	-	7,300	-	20,000	7,300	4,500	900	1,700	4,200	4,200	1,500	17,000
44	Spread across Stakeholders via interties with New Pipeline to MB and Portable Wellhead Treatment (20,000 AFY)	14 new wells	18,000	2,000	7,300	-	20,000	7,300	4,500	900	1,700	4,200	4,200	1,500	17,000

Appendix B
Facility Operations and Maintenance Plan

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Subject	**Facility Operations and Maintenance Plan**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 29, 2019

1. Introduction

The Water Replenishment District of Southern California (WRD) is responsible for managing and replenishing both the West Coast and Central groundwater basins. In the West Coast Basin, a significant saline plume of groundwater with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, and Lower San Pedro aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To fully use the West Coast Basin, WRD has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. Program goals include treating the plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process. The Program will study the following components:

- Where to extract the plume water
- Where and how to treat the plume water
- How to convey the treated potable water to the Program stakeholders
- How to manage the brine stream

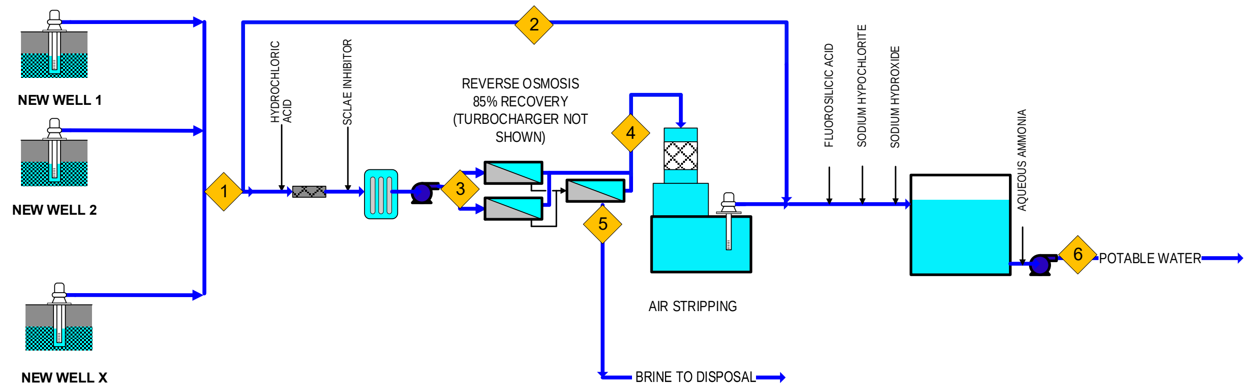
The Program includes the analysis of numerous "Projects," consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of the components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed in dollars per acre-foot (AF) of treated water.

As a part of the Program, WRD has initiated a regional planning study to evaluate the feasibility of remediating the saline plume with seven additional stakeholders (known as the Stakeholder Group) who pump and sell potable water in the West Coast Basin. The Stakeholder Group has expressed interest in either treating the saline plume, receiving the treated water, or both, as part of the Program. The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

Previous work in the Program has established that the shortlisted Projects for further evaluation involve groundwater treatment with reverse osmosis (RO) followed by air stripping (AS). A process flow diagram of the treatment process and the expected mass balance for a 12,500 acre-foot-per-year (AFY) (feed) flow Project are included on Figure 1-1 and in Table 1-1. The shortlisted Projects include those with three different total extracted groundwater capacities, with each capacity having the option for a 2,000-AFY portable wellhead treatment unit, as listed in Table 1-2.

Figure 1-1. 12,500-AFY Centralized Treatment Process Flow Diagram (Project 18)



Stream #	1	2	3	4	5	6
Flow, AFY	12489	161	12327	10478	1849	10640
Flow, gpm	7743	100	7643	6497	1146	6597
TDS, mg/L	6580	6580	6580	140	43073	350
Pressure, psig	60	60	375	10	0	100

Notes:

% = percent

gpm = gallon(s) per minute

mg/L = milligram(s) per liter

psig = pound(s) per square inch gauge

Table 1-1. 12,500-AFY Centralized Treatment Mass Balance (Project 18)

Mass Balance - WRD FS					
Primary RO recovery:	85%	Based upon 5-year membrane age			
CCRO Recovery:	0%				
Overall Recovery:	85%			Arsenic Rejection:	90%
Bypass (gpm):	100			Selenium Rejection:	96%
Permeate Quality FOS:	1.3	CPA6LD ->CPA5LD		Arsenite Rejection:	82%
				Arsenate Rejection:	98.5%

Table 1-1. 12,500-AFY Centralized Treatment Mass Balance (Project 18)

Parameter	RW Well Feed	RO System: ROf Feed to RO	RO System: ROwc RO Concentrate	RO System: ROp RO Permeate	RO System: ROp RO Permeate (with FOS)	Decarbonated ROp	Bypass RO Bypass	Blend	Fp Final	MCL
Flow (mgd)	11.1	11.0	1.6	9.3	9.3	9.3	0.14	9.5	**9.5**	--
(gpm)	7,743	7,643	1,146	6,497	6,497	6,497	100	6,592	**6,592**	--
(AFY)	12,490	12,328	1,849	10,479	10,479	10,479	161	10,640	**10,640**	--
Calcium (mg/L)	646	646	4,279	4.8	6.2	6.2	646	16	**16**	--
Magnesium (mg/L)	351	351	2,325	2.6	3.4	3.4	351	8.7	**8.7**	--
Sodium (mg/L)	1,181	1,181	7,636	41.8	54.3	54.3	1,181	71	**104**	--
Potassium (mg/L)	65	65	417	2.9	3.8	3.8	65.0	4.7	**4.7**	--
Ammonia (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	--
Barium (mg/L)	0.82	0.8	5.4	0.006	0.01	0.01	0.82	0.02	**0.02**	2
Bicarbonate (mg/L)	171	163	1,052	5.8	5.8	5.8	171	8.3	**100**	--
Sulfate (mg/L)	224	224	1,487	1.1	1.4	1.4	224	4.8	**4.8**	250
Chloride (mg/L)	3,980	3,985	26,119	79	102	102	3,980	161	**161**	250
Fluoride (mg/L)	0.16	0.2	1.0	0.01	0.0	0.0	0.2	0.0	**0.0**	2
Nitrate (mg/L)	1.40	1.4	8.7	0.1	0.2	0.2	1.4	0.2	**0.2**	10
Silica (mg/L)	28	28.0	184	0.5	0.7	0.7	28.0	1.1	**1.1**	--
Boron	0.23	0.2	0.7	0.15	0.21	0.21	0.23	0.21	**0.21**	1
Iron (mg/L)	0.18	0.18	1.2	0.001	0.001	0.001	0.180	0.004	**0.004**	0.3
Manganese (mg/L)	0.29	0.29	1.9	0.002	0.003	0.003	0.290	0.01	**0.01**	0.05
Nickel (µg/L)	3.2	3.2	21.2	0.02	0.03	0.03	3.2	0.08	**0.08**	100
Arsenic (µg/L)	3.0	3.0	19.0	0.2	0.2	0.2	3.0	0.3	**0.3**	10
Selenium (µg/L)	32	32	210.6	0.5	0.6	0.6	32.0	1.1	**1.1**	50
Methane (mg/L)	7.0	7.0	7.0	7.0	7.0	0.07	7.0	0.2	**0.2**	--
TDS (reported)	7,694	7,694								
TDS (calculated)	6,580	6,580	43,094	136	176	176	6,580	273	**361**	500
pH	7.9	7.5	8.3	6.0	6.0	6.1	7.9	6.2	**8.4**	6.5-8.5
Temperature (°F)	71	71	71	71	71	71	71	71	**71**	--
CO_2 (mg/L)	3.1	9.1	9.1	9.1	9.1	8.0	3.1	7.9	**0.7**	--
LSI	1.3	0.9	3.2	-4.0	-3.9	-3.8	1.3	-3.1	**0.1**	--

Notes:

The pertinent drinking water MCLs are listed with the following color codes:

black = EPA primary MCL

purple = EPA secondary MCL

green = California MCL or notification level

µg/L = microgram(s) per liter

°F = degree(s) Fahrenheit

CCRO =closed-circuit reverse osmosis

CO_2 = carbon dioxide

CPA = Composite Polyamide

FOS = factor of safety

Fp = finished product water

FS = feasibility study

LSI = Langelier saturation index

MCL = maximum contaminant level

mgd = million gallon(s) per day

ROf = reverse osmosis feed

ROp = reverse osmosis permeate

Rowc = reverse osmosis concentrate or brine

RW = raw water (well feed)

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Table 1-2. List of Preferred Projects for Further Evaluation

Potential Project - General Description		Extraction Wells	Treatment Locations, AFY				Total New Extraction, AFY	Total Existing Extraction (Goldsworthy and Brewer), AFY	Water Delivery Locations, AFY						Total New Product Delivery, AFY
			Elm and Faysmith (Torrance)	Wellhead	Goldsworthy and Brewer	JWPCP			Torrance	Golden State Water	Manhattan Beach	LADWP	Cal Water	Lomita	
18	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	3,872	850	944	2,597	1,417	944	10,625
19	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (12,500 AFY)	10 new wells	10,500	2,000	7,300	-	12,500	7,300	3,872	850	944	2,597	1,417	944	10,625
41	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach (16,000 AFY)	9 new wells	16,000	-	7,300	-	16,000	7,300	3,900	900	1,700	2,900	2,900	1,300	13,600
42	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (16,000 AFY)	12 new wells	14,000	2,000	7,300	-	16,000	7,300	3,900	900	1,700	2,900	2,900	1,300	13,600
43	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach (20,000 AFY)	11 new wells	20,000	-	7,300	-	20,000	7,300	4,500	900	1,700	4,200	4,200	1,500	17,000
44	Spread across Stakeholders via Interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (20,000 AFY)	14 new wells	18,000	2,000	7,300	-	20,000	7,300	4,500	900	1,700	4,200	4,200	1,500	17,000

Notes:

- = component not included in Project

JWPCP = Joint Water Pollution Control Plant

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2. Operations Parameters

This section discusses key drinking water regulations and treated water quality goals.

2.1 Key Drinking Water Regulations

This section describes the government agencies responsible for enforcing the drinking water regulations, provides a brief description of the current regulations, and presents information on how the regulations are applicable to the Projects. Enforcement of drinking water regulations is through the California State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW). Drinking water regulations are found in the California Code of Regulations (CCR), Title 17, Division 1, Chapter 5, and Title 22, Division 4.

Water treatment quality regulations are separated into two distinct groups: primary standards and secondary standards. Primary standards are for the protection of public health. Primary standards include MCLs for:

- Microorganisms
- Disinfectants
- Disinfection by-products (DBPs)
- Inorganic chemicals
- Organic chemicals
- Radionuclides

Secondary standards are aesthetic considerations, or items that affect the appearance or taste of drinking water but are not known to affect public health. The secondary standards are not federally enforceable but are intended as guidelines. However, California has more stringent requirements and generally requires water providers to comply with secondary standards. The Projects in the Program are designed to meet the federal primary and secondary drinking water regulations and the California drinking water regulations, as indicated in the Conceptual System Design and Program Requirements (CSDPR), Task 1 of this Program.

Source waters are typically divided into two categories for regulation: surface water and groundwater. Systems are classified as surface water if they have at least one source that is surface water or groundwater under the direct influence (GUDI) of surface water. Systems are classified as groundwater if they do not meet the surface water definition.

The source water for this Program will be extracted from deep wells, drawing water from between 300 and 1,000 feet below grade. Although the pertinent historical monitoring well data collected in the area do not include data on macroorganisms, algae, or other pathogens such as giardia and cryptosporidium, the historical data for turbidity, conductivity, and pH are relatively stable and do not display rapid shifts in characteristics indicative of the groundwater being under the influence of surface water. Therefore, the source water for the Program is groundwater that is not under the influence of surface water.

Table 2-1 lists the applicable drinking water regulations for the Program. The primary regulatory drivers for water treatment include regulations that address contaminant removal and DBP limits.

Table 2-1. Applicable Drinking Water Regulations

	Quantity
Existing Regulations	EPA National Primary and Secondary Drinking Water Regulations
	Groundwater Rule
	Stage 2 D/DBP Rule
	Arsenic Rule
	Radionuclides Rule
	Phase II/V Rules (Chemical Phase Rules)
	TCR and Revised TCR
	Consumer Confidence Report Rule
	Public Notification Rule
Proposed Regulations	Radon Rule
	Perchlorate Rule
	PFOA and PFOS Draft Recommendation

Notes:
EPA = Environmental Protection Agency
D/DBP = Disinfectant and Disinfection By-product
TCR = Total Coliform Rule
PFOA = Perfluorooctanoic Acid
PFOS = Perfluorooctane Sulfonate

2.1.1 National Primary and Secondary Drinking Water Regulations

The National Primary Drinking Water Regulations (NPDWR) are legally enforceable standards and that apply to public water systems. Primary standards and treatment techniques protect public health by limiting the levels of contaminants in drinking water. National Secondary Drinking Water Regulations are non-enforced guidelines established to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor.

2.1.2 Groundwater Rule

The purpose of the GWR is to reduce disease incidence associated with harmful microorganisms in drinking water. Water systems that have groundwater sources may be susceptible to fecal contamination. In many cases, fecal contamination can contain disease-causing pathogens.

To avoid triggered source water monitoring required under this rule, the Project must provide at least 4-log virus inactivation, removal, or a state-approved combination of the two. Compliance monitoring is required to demonstrate effectiveness of the treatment processes. The RO system provides a barrier to viruses. In addition, 4-log inactivation of viruses is easily achieved with chlorine disinfection and clearwell residence time prior to the addition of ammonia (post-clearwell) for a residual in the disinfection system.

2.1.2 Disinfectant and Disinfection Byproduct Rule

The Stage 1 D/DBP Rule reduces receptor exposure to DBPs for customers of community water systems that add a disinfectant to the drinking water during any part of the treatment process. The Stage 1 D/DBP Rule includes:

- Maximum residual disinfectant level goals and maximum residual disinfectant levels (MRDLs) for chlorine, chloramines, and chlorine dioxide

- Maximum contaminant level goals (MCLGs) and MCLs for total trihalomethanes (TTHMs), haloacetic acids five (HAA5), bromate, and chlorite
- Treatment technique requirements for DBP precursors

The Stage 2 D/DBP Rule builds upon the Stage 1 D/DBP Rule to address risks from microbial pathogens and D/DBP (specifically, TTHM and HAA5), which can form in water through disinfection used to control pathogens. Monitoring for TTHM and HAA5 concentrations must comply with the disinfection requirements of 40 *Code of Federal Regulations* (CFR) 141.72(b) and monitoring requirements of 40 CFR 141.74(c).

For reference, the Stage 2 D/DBP Rule amended the distribution system compliance requirements. The revised distribution sampling points are determined through an initial distribution system evaluation consisting of 1 year of monitoring, about every 60 days, at eight sampling sites for each water treatment plant (in addition to the Stage 1 D/DBP Rule compliance monitoring sites). Systems with sufficiently low DBPs (TTHM and HAA5 concentrations less than 0.040 mg/L and 0.030 mg/L, respectively) in all samples taken in the previous 2 years may be exempt from initial distribution system evaluation monitoring.

As the Projects in this Program will be adding chloramines to the potable product water produced for disinfection residual (per Task 1 CSDPR), controls and operator attention will be required to confirm that the levels of chloramines and DBPs do not exceed the limits shown in Table 2-2 as of April 2019.

Table 2-2. Chloramine and Disinfection By-product Limits in Potable Water

Constituent	MCL (mg/L)
Chloramines	4.0 as chlorine (maximum residual disinfectant levels)
TTHMs	0.08
HAA5	0.06

The feedwater total organic carbon (TOC) is expected to be reasonably low, approximately 1.1 mg/L. Furthermore, the RO system will remove nearly all of the TOC and DBP precursors prior to chlorination, so DBP formation potential should be low, especially with the use of chloramines for disinfection residual.

2.1.3 Arsenic Rule

The revised Arsenic Rule adopted a new standard to improve public health by reducing receptor exposure to arsenic in drinking water. The rule lowered the MCL for arsenic from 0.05 to 0.01 mg/L and set an MCLG of 0.0 mg/L. This rule also revised monitoring requirements. Compliance with this rule is based on a running annual average at each sampling location calculated from quarterly samples.

Arsenic levels in the well source water are expected to be approximately 0.003 mg/L, which is substantially less than the 0.01-mg/L MCL. Therefore, compliance with the Arsenic Rule will be met.

2.1.4 Radionuclides Rule

The Radionuclides Rule was developed to reduce receptor exposure to radionuclides in drinking water. The revised Radionuclides Rule retained the existing MCLs for combined radium-226 and radium-228, gross alpha particle radioactivity, and beta particle and photon activity. The rule established an MCL for uranium of 0.03 mg/L.

Each of these constituents has been recommended for additional sampling in the CSDPR because data are limited in the monitoring wells of interest. If radionuclides are detected, the RO system will provide some removal.

2.1.5 Phase II/V Rules

The Phase II/V Rules regulate more than 65 contaminants in the following 3 contaminant groups: inorganic chemicals, volatile organic compounds (VOCs), and synthetic organic chemicals. The rule establishes monitoring and best available technologies for removal of the 65 contaminants and reporting requirements for these contaminants.

Each of these contaminants has been recommended for additional sampling in the CSDPR because data are limited in the monitoring wells of interest. In general, RO provides substantial removal of charged inorganics and compounds of more than 200 to 250 molecular weight. In addition, the air stripper will provide substantial removal of VOCs should these be present in the well water.

2.1.6 Total Coliform Rule

The TCR sets both health goals (MCLGs) and legal limits (MCLs) for the presence of total coliforms in drinking water. The presence of any coliforms in drinking water may indicate that there could be other disease-causing agents in the water. The rule also details the type and frequency of testing that water systems must undertake and is dependent on the number of people served. For example, a potable distribution system serving 500,000 people must collect a minimum of 210 samples per month in the potable distribution system. These total coliform samples must be collected at regular intervals at sites that are representative of water quality throughout the distribution system according to a written sampling plan.

The major provisions of the Revised TCR include the following:

- An MCLG and an MCL for Escherichia coli (E. coli) for protection against potential fecal contamination
- A total coliform treatment technique requirement
- Requirements for monitoring total coliforms and E. coli according to a sample siting plan and schedule specific to the public water supply
- Provisions allowing the public water supplies to transition to the Revised TCR using their existing TCR monitoring
- Frequency, including public water supplies on reduced monitoring under the existing TCR
- Requirements for seasonal systems (such as noncommunity water systems not operated on a year-round basis) to monitor and certify the completion of state-approved startup procedures (this is not applicable to this WRD Program)
- Requirements for assessments and corrective action when monitoring results show that public water supplies may be vulnerable to contamination
- Public notification requirements for violations
- Specific language for community water systems to include in their Consumer Confidence Reports when they must conduct an assessment or if they incur an E. coli MCL violation

E. coli is unlikely to be present in the well water; nonetheless, specific sampling is included in this document so that no E. coli or heterotrophic plate count (HPC) bacteria are delivered into the potable water system. The RO system provides a pathogen barrier if there are any coliforms present in the source water. Chloramine disinfection provides additional protection against coliforms.

As these Projects under consideration will deliver potable water into existing distribution systems, sampling of these distribution systems for compliance with the TCR should already be in place.

2.1.7 Consumer Confidence Report Rule

The Consumer Confidence Report Rule requires public water supply systems to provide drinking water quality reports annually to consumers. Each stakeholder in the Program provides these annual reports.

2.1.8 Public Notification Rule

Public notification is required by public water supply providers to let consumers know about a problem with their drinking water. The Public Notification Rule requires faster public notice in emergencies to communicate the potential health risks from drinking water violations. The Public Notification Rule also specifies time limits and distribution requirements for public notices and provides standard language that may be used in notifications.

2.1.9 Proposed Regulations

No enforceable standards have been set for radon, perchlorate, perfluorooctanoic acid (PFOA) or perfluorooctane sulfonate (PFOS) as of yet. The monitoring wells have demonstrated that the levels of perchlorate in the area are less than the detection limit. Radon has been recommended for additional sampling in the CSDPR because data are limited in the monitoring wells of interest. Interim recommendations for groundwater contaminated with PFOA and/or PFOS have been drafted.

2.2 Treated Water Quality Goals

The Projects in the Program are being designed with the capability to meet all applicable primary and secondary drinking water standards. The facility is also being designed to meet the more stringent water quality goals that have been set for this project and that are summarized in Table 2-3.

Table 2-3. Key Treated Water Quality Goals and Regulations

Constituent	Goal	MCL	Regulation
Chloride, mg/L	200	250	Secondary MCL
Manganese, mg/L	0.03	0.05	Secondary MCL
Methane, mg/L	0.2	-	-
Odor, TON	2	3	Secondary MCL
TDS, mg/L	400	500	Secondary MCL

Notes:

- = not applicable

TON = Threshold Odor Number

2.3 Effluent Management

The Project will produce a continuous effluent consisting primarily of RO brine waste having maximum constituent concentrations as indicated in the Brine Discharge Evaluation Technical Memorandum of the Program and repeated in Table 2-4. Two options exist for brine management, including discharge to the Los Angeles County Sanitation Districts' (LACSD's) collection system (sewer), and discharge directly to the LACSD JWPCP outfall.

Table 2-4 compares the Project effluent quality to the requirements for the LACSD sewer. None of the LACSD requirements are expected to be problematic for any of the Projects. However, the Project levels of cyanide and dissolved sulfide in the feedwater are unknown because, historically, the monitoring wells have not been tested for these constituents, so the levels of these two constituents would need to be confirmed in future phases of the Program, as recommended in the CSDPR.

Table 2-4. Expected Project Effluent and Water Quality Limitations for Discharge to LACSD Sewer

Constituent	Quantity	Estimated Project Effluent (Brine) Concentration	Unit
Arsenic	3	0.02	mg/L
Cadmium	15	<0.01[a]	mg/L
Total Chromium	10	--[b]	mg/L
Copper	15	<0.15[a]	mg/L
Cyanide (total)	10	--[b]	mg/L
Lead	40	<0.01[a]	mg/L
Mercury	2	<0.002[a]	mg/L
Nickel	12	<0.041	mg/L
Silver	5	<0.01[a]	mg/L
Sulfide (dissolved)	0.1	--[b]	mg/L
Zinc	25	<1[a]	mg/L
pH	>6	7.8	-
Total Identifiable Chlorinated Hydrocarbons	None	None	mg/L

[a] Pertinent monitoring well concentrations for these constituents are less than the method detection limit.

[b] No pertinent monitoring well data are available for these constituents.

Notes:

< = less than

> = greater than

The requirements for the quality of the effluent that could be sent to the LACSD JWPCP outfall have yet to be determined.

2.4 Operating Parameters and Intervals

This section reviews the treatment process, monitoring, and critical parameters.

2.4.1 Treatment Process

RO uses a semipermeable membrane material that can separate dissolved ions and elements through a diffusion-controlled process. RO membranes reject ions and dissolved organics exceeding a molecular weight of 200. RO membranes require feedwater with minimal suspended solids and colloids to prevent fouling and high headloss across the membranes. In addition, although the Projects will not use any oxidants, polyamide membranes are also degraded by free chlorine and other oxidants, so care must be taken so that the membranes do not come in contact with such oxidants.

Pretreatment of the source water will be required to protect the RO membranes from particulates and for scale control. To prevent mineral scaling in the RO brine, antiscalant will be added to the RO feedwater and will be pH-adjusted with hydrochloric acid. A decrease in the feed pH may be required to assist with sparingly soluble salt scale inhibition, and since sulfate salts of barium and calcium are a scaling concern, hydrochloric acid has been selected over sulfuric acid. In addition, the feedwater will pass through a 10-micrometer (μ) cartridge filter upstream of the RO skids to remove particulate matter from the well water.

The RO permeate will pass through a counter-current air stripper to remove odor, and incidentally, methane as well. The permeate will be pumped to the top of the air strippers and will flow downward through inert plastic media designed to increase the surface area between the water and the air. Air will be forced upward by a blower at ground level. As indicated in the CSDPR of this Program, additional water testing is required to identify and quantify the odorous compounds in the groundwater. Assuming the odor is from hydrogen sulfide, the air stripper effluent air can be passed through activated carbon for odor removal. Note that natural methane gas is odorless.

Remineralization and post-treatment are required so that the product potable water is suitable for consumption and will consist of:

- Carbon dioxide
- Sodium hydroxide
- Hydrofluosilicic acid
- Sodium hypochlorite
- Ammonium hydroxide

2.4.2 Monitoring and Critical Parameters

Proper operation and rejection of the RO will be required to meet the chloride, TDS, and manganese key treatment goals listed in Table 2-3. The online monitoring of each RO train's permeate conductivity will provide evidence of proper RO performance. The air stripper's blowers will need to be operational to provide air for the necessary mass transfer for methane and odor removal, assuming that the cause of the odor is volatile and susceptible to AS, like hydrogen sulfide (see CSDPR for odor recommendations). Online monitoring of an air pressure transmitter on the blower effluent of each air stripper will provide confidence in proper blower operation. A complete list of the most critical online monitors and analyzers is included in Table 2-5.

Table 2-5. Critical Online Instruments and Analyzers

Instrument	Purpose
Individual RO Train Permeate Conductivity	Evidence of the necessary rejection of dissolved salts, including chloride, TDS, and manganese, as well as color
Air Stripper Blower Effluent Pressure	Verification of air flow required for odor and methane removal
Finished Water pH, Free Chlorine (entering clearwell), Chloramine (after clearwell) Fluoride, Conductivity	Drinking water quality verification

In addition, Operations staff will need to perform grab sampling and analysis to verify the finished, potable drinking water quality; check the performance of online analyzers; and confirm the proper operation of the treatment plant. Table 2-6 lists the sampling and analysis performed by the Operations staff at the 11-mgd Reynolds Desalter (Sweetwater Authority in Chula Vista, California) that has been in operation for approximately 10 years. It is suggested that the Project follow a similar grab sampling and analysis scheme, shown in Table 2-6. These items were added because of the nature of the feedwater of the Program.

Table 2-6. Operator Grab Sampling and Analysis Frequency

Parameter	Frequency	Location
Temperature	Daily	RO feed, finished water (potable)
Conductivity	Daily	RO feed, finished water (potable)
pH	Daily	RO feed, finished water (potable)
Turbidity	Daily	RO feed, finished water (potable)
Free chlorine	Daily	Entering clearwell
Fluoride	Daily	Finished water (potable)
Chloramines	Daily	Finished water (potable)
Color	Daily	Finished water (potable)
Manganese	Weekly	Finished water (potable)
Iron	Weekly	Finished water (potable)
Sulfate	Weekly	Finished water (potable)
Chloride	Weekly	Finished water (potable)
TDS	Weekly	Finished water (potable)
Odor	Weekly	Finished water (potable)
Total and Fecal Coliform	Weekly	Discharge of each individual well, plant inlet (RO feed), individual RO train permeate, finished water (potable)
HPC Bacteria	Weekly	Discharge of each individual well, plant inlet (RO feed), individual RO train permeate, finished water (potable)

3. Required Labor and Staffing

Raw operating and maintenance (O&M) labor rates at other membrane-based potable water treatment plants in southern California are listed in Table 3-1.

Table 3-1. Southern California Water Treatment Plant Raw 2019 Staffing Rates

Plant	Position	Responsibilities	Hourly Rate[a] ($)		
			Minimum	Average	Maximum
Groundwater Desalter	Operator 1	Plant operations, plant drinking water regulation compliance, onsite analysis and data collection, sample collection and lab coordination, procurement of chemicals	30.55	33.71	36.88
	Operator 2		34.33	38.03	41.72
	Operator 3		37.89	41.97	46.06
	Maintenance/ I&C 1	Calibration of instruments, repair and maintenance of plant equipment, service of wells and distribution system	26.82	29.71	32.60
	Maintenance/ I&C 2		29.60	32.79	35.98
	Maintenance/ I&C 3		32.67	36.19	39.72
Surface Water Treatment Plant	Lead Operator T4/T3	Plant operations, plant drinking water regulation compliance, onsite analysis and data collection, sample collection and lab coordination, procurement of chemicals	37.89	41.97	46.06

[a]These are raw labor rates. A 1.6 multiplier is typically applied to convert to fully loaded rates that include benefits.

Note:

I&C = instrumentation and controls

3.1.1 Project Staffing

California regulations do not have a specific requirement for the number of staff needed to operate a treatment facility. Regulations classify water treatment facilities (Title 22 CCR 64413.1) to determine the level of certification and knowledge an operator must have to operate a facility as a chief or shift operator (22 CCR 63765). Each utility is required to designate at least one chief and shift operator, and these individuals must be onsite at all times, unless an equal degree of operational oversight and reliability is provided, and the operator is able to be contacted within 1 hour (22 CCR 64413.5).

The Projects in the Program will require Grade T2 Treatment Operator Certification based on 22 CCR 64413.1. Therefore, the plant may be assigned a T2 treatment classification requiring a T2 certified chief operator and T1 or higher shift operators. In 22 CCR 64413.1, the Projects would be T2 facilities; however, it is recommended that WRD contact the Regional Water Quality Control Board (RWQCB) in a future phase of the Project to verify that the Projects will be T2 facilities. Jacobs Engineering Group Inc. (Jacobs) has some concerns that the treatment facility classification may be increased because the product water will be sent to multiple agencies; thus, T3 facilities are assumed as a worst-case operating labor condition.

The existing Goldsworthy and Reynolds potable groundwater desalters have operators onsite during regular hours on weekdays, and a few hours on weekends to collect readings. A similar arrangement has been worked out for the new potable groundwater desalter at Twentynine Palms Marine Corp Base in California. Each of these treatment plants has remote monitoring, either via supervisory control and data acquisition (SCADA) systems, by existing resources at another treatment facility (Reynolds and Twentynine Palms), or via iPads assigned to the Operations staff (Goldsworthy)

The quantity of Project staffing will depend upon the entity selected to operate the facility, and whether or not that entity can draw on existing resources to remotely monitor the Project. The level of staffing is considered the same for all six Projects in the Program, and the portable wellhead treatment system will be tied into the SCADA system at the centralized treatment plant and covered by the centralized operators, including regular monitoring via the SCADA system.

In accordance with Title 22 CCR 64413.1, the wells and distribution system will need to be maintained by a Class D4 distribution system operator because the Project will likely serve potable water to between 50,000 and 5 million people.

3.1.1.1 Scenario 1, Project Monitored Remotely by Another Existing Facility

If the Project SCADA system can be monitored remotely by an existing facility using existing resources, an approximation of the O&M labor would include one new treatment plant operator (T3), one new distribution operator to service the up to 11 new wells and distribution system, and the part-time assistance of an existing operator and an existing maintenance/I&C individual for equipment calibration and servicing. The part-time individuals would be existing full-time workers with only part of their time allocated to the Program.

Table 3-2 includes the details of the annual labor costs under Scenario 1, with fully loaded rates and 20 percent added for potential overtime. The treatment operators are each conservatively assumed to have the average of the Operator 3 (T3) rates from Table 3-1.

Table 3-2. Annual Treatment Plant Labor Scenario 1, Using Existing Resources

Hours per Week	Cost ($)	Comments
48	2,015	Operator 3 (T3)
40	1,521	Operator 2 (D4)
4	131	Maintenance and I&C 2
	3,667	Total per week wages only
	5,867	Total per week, including benefits
	305,087	Annual
	366,104	Annual, including 20% contingency for OT

Notes:
OT = overtime

3.1.1.2 Scenario 2, Stand-alone Facility

If the O&M staff for the Project cannot be drawn or shared from existing local resources, the plant will need to be staffed to handle remote monitoring 24 hours a day and 7 days per week. This staffing will include a supervision T3 operator, three additional T2 grade operators, one D4 distribution operator, and one maintenance/I&C worker. Table 3-3 includes the details of the annual labor costs under Scenario 2.

Table 3-3. Annual Treatment Plant Labor Scenario 2, Labor for Remote Monitoring 24/7

Hours per Week	Cost ($)	Comments
120	4,563	Operator 2
40	1,679	Operator 3 (T3)
40	1,679	Operator 2 (D4)
40	1,312	Maintenance and I&C 2
	9,233	Total per week wages only
	14,772	Total per week, including benefits
	768,144	Annual
	921,773	Annual, including 20% contingency for OT

4. Support Infrastructure

At a minimum, support facilities will be required at the centralized Projects for the electrical, onsite water quality testing, and operator control room. The electrical control room will house the switchgear required for all equipment. Onsite laboratory testing will consist of analyses, such as pH, conductivity, free and total chlorine, and others, that can be performed with a Hach test kit and that are required for water quality and analyzer verification. The operators will spend most of their time onsite, monitoring and controlling the process from the SCADA system screens located in the control room.

Table 4-1 displays the details of the support infrastructure footprint at the Goldsworthy (original design including room for expansion), Reynolds, and the new Twentynine Palms desalters and a recommended footprint for the support infrastructure for the Projects in the Program. The following are pertinent:

- None of the desalters includes space set aside for tours or research and development.
- The Projects in the Program will treat groundwater with much higher salinity than the others listed; thus, will require a higher ratio of electrical room footprint to product water produced.
- Because of the limited footprint at the preferred centralized Project site for the Program, no room has been set aside for office space or material storage. However, approximately 1,200 square feet (ft^2) have been set aside (20,000-AFY Project and more for the 12,500-AFY and 16,000-AFY Projects) for potential future pretreatment requirements.

Table 4-1. Support Infrastructure at Similar Desalters

Footprint	Goldsworthy (ft^2)	Reynolds (ft^2)	Twentynine Palms (ft^2)	Centralized Recommendation (ft^2)
Feed Capacity AFY/ Product mgd	6,500/5[a]	15,200/11	3,600/3	12,500/9.5 to 20,000/15.3
Office Space	None	100	150	None
Shop and Repair Facilities	None	None	1,200	None
Material Storage	None	~500 (144 + mezzanine)	1,000	None[b]
Research and Development Area	None	None	None	None
Tour Facilities	None	None	None	None
Meeting Space	None	1,500	450	None
Laboratory Space	None	150	800	300
Electrical Room	620	700	1,000[c]	900 to 1,250[d]
Control Room area	450 (includes restroom)	500	600	600
Treatment Equipment	8,000	24,000[e]	12,000[f]	15,000 - 18,000

[a] Original building, including expansion area.

[b] Although no dedicated space has been allocated to "storage," the centralized treatment plant buildings each have space allocated for potential additional pretreatment that could be used for storage.

[c] Includes secondary CCRO and spray evaporators for evaporation ponds.

[d] Feedwater salinity and energy consumption are higher in the Centralized Recommendation (Program) than in any of the other desalters in this table.

[e] Includes 60-foot-diameter above-grade product water storage tank.

[f] Includes secondary CCRO and tank.

5. Operating and Maintenance Budget

The Projects are assumed to operate at design capacity for 350 days per year, leaving 15 days for maintenance and unexpected shutdowns.

5.1 Energy

The Projects are assumed to run on electricity supplied from the grid, with an average cost of electricity assumed to be $0.105 per kilowatt hour (kWh). Typically, no natural gas will be consumed. Task 2 of the Program provides details of alternate options to grid power.

From the Source Water Quality Characterization (completed Task 1E of this Program), the initial Project feed salinity is expected to be approximately 6,500 mg/L. Over time, as barrier injection water continues and the saline plume is treated by this Project and by the existing Goldsworthy and Brewer desalters, the salinity level is expected to slowly decrease in the aquifers to that of drinking water. The time it will take for decrease depends on the size of the Project and is expected to be approximately 14.3, 16.8, and 19.8 years for Projects withdrawing 20,000 AFY, 16,000 AFY, and 12,500 AFY, respectively.

As the salinity decreases, the osmotic pressure that the RO needs to overcome to produce product water decreases. The RO feed pressure will, therefore, decrease over time; thus, the energy use of the Projects will decrease, as well. The RO will use a turbocharger for energy recovery, and the projected initial feed pressure will be approximately 375 psig, reducing to approximately 135 psig just before water in the aquifers reaches drinking water quality. The mid-point RO feed pressure is projected to be approximately 280 psig.

Table 5-1 displays the breakdown of the annual energy expenditure of the 12,500-AFY centralized Project (Project 18 in Table 1-2) over time. It is assumed that the wells will need to have a pressure of 150 psig to lift the groundwater from the aquifer and deliver it to the Project at a 50- to 60-psig feed pressure, which is necessary for cartridge filtration and proper RO high-pressure pump suction pressure. In addition, the required product water pump discharge pressure is 100 psig to get the product water into the distribution system.

Table 5-1. 12,500-AFY Annual Centralized Project Energy Use[a]

Annual Electrical Costs, sample 12,500 AFY	6500 mg/L TDS Year 1 ($)	3500 mg/L TDS Year 10 ($)	600 mg/L TDS Year 19 ($)
Wells	817,000	817,000	817,000
RO	1,774,000	1,306,000	614,000
Air Stripper	51,000	51,000	51,000
Liquid Chemicals	17,700	17,700	17,700
Vertical Turbine Pump Station	477,000	477,000	477,000
Carbon Dioxide Solution Feed System (Recarbonation)	32,000	32,000	32,000
	3,200,000	2,700,000	2,000,000

[a] Supporting infrastructure energy, such as lighting, is included in each section (e.g., wells, RO).

Projects 19, 42, and 44 consist of centralized treatment facilities of 10,500, 14,000, and 18,000 AFY, respectively, in combination with a 2,000-AFY portable wellhead treatment system. Possible treatment facilities are listed in Table 5-2 with their estimated electrical costs.

Table 5-2. Annual Electrical Costs at Each Treatment Location

Annual Electrical Costs at each Treatment Location	6500 mg/L TDS Year 1 ($)	3500 mg/L TDS Year 10 ($)	600 mg/L TDS Year 19 ($)
2,000 AFY Portable Well Head Treatment Unit including Well	620,000	550,000	430,000
10,500 AFY Project Including Wells	2,800,000	2,400,000	1,800,000
12,500 AFY Project including Wells	3,200,000	2,700,000	2,000,000
14,000 AFY Project including wells	3,500,000	3,000,000	2,200,000
16,000 AFY Project including wells	4,000,000	3,300,000	2,400,000
18,000 AFY Project including wells	4,400,000	3,700,000	2,700,000
20,000 AFY Project including wells	4,800,000	4,000,000	2,900,000

5.2 Chemicals

Antiscalant and hydrochloric acid will be dosed continuously in the RO feedwater to prevent scaling. Jacobs has coordinated with Avista Technologies Inc. (Avista) for the proper antiscalant for use in the Program. Vitec 1500 will allow 85 percent recovery on the RO without scaling at a substantially lower dose and cost than the Vitec 4000 antiscalant assumed in Task 1 of this Program. Although Vitec 1500 is not in the Avista Advisor software, it has been in use for 4 years and is the current antiscalant at the West Basin Municipal Water District's Edward C Little Water Recycling Facility.[1]

In addition, carbon dioxide, sodium hydroxide, hydrofluorosilicic acid, sodium hypochlorite, and ammonium hydroxide will be continuously dosed in post-treatment and remineralization of the RO permeate water. Jacobs has coordinated with WRD and revised the chemical costs of sodium hydroxide, aqueous ammonia (ammonium hydroxide), and sodium hypochlorite to coincide with WRD's latest chemical quotations. Table 5-3 provides the details of the chemical consumption for the 12,500-AFY centralized Project. The RO clean-in-place frequency is assumed to be three times per year, consisting of solid chemicals, including separate solutions of 2 percent citric acid and a combination of:

- 1 percent trisodium phosphate
- 1 percent sodium tripolyphosphate
- 1 percent sodium ethylene diamine triacetic acid
- 0.1 percent sodium hydroxide

Neutralization chemical use is included in the clean-in-place consumption.

Table 5-3. 12,500-AFY Centralized Project Annual Chemical Use

Chemical Type	dose, mg/L	Cost ($)	gpd	Gal/month	$/year
Antiscalant	1.5	1,506	14	418	38,000
37% Hydrochloric Acid	5.0	510	174	5,231	49,000
Carbon Dioxide	47	168	**kg**	50,555	112,000
50% Sodium Hydroxide	51	530	645	19,350	384,000
Hydrofluorosilicic Acid	1.0	5,507	19	583	78,000
12.5% Sodium Hypochlorite	3.5	1,407	277	8,300	77,000
29% Ammonium Hydroxide	1.7	4,266	85	2,546	93,000
CIP Chemicals					217,000
					1,048,000

Note:
CIP = clean-in-place
gpd = gallon(s) per day

The total chemical costs at each treatment location are indicated in Table 5-4.

[1] Per conversations with Avista

Table 5-4. Annual Chemical Costs at Each Treatment Location

Project/Location	Cost ($)
2,000-AFY Portable Well Head Treatment Unit, including Well	170,000
10,000-AFY Project, including Wells	880,000
12,500-AFY Project, including Wells	1,050,000
14,000-AFY Project, including Wells	1,180,000
16,000-AFY Project, including Wells	1,340,000
18,000-AFY Project, including Wells	1,510,000
20,000-AFY Project, including Wells	1,680,000

5.3 Other Consumables, Equipment Replacement, and Repair

Routine consumables include cartridge filter replacements, estimated to be 8 times per year, and RO membrane replacement, estimated to be every 5 years. Jacobs has a division that operates water treatment plants, including those treatment plants based on membrane treatment, and general replacement and repair of the plants have proven to be approximately 3.2 percent of the installed equipment cost per year. Table 5-5 lists the annual regular consumables and anticipated equipment replacement and repair costs of the 12,500-AFY centralized treatment facility. The repair and replacement costs cover the treatment plant and the wells.

Table 5-5. 12,500-AFY Centralized Annual Consumables, Repair, and Replacement Costs

Consumable	Quantity Replaced	Cost ($)	$/year
Cartridge Filters - Pre RO	5,632	16.79	95,000
Cartridge Filters - RO CIP	18	16.79	302
RO Membranes	340	514	175,000
Repair and Replacement			760,000
Total			1,030,000

Table 5-6 lists the annual regular consumables and anticipated equipment replacement and repair costs at each treatment location.

Table 5-6. Annual Consumables, Repair, and Replacement Costs at Each Treatment Location

Project/Location	Cost ($)
2,000-AFY Portable Well Head Treatment Unit, including Well	300,000
10,500-AFY Project, including Wells	910,000
12,500-AFY Project, including Wells	1,030,000
14,000-AFY Project, including Wells	1,100,000
16,000-AFY Project, including Wells	1,300,000
18,000-AFY Project, including Wells	1,400,000
20,000-AFY Project, including Wells	1,600,000

5.4 Labor

Labor costs are presented in Section 3.

5.5 Outside Laboratory Analysis Fees

Compliance with the Department of Public Health guidelines will require that a certified external laboratory perform periodic testing on the finished potable water as follows:

- Weekly: Metals, sulfate, chloride, TDS, total coliform and E.coli, HPC bacteria, odor
- Monthly: Raw fluoride, nitrite, nitrate
- Quarterly: TTHMs, HAA5, synthetic organic chemicals, VOCs, radiologicals (triennial)
- Annually: General mineral, inorganics, organics, general physical, secondary standards

Additional external laboratory fees are incurred for the facility with multiple treatment trains for troubleshooting and verification purposes. Table 5-7 lists external laboratory fees at each treatment location.

Table 5-7. Annual External Laboratory Fees at Each Treatment Location

Project/Location	Cost ($)
2,000-AFY Portable Well Head Treatment Unit, including Well	$150,000
10,500-AFY Project, including Wells	$250,000
12,500-AFY Project including Wells	$250,000
14,000-AFY Project, including Wells	$250,000
16,000-AFY Project, including Wells	$300,000
18,000-AFY Project, including Wells	$300,000
20,000-AFY Project, including Wells	$300,000

5.6 Environmental Compliance and Total Annual Operations and Maintenance for Each Potential Project

The total O&M costs for each Project include the following:

- Energy
- Chemicals
- Labor
- Consumables repair and replacement
- External laboratory fees

A 25 percent contingency is added to the total cost to cover additional costs for:

- Trucks
- Forklifts
- Personal protective equipment
- Training
- Tools
- SCADA operating system license
- Internal laboratory equipment consumables
- Environmental compliance issues that require operator attention

5.6.1 Environmental Compliance

The following are environmental compliance issues that will require operator attention:

- Aqueous ammonia is used in quantities of greater than or equal to 500 pounds. Therefore, a California Accidental Release Prevention Program (CalARP) will need to be prepared (per CCR Title 19, Division 2, Chapter 4.5). The CalARP will be audited every 3 years; require a complete review every 5 years; and include hazard analysis, offsite consequence modeling, and training.
- Construction and operation of treatment plant equipment and power generation equipment, including emergency backup power generation equipment, will require a permit from the South Coast Air Quality Management District (SCAQMD). Following construction, the permitted equipment will be subject to the SCAQMD's inspections to determine whether the facility is operating in compliance with applicable permit and clean air requirements. An annual inspection will be required.
- The operators will need to prepare a Hazardous Materials Business Plan (HMBP) (California Health and Safety Code Chapters 6.5, 6.7, 6.95, Title 19, 22, and 23) for site chemicals, including flammables related to the onsite generator. Specifically, the HMBP is required for storage and handling of chemicals and fuel in quantities that exceed reporting thresholds (55 gallons for liquids, 500 pounds for solids, or 200 cubic feet [ft^3] for gas). The HMBP will include:
  - Quantities
  - Details on storage and labeling
  - Waste disposal manifests
  - Spill control and response procedures
  - Operator training

  An annual inspection will be required by the Certified Unified Program Agency (CUPA), which is the Los Angeles County Fire Department; and an annual online update will be required in the California Emergency Response System (CERS).
- A Spill Prevention Control Countermeasure also regulated by the Los Angeles County Fire Department, will be required. This countermeasure will include a monthly site inspection by plant staff of all petroleum-based containers, storage, and monitoring of electrical transformers for leakage.
- Operation of a public water system requires acquisition of a Water Supply Permit from the SWRCB DDW, and associated monitoring and reporting.

5.6.2 Total Annual Operations and Maintenance

Table 1-2 provides the descriptions of the Projects. Projects 19, 42, and 44 are combinations of the 2,000-AFY portable wellhead treatment and 10,500-AFY, 14,000-AFY, and 18,000-AFY centralized treatment.

Regarding labor, no shared resources are assumed, and the labor included in the total O&M costs is that displayed in Table 3-3. Because this labor includes enough personnel to provide constant remote supervision, no additional labor is included for Projects that include the portable wellhead treatment unit. The portable wellhead treatment unit will be tied in to the centralized treatment SCADA system, and the centralized treatment plant O&M personnel will support each treatment location.

The total O&M is displayed in Table 5-8 for three different feedwater salinities: Year 1, midpoint, and the last year of treatment plant operation. The energy will vary with what is anticipated to be decreasing salinity over time. Section 5.1 provides an explanation and the treatment duration.

Table 5-8. Total Annual O&M Costs for the Projects

Total Annual O&M Costs	6500 mg/L TDS Year 1 ($)	3500 mg/L TDS Midpoint ($)	600 mg/L TDS Year X ($)
Project 18	8,000,000	7,400,000	6,500,000
Project 19	9,000,000	8,400,000	7,500,000
Project 41	9,700,000	8,800,000	7,700,000
Project 42	10,500,000	10,000,000	8,600,000
Project 43	11,500,000	10,700,000	9,600,000
Project 44	12,500,000	11,500,000	10,100,000

Appendix C
Power Supply Plan

JACOBS®

Technical Memorandum

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Subject	**Power Supply Plan**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 29, 2019

1. Executive Summary

Through ongoing coordination with the Water Replenishment District of Southern California (WRD), Jacobs Engineering Group Inc. (Jacobs) has been evaluating several opportunities to treat the saline plumes located in the West Coast Basin and integrate into the municipal water supply. To date, Jacobs analyzed multiple applicable water filtration plants and volume configurations. The result of Task 1 deemed that three plant configurations and subconfigurations are applicable for further evaluation:

- Project 18: 12.5,000 acre-foot per year (AFY) desalter with 7 new extraction wellheads
- Project 19: 10.5,000 AFY desalter with 10 new extraction wellheads with portable wellhead treatment (totaling 12.5,000 AFY of extraction)
- Project 41: 16,000 AFY desalter with 9 new extraction wellheads
- Project 42: 14,000 AFY desalter with 12 new extraction wellheads with portable wellhead treatment (totaling 16,000 AFY of extraction)
- Project 43: 20,000 AFY desalter with 11 new extraction wellheads
- Project 44: 18,000 AFY desalter with 14 new extraction wellheads with portable wellhead treatment (totaling 20,000 AFY of extraction)

Using the anticipated electrical loads of recommended plant sizes, the Task 2 – Power Supply Plan (PSP) is one of the next steps in the overall Project evaluation. The goal of Task 2 is to analyze and recommend the most applicable and feasible, environmentally efficient, cost-effective, and long-term equipment configuration to meet the electric power demand loads of the brackish reclaimed water facility. This assessment provides a screening of power options, including conventional generation and renewable energy, that meet the needs of the overall energy strategy in comparison to the baseline purchased electricity.

A methodical evaluation of power generating facility selection began with the establishment of the Project baseline for the amount of purchased electricity required from the utility provider for each of the new water treatment facility projects. The PSP details the extent of the transmission infrastructure that may be required, and a review of purchased power from Southern California Edison (SCE), a community choice aggregation (CCA), or a wholesale market broker.

Through the feasibility evaluation, Jacobs determined that there is not a significant cost savings to service equipment loads outside of the water treatment facility with the power generating equipment options. Jacobs recommends purchasing power from SCE to service the individual wellhead locations and portable wellhead treatment. Determination should be made after a more detailed evaluation is performed. As such, only the loads at the Elm and Faysmith facility for the various Project capacities were evaluated in this study.

With input from WRD, an equipment grading matrix was created with several different criteria, each weighted differently to prioritize several factors. The matrix in Appendix A shows the advantages and disadvantages of the feasible equipment configurations for comparison, with the recommended option being fuel cell servers and the preferred alternative being reciprocating engines for most of the feasible water filtration plant sizes. Both technologies have some advantages and disadvantages but will ultimately meet the requirements of the facility. Jacobs recommends that the feasible and preferred alternative options identified in the results be carried forward into a more detailed evaluation that incorporates a right sizing analysis, a high-resolution performance analysis that further evaluates specific equipment models and performance sensitivity, and provides a more in-depth description of the facility operations.

2. Evaluation Approach

2.1 Power Selection Process and Considerations

Power selection is a methodical process that screens the viable Project alternatives in increasing rigor and detail. The evaluation and selection processes are based upon the annual base electric power demands of each of three Elm and Faysmith plant capacities. The plant normal operations are assumed to create a steady and constant electrical demand for continuous operation of 350 days a year. As such, the constant electrical load will be referred to as the Project electrical loads that will be used as the benchmark for the evaluation.

The Project electric loads will be used as the basis to analyze and screen the viable power alternatives. Alternatives that do not meet the facility load requirements will be rejected, and those that do will be retained to further evaluate their merits with comparison to other feasible equipment configurations. As a secondary consideration, each alternative will be evaluated for their greenhouse gas (GHG) footprint. The California Energy Commission developed the Renewables Portfolio Standard (RPS), which indicates that California's goal is to have 60 percent power generation from renewable energy by 2030 and 100 percent renewable energy by 2045 (CPUC, 2019a). Although the RPS standard was derived for retail sellers of electricity (that is, investor owned utilities, public owned utilities, electric service providers, and community choice aggregations [CCAs]), the decision matrix will consider California emission reduction regulations and renewable goals. While GHG emissions and renewable energies are an important consideration, the electric loads, air permitting restraints, footprint, reliability, and economical aspects of the evaluation are also important in the overall recommendation.

The evaluation process is a relatively high-level, qualitative screening and selection process that will be based on the engineering knowledge, expertise, judgement, and experience of alternatives that are deemed favorable. At the beginning of this evaluation, it can be readily discerned which alternatives clearly do not meet the evaluation selection and water treatment facility requirements. For example, Project 43 (20,000 acre-feet per year [AFY]) has an approximate electrical demand of 4 megawatts (MW). With this base load, photovoltaic (PV) solar panels would require an estimated 16 acres of land. With the 1-acre space available, approximately 250 kilowatts (kW) of power could be produced. Based on the high-level screening, it is determined that PV panels would not be a realistic application for the plant due to the small amount of energy generated and insignificant impact on the water treatment facility's electrical demand; thus, PV panels are removed from further analysis.

As such, the overall selection process is intended to be a phased effort, with increasing levels of evaluation that help quantify the viability of each option as the process moves to the recommendations. The overall objective of this evaluation is to provide a selection process that is expeditious, clear, and concise, and maintains confidence in the validity of the final selection as being the best available option that will meet the overall requirements of the facility.

2.2 Major System Design Criteria

The power generation selection process has been performed based on the general project criteria presented as follows:

- The facility electric power demands for three site configurations:
  - 12,500-AFY site - 2.5 MW
  - 16,000-AFY site - 3 MW
  - 20,000-AFY site - 4 MW
- In addition to these facilities, extraction wells feeding the Project site (Elm and Faysmith) will each require an extraction pump approximately sized at 150 horsepower (HP), with a possibility of a 0.4-MW portable water treatment facility for each site capacity (that is, Projects 19, 42, and 44). The quantities of pumps for each of the plant configuration options are:
  - 12,500-AFY site - 7 x 150-HP pumps
  - 16,000-AFY site - 9 x 150-HP pumps
  - 20,000-AFY site - 11 x 150-HP pumps
- The lengths of study (operations) for the three site configurations are:
  - 12,500-AFY site - 20 years
  - 16,000-AFY site - 17 years
  - 20,000-AFY site - 15 years
- The power generating selection will be cost-effective, high-efficiency, and capable of meeting a major portion of the facility utility requirements and demands.
- The power generating selection air permit emissions and carbon footprint impacts will be considered.
- The power generating selections will have a reasonably proven operational history and a United States (U.S.)-based product support capability.
- Plant performance comparisons will be based upon the following site ambient conditions:
  - Average annual dry bulb temperature of 76 degrees Fahrenheit (°F)
  - Average annual wet bulb of 66°F
  - Plant location elevation of a nominal 97 feet above mean sea level (amsl)
- Utility costs for the Elm and Faysmith facility are based upon the following values:
  - Electric Rate - $0.105/ kilowatt-hour (kWh) (WRD)
  - Natural Gas Rate - $5.50/ million British thermal units (MMBtu)
- Fuel supply sources will be readily available to support the long-term operation of the selected alternative. In the case of natural gas fuel source, the design gas supply pressure to any new facility will be a minimum of 15 pounds per square inch gauge (psig). Available gas pressure at the site can be assumed to be 60 psig based upon the Southern California Gas Company (SoCalGas) high-pressure distribution map (PHMSA, 2016). Dual fuel capabilities will not be considered in the evaluation.
- The power supply recommendation(s) selection will be capable of:
  - Electric power parallel operation with the utility power grid
  - Continuous service with reliable operation
  - Being located within the existing site boundaries at the Elm and Faysmith site for onsite power generation because:
    - Offsite generation is not being fully considered due to the land, power delivery, utility, and easement requirements that would be necessary to feed the plant.
  - Facilitating a soft plant shutdown to gradually decrease operations
- The power generation selection will be located outdoors in an acoustic enclosure.
- The power generation selection will maximize the level of electric power reliability. All options will incorporate some means of redundant power, either with equipment redundancy or grid backup.

The early evaluation process is intended to quickly evaluate the range of power production technologies available without expending significant amounts of time and expense. The initial portions of the screening process are based on making the obvious and intuitive qualitative choices without detailed analysis. These screening decisions are straightforward and based upon extensive knowledge, expertise, and experience with all major facility design considerations, as well as how each applies to the specific water treatment facility load application. The screening process is appropriate to make choices between power generating technologies that have sufficiently clear distinctions. With this strategy, the detailed evaluation is reserved for comparing technologies that meet all the acceptance criteria.

2.3 Selection Process Acceptance Criteria

The evaluation screening criteria and considerations for the various power generation configurations are as follows:

- Provide electric power to match the water treatment facility utility loads.
- Use proven technology to provide a long and trouble-free service life.
- Minimize air emissions, including permitting pollutants and greenhouse gas (GHG) emissions.
- Provide an acceptable level of overall service reliability.
- Provide a cost-effective capital cost that can be realistically funded.
- Provide a cost-effective and realistic level of operations and maintenance (O&M) costs.
- Use equipment with a footprint that can be located on the specified site location.

The evaluation criteria and matrix are further described within the Matrix Evaluations section of the feasibility study to highlight the acceptance criteria and provide information to support the power generation recommendations.

3. Water Treatment Facility Location

The most likely site where the water treatment facility will be located is between Elm Avenue and Faysmith Avenue, and Maricopa Street and Torrance Boulevard in Torrance, California. The proposed location of the water treatment facility is a 2-acre greenfield site in the middle of a residential neighborhood, which will be equally split for the treatment plant and a future city park. The space available on the Elm and Faysmith site for power generating equipment is limited due to the space that will be occupied by the water treatment equipment. As a result, space will be considered a factor in the decision matrix for the power generating equipment.

4. Electric Utility Rates

With direction from WRD, the SCE utility rate is assumed to be $0.105/kWh and will be used throughout this study. However, based upon research into existing utility rates in the Torrance, California area and analysis of existing WRD utility bills, Jacobs estimates that the all-in rate, including demand and energy charges, is approximately $0.13/kWh. Standby charges were not considered as part of this evaluation.

In addition to the electrical rate used in this evaluation, SCE provides an option for customers to allocate an additional $0.035/kWh to support renewable energy generation. Upon their discretion, WRD has an opportunity, at an increased electrical rate, to invest in renewable energy without the commitment of owning and operating the equipment. A more detailed analysis on the utility rate structure should be developed with a future in-depth study to verify the accuracy of the utility rates, as they can have a major impact on the economics of all power generating options and evaluations.

5. Baseline Cases

5.1 Project Electric Load Description

As noted, the baseline options for each water treatment facility configuration are developed to establish the electric costs associated with purchasing all electricity from the local utility provider, SCE. In the event of a grid outage, an emergency backup generator will be included as part of each baseline option to facilitate a soft shutdown. For this study, it is assumed that the purchased electricity is available at 4,160 volts (V) and does not require an exterior transformer at the facility site.

5.2 Baseline Utility Loads

Baseline utility loads for the water treatment facility are broken up by the three main facility configurations and treatment capacities, each with a suboption of portable wellhead(s). Though the facility power demand loads will vary slightly for the various treatment capacities at the Elm and Faysmith facility, a nominal facility power demand for each treatment capacity is used for the purposes of this feasibility study. Further refinement of the actual facility power demands should be determined in the more detailed analysis. It is assumed that the load will be base loaded at each of the recommended capacities for the Elm and Faysmith site. The facility will run for 24 hours a day, 350 days of the year. Table 1 represents the feasible Projects' capacities and baseline utility load requirements.

Table 1. WRD Regional Brackish Water Baseline Power Requirements

Projects	Description	Total Capacities (AFY)	Facility Power Demand (MW)	Extraction Wells	150-HP Pumps	Total Pump Load (MW)	Portable Treatment Load (MW)[a]	Total Treatment Facility Demand (MW)	Total Annual Consumption (MWh)
18	Desalter	12,500	2.5	7	7	0.8	0	3.3	27,586
19	Project 18, with the addition of portable wellhead treatment for remediation	10,500	2.5	7	7	0.8	0.4	3.7	30,946
41	Desalter without portable wellhead treatment	16,000	3	9	9	1.0	0	4.0	33,667
42	Desalter, including portable wellhead treatment	14,000	3	9	9	1.0	0.4	4.4	37,027
43	Desalter without portable wellhead treatment	20,000	4	11	11	1.2	0	5.2	43,949
44	Desalter, including portable wellhead treatment	18,000	4	11	11	1.2	0.4	5.6	47,309

[a] Additional pumps may be installed, but only a single pump will be in operation.

Notes:

MWh = megawatt-hour(s)

Due to additional infrastructure required, generating and distributing power to each of the wellhead locations would not be cost-effective compared to purchasing power from SCE with local electrical equipment to operate the 150-HP pumps. As such, only the electrical load demand at the Elm and Faysmith site for each project capacity will be evaluated. The exclusion of the multiple extraction wells from the baseline and power generating options will not have a factor on the overall system categorization and final recommendation, as the additional load would be subjected to all options across the evaluation.

6. Power Transmission Requirements

Each of the facilities will require new electrical service, which creates necessary coordination with SCE for transmission line easements. This can be handled one of two ways:

1) SCE can be hired to conduct easement title research for WRD, including a records research and survey for a fee.
2) WRD can obtain a third party to develop a title report that can then be used for coordination with SCE.

It is anticipated that the facility will be served from the existing aerial 5-kilovolt (kV) infrastructure adjacent to the site. Jacobs assumes adequate capacity exists in the system for the total plant load. Coordination with the Utility Planning Department will be required once a plant configuration is determined for confirmation. SCE provides the electrical infrastructure up to the service point, including the service lateral, at no charge to WRD. The service point is defined by the utility, often at the line side of the service equipment main disconnect. The 4,160-V main breaker would provide the role of service equipment main disconnect in the WRD facility. SCE will supply temporary construction power for a fee determined once construction power needs are identified.

Utility interconnection with paralleled generation requires varying levels of protective functions set forth by the utility based on variables, like load size, voltage, and reliability requirements, as examples. Further coordination with the utility will be required to identify exact protective functions, and their maximum and minimum limits. Jacobs recommends installation of multifunction microprocessor-based protective relays, such as SEL-751, SEL-700G, GE Multilin UR, and GE Multilin G60. These relays are modular and can be customized as needed to provide required functionality.

7. Generating Options

For achieving electrical independence from SCE, there are a variety of technologies available for the preliminary evaluation to maintain the treatment plant operation and overall lifecycle cost (LCC). These technologies range from renewable energy sources, to power generating equipment, to fuel cells.

7.1 Onsite Power Generation

7.1.1 Solar Photovoltaic

PV technology uses an array of solar panels to harvest the sun’s energy for the generation of electricity. Solar panel PVs provide electricity without generation of GHGs and are most efficient coincident with peak electricity demand. Solar electric power is considered a varying power generation alternative, which means that is it not capable of providing a fixed amount of power generation and is dependent on weather conditions unless it is coupled with another type of technology, such as battery storage. While providing great benefit, solar PV requires a large amount of land area and carries significant capital cost for installation, approximately 4 acres of space is required to produce 1 MW of electricity.

Given that the total amount of space at this site is only an acre, not including equipment, the maximum amount of electricity that can be produced is approximately 250 kW. Since power production is exclusively based on clear weather conditions, battery storage would also need to be considered to improve reliability of the facility for 24-hour operation. Given the limited available space on the Elm and Faysmith site, solar technology would not generate the total electrical capacity for the water facility required. Solar generation could offset a portion of the power demand for the facility; however, it would not have a significant impact on the water treatment facility’s electrical demand. Although solar power can be used to enhance the renewable portfolio for WRD, it is not viewed as a viable primary energy source. Due to the high capital cost and low electric generation, onsite solar PVs are not considered feasible for further evaluation.

7.1.2 Battery Storage

Battery storage technology uses electrochemical batteries to store power from generating equipment or the utility grid. Battery storage has many applications and is most commonly coupled with renewable energy sources to store power and to distribute when renewables are not generating at full capacity. Another application of battery storage is the ability to charge the batteries from the grid during nonpeak demand times and to dissipate that stored energy during high peak demand periods, often called peak shaving. Peak shaving can have a significant impact on electrical costs at a facility by reducing the demand charges and is commonly used for facilities that are purchasing wholesale power or on a rate-based utility schedule. Battery storage is a commercially viable alternative; however, it is still relatively expensive and is maintenance intensive for battery replacement and disposal.

As the electrical rate in this evaluation is fixed, there would be no peak demand periods to impact the utility costs in relation to the grid. In combination with the fixed electrical rate and limited renewable energy production onsite, battery storage was not considered further in this evaluation. Dependent on a more defined variable electrical rate structure with SCE, battery storage may be a configuration that could be evaluated in the future detailed study to take advantage of peak and off-peak rate periods.

7.1.3 Wind Turbines

Wind turbines operate on the principle of using wind to turn an electric generator. For large installations, turbine sizes typically begin at 20 kW of peak electrical production but can reach sizes up to 3 MW. Wind-generated electric power is a commercially viable nonfirm alternative; however, it is still a relatively expensive alternative and not suitable for reliable service to a water treatment facility.

Wind energy is primarily focused in a location that has relatively strong and consistent wind. Based on the limited available ground space onsite and the proximity to a residential area, it would be impractical. If wind is to be used at the water treatment facility, only small, building-mounted wind turbines can be implemented. These smaller turbines provide a very small amount of the energy and will not have a significant impact on the water treatment facility's electrical demand. Although wind turbines can be used to enhance the renewable portfolio for WRD, it is not viewed as a viable primary energy source.

7.1.4 Biogas

Biogas is an organic gas, produced from human, animal, or plant waste through anaerobic digestion. Organic waste is separated before bacteria digests it into biogas. Biogas can be used to fuel equipment, such as boilers, turbines, or reciprocating engines. The quantity of methane, 7 milligrams per liter (mg/L), inherent to the well water will not be sufficient to impact facility demands. To generate the required electric power required for the water treatment facility, a large and continuous biogas fuel stream would be required. Additionally, the use of biogas would likely require additional investment for biogas treatment to remove water and a large host of entrained elements, particularly siloxanes and hydrogen sulfide. Due to the geographic location of the facility and no proximity of a biogas fuel supplier, biogas is not viewed as a viable energy source.

7.1.5 Renewable Natural Gas

Renewable natural gas (RNG) is derived from biogas by refining it further than the biogas used at landfills or wastewater treatment facilities. This additional treatment consists of removing a large amount of the inherent carbon dioxide concentrations in biogas to meet the required concentration. There are a few companies that engage in gathering and treating biogas at landfill or wastewater treatment sites, and then inject this RNG into the local distribution or transmission system. Thus, RNG is a renewable energy source for WRD, whether it is used for fuel cells or combustion-based power generation resources, such as gas turbines or gas reciprocating engines. Procurement of RNG is negotiated through a local gas supplier. Based upon initial estimates, the cost of procuring RNG through a local gas supplier could be in excess of $30/MMBtu (SoCalGas, 2019). Compared to the previously stated cost of regular natural gas ($5.50/MMBtu), this approximately 5 times greater cost difference makes RNG commercially nonviable.

7.1.6 Combustion Turbine Generators

Combustion turbine generators (CTGs) use internal components to compress ambient air and mix it with the fuel source in the combustion chamber to rotate the main turbine shaft. The rotating shaft paired with the generator converts the mechanical energy into electricity for end-use. These turbines can range anywhere from 1 to 40 MW and can commonly be found in large utility plants. The cycle efficiency for combustion gas turbines is generally in the 28 to 36 percent range for models in the 2.5 to 4.5 MW range. They can be configured to be produce electricity to meet base loads or to overcome peaking electrical demands.

CTGs often offer flexibility in configuration to meet project requirements. In the simple cycle configuration, the CTG uses the combustion and generation process to create electrical power as the final form of energy. CTGs can also be configured in a combined heat and power (CHP) arrangement, where the high temperature exhaust that would be otherwise be vented to atmosphere is used to create steam. This steam can then be used in a steam turbine generator for additional power production or used for an array of heating applications at a facility. Based on the operational needs of the water treatment facility, there is not a significant demand for waste heat or additional power generation that would promote CHP or combined cycle advantages.

With regards to the site layout and space allocation, CTGs can be a compact prepackage unit for simple cycle operation. However, depending on the constraints of the air permitting limits, necessary selective catalytic reduction (SCR) and catalyst equipment sections required to reduce emissions would increase the overall dimensions and increase overall equipment size. It is likely that extensive combustion controls and postcombustion treatment will be required to reduce the criteria pollutant concentrations down to the local requirements. Additionally, available emission reduction technologies may not be sufficient to meet requirements, resulting in the need to purchase emissions credits. Given the operational flexibility, reliability, and footprint, CTGs should be considered a feasible option.

7.1.7 Microturbines

Microturbines are small combustion turbines that use gaseous or liquid fuels to generate power. Microturbine sizes are available from 25 to 300 kW and can be integrated into modular packages exceeding 1 MW. The cycle efficiency for microturbines are generally in the range of 28 to 36 percent.

Microturbines are not considered a feasible option because the simple cycle efficiency is similar to that of the larger combustion turbines, but they typically carry a higher capital cost. As a result, they would not provide savings relative to the other options evaluated.

7.1.8 Gas Reciprocating Engines

Gas reciprocating engines use expansion of combustion gases to drive a piston within a cylinder and convert that movement onto a crankshaft to generate power. Gas reciprocating engines are found in varying arrangements and can range in capacities of 1 to 20 MW. The cycle efficiency for gas reciprocating engines is generally in the 42 to 44 percent range for the larger models in the 2.5- to 4-MW range, which operate with twin turbochargers. The gas supply pressure requirements for gas reciprocating engines are generally less than 65 psig at the site meter. The engines can be configured to accept various types of fuel and, similar to the CTG, can recover heat from the exhaust of the engine to produce hot water or steam. However, the heat recovery option for the reciprocating engines offer no significant benefit to the facility. The gas reciprocating engines can be installed as a compact packaged unit that reduce the required space for O&M.

Gas engines for electrical power production inherently have many benefits that suit the proposed facility. The main benefit is the high operational reliability with proper maintenance, as proved with a long history of industry use. Secondly, the unit can accommodate both “island” or parallel mode operations with the electrical grid. With the engine’s ability to respond to electric load variations quickly and accurately, the facility can remain operational through unexpected load excursions or utility grid outages.

It is likely that extensive combustion controls and postcombustion treatment will be required to reduce the criteria pollutant concentrations down to the local requirements. Additionally, available emission reduction technologies may not be sufficient to meet requirements, resulting in the need to purchase emissions credits. Given the operational flexibility and reliability, gas reciprocating engines should be considered a feasible option.

7.1.9 Fuel Cells

Relative to other power generating technologies, fuel cells are an emerging technology that provide efficient power production. A fuel cell generates power by an electrochemical reaction that mixes fuel with air to produce electricity. Fuel cells typically operate on biogas, natural gas, or RNG. Fuel cell technology has very high efficiencies ranging from 47 to 50 percent, and emit extremely low levels of nitrogen oxide (NOx), sulfur oxide (SOx), and particulate matter (PM). There are opportunities to recover waste heat, but as noted earlier, this is not applicable for the current facility design.

In general, fuel cell technology is in the early stages of industrial, use with several units currently in commercial service, when compared to combustion generation. Most of the fuel cell units being offered in the marketplace are relatively small units, ranging from 1 watt (W) to 400 kW of electrical generation. This size of unit is intended for small electric power applications, such as mobile applications for transit, material handling, and backup electric power sources. Like all technologies, there are manufacturers that provide proprietary designs that can accommodate a larger production capacity by either a single equipment skid or modular configurations. As such, this evaluation analyzes both configurations.

One fuel cell manufacturer offers patented Carbonate Direct Fuel Cell technology units in larger capacities for industrial service, and stationary power electric and cogeneration applications. It currently offers models with rated capacities of 1.4, 2.8, and 3.7 MW.

Another manufacturer can provide a modular configuration of 300 kW “servers” that can be multiplied to fit the electrical demands. These units do not have any waste heat, which results in an overall efficiency of greater than 56 percent. Considering these servers do not actually use combustion in their process, the units do not emit any smog particulates (such as NOx or sulfur dioxide [SO_2]) and meet the South Coast Air Quality Management District (SCAQMD) emission requirements (SCAQMD, 2019).

These fuel cell units have minimal space requirements and have quiet operations, making them suitable for a spaced-constrained urban location. Fuel cell technology can be procured for any facility, but due to the high capital investment and the long duration of payback, projects are commonly rolled into a Power Purchasing Agreement (PPA). As a brief explanation, the PPA agreement offers no upfront cost to the end-user but requires a long-term contract of a predetermined electrical rate. The rate is arranged such that the capital investment and operating costs are recovered by the investor over the term of the project. The end-user would ultimately be responsible for the natural gas utility bill in addition to the payment of the PPA. The PPA is seen to have the benefits of no upfront costs but has the disadvantage of a lower LCC in comparison to the other options. Given the reliability, efficiency, footprint, and low emissions, fuel cell technology should be considered a feasible option.

7.2 Offsite Generation Options

Offsite generation options have not been evaluated in detail due the significant capital investment required for procuring additional land to install the electrical distribution and transmission infrastructure required to directly supply power to the facility. The capital investment compared to the power demand requirements of the water treatment facility would translate to an unfavorable payback period for WRD. Additionally, tying into an existing transmission and distribution system will require an interconnection agreement with SCE, a complicated process that will require additional engineering and coordination with SCE to allow power to be introduced at the site chosen for offsite generation. Existing transmission and distribution system interconnection would also require compliance with the RPS obligations already noted.

7.2.1 Solar

While providing great benefit, solar PV requires a large amount of land area and carries significant capital cost for installation. A large ground-mounted solar PV power plant requires space for the PV cells and other accessories, requiring 4 acres of land to produce 1 MW of electricity. To fully offset the load of the water treatment facility and well locations, approximately 25 acres of land would need to be purchased, and significant electrical distribution and transmission infrastructure would need to be installed. Considering the significant capital investment to supply such a small electrical capacity to the water treatment facility, offsite solar renewables should not be considered a feasible option for WRD.

7.2.2 Wind Turbines

As noted, wind turbines operate on the principle of using wind to turn an electric generator. For large installations, turbine sizes typically begin at 20 kW of peak electrical production but can reach sizes up to 3 MW. To meet the demand for the water treatment facility and extraction wells, a wind farm array would be required and would operate best with smooth flowing wind; typical spacing would be approximately 250 feet. Wind generation would require a significant amount of land, and significant electrical distribution and transmission infrastructure would need to be installed. Considering the significant capital investment to supply such a small electrical capacity to the water treatment facility, offsite wind generation should not be considered a feasible option for WRD.

7.2.3 Biogas

A landfill gas (LFG) or wastewater treatment facility could be developed as an offsite generation option. However, proximity and availability of LFG would be the driving factor to consider the feasibility of this option. As there are no large landfill facilities located close to Torrance or close to a biogas fuel supplier, biogas is not viewed as a viable offsite energy source.

7.2.4 Combustion Turbine Generators and Gas Reciprocating Engines

Combustion turbine generator and gas reciprocating engine technologies share the exact same qualities as mentioned in the onsite generation section. Offsite generation could be considered feasible in locations where biogas can be used to take advantages of many of the tax credits in the California area. Provided that there are no close biogas producers to the Elm and Faysmith facility, the cost of procuring land, transmission and distribution, permitting, and easements make this option infeasible for the Elm and Faysmith facility for any of the capacity options. Additionally, an SCE existing transmission and distribution system interconnection would require compliance with the RPS obligations , which would make combustion turbine generators and gas reciprocating engines not viable power generation options.

8. Community Choice Aggregations

CCAs are a means for cities in Southern California to aggregate renewable energy sources for their residents. Several cities have already formed a CCA, one of which being the City of Pico Rivera, which has formed Pico Prime so that its residents and retail customers can purchase renewable energy and take advantage of economy of scale that the city can provide but one that the typical retail customer cannot.

Quoting right from the CCA website for the City of Lancaster (CalChoice, 2018):

> *"Beginning and operating a CCA is a complex process. Through CalChoice, each City has access to experienced staff who have been through the implementation and operational process. This allows each City to avoid common pitfalls that come with starting from scratch and to operate their CCA as efficiently as possible."*

Given the complexity of setting up its own CCA for WRD, buying electrical energy from an existing CCA may be more beneficial for WRD. However, the price of electricity is approximately $0.15 /kWh, which is higher than the base rate from SCE, much of it being due to the fact that CCA's aggregate renewable energy portfolio is significantly higher than SCE's (Lancaster Choice Energy, 2019). If WRD desires to invest in renewables and claim the environmental benefit without having to implement its own technology, CCAs are managed by the California Energy Commission and are held to the California RPS goals.

A CCA would not be a low-cost alternative for WRD in comparison to purchased or generating power options; however, if WRD is interested in participating in the RPS program without implementing its own renewable technology, a CCA could be considered.

9. Wholesale Power Market Purchase

The wholesale power market in California is administered by the California Independent System Operator (CAL ISO). CAL ISO procedures and programs manage the flow of electricity by matching demand with supply within the transmission system to avoid congestion (California ISO, 2019).

CAL ISO has many programs in place to accomplish these goals, which include a marketplace where power generation capacity bids into the market where electric distribution companies and other wholesale buyers place bids. The CAL ISO energy market comprises distinct day-ahead and real-time processes.

To participate in the wholesale market, each participant is required to use the services of a Scheduling Coordinator (SC), and this person or company must be certified by the CAL ISO. SCs have certain prescribed training and examination requirements. The CAL ISO maintains a list of SCs who have been certified.

The cost and complexity of obtaining certification for an SC would not be practical for WRD, due to the extensive training and new workforce required to participate in the market on an hourly basis. The better approach would be to contract for that service with a few SCs who are already providing such service for a number of cities in Southern California, such as the cities of Pasadena, Riverside, Pico Rivera, and many others. A list of all SCs is attached to this report in Appendix B.

When a facility option (thus, the power requirement) has been selected, WRD could negotiate for the services of an SC for wholesale power purchases, which could have significant cost savings over the baseline electricity rates from SCE. However, entering the wholesale power market can be susceptible to a lot of risk due to volatility of the market rates.

10. Permitting Requirements

All self-generation options considered by WRD need to meet the strict emission and control requirements set forth by the SCAQMD. The SCAQMD is responsible for regulating and permitting stationary sources in the South Coast Air Basin where the Project is located. New construction of equipment that would emit air pollutants is required to obtain permits from SCAQMD for construction and operation and comply with the applicable requirements in SCAQMD's source-specific rules and new source review rules for emission control. New combustion-based power generation may trigger the emission offsets requirements and the use of best available control technologies. The availability and cost of emission credits need to be carefully evaluated by WRD as any and all combustion-based self-generation is being considered.

11. Tax Incentives and Rebates

Federal, state, and local regulations were analyzed to determine the applicability of available rebates or incentives (DOE, 2019a, b). While many incentive programs were analyzed for applicability, only those that were deemed probable are discussed in this section. A more detailed study is recommended to evaluate these incentives against the power generating equipment options.

11.1 Federal

At the federal level, there are no direct energy incentives available for this Project; however, two tax incentives exist in the form of the Modified Accelerated Cost-Recovery System (MACRS) and the

Business Energy Investment Tax Credit (ITC). Because both programs are governed and administered through the Internal Revenue Service (IRS), a thorough analysis by a licensed tax professional is recommended through Project scope finalization to confirm the tax code has not changed before these are pursued.

The MACRS allows a certain investment property to be depreciated at an accelerated rate according to the IRS depreciation chart and type of property. For fuel cells and other advanced technologies, 100 percent of the investment value can be depreciated over 5 years. For gas reciprocating engines and other traditional power generation equipment, 100 percent of the investment value can be depreciated over 15 years. The incentive comes in the form of an annual tax deduction for the amount depreciated, not a direct credit.

The ITC allows for a 30 percent tax credit of the investment value if qualifying advanced technologies (solar, fuel cells, or wind) are used. If geothermal, microturbines, or CHP technologies are used, then the ITC allows for a 10 percent tax credit of the investment value.

11.2 State

At the state level, up-front incentives and tax incentives were investigated (CPUC, 2019b; California State Board of Equalization, 2019). The main up-front incentive is the California Self-Generation Incentive Program (SGIP). This incentive program has been successfully used in the past for projects of similar scope. Unfortunately, due to recent policy changes enacted in 2017, this program requires 50 percent blended biogas in 2019 and 100 percent biogas in 2020 as a fuel source. In addition to the new biogas requirement, there is also a waste heat to power requirement and a minimum 10-year average efficiency requirement. Because the wastewater treatment process is unable to provide the amount of biogas necessary, and based on a conservative assumption that the adjacent natural gas transmission pipe will not be 100 percent biogas, the Project will not be eligible for the SGIP, and no additional investigation was done to determine whether the other SGIP requirements would be met by the proposed equipment.

The state tax incentive is based on the California Revenue and Taxation Code Publication 61. This portion of the California tax code exempts power generation and distribution equipment from the 3.9375 percent state sales and use tax when the equipment is purchased.

11.3 Local

While investigating local incentives, an additional utility-driven incentive was found and is only applicable with the use of fuel cell technology. Based on Rule 21 for SCE, the program allows an agreement between WRD and SCE such that WRD would not be responsible for paying standby and departing load charges for connection to the electrical grid (SCE, 2018).

12. Power Generation Screening

12.1 Introduction

The purpose of the Task 2 - Power Supply Plan (PSP) screening analysis is to assess the relative performance benefits of a broad spectrum of potential options involving power generation using the projected annual electrical demand data. With the evaluation, the options were narrowed to a few configurations for consideration.

The screening analysis included consideration of the following factors:

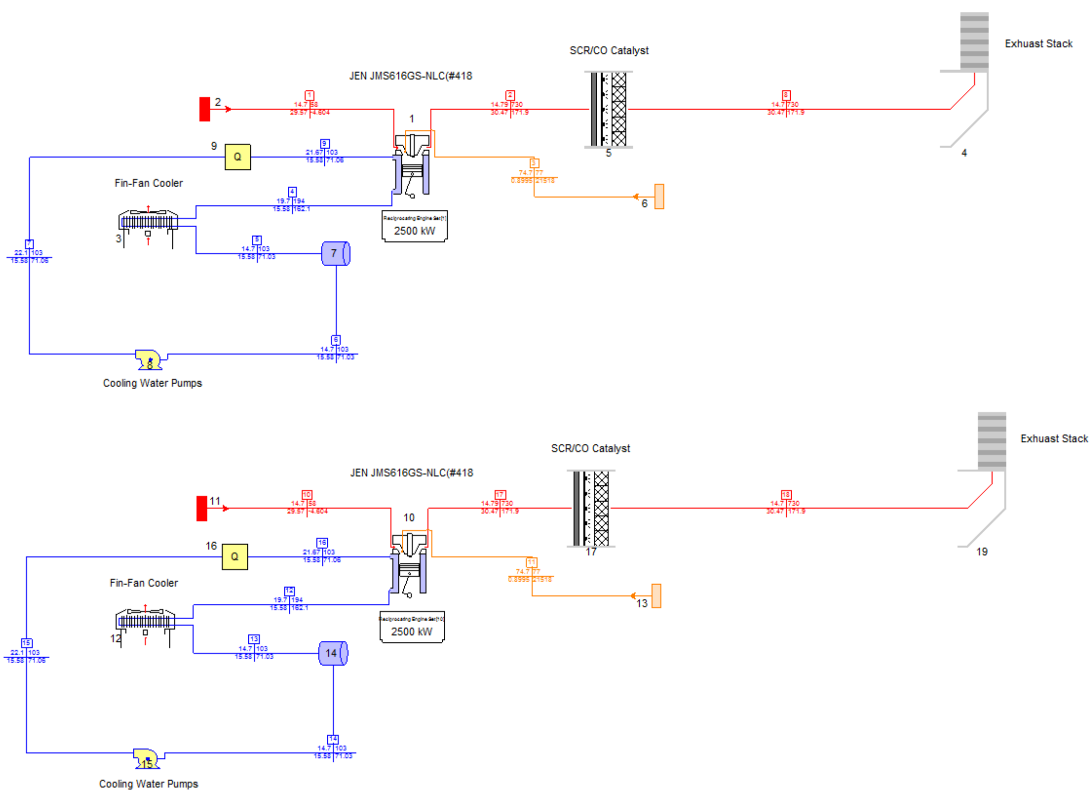
- Optimization of equipment sizing, selection, and configuration to maximize beneficial use of base load capacity with respect to the full anticipated range of the facility's electric demands
- Utility consumption and associated costs
- Estimated incremental O&M costs for each power generation configuration

12.2 Modeling Approach

Thermoflow Inc.'s THERMOFLEX software was used to construct computer-based simulation models of the various power generation configurations that were evaluated for this analysis, including reciprocating engine and gas turbine-based options.

THERMOFLEX, part of the Thermoflow heat balance software suite, is a graphical heat balance software package that permits the user to create a component-by-component model of virtually any type of power plant or thermal system and simulate its performance under varying load and ambient conditions. The software allows for initial design point definition of plant equipment performance, and subsequent variable-load analysis of the as-designed components considering the associated efficiency impacts of off-design operation. The models were run to verify new equipment sizing criteria, as well as simulate plant performance for selected thermal and electric demands and varying ambient conditions. A sample THERMOFLEX output diagram for a reciprocating engine option is included on Figure 1.

Figure 1. Example THERMOFLEX Heat Balance Model



A dedicated THERMOFLEX heat balance model was constructed for each of the power generation options discussed herein. Once the models were set for sizing and design-point performance characteristics, simulation runs were conducted for each of the load points and average ambient conditions described previously, culminating in estimated annual totals for fuel consumption and energy output for each scenario.

12.3 Description of Evaluated Plant Configurations

A broad range of equipment configurations was considered in the initial screening analysis for the predetermined facility demand sizes set in Task 1. The impact of the additional loads at the wellheads were not evaluated for the 12,500- and 16,000-AFY Projects. Only the facility power demand loads, as shown in Table 1, will be evaluated. Impact of the additional loads associated with the remote wellhead sites were only evaluated in the 20,000-AFY capacity facility Projects 43 and 44. A summary of each of the evaluated plant configurations is provided in this section.

12.3.1 12,500-AFY Water Treatment Facility

This option evaluates the power generating technologies to serve only the facility power demand loads of a 12,500-AFY capacity Project. These power generation options should be considered for both Projects 18 and 19. A summary of the power generation options, as well as the installed capacities, followed by a brief description, are provided in and after Table 2.

Table 2. Evaluated Plant Capacities – 12,500-AFY Facility

Option	Installed Capacities, kW
Baseline	2,500
Option 1 - Reciprocating Engine 1	2,656
Option 2 - Reciprocating Engine 2	2,880
Option 3 - Fuel Cell Plant	2,800
Option 4 - Gas Turbine	3,510
Option 5 - Fuel Cell Servers	2,500
Option 6 - Fuel Cell Servers- PPA	2,500

- Baseline: The baseline plant configuration assumes that power is purchased from the grid.
- Option 1: A single reciprocating engine capable of providing 2,656 kW at 100 percent capacity; however, will operate part loaded to match the base load demand of 2,500 kW.
- Option 2: Similar to Option 1 but has a slightly higher capacity of 2,880 kW at 100 percent output and will operate part loaded at the 2,500-kW base load demand.
- Option 3: Fuel cell technology that is capable of producing 2,800 kW at 100 percent capacity that will operate at 2,500 kW to match base load demand.
- Option 4: Simple cycle gas turbine with a gross generating capacity of 3,510 kW that will operate part loaded at the 2,500-kW base load demand.
- Option 5: Multiple, small 300-kW fuel cell servers to meet the 2,500-kW peak demand load.
- Option 6: A PPA with the fuel cell server company to provide 2,500 kW of baseload demand at a fixed electric rate.

12.3.2 16,000-AFY Water Treatment Facility

This option evaluates the power generating technologies to serve only the facility power demand loads of 16,000-AFY capacity projects. These power generation options should be considered for both Projects 41 and 42. A summary of the power generation options, as well as the installed capacities, followed by a brief description, are provided in and after Table 3.

Table 3. Evaluated Plant Capacities – 16,000-AFY Facility

Option	Installed Capacities, kW
Baseline	3,000
Option 1 - Reciprocating Engine 1	3,334
Option 2 - Reciprocating Engine 2	3,039
Option 3 - Fuel Cell Plant	2,800
Option 4 - Gas Turbine	3,510
Option 5 - Fuel Cell Servers	3,000
Option 6 - Fuel Cell Servers- PPA	3,000

- Baseline: The baseline plant configuration assumes that power is purchased from the grid.
- Option 1: Single reciprocating engine capable of providing 3,334 kW at 100 percent capacity that will operate part loaded at the 3,000-kW base load demand.
- Option 2: Similar to Option 1 but has a slightly lower capacity of 3,049 kW at 100 percent output and will operate part loaded at the 3,000-kW base load demand.
- Option 3: Fuel cell technology that will operate at its peak capacity of 2,800 kW. An additional 200 kW will need to be purchased from the grid to meet the base load demand of 3,000 kW.
- Option 4: Simple cycle gas turbine with a gross generating capacity of 3,510 kW that will operate part loaded at the 3,000-kW base load demand.
- Option 5: Multiple, small 300-kW fuel cell servers to meet the 3,000-kW peak demand load.
- Option 6: A PPA with the fuel cell server company to provide 3,000 kW of baseload demand at a fixed electric rate.

12.3.3 20,000-AFY Water Treatment Facility

This option evaluates the power generating technologies to serve only the facility power demand loads of 20,000-AFY capacity projects. A summary of the power generation options, as well as the installed capacities, followed by a brief description, are provided in and after Table 4.

Table 4. Evaluated Plant Capacities – 20,000-AFY Facility

Option	Installed Capacities, kW
Baseline	4,000
Option 1 - Reciprocating Engine 1	4,376
Option 2 - Reciprocating Engine 2	5,000
Option 3 - Fuel Cell Plant	3,700
Option 4 - Gas Turbine	4,600
Option 5 - Fuel Cell Servers	4,000
Option 6 - Fuel Cell Servers- PPA	4,000

- Baseline: The baseline plant configuration assumes that power is purchased from the grid.
- Option 1: Single reciprocating engine capable of providing 4,376 kW at 100 percent capacity that will operate part loaded at the 4,000-kW base load demand.

- Option 2: Similar to Option 1 but has a slightly higher capacity of 5,000 kW at 100 percent output and will operate part loaded at the 4,000-kW base load demand.
- Option 3: Fuel cell technology that is capable of producing 3,700 kW; 300 kW of supplemental power will need to be purchased from the grid to meet the base load demand of 4,000 kW.
- Option 4: Simple cycle gas turbine with a gross generating capacity of 4,600 kW that will operate part loaded at the 4,000-kW base load demand.
- Option 5: Multiple, small 300-kW fuel cell servers to meet the 4,000-kW peak demand load.
- Option 6: A PPA with the fuel cell server company to provide 4,000 kW of baseload demand at a fixed electric rate.

12.3.4 Project 43 - 20,000-AFY Water Treatment Facility with Wellhead Locations

As an example of the minimal savings impact of the additional loads associated with the remote wellhead sites, Project 43 was evaluated for the total treatment facility demand. The total treatment facility demand includes the facility power demand and 11 remote wellhead locations, as shown in Table 1. A summary of the power generation options, as well as the installed capacities, followed by a brief description, are provided in and after Table 5.

Table 5. Project 43 – Evaluated Plant Capacities – 20,000-AFY Facility with Wellheads

Option	Installed Capacities, kW
Baseline	5,232
Option 1 - Reciprocating Engine 1	5,917
Option 2 - Reciprocating Engine 2	5,700
Option 3 - Fuel Cell Plant	3,700
Option 4 - Gas Turbine	5,670
Option 5 - Fuel Cell Servers	5,232
Option 6 - Fuel Cell Servers- PPA	5,232

- Baseline: The baseline plant configuration assumes that power is purchased from the grid.
- Option 1: Single reciprocating engine capable of providing 5,917 kW at 100 percent capacity and will operate part loaded at the 5,232-kW base load demand.
- Option 2: Similar to Option 1 but has a slightly lower capacity of 5,700 kW at 100 percent output and will operate part loaded at the 5,232-kW base load demand.
- Option 3: Fuel cell technology that is capable of producing 3,700 kW; 1,532 kW of supplemental power will need to be purchased from the grid to meet the base load demand of 5,232 kW.
- Option 4: Simple cycle gas turbine with a gross generating capacity of 5,670 kW that will operate part loaded at the 5,232-kW base load demand.
- Option 5: Multiple, small 300-kW fuel cell servers to meet the 5,232-kW peak demand load.
- Option 6: A PPA with the fuel cell server company to provide 5,232 kW of baseload demand at a fixed electric rate.

12.3.5 Project 44 - 20,000-AFY Water Treatment Facility with Wellhead Locations and Portable Water Treatment

As an example of the minimal savings impact of the additional loads associated with the remote wellhead sites and portable water treatment skid, Project 44 was evaluated for the total treatment facility demand. The total treatment facility demand includes the facility power demand, 11 remote wellhead locations, and a portable water treatment skid, as shown in Table 1. A summary of the power generation options, as well as the installed capacities, followed by a brief description, are provided in Table 6.

Table 6. Project 44 – Evaluated Plant Capacities – 20,000-AFY Facility with Wellhead and Portable Water Treatment

Option	Installed Capacities, kW
Baseline	5,632
Option 1 - Reciprocating Engine 1	5,917
Option 2 - Reciprocating Engine 2	5,700
Option 3 - Fuel Cell Plant	3,700
Option 4 - Gas Turbine	6,290
Option 5 - Fuel Cell Servers	5,632
Option 6 - Fuel Cell Servers- PPA	5,632

- Baseline: The baseline plant configuration assumes that power is purchased from the grid.
- Option 1: Single reciprocating engine capable of providing 5,917 kW at 100 percent capacity and will operate part loaded at the 5,632-kW base load demand.
- Option 2: Similar to Option 1 but has a slightly lower capacity of 5,700 kW at 100 percent output and will operate part loaded at the 5,632-kW base load demand.
- Option 3: Fuel cell technology that is capable of producing 3,700 kW; 1,932 kW of supplemental power will need to be purchased from the grid to meet the base load demand of 5,632 kW.
- Option 4: Simple cycle gas turbine with a gross generating capacity of 6,290 kW that will operate part loaded at the 5,632-kW base load demand.
- Option 5: Multiple, small 300-kW fuel cell servers to meet the 5,632-kW peak demand load.
- Option 6: A PPA with the fuel cell server company to provide 5,632 kW of baseload demand at a fixed electric rate.

12.4 Results Summary

Results of the annual comparative performance calculations for each of the described plant options are presented in Tables below for each set of electric demand profile assumptions. Additional lifecycle cost information can be found in Appendix C.

Definitions of the relevant terminologies are as follows:

- Installed Cost: The total proposed cost for each option, including major equipment, construction, planning, engineering, and permitting cost. Supporting cost estimates can be found in Appendix D. These are preliminary cost estimates which do not represent actual construction cost or contractor bid prices. Contingencies have been included in this estimate to account for unknown factors. Design development issues, scope changes, and market conditions at the time of bidding may affect actual construction costs.
- Fuel costs: Total annual fuel cost, obtained by multiplying the fuel consumption figure by the composite fuel cost in dollars per MMBtu. Assumes composite fuel cost for the tabulation is $5.50/MMBtu, on a high heating value (HHV) basis.
- Electricity costs: Total annual purchased electricity cost, obtained by multiplying the total annual purchased electricity figure by the composite electrical rate in dollars per kWh. Assumes composite electrical rate for the tabulation is $0.105/kWh.
- Total utility costs: Summation of fuel costs and purchased electricity costs.

- Incremental O&M costs: The additional annual O&M costs estimated to be associated with the generation equipment itself.
- Year LCC Savings: The total lifecycle savings compared to the baseline option. The savings is in addition to the recovery of the initial capital investment. Terms of lifecycle savings vary for all Project options.

As shown in Table 7, the initial screening results summarized for the 12,500-AFY site indicate generally superior performance by the reciprocating engine and fuel cell server configurations.

Table 7. 12,500-AFY Lifecycle Cost Analysis

Option	Estimated Installed Costs ($)	Annual Purchased Utility Costs (2018 rates)			Incremental Annual O&M Costs ($)	20-Year LCC ($)	20-Year LCC Savings ($)
		Fuel ($)	Electricity ($)	Total Utility Cost ($)			
Baseline	200,000	0	2,205,000	2,205,000	0	44,584,287	-
Option 1 - 2.7-MW Reciprocating Engine	7,142,000	996,335	25,200	1,021,535	452,683	36,879,867	7,704,420
Option 2 - 2.9-MW Reciprocating Engine	7,825,000	1,200,900	25,200	1,226,100	535,640	43,354,022	1,230,265
Option 3 - Fuel Cell	12,435,000	920,131	25,200	945,331	800,000	47,090,802	-2,506,515
Option 4 - 3.5-MW Gas Turbine	8,284,000	1,732,339	25,200	1,757,539	535,640	54,904,759	-10,320,471
Option 5 - Fuel Cell Server	10,743,000	778,355	0	778,355	630,000	38,793,070	5,791,218
Option 6 - Fuel Cell Server (PPA)	200,000	778,355	1,428,000	2,206,355	0	45,165,171	-580,883

Notes:

\- = not applicable

The reciprocating engine in Option 1 has lower capital and O&M costs compared to the fuel cell server. The reciprocating engines also have an operational advantage when it comes to load following and response time to grid outages compared to the fuel cell servers. The fuel cell servers in Option 5 offer an excellent heat rate and efficiency, which ultimately lowers the utility cost. Fuel cells do have a higher O&M cost; however, they offer better maintenance options by being able to isolate small sections of the server for replacement and repair compared to a reciprocating engine that would require a few days of outage to repair major equipment. Fuel cells are not capable of operating when the grid experiences an outage due to the inability to follow a variable load profile; therefore, implementation of energy storage or emergency generators must be considered for soft shutdown operation. Given the small amount of space available on the site, energy storage would be challenging to install.

An additional evaluation was undertaken to assess the ability of each plant configuration to operate over the full range of anticipated demand conditions, specifically the maximum and minimum electrical conditions. All of the power generation configurations listed are capable of meeting the peak electrical demand.

The fuel cell PPA is a unique opportunity because the manufacturer will install, maintain, and operate the equipment and charge WRD a fixed electric rate. WRD would still be responsible for purchasing the gas through SoCalGas but could offer greater savings compared to the baseline if the assumed utility rate is greater than the assumed $0.105/kWh. A more detailed study into the electrical rates for this facility is recommended due to the significant impact on the LCC savings. In addition to the lifecycle cost analysis, simple payback durations for each option are detailed in Table 8.

Table 8. 12,500-AFY Simple Payback

Option	Simple Payback (Years)
Baseline	-
Option 1 - Reciprocating Engine 1	9.77
Option 2 - Reciprocating Engine 2	17.65
Option 3 - Fuel Cell Plant	No payback
Option 4 - Gas Turbine	No payback
Option 5 - Fuel Cell Server	13.34
Option 6 - Fuel Cell Server PPA	-

As seen in Table 8, Options 1 and 5 provide the best simple payback. Considering the much lower electrical demand is for the 12.5,000-AFY facility capacity compared to the amount of utility and O&M cost savings, payback durations are closer to 9-15 years. The reciprocating engine offers the most payback due to the lower capital cost required to install the equipment, and the lower maintenance cost compares to the fuel cell servers. The fuel cell server PPA does not have any payback because there is no initial major capital investment to install and maintain the equipment. The PPA would be very similar to purchasing power from SCE; however, there is a guaranteed electric rate through the duration of the agreement. A PPA could be considered a good alternative if the payback duration is not deemed acceptable. Jacobs recommends a more detailed analysis be performed on the feasible options described.

As shown in Table 9, the initial screening results summarized for the 16,000-AFY site indicate generally superior performance by the reciprocating engine and fuel cell server configurations.

Table 9. 16,000-AFY Lifecycle Cost Analysis

Option	Estimated Installed Costs ($)	Annual Purchased Utility Costs (2018 rates)			Incremental Annual O&M Costs ($)	17-Year Lifecycle Cost ($)	17-Year LCC Savings ($)
		Fuel ($)	Electricity ($)	Total Utility Cost ($)			
Baseline	200,000	0	2,646,000	2,646,000	0	45,602,696	-
Option 1- 3.3-MW Reciprocating Engine 1	7,283,000	1,191,810	30,240	1,222,050	496,891	37,053,204	8,549,492
Option 2- 3.04-MW Reciprocating Engine 2	7,835,000	1,200,900	30,240	1,231,140	496,891	37,789,074	7,813,622
Option 3- Fuel Cell Plant	12,435,000	879,825	204,624	1,084,449	800,000	44,585,387	1,017,309
Option 4- Gas Turbine	8,284,000	1,977,689	30,240	2,007,929	584,582	53,451,224	-7,848,529
Option 5- Fuel Cell Servers	12,217,000	934,025	0	934,025	756,000	41,126,447	4,476,249
Option 6- Fuel Cell Servers- PPA	200,000	934,025	1,688,400	2,622,425	0	45,800,066	-197,370

Many of the lifecycle comments mentioned in the 12,500-AFY site still remain true for the larger facility configuration. Similarly, to the 12,500-AFY facility, fuel cell servers offer some great advantages but will require energy storage or emergency generators to maintain the soft shutdown capabilities of the facility. Based on the high capital cost for the fuel cells, a more detailed analysis of the federal, state, and local incentives impact each option is recommended.

An additional evaluation was undertaken to assess the ability of each plant configuration to operate over the full range of anticipated demand conditions, specifically the maximum and minimum electrical conditions. All the of the configurations listed are capable of meeting the peak electrical demand except for the Option 3 fuel cell plant. The baseload capacity of Option 3 is only 2,800 kW, which will require 200 kW of supplemental power from the grid to meet the base demand of the facility. In addition to the lifecycle cost analysis, simple payback durations for each option are detailed in Table 10.

Table 10. 16,000-AFY Simple Payback

Option	Simple Payback (Years)
Baseline	-
Option 1 - Reciprocating Engine 1	7.86
Option 2 - Reciprocating Engine 2	8.54
Option 3 - Fuel Cell Plant	16.33
Option 4 - Gas Turbine	No payback
Option 5 - Fuel Cell Server	12.78
Option 6 - Fuel Cell Server PPA	-

As detailed in Table 10, only Options 1 and 2 are considered to have a reasonable payback period. The fuel cell servers have about a 13-year payback, which is mainly contributed to the high capital cost to install the equipment. The main difference between the reciprocating engine options compared to the gas turbine and fuel cell options are the relatively low cost to operate and maintain the equipment. Though the fuel cells are more efficient, the annual utility cost savings are not significant enough to offset the initial capital investment and higher O&M costs for the reciprocating engines. The fuel cell server PPA does not have any payback because there is no initial capital investment to install and maintain the equipment. The PPA would be very similar to purchasing power from SCE; however, the electric rate is guaranteed for the duration of the agreement compared to SCE real-time pricing schedules. A PPA is considered a good option if SCE rates are confirmed to be higher than the assumed rate of $0.105/kWh. Jacobs recommends a more detailed analysis be performed on the feasible options described.

As shown in Table 11, the initial screening results summarized for the 20,000-AFY site indicate that every option but Option 6 provides excellent LCC savings.

Table 11. 20,000-AFY Lifecycle Cost Analysis

Option	Estimated Installed Costs ($)	Annual Purchased Utility Costs (2019 rates)			Incremental Annual O&M Costs ($)	15-Year LCC ($)	15-Year LCC Savings ($)
		Fuel ($)	Electricity ($)	Total Utility Cost ($)			
Baseline	200,000	0	3,528,000	3,528,000	0	53,655,539	-
Option 1 - 4.373-MW Reciprocating Engine	9,548,000	1,573,903	40,320	1,614,223	530,640	42,696,393	10,959,146
Option 2 – 5-MW Reciprocating Engine	10,490,000	1,461,869	40,320	1,502,189	613,680	43,065,814	10,589,725
Option 3 - Fuel Cell	15,895,000	1,056,850	301,896	1,358,746	900,000	50,253,521	3,402,018
Option 4 - 4.6-MW Gas Turbine	9,833,000	1,848,163	40,320	1,888,483	696,720	49,619,530	4,036,008
Option 5 - Fuel Cell Servers	16,290,000	1,245,367	0	1,245,367	1,008,000	50,560,161	3,095,378
Option 6 - Fuel Cell Server (PPA)	200,000	1,245,367	2,217,600	3,462,967	0	53,414,638	240,901

Reciprocating engines do offer the most in terms of lifecycle savings; however, fuel cell servers can be considered a good option. Reciprocating engines offer greater flexibility in generation capabilities by being able to load follow and rapidly respond to grid outages to continue to operate when the grid is down. Both reciprocating options offer lower capital and maintenance costs compared to the fuel cell server. The fuel cell servers are the most efficient options, and as a result, have the lowest annual fuel cost. Fuel cell servers have the best availability and are capable of isolating small sections of the servers for maintenance compared to the reciprocating engine options, which would require a full shutdown of the equipment to perform maintenance. Similar to the water treatment facility options presented, fuel cell servers offer some great advantages but will require energy storage or emergency generators to maintain the soft shutdown capabilities of the facility.

An additional evaluation was undertaken to assess the ability of each plant configuration to operate over the full range of anticipated demand conditions, specifically the maximum and minimum electrical conditions. All of the configurations listed can meet the peak electrical demand except for Option 3. Option 3 is only capable of producing a maximum base load of 3,700 kW, which will require 300 kW of supplemental power to meet the facility's base demand. In addition to the lifecycle cost analysis, simple payback durations for each option are detailed in Table 12.

Table 12. 20,000-AFY Simple Payback

Option	Simple Payback (Years)
Baseline	-
Option 1 - Reciprocating Engine 1	6.90
Option 2 - Reciprocating Engine 2	7.43
Option 3 - Fuel Cell Plant	12.52
Option 4 - Gas Turbine	10.43
Option 5 - Fuel Cell Server	12.78
Option 6 - Fuel Cell Server PPA	-

As detailed in Table 12, only Options 1 and 2 provide the shortest payback period. Given that most options have relatively good LCC savings, Options 1 and 2 have the lowest first cost, and as a result, have the shortest payback period. The gas turbine (Option 4) had a similar capital cost compared to Options 1 and 2; however, the gas turbine efficiency was much lower, resulting in higher utility costs. This, coupled with a higher O&M costs, results in a payback period in excess of 10 years.

Due to the environmental considerations for the reciprocating engines and gas turbines, the next best option, Option 5, should also be considered for future evaluation. The fuel cell server PPA does not have any payback because there is no initial capital investment to install and maintain the equipment. The PPA would be very similar to purchasing power from SCE; however, the electric rate is guaranteed for the duration of the agreement compared to SCE real-time pricing schedules. The PPA is considered a good alternative if SCE rates are confirmed to be higher than the assumed rate of $0.105/kWh. Jacobs recommends a more detailed analysis be performed on the feasible options described.

Due to the increase in capital cost of adding the distribution to the wellhead locations and the larger generating equipment capacities, the only options that provide lifecycle savings are the reciprocating engines. The cost of increasing the size of a reciprocating engine is small relative to the cost to install more fuel cell capacity or increase the size of a gas turbine. The main difference between options for the 20,000-AFY site and Project 43 is the addition of the load from the 11 wellhead pumps. Comparing the additional capital investments and the lifecycle savings from Tables 11 and 13, the cost savings is not significant enough to consider distributing power from the Elm and Faysmith site. The larger demand loads require larger equipment selections that could have an impact to the amount of space available at the facility.

Based upon the findings in Table 13, it can be concluded that the smaller facility capacities would also not see any cost benefit to distributing power to those remote wellhead sites due to their lower annual demand.

Table 13. Project 43 – 20,000-AFY with Wellhead Pumps Lifecycle Cost Analysis

Option	Estimated Installed Costs ($)	Annual Purchased Utility Costs (2019 rates)			Incremental Annual O&M Costs ($)	15-Year LCC ($)	15-Year LCC Savings ($)
		Fuel ($)	Electricity ($)	Total Utility Cost ($)			
Baseline	200,000	0	4,614,624	4,614,624	0	70,117,381	-
Option 1 - 5.9-MW Reciprocating Engine	14,475,000	2,228,702	52,739	2,281,441	696,720	60,627,770	9,489,611
Option 2 - 5.7-MW Reciprocating Engine	13,821,000	2,141,697	52,739	2,194,436	738,240	59,154,499	10,962,882
Option 3 - Fuel Cell	19,170,000	1,388,520	1,056,850	2,445,370	900,000	70,121,363	-3,982
Option 4 - 5.7-MW Gas Turbine	17,181,000	2,958,130	52,739	3,010,868	738,240	75,505,425	-5,388,044
Option 5 - Fuel Cell Server	25,682,000	1,628,940	0	1,628,940	1,318,464	70,682,357	-564,976
Option 6 - Fuel Cell (PPA)	3,475,000	1,628,940	2,900,621	4,529,561	0	73,416,282	-3,298,901

The primary benefit for consideration of distributing power to the remote well sites is the resiliency benefit. A WRD-owned power generation facility would allow continued operation during a grid outage.

An additional evaluation was undertaken to assess the ability of each plant configuration to operate over the full range of anticipated demand conditions, specifically the maximum and minimum electrical conditions. All the of the configurations listed are capable of meeting the peak electrical demand, except for Option 3. Option 3 is only capable of producing a maximum base load of 3,700 kW, which will require 1,532 kW of supplemental power to meet the facility's base demand. Given that the 3,700-kW facility is the largest, this configuration can be installed without impacting the tight space constraints at the Elm and Faysmith site, larger generation options were not considered. Supplementing power to the facility by 30 percent to meet the demand to power the facility and the remote wellhead locations is not considered to be a feasible option. In addition to the lifecycle cost analysis, simple payback durations for each option are detailed in Table 14.

Table 14. Project 43 – 20,000-AFY Simple Payback

Option	Simple Payback (Years)
Baseline	-
Option 1 - Reciprocating Engine 1	8.85
Option 2 - Reciprocating Engine 2	8.22
Option 3 - Fuel Cell Plant	15.10
Option 4 - Gas Turbine	19.85
Option 5 - Fuel Cell Server	15.40
Option 6 - Fuel Cell Server PPA	-

As shown in Table 14, option rankings with the greatest payback remained the same compared to the 20,000-AFY water treatment facility in Table 12, with the exception of the gas turbine. The main reason for the dramatic increase in payback for the gas turbine was attributed to the increase in cost of a larger turbine. Installing the additional capacity to service the additional load at the wellhead locations only linearly increased the simple payback duration, providing no economic incentive to be considered a feasible option.

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Similar to the 20,000-AFY site in Table 11, the initial screening results summarized for the 20,000-AFY site in Table 15 indicate generally superior performance by both reciprocating engine configurations.

Table 15. Project 44 – 20,000-AFY with Wellhead Pumps and Portable Water Treatment Skid Lifecycle Cost Analysis

Option	Estimated Installed Costs ($)	Annual Purchased Utility Costs (2019 rates)			Incremental Annual O&M Costs ($)	15-Year LCC ($)	15-Year LCC Savings ($)
		Fuel ($)	Electricity ($)	Total Utility Cost ($)			
Baseline	200,000	0	4,967,424	4,967,424	0	75,462,135	-
Option 1 - 5.9-MW Reciprocating Engine	15,162,000	2,358,959	56,771	2,415,729	696,720	63,454,508	12,007,627
Option 2 - 5.7-MW Reciprocating Engine	14,435,000	2,283,828	56,771	2,340,599	696,720	61,515,334	13,946,800
Option 3 - Fuel Cell	19,697,000	1,056,850	1,741,320	2,798,170	900,000	72,060,117	3,402,018
Option 4 - 6.3-MW Gas Turbine	18,601,000	3,090,122	56,771	3,146,892	738,240	79,121,813	-3,659,678
Option 5 - Fuel Cell 2	28,587,000	1,753,477	0	1,753,477	1,419,264	77,065,413	-1,603,278
Option 6 - Fuel Cell (PPA)	4,002,000	1,753,477	3,122,381	4,875,858	0	79,285,026	-3,822,891

The main difference between the 20,000-AFY site and Project 44 is the addition of the load from the 11 wellhead pumps and a portable water treatment skid. Comparing the additional capital investments and the lifecycle savings from the 20,000-AFY site and Project 44, the cost savings is not significant enough to consider distributing power from the Elm and Faysmith site. The larger demand loads require larger equipment selections that could have an impact on the amount of space available at the facility. Based upon the findings in Table 15, it can be concluded that the smaller facility capacities would also not see any cost benefit to distributing power to those remote wellhead sites due to their lower annual demand. The primary benefit for consideration of distributing power to the remote well sites is the resiliency benefit. A WRD-owned power generation facility would allow continued operation during a grid outage.

An additional evaluation was undertaken to assess the ability of each plant configuration to operate over the full range of anticipated demand conditions, specifically the maximum and minimum electrical conditions. All the of the configurations listed are capable of meeting the peak electrical demand, except for Option 3. Option 3 is only capable of producing a maximum base load of 3,700 kW, which will require 1,932 kW of supplemental power to meet the facility’s base demand. Given that the 3,700-kW facility is the largest capacity, this configuration can be installed without impacting the space constraints at the Elm and Faysmith site, larger generation options were not considered. Supplementing power to the facility by approximately 50 percent to meet the demand of the facility and the remote wellhead locations is not considered to be a feasible option. In addition to the lifecycle cost analysis, simple payback durations for each option are detailed in Table 16.

Table 16. Project 44 – 20,000-AFY Simple Payback

Option	Simple Payback (Years)
Baseline	-
Option 1 - Reciprocating Engine 1	8.17
Option 2 - Reciprocating Engine 2	7.48
Option 3 - Fuel Cell Plant	15.52
Option 4 - Gas Turbine	17.19
Option 5 - Fuel Cell Server	15.93
Option 6 - Fuel Cell Server PPA	-

As detailed in Table 16, the rankings of the options that had the shortest simple payback period remained the same compared to the 20,000-AFY facility in Table 12, apart from the gas turbine. Installing the additional capacity to service the additional load at the wellhead locations only linearly increased the simple payback duration, providing no economic incentive to be considered a feasible option.

12.5 Wellhead Pump Electrical Distribution

Jacobs evaluated multiple options for providing power to each wellhead pump site, as follows:

- **Distributing power from the treatment facility -** This option explored the feasibility of running underground concrete encased electrical duct banks to each wellhead site. Power would be distributed at 4,160 V through utility switches and loop fed transformers using the same trench as the planned water pipes. Each site would transform the 4,160 V into 480 V and feed the pumps.
- **Power derived from the SCE grid -** This option represents the baseline case in which each wellhead site is fed from the local SCE grid at 4,160 V, and power is distributed by transformers and other equipment as required.
- **Power derived from the SCE grid with local backup generation -** This is the same option as the last option, with the addition of an emergency generator local to each site for operation when the SCE grid is offline.

Distribution from the treatment facility and local backup options have significant upfront capital costs and should only be considered if resiliency from grid outages is desired. Distribution from the treatment facility is approximately double the cost of local generation but comes with the benefit of less maintenance, requiring service to only one generating facility. Local backup generation comes with half the capital cost but significantly greater maintenance costs due to the need for up to 10 diesel generators. Due to cost considerations, backup generation for the wellhead in either form is not recommended.

12.6 Resiliency

Regarding the resiliency of the water treatment facility, WRD clarified that backup power would only be required to bring the plant down slowly so that they have enough power to flush the membrane systems. The water treatment facility would only require enough backup power to operate controls, lighting, and a 50-kW flush pump and ancillary equipment required to flush the membranes. Each option in consideration identified how this facility would react to a grid outage. Based on the results of the study, it was determined that the most feasible options were reciprocating engines and fuel cell servers for any plant configuration. Although fuel cell servers provide several great advantages, they are not capable of responding to a grid outage to power the facility. To maintain the level of resiliency that WRD requested, an emergency backup generator large enough to handle the load required to drain the membranes is recommended, which is 400 kW. The fuel cell manufacturer is also capable of installing enough backup battery storage to softly bring down the plant in a controlled manner but would impact the space available at the facility and require additional capital expenditure. Reciprocating engines can operate during grid outages by being able to quickly respond to the load fluctuations and ramp up and down as necessary. Jacobs recommends backup generation options be looked at in a more detailed study.

When considering how the remote wellhead locations and a possible temporary portable wellhead treatment skid will be powered, Jacobs determined, through the high-level feasibility evaluation, that there was not any significant cost savings to service those loads from the water treatment facility power generating equipment. Though there is not a significant cost savings, running power directly to the wellheads from the water treatment facility at the Elm and Faysmith site would provide resilient power through major grid outages. If these wellheads were to be powered directly from the grid and experienced an outage, the pumps would not be able to operate. Based on information provided by WRD that this is considered to be a noncritical facility, other than the requirement for a soft shutdown to drain the membrane systems within the treatment process, Jacobs recommends purchasing power from SCE to service those individual wellhead locations and portable wellhead treatment. Determination should be made after a more detailed evaluation is performed.

13. Matrix Evaluations

As mentioned in the Selection Process Acceptance Criteria, an evaluation matrix for each feasible generation option for the Elm and Faysmith site capacities was developed to identify the most feasible option. Subsequently, each generation option was graded on a weighted scale with the following criteria:

- **Site Layout -** How the equipment fits and is accessible on the site.
- **Load Follow and Match** - The ability to meet the total demand of the facility, and the ability to follow and vary its load based upon the demand of the water treatment facility. Considering the backup power source is the grid, redundancy is also evaluated in the event the grid experiences an outage.
- **Rebates and Public Incentives -** The potential for additional savings through various government incentives for power generating equipment
- **LCC** – The total LCC savings compared to the baseline or purchasing power from the grid.
- **Emissions: Pollutants** - Comparing pollutants, such as PM, for each generating option.
- **Emissions: GHG** - Comparing the GHG emissions, such as SOx, carbon dioxide (CO_2), and NOx for each generation option.
- **Permitting Requirements** - The complexity of permitting for each generation equipment type.
- **Reliability and Availability** - The reliability of the power generation options and the effects of normal maintenance requirements on facility operations.
- **O&M** - How much maintenance would be required and the cost of operating the power generation equipment.

Each component is weighted differently, and the total score is summed to represent a score of 100 points. The option that has the highest score will be considered the recommended option, and the second highest score would be the preferred alternative. For each of the Elm and Faysmith plant capacities, a decision matrix was developed and is provided in Appendix A of this report.

14. Recommendations

The following recommendations were derived from the analysis discussed herein:

- It is highly recommended to progress into a more detailed evaluation with a future right sizing analysis incorporating the recommended options described herein. A right sizing analysis is a high-resolution performance analysis that further evaluates specific equipment models and performance sensitivity, and provides a more in-depth description of the facility operations.
- Due to the complexity of the CCAs and the higher electrical rates by joining a CCA, it is not recommended to pursue a CCA. If WRD desires to invest in renewables and claim the environmental

benefit without having to implement its own technology through the California Energy Commission's RPS program, a CCA could be considered a feasible option.

- It is not recommended that the power supplied from the generation options be distributed to the remote wellhead locations and portable water treatment skid. The initial capital cost outweighs the savings from generating the power from the facility compared to purchased power from SCE. If resiliency is a major consideration for these facility loads, backup power generators can be considered.
- Based upon the Decision Matrix in Appendix A and Lifecycle Summary Charts for each of the water treatment facility capacities, it is recommended that the following plant configurations be carried forward for a more high-resolution right sizing analysis:
  - 12,500 AFY with no generating power to wellhead locations:
    - Recommended: Option 5 - 2.5-MW fuel cell server
    - Preferred Alternative: Option 1 – 2,656-kW reciprocating engine
  - 16,000 AFY with no generating power to wellhead locations:
    - Recommended: Option 5 – 3-MW fuel cell server
    - Preferred Alternative: Option 1 – 3,334-kW reciprocating engine
  - 20,000 AFY with no generating power to wellhead locations:
    - Recommended: Option 1 - 4,376-kW reciprocating engine
    - Preferred Alternative 1: Option 2 – 5,000-kW reciprocating engine
    - Preferred Alternative 2: Option 5 – 4-MW fuel cell server
  - Project 43 - 20,000-AFY + 11 wellhead pumps with portable water treatment skid:
    - Recommended: Option 1 – 5,917-kW reciprocating engine
    - Preferred Alternative: Option 2 – 5,732-kW reciprocating engine
  - Project 44- 20,000-AFY + 11 wellhead pumps without portable water treatment skid:
    - Recommended: Option 1 – 5,917-kW reciprocating engine
    - Preferred Alternative: Option 2 – 5,732-kW reciprocating engine

If WRD determines that the self-generation options recommended are not feasible, Jacobs recommends negotiating a rate with SCE or contracting the services of an SC for wholesale power purchases, which could have significant cost savings over the baseline electricity rates from SCE.

15. References

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Appendix A
Decision Matrix

12,500 AFY Capacity Decision Matrix

		Option 1- Reciprocating Engine		Option 2- Reciprocating Engine		Option 3- Fuel Cell		Option 4- Combustion Turbine		Option 5- Fuel Cell Server		Option 6- Fuel Cell Server (PPA)	
Evaluation Criteria	Points	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
Site Layout	20	20	900 sq ft	19	1000 sq. ft	12	4900 sq ft	15	1800 sq. ft	15	1800 sq. ft	15	1800 sq. ft
Load Match/Follow	10	10		10		7	Very limited Load Following Capabilities	10		5	Will match baseload however no redundancy availible in the event of a grid outage.	5	Will match baseload however no redundancy availible in the event of a grid outage.
Rebates/Public Incentives	5	2	Baseline Rebate CA State Sales Tax	2	Baseline Rebate CA State Sales Tax	4	Baseline Rebate CA State Sales Tax, Rule 21 Interconnect and Business Energy Investment Tax Credit (ITC)	2	Baseline Rebate CA State Sales Tax	5	Baseline Rebate CA State Sales Tax, Rule 21 Interconnect and Business Energy Investment Tax Credit (ITC)	5	Baseline Rebate CA State Sales Tax, Rule 21 Interconnect and Business Energy Investment Tax Credit (ITC)
Life Cycle Cost	20	20	Best Life Cycle Cost Savings	3	% reduction compared to highest cost saving option	0	% reduction compared to highest cost saving option	0	No Life Cycle Savings	16	% reduction compared to highest cost saving option	0	% reduction compared to highest cost saving option
Emissions: Pollutants (NOx, SOx, CO)	10	4	Nox- .286 lb/MWh; CO- .602 lb/MWh	4	Will require additional SCR to meet emission limits	9	Nox- 0.01 lb/MWh; SOx- 0.0001 lb/MWh;	4	Will require additional SCR to meet emission limits	10	Nox- 0.0017 lb/MWh; SOX- Negligible	10	Nox- 0.0017 lb/MWh; SOX- Negligible
Carbon Emissions (CO2)	10	6		6		9	CO2- 725 lb/MWh	6		10	CO2- 679-833 lbs/MWh	10	CO2- 679-833 lbs/MWh
Permitting Requirements	10	3	Must comply with SCAQMD rule 1110.2	3	Must comply with SCAQMD rule 1110.2	9	Approved technology by the AQMD	3	Must comply with SCAQMD rule 1110.2	10	Approved technology by the AQMD	10	Approved technology by the AQMD
Reliability/Availability	10	9	Rated for 97% availibility	9	Rated for 97% availibility	9	Rated for 97% availibility	9	Rated for 97% Availibility	10	Proven Technology- Can isolate cells that are in need of repair	10	Proven Technology- Can isolate cells that are in need of repair
Operation and Maintenance	5	5	Best Annual O&M Cost	4	% cost addition to best option	3	% cost addition to best option	4	% cost addition to best option	3	% cost addition to best option	5	No O&M Cost
TOTALS	**100**	79		60		62		53		84		70	

16,000 AFY Capacity Decision Matrix

		Option 1- Reciprocating Engine		Option 2- Reciprocating Engine		Option 3- Fuel Cell		Option 4- Combustion Turbine		Option 5- Fuel Cell Server		Option 6- Fuel Cell Server (PPA)	
Evaluation Criteria	Points	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
Site Layout	20	20	1120 sq ft	19	1200 sq. ft	12	4900 sqft	16	1800 sq. ft	15	2250 sq. ft	15	2250 sq. ft
Load Match/Follow	10	10		10		5	Will require supplemental power to meet demand. Limited load following capabilities. No redundancy	10		5	Will match baseload however no redundancy availible in the event of a grid outage.	5	Will match baseload however no redundancy availible in the event of a grid outage.
Rebates/Public Incentives	5	2	Baseline Rebate CA State Sales Tax	2	Baseline Rebate CA State Sales Tax	4	Baseline Rebate CA State Sales Tax, Rule 21 Interconnect and Business Energy Investment Tax Credit (ITC)	2	Baseline Rebate CA State Sales Tax	5	Baseline Rebate CA State Sales Tax, Rule 21 Interconnect and Business Energy Investment Tax Credit (ITC)	5	Baseline Rebate CA State Sales Tax, Rule 21 Interconnect and Business Energy Investment Tax Credit (ITC)
Life Cycle Cost	20	20	Best Life Cycle Cost Savings	18	% reduction compared to highest cost saving option	3	% reduction compared to highest cost saving option	0	No life Cycle Cost Savings	11	% reduction compared to highest cost saving option	0	% reduction compared to highest cost saving option
Emissions: Pollutants (NOx, CO)	10	4	Will require additional SCR to meet emission limits	4	Will require additional SCR to meet emission limits	9	Nox- 0.01 lb/MWh; SOx- 0.0001 lb/MWh	4	Will require additional SCR to meet emission limits	10	VOCs- 0.0159 lbs/MWh, Nox- 0.0017 lb/MWh; SOX- Negligible	10	VOCs- 0.0159 lbs/MWh, Nox- 0.0017 lb/MWh; SOX- Negligible
Carbon Emissions (CO2)	10	6		6		9	CO2- 725 lb/MWh	6		10	CO2- 679-833 lbs/MWh	10	CO2- 679-833 lbs/MWh
Permitting Requirements	10	3	Must comply with SCAQMD rule 1110.2	3	Must comply with SCAQMD rule 1110.2	9	Approved technology by the AQMD	3	Must comply with SCAQMD rule 1110.2	10	Approved technology by the AQMD	10	Approved technology by the AQMD
Reliability/Availability	10	9	Rated for 97% availibility	9	Rated for 97% availibility	9	Rated for 97% availibility	9	Rated for 97% availibility	10	Proven Technology- Can isolate cells that are in need of repair	10	Proven Technology- Can isolate cells that are in need of repair
Operation and Maintenance	5	5	Best Annual O&M cost	4	% cost addition to best option	3	% cost addition to best option	4	% cost addition to best option	3	% cost addition to best option	5	No O&M Cost
TOTALS	**100**	79		75		63		54		79		70	

20,000 AFY Capacity Decision Matrix														
		Option 1- Reciprocating Engine		Option 2- Reciprocating Engine		Option 3- Fuel Cell		Option 4- Combustion Turbine		Option 5- Fuel Cell Server		Option 6- Fuel Cell Server (PPA)	
Evaluation Criteria	Points	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments	Score	Comments
Site Layout	20	20	1120 sq ft	19	1200 sq ft	12	7300 sq ft	15	2200 sq ft	14	3100 sq ft	14	3100 sq ft
Load Match/Follow	10	10		10		5	Will still require supplemental power to be supplied to match demand. And will not be able to follow load or derate.	10		5	Will match baseload however no redundancy availible in the event of a grid outage.	5	Will match baseload however no redundancy availible in the event of a grid outage.
Rebates/Public Incentives	5	2	Baseline Rebate CA State Sales Tax	2	Baseline Rebate CA State Sales Tax	4	Baseline Rebate CA State Sales Tax, Rule 21 Interconnect and Business Energy Investment Tax Credit (ITC)	2	Baseline Rebate CA State Sales Tax	5	Baseline Rebate CA State Sales Tax, Rule 21 Interconnect and Business Energy Investment Tax Credit (ITC)	5	Baseline Rebate CA State Sales Tax, Rule 21 Interconnect and Business Energy Investment Tax Credit (ITC)
Life Cycle Cost	20	20	Best Life Cycle Cost Savings	19	% reduction compared to highest cost saving option	7	% reduction compared to highest cost saving option	6	% reduction compared to highest cost saving option	5	% reduction compared to highest cost saving option	0	% reduction compared to highest cost saving option
Emissions: Pollutants (NOx, CO)	10	4	Will require additional SCR to meet emission limits	4	Will require additional SCR to meet emission limits	9	Nox- 0.01 lb/MWh; SOx- 0.0001 lb/MWh	4	Will require additional SCR to meet emission limits	10	VOCs- 0.0159 lbs/MWh; Nox- 0.0017 lb/MWh; SOX- Negligible	10	VOCs- 0.0159 lbs/MWh; Nox- 0.0017 lb/MWh; SOX- Negligible
Carbon Emissions (CO2)	10	6		6		10	CO2- 725 lb/MWh	6		10	CO2- 679-833 lbs/MWh	10	CO2- 679-833 lbs/MWh
Permitting Requirements	10	3	Must comply with SCAQMD rule 1110.2	3	Must comply with SCAQMD rule 1110.2	9	Approved technology by the AQMD	3	Must comply with SCAQMD rule 1110.2	10	Approved technology by the AQMD	10	Approved technology by the AQMD
Reliability/Availability	10	9	Rated for 97% availibility	9	Rated for 97% availibility	9	Relatively new technology. Not many of these models in service.	9	Rated for 97% availibility	10	Proven Technology- Can isolate cells that are in need of repair	10	Proven Technology- Can isolate cells that are in need of repair
Operation and Maintenance	5	5	Best O&M cost	4	% cost addition to best option	3	% cost addition to best option	4	% cost addition to best option	3	% cost addition to best option	5	No O&M Cost
TOTALS	**100**	79		76		68		59		72		69	

Appendix B
Scheduling Coordinator List

California ISO
List of SCs, CRR Holders, Convergence Bidding Entities
3/15/2019

NOTE: Submit a CIDI case for inquires. If no CIDI access, please contact your Client Representative. If your company not listed below, please go to Contact Us on the ISO web site.

Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
3 Phases Energy Services, LLC	TPES		TPES Allocation/Auction		Mike Mazur	310-714-3907	Mark Richardson: 916-608-7304	1
ACES Power Marketing	ACES				Stephen Figueroa	317-344-7254	Mark Richardson: 916-608-7304	2
Agera Energy LLC			BPE5, GECB Allocation		Shazma Khan	713-323-0559	Mark Richardson: 916-608-7304	3
Amber Power			APWR Auction	APWR	Michael Rosenberg	214-418-6453	Mark Richardson: 916-608-7304	4
American PowerNet Management, LP	APNM				Greg Krajnik	610-372-8500 x1011	Mark Richardson: 916-608-7304	5
Appian Way Energy Partners West, LLC			AWEW Auction	AWEW	John Westlund	857-285-6553	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	6
APX, Inc.	ACPL, AEID, APSX, APX1, APX3, APX4, APX5, APX6, APX7, APX9, APXB, APXC, APXO, APXW, APXY, APXZ, ASHL, ASPI, CCSF, CSFO, CSFS, EMUD, APXG, APXD, ABLP, CPSF, APXR, AREC, ASUN, REC1, REC2, SUN1, SUN2, AMS1, ATG1, AQUN, ASF1, APXP, ARUN, APXM, ACHW, APXE, ECO1, ASCO, AMPD, STNU, COLB				Paul Innamorato	408-517-2126	Mark Richardson: 916-608-7304	7
Arizona Electric Power Cooperative, Inc.	AZCO, AMWD, AZGT		AZCO Allocation/Auction		Kristine McMinimy	520-586-5130	Mark Richardson: 916-608-7304	8
Arizona Public Service Company	APS1, APS4	APS5			Jessica Kelsey	602-250-4069	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	9
Arizona Public Service Company - Transmission		AZPE					Monica Mouanetry: 916-608-1129	10
ATNV Energy			ATNV Auction	ATNV	Sandra Ionescu	832-975-8110	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	11

NOTE: Submit a CIDI case for inquires. If no CIDI access, please contact your Client Representative. If your company not listed below, please go to Contact Us on the ISO web site.								
Market Participant (Client)	**Scheduling Coordinator SCID**	**Energy Imbalance Market (EIM)**	**CRR Holder Allocation / Auction**	**Convergence Bidding**	**Client Contact Name**	**Client Contact Phone**	**Client Representatives**	
Automated Algorithms LLC				AUTO	Josh Jouffray	210-392-9616	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	12
Avangrid Renewables, LLC	PPMT, PCPM, PPM3, BKW1, BJN2, ECBO			PCPM	Ryan Leonard	317-224-9076	Mark Richardson: 916-608-7304	13
Avista Corporation	AVWP				Robert Follini	509-495-4073	Mark Richardson: 916-608-7304	14
Bilton Wong Power, Inc.			BWPI Auction	BWPI	Bobby Wong	403-598-1506	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	15
Bia Capital Management LLC				BCM1	Greg Moeller	617-407-3267	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	16
BioUrja Power, LLC			BIOP Auction	BIOP	Cody Moore	832-775-9066	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	17
BJ Energy, LLC			BJEN Auction		Anna Wood	212-219-6063	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	18
Blackout Power Trading, Inc.			BPTI Auction	BPTI	Brian Darichuk	403-404-2104	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	19
Blythe Solar 110, LLC	BLS1				William Key	561-304-5215	Mark Richardson: 916-608-7304	20
Bonneville Power Administration	BPA1				Leslie Pompel	503-230-5048	Mark Richardson: 916-608-7304	21
Boston Energy Trading and Marketing, LLC (formerly Edison Mission Marketing & Trading, Inc.)	EMMT, EMM1, EMM2, EMM3, EMM4, EMM5, EMM6		EMM1, EMM2 Auction	EMM1, EMM2	Michael Kramek	617-279-3364	Mark Richardson: 916-608-7304	22
BP Energy Company	BPEC, BPE3, BPE4, BPE5, BPE6, BPE7		BPEC Auction	BPEC, BPE3, BPE4	Shazma Khan	713-323-0559	Mark Richardson: 916-608-7304	23
Brookfield Energy Marketing LP	BMLP		BMLP Auction	BMLP	Steve Zuretti	213-995-9008	Mark Richardson: 916-608-7304	24

NOTE: Submit a CIDI case for inquires. If no CIDI access, please contact your Client Representative. If your company not listed below, please go to Contact Us on the ISO web site.								
Market Participant (Client)	**Scheduling Coordinator SCID**	**Energy Imbalance Market (EIM)**	**CRR Holder Allocation / Auction**	**Convergence Bidding**	**Client Contact Name**	**Client Contact Phone**	**Client Representatives**	
California Department of Water Resources	CDWR, CMWD, CWR2, CWR3, CWRT, CWBR		CDWR Allocation/Auction	CWR2	Katy Aflatouni	916-574-0318	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	25
Calpine Energy Services, LP	CALJ, CPAJ, CPLE, PSEJ, OPPJ, CHAM, CPAL, STNL, STNG, MECR, GECR		CALJ, STNG Allocation/Auction	CALJ, CPAJ, CPLE, OPPJ, STNG	Mary Lindsay	713-332-5175	Mark Richardson: 916-608-7304	26
Calpine Energy Solutions	SEES, SEE2		SEES Allocation/Auction	SEES	Justin Pannu	619 684-8182	Mark Richardson: 916-608-7304	27
Castleton Commodities Merchant Trading L.P.	LDES		LDES Auction	LDES	Leonardo Nesci	203-564-8030	Mark Richardson: 916-608-7304	28
Citigroup Energy, Inc.	CITI		CITI Auction	CITI	Barry Trayers	713-752-5244	Monica Mouanetry: 916-608-1129 Mark Richardson: 916-608-7304	29
City and County of San Francisco			SFHH, CPCR Allocation		Sunita Jones	415-554-1575	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	30
City of Anaheim	ANHM, RGWD, MWD1, SGWF, ANA1, ANA2, BOWR, WSLR		ANHM Allocation/Auction		Tiana Baldwin	714-765-4457	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	31
City of Azusa	AZUA		AZUA Allocation/Auction		Richard Torres	626-812-5211	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	32
City of Banning	BAN1		BAN1 Allocation/Auction		Jim Steffens	951-922-3266	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	33
City of Burbank	BWPM, BWPC				Fred LeBlanc	818-238-3699	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	34
City of Cerritos			CRLC Allocation/Auction		Vince Brar	562-916-1222	Mark Richardson: 916-608-7304	35
City of Colton			CLTN Allocation/Auction		Jeannette Olko	909-370-6196	Mark Richardson: 916-608-7304	36
City of Corona	COR1, COR2		COR1 Allocation/Auction		Curtis Showalter	951-279-3677	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	36

NOTE: Submit a CIDI case for inquires. If no CIDI access, please contact your Client Representative. If your company not listed below, please go to Contact Us on the ISO web site.								
Market Participant (Client)	**Scheduling Coordinator SCID**	**Energy Imbalance Market (EIM)**	**CRR Holder Allocation / Auction**	**Convergence Bidding**	**Client Contact Name**	**Client Contact Phone**	**Client Representatives**	
City of Glendale	GLEN				Ramon Abueg	818-548-3297	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	37
City of Pasadena	PASA, PAS2, PAS3		PASA Allocation/Auction		Erik Johnson	626-744-7920	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	38
City of Pico Rivera, dba Rivera Innovation Municipal Energy			DEB1 Allocation/Auction		Rene Bobadilla	562-801-4379	Monica Mouanetry: 916-608-1129 Mark Richardson: 916-608-7304	39
City of Rancho Cucamonga	RCMU				Fred Lyn	909-477-2740 x4(	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	40
City of Rancho Mirage			DEB4 Allocation / Auction		Jay Robertson	713-877-5712	Mark Richardson: 916-608-7304	41
City of Riverside	RVSD, SCP1, APL1, SCP2, SCP3, SCP4, SCP5, WIN1, BIO1		RVSD Allocation/Auction		Jesus Martinez	951-826-8527	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	42
City of Roseville (Roseville Electric)	RSVL			RSVL	Brian Zard	916-746-1671	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	43
City of San Jacinto			DEB3 Allocation / Auction		Jay Robertson	713-877-5712	Mark Richardson: 916-608-7304	44
City of Solana Beach			TEAS Allocation/Auction		Gregory Wade	858-720-2431	Mark Richardson: 916-608-7304	45
City of Santa Clara dba Silicon Valley Power	SNCL		SNCL Allocation/Auction		Ken Kohtz	408-615-2192	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	46
City of Tacoma, Department of Public Utilities, Light Division	TCM1			TCM1	Mara Becker	253-502-8338	Mark Richardson: 916-608-7304	47
City of Vernon	VERN		VERN Allocation/Auction		Efrain Sandoval	323-826-1424	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	48
Clean Power Alliance of Southern California			TEAL Allocation/Auction		Ted Bardacke	213-974-2563	Monica Mouanetry: 916-608-1129 Mark Richardson: 916-608-7304	49

NOTE: Submit a CIDI case for inquires. If no CIDI access, please contact your Client Representative. If your company not listed below, please go to Contact Us on the ISO web site.

Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
Clear Power LLC			CCCP Auction	CCCP	Tom Wilson	916-985-9461	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	50
Comision Federal De Electricidad	CFE1				Ana Gonzalez	01152-686-558-1	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	51
Commercial Energy of Montana	CEM1				Robert Gunnin	949-679-24-37	Mark Richardson: 916-608-7304	52
Commercial Energy of Montana dba Commercial Energy of California			CEM1 Allocation/Auction		Robert Gunnin	949-679-24-37	Mark Richardson: 916-608-7304	53
ConocoPhillips Company	CNCO, CNCP, CNCH, CNCG		CNCO Auction	CNCO	Terri Clynes	281-293-4606	Mark Richardson: 916-608-7304	54
Consolidated Edison Energy, Inc.	CEE1			CEE1	Norman Mah	914-993-2164	Mark Richardson: 916-608-7304	55
Constellation NewEnergy, Inc.	NEI1, NECB		NEI1 Allocation/Auction	NEI1, NECB	Stephanie Mannion	410-470-3177	Mark Richardson: 916-608-7304	56
Covanta Delano, Inc.	COV1, COV2				Sami Kabbani	973-882-4177	Mark Richardson: 916-608-7304	57
Covanta Stanislaus, Inc.	STAN				Jeff Ruoss	209-827-2202	Mark Richardson: 916-608-7304	58
CP Energy Marketing (US), Inc.	EEMU			EEMU	Josh Campbell	403-717-8948	Mark Richardson: 916-608-7304	59
CWP Energy, Inc.	CWPE		CWPE Auction	CWPE	Eric Kohucik	514-871-2048	Mark Richardson: 916-608-7304	60
Darby Energy, LLC			DARB Auction	DARB	Jamie Miano	610-617-2669	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	61
DC Energy California, LLC	DCEC		DCEC Auction	DCEC	Matthew Tate	703-760-4390	Mark Richardson: 916-608-7304	62

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Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
Desert Community Energy			TEAD Auction Allocation		Katie Borrows	760-346-1127	Mark Richardson: 916-608-7304	63
Direct Energy Business, LLC	SEL1, SEL2, DEML, LCES, PCEA, DEB1, DEBM, DEB2, DEB3, DEB4		SEL1, DEML, SEL2, DEB2 Allocation/Auction	DEML	Jay Robertson	713-877-5712	Mark Richardson: 916-608-7304	64
DTE Energy Trading Inc.	DTET, DTEX		DTET, DTEX Auction	DTET, DTEX	Jason Greg	734-887-2024	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	65
Dynasty Energy California Inc.			DECI Auction	DECI, DEC2	Jason Brown	403-629-8086	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	66
Dynegy Marketing and Trade, LLC	ECH1, DYN1, DYN2			DYN1	Brett Kampwerth	713-767-4051	Mark Richardson: 916-608-7304	67
Eagle's View Partners, Ltd				EVMS	Peter Owczarek	212-421-7300	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	68
East Bay Community Energy Authority			NEBC		Gillian Biedler	916-781-4219	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	69
Eastside Power Authority			WEPA Allocation/Auction		Cori Bradley	916-405-8923	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	70
EDF Industrial Power Services (CA), LLC			EIPS Allocation/Auction		Byron Pollard	281-653-1641	Mark Richardson: 916-608-7304	71
EDF Trading North America, LLC	EAGL, EAG2, EDF3, EDF4, EDF5, EDF6, EIPS, EDF7, EDF8, EDF9, EDFM, EDFR, ANAE, EDF1, EDF2, EBAT	EDF1	EAGL, EAG2, EDF3, EDF4, EDF5, EDF6, EDF7, EDF8, EDF9, EDFM Auction	EAGL, EAG2, EDF3, EDF4, EDF5, EDF6, EDF7, EDF8, EDF9, EIPS, EDFM	Jason Cox	281-781-0357	Mark Richardson: 916-608-7304	72
EDMS, LLC	EDMS, EDM7				Daniel Hill	858-678-0118	Mark Richardson: 916-608-7304	73
EDP Renewables North America LLC			EDPR Auction	EDPR	Cedric Kouam	713-356-2490	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	74

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Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
Engelhart CTP (US), LLC	BTGP, BTG1		BTGP Auction	BTGP	Paul Marcon	203-349-7599	Mark Richardson: 916-608-7304	75
ETC Endure Energy LLC				ENDU	Clark Foy	913-956-4500	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	76
ETRACOM, LLC			ETRA Auction	ETRA	Michael Rosenberg	214-418-6453	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	77
Exelon Generation Company, LLC	EXPT, ECCG, SOMA, EXWV, EXSF		EXPT, CPSC Auction	EXPT	Dirk Van Der Laan	610-765-6717	Mark Richardson: 916-608-7304	78
FANTODS, LLC			FANT Auction	FANT	Louie Perkins	503-840-8331	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	79
Franklin Power, LLC			FRPO Auction		Anna Wood	212-219-6063	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	80
Freepoint Commodities, LLC			FPC1 Auction	FPC1	Nan Swan	203-542-6752	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	81
Galt Power Inc.	GALT, CES1, OHM1, BTRY, EDDR, JNET		GALT Auction		Mike McGuffin	916-932-7227	Mark Richardson: 916-608-7304	82
Golden Dome LLC (previously, Ecesis LLC)			ECES Auction	ECES	Chris Riley	305-374-3600	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	83
Golden Hills Wind, LLC	GHW1				William Key	561-304-5215	Mark Richardson: 916-608-7304	84
Golden State Water Company dba Bear Valley Electric Service			APXG Allocation/Auction		Tracy Drabant	909-866-1666	Mark Richardson: 916-608-7304	85
Gridmatic Inc.				GRDM	Matt Wytock	650-489-6288	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	86
Group628, LLC				GRP6	Shengqi Ye	812-360-4803	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	87
Guzman Energy, LLC	GUZC, GUZM		GUZC, GUZM Auction	GUZC, GUZM	Chris Riley	305-675-3600	Mark Richardson: 916-608-7304	88

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Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
Guzman Energy Partners, LLC	GREP				Chris Riley	305-675-3600	Mark Richardson: 916-608-7304	89
Heartland Power Inc.				HLP1	Darren Wong	403-397-2779	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	90
Hexis Energy Trading				HEXI	Bret DeBenedictis	303-217-1346	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	92
Hopewell Capital Partners, LP				HCP1, HCP2	Curtis Turner	713-851-3728	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	93
Idaho Power Company - Transmission		IPCE			Kathy Anderson	208-388-5676	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	94
Idaho Power Company - Merchant		IPCM			Kathy Anderson	208-388-5676	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	95
Imperial Irrigation District	IIDE				Tim Hamilton	760-482-3391	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	96
Inertia Power VII, LLC			INER Auction	INER, INP2, INP3	Noha Sidhom	571-242-0469	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	98
Intergrid Management Group LLC			INMG Auction		Igor Kliakhandler	832-382-5335	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	99
Inland Empire Energy Center, LLC	IEEC				Frank Escobedo	951-928-5941	Mark Richardson: 916-608-7304	100
J. Aron and Company, LLC	ARON, JAC1, ARNW		ARON Auction	ARON	Kelly Brooks	212-855-6188	Mark Richardson: 916-608-7304	101
Just Energy	CECO		CECO Allocation/Auction	CECO	Adnan Poonawala	713-544-8157	Mark Richardson: 916-608-7304	102
Keni Energy LLC				KENI	Valery Kogan	Israel 972-52-6032083	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	103
LCG Consulting			LCGC Auction		Madeline Chen	650-962-9670 x1	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	104
Leapfrog Power, Inc.	LEAP				Remco van den Elzen	408-495-3186	Mark Richardson: 916-608-7304	104

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Market Participant (Client)	**Scheduling Coordinator SCID**	**Energy Imbalance Market (EIM)**	**CRR Holder Allocation / Auction**	**Convergence Bidding**	**Client Contact Name**	**Client Contact Phone**	**Client Representatives**	
Liberty Power Holdings LLC	LPHO				Alberto Daire	954-598-7003	Mark Richardson: 916-608-7304	105
Los Angeles Department of Water and Power	LDWP, DWPT				John Giese	818 -771 - 6558	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	106
LTSTE Investments, LLC				LTST	David Froot	978-394-3012	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	107
Macquarie Energy LLC	MACQ, MAC1		MACQ Auction	MACQ, MAC1	Matt Dagostino	713-275-6112	Mark Richardson: 916-608-7304	108
MAG Energy Solutions, Inc.	MAG1		MAG1 Auction	MAG1	Simon Pelletier	514-227-1654 x1(	Mark Richardson: 916-608-7304	109
Marin Clean Energy	MCEE		MCEE Allocation/Auction		Dawn Weisz	415-261-8233	Mark Richardson: 916-608-7304	110
Merced Irrigation District	MEID				Richard Dragonajtys	209-354-2844	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	111
Mercuria Energy America, Inc.			MEA1, MEA2 Auction	MEA1, MEA2	Andrew Davis	832-209-2331	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	112
MET West Trading, LLC			METW Auction	METW	Robert Marsh	617-475-1575	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	113
Midway Sunset Cogeneration Company	MWSC				Greg Jans	661-768-3018	Mark Richardson: 916-608-7304	114
Modesto Irrigation District	MID1, MID4, CSFM		MID1 Allocation/Auction	MID1	Amy Burrow	209-557-1544	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	115
Montana Wind Energy, Inc.			MTWE Auction		Yangping Li	406-587-9505	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	116
Monterey CA, LLC			MOCA Auction	MOCA	Pete Jones	302-463-1136	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	117
Morgan Stanley Capital Group Inc.	MSCG (inactive), MSG2, MSG3, PCF1, PCF2	MSG2	MSCG Auction	MSCG	Patrick Murray	914-225-1435	Mark Richardson: 916-608-7304	118

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Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
Monterey Bay Community Power Authority			TEAM Allocation / Auction		Tom Habashi	831-641-7215	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	119
NDC Partners LLC				NDCP	Aleksandr Berkovich	619-549-2630	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	120
Nevada Power Company		NVE1					Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	121
Nevada Power Company dba NV Energy	NVPM	NEIM			Vincetn Burton	702-402-5667	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	122
NextEra Energy Marketing, LLC	FPPM, PMI1, PMI2, PMI3, PMI4, PMI5, PMI6		BLYE, FPPM, PMI3 Auction	FPPM, PMI3	Bill Key	561-625-7111	Mark Richardson: 916-608-7304	123
Northern California Power Agency	NCPA, BRT1, NEBC, NSJC		NCPA Allocation/Auction		Tony Zimmer	916-781-4229	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	124
NorthStar SW Ltd.			NSSW Auction	NSSW	Bahi Kandavel	647-987-8348	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	125
NRG California South, LP	NES1		NES1 Auction	NES1	Taylor Roye	609-524-4890	Mark Richardson: 916-608-7304	126
NRG Power Marketing LLC	NRG1, NRG2, NRS1, NRTR		NRG1, NRTR Auction	NRG1, NRTR	Taylor Roye	609-524-4890	Mark Richardson: 916-608-7304	127
Olivine, Inc.	OLVN, OLV1, OLV2, OLV3, OLV4				Spence Gerber	916-259-3690	Mark Richardson: 916-608-7304	128
PacifiCorp - Merchant	PAC1, PAC3	PAC1			Todd Carpenter	503-813-6046	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	129
PacifiCorp - Transmission	PAC7	PACE, PACW			Brian McClelland	503-251-5162	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	130
Pacific Gas and Electric Company (PG&E - Trading)	PCG2, PCG3, PCG4, PCG5, PCWA		PCG2 Allocation/Auction	PCG2,PCG4, PCG5	Amol Patel	415-973-6510	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	131
PALMco Power CA	PMCO				Byron Farnsworth	718-696-0121	Mark Richardson: 916-608-7304	132
Peak Energy Capital LP			PEC1 Auction		Jeffrey Lamp	713-854-9008	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	133

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Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
Pechanga Band of Luisen Indians dba Pechanga Tribal Utility			PTUA Allocation		Breann Nu'uhiwa	951-770-6174	Mark Richardson: 916-608-7304	134
PG&E - Transmission	PGAB, BART, NMSL, TO05				Rich Fields	415-973-3394	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	135
Peninsula Clean Energy Authority			PCEA Allocation/Auction		George Wiltsee	626-890-8346	Mark Richardson: 916-608-7304	136
Pilot Power Group, Inc.	PIPO, PIP7, KING		PIPO Allocation/Auction		Ty Bettis	858-678-7770	Mark Richardson: 916-608-7304	137
Pioneer Community Energy	PCCE		PCCE Auction/Allocation		Gillian Biedler	916-7814256	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	138
Placer County Water Agency	MFP1				Katie Swanberg	530-823-4862	Mark Richardson: 916-608-7304	139
Port of Stockton (Stockton Port District)			PSTN Allocation/Auction		Juan G. Villaneuva	209-946-0246	Mark Richardson: 916-608-7304	140
Portland General Electric Company	PORT	PGEN	PORT Auction	PORT	Cathy Kim	503-464-2542	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	141
Portland General Electric Company Transmission		PGEE			Bob Frost	503-404-8916	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	142
Power and Water Resources Pooling Authority	PWPA		PWPA Auction		Scott Billiot	317-344-7229	Mark Richardson: 916-608-7304	143
Powerex Corp.	PWRX, PWR2		PWRX Auction	PWRX, PWR2	Rob Gosselin	604-891-6080	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	144
Powerex Corp.		PWRE, PWRM			Jeff Spires	604-891-5074	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	145
Precept Power LLC				PRCP	Daron Green	314-363-5204	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	146

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Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
Public Service Company of Colorado (Xcel Energy)	PSCO, PSCB		PSCO Auction	PSCB	Shawn Bryant	303-571-2843	Mark Richardson: 916-608-7304	147
Public Service Company of New Mexico	PNMM				Steven Maestas	505-241-2176	Mark Richardson: 916-608-7304	148
Puget Sound Energy	PSE1	PSE2			Phillip Haines	425-462-3471	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	149
Puget Sound Energy - Transmission		PUG1					Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	150
Quattro Energy, LP (previously Calicot Energy LLC)			CCOT Auction	CCOT	JP Crametz	650-462-7202	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	151
Rainbow Energy Marketing Corporation	REMC, REM1, REM2, REM3, REM4, REM5, REM6, REM7			REMC, REM1, REM2, REM5, REM6, REM7	Rodney Drake	913-236-6600	Mark Richardson: 916-608-7304	152
Red Wolf CT, LLC				RWCT	Wesley Allen	919-341-5171	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	153
Redwood Coast Energy Authority			TEAH Allocation				Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	154
Rising Tree Wind Farm LLC	RTWF				Cedric Kouam	713-356-2490	Mark Richardson: 916-608-7304	155
Royal Bank of Canada	RBC1			RBC1	Christian Fraiture	212-618-7806	Mark Richardson: 916-608-7304	156
Rubicon NYP Corp	ICON			ICON	Jean-Philippe Taillon	514-232-1764	Mark Richardson: 916-608-7304	157
Saavi Energy Solutions (previously InterGen Energy Solutions)	ISE1				Victor Ureta	52 (55) 1500 484	Mark Richardson: 916-608-7304	158
Sacramento Municipal Utility District	SMUD, SMD3, VCEA, SEIM		SMUD Allocation/Auction	SMUD, SMD3	Jeffrey Giannani	916-732-6078	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	159
Salt River Project	SRP1				Brett Smith	602 236-4543	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	160

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Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
San Diego Gas & Electric Company	SDG3, SDG4, SDGW		SDG3 Allocation/Auction	SDG3	Andy Scates	858-637-3749	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	161
San Diego Gas & Electric Transmission	SDGE, TO02				Chris Soderlund	619-725-8665	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	162
San Francisco Bay Area Rapid Transit Authority (BART)			BRT1 Allocation		Nathanael Miksis	510-287-4703	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	163
Saracen Energy West, LP			SEW1 Auction	SEW1	Shan Zhong	713-366-7066	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	164
Sempra Gas & Power Marketing, LLC	SGPM, TERM, CERD		SGPM, TERM Auction	SGPM, TERM	Kevin Ding	619-696-4017	Mark Richardson: 916-608-7304	165
Sesco Caliso, LLC			ECAL, WCAL, NCAL Auction	ECAL, WCAL, NCAL, SCAL, YCAL	Keith Torrillo	724-837-2655 ext	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	166
Sequoia Power Trading, LLC			SEQT Auction	SEQT	Hua Bai	832-664-1773	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	167
Shell Energy North America (US), L.P.	CRLP, CLTN, CRN1, CTID, CRLL, IVLY, CRLC,CSFT, CRLT, PSTN, TMCO, KMPD, CLPH, SCPA, RETQ, YCWA, PTUA, IGLR, AVCE, CRLU		CRLL, CRLP, CRLT Allocation/Auction	CRLP, CRLT, CRLL	Chris Nichol	509-688-6110	Mark Richardson: 916-608-7304	168
Sierra Pacific Power Company	SPPC, SPPN, SPPX				John Hughes	702-579-1970	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	169
Silicon Valley Clean Energy Authority	SVC1		SVC1		Christine Vangelatos	916-985-9461	Mark Richardson: 916-608-7304	170
Sirius Power Trading LLC			SPTL Auction	SPTL	Richard Wu	203-434-1857	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	171
SOHO Energy, LLC			SOHO Auction		Daniel Simpson	212-850-8877	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	172
Solios Power, LLC			SPLC Auction	SPLC	Derrick Ang	617-876-5006	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	173
Sonoma Clean Power Authority			SCPA Allocation		Deb Emerson	707-978-3468	Mark Richardson: 916-608-7304	174

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Market Participant (Client)	**Scheduling Coordinator SCID**	**Energy Imbalance Market (EIM)**	**CRR Holder Allocation / Auction**	**Convergence Bidding**	**Client Contact Name**	**Client Contact Phone**	**Client Representatives**	
Southern California Edison Company	SCE1, SCE2, SCE5, SCE6, SCE7, SCE8, SCE9, SC10		SCE1 Allocation/Auction	SCE1, SCE7	Tony Frontino	626-302-3727	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	174
Southern California Edison - TO	TO03				Thomas Batello	626-308-6549	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	175
TEC Energy Inc.	TECX			TECX	Etienne Lapointe	514-502-8068	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	176
Tenaska Power Services Co.	TNSK, TSC1, TSC2, TSC3, TSC4, TSC5, TSC6, TSC7, TSC8, TSC9, TS10, TS11, TS12, TS13, TS14, TS15, TS16, TS17, TS18, TS19, TS20, TS21, TS22, TS23, TS24, TS25, TS26, TS27, TS28, TS29, TS30	TS13	TNSK, TSC1, TSC2, TSC3,TSC4, TSC5, TSC6,TS10 Auction	TNSK, TSC1, TSC2, TSC3, TSC4, TSC5, TSC6, TS13, TS14, TS15, TS16, TS17, TS18, TS19, TS20, TS21, TS22, TS23, TS24, TS25, TS26, TS27, TS28, TS29, TS30	Jeremy Carpenter	817-303-1869	Mark Richardson: 916-608-7304	177
TGP Energy Management, LLC	TGEM				Don Vawter	949-525-3950	Mark Richardson: 916-608-7304	178
The Energy Authority, Inc	TEA1, TEAU, TEAN, TEAV, TEAH, TEAL, TEAM, TEAS, TEAD		TEA1, TEAN, TEAV Auction	TEA1, TEAN, TEAV	Scott Gleason	452-460-1140	Mark Richardson: 916-608-7304	179
The Regents of the University of California			TEAU Allocation		Mark Byron	510-287-3846	Mark Richardson: 916-608-7304	180
Thordin ApS				THOR	Soren Bondo Anderson	45 31 223047	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	181
Tios Capital, LLC				TIOS	Brian Fujito	571-216-9582	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	182
Tommy Energy Solutions Corp				TMEC	Kejun Han	408-753-9782	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	183
Town of Apple Valley dba Apple Valley Choice Energy			AVCE Allocation/Auction		Joseph Moon	760-240-7000 x7021	Mark Richardson: 916-608-7304	184
Trane Grid Service LLC (previously, FM Energy Scheduling, LLC)	FMES				Chad Singer	502-214-9333	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	185

NOTE: Submit a CIDI case for inquires. If no CIDI access, please contact your Client Representative. If your company not listed below, please go to Contact Us on the ISO web site.								
Market Participant (Client)	**Scheduling Coordinator SCID**	**Energy Imbalance Market (EIM)**	**CRR Holder Allocation / Auction**	**Convergence Bidding**	**Client Contact Name**	**Client Contact Phone**	**Client Representatives**	
TransAlta Energy Marketing (U.S.) Inc.	TEMU, TEM1		TEMU, TEM1 Auction	TEMU, TEM1	Myrna Castro	403-267-4688	Mark Richardson: 916-608-7304	186
TransCanada Energy Sales Ltd.	TCES		TCES Auction	TCES	Conor Loewer	403-920-5036	Mark Richardson: 916-608-7304	187
Triolith Energy Fund, LP				TRIO	Michael Workman	727-365-3928	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	188
TrueLight Energy Fund, LP				TRUE	Joe Prosack	207-939-1017	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	189
Trumpet Trading, LLC				TRUM	Candice Greene	864-593-1178	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	190
Tucson Electric Power Company	TEP1				Michael Bowling	520-745-7124	Mark Richardson: 916-608-7304	191
Tungsten Power LP				TUNG	Peter Zhang	310-873-3060	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	192
Turlock Irrigation District	TIDS, TIDM				Nicole Lange	209-883-8602	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	193
Tyne Hill Investments LP			CTYN Auction	CTYN	Hanish Dayal	412-974-0201	Mark Richardson: 916-608-7304	194
Twin Eagle Resource Management, LLC	TWIN, TWNX, TWAL				Kyle Higgs	281-653-0865	Mark Richardson: 916-608-7304	195
Uncia Energy LP - Series C			UNCC Auction	UNCC	Callias Beitel	303-809-6053	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	196
Uniper Global Commodities North America LLC (formerly E.On)			EONG Auction		Felix Khalatnikov	312-840-4559	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	197
Valley Clean Energy Alliance			VCEA Allocation		Elizabeth Lilley	916-732-6849	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	198
Valley Electric	TO17						Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	199

NOTE: Submit a CIDI case for inquires. If no CIDI access, please contact your Client Representative. If your company not listed below, please go to Contact Us on the ISO web site.

Market Participant (Client)	Scheduling Coordinator SCID	Energy Imbalance Market (EIM)	CRR Holder Allocation / Auction	Convergence Bidding	Client Contact Name	Client Contact Phone	Client Representatives	
Valley Electric Association, Inc.	VBOB		VBOB Allocation/Auction	VBOB	Steve LaFond	206-209-9553	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	200
Vectra Capital, LLC			VCAP Auction		Robert Esposito	646-568-1753	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	201
Velocity American Energy Master I, LP			VAEM, VAE1, VAE2, VAE3, VAE6 Auction	VAE1, VAE2, VAE3, VAE4, VAE5, VAE6	Aaron Easterling	713-490-7648	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	202
Viasyn, Inc.	VSYN, VSN2, VSN3, VSN4,VSN5, VSN6, VSN7, VSN8				Phillip Ho	925-904-1900	Mark Richardson: 916-608-7304	203
Vitol, Inc.	VTOL		VTOL Auction	VTOL	Kolby Kettler	713-230-2632	Mark Richardson: 916-608-7304	204
Wellhead Power eXchange, LLC	WPX1				Grant McDaniel	916-447-5171	Mark Richardson: 916-608-7304	205
Western Area Power Administration Desert Southwest Region	DSWM, DSED, DSMA, DSNV, DSSD		DSWM Allocation/Auction		Norma Jenson-Shorty	602-605-2769	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	206
Western Area Power Administration, Sierra Nevada Region (WAPA)	WCSL, WDIS, WEPA, WFLS, WMKT, WNAS, WNML, WPAC, WPUL, WPWR, WRDG, WSLW, WSNR, WTRN, WDOE, WCRS		WFLS, WNAS, WPUL, WSNR, WTRN, WDOE Allocation/Auction	WFLS, WNML, WPAC, WSLW, WSNR, WDOE	Tong Wu	916-353-4016	Diana Attisani: 916-351-4430 Steve Dainard: 916-608-5861	207
Whitney Point solar, LLC	WHPT				William Key	561-304-5214	Mark Richardson: 916-608-7304	208
XO Energy CAL, LP			XOCR Auction	XOCA	John Charette	610-400-3344	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	209
Yuma Electric, LLC			YUMA Auction	YUMA	Cyril Canezin	832-203-8725	Steve Cassinelli: 916-608-5888 Monica Mouanetry: 916-608-1129	210
ZGlobal Inc.	ZGBL, ZEUS, ZES1, MCE1, SVCE, METS		ZEUS Auction	ZEUS	Christine Vangelatos	916-9859461	Mark Richardson: 916-608-7304	211

Appendix C
Lifecycle Cost Summaries

SUMMARY OF LIFE CYCLE COST COMPARISONS WRD 12,500 AFY POWER ANALYSIS									
		Annual Purchased Utility Costs (2018 rates)			Incremental				
Option	Estimated Installed Costs	Fuel	Electricity	Total Utility Cost	Annual O&M Costs	20-Year Life Cycle Cost	20-Year LCC Savings	Simple Payback (Years)	Rank
Baseline	$200,000	$0	$2,205,000	$2,205,000	$0	$44,584,287	N/A	N/A	N/A
Option 1- 2.7 MW Reciprocating Engine	$7,142,000	$996,335	$25,200	$1,021,535	$452,683	$36,879,867	$7,704,420	9.77	1
Option 2- 2.9 MW Reciprocating Engine	$7,825,000	$1,200,900	$25,200	$1,226,100	$535,640	$43,354,022	$1,230,265	17.65	3
Option 3- Fuel Cell	$12,435,000	$920,131	$25,200	$945,331	$800,000	$47,090,802	**-$2,506,515**	No Payback	5
Option 4- 3.5 MW Gas Turbine	$8,284,000	$1,732,339	$25,200	$1,757,539	$535,640	$54,904,759	**-$10,320,471**	No Payback	6
Option 5- Fuel Cell Server	$10,743,000	$769,459	$0	$769,459	$630,000	$38,607,718	$5,976,569	13.34	2
Option 6- Fuel Cell Server (PPA)	$200,000	$769,459	$1,428,000	$2,197,459	$0	$44,979,819	**-$395,532**	N/A	4

SUMMARY OF LIFE CYCLE COST COMPARISONS WRD 16,000 AFY POWER ANALYSIS									
Option	Estimated Installed Costs	Annual Purchased Utility Costs (2018 rates)			Incremental	17-Year Life Cycle Cost	17-Year LCC Savings	Simple Payback (Years)	Rank
		Fuel	Electricity	Total Utility Cost	Annual O&M Costs				
Baseline	$200,000	$0	$2,646,000	$2,646,000	$0	$45,602,696	N/A	N/A	N/A
Option 1- 3.3 MW Reciprocating Engine	$7,283,000	$1,191,810	$30,240	$1,222,050	$496,891	$37,053,204	$8,549,492	7.86	1
Option 2- 3.04 MW Reciprocating Engine	$7,835,000	$1,200,900	$30,240	$1,231,140	$496,891	$37,789,074	$7,813,622	8.54	2
Option 3- Fuel Cell Plant	$12,435,000	$879,825	$204,624	$1,084,449	$800,000	$44,585,387	$1,017,309	16.33	4
Optoin 4- Gas Turbine	$8,284,000	$1,977,689	$30,240	$2,007,929	$584,582	$53,451,224	**-$7,848,529**	No Payback	6
Option 5- Fuel Cell Servers	$12,217,000	$934,025	$0	$934,025	$756,000	$41,126,447	$4,476,249	12.78	3
Option 6- Fuel Cell Servers- PPA	$200,000	$934,025	$1,688,400	$2,622,425	0	$45,800,066	**-$197,370**	N/A	5

SUMMARY OF LIFE CYCLE COST COMPARISONS WRD 20,000 AFY POWER ANALYSIS									
Option	Estimated Installed Costs	Annual Purchased Utility Costs (2019 rates)			Incremental	15-Year Life Cycle Cost	15-Year LCC Savings	Simple Payback (years)	Rank
		Fuel	Electricity	Total Utility Cost	Annual O&M Costs				
Baseline	$200,000	$0	$3,528,000	$3,528,000	$0	$53,655,539	N/A	N/A	N/A
Option 1- 4.373 MW Reciprocating Engine	$9,548,000	$1,573,903	$40,320	$1,614,223	$530,640	$42,696,393	$10,959,146	6.90	1
Option 2- 5 MW Reciprocating Engine	$10,490,000	$1,461,869	$40,320	$1,502,189	$613,680	$43,065,814	$10,589,725	7.43	2
Option 3- Fuel Cell	$15,895,000	$1,056,850	$301,896	$1,358,746	$900,000	$50,253,521	$3,402,018	12.52	4
Option 4- 4.6 MW Gas Turbine	$9,833,000	$1,848,163	$40,320	$1,888,483	$696,720	$49,619,530	$4,036,008	10.43	3
Option 5- Fuel Cell Servers	$16,290,000	$1,245,367	$0	$1,245,367	$1,008,000	$50,560,161	$3,095,378	12.78	5
Option 6- Fuel Cell Server (PPA)	$200,000	$1,245,367	$2,251,200	$3,496,567	0	$53,923,662	**-$268,123**	N/A	6

SUMMARY OF LIFE CYCLE COST COMPARISONS Project 43- WRD 20,000 AFY POWER ANALYSIS+ 11 Wellhead/Pumps									
Option	Estimated Installed Costs	Annual Purchased Utility Costs (2019 rates)			Incremental	15-Year Life Cycle Cost	15-Year LCC Savings	Simple Payback (years)	Rank
		Fuel	Electricity	Total Utility Cost	Annual O&M Costs				
Baseline	$200,000	$0	$4,614,624	$4,614,624	$0	$70,117,381	N/A	N/A	N/A
Option 1- 5.9 MW Reciprocating Engine	$14,475,000	$2,228,702	$52,739	$2,281,441	$696,720	$60,627,770	$9,489,611	8.85	2
Option 2- 5.7 MW Reciprocating Engine	$13,821,000	$2,141,697	$52,739	$2,194,436	$738,240	$59,154,499	$10,962,882	8.22	1
Option 3- Fuel Cell	$19,170,000	$1,388,520	$1,056,850	$2,445,370	$900,000	$70,121,363	**-$3,982**	15.10	3
Option 4- 5.7 MW Gas Turbine	$17,181,000	$2,958,130	$52,739	$3,010,868	$738,240	$75,505,425	**-$5,388,044**	19.85	6
Option 5- Fuel Cell Server	$25,682,000	$1,628,940	$0	$1,628,940	$1,318,464	$70,682,357	**-$564,976**	15.40	4
Option 6- Fuel Cell (PPA)	$3,475,000	$1,628,940	$2,900,621	$4,529,561	$0	$73,416,282	**-$3,298,901**	N/A	5

SUMMARY OF LIFE CYCLE COST COMPARISONS Project 44- WRD 20,000 AFY POWER ANALYSIS+ 11 Wellhead/Pumps and Water Treatment Skid									
		Annual Purchased Utility Costs (2019 rates)			Incremental				
Option	Estimated Installed Costs	Fuel	Electricity	Total Utility Cost	Annual O&M Costs	20-Year Life Cycle Cost	20-Year LCC Savings	Simple Payback (years)	Rank
Baseline	$200,000	$0	$4,967,424	$4,967,424	$0	$75,462,135	N/A	N/A	N/A
Option 1- 5.9 MW Reciprocating Engine	$15,162,000	$2,358,959	$56,771	$2,415,729	$696,720	$63,454,508	$12,007,627	8.17	2
Option 2- 5.7 MW Reciprocating Engine	$14,435,000	$2,283,828	$56,771	$2,340,599	$696,720	$61,515,334	$13,946,800	7.48	1
Option 3- Fuel Cell	$19,697,000	$1,056,850	$1,741,320	$2,798,170	$900,000	$72,060,117	$3,402,018	15.52	3
Option 4- 6.3 MW Gas Turbine	$18,601,000	$3,090,122	$56,771	$3,146,892	$738,240	$79,121,813	**-$3,659,678**	17.19	5
Option 5- Fuel Cell #2	$28,587,000	$1,753,477	$0	$1,753,477	$1,419,264	$77,065,413	**-$1,603,278**	15.93	4
Option 6- Fuel Cell (PPA)	$4,002,000	$1,753,477	$3,122,381	$4,875,858	0	$79,285,026	**-$3,822,891**	N/A	6

Appendix D
Cost Estimates

WRD- Regional Brackish Water Reclaimation 12,500 AFY Facility
Option 1- 2.656 MW Reciprocating Engine **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Reciprocating Engines	1	EA	$ 2,280,000	$ 2,280,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 600,000	$ 600,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 515,000	$ 515,000	10%	5%
SubTotal				**$ 3,395,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	30%
CEMS Cabinet	1	LS	$ 250,000	$ 250,000	10%	30%
SCR/Ammonia System	1	LS	$ 100,000	$ 100,000	10%	30%
Air Compression System	1	LS	$ 20,000	$ 20,000	10%	30%
SubTotal				**$ 445,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	30%
Grounding	1	LS	$ 50,000	$ 50,000	10%	30%
Foundations	1	LS	$ 120,000	$ 120,000	10%	30%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	30%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	30%
Mechanical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	30%
Electrical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	30%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	30%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	30%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	30%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	30%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	30%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	30%
Control Software Engineering and Screen Developmen	-	LS	$ 220,000	$ -	10%	30%
SubTotal				**$ 850,000**		
Combined Material and Labor Subtotal				**$ 4,690,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 422,100	$ 422,100		
Overhead (5%)	1	LS	$ 234,500	$ 234,500		
Bond and Insurance (1.35%)	1	LS	$ 63,315	$ 63,315		
General Contractor Fees (5%)	1	LS	$ 234,500	$ 234,500		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 469,000	$ 469,000		
SubTotal				**$ 1,423,000**		
Total Construction Contingency				**$ 470,000**		
Total Design Contingency				**$ 559,000**		
Total Construction Cost				**$ 7,142,000**		

WRD- Regional Brackish Water Reclaimation 12,500 AFY Facility
Option 2- 2.88 MW Reciprocating Engine 706641CH
PROJECT COST ESTIMATE 5/2/2019

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Reciprocating Engine	1	EA	$ 2,750,000	$ 2,750,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 600,000	$ 600,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 515,000	$ 515,000	10%	5%
SubTotal				**$ 3,865,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	30%
CEMS Cabinet	1	LS	$ 250,000	$ 250,000	10%	30%
SCR/Ammonia System	1	LS	$ 100,000	$ 100,000	10%	30%
Air Compression System	1	LS	$ 20,000	$ 20,000	10%	30%
SubTotal				**$ 445,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	30%
Grounding	1	LS	$ 50,000	$ 50,000	10%	30%
Foundations	1	LS	$ 120,000	$ 120,000	10%	30%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	30%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	30%
Mechanical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	30%
Electrical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	30%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	30%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	30%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	30%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	30%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	30%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	30%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	30%
SubTotal				**$ 850,000**		
Combined Material and Labor Subtotal				**$ 5,160,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 464,400	$ 464,400		
Overhead (5%)	1	LS	$ 258,000	$ 258,000		
Bond and Insurance (1.35%)	1	LS	$ 69,660	$ 69,660		
General Contractor Fees (5%)	1	LS	$ 258,000	$ 258,000		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 516,000	$ 516,000		
SubTotal				**$ 1,566,000**		
Total Construction Contingency				**$ 517,000**		
Total Design Contingency				**$ 582,000**		
Total Construction Cost				**$ 7,825,000**		

WRD- Regional Brackish Water Reclaimation 12,500 AFY Facility
Option 3- Fuel Cell Plant — **706641CH**
PROJECT COST ESTIMATE — **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Fuel Cell Plant	1	EA	$ 10,600,000	$ 10,600,000	10%	5%
Federal Incentive Tax Credit	1	EA	$ (3,180,000)	$ (3,180,000)	10%	5%
Packaged Electrical Control Module	1	EA	$ 515,000	$ 515,000	10%	5%
SubTotal				**$ 7,935,000**		
Balance of Plant Equipment Costs						
BOP INCLUDED IN FUEL CELL PLANT ESTIMATE	1	LS	$ -	$ -	10%	30%
SubTotal				**$ -**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 120,000	$ 120,000	10%	5%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	5%
Electrical Installation/Labor	1	LS	$ 40,000	$ 40,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	5%
Process Control Valves	3		$ 15,000	$ 45,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Developmen	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 620,000**		
Combined Material and Labor Subtotal				**$ 8,555,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 769,950	$ 769,950		
Overhead (5%)	1	LS	$ 427,750	$ 427,750		
Bond and Insurance (1.35%)	1	LS	$ 115,493	$ 115,493		
General Contractor Fees (5%)	1	LS	$ 427,750	$ 427,750		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 855,500	$ 855,500		
SubTotal				**$ 2,596,000**		
Total Construction Contingency				**$ 856,000**		
Total Design Contingency				**$ 428,000**		
Total Construction Cost				**$ 12,435,000**		

WRD- Regional Brackish Water Reclaimation 12500 AFY Facility
Option 4- 3.51 MW Gas Turbine 706641CH
PROJECT COST ESTIMATE 5/2/2019

DESCRIPTION	QTY	UM		CONSTRUCTION UNIT $$		CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment								
Gas Turbine Package	1	EA	$	2,664,000	$	2,664,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$	650,000	$	650,000	10%	5%
Packaged Electrical Control Module	1	EA	$	515,000	$	515,000	10%	5%
SubTotal					**$**	**3,829,000**		
Balance of Plant Equipment Costs								
Fuel Gas Compressor and Conditioning Skid	1	LS	$	300,000	$	300,000	10%	5%
CEMS Cabinet	1	LS	$	200,000	$	200,000	10%	5%
SCR/Ammonia System	1	LS	$	100,000	$	100,000	10%	5%
Air Compression System	1	LS	$	20,000	$	20,000	10%	5%
SubTotal					**$**	**620,000**		
Site Construction								
Rigging and Cranes	1	LS	$	100,000	$	100,000	10%	5%
Grounding	1	LS	$	50,000	$	50,000	10%	5%
Foundations	1	LS	$	150,000	$	150,000	10%	5%
Structural Steel	1	LS	$	25,000	$	25,000	10%	5%
Mechanical Piping	1	LS	$	80,000	$	80,000	10%	5%
Mechanical Installation/Labor	1	LS	$	200,000	$	200,000	10%	5%
Electrical Installation/Labor	1	LS	$	200,000	$	200,000	10%	5%
Cable, Conduit and Tray	1	LS	$	50,000	$	50,000	10%	5%
Lighting Protection	1	LS	$	40,000	$	40,000	10%	5%
Process Instruments	35	LS	$	3,000	$	105,000	10%	5%
Process Control Valves	10	LS	$	15,000	$	150,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$	100,000	$	100,000	10%	5%
Process Control Hardware	-	LS	$	115,000	$	-	10%	5%
Control Software Engineering and Screen Development	-	LS	$	220,000	$	-	10%	5%
SubTotal					**$**	**1,250,000**		
Combined Material and Labor Subtotal					**$**	**5,699,000**		
Miscellaneous Contractor Costs								
General Conditions and Project Staff (9%)	1	LS	$	512,910	$	512,910		
Overhead (5%)	1	LS	$	284,950	$	284,950		
Bond and Insurance (1.35%)	1	LS	$	76,937	$	76,937		
General Contractor Fees (5%)	1	LS	$	284,950	$	284,950		
Material Sales Tax	-	LS	$	-	$	-		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$	569,900	$	569,900		
SubTotal					**$**	**1,730,000**		
Total Construction Contingency					**$**	**570,000**		
Total Design Contingency					**$**	**285,000**		
Total Construction Cost					**$**	**8,284,000**		

WRD- Regional Brackish Water Reclamation 12,500 AFY Facility
Option 5- Fuel Cell Server (2.5 MW) **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Fuel Cell Server	1	EA	$ 12,000,000	$ 12,000,000	10%	5%
Federal Investment Tax Credit	1	EA	$ (3,750,000)	$ (3,750,000)	10%	5%
SubTotal				**$ 8,250,000**		
Balance of Plant Equipment Costs						
BOP INCLUDED IN FUEL CELL SERVER ESTIMATE	1	LS	$ -	$ -	10%	30%
SubTotal				**$ -**		
Site Construction						
Grounding	1	LS	$ 80,000	$ 80,000	10%	5%
Foundations	1	LS	$ 120,000	$ 120,000	10%	5%
Structural Steel	1	LS	$ 50,000	$ 50,000	10%	5%
Electrical Installation/Labor	1	LS	$ 40,000	$ 40,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	20	LS	$ 3,000	$ 60,000	10%	5%
Process Control Valves	4		$ 15,000	$ 60,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
SubTotal				**$ 500,000**		
Combined Material and Labor Subtotal				**$ 8,750,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	-	LS	$ 787,500	$ -		
Overhead (5%)	-	LS	$ 437,500	$ -		
Bond and Insurance (1.35%)	1	LS	$ 118,125	$ 118,125		
General Contractor Fees (5%)	-	LS	$ 437,500	$ -		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	-	LS	$ 875,000	$ -		
SubTotal				**$ 118,000**		
Total Construction Contingency				**$ 1,250,000**		
Total Design Contingency				**$ 625,000**		
Total Construction Cost				**$ 10,743,000**		

WRD- Regional Brackish Water Reclaimation 16,000 AFY Facility
Option 1- 3.3 MW Reciprocating Engine **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Generators	1	EA	$ 2,720,000	$ 2,720,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 650,000	$ 650,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 515,000	$ 515,000	10%	5%
SubTotal				**$ 3,885,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	5%
CEMS Cabinet	1	LS	$ 150,000	$ 150,000	10%	5%
Air Compression System	1	LS	$ 20,000	$ 20,000	10%	5%
SubTotal				**$ 245,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 150,000	$ 150,000	10%	5%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	5%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	5%
Mechanical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	5%
Electrical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	5%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 880,000**		
Combined Material and Labor Subtotal				**$ 5,010,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 450,900	$ 450,900		
Overhead (5%)	1	LS	$ 250,500	$ 250,500		
Bond and Insurance (1.35%)	1	LS	$ 67,635	$ 67,635		
General Contractor Fees (5%)	1	LS	$ 250,500	$ 250,500		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 501,000	$ 501,000		
SubTotal				**$ 1,521,000**		
Total Construction Contingency				**$ 502,000**		
Total Design Contingency				**$ 250,000**		
Total Construction Cost				**$ 7,283,000**		

WRD- Regional Brackish Water Reclamation 16,000 AFY Facility
Option 2- 3.04 MW Reciprocating Engine **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Generators	1	EA	$ 3,100,000	$ 3,100,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 650,000	$ 650,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 515,000	$ 515,000	10%	5%
SubTotal				**$ 4,265,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	5%
CEMS Cabinet	1	LS	$ 150,000	$ 150,000	10%	5%
Air Compression System	1	LS	$ 20,000	$ 20,000	10%	5%
SubTotal				**$ 245,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 150,000	$ 150,000	10%	5%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	5%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	5%
Mechanical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	5%
Electrical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	5%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 880,000**		
Combined Material and Labor Subtotal				**$ 5,390,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 485,100	$ 485,100		
Overhead (5%)	1	LS	$ 269,500	$ 269,500		
Bond and Insurance (1.35%)	1	LS	$ 72,765	$ 72,765		
General Contractor Fees (5%)	1	LS	$ 269,500	$ 269,500		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 539,000	$ 539,000		
SubTotal				**$ 1,636,000**		
Total Construction Contingency				**$ 540,000**		
Total Design Contingency				**$ 269,000**		
Total Construction Cost				**$ 7,835,000**		

WRD- Regional Brackish Water Reclaimation 16,000 AFY Facility
Option 3- Fuel Cell Plant (2.8 MW) **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Fuel Cell Plant	1	EA	$ 10,600,000	$ 10,600,000	10%	5%
Federal Incentive Tax Credit	1	EA	$ (3,180,000)	$ (3,180,000)	10%	5%
Packaged Electrical Control Module	1	EA	$ 515,000	$ 515,000	10%	5%
SubTotal				**$ 7,935,000**		
Balance of Plant Equipment Costs						
BOP INCLUDED IN FUEL CELL PLANT ESTIMATE	1	LS	$ -	$ -	10%	30%
SubTotal				**$ -**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 120,000	$ 120,000	10%	5%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	5%
Electrical Installation/Labor	1	LS	$ 40,000	$ 40,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	5%
Process Control Valves	3		$ 15,000	$ 45,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Developmen	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 620,000**		
Combined Material and Labor Subtotal				**$ 8,555,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 769,950	$ 769,950		
Overhead (5%)	1	LS	$ 427,750	$ 427,750		
Bond and Insurance (1.35%)	1	LS	$ 115,493	$ 115,493		
General Contractor Fees (5%)	1	LS	$ 427,750	$ 427,750		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 855,500	$ 855,500		
SubTotal				**$ 2,596,000**		
Total Construction Contingency				**$ 856,000**		
Total Design Contingency				**$ 428,000**		
Total Construction Cost				**$ 12,435,000**		

WRD- Regional Brackish Water Reclaimation 16,000 AFY Facility
Option 4- 3.51 MW Gas Turbine **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Reciprocating Engines	1	EA	$ 2,664,000	$ 2,664,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 650,000	$ 650,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 515,000	$ 515,000	10%	5%
SubTotal				**$ 3,829,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 300,000	$ 300,000	10%	5%
CEMS Cabinet	1	LS	$ 200,000	$ 200,000	10%	5%
SCR/Ammonia System	1	LS	$ 100,000	$ 100,000	10%	5%
Air Compression System	1	LS	$ 20,000	$ 20,000	10%	5%
SubTotal				**$ 620,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 100,000	$ 100,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 150,000	$ 150,000	10%	5%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	5%
Mechanical Piping	1	LS	$ 80,000	$ 80,000	10%	5%
Mechanical Installation/Labor	1	LS	$ 200,000	$ 200,000	10%	5%
Electrical Installation/Labor	1	LS	$ 200,000	$ 200,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	35	LS	$ 3,000	$ 105,000	10%	5%
Process Control Valves	10	LS	$ 15,000	$ 150,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Developmen	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 1,250,000**		
Combined Material and Labor Subtotal				**$ 5,699,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 512,910	$ 512,910		
Overhead (5%)	1	LS	$ 284,950	$ 284,950		
Bond and Insurance (1.35%)	1	LS	$ 76,937	$ 76,937		
General Contractor Fees (5%)	1	LS	$ 284,950	$ 284,950		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 569,900	$ 569,900		
SubTotal				**$ 1,730,000**		
Total Construction Contingency				**$ 570,000**		
Total Design Contingency				**$ 285,000**		
Total Construction Cost				**$ 8,284,000**		

WRD- Regional Brackish Water Reclamation 16,000 AFY Facility
Option 5- Fuel Cell Server (3 MW) **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM		CONSTRUCTION UNIT $$		CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment								
Fuel Cell Severs	1	EA	$	14,400,000	$	14,400,000	10%	5%
Federal Investment Tax Credit	1	EA	$	(4,500,000)	$	(4,500,000)	10%	5%
SubTotal					**$**	**9,900,000**		
Balance of Plant Equipment Costs								
BOP INCLUDED IN FUEL CELL SERVER ESTIMATE	1	LS	$	-	$	-	10%	30%
SubTotal					**$**	**-**		
Site Construction								
Grounding	1	LS	$	80,000	$	80,000	10%	5%
Foundations	1	LS	$	150,000	$	150,000	10%	5%
Structural Steel	1	LS	$	50,000	$	50,000	10%	5%
Electrical Installation/Labor	1	LS	$	80,000	$	80,000	10%	5%
Cable, Conduit and Tray	1	LS	$	50,000	$	50,000	10%	5%
Lighting Protection	1	LS	$	40,000	$	40,000	10%	5%
Process Instruments	30	LS	$	3,000	$	90,000	10%	5%
Process Control Valves	4		$	15,000	$	60,000	10%	5%
Process Control Hardware	-	LS	$	115,000	$	-	10%	5%
SubTotal					**$**	**600,000**		
Combined Material and Labor Subtotal					**$**	**10,500,000**		
Miscellaneous Contractor Costs								
General Conditions and Project Staff (9%)	-	LS	$	945,000	$	-		
Overhead (5%)	-	LS	$	525,000	$	-		
Bond and Insurance (1.35%)	1	LS	$	141,750	$	141,750		
General Contractor Fees (5%)	-	LS	$	525,000	$	-		
Material Sales Tax	-	LS	$	-	$	-		
1 Yr Price Escalation (Construction in 2020) - 10%	-	LS	$	1,050,000	$	-		
SubTotal					**$**	**142,000**		
Total Construction Contingency					**$**	**1,050,000**		
Total Design Contingency					**$**	**525,000**		
Total Construction Cost					**$**	**12,217,000**		

WRD- Regional Brackish Water Reclamiation 20,000 AFY Facility
Option 1- 4.376 MW Reciprocating Engine **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Reciprocating Engine	1	EA	$ 3,970,000	$ 3,970,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 700,000	$ 700,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 550,000	$ 550,000	10%	5%
SubTotal				**$ 5,220,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	30%
CEMS Cabinet	1	LS	$ 150,000	$ 150,000	10%	30%
Air Compression System	1	LS	$ 20,000	$ 20,000	10%	30%
SubTotal				**$ 245,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	30%
Grounding	1	LS	$ 50,000	$ 50,000	10%	30%
Foundations	1	LS	$ 175,000	$ 175,000	10%	30%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	30%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	30%
Mechanical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	30%
Electrical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	30%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	30%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	30%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	30%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	30%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	30%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	30%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	30%
SubTotal				**$ 905,000**		
Combined Material and Labor Subtotal				**$ 6,370,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 573,300	$ 573,300		
Overhead (5%)	1	LS	$ 318,500	$ 318,500		
Bond and Insurance (1.35%)	1	LS	$ 85,995	$ 85,995		
General Contractor Fees (5%)	1	LS	$ 318,500	$ 318,500		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 637,000	$ 637,000		
SubTotal				**$ 1,933,000**		
Total Construction Contingency				**$ 638,000**		
Total Design Contingency				**$ 607,000**		
Total Construction Cost				**$ 9,548,000**		

WRD- Regional Brackish Water Reclaimation 20,000 AFY Facility
Option 2- 5 MW Reciprocating Engine — **706641CH**
PROJECT COST ESTIMATE — **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Reciprocating Engine	1	EA	$ 4,500,000	$ 4,500,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 700,000	$ 700,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 550,000	$ 550,000	10%	5%
SubTotal				**$ 5,750,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	30%
CEMS Cabinet	1	LS	$ 250,000	$ 250,000	10%	30%
Air Compression System	1	LS	$ 20,000	$ 20,000	10%	30%
SubTotal				**$ 345,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	30%
Grounding	1	LS	$ 50,000	$ 50,000	10%	30%
Foundations	1	LS	$ 175,000	$ 175,000	10%	30%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	30%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	30%
Mechanical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	30%
Electrical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	30%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	30%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	30%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	30%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	30%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	30%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	30%
Control Software Engineering and Screen Developmen	-	LS	$ 220,000	$ -	10%	30%
SubTotal				**$ 905,000**		
Combined Material and Labor Subtotal				**$ 7,000,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 630,000	$ 630,000		
Overhead (5%)	1	LS	$ 350,000	$ 350,000		
Bond and Insurance (1.35%)	1	LS	$ 94,500	$ 94,500		
General Contractor Fees (5%)	1	LS	$ 350,000	$ 350,000		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 700,000	$ 700,000		
SubTotal				**$ 2,125,000**		
Total Construction Contingency				**$ 701,000**		
Total Design Contingency				**$ 664,000**		
Total Construction Cost				**$ 10,490,000**		

WRD- Regional Brackish Water Reclaimation 20,000 AFY Facility
Option 3- Fuel Cell Plant (3.7 MW) **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Fuel Cell Plant	1	EA	$ 14,000,000	$ 14,000,000	10%	5%
Federal Incentive Tax Credit	1	EA	$ (4,200,000)	$ (4,200,000)	10%	5%
Packaged Electrical Control Module	1	EA	$ 515,000	$ 515,000	10%	5%
SubTotal				**$ 10,315,000**		
Balance of Plant Equipment Costs						
BOP INCLUDED IN FUEL CELL PLANT ESTIMATE	1	LS	$ -	$ -	10%	30%
SubTotal				**$ -**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 120,000	$ 120,000	10%	5%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	5%
Electrical Installation/Labor	1	LS	$ 40,000	$ 40,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	5%
Process Control Valves	3		$ 15,000	$ 45,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Developmen	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 620,000**		
Combined Material and Labor Subtotal				**$ 10,935,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 984,150	$ 984,150		
Overhead (5%)	1	LS	$ 546,750	$ 546,750		
Bond and Insurance (1.35%)	1	LS	$ 147,623	$ 147,623		
General Contractor Fees (5%)	1	LS	$ 546,750	$ 546,750		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 1,093,500	$ 1,093,500		
SubTotal				**$ 3,319,000**		
Total Construction Contingency				**$ 1,094,000**		
Total Design Contingency				**$ 547,000**		
Total Construction Cost				**$ 15,895,000**		

WRD- Regional Brackish Water Reclaimation 20,000 AFY Facility
Option 4- 4.57 MW Combustion Turbine
PROJECT COST ESTIMATE

706641CH
5/2/2019

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Combustion Turbine	1	EA	$ 3,500,000	$ 3,500,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 700,000	$ 650,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 550,000	$ 550,000	10%	5%
SubTotal				**$ 4,700,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 400,000	$ 400,000	10%	5%
CEMS Cabinet	1	LS	$ 200,000	$ 200,000	10%	5%
SCR/Ammonia System	1	LS	$ 100,000	$ 100,000	10%	5%
Air Compression System	1	LS	$ 20,000	$ 20,000	10%	5%
SubTotal				**$ 720,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 150,000	$ 150,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 225,000	$ 225,000	10%	5%
Structural Steel	1	LS	$ 50,000	$ 50,000	10%	5%
Mechanical Piping	1	LS	$ 80,000	$ 80,000	10%	5%
Mechanical Installation/Labor	1	LS	$ 200,000	$ 200,000	10%	5%
Electrical Installation/Labor	1	LS	$ 200,000	$ 200,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 60,000	$ 60,000	10%	5%
Lighting Protection	1	LS	$ 80,000	$ 80,000	10%	5%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	5%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Developmen	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 1,345,000**		
Combined Material and Labor Subtotal				**$ 6,765,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 608,850	$ 608,850		
Overhead (5%)	1	LS	$ 338,250	$ 338,250		
Bond and Insurance (1.35%)	1	LS	$ 91,328	$ 91,328		
General Contractor Fees (5%)	1	LS	$ 338,250	$ 338,250		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 676,500	$ 676,500		
SubTotal				**$ 2,053,000**		
Total Construction Contingency				**$ 677,000**		
Total Design Contingency				**$ 338,000**		
Total Construction Cost				**$ 9,833,000**		

WRD- Regional Brackish Water Reclamation 20,000 AFY Facility
Option 5- Fuel Cell Server- (4 MW) **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Fuel Cell Servers	1	EA	$ 19,250,000	$ 19,250,000	10%	5%
Federal Tax Incentive Credit	1	EA	$ (6,000,000)	$ (6,000,000)	10%	5%
SubTotal				**$ 13,250,000**		
Balance of Plant Equipment Costs						
BOP INCLUDED IN FUEL CELL SERVER ESTIMATE	1	LS	$ -	$ -	10%	30%
SubTotal				**$ -**		
Site Construction						
Grounding	1	LS	$ 100,000	$ 100,000	10%	5%
Foundations	1	LS	$ 200,000	$ 200,000	10%	5%
Structural Steel	1	LS	$ 80,000	$ 80,000	10%	5%
Electrical Installation/Labor	1	LS	$ 100,000	$ 100,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 80,000	$ 80,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	35	LS	$ 3,000	$ 105,000	10%	5%
Process Control Valves	3		$ 15,000	$ 45,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
SubTotal				**$ 750,000**		
Combined Material and Labor Subtotal				**$ 14,000,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	-	LS	$ 1,260,000	$ -		
Overhead (5%)	-	LS	$ 700,000	$ -		
Bond and Insurance (1.35%)	1	LS	$ 189,000	$ 189,000		
General Contractor Fees (5%)	-	LS	$ 700,000	$ -		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	-	LS	$ 1,400,000	$ -		
SubTotal				**$ 189,000**		
Total Construction Contingency				**$ 1,400,000**		
Total Design Contingency				**$ 701,000**		
Total Construction Cost				$ 16,290,000		

WRD- Regional Brackish Water Reclaimation- Project 43
Option 1- 5.917 MW Reciprocating Engine 706641CH
PROJECT COST ESTIMATE 5/2/2019

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Generator	1	EA	$ 4,250,000	$ 4,250,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 750,000	$ 750,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 550,000	$ 550,000	10%	5%
SubTotal				**$ 5,550,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	30%
CEMS Cabinet	1	LS	$ 150,000	$ 150,000	10%	30%
Electrical Distribution for Wellhead locations	1	LS	**$ 3,275,000**	$ 3,275,000	0%	0%
SubTotal				**$ 3,500,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	30%
Grounding	1	LS	$ 50,000	$ 50,000	10%	30%
Foundations	1	LS	$ 200,000	$ 200,000	10%	30%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	30%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	30%
Mechanical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	30%
Electrical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	30%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	30%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	30%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	30%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	30%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	30%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	30%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	30%
SubTotal				**$ 1,030,000**		
Combined Material and Labor Subtotal				**$ 10,080,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 907,200	$ 907,200		
Overhead (5%)	1	LS	$ 504,000	$ 504,000		
Bond and Insurance (1.35%)	1	LS	$ 136,080	$ 136,080		
General Contractor Fees (5%)	1	LS	$ 504,000	$ 504,000		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 1,008,000	$ 1,008,000		
SubTotal				**$ 3,059,000**		
Total Construction Contingency				**$ 681,000**		
Total Design Contingency				**$ 655,000**		
Total Construction Cost				**$ 14,475,000**		

WRD- Regional Brackish Water Reclaimation- Project 43
Option 2- 5.7 MW Reciprocating Engine **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Generator	1	EA	$ 3,800,000	$ 3,800,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 750,000	$ 750,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 550,000	$ 550,000	10%	5%
SubTotal				**$ 5,100,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	30%
CEMS Cabinet	1	LS	$ 150,000	$ 150,000	10%	30%
Electrical Distribution for Wellhead locations	1	LS	$ 3,275,000	$ 3,275,000	0%	0%
SubTotal				**$ 3,500,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	30%
Grounding	1	LS	$ 50,000	$ 50,000	10%	30%
Foundations	1	LS	$ 200,000	$ 200,000	10%	30%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	30%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	30%
Mechanical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	30%
Electrical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	30%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	30%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	30%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	30%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	30%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	30%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	30%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	30%
SubTotal				**$ 1,030,000**		
Combined Material and Labor Subtotal				**$ 9,630,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 866,700	$ 866,700		
Overhead (5%)	1	LS	$ 481,500	$ 481,500		
Bond and Insurance (1.35%)	1	LS	$ 130,005	$ 130,005		
General Contractor Fees (5%)	1	LS	$ 481,500	$ 481,500		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 963,000	$ 963,000		
SubTotal				**$ 2,923,000**		
Total Construction Contingency				**$ 636,000**		
Total Design Contingency				**$ 632,000**		
Total Construction Cost				**$ 13,821,000**		

WRD- Regional Brackish Water Reclamation Project 43
Option 3- Fuel Cell Plant (3.7 MW) — **706641CH**
PROJECT COST ESTIMATE — **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$		CONSTRUCTION TOTAL		Construction Contingency	Design Contingency
Major Equipment								
Fuel Cell Plant	1	EA	$	14,000,000	$	14,000,000	10%	5%
Federal Incentive Tax Credit	1	EA	$	(4,200,000)	$	(4,200,000)	10%	5%
Packaged Electrical Control Module	1	EA	$	515,000	$	515,000	10%	5%
SubTotal					**$**	**10,315,000**		
Balance of Plant Equipment Costs								
Electrical Distribution for Wellhead locations	1	LS	$	3,275,000	$	3,275,000	10%	30%
SubTotal					**$**	**3,275,000**		
Site Construction								
Rigging and Cranes	1	LS	$	75,000	$	75,000	10%	5%
Grounding	1	LS	$	50,000	$	50,000	10%	5%
Foundations	1	LS	$	120,000	$	120,000	10%	5%
Structural Steel	1	LS	$	25,000	$	25,000	10%	5%
Electrical Installation/Labor	1	LS	$	40,000	$	40,000	10%	5%
Cable, Conduit and Tray	1	LS	$	50,000	$	50,000	10%	5%
Lighting Protection	1	LS	$	40,000	$	40,000	10%	5%
Process Instruments	25	LS	$	3,000	$	75,000	10%	5%
Process Control Valves	3		$	15,000	$	45,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$	100,000	$	100,000	10%	5%
Process Control Hardware	-	LS	$	115,000	$	-	10%	5%
Control Software Engineering and Screen Developmen	-	LS	$	220,000	$	-	10%	5%
SubTotal					**$**	**620,000**		
Combined Material and Labor Subtotal					**$**	**14,210,000**		
Miscellaneous Contractor Costs								
General Conditions and Project Staff (9%)	1	LS	$	1,278,900	$	1,278,900		
Overhead (5%)	1	LS	$	710,500	$	710,500		
Bond and Insurance (1.35%)	1	LS	$	191,835	$	191,835		
General Contractor Fees (5%)	1	LS	$	710,500	$	710,500		
Material Sales Tax	-	LS	$	-	$	-		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$	1,421,000	$	1,421,000		
SubTotal					**$**	**4,313,000**		
Total Construction Contingency					**$**	**1,422,000**		
Total Design Contingency					**$**	**1,530,000**		
Total Construction Cost					**$**	**21,475,000**		

WRD- Regional Brackish Water Reclaimation- Project 43
Option 4- 5.67 MW Gas Turbine **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Gas Turbine	1	EA	$ 5,300,000	$ 5,300,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 700,000	$ 650,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 550,000	$ 550,000	10%	5%
SubTotal				**$ 6,500,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 400,000	$ 400,000	10%	5%
CEMS Cabinet	1	LS	$ 200,000	$ 200,000	10%	5%
SCR/Ammonia System	1	LS	$ 100,000	$ 100,000	10%	5%
Electrical Distribution for Wellhead locations	1	LS	$ 3,275,000	$ 3,275,000	10%	5%
SubTotal				**$ 3,975,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 150,000	$ 150,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 225,000	$ 225,000	10%	5%
Structural Steel	1	LS	$ 50,000	$ 50,000	10%	5%
Mechanical Piping	1	LS	$ 80,000	$ 80,000	10%	5%
Mechanical Installation/Labor	1	LS	$ 200,000	$ 200,000	10%	5%
Electrical Installation/Labor	1	LS	$ 200,000	$ 200,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 60,000	$ 60,000	10%	5%
Lighting Protection	1	LS	$ 80,000	$ 80,000	10%	5%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	5%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 1,345,000**		
Combined Material and Labor Subtotal				**$ 11,820,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 1,063,800	$ 1,063,800		
Overhead (5%)	1	LS	$ 591,000	$ 591,000		
Bond and Insurance (1.35%)	1	LS	$ 159,570	$ 159,570		
General Contractor Fees (5%)	1	LS	$ 591,000	$ 591,000		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 1,182,000	$ 1,182,000		
SubTotal				**$ 3,587,000**		
Total Construction Contingency				**$ 1,183,000**		
Total Design Contingency				**$ 591,000**		
Total Construction Cost				**$ 17,181,000**		

WRD- Regional Brackish Water Reclaimation- Project 43
Option 5- Fuel Cell Server- 5.25 MW — 706641CH
PROJECT COST ESTIMATE — 5/2/2019

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Fuel Cell- 5.25 MW	1	EA	$ 25,300,000	$ 25,300,000	10%	5%
Federal Incentive Tax Credit	1	EA	$ (7,875,000)	$ (7,875,000)	10%	5%
SubTotal				**$ 17,425,000**		
Balance of Plant Equipment Costs						
Electrical Distribution for Wellhead locations	1	LS	$ 3,275,000	$ 3,275,000	0%	30%
SubTotal				**$ 3,275,000**		
Site Construction						
Grounding	1	LS	$ 150,000	$ 150,000	10%	5%
Foundations	1	LS	$ 200,000	$ 200,000	10%	5%
Structural Steel	1	LS	$ 100,000	$ 100,000	10%	5%
Electrical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 100,000	$ 100,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	40	LS	$ 3,000	$ 120,000	10%	5%
Process Control Valves	6		$ 15,000	$ 90,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
SubTotal				**$ 950,000**		
Combined Material and Labor Subtotal				**$ 21,650,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	-	LS	$ 1,948,500	$ -		
Overhead (5%)	-	LS	$ 1,082,500	$ -		
Bond and Insurance (1.35%)	1	LS	$ 292,275	$ 292,275		
General Contractor Fees (5%)	-	LS	$ 1,082,500	$ -		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	-	LS	$ 2,165,000	$ -		
SubTotal				**$ 292,000**		
Total Construction Contingency				**$ 1,838,000**		
Total Design Contingency				**$ 1,902,000**		
Total Construction Cost				$ 25,682,000		

WRD- Regional Brackish Water Reclaimation- Project 44
Option 1- 5917 MW Reciprocating Engine **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Generator	1	EA	$ 4,250,000	$ 4,250,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 750,000	$ 750,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 550,000	$ 550,000	10%	5%
SubTotal				**$ 5,550,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	30%
CEMS Cabinet	1	LS	$ 150,000	$ 150,000	10%	30%
Electrical Distribution for Wellheads and portable water treatment skid	1	LS	$ 3,802,000	$ 3,802,000	0%	0%
SubTotal				**$ 4,027,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	30%
Grounding	1	LS	$ 50,000	$ 50,000	10%	30%
Foundations	1	LS	$ 200,000	$ 200,000	10%	30%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	30%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	30%
Mechanical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	30%
Electrical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	30%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	30%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	30%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	30%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	30%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	30%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	30%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	30%
SubTotal				**$ 1,030,000**		
Combined Material and Labor Subtotal				**$ 10,607,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 954,630	$ 954,630		
Overhead (5%)	1	LS	$ 530,350	$ 530,350		
Bond and Insurance (1.35%)	1	LS	$ 143,195	$ 143,195		
General Contractor Fees (5%)	1	LS	$ 530,350	$ 530,350		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 1,060,700	$ 1,060,700		
SubTotal				**$ 3,219,000**		
Total Construction Contingency				**$ 681,000**		
Total Design Contingency				**$ 655,000**		
Total Construction Cost				**$ 15,162,000**		

WRD- Regional Brackish Water Reclaimation- Project 44
Option 2- 5.7 MW Reciprocating Engine 706641CH
PROJECT COST ESTIMATE 5/2/2019

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Natural Gas Generator	1	EA	$ 3,800,000	$ 3,800,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 750,000	$ 750,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 500,000	$ 500,000	10%	5%
SubTotal				**$ 5,050,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 75,000	$ 75,000	10%	30%
CEMS Cabinet	1	LS	$ 150,000	$ 150,000	10%	30%
Electrical Distribution for Wellheads and portable water treatment skid	1	LS	$ 3,802,000	$ 3,802,000	0%	0%
SubTotal				**$ 4,027,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	30%
Grounding	1	LS	$ 50,000	$ 50,000	10%	30%
Foundations	1	LS	$ 200,000	$ 200,000	10%	30%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	30%
Mechanical Piping	1	LS	$ 40,000	$ 40,000	10%	30%
Mechanical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	30%
Electrical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	30%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	30%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	30%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	30%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	30%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	30%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	30%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	30%
SubTotal				**$ 1,030,000**		
Combined Material and Labor Subtotal				**$ 10,107,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 909,630	$ 909,630		
Overhead (5%)	1	LS	$ 505,350	$ 505,350		
Bond and Insurance (1.35%)	1	LS	$ 136,445	$ 136,445		
General Contractor Fees (5%)	1	LS	$ 505,350	$ 505,350		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 1,010,700	$ 1,010,700		
SubTotal				**$ 3,067,000**		
Total Construction Contingency				**$ 631,000**		
Total Design Contingency				**$ 630,000**		
Total Construction Cost				**$ 14,435,000**		

WRD- Regional Brackish Water Reclaimation Project 44
Option 3- Fuel Cell Plant (3.7 MW) **706641CH**
PROJECT COST ESTIMATE **5/2/2019**

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Fuel Cell Plant	1	EA	$ 14,000,000	$ 14,000,000	10%	5%
Federal Incentive Tax Credit	1	EA	$ (4,200,000)	$ (4,200,000)	10%	5%
Packaged Electrical Control Module	1	EA	$ 515,000	$ 515,000	10%	5%
SubTotal				**$ 10,315,000**		
Balance of Plant Equipment Costs						
Electrical Distribution for Wellheads and portable water tr	1	LS	$ 3,802,000	$ 3,802,000	10%	30%
SubTotal				**$ 3,802,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 75,000	$ 75,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 120,000	$ 120,000	10%	5%
Structural Steel	1	LS	$ 25,000	$ 25,000	10%	5%
Electrical Installation/Labor	1	LS	$ 40,000	$ 40,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 50,000	$ 50,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	5%
Process Control Valves	3		$ 15,000	$ 45,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Developmen	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 620,000**		
Combined Material and Labor Subtotal				**$ 14,737,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 1,326,330	$ 1,326,330		
Overhead (5%)	1	LS	$ 736,850	$ 736,850		
Bond and Insurance (1.35%)	1	LS	$ 198,950	$ 198,950		
General Contractor Fees (5%)	1	LS	$ 736,850	$ 736,850		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 1,473,700	$ 1,473,700		
SubTotal				**$ 4,473,000**		
Total Construction Contingency				**$ 1,474,000**		
Total Design Contingency				**$ 1,688,000**		
Total Construction Cost				**$ 22,372,000**		

WRD- Regional Brackish Water Reclamation- Project 44
Option 4- 6.29 MW Gas Turbine
PROJECT COST ESTIMATE

706641CH
5/2/2019

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Gas Turbine	1	EA	$ 5,750,000	$ 5,750,000	10%	5%
SCR/Oxidation Catalyst Emissions Control System	1	LS	$ 700,000	$ 650,000	10%	5%
Packaged Electrical Control Module	1	EA	$ 550,000	$ 550,000	10%	5%
SubTotal				**$ 6,950,000**		
Balance of Plant Equipment Costs						
Fuel Gas Compressor and Conditioning Skid	1	LS	$ 400,000	$ 400,000	10%	5%
CEMS Cabinet	1	LS	$ 200,000	$ 200,000	10%	5%
SCR/Ammonia System	1	LS	$ 100,000	$ 100,000	10%	5%
Electrical Distribution for Wellheads and portable water treatment skid	1	LS	$ 3,802,000	$ 3,802,000	10%	5%
SubTotal				**$ 4,502,000**		
Site Construction						
Rigging and Cranes	1	LS	$ 150,000	$ 150,000	10%	5%
Grounding	1	LS	$ 50,000	$ 50,000	10%	5%
Foundations	1	LS	$ 225,000	$ 225,000	10%	5%
Structural Steel	1	LS	$ 50,000	$ 50,000	10%	5%
Mechanical Piping	1	LS	$ 80,000	$ 80,000	10%	5%
Mechanical Installation/Labor	1	LS	$ 200,000	$ 200,000	10%	5%
Electrical Installation/Labor	1	LS	$ 200,000	$ 200,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 60,000	$ 60,000	10%	5%
Lighting Protection	1	LS	$ 80,000	$ 80,000	10%	5%
Process Instruments	25	LS	$ 3,000	$ 75,000	10%	5%
Process Control Valves	5	LS	$ 15,000	$ 75,000	10%	5%
Process Control Cable and Instrument Air	1	LS	$ 100,000	$ 100,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
Control Software Engineering and Screen Development	-	LS	$ 220,000	$ -	10%	5%
SubTotal				**$ 1,345,000**		
Combined Material and Labor Subtotal				**$ 12,797,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	1	LS	$ 1,151,730	$ 1,151,730		
Overhead (5%)	1	LS	$ 639,850	$ 639,850		
Bond and Insurance (1.35%)	1	LS	$ 172,760	$ 172,760		
General Contractor Fees (5%)	1	LS	$ 639,850	$ 639,850		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	1	LS	$ 1,279,700	$ 1,279,700		
SubTotal				**$ 3,884,000**		
Total Construction Contingency				**$ 1,280,000**		
Total Design Contingency				**$ 640,000**		
Total Construction Cost				**$ 18,601,000**		

WRD- Regional Brackish Water Reclaimation- Project 44
Option 5- Fuel Cell Servers- (5.7MW) 706641CH
PROJECT COST ESTIMATE 5/2/2019

DESCRIPTION	QTY	UM	CONSTRUCTION UNIT $$	CONSTRUCTION TOTAL	Construction Contingency	Design Contingency
Major Equipment						
Fuel Cells (2.7 MW)	1	EA	$ 27,550,000	$ 27,550,000	10%	5%
Federal Investment Tax Credit	1	EA	$ (8,550,000)	$ (8,550,000)	10%	5%
SubTotal				**$ 19,000,000**		
Balance of Plant Equipment Costs						
Electrical Distribution for Wellheads and portable water tr	1	LS	$ 3,802,000	$ 3,802,000	10%	30%
SubTotal				**$ 3,802,000**		
Site Construction						
Grounding	1	LS	$ 150,000	$ 150,000	10%	5%
Foundations	1	LS	$ 200,000	$ 200,000	10%	5%
Structural Steel	1	LS	$ 100,000	$ 100,000	10%	5%
Electrical Installation/Labor	1	LS	$ 150,000	$ 150,000	10%	5%
Cable, Conduit and Tray	1	LS	$ 100,000	$ 100,000	10%	5%
Lighting Protection	1	LS	$ 40,000	$ 40,000	10%	5%
Process Instruments	40	LS	$ 3,000	$ 120,000	10%	5%
Process Control Valves	6		$ 15,000	$ 90,000	10%	5%
Process Control Hardware	-	LS	$ 115,000	$ -	10%	5%
SubTotal				**$ 950,000**		
Combined Material and Labor Subtotal				**$ 23,752,000**		
Miscellaneous Contractor Costs						
General Conditions and Project Staff (9%)	-	LS	$ 2,137,680	$ -		
Overhead (5%)	-	LS	$ 1,187,600	$ -		
Bond and Insurance (1.35%)	1	LS	$ 320,652	$ 320,652		
General Contractor Fees (5%)	-	LS	$ 1,187,600	$ -		
Material Sales Tax	-	LS	$ -	$ -		
1 Yr Price Escalation (Construction in 2020) - 10%	-	LS	$ 2,375,200	$ -		
SubTotal				**$ 321,000**		
Total Construction Contingency				**$ 2,375,000**		
Total Design Contingency				**$ 2,139,000**		
Total Construction Cost				$ 28,587,000		

Appendix D
Site Civil Plan

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Memorandum

Subject	**Site Civil Plan**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Attention	Water Replenishment District
Date	June 18, 2019

A high-level Site Civil Plan was developed for the centralized treatment facility at the Elm and Faysmith site. This Site Civil Plan includes a Grading Plan and Utility Plan. Both plans were developed using the 12,500-acre-foot-per-year layout.

1. Grading Plan

A preliminary grading plan was developed to estimate excavation quantities and lay out the site facilities. The existing site is relatively flat with a low elevation of 101 feet above mean sea level (amsl) as found on Google Earth software on the northern boundary, and 109 feet amsl on the southern boundary. The area for the proposed development is in the northern portion of the site and has an average elevation of 105 feet amsl. The proposed finished surface elevation for the building was chosen to be 105 feet amsl to minimize excavation and to provide a flat pad for building construction. This elevation minimizes cut and fill, which, in turn, minimizes import and export of soil material. From the building boundary, the site will be graded at 2 percent for 20 feet to direct storm runoff away from the building and allow vehicle access around the building. From the edge of driveway, the site will be graded 2:1(horizontal:vertical) to the existing grade for slope stability.

The existing topography of the site was estimated using the Google Earth Pro elevation profile feature, which gives an approximate elevation of a point on a desired path. A grid with square spacings of 25 feet was laid over the site, and elevation points were gathered at grid intersections on May 6, 2019. Using AutoCAD Civil 3D 2018 grading tools and the elevation points, the study team created a proposed surface. Civil 3D was also used to calculate the following earthwork quantities:

- Cut = 1,475 cubic yards
- Fill = 15 cubic yards
- Net cut = 1,460 cubic yards

Additionally, an onsite underground storage tank is proposed, and earthwork quantities for the tank are the following:

- Area = 6,300 square feet
- Depth = 16 feet
- Excavation volume = 3,733 cubic yards

The contours and elevations for this grading plan are to be used for planning purposes only. A topographic survey with survey grade equipment is required to accurately capture the earthwork quantities. In addition, a Geotechnical Report will be required to evaluate the soil conditions for development.

Storm drain runoff is anticipated to sheet-flow off the site to a perimeter ditch. Storm drain piping is not anticipated. If storm drain pipe is required, polyvinyl chloride (PVC) pipe will be used. There are no storm drain catch basins within the immediate vicinity of the site. A bioswale is proposed on the northern side of the site that will treat storm runoff from the facility prior to discharge to Elm Avenue. A diagram of the preliminary grading plan is attached.

2. Utility Plan

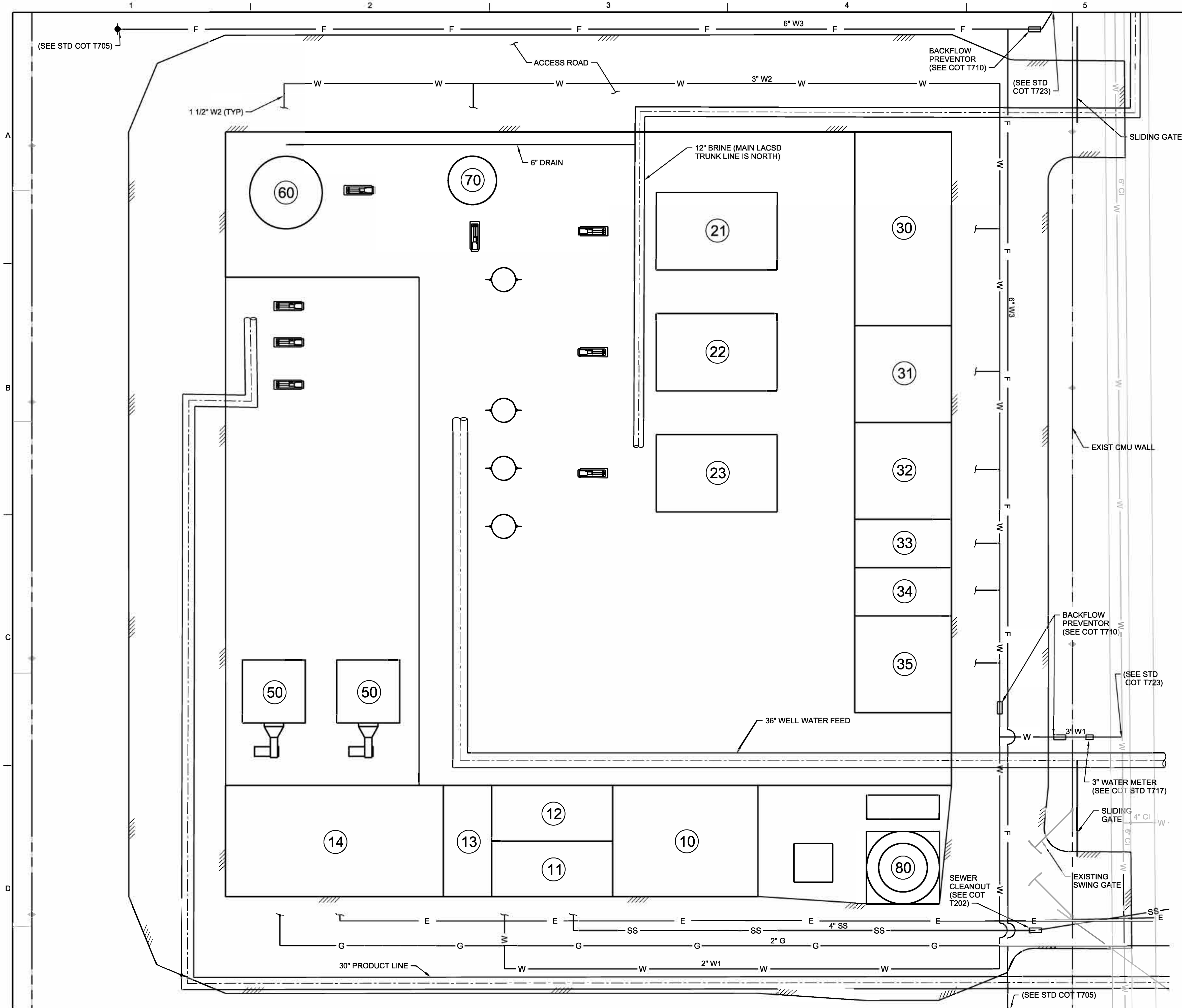
Potable water, sewer, and fire water lines will tie into main lines coming from the eastern portion of the site. Yard piping will have a minimum cover of 36 inches, unless otherwise noted in the site plans. Piping will be at least 10 feet from new structures, except for building connections. Water and sewer plans were provided by the City of Torrance Planning Office.

Yard piping requirements for potable water and fire water are as follows:

- Potable water: Point of connection will be off the new water main just south of Plant Operations Building.
  - W1 main pipe material will be polyvinyl chloride (PVC) in conformance with American Water Works Association (AWWA) C900.
  - W1 service line pipe materials will be PVC piping with solvent cement joints in conformance with ASTM International (ASTM) D1785 or ASTM D2241.
  - System will include a backflow preventer (T 710) and a “Neptune” meter (T719-2) provided by the City of Torrance.
  - W2 lines are for the eyewash and hose bibs and will branch off the plant water line. Pipe laterals will supply water to eyewashes in each chemical storage area.
- Fire water: The fire water line will connect to the main line at the north gate and provide two hydrants and a connection for building sprinklers.
  - Pipe material will be PVC in conformance with AWWA C900.
  - System will include backflow preventer.

Natural gas piping material will be high-density polyethylene in conformance with ASTM D3350 and ASTM 2513. The gas main line plans were provided by Southern California Gas Company. A diagram of the utility plan is attached.

Attachments



FACILITY LEGEND

- (XX) FACILITY LEGEND
- (10) CONTROL ROOM
- (11) RESTROOM /SHOWER
- (12) LABORATORY
- (13) TELECOM /SERVER
- (14) ELECTRICAL ROOM
- (21) REVERSE OSMOSIS 1
- (22) REVERSE OSMOSIS 2
- (23) REVERSE OSMOSIS 3
- (24) REVERSE OSMOSIS 4
- (30) NaOH STORAGE AND FEED
- (31) NaOCl STORAGE AND FEED
- (32) NH4OH STORAGE AND FEED
- (33) FSA STORAGE AND FEED
- (34) TI STORAGE AND FEED
- (35) HCl STORAGE AND FEED
- (40) CLEARWELL (1 HR)
- (50) A.S. UNITS
- (60) NEUTRALIZATION
- (70) CIP
- (80) CARBON DIOXIDE

- FIRE HYDRANT
- W — W1 POTABLE WATER OR W2 PLANT WATER (SEE PLANS FOR LABEL)
- F — W3 FIRE WATER
- W — EXIST WATER LINE
- SS — SANITARY SEWER LINE
- SS — EXIST SANITARY SEWER LINE
- G — GAS LINE
- E — ELECTRICAL LINE

N

0 10 20 40
1"=10'

NOT FOR CONSTRUCTION

NO.	DATE	REVISION	BY	APVD

DSGN A MONTGOMERY
DR A GORDEN
CHK G NGUYEN
APVD A HEISE

JACOBS
2600 Michelson Drive, Suite 500
Irvine, California 92612
Phone: (949) 224-7500

Brackish Water Reclamation Program Feasibility Study
Torrance, CA
Water Replenishment District of Southern California
Lakewood, CA

CIVIL

SITE UTILITY PLAN

AS SHOWN
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	MAY 2019
PROJ	706641
DWG	FIGURE 1
SHEET	X of X

PRELIMINARY

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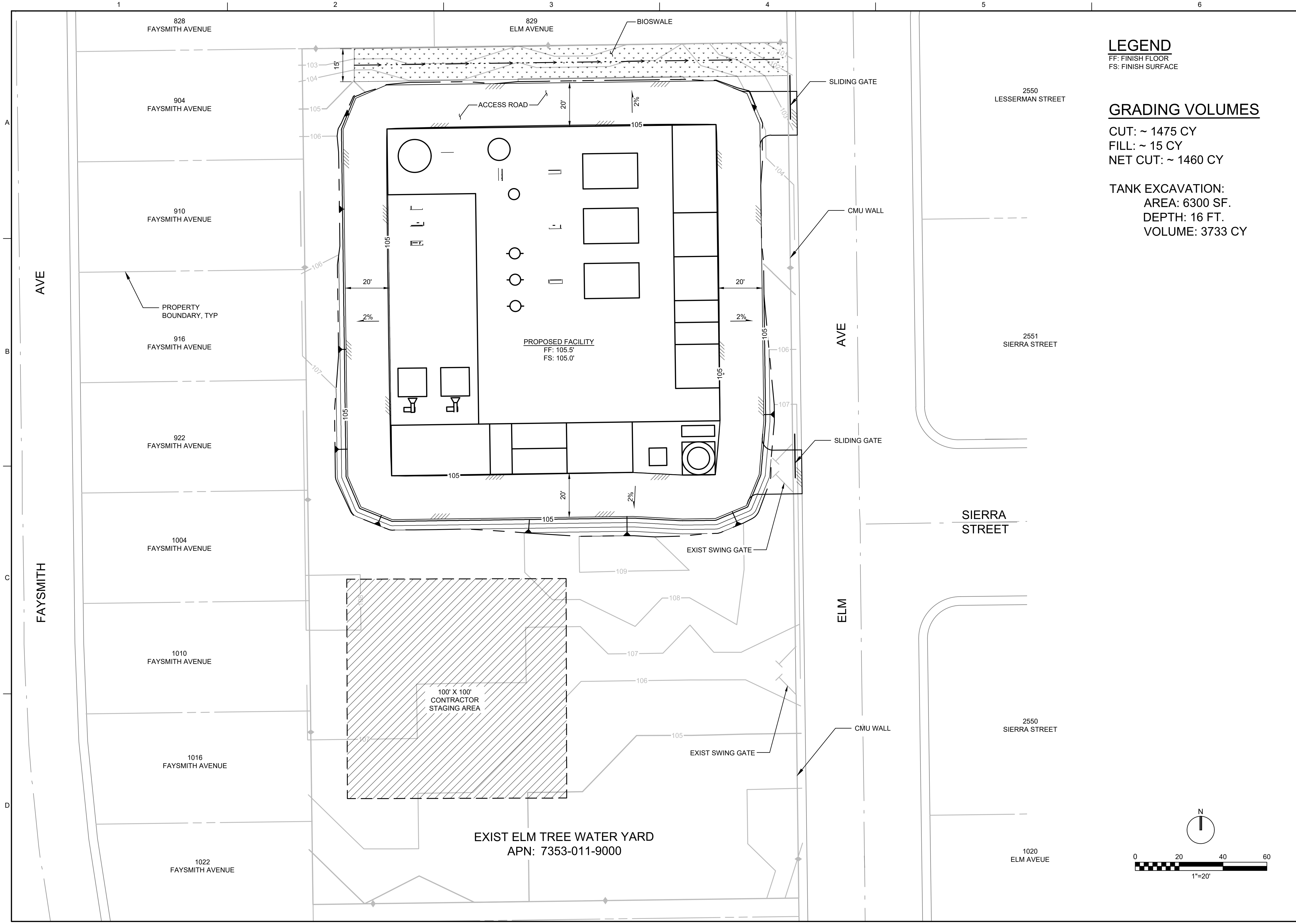

NOT FOR CONSTRUCTION

NO.	DATE	REVISION	BY	APVD

DSGN A MONTGOMERY | DR A GORDEN | CHK G NGUYEN | APVD A HEISE

JACOBS
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Phone: (949) 224-7500

Brackish Water Reclamation Program Feasibility Study
Torrance, CA
Water Replenishment District of Southern California
Lakewood, CA

CIVIL
PRELIMINARY GRADING PLAN

AS SHOWN
VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"

DATE	MAY 2019
PROJ	706641
DWG	FIGURE 2
SHEET	X of X

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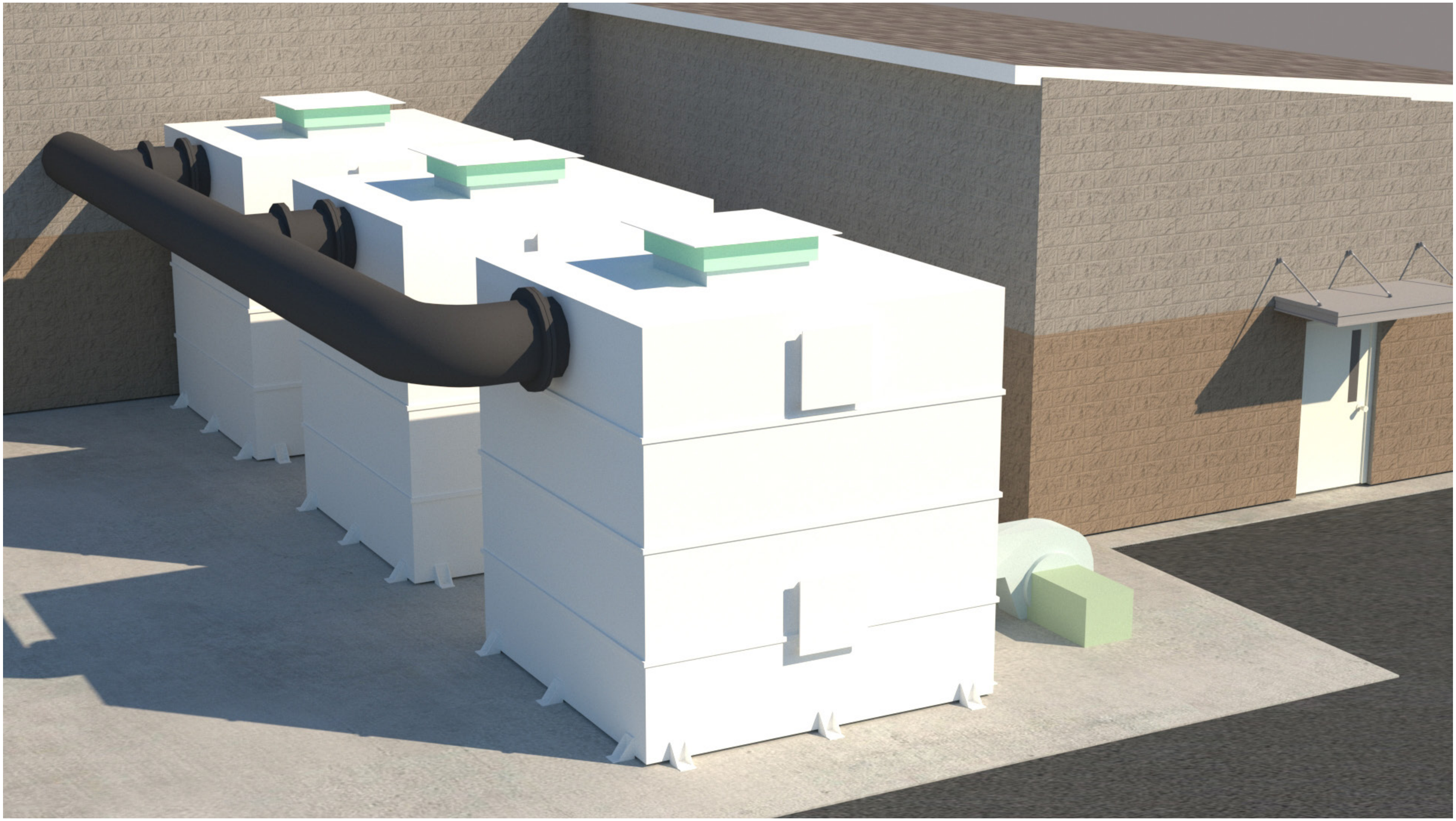
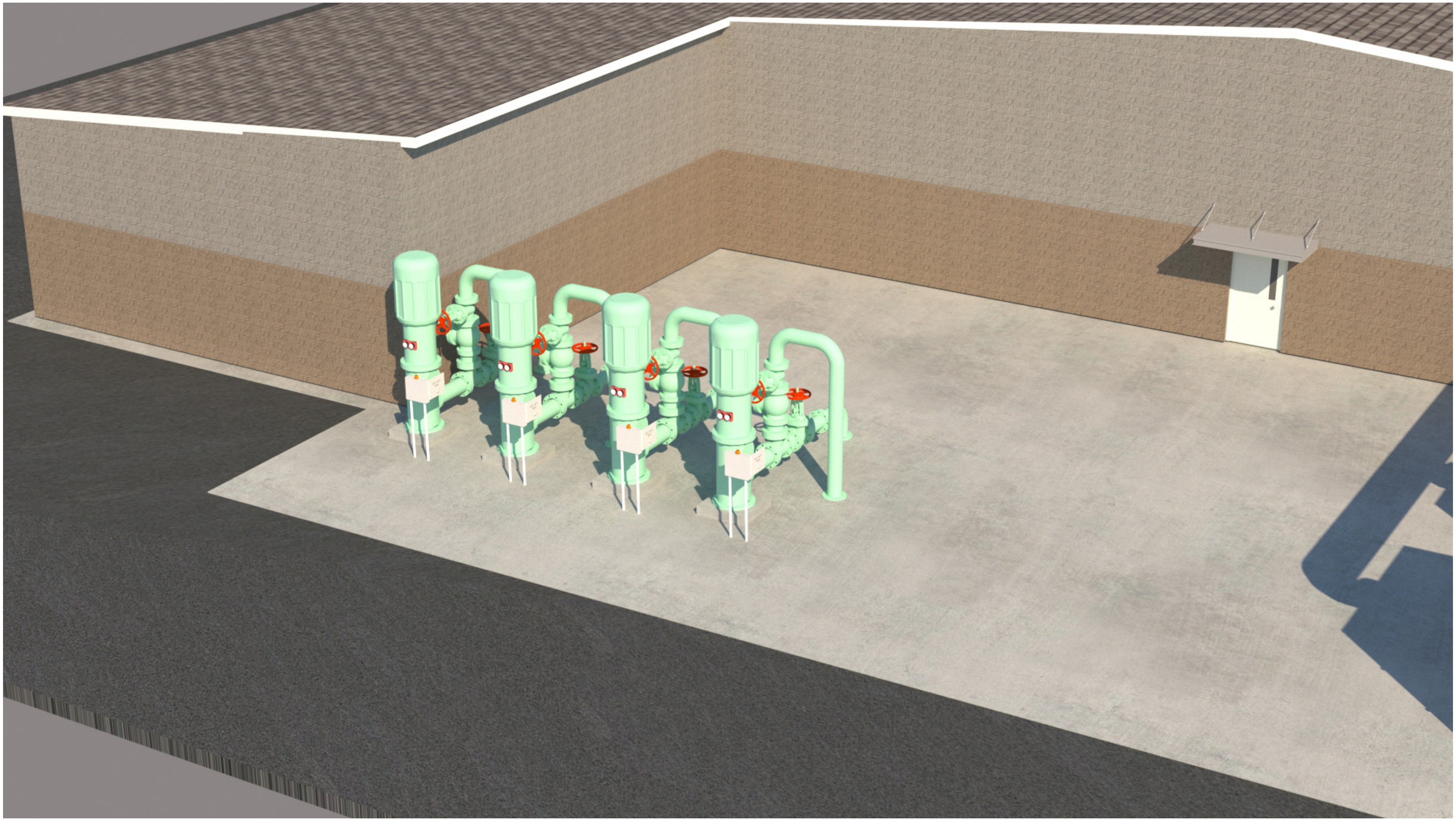
Appendix E
Facility Renderings

20,000 AFY Centralized Treatment Facility

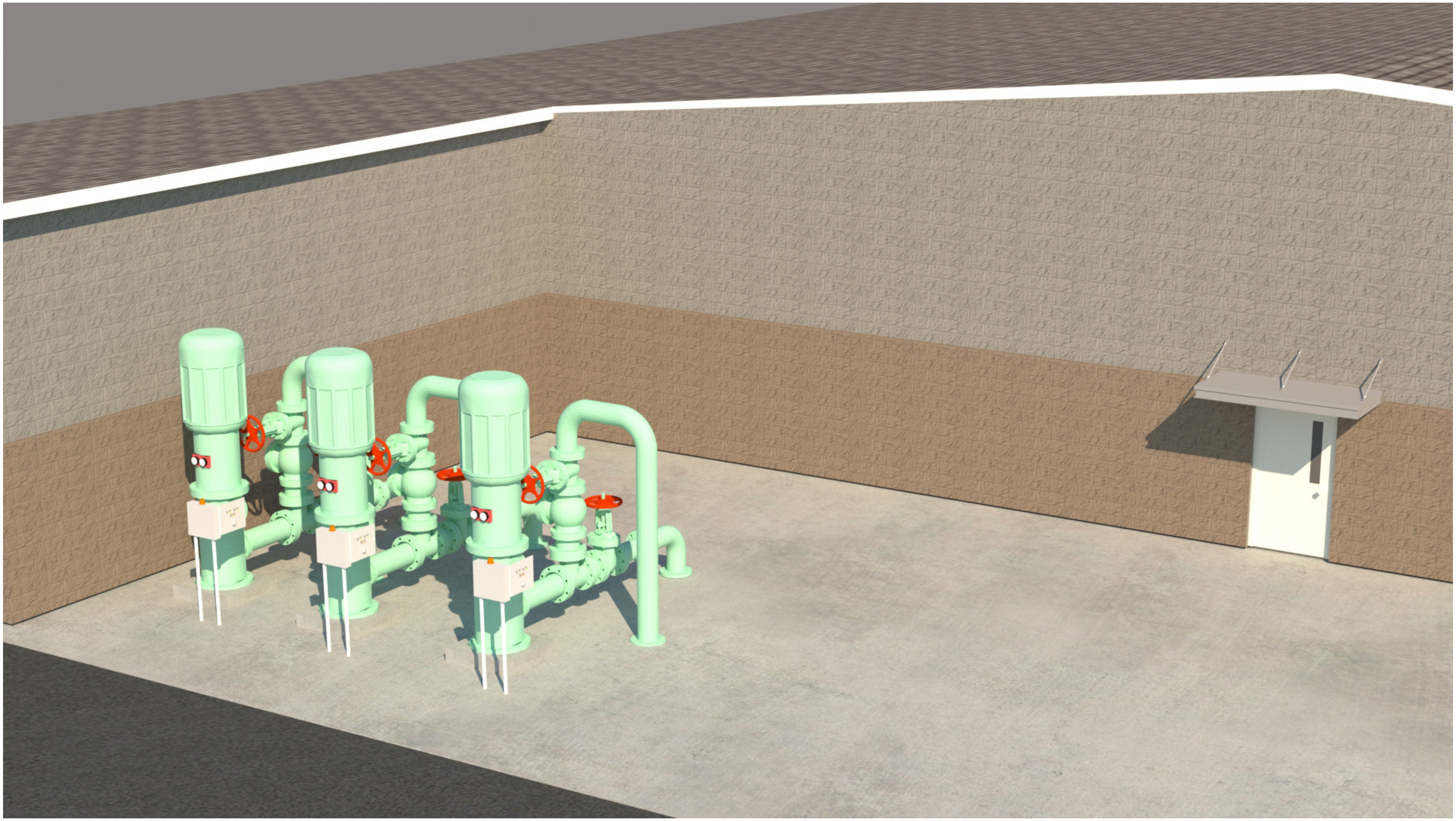

150’
160’

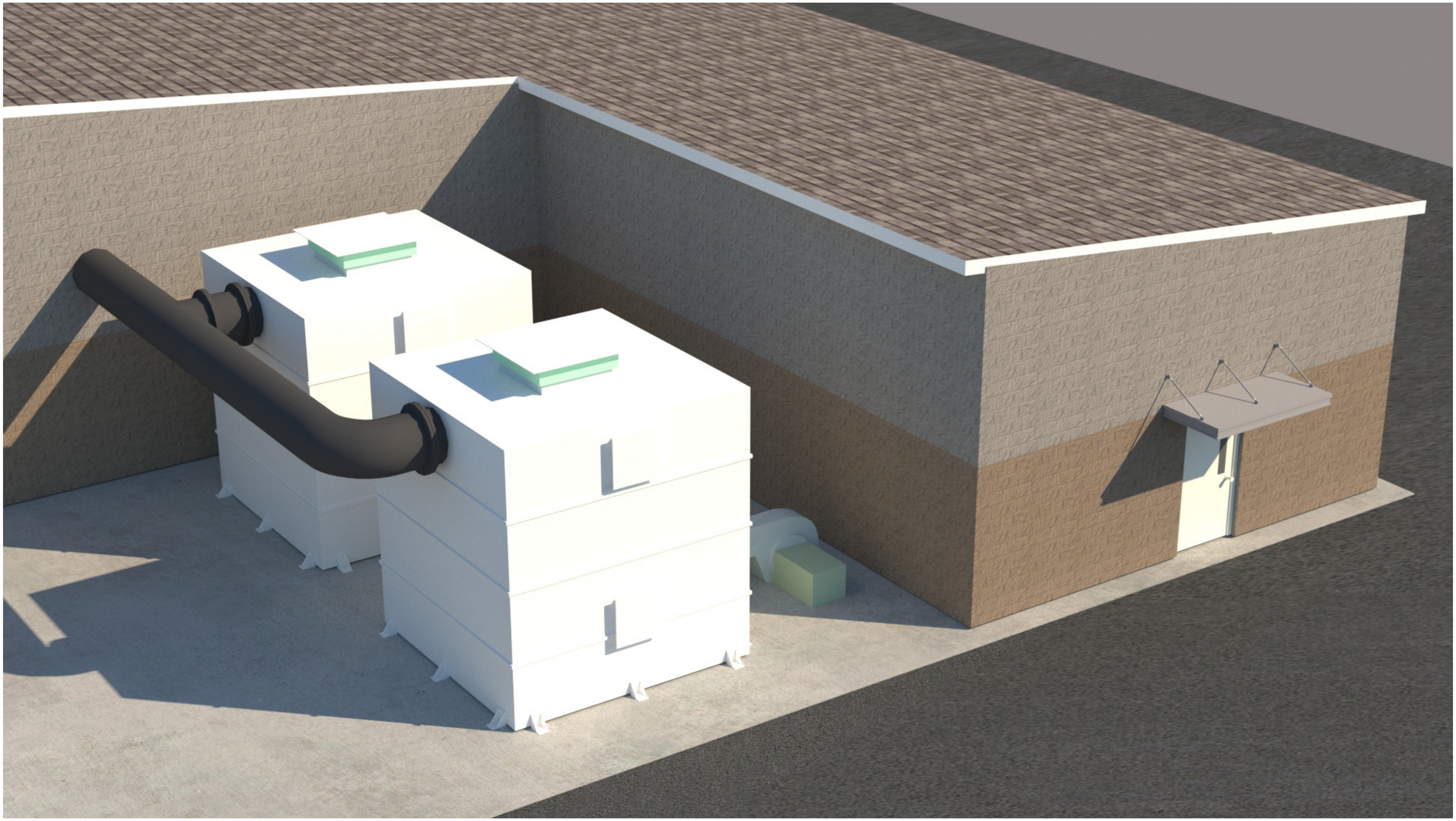




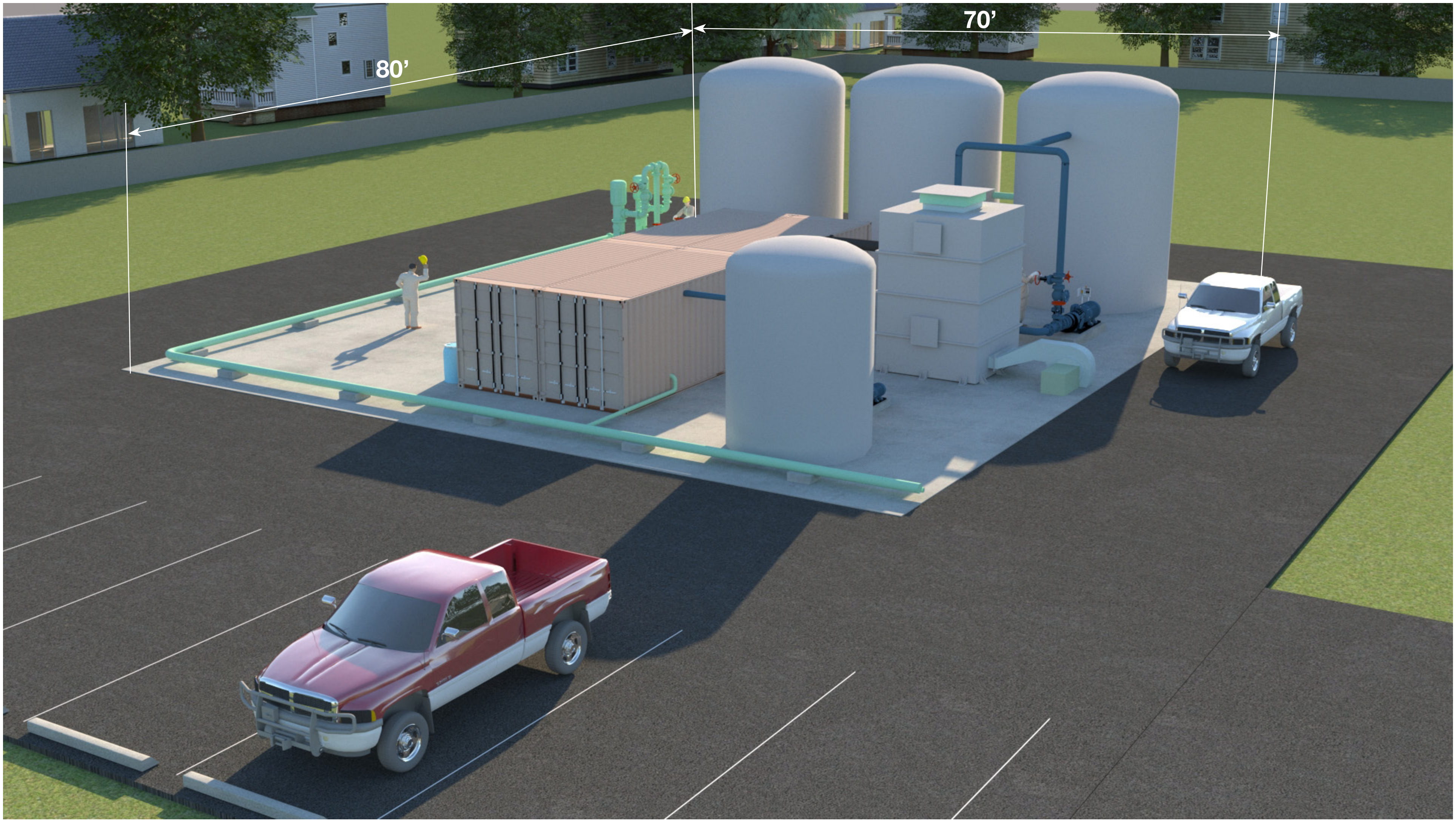
12,500 AFY Centralized Treatment Facility

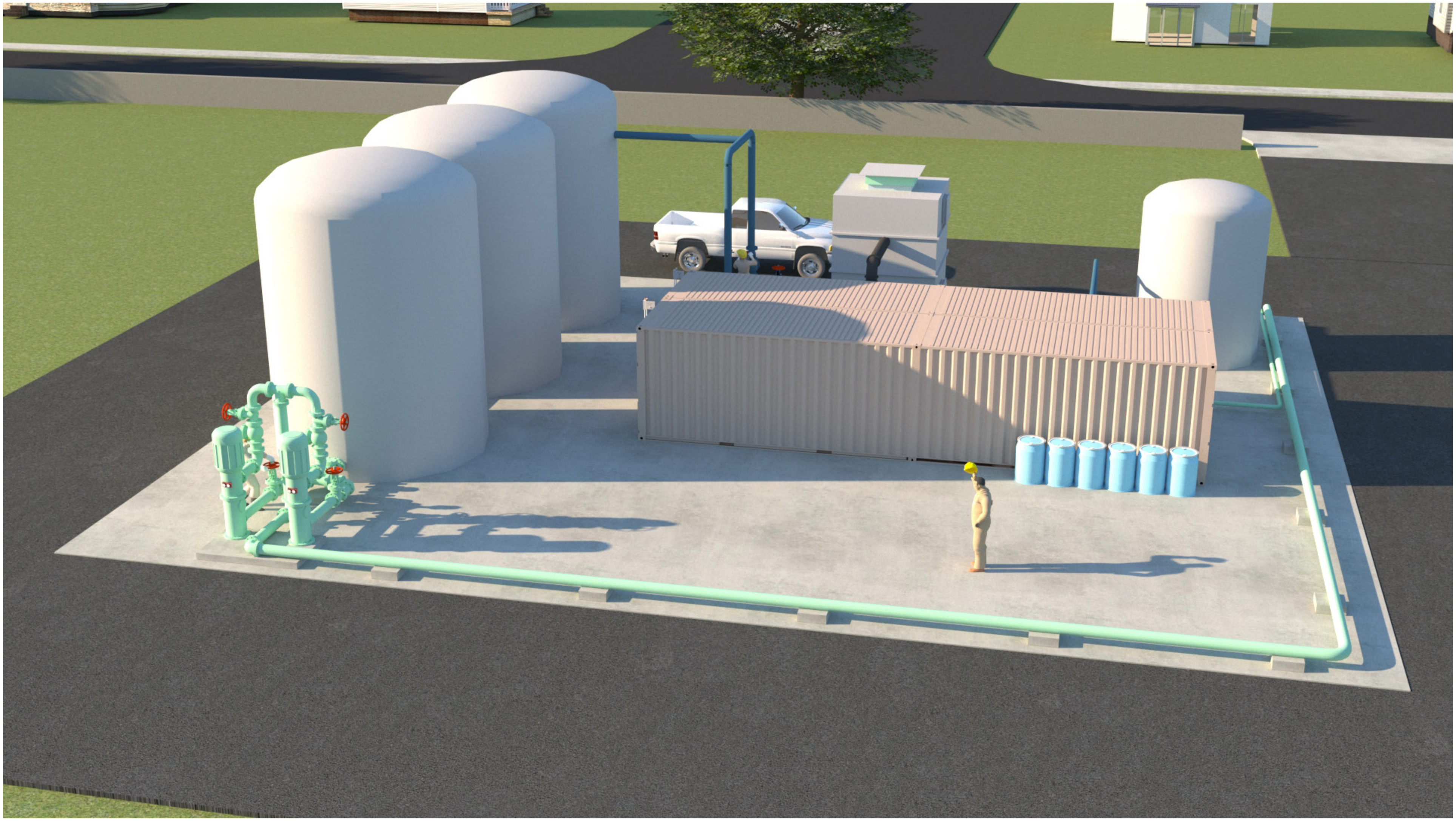

150’
160’

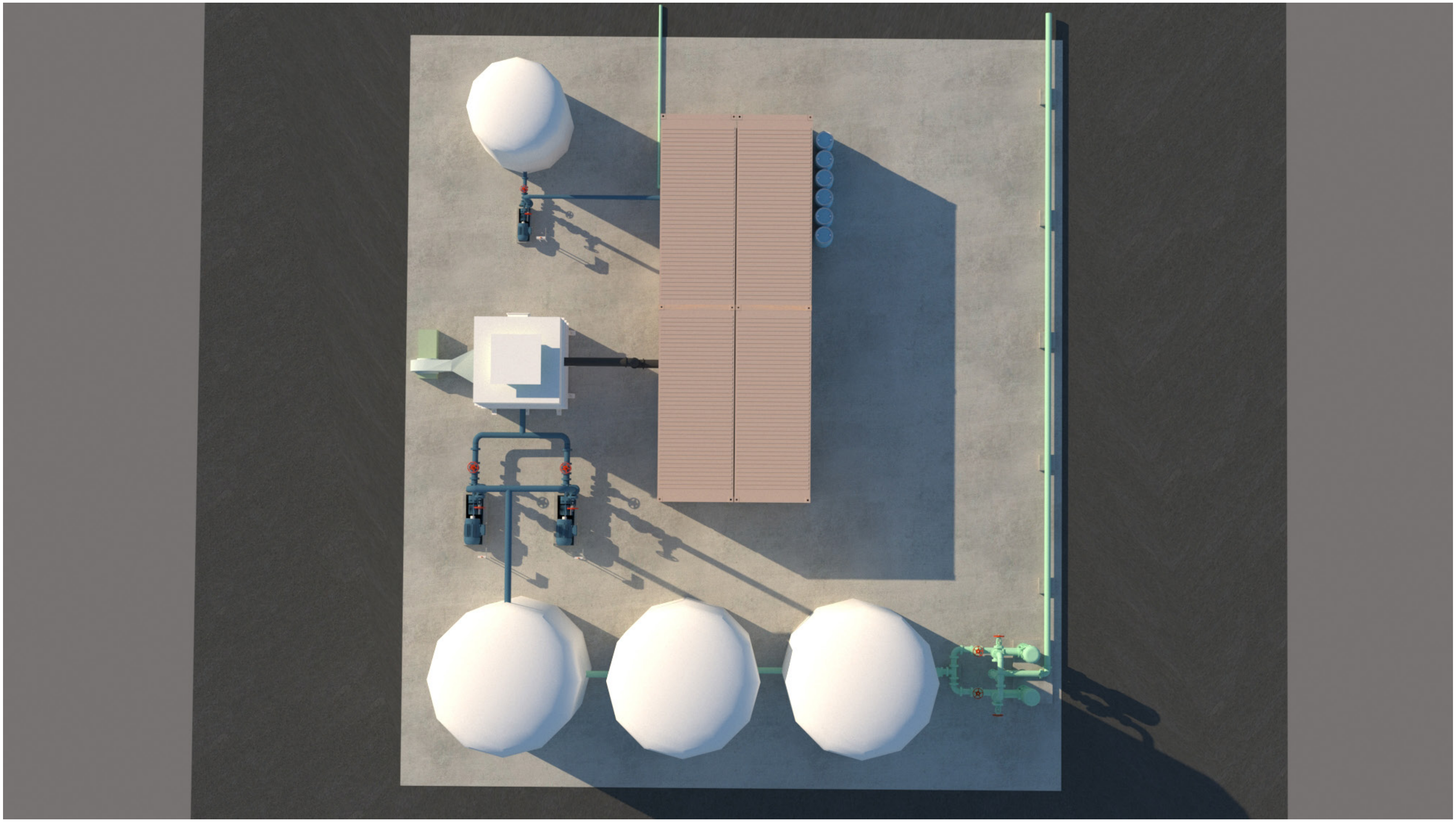




Portable Wellhead Treatment Unit


80’
70’





Appendix F
Environmental Review Plan

JACOBS

Technical Memorandum

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Subject	**Environmental Review Plan**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 29, 2019

1. Introduction

The Water Replenishment District of Southern California (WRD) is responsible for managing and replenishing both the West Coast and Central groundwater basins. In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, Lynwood, and Lower San Pedro (equivalent to Sunnyside) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To fully use the West Coast Basin, WRD has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. Program goals include treatment of the saline plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process.

The Program includes evaluation of six possible project alternatives, which consist of varying components related to:

- Plume water extraction
- Treatment
- Conveyance of treated potable water to the Program stakeholders
- Brine stream management

As a part of the Program, a high-level environmental screening of the Project alternatives has been completed. This screening was based on the January 2019 amended California Environmental Quality Act (CEQA) Initial Study (IS) Checklist, and includes a desktop review that differentiates potential environmental impacts by Project alternative, and identifies resource areas where additional technical studies will be needed to support a Project-specific CEQA evaluation.

2. Background

This section provides a brief background of the geographic area, existing facilities, and stakeholders associated with the Program.

2.1 Location

The affected aquifers, and subsequent saline plume of groundwater, are located in southwestern Los Angeles County, California. The saline plume largely underlies Torrance. Proposed facilities, including wells, pipelines, and treatment plants, would be located in multiple jurisdictions within southwestern Los Angeles County.

The central treatment facility, referred to as the permanent desalter facility, along with 7 to 10 new extraction wells (wells) and associated underground conveyance pipelines to the permanent desalter facility would be located in Torrance. A new dedicated underground brine disposal conveyance pipeline would be constructed between the permanent desalter facility and the Los Angeles County Sanitation

District's (LACSD's) Joint Water Pollution Control Plant (JWPCP) located in Carson. A new underground potable water conveyance pipeline would be constructed between Torrance and Manhattan Beach. Refer to Figure 2-1 for Program component locations.

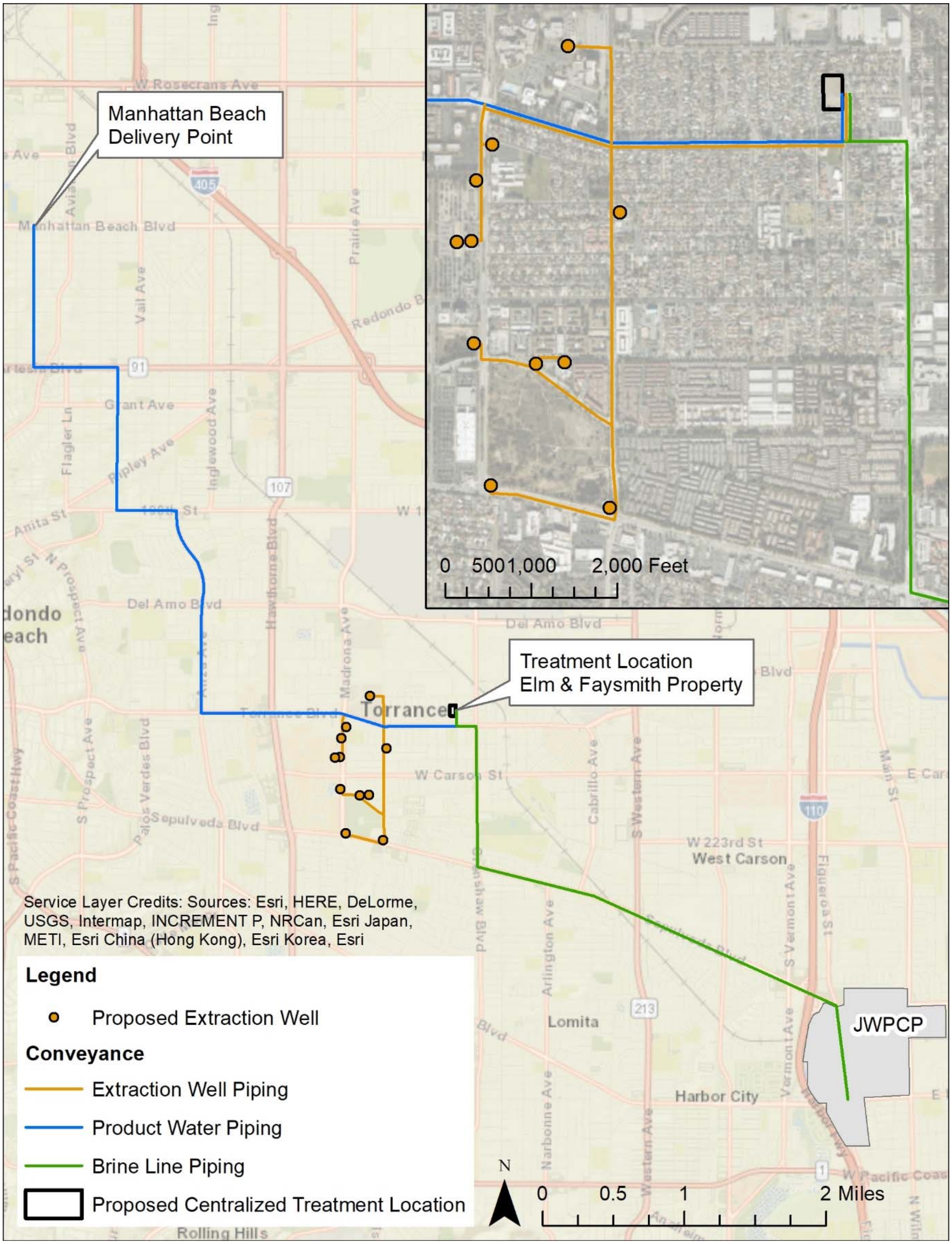

Figure 2-1. Program Components

2.2 Stakeholders

As a part of the Program, WRD has initiated a regional planning effort to evaluate the feasibility of remediating the saline plume with seven additional stakeholders who pump and sell potable water in the basin. The stakeholders have expressed interest in either treating the saline plume, receiving the treated water, or both, as part of this Program. The stakeholders include the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWB)

2.3 Existing Available Facilities

2.3.1 Existing Desalter Facilities

Two existing desalter facilities are within the area: the Robert W. Goldsworthy and C. Marvin Brewer Desalters, located in Torrance. The Brewer Desalter, operated by WBMWD, began operations in July 1993 and is currently undergoing a well assessment and well rehabilitation project to improve and increase water production (WBMWD, 2019). The Goldsworthy Desalter, operated by the City of Torrance, has been operating since 2002 and is currently completing an expansion project (WRD, 2019).

2.3.2 Existing Pipelines

The Madrona Lateral is an existing, partially unused recycled water pipeline owned by WBMWD. The Madrona Lateral runs through Torrance. An existing sewer and potable water network exists throughout Los Angeles County. The Program would connect with existing pipeline networks, as feasible, and has direct potable water system interconnects to all stakeholders, with the exception of the City of Manhattan Beach.

2.3.3 Existing Wells

A network of groundwater wells are located within southwestern Los Angeles County, some of which are currently unused. The Program may use some existing wells and connect to new brackish water pipelines, as feasible.

3. Program Components

3.1 New Permanent Desalter Facility

The Program would include the installation of a desalter facility (permanent desalter facility) located on a 2-acre property owned by the City of Torrance at 1001 Elm Avenue, within Torrance. The Program would use approximately 1 acre of the property, which is located between Elm Avenue and Faysmith Avenue (at the intersection of Elm Avenue and Sierra Street). Residential properties are located adjacent to the property to the north, west, and south. Elm Avenue borders the property to the east. Refer to Figure 3-1 for the location of the proposed desalter facility. Other vacant properties may be considered as an alternative to this location. A few potential, alternative sites are provided in the *Project Entitlements and Acquisition Plan,* included in this Feasibility Study.

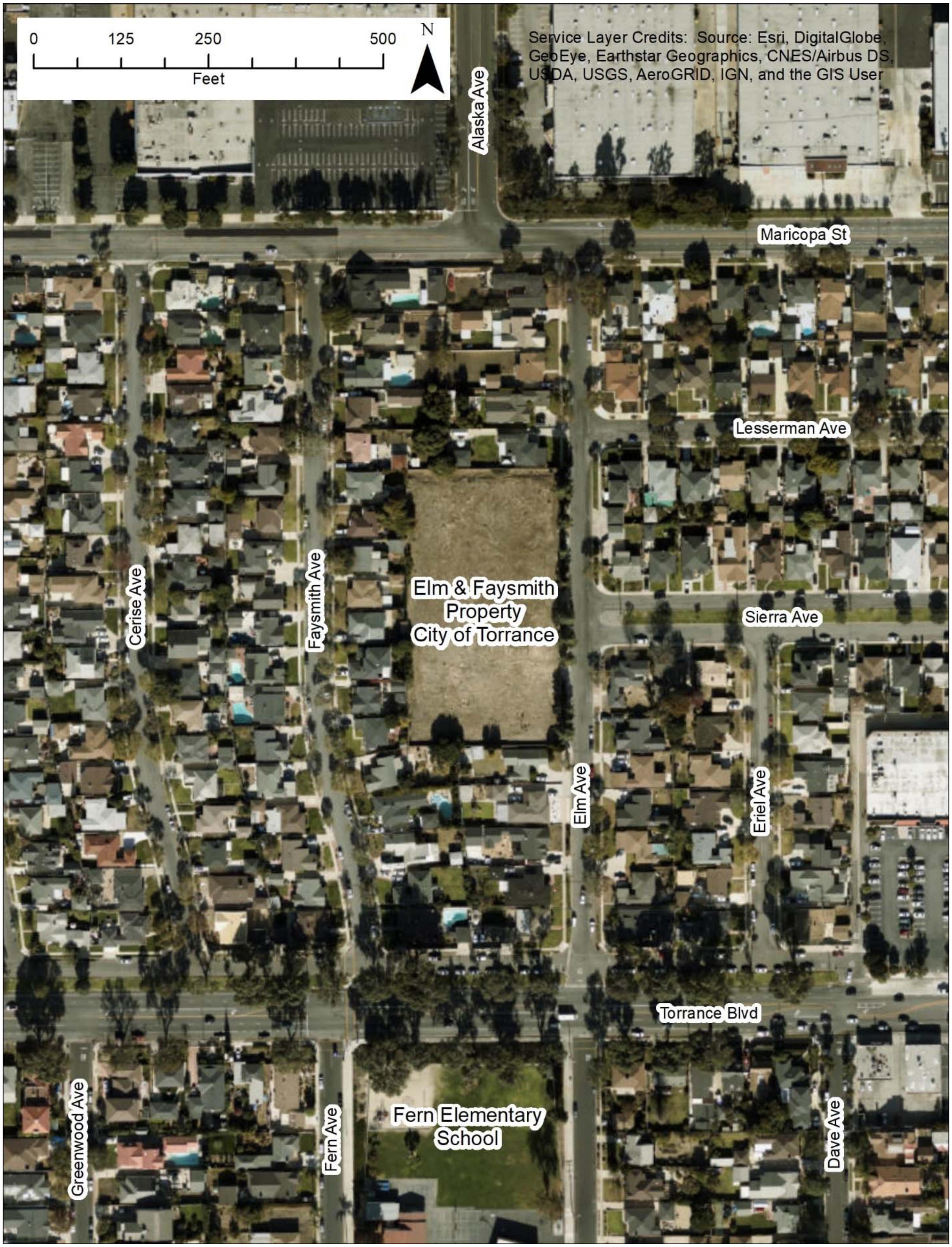

Figure 3-1. Proposed Desalter Facility Location

The property is disturbed and was previously used by the City of Torrance for Public Works support. It is presently vacant with ruderal vegetation. Currently, an approximately 6-foot-high block wall runs along the perimeter of the property, and two fenced driveways extend onto Elm Avenue for ingress and egress.

The permanent desalter facility has a designated land use of Public Use (PU). According to the City of Torrance, the parcel has been identified as one that has inconsistent zoning, and a zone change in the near future will classify the parcel to PU to be consistent with the Land Use Designation in the General Plan. The PU zone allows for water district facilities as permissible by right; however, development entitlements may be required.

The permanent desalter facility would be the centralized brackish water treatment facility of the Program. Brackish groundwater would be pumped from the extraction wells to the permanent desalter facility and treated by a combination of chemical and physical processes to reduce saline concentrations. Brine waste would be disposed from the permanent desalter facility without requiring waste storage (Section 3.2). The facility would be manned and maintained by Program personnel and contracted services, such as landscaping contractors.

The permanent desalter facility includes the following components:

- Control room
- Laboratory
- Telecommunications and server room
- Electrical room
- Reverse osmosis equipment
- Chemical storage
- 600,000-gallon subsurface water storage tank
- Air stripping units
- Neutralization equipment
- Clean-in-place equipment
- Ancillary facilities (such as restrooms and shower)

Construction of the permanent desalter facility would involve the use of public roads, including Torrance Boulevard and Elm Avenue, for vehicle, materials, equipment, and personnel access. Site preparation activities would include onsite vegetation clearing. Major construction activities would include soil excavation for the 600,000-gallon subsurface water storage tank and pipeline connections, as well as surface modifications and concrete foundation pouring to accommodate structures and equipment. Above-grade construction would involve pipeline connections, engineered structural framing, and the installation of equipment.

Typical equipment used during the permanent desalter facility construction would include:

- Pickup trucks
- Forklifts
- Water trucks
- Backhoes
- Jack hammers
- Compactors
- Front-end loaders
- Dozers
- Generators
- Air compressors
- Manlifts
- Cranes
- Delivery trucks
- Dump trucks
- Concrete trucks
- Pile-driving equipment, which be necessary during construction

3.2 New Pipelines

The Project would require a series of new underground pipeline networks for conveying brackish water to the permanent desalter facility, conveying treated water to Program stakeholders, and conveying brine waste. These pipelines would be constructed subsurface along existing roadways in Torrance, Manhattan Beach, and Carson, with the exception of trenchless construction at railroad and highway crossings.

A network of new brackish water pipelines would be required in Torrance to convey extracted brackish water from new wells to the permanent desalter facility. These new pipelines would be between 12 and 36 inches in diameter and would be constructed underground along existing paved roadways. Final routes of the brackish water pipelines have not been determined. The conceptual level locations of the brackish water pipelines are shown on Figure 2-1.

A new underground potable water conveyance pipeline would be required from the permanent desalter facility to the potable water supply system in Manhattan Beach. The new potable water conveyance pipeline would be located below existing paved roadways. The permanent desalter facility, via the City of Torrance water system, has direct potable water system interconnects to all stakeholders, with the exception of the City of Manhattan Beach and Golden State Water (a potential, but currently non-existent, intertie location has been identified for GSW). Precise routes of the treated water underground pipelines or conduit sizes have not been determined. The conceptual level location of the new underground potable water conveyance pipeline is shown on Figure 2-1.

A new dedicated 12-inch-diameter brine disposal conveyance pipeline would be required from the permanent desalter facility to the effluent outfall systems of the LACSD JWPCP located in Carson. This new pipeline would be located underground along existing paved roadways, as feasible. Trenchless crossings at railroad and highway features may be required. The proposed route of the new dedicated brine pipeline is described in Table 3-1.

Table 3-1. Dedicated Brine Pipeline Route

Street	Pipe Length [a] (feet)	Pipe Route
Elm Avenue	585	South along Elm Avenue (60-foot ROW) from the permanent desalter facility at the Elm Avenue and Faysmith Avenue property to the Torrance Boulevard intersection
Torrance Boulevard	4,800	East along Torrance Boulevard (110-foot ROW) from Elm Avenue intersection to Cabrillo Avenue
Cabrillo Avenue	6,450	South along Cabrillo Avenue (84-foot ROW) from Torrance Boulevard intersection to Sepulveda Boulevard intersection
Sepulveda Boulevard	9,160	East along Sepulveda Boulevard (104-foot ROW) from Cabrillo Avenue intersection to east of I-110 crossing
I-110 Crossing	1,400 (tunnel is 200 to 700 feet depending on crossing location)	North from Sepulveda Boulevard through new easement (parking lot on the western side of I-110), east across I-110, southeast through new easement (parking lot on the eastern side of I-110), and then to Figueroa Street
Figueroa Street	750	South along Figueroa Street (100-foot ROW) from easement to Sepulveda Boulevard, then proceeding across Sepulveda Boulevard to the JWPCP

[a] Approximate pipe length based on desktop analysis

Notes:

I-110 = Interstate 110

ROW = right-of-way

Another option for brine disposal would be to connect the permanent desalter facility to an existing nearby sanitary sewer line. This relatively short-length connection would be made via a new underground pipeline. The size of the conduit, which would discharge brine to the sanitary sewer line, and the location of the sanitary sewer connection have not been determined.

Construction of the new underground pipelines would require open trenching along existing roadways, except for trenchless crossings at railroad and highway features where high-density polyethylene piping could be used. Trenching would be braced using a trench box or speed shoring. The active work area would extend approximately 5 to 10 feet to one side of the trench and 20 to 30 feet to the other side, allowing for access by trucks and loaders. The minimum construction ROW is typically 25 feet. Staging areas would be necessary along the construction routes. Removed pavement, soil, and materials would be hauled offsite and disposed in accordance with applicable state and local regulations. Imported backfill and paving materials would be delivered to the construction site or to stockpiles at staging areas. Encroachment permits and traffic control would be required for construction within streets and other public jurisdictional areas.

Typical equipment used during underground pipeline construction would include:

- Pavement saws
- Jack hammers
- Air compressors
- Excavators
- Front-end loaders
- Dump trucks
- Pickup trucks
- Concrete trucks
- Backhoes
- Forklifts
- Delivery trucks
- Asphalt trucks
- Compactors
- Paving machines
- Rollers

3.3 New Wells

The Project would consist of 7 to 10 new wells at locations throughout Torrance. These wells would extract brackish water from the trapped underground saline. The new wells would connect with new brackish water underground pipelines to convey brackish water to the permanent desalter facility. Although the quantity and precise location of each potential well has not been determined, general locations have been identified and are described in Table 3-2. The number of wells is dependent on the Project alternative selected.

Table 3-2. General Well Locations, Land Use Designation, and Zoning Requirements

General Well Location	Land Use Designation	Zoning Requirements
El Dorado Street and Fern Avenue (Greenwood Park), Torrance	Public/Quasi-Public/ Open Space	PU – Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
5006 Lee Street (Paradise Park), Torrance	Public/Quasi-Public/ Open Space	PU – Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
22526 Ocean Avenue, Torrance	Public/Quasi-Public/ Open Space	PU – Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
21800 Talisman Street (sump), Torrance	Public/Quasi-Public/ Open Space	PU - Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
3300 Sepulveda Boulevard (Madrona Marsh District), Torrance	Public/Quasi-Public/ Open Space	Planned Development (PU) – Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.

Table 3-2. General Well Locations, Land Use Designation, and Zoning Requirements

General Well Location	Land Use Designation	Zoning Requirements
Sepulveda Boulevard and Maple Avenue (Madrona Marsh District), Torrance	Public/Quasi-Public/ Open Space	Planned Development (PU) – Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
3201 Plaza Del Amo, Torrance	Public/Quasi-Public/ Open Space	Planned Development (PU) – Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
Madrona Avenue and Opal Street (Madrona Middle School), Torrance	Public/Quasi-Public/ Open Space	PU – Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
El Dorado Street and Maple Avenue (sump), Torrance	Public/Quasi-Public/ Open Space	PU - Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
Madrona Avenue and Fashion Way (Madrona Middle School), Torrance	Public/Quasi-Public/ Open Space	PU – Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
Del Amo Center (adjacent to parking lot) – 2 wells, Torrance	Commercial Center	Hawthorne Boulevard Corridor Specific Plan Area (HBCSP DA-1) – Per HBCSP Table IV-1 *Permitted Land Use Matrix*, water wells (public utilities excluding offices) are conditionally permitted in this district.
Monterey Street	Public/Quasi-Public/ Open Space	Planned Development (PU) – Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
Police Station (Civic Center District), Torrance	Public/Quasi-Public/ Open Space	PU - Per Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in this district.
21735 Madrona Avenue (sump), Torrance	Commercial Center	HBCSP DA-2 – Per HBCSP Table IV-1 *Permitted Land Use Matrix*, water wells (public utilities excluding offices) are conditionally permitted in this district.

A portable wellhead treatment unit is proposed as a component of multiple alternatives. The portable wellhead treatment unit, likely a containerized unit, would be temporarily placed at a well location for brackish water treatment for a number of years (assumed to be less than 5 years); after which, the chloride concentration of that particular well's extraction material would decrease to less than 500 milligrams per liter (mg/L). At this point, the portable wellhead treatment unit would be relocated to a new area where a new well would be constructed, and the process would be repeated.

Construction of the extraction wells would require limited site preparation due to the scale of construction. Initial construction activities would involve the drilling of a pilot hole by a drill rig for approximately 2 weeks (24 hours per day). Bentonite and water would be used for the pilot borehole. A recirculating system with an enclosed tank would be used to contain the bentonite slurry. Upon drilling completion, additional well components would be installed, including well casing, monitoring tubes, gravel packing, and seals. After the well structure is constructed, a diesel test pump would be installed for well development. Well construction would be completed by installing all of the final well and wellhead facilities and connecting to new underground pipelines.

Typical equipment used during extraction well construction would include:

- Excavators
- Front-end loaders
- Dump trucks
- Pickup trucks
- Backhoes

- Forklifts
- Delivery trucks
- Drill rigs
- Vacuum trucks
- Cranes

4. Alternatives

This environmental screening evaluates six possible alternatives, and each resource area will analyze the feasibility for the six alternatives. Each alternative consists of combinations of options for each of the following Project components:

- Brackish water extraction
- Brackish water treatment
- Conveyance of:
  - Brackish water to treatment
  - Treated water to purveyors
- Brine disposal
- Groundwater replenishment volume

4.1 Project 18

Project 18 would extract 12,500 acre-feet per year (AFY) of brackish water that would be pumped and treated at the desalter at Elm Avenue and Faysmith Avenue. Project 18 assumes that all stakeholders receive water in roughly equal amounts. Seven new wells would be required for Project 18; however, the precise locations of these new wells have not been determined.

To convey brackish water from the wells to the permanent desalter facility, conveyance pipe between 12 and 36 inches in diameter would be required. Project 18 takes advantage of interties and the Madrona Lateral to reduce the amount of new piping needed. New treated water underground pipelines would deliver treated water to Program stakeholders. An additional pipe would be needed to deliver water to Manhattan Beach.

If a brine discharge connection from the permanent desalter facility to a nearby sanitary sewer line is not constructed, approximately 4.5 miles of a new dedicated 12-inch-diameter brine pipeline would be required from the permanent desalter facility to the effluent outfall systems of the LACSD JWPCP located in Carson.

4.2 Project 19

Project 19 would extract 12,500 AFY of brackish water that would be pumped and treated at the permanent desalter facility. Project 19 assumes that all stakeholders receive water in roughly equal amounts. This alternative includes 10 new wells, along with a portable wellhead treatment unit used for targeted treatment of areas outside of the main plume, particularly for the upper Gage aquifer.
The location of these 10 new wells has not been determined.

To convey brackish water from the wells to the permanent desalter facility, conveyance pipe between 12 and 36 inches in diameter would be required. Project 19 takes advantage of interties and the Madrona Lateral to reduce the amount of new piping needed. New treated water underground pipelines would deliver treated water to Program stakeholders. An additional pipe would be needed to deliver water to Manhattan Beach.

If a brine discharge connection from the permanent desalter facility to a nearby sanitary sewer line is not constructed, approximately 4.5 miles of a new dedicated 12-inch-diameter brine pipeline would be required from the permanent desalter facility to the effluent outfall systems of the LACSD JWPCP located in Carson.

4.3 Project 14A

Project 14A would extract 20,000 AFY of brackish water that would be pumped and treated at the permanent desalter facility. The City of Torrance, LADWP, Cal Water, and the City of Lomita would receive treated water (GSWC and the City of Manhattan Beach would not receive any treated water). Ten new wells would be required for Project 14A, along with a portable wellhead treatment unit used for targeted treatment of areas outside of the main plume, particularly for the upper Gage aquifer. The location of these 10 new wells has not been determined.

To convey brackish water from the wells to the permanent desalter facility, conveyance pipe between 12 and 36 inches in diameter would be required. Project 14A takes advantage of interties and the Madrona Lateral to reduce the amount of new piping needed. New treated water underground pipelines would deliver treated water to Program stakeholders.

If a brine discharge connection from the permanent desalter facility to a nearby sanitary sewer line is not constructed, approximately 4.5 miles of a new dedicated 12-inch-diameter brine pipeline would be required from the permanent desalter facility to the effluent outfall systems of the LACSD JWPCP located in Carson.

4.4 Project 14B

Project 14B would extract 20,000 AFY of brackish water that would be pumped and treated at the permanent desalter facility. The City of Torrance, LADWP, Cal Water, and the City of Lomita would receive treated water (GSWC and the City of Manhattan Beach would not receive any treated water). Ten new wells would be required for Project 14B. The location of these 10 new wells has not been determined.

To convey brackish water from the wells to the permanent desalter facility, conveyance pipe between 12 and 36 inches in diameter would be required. Project 14B takes advantage of interties and the Madrona Lateral to reduce the amount of new piping needed. New treated water underground pipelines would deliver treated water to Program stakeholders.

If a brine discharge connection from the permanent desalter facility to a nearby sanitary sewer line is not constructed, approximately 4.5 miles of a new dedicated 12-inch-diameter brine pipeline would be required from the permanent desalter facility to the effluent outfall systems of the LACSD JWPCP located in Carson.

4.5 New Project A

New Project A would extract 16,000 AFY of brackish water that would be pumped and treated at the permanent desalter facility. The City of Torrance, LADWP, Cal Water, and the City of Lomita would receive treated water (GSWC and the City of Manhattan Beach would not receive any treated water). Ten new wells would be required for New Project A, along with a portable wellhead treatment unit used for targeted treatment of areas outside of the main plume, particularly for the upper Gage aquifer. The location of these 10 new wells has not been determined.

To convey brackish water from the wells to the permanent desalter facility, conveyance pipe between 12 and 36 inches in diameter would be required. New Project A takes advantage of interties and the Madrona Lateral to reduce the amount of new piping needed. New treated water underground pipelines would deliver treated water to Program stakeholders.

If a brine discharge connection from the permanent desalter facility to a nearby sanitary sewer line is not constructed, approximately 4.5 miles of a new dedicated 12-inch-diameter brine pipeline would be required from the permanent desalter facility to the effluent outfall systems of the LACSD JWPCP located in Carson.

4.6 New Project B

New Project B would extract 16,000 AFY of brackish water that would be pumped and treated at the permanent desalter facility. The City of Torrance, LADWP, Cal Water, and the City of Lomita would receive treated water (GSWC and the City of Manhattan Beach would not receive any treated water). Ten new wells would be required for New Project B. The location of these 10 new wells has not been determined.

To convey brackish water from the wells to the permanent desalter facility, conveyance pipe between 12 and 36 inches in diameter would be required. New Project B takes advantage of interties and the Madrona Lateral to reduce the amount of new piping needed. New treated water underground pipelines would deliver treated water to Program stakeholders.

If a brine discharge connection from the permanent desalter facility to a nearby sanitary sewer line is not constructed, approximately 4.5 miles of a new dedicated 12-inch-diameter brine pipeline would be required from the permanent desalter facility to the effluent outfall systems of the LACSD JWPCP located in Carson.

5. Environmental Screening Checklist

This section documents the screening process used to identify and focus on the feasibility of the six alternatives. The Environmental Screening Checklist closely follows the CEQA IS format prepared by the Governor's Office of Planning and Research. Due to the high redundancy of the components making up the six alternatives, the evaluation of each alternative will focus on the differences of each. A Summary of Conclusions and Areas of Greatest Concern are provided in this section, followed by the Environmental Screening Checklist.

5.1 Summary of Conclusions and Areas of Greatest Concern

5.1.1 Summary of Conclusions

Based on the completion of the Environmental Screening Checklist, included herein, the Project may result in direct and indirect adverse impacts related to:

- Aesthetic
- Air quality
- Biological resources
- Cultural resources
- Hazardous materials
- Water quality
- Noise
- Transportation

Following selection of a proposed Project, a complete environmental review would be completed to determine which environmental resource(s) would be impacted and to what level the impact(s) would occur. As part of the Project-specific environmental review, appropriate mitigation measures would be identified to avoid or minimize potentially significant environmental impacts. The level of significance will need to be determined during Project-specific CEQA review.

5.1.2 Areas of Greatest Concern

Of the resources identified where the Project may result in direct and indirect adverse impacts, the areas of greatest concern include aesthetics, air quality, and noise. Potential impacts related to these resources are of greatest concern because they could directly affect the adjacent residential property owners. To support a thorough evaluation of potential impacts and identification of appropriate mitigation measures as part of Project-specific CEQA review, the following technical studies are recommended:

- Visual Impact Analysis: To evaluate potential aesthetics impacts, a visual impact analysis, including preparation of simulations or renderings of the proposed desalter facility from a range of key observation points, should be completed.
- Air Emissions Calculations: To evaluate potential construction- and operation-related air quality impacts, it is recommended that emissions estimates be calculated using construction equipment and on-road vehicle emissions factors from South Coast Air Quality Management District (SCAQMD). Fugitive dust emissions should be estimated using the emission factor accepted by SCAQMD and in accordance with the California Air Pollution Control Officers Association (CAPCOA) California Emissions Estimator Model® (CalEEMod) tool. SCAQMD emissions standards for proposed aeration treatment should also be considered. In addition, the potential for localized odors from the use of chemicals, along with the overall process of treating brackish water to potable water, should be evaluated.
- Noise Evaluation: A noise evaluation is recommended to determine whether the Project would generate a substantial temporary or permanent increase in ambient noise levels in the vicinity of the Project in excess of standards established in the local noise ordinances.

Several other technical studies are recommended herein to support Project-specific CEQA review, and include:

- Hazards Evaluation: An analysis of the Project's transport, storage, use, and disposal of hazardous materials is recommended to determine the level of potential hazard to the public or environment.
- Water Quality Analysis: A hydrology and water quality analysis is recommended to determine Project impacts to water quality standards and waste discharge requirements, or whether the Project would substantially degrade surface or groundwater quality, including degradation associated with adjacent shallow groundwater contamination.
- Transportation Analysis: A transportation analysis is recommended to determine the impacts to traffic and transportation caused by the Project's construction and long-term operations.
- Biological Resources Evaluation: To evaluate potential Project-related impacts to biological resources, it is recommended that a desktop data review of the California Natural Diversity Database (CNDDB) be completed and a reconnaissance-level field survey be performed to document the resources present.
- Cultural Resources Evaluation: To evaluate potential Project-related impacts to cultural resources, it is recommended that a California Historical Resources Information System (CHRIS) records search be completed for a 0.5-mile buffer zone around the proposed disturbance area. The CHRIS records search will include a review of all recorded archaeological sites, as well as all known cultural resource survey and excavation reports. It is also recommended that the National Register of Historic Places (NRHP) online database and the California Register, California Historical Landmarks, and California Points of Historical Interest be examined.

5.2 Impact Categories in Environmental Screening Checklist

Impacts in the Environmental Screening Checklist are separated into the following categories:

- No Impact
- Less-Than-Significant Impact
- Less-Than-Significant with Mitigation Incorporated
- Potentially Significant Impact

Each of these are described in this section. Checklist boxes are checked for items where all Project alternatives are expected to have No Impact. For items with the potential for impacts, including less-than-significant impacts, the level of significance boxes are not checked, and it is identified that the level of significance will need to be determined during Project-specific CEQA review. Technical studies needed to support Project-specific CEQA review are also identified.

- No Impact. This category applies when a project would not create an impact in the specific environmental issue area. A No Impact finding does not require an explanation when the finding is adequately supported by the cited information sources (for example, exposure to a tsunami is clearly not a risk for projects not near the coast). A finding of No Impact is explained where the finding is based on project-specific factors, as well as general standards (for example, the project would not expose sensitive receptors to pollutants, based on a project-specific screening analysis).
- Less-Than-Significant Impact. This category is identified when the project would result in impacts less than the threshold of significance.
- Less-Than-Significant with Mitigation Incorporated. This category is identified when the project would have a substantial adverse impact on the environment, but that impact could be reduced to a less-than-significant level with incorporation of a mitigation measure(s).
- Potentially Significant Impact. This category is applicable if there is substantial evidence that a significant adverse effect might occur, and no feasible mitigation measures are foreseen to reduce impacts to a less-than-significant level. If there are one or more Potentially Significant Impact entries when the determination is made, an environmental impact report is required.

5.3 Resource Areas

This section presents the completed checklist.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
I. Aesthetics. Except as provided in Public Resources Code (PRC) Section 21099, would the project:				
a) Have a substantial adverse effect on a scenic vista?	☐	☐	☐	☒
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☐	☒
c) In non-urbanized areas, substantially degrade the existing visual character or quality of public views of the site and its surroundings? (Public views are those that are experienced from a publicly accessible vantage point). If the project is in an urbanized area, would the project conflict with applicable zoning and other regulations governing scenic quality?	☐	☐	☐	☐
d) Create a new source of substantial light or glare, which would adversely affect day or nighttime views in the area?	☐	☐	☐	☐

a) All Project alternatives – The City of Torrance General Plan designates Torrance Boulevard, between Highway 213 and Madrona Avenue, as a Scenic View Corridor. The permanent desalter facility would be located approximately 350 feet north of Torrance Boulevard and would not be visible from the Scenic View Corridor. The permanent desalter facility would not impact the Scenic View Corridor along Torrance Boulevard.

All new pipelines, with the exception of those located at the permanent desalter facility and portable wellhead treatment unit, would be located below the surface and would not be visible. No new wells would be located near a scenic resource, including Torrance Boulevard, and wells would not be visible from designated scenic resources.

For these reasons, all alternatives are expected to have No Impact.

b) All Project alternatives – The Project is not located in the vicinity of a designated State Scenic Highway; therefore, no Project alternative would substantially damage a scenic resource, including trees, rock outcroppings, and historic buildings within a state scenic highway (DOT, 2019). For this reason, all alternatives are expected to have No Impact.

c) All Project alternatives – The Project is entirely located within an urbanized area of southwestern Los Angeles County. The permanent desalter facility has a designated land use of Public Use (PU). According to the City of Torrance, the parcel has been identified as one that has inconsistent zoning, and a zone change in the near future will classify the parcel to PU to be consistent with the Land Use Designation in the General Plan. The PU zone allows for water district facilities as permissible by right; however, development entitlements may be required. The PU district zoning does not specify development standards, such as building height or setbacks. However, the structures, equipment, and land use at the permanent desalter facility may require a discretionary review and approval by the City of Torrance. This potential discretionary review process could require visual mitigation, including vegetation installation, site layout alterations and setbacks, and structural limitations to shield adverse visual impacts to surrounding properties. The proposed zone change to PU would need to be included in the Project-specific CEQA evaluation. The level of significance will need to be determined during Project-specific CEQA review.

New water wells within Torrance are conditionally permitted in all zoning districts (with the exception of M-1 and M-2 zones, which permit water wells by right). The discretionary review for Conditional Use Permits could require structural or vegetation installation to shield adverse visual impacts to the public. The level of significance will need to be determined during Project-specific CEQA review.

All new pipelines, outside of the permanent desalter facility and the portable wellhead treatment unit, would be subsurface and would not conflict with zoning or other regulations governing scenic quality. For this reason, all pipeline alternatives are expected to have No Impact.

The City of Torrance uses Architectural Design Guidelines to assist property owners in the restoration, renovation, and preservation of residential structures of special significance to the heritage of Torrance. Because the Project does not affect any structures of special significance, design of Project components would not require compliance with Architectural Design Guidelines.

The Project alternatives could require mitigation to comply with regulations governing scenic quality. It is recommended that a visual impact analysis, including preparation of visual simulations or renderings, be prepared to determine impact levels and appropriate mitigation, if required.

d) All Project alternatives – The permanent desalter facility would include outdoor lighting for security and safety purposes. The Torrance Airport – Zamperini Field is in the vicinity of the Project; however, no components reach a height that would trigger Federal Aviation Administration (FAA) safety lighting or marker balls. The level of outdoor security and safety lighting at the permanent desalter facility would not be roughly consistent with typical outdoor residential lighting employed by neighboring properties; however, the level of significance will need to be determined during Project-specific CEQA review. No lighting would be required for new wells or underground pipelines; therefore, there would be No Impact from these Project features.

Material used at the permanent desalter facility would not cause significant reflectivity in the daylight. Furthermore, the perimeter wall and visual buffers, such as vegetation, would screen any eye-level glare from the nearby properties.

Material used for the new wells would not cause significant reflectivity in the daylight. Furthermore, visual buffers, such as vegetation, would mitigate eye-level glare. All new pipelines, outside of the permanent desalter and the portable wellhead treatment unit, would be subsurface and would not result in glare or night lighting.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
II. Agriculture and Forestry Resources. In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the *California Agricultural Land Evaluation and Site Assessment Model* (1997) prepared by the California Department of Conservation (DOC) as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board (CARB). Would the project:				
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☐	☒
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☐	☒
c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in PRC Section 12220[g]), timberland (as defined by PRC Section 4526), or timberland zoned Timberland Production (as defined by Government Code Section 51104[g])?	☐	☐	☐	☒
d) Result in the loss of forest land or conversion of forest land to non-forest use?	☐	☐	☐	☒

a) All Project alternatives – The Project components would not be located on land designated Important Farmland by the California Department of Conservation (DOC, 2016a). Therefore, the Project would not convert Important Farmland (as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program) to non-agricultural use. For this reason, all Project alternatives are expected to have No Impact.

b) All Project alternatives – The Project components would not be located in districts zoned for agricultural use. Therefore, there would be no conflicts between the Project and land zoned for agricultural use. For this reason, all Project alternatives are expected to have No Impact.

The Project components are not located on land subject to a Williamson Act contract (DOC, 2016b). Therefore, there would be no conflicts between the Project and land subject to a Williamson Act contract. For this reason, all Project alternatives are expected to have No Impact.

c) All Project alternatives – The Project components are not located in districts zoned for agricultural use. The Project would not require the rezoning of forest land (as defined in PRC Section 12220[g]), timberland (as defined by PRC Section 4526), or timberland zoned Timberland Production (as defined by Government Code Section 51104[g]). For this reason, all Project alternatives are expected to have No Impact.

d) All Project alternatives – The Project components would not be located on forest land (as defined in PRC Section 12220[g]). Therefore, there would be no loss of forest land or a conversion of forest land to non-forest use. For this reason, all Project alternatives are expected to have No Impact.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
III. Air Quality. Where available, the significance criteria established by the applicable air quality management district or air pollution control district may be relied upon to make the following determinations. Would the project:				
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☐
b) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard?	☐	☐	☐	☐
c) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☐	☐
d) Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?	☐	☐	☐	☐

a) All Project alternatives – The Project would involve temporary construction emissions from equipment and vehicles, and dust emissions associated with excavation and grading activities. The construction equipment and vehicles would comply with existing air quality regulations in the State of California, including CARB and the South Coast Air Quality Management District (SCAQMD). In addition, standard dust suppression measures (for example, site watering, track-out control) would be employed during construction to minimize potential dust impacts.

Operation of the Project would involve the use of equipment and vehicles, including material delivery vehicles and the storage and use of chemicals, which would be required to comply with existing air quality regulations of CARB and SCAQMD, as well as the City of Torrance Energy Efficiency Climate Action Plan.

To evaluate potential construction- and operation-related air quality impacts, it is recommended that emissions estimates be calculated using construction equipment and on-road vehicle emissions factors from SCAQMD. Fugitive dust emissions should be estimated using the emission factor accepted by SCAQMD and in accordance with the California Air Pollution Control Officers Association (CAPCOA) California Emissions Estimator Model® (CalEEMod) tool. The results of the emissions calculations would identify the Project's compliance with applicable air quality plans, and identify whether conflicts or obstruction would occur, and if so, the level of significance. In addition, the potential for localized odors from the use of chemicals, along with the overall process of treating brackish water to potable water, should be evaluated. Appropriate air quality mitigation measures would be identified and would likely result in a less-than-significant impact with mitigation incorporated determination. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – The Project would result in a net increase of criteria pollutants during construction (temporary) and operations. The recommended emissions calculations would identify whether the Project's emissions would result in a cumulatively considerable net increase of any criteria pollutant for which the Project region is non-attainment under an applicable federal or state ambient air quality standard, and if so, the level of significance. Appropriate air quality mitigation measures would be identified and would likely result in a less-than-significant impact with mitigation incorporated determination. The level of significance will need to be determined during project-specific CEQA review.

c) All Project alternatives – Construction of the Project would expose sensitive receptors, including adjacent residences and schools, to temporary equipment, vehicle, and dust emissions. In particular, construction of the permanent desalter facility would expose surrounding residential units located on Faysmith Avenue, Elm Avenue, Sierra Street, and Lesserman Street to Project-related emissions. In addition, there is potential for localized odor impacts from the use of chemicals to nearby sensitive receptors. Mitigation of potential significant air quality impacts during construction would reduce the impact to less-than-significant.

Operation of the Project would involve the delivery, storage, and use of chemicals at the permanent desalter facility. The infrequent use of hauling trucks to deliver chemicals would not result in the exposure of sensitive receptors to substantial pollutant concentrations.

The operation of new wells and underground pipelines would not expose sensitive receptors to substantial pollutant concentrations.

The recommended emissions calculations would identify the significance level associated with exposure of sensitive receptors to potential pollutant concentrations. The potential for localized odors from the use of chemicals, along with the overall process of treating brackish water to potable water, should be evaluated. Appropriate air quality mitigation measures would be identified and would likely result in a less-than-significant impact with mitigation incorporated determination. The level of significance will need to be determined during Project-specific CEQA review.

d) All Project alternatives – Construction of the Project would result in emissions, including those leading to odors, which could have an adverse effect on a substantial number of people. In particular, construction of the permanent desalter facility could have a significant air quality impact on surrounding residential units located on Faysmith Avenue, Elm Avenue, Sierra Street, and Lesserman Street. Mitigation of potential significant air quality impacts during construction would reduce the impact to less-than-significant.

Operation of the Project would involve the delivery, storage, and use of chemicals at the permanent desalter facility. The infrequent use of hauling trucks to deliver chemicals would result in an insignificant increase in local emissions. However, the use of these chemicals, along with the overall process of treating brackish water to potable water, could result in localized odors. This potential impact will require Project-level evaluation, and appropriate mitigation (such as facility enclosures or air ventilation filters) would be required to minimize potential odor-related impacts affecting the public. The level of significance will need to be determined during Project-specific CEQA review.

The operation of new wells and underground pipelines would not result in odor-related emissions that would adversely affect a substantial number of people.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
IV. Biological Resources. Would the project:				
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service?	☐	☐	☐	☐
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service?	☐	☐	☐	☐
c) Have a substantial adverse effect on state or federally protected wetlands (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☐	☐
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☐	☒
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☐
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☒

a) All Project alternatives – The Project is located on developed or previously disturbed land. However, to evaluate potential Project-related impacts to biological resources, it is recommended that a desktop data review of the California Natural Diversity Database (CNDDB) be completed and a reconnaissance-level field survey be performed to document the resources present. The CNDDB review and field survey would identify whether the Project could have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife (DFW) or U.S. Fish and Wildlife Service (USFWS). Given the urban and developed and disturbed characteristics of the Project site, it is anticipated that potential impacts would be less-than-significant, or less-than-significant with mitigation incorporated. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – The Project is located on developed or previously disturbed land. However, to determine whether the Project would have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations or by the DFW or USFWS, the recommended reconnaissance-level field survey should be performed. Given the urban and developed and disturbed characteristics of the Project site, it is anticipated that potential impacts would be less-than-significant, or less-than-significant with mitigation incorporated.

c) All Project alternatives – The Project is located on developed or previously disturbed land. However, to determine whether the Project would have a substantial adverse effect on state or federally protected wetlands (including, marsh, vernal pool, coastal areas) through direct removal, filling, hydrological interruption, or other means, the recommended reconnaissance-level field survey should be performed. Given the urban and developed and disturbed characteristics of the Project site, it is anticipated that potential impacts would be less-than-significant, or less-than-significant with mitigation incorporated. The level of significance will need to be determined during Project-specific CEQA review.

d) All Project alternatives – The Project is located on developed or previously disturbed land, and is in an urban setting. It is not anticipated that the Project would interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites. For this reason, all Project alternatives are expected to have No Impact.

e) All Project alternatives – The Project is located on developed or previously disturbed land. It is not anticipated that the Project would conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance. However, the level of significance will need to be determined during Project-specific CEQA review.

f) All Project alternatives – The Project is not located in an area with an adopted Habitat Conservation Plan; Natural Community Conservation Plan; or other approved local, regional, or state habitat conservation plan. For these reasons, all alternatives are expected to have No Impact.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
V. Cultural Resources. Would the project:				
a) Cause a substantial adverse change in the significance of a historical resource pursuant to Section 15064.5?	☐	☐	☐	☐
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to Section 15064.5?	☐	☐	☐	☐
c) Disturb any human remains, including those interred outside of formal cemeteries?	☐	☐	☐	☐

a) All Project alternatives – The Project is located on developed or previously disturbed land. However, to evaluate potential Project-related impacts to cultural resources, it is recommended that a California Historical Resources Information System (CHRIS) records search be completed for a 0.5-mile buffer zone around the proposed disturbance area. The CHRIS records search will include a review of all recorded archaeological sites, as well as all known cultural resource survey and excavation reports. It is also recommended that the National Register of Historic Places (NRHP) online database and the California Register, California Historical Landmarks, and California Points of Historical Interest be examined. The records search would identify if the Project would have a substantial adverse change in the significance of a historical resource pursuant to Section 15064.5. Given the urban and developed and disturbed characteristics of the Project site, it is anticipated that any historical resources present would be lacking in integrity, and that potential impacts would be less-than-significant, or less-than-significant with mitigation incorporated. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – The Project is located on developed or previously disturbed land. However, to evaluate potential Project-related impacts to cultural resources, it is recommended that a CHRIS records search be completed for a 0.5-mile buffer zone around the proposed disturbance area. The CHRIS records search will include a review of all recorded archaeological sites, as well as all known cultural resource survey and excavation reports. It is also recommended that the NRHP online database and the California Register, California Historical Landmarks, and California Points of Historical Interest be examined. The records search would identify whether the Project would have a substantial adverse change in the significance of an archaeological resource pursuant to Section 15064.5. The level of significance will need to be determined during Project-specific CEQA review.

c) All Project alternatives – The Project is located on developed or previously disturbed land and would impact previously disturbed areas. The Project would not involve any excavation into undeveloped lands. Therefore, the proposed Project would not disturb any known human remains, including those interred outside of formal cemeteries. However, in the event of the unanticipated discovery of human remains during construction, according to State Health and Safety Code Section 7050.5, further disturbances and activities will cease in any area or nearby area suspected to overlie remains, and the county coroner will be contacted. Pursuant to PRC Section 5097.98, if the remains are thought to be Native American, the coroner will notify the Native American Heritage Commission, which will then notify the Most Likely Descendant. The level of significance will need to be determined during Project-specific CEQA review.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
VI. Energy. Would the project:				
a) Result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources during project construction or operation?	☐	☐	☐	☐
b) Conflict with or obstruct a state or local plan for renewable energy or energy efficiency?	☐	☐	☐	☐

a) All Project Alternatives – Construction of the Project would result in the consumption of energy resources, including fossil fuels. The consumption of energy is necessary to efficiently construct the Project consistent with established standards, such as the California Building Code. Although construction activities would consume energy, the scale and time frame of the Project's construction is such that any minor inefficient energy consumption would not significantly impact the environment.

Operation of the Project would result in the consumption of energy resources, including the use of fossil fuels for activities, such as water pumping, material transport, maintenance of equipment, and water treatment operation. However, wasteful, inefficient, or unnecessary consumption of energy resources is not anticipated. Nonetheless, the level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – Section 3.12 of the City of Torrance General Plan aims to promote efficient use and conservation of energy resources. The Project would result in an increased use in energy resources during construction and operation. Like all energy distributed in the area, the energy used for the Project would be created from multiple sources, including both renewable and nonrenewable sources, dependent on energy provider Southern California Edison. The Project would not result in significant wasteful or inefficient use of energy. Because the Project is compatible with renewable energy and would not involve the inefficient use of energy, the Project would not conflict or obstruct a plan for renewable energy or energy efficiency. Nonetheless, the level of significance will need to be determined during Project-specific CEQA review.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
VII. Geology and Soils. Would the project:				
a) Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☐	☒
ii) Strong seismic ground shaking?	☐	☐	☐	☒
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☐	☒
iv) Landslides?	☐	☐	☐	☒
b) Result in substantial soil erosion or the loss of topsoil?	☐	☐	☐	☐
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse?	☐	☐	☐	☐
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	☐	☐	☐	☐
e) Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?	☐	☐	☐	☒
f) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☐	☒

a) (Questions i-iv) All Project alternatives – Construction and operation of the Project would not cause substantial adverse effects related to rupture of a known earthquake fault, strong seismic ground shaking, seismic-related ground failure including liquefaction, or landslides. For this reason, all Project alternatives are expected to have No Impact.

b) All Project alternatives – The Project would result in earthmoving construction activities, including excavation, grading, drilling, and foundation installation. To minimize soil erosion or the loss of topsoil, construction best management practices (BMPs) would be implemented in accordance with the Stormwater Pollution Prevention Plan (SWPPP). The level of significance will need to be determined during Project-specific CEQA review.

c) All Project alternatives – The proposed desalter facility and associated wells and pipelines are not anticipated to be located on a geologic unit that has the potential to result in onsite or offsite subsidence. To reduce potential adverse effects associated with offsite landslide, lateral spreading, subsidence, liquefaction, or collapse, the Project would be designed and constructed in conformance with applicable building codes and seismic engineering standards, and applicable regulatory requirements. The level of significance will need to be determined during Project-specific CEQA review.

d) All Project alternatives – Project design would consider soil conditions, including whether the site may be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (UBC) (1994), creating substantial risks to life or property. To reduce potential adverse effects associated with expansive soils, the Project would be designed and constructed in conformance with applicable building codes and seismic engineering standards and applicable regulatory requirements. The level of significance will need to be determined during Project-specific CEQA review.

e) All Project alternatives – Septic tanks or alternative wastewater disposal systems are not part of the Project. For this reason, all Project alternatives are expected to have No Impact.

f) All Project alternatives – The proposed desalter facility and associated wells and pipelines are located on developed land and would impact previously disturbed areas. No known unique paleontological or geologic resources are present in the Project area. The Project site has been graded, leveled, developed, and vacated. Therefore, the construction of Project facilities would not result in direct or indirect impacts to a unique paleontological resource or site, or unique geologic feature. For this reason, all Project alternatives are expected to have No Impact.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
VIII. Greenhouse Gas Emissions. Would the project:				
a) Generate greenhouse gas (GHG) emissions, either directly or indirectly, that may have a significant impact on the environment?	☐	☒	☐	☐
b) Conflict with an applicable plan, policy, or regulation adopted for the purpose of reducing the GHG emissions?	☐	☐	☐	☐

a) All Project alternatives – Direct GHG emissions would occur during Project construction and would include emissions from fuel combustion in construction equipment, haul trucks, and worker commute vehicles. These construction-related emissions would occur in Torrance and Carson. Alternatives 18 and 19 would also result in GHG emissions within Manhattan Beach due to the construction of underground pipelines. During operations, a direct emission increase of GHG from the Project would be expected from sources located in Torrance, due to the use of equipment and vehicles.

Indirect GHG emissions would occur during operations due to the increased power demand. The Project would use electricity from California's power grid that meets the Renewables Portfolio Standard, consistent with the Assembly Bill 32 GHG and Senate Bill 32 GHG emission reduction goals and the latest strategies for achieving the GHG reduction goals in the *2017 Climate Change Scoping Plan Update: The Proposed Strategy for Achieving California's 2030 Greenhouse Gas Target* (CARB, 2017).

To evaluate potential construction- and operation-related GHG emissions, it is recommended that GHG emissions estimates be calculated using construction equipment and on-road vehicle emissions factors from SCAQMD. The results of the GHG emissions calculations would identify levels of increased GHG emissions generated by the Project, both directly and indirectly. Appropriate GHG emissions mitigation measures would be identified and would likely result in a less-than-significant impact with mitigation incorporated determination. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – Direct GHG emissions would occur during Project construction and would include emissions from fuel combustion in construction equipment, haul trucks, and worker commute vehicles. These construction-related emissions would occur in Torrance and Carson. Alternatives 18 and 19 would also result in GHG emissions within Manhattan Beach due to the construction of underground pipelines. During operations, a direct emission increase of GHG from the Project would be expected from sources located in Torrance, due to the use of equipment and vehicles.

The Project would not conflict with an applicable plan, policy, or regulation adopted to reduce GHG emissions. On June 1, 2005, Executive Order S-3-05 was signed and set a goal to reduce California's GHG emissions to (1) year 2000 levels by 2010, (2) year 1990 levels by the 2020, and (3) 80 percent below year 1990 levels by 2050. In 2006, this goal was further reinforced with the passage of Assembly Bill 32. In 2016, the Legislature passed Senate Bill 32, which established a new target for GHG emissions reductions in the state at 40 percent of 1990 levels by 2030. On January 20, 2017, CARB released the *2017 Climate Change Scoping Plan Update: The Proposed Strategy for Achieving California's 2030 Greenhouse Gas Target* (CARB, 2017). This Scoping Plan Update establishes a proposed framework of action for the state to meet Senate Bill 32 GHG reduction goals.

Operational-related GHG emissions would occur within Torrance. Within the City of Torrance General Plan, Community Resources (CR) Element, Policies 14.1 through 14.4 aim to reduce the city's overall carbon footprint and counteract the effects of global warming through a reduction in the emission of GHG within Torrance. These policies are summarized as follows:

- Policy CR.14.1: Support CARB in its ongoing plans to implement Assembly Bill 32, and fully follow any new Assembly Bill 32-related regulations.
- Policy CR.14.2: Develop and implement GHG emissions reduction measures, including discrete, early-action GHG-reducing measures that are technologically feasible and cost-effective.
- Policy CR.14.3: Pursue actions recommended in the U.S. Mayors Climate Protection Agreement to meet Assembly Bill 32 requirements.
- Policy CR.14.4: Act as a leader and example in sustainability and reduction in GHG emissions by conducting city business in the most GHG-sensitive way.

The Project would also be required to comply with the City of Torrance Energy Efficiency Climate Action Plan.

To evaluate potential construction- and operation-related GHG emissions, it is recommended that GHG emissions estimates be calculated using construction equipment and on-road vehicle emissions factors from SCAQMD. The results of the GHG emissions calculations would identify levels of increased GHG emissions generated by the Project, both directly and indirectly. Appropriate GHG emissions mitigation measures would be identified and would likely result in a less-than-significant impact with mitigation incorporated determination. The level of significance will need to be determined during Project-specific CEQA review.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
VIV. Hazards and Hazardous Materials. Would the project:				
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☒	☐	☐
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☐	☐	☐
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☐
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☐	☐
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public-use airport, would the project result in a safety hazard or excessive noise for people residing or working in the Proposed Project area?	☐	☐	☐	☐
f) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☐
g) Expose people or structures, either directly or indirectly, to a significant risk of loss, injury, or death involving wildland fires?	☐	☐	☐	☒

a) All Project alternatives – The Project involves the routine transport, use, and disposal of hazardous materials, including sodium hydroxide, ammonium hydroxide, hydrofluorosilicic acid, hydrochloric acid, and equipment fuels. Transporting these materials has the potential to create a significant hazard to the public or the environment.

An analysis of the Project's hazardous materials would be required to determine the level of potential hazard to the public or environment and any mitigation required. At a minimum, chemicals would be transported, stored, used, and disposed in accordance with federal, state, and local regulations. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – The Project involves the routine transport, use, and disposal of hazardous materials including sodium hydroxide, ammonium hydroxide, hydrofluorosilicic acid, hydrochloric acid, and equipment fuels. A reasonably foreseeable upset and accident conditions involving the release of hazardous materials has the potential to create a significant hazard to the public or the environment.

An analysis of the Project's hazardous materials would be required to determine the level of potential hazard to the public or environment and any mitigation required. A Hazardous Materials Business Plan would likely need to be submitted to the Certified Unified Program Agency, and appropriate spill containment would be accounted for by the design. The level of significance will need to be determined during Project-specific CEQA review.

c) All Project alternatives – The Project involves components, including the permanent desalter facility, within 0.25 mile of a school. Although the Project is not expected to emit hazardous materials, substances, or waste, the Project would handle hazardous materials or acutely hazardous materials, including sodium hydroxide, ammonium hydroxide, hydrofluorosilicic acid, hydrochloric acid, and equipment fuels. To avoid or minimize impacts to nearby schools, mitigation could be required, which may include routing chemical delivery trucks away from schools, or outside of morning and afternoon school start and dismissal hours.

An analysis of the Project's hazardous materials would be required to determine the level of potential hazard to nearby schools and any mitigation required. The level of significance will need to be determined during Project-specific CEQA review.

d) All Project alternatives – According to the EnviroStor database, no concept-level Project components are located on hazardous materials sites, pursuant to Government Code Section 65962.5 (DTSC, 2019). Therefore, the Project would not be anticipated to impact sites listed due to hazardous materials, pursuant to Government Code Section 65962.5. Nonetheless, the level of significance will need to be determined during Project-specific CEQA review.

e) All Project alternatives – The Project involves components within 2 miles of the Torrance Airport – Zamperini Field, which is subject to the Los Angeles County Airport Land Use Plan (LADRP, 1991). However, the Project does not involve new structures reaching a height that would cause a safety hazard for aircraft operations. To determine whether noise levels from the Project would expose people residing or working in the Project area to excessive noise levels, a noise analysis would be required. The level of significance will need to be determined during Project-specific CEQA review.

f) All Project alternatives – Construction of the Project would involve components in Torrance, Carson, and Manhattan Beach (for Alternatives 18 and 19). During construction, lane closures on roadways would require encroachment permits from these three jurisdictions. During the permitting process, conformity of the Project to emergency response plans and practices is evaluated. The Project would be required to mitigate potential impacts to emergency response and evacuation plans, according to the conditions of approval applied to encroachment permits. Operation of the Project would not conflict or interfere with emergency plans. The level of significance will need to be determined during Project-specific CEQA review.

g) All Project alternatives – The Project is located in an urbanized area in southwestern Los Angeles County and does not include any elements associated with potential ignition sources for wildland fires. Therefore, the Project would not expose people or structures, either directly or indirectly, to a significant risk of loss, injury, or death involving wildland fires. For this reason, all Project alternatives are expected to have No Impact.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
X. Hydrology and Water Quality. Would the project:				
a) Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality?	☐	☐	☐	☐
b) Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?	☐	☐	☐	☒
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would:				
i) result in substantial erosion or siltation onsite or offsite;	☐	☐	☐	☐
ii) substantially increase the rate or amount of surface runoff in a manner which would result in flooding onsite or offsite;	☐	☐	☐	☐
iii) create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff; or	☐	☐	☐	☐
iv) impede or redirect flood flows?	☐	☐	☐	☐
d) In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation?	☐	☐	☐	☐
e) Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?	☐	☐	☐	☐

a) All Project alternatives – It is recommended that a hydrology and water quality analysis be completed to determine Project impacts to water quality standards and waste discharge requirements, or whether the Project would substantially degrade surface or groundwater quality. The level of significance will need to be determined during Project-specific CEQA review.

Refer to the following item c) for evaluation of stormwater impacts during construction of the desalter facility and associated conveyance pipelines.

During construction of extraction wells, well development water would need to be managed and discharged in accordance with the water quality standards and waste discharge requirements of the Los Angeles Regional Water Quality Control Board (RWQCB). This may include obtaining a limited threat discharge permit from RWQCB). If water quality standards cannot be achieved, alternative management of well development water would occur. This may include direct discharge to the sanitary sewer or to a temporary onsite tank, with subsequent transport via vacuum truck to the Joint Water Pollution Control Plant (JWPCP).

During operation, according to the City of Torrance, for development equal to 1 acre or more of disturbed area that adds more than 10,000 square feet (ft^2) of impervious surface area, stormwater needs to be retained onsite and account for an 85th percentile 24-hour runoff event as determined from the Los Angeles County 85th percentile precipitation isohyetal map, or the volume of runoff produced from a 0.75-inch 24-hour rain event, whichever is greater. The desalter facility, which is approximately 1 acre, would need to achieve these water retention requirements.

b) All Project alternatives – The objective of the Project is to improve groundwater conditions in the Los Angeles Basin. Brackish water would be pumped out of aquifers, treated, and distributed for public use. Initially, groundwater supplies would decrease as brackish water is pumped out of the aquifers. However, water with appropriate levels of salinity would be returned to the subsurface aquifers via natural and assisted methods. The Project would have a beneficial impact on groundwater quality. For this reason, all Project alternatives are expected to have No Impact.

c) All Project alternatives – The Project would comply with RWQCB requirements, including a SWPPP that would address pollutant discharges, erosion, and drainage impacts. Components of the Project would not substantially alter the existing drainage pattern of the site, including through alteration of the course of a stream or river or through the addition of impervious surfaces. The permanent desalter facility would add approximately 1 acre of impervious surface to an undeveloped, relatively flat property. No existing natural waterways would be impacted by the Project. The Project proposes well sites within property currently used as a sump for stormwater collection; however, the Project would not interfere with drainage.

During construction of the Project, vegetation and paved surfaces would be removed, exposing surfaces to erosional forces. BMPs outlined by the SWPPP and potential mitigation measures would be required to avoid or minimize erosion during construction. During operation of the Project, the sites would be revegetated and designed to avoid erosion and achieve the required level of stormwater retention.

i) The Project would comply with the SWPPP and implement BMPs and mitigation measures during construction if needed, and would be designed to avoid erosion. These factors would prevent substantial erosion or siltation onsite or offsite.

ii) Due to the Project scope and scale, no substantial increase in the rate or amount of surface runoff would result in flooding onsite or offsite. Stormwater runoff would not significantly increase due to the addition of impervious surfaces; however, this minimal increase would be designed to achieve the required level of stormwater retention prior to flowing into existing drainage networks.

iii) Stormwater runoff would increase due to the addition of impervious surfaces; however, this minimal increase would be designed to achieve the required level of stormwater retention prior to flowing into existing drainage networks. Due to the Project scope and scale, no substantial increase in the rate or amount of surface runoff would result in exceeding the capacity of existing planned stormwater drainage systems.

iv) Project components are located within flood control areas, such as sumps. However, the scope, scale, design, and placement of Project components would not significantly impede or redirect flood flows.

The level of significance will need to be determined during Project-specific CEQA review.

d) Portions of the Project, specifically, the wells and associated pipelines located at 21735 Madrona Avenue, Monterey Street, 3201 Plaza Del Amo, and 3330 Sepulveda Boulevard, are located in flood zones, as defined by the Federal Emergency Management Agency (FEMA). No pollutants are associated with the wells or pipelines, and these components would not have potential for pollutant releases due to inundation. The permanent desalter facility is not located within a flood, tsunami, or seiche zone and would not have potential for pollutant releases due to inundation (FEMA, 2019).

Alternative Projects 19, 14a, and New Project A – The portable wellhead treatment unit, when placed at 21735 Madrona Avenue, Monterey Street, 3201 Plaza Del Amo, and 3330 Sepulveda Boulevard, would be located within a flood zone. This exposes the unit to potential inundation by flooding events and risks the release of pollutants. Mitigation would be required to prevent the release of pollutants in an inundation event. The level of significance will need to be determined during Project-specific CEQA review.

e) All Project alternatives – The Project objective is to improve groundwater quality in the Los Angeles Basin. Impacts of the Project would be beneficial to groundwater quality and management.

During construction, the Project would be subject to RWQCB requirements, including an SWPPP, which would address pollutant discharges, erosion, and drainage impacts. Compliance with existing water quality regulations would prevent negative impacts to groundwater quality and management. Therefore, the Project would not conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan. Nonetheless, the level of significance will need to be determined during Project-specific CEQA review.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XI. Land Use and Planning. Would the project:				
a) Physically divide an established community?	☐	☐	☐	☒
b) Cause a significant environmental impact due to a conflict with any land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental impact?	☐	☐	☐	☐

a) All Project alternatives – The Project involves a 1-acre permanent desalter facility, new wells, and underground pipelines along existing roadways. Although the permanent desalter facility, underground pipelines, and several well locations are located within an established community, no Project component would physically divide an established community. For this reason, all Project alternatives are expected to have No Impact.

b) The permanent desalter facility is located on property with a land use designation of Public/Quasi-Public/Open Space. According to the City of Torrance, the parcel has been identified as one that has inconsistent zoning, and a zone change in the near future will classify the parcel to PU to be consistent with the Land Use Designation in the General Plan. The PU zone allows for water district facilities as permissible by right; however, development entitlements may be required. The PU district zoning does not specify development standards, such as building height or setbacks. However, the structures, equipment, and land use at the permanent desalter facility may require a discretionary review and approval by the City of Torrance. The proposed zone change to PU would need to be included in the Project-specific CEQA evaluation. Further consultation with the City of Torrance is required to determine timing and process for completing the zone change and the appropriate land use review process (for example, Conditional Use Permit process).

Twelve of the 14 locations for new wells are within the PU district. In accordance with Municipal Code Section 95.3.11 *Public Utilities*, water wells are conditionally permitted in the PU district. The remaining two locations for new wells are within the Hawthorne Boulevard Corridor Specific Plan (HBCSP) area. According to Table IV-1 *Permitted Land Use Matrix*, water wells (public utilities excluding offices) are conditionally permitted in the Del Amo Business Sub—District One (DA-1) and Del Amo Business Sub—District Two (DA-2).

The underground pipelines would be located along existing roadways and would not be subject to land use plans, policies, and regulations. The underground pipelines would be subject to appropriate right-of-way (ROW) easements, encroachment permits, and circulatory policies established by entities, including the City of Torrance, City of Manhattan Beach (for Alternatives 18 and 19), and City of Carson; railroad agencies; and utilities.

Alternative Projects 19, 14a, and New Project A – The portable wellhead treatment unit is not explicitly identified within the City of Torrance land use documents. Further consultation with the City of Torrance is required to determine the appropriate land use review process (for example, Conditional Use Permit process).

The level of significance will need to be determined during Project-specific CEQA review.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XII. Mineral Resources. Would the project:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	☐	☐	☐	☐
b) Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?	☐	☐	☐	☒

a) All Project alternatives – The Project sites are located in areas designated MRZ-1, MRZ-2, and MRZ-3 by the California Department of Conservation (DOC, 2019). MRZ-1 areas are geographies where geologic information indicates that little likelihood exists for the presence of significant mineral resources. MRZ-2 areas are geographies where adequate information indicates that significant mineral deposits are present, or where it is judged that a high likelihood for their presence exists. MRZ-3 areas are classified as geographies containing known or inferred mineral occurrences of undetermined mineral resource significance.

The scale of the Project indicates that any loss of known mineral resources that would be of value to the region and the residents of the state would be minimal. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – The Project is not located on or near a site delineated on a local general plan, specific plan, or other land use plan as being locally important to mineral resource recovery. Therefore, the Project would not result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan. For these reasons, all alternatives are expected to have No Impact.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XIII. Noise. Would the project:				
a) Result in generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☐	☐
b) Result in generation of excessive ground-borne vibration or ground-borne noise levels?	☐	☐	☐	☐
c) For a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within 2 miles of a public airport or public-use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☒

a) The City of Torrance establishes noise standards within the Municipal Code, Chapter 6. During construction of the Project, it would be unlawful for construction personnel working in Torrance to operate power construction tools, equipment, or engage in the performance of any outside construction or repair work on buildings, structures, or projects in or adjacent to a residential area involving the creation of noise beyond 50 decibels (dB) as measured at property lines, except between the hours of 7:30 a.m. and 6:00 p.m., Monday through Friday, and 9:00 a.m. to 5:00 p.m. on Saturdays. Construction of the Project would be prohibited on Sundays and holidays observed by City Hall.

   The City of Torrance divides the area into four Regions: 1 through 4. The Project would be located entirely within Region 4. The daytime maximum noise level in Region 4 is 55 dB. However, Section 46.7.2(c) of the Municipal Code provides corrections to established noise limits. If the noise contains a steady, audible tone, such as a whine, screech, or hum, or if the noise occurs on Sunday between 12:01 a.m. and 12:01 p.m., the maximum noise level in Region 4 would be 50 dB.

   The City of Carson refers noise standards to Los Angeles County, Chapter 12.08 of Title 12 of the Los Angeles County Code, entitled "Noise Control Ordinance of County of Los Angeles." During construction of the Project, operating or causing the operation of any tools or equipment used in construction, drilling, repair, alteration, or demolition work between weekday hours of 7:00 p.m. and 7:00 a.m., or at any time on Sundays or holidays, such that the sound therefrom creates a noise disturbance across a residential or commercial real-property line, except for emergency work of public service utilities or by variance issued by the health officer, is prohibited. No operational noise would result from underground pipelines within Carson.

   Project Alternatives 18 and 19 – The City of Manhattan Beach establishes noise standards within the Municipal Code, Chapter 9. During construction of the Project, all construction would need to be conducted between the hours of 7:30 a.m. and 6:00 p.m., Monday through Friday (except national holidays), and 9:00 a.m. to 6:00 p.m. on Saturdays. Construction activity would be prohibited at all other hours and on Sundays and national holidays. No operational noise would result from underground pipelines within Manhattan Beach.

   All Project alternatives – To determine whether the Project would generate a substantial temporary or permanent increase in ambient noise levels in the vicinity of the Project in excess of standards established in the local noise ordinances and whether mitigation measures would be required, a noise evaluation is recommended. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – The Project would involve ground-borne vibration and ground-borne noise due to drilling and pile-driving activities. To determine whether the Project would generate excessive ground-borne vibration or ground-borne noise levels and whether mitigation measures would be required, a vibration and noise analysis would be required. The level of significance will need to be determined during Project-specific CEQA review.

c) All Project alternatives – The Project involves components within 2 miles of the Torrance Airport – Zamperini Field, which is subject to the Los Angeles County Airport Land Use Plan (LADRP, 1991). The Project does not involve the placement of housing. For this reason, all alternatives are expected to have No Impact.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XIV. Population and Housing. Would the project:				
a) Induce substantial unplanned population growth in an area, either directly (e.g., by proposing new homes and businesses) or indirectly (e.g., through extension of roads or other infrastructure)?	☐	☐	☐	☐
b) Displace substantial numbers of existing people or housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☒

a) All Project alternatives – The Project would not directly induce substantial unplanned population growth. The objective of the Project is to improve groundwater quality; it does not involve the construction of new dwelling units or make habitable space available for new members of the population. Although the Project would provide for greater groundwater quality for public consumption, the Project would not indirectly induce substantial unplanned population growth. The Project would require additional operations and maintenance personnel in the area; however, these additional employment opportunities do not encourage or promote a substantial number of new residences or visitors in the area.

b) All Project alternatives – The Project does not include the displacement of people or housing. All Project components would be located on uninhabited sites and do not necessitate the construction of replacement housing. For these reasons, all alternatives are expected to have No Impact.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XV. Public Services. Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the following public services?				
a) Fire protection	☐	☐	☐	☐
b) Police protection	☐	☐	☐	☐
c) Schools	☐	☐	☐	☐
d) Parks	☐	☐	☐	☐
e) Other public facilities	☐	☐	☐	☐

a) All Project alternatives – The Project would not impact fire protection facilities associated with the provision of new or physically altered fire protection facilities to maintain acceptable service ratios, response times, or other performance objectives. The Project would involve the temporary closure of lanes on roadways during construction, which may affect emergency response times. However, all lane closures would require encroachment permits, including necessary traffic control mitigation, which would be reviewed for conformity to emergency response requirements by the issuing agency. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – The Project would potentially include a new well and underground pipelines at the police station located in Torrance Civic Center. The potential well and pipeline construction would involve a temporary closure of the immediate area around construction.

The Project would involve the temporary closure of lanes on roadways during construction, which may affect emergency response times. However, all lane closures would require encroachment permits, including necessary traffic control mitigation, which would be reviewed for conformity to emergency response requirements by the issuing agency. The level of significance will need to be determined during Project-specific CEQA review.

c) All Project alternatives – The Project would potentially include new wells and underground pipelines on school property, specifically, the wells located at:

– El Dorado Street and Fern Avenue (Greenwood Park)
– 5006 Lee Street (Paradise Park)
– Madrona Avenue and Opal Street (Madrona Middle School)
– 22526 Ocean Avenue (Discovery Park)
– Madrona Avenue and Fashion Way (Madrona Middle School)

The potential well and pipeline construction would involve a temporary closure of the immediate area around construction.

The Project would involve the temporary closure of lanes on roadways during construction, which may affect school activities, such as pick-up and drop-off during peak traffic hours. However, all lane closures would require encroachment permits, including necessary traffic control mitigation, which would be reviewed for conformity to circulatory requirements by the issuing agency. The level of significance will need to be determined during Project-specific CEQA review.

d) All Project alternatives – The Project involves the construction and operation of new wells that are located in established parks, specifically, the wells located at:

– El Dorado Street and Fern Avenue (Greenwood Park)
– 5006 Lee Street (Paradise Park)
– 3330 Sepulveda Boulevard (Madrona Marsh Nature Center)
– Sepulveda Boulevard and Maple Avenue (Madrona Marsh Nature Center)

The potential well and pipeline construction would involve a temporary closure of the immediate area around construction. The level of significance will need to be determined during Project-specific CEQA review.

e) All Project alternatives – The Project involves the construction and operation of new wells that are located in establish public facilities, specifically, the wells located at 3201 Plaza Del Amo (Madrona Marsh Nature Center building) and Monterey Street (Madrona Marsh Nature Center building). The potential well and pipeline construction would involve a temporary closure of the immediate area around construction. The level of significance will need to be determined during Project-specific CEQA review.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XVI. Recreation. Would the project:				
a) Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☐	☐
b) Include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?	☐	☐	☐	☒

a) All Project alternatives – The Project involves the construction and operation of new wells that are located in neighborhood parks, specifically, the wells located at:

- El Dorado Street and Fern Avenue (Greenwood Park)
- 5006 Lee Street (Paradise Park)
- 3330 Sepulveda Boulevard (Madrona Marsh Nature Center)
- Sepulveda Boulevard and Maple Avenue (Madrona Marsh Nature Center)

The potential well and pipeline construction would involve a temporary closure of the immediate area around construction. During the affected park's temporary closures, an increased use in alternative parks may occur. However, the influx of public users at non-Project-related parks is not expected to result in substantial physical deterioration or accelerated deterioration at the alternative facilities. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – The Project does not involve the construction of recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment. For this reason, all alternatives are expected to have No Impact.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XVII. Transportation. Would the project:				
a) Conflict with a program plan, ordinance, or policy addressing the circulation system, including transit, roadway, bicycle and pedestrian facilities?	☐	☐	☐	☐
b) Conflict or be inconsistent with CEQA Guidelines Section 15064.3, subdivision (b)?	☐	☐	☐	☐
c) Substantially increase hazards due to a geometric design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☐	☐
d) Result in inadequate emergency access?	☐	☐	☐	☐

a) All Project alternatives – It is recommended that a transportation analysis be completed to determine whether the Project conflicts with a Project plan, ordinance, or policy addressing the circulation system, including transit, roadway, bicycle, and pedestrian facilities. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – It is recommended that a transportation analysis be completed to determine whether the Project conflicts with or is inconsistent with CEQA Guidelines Section 15064.3, subdivision (b). The level of significance will need to be determined during Project-specific CEQA review.

c) All Project alternatives – It is recommended that a transportation analysis be completed to determine whether the Project could substantially increase hazards due to a geometric design feature (for example, sharp curves or dangerous intersections) or incompatible uses (for example, farm equipment). The level of significance will need to be determined during Project-specific CEQA review.

d) All Project alternatives – It is recommended that a transportation analysis be completed to determine whether the Project could result in inadequate emergency access. The level of significance will need to be determined during Project-specific CEQA review.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XVIII. Tribal Cultural Resources. Would the project:				
a) Cause a substantial adverse change in the significance of a tribal cultural resource, defined in PRC Section 21074 as either a site, feature, place, or cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:				
i) Listed or eligible for listing in the California Register of Historical Resources, or in a local register or historical resources as defined in PRC Section 5020.1(k), or	☐	☐	☐	☐
ii) A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of PRC Section 5024.1 In applying the criteria set forth in subdivision (c) of PRC Section 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe.	☐	☐	☐	☐

a) (Questions i-ii) All Project alternatives – The Project will be required to reach out to California Native American Tribes, as defined in PRC Section 21074. Based on this consultation process, a determination will be made regarding the presence of tribal cultural resources in the Project area.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XIX. Utilities and Service Systems. Would the project:				
a) Require or result in the relocation or construction of new water or expanded water, wastewater treatment, or stormwater drainage; electric power; natural gas; or telecommunications facilities, the construction or relocation of which could cause significant environmental effects?	☐	☐	☐	☐
b) Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry, and multiple dry years?	☐	☐	☐	☒
c) Result in a determination by the wastewater treatment provider, which serves or may serve the project, that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☐
d) Generate solid waste in excess of state or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals?	☐	☐	☐	☐
e) Comply with federal, state, and local management and reduction statutes and regulations related to solid waste?	☐	☐	☐	☐

a) All Project alternatives – The Project involves the construction of new groundwater treatment facilities. During construction, there is potential for significant environmental impacts. A complete environmental review of the Project and potential impacts to the environment would be required to determine which environmental resource(s) would be impacted and to what level the impact(s) would occur. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – The Project does not include habitable facilities that would require a potable water supply. For this reason, all alternatives are expected to have No Impact. Upon completion of the construction, there would be a beneficial impact from the Project on local groundwater supplies.

c) All Project alternatives – The Project involves the construction of new groundwater treatment facilities. Wastewater from the Project would be in the form of brine and water pumped from the wells during construction and initial operations. Brine wastewater would be pumped via underground pipelines to the JWPCP in Carson, following approval by the Los Angeles County Sanitation District (LACSD). Water pumped from the wells during construction and initial operations may be expelled onto permeable surfaces for evaporation and absorption back into the aquifer or pumped to the sanitary sewer network. The level of significance will need to be determined during Project-specific CEQA review.

d) All Project alternatives – During construction and operation of the Project, solid waste would be generated and hauled to appropriate facilities, including landfills, recycling centers, and repurpose yards. To determine whether the Project would generate solid waste in excess of state or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals, anticipated solid waste generation from the Project would be evaluated. The level of significance will need to be determined during Project-specific CEQA review.

e) All Project alternatives – The Project would comply federal, state, and local management and reduction statutes and regulations related to solid waste disposal during construction and operational activities. The level of significance will need to be determined during Project-specific CEQA review.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XX. Wildfire. If located in or near state responsibility areas or lands classified as very high fire hazard severity zones, would the project:				
a) Substantially impair an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☒
b) Due to slope, prevailing winds, and other factors, exacerbate wildfire risks, and thereby expose project occupants to pollution concentrations from a wildfire or the uncontrolled spread of wildfire?	☐	☐	☐	☒
c) Require the installation or maintenance of associated infrastructure (i.e., roads, fuel breaks, emergency water sources, power lines, or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?	☐	☐	☐	☒
d) Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?	☐	☐	☐	☒

a) All Project alternatives – The Project is not located in a state responsibility area or in a Very High Fire Hazard Severity Zone (CalFire, 2012). For this reason, all alternatives are expected to have No Impact.

b) All Project alternatives – The Project is located in a heavily urbanized and relatively flat area of southwestern Los Angeles County. The Project is not located in a Very High Fire Hazard Severity Zone (CalFire, 2012). Components of the Project do not involve ignition sources that could start wildfires. Therefore, the Project would not expose occupants to pollution concentration from a wildfire or the uncontrolled spread of wildfire. For these reasons, all alternatives are expected to have No Impact.

c) All Project alternatives – The Project involves the construction of new groundwater treatment facilities. No Project component would cause an exacerbation to fire risk. For these reasons, all alternatives are expected to have No Impact.

d) All Project alternatives - The Project is located in a heavily urbanized and relatively flat area of southwestern Los Angeles County. The Project is not located in a Very High Fire Hazard Severity Zone (CalFire, 2012). Components of the Project do not involve ignition sources that could start wildfires. The Project sites are located on relatively flat surfaces. Therefore, the Project would not expose people or structures to significant risks, including downslope or downstream flooding or landslides as a result of runoff, post-fire slope instability, or drainage changes. For these reasons, all alternatives are expected to have No Impact.

	Potentially Significant Impact	Less-Than-Significant Impact with Mitigation Incorporated	Less-Than-Significant Impact	No Impact
XXI. Mandatory Findings of Significance.				
a) Does the project have the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory?	☐	☐	☐	☐
b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?	☐	☐	☐	☐
c) Does the project have environmental effects that cause substantial adverse effects on human beings, either directly or indirectly?	☐	☐	☐	☐

a) All Project alternatives – The Project sites are located within existing disturbed and urbanized areas. To evaluate potential Project-related impacts to biological resources, it is recommended that a desktop data review of the California Natural Diversity Data Base CNDDB be completed and a reconnaissance-level field survey be performed to document the resources present. The CNDDB review and field survey would identify whether the Project could have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the DFW or USFWS. Given the urban and developed and disturbed characteristics of the Project site, it is anticipated that potential impacts would be less-than-significant, or less-than-significant with mitigation incorporated.

To evaluate potential Project-related impacts to cultural resources, it is recommended that a CHRIS records search be completed for a 0.5-mile buffer zone around the proposed disturbance area. The CHRIS records search will include a review of all recorded archaeological sites, as well as all known cultural resource survey and excavation reports. It is also recommended that the NRHP online database and the California Register, California Historical Landmarks, and California Points of Historical Interest be examined. The records search would identify whether the Project would have a substantial adverse change in the significance of a historical resource pursuant to Section 15064.5. Given the urban and developed and disturbed characteristics of the Project site, it is anticipated that any historical resources present would be lacking in integrity, and that potential impacts would be less-than-significant, or less-than-significant with mitigation incorporated.

A complete environmental review of the Project and potential impacts to the environment would be required to determine which environmental resource(s) would be impacted and to what level the impact(s) would occur. The level of significance will need to be determined during Project-specific CEQA review.

b) All Project alternatives – According to Section 15355 of the CEQA Guidelines, cumulative impacts refer to:

> *"Two or more individual effects which, when considered together are considerable or which compound or increase other environmental effects. The individual effects may be changes resulting from a single project or a number of separate projects. The cumulative impact from several projects is the change in the environment that results from the incremental impact of the project when added to other closely related past, present, and*

reasonably foreseeable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time."

A complete environmental review of the Project and potential impacts to the environment would be required to determine which environmental resource(s) would be impacted and to what level the impact(s) would occur. Upon completion of a complete environmental review of the Project, an analysis would be conducted to determine which, if any, resources would sustain impacts that are individually limited but cumulatively considerable. The scale or geographic scope of related projects varies for each impact category. For instance, cumulative geology and soils or aesthetics impacts are considered localized, while cumulative traffic and transportation and air quality impacts are considered regional. The level of significance will need to be determined during Project-specific CEQA review.

c) All Project alternatives – Based on the completion of the Environmental Screening Checklist, included herein, the Project could result in direct and indirect adverse impacts on human beings.

The Project involves the construction of equipment and facilities that may cause an aesthetic impact on the local environment. The Project components could require mitigation to comply with regulations governing scenic quality. It is recommended that a visual impact analysis, including preparation of visual simulations or renderings, be prepared to determine impact levels and appropriate mitigation, if required.

Air quality in the immediate vicinity of Project components would be impacted by the Project. The Project would result in a net increase of criteria pollutants during construction (temporary) and operations. An air quality analysis, including emissions calculations, is recommended to identify whether the Project's emissions would result in a significant impact, and, if so, mitigation measures to reduce the impacts to a less-than-significant level. In addition, the potential for localized odors from the use of chemicals, along with the overall process of treating brackish water to potable water, should be evaluated.

The Project involves the routine transport, use, and disposal of hazardous materials, including sodium hydroxide, ammonium hydroxide, hydrofluorosilicic acid, hydrochloric acid, and equipment fuels. Transporting these materials has the potential to create a significant hazard to the public or the environment. An analysis of the Project's hazardous materials is recommended to determine the level of potential hazard to the public or environment and any mitigation required. At a minimum, chemicals would be transported, stored, used, and disposed in accordance with federal, state, and local regulations.

The Project could have negative impacts on the local hydrology and water quality. During construction of extraction wells, well development water would need to be managed and discharged in accordance with the water quality standards and waste discharge requirements of the RWQCB. This may include obtaining a limited threat discharge permit from RWQCB. If water quality standards cannot be achieved, alternative management of well development water would occur. This may include direct discharge to the sanitary sewer or to a temporary onsite tank, with subsequent transport via vacuum truck to the JWPCP. During operation, according to the City of Torrance, for development equal to 1 acre or more of disturbed area that adds more than 10,000 ft^2 of impervious surface area, stormwater needs to be retained onsite and account for an 85th percentile 24-hour runoff event as determined from the Los Angeles County 85th percentile precipitation isohyetal map, or the volume of runoff produced from a 0.75-inch, 24-hour rain event, whichever is greater. The desalter facility, which is approximately 1 acre, would need to achieve these water retention requirements. A hydrology and water quality analysis is recommended to determine Project impacts to water quality standards and waste discharge requirements, or whether the Project would substantially degrade surface or groundwater quality.

The Project could have adverse noise impacts to the community in the immediate vicinity of Project components. Carson, Torrance, and Manhattan Beach have established noise standards, including noise levels and allowable construction time frames. To determine whether the Project would generate a substantial temporary or permanent increase in ambient noise levels in the vicinity of the Project in excess of standards established in the local noise ordinances and whether mitigation measures would be required, a noise evaluation is recommended.

The Project would involve the temporary closure of lanes on roadways during construction, which may affect emergency response times; commute times; school activities, such as pick-up and drop-off; and access to properties in the immediate vicinity. Compliance with encroachment permits issued by the various jurisdictions would mitigate traffic impacts. However, a transportation analysis is recommended to determine the impacts to traffic and transportation caused by the Project's construction and additional mitigation, if necessary.

A complete environmental review of the Project and potential impacts to the environment would be required to determine which environmental resource(s) would be impacted and to what level the impact(s) would occur. Upon completion of a complete environmental review of the Project, an analysis would be conducted to determine which, if any, resources could have environmental effects that cause substantial adverse effects on human beings, either directly or indirectly. The level of significance will need to be determined during Project-specific CEQA review.

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Appendix G
Project Permitting Plan

JACOBS

Technical Memorandum

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Subject	**Project Permitting Plan**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 29, 2019

1. Background

The Water Replenishment District of Southern California (WRD) is responsible for managing and replenishing both the West Coast and Central groundwater basins. In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, Lynwood, and Lower San Pedro (equivalent to Sunnyside) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To fully use the West Coast Basin, WRD has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. Program goals include treatment of the saline plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process. The Program includes the evaluation of six possible Project alternatives, which are composed of varying components related to plume water extraction, treatment, conveyance of treated potable water to Program stakeholders, and brine stream management.

This Technical Memorandum (TM) presents the Project Permitting Plan, which has been prepared for the Program to identify the following:

- Applicable federal, state, and local laws and regulations
- Potential permits and approvals
- Additional technical studies needed to support permit applications
- Acquisition schedule and approach

2. Regulatory Setting

This section provides a brief review of applicable federal, state, and local laws and regulations that may be applicable to various components of the Program. Potential permits or regulatory approvals that may be required for Program implementation are included in Section 3.

2.1 Federal

2.1.1 Clean Water Act

The Clean Water Act (CWA) (33 United States Code [U.S.C.] 1251 et seq.) was enacted with the intent of restoring and maintaining the chemical, physical, and biological integrity of waters of the United States. The CWA requires states to set standards to protect, maintain, and restore water quality through the regulation of point source and specific nonpoint pollution source discharges to surface water.

Section 402. Under Section 402 of the CWA, the California State Water Resources Control Board (SWRCB), the applicable Regional Water Quality Control Board (RWQCB), or both issues National Pollutant Discharge Elimination System (NPDES) permits for discharges (point source and non-point source, such as stormwater) into surface waters of the United States. The federal NPDES program has been delegated to the State of California for implementation through SWRCB and the nine RWQCBs. In California, NPDES permits are also referred to as waste discharge requirements (WDRs) that regulate discharges to waters of the State (see Section 2.2.1).

2.1.2 Clean Air Act

The Federal Clean Air Act (CAA) of 1963 and its subsequent amendments form the basis for the nation's air pollution control effort. The U.S. Environmental Protection Agency (EPA) is responsible for implementing most aspects of the CAA. Basic elements of the act include the following:

- National Ambient Air Quality Standards (NAAQS) for major air pollutants
- Hazardous air pollutant standards
- Attainment plans
- Motor vehicle emission standards
- Stationary source emission standards and permits
- Acid rain control measures
- Stratospheric ozone (O_3) protection and enforcement provisions

The CAA delegates enforcement of the federal standards to the states. In California, the California Air Resources Board (CARB) is responsible for enforcing air pollution regulations. CARB, in turn, delegates to local air agencies the responsibility of regulating stationary emission sources. The Program is located within the South Coast Air Basin (SCAB), which is regulated by the South Coast Air Quality Management District (SCAQMD).

2.1.3 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires all federal agencies to assess the environmental effects of their proposed actions prior to making decisions. These requirements apply when the action is proposed by the federal agency or when another public or private entity's proposed action is being approved, permitted, funded (in whole or in part), or otherwise authorized by a federal agency. If the proposed action does not fit within a NEPA Categorical Exclusion, the federal agency must prepare an environmental assessment (EA). If the EA does not identify a significant impact, the federal agency will prepare a finding of no significant impact (FONSI). If the proposed action will have significant impacts on the human environment, an environmental impact statement (EIS) must be prepared.

2.2 State

2.2.1 Porter-Cologne Water Quality Control Act

The Porter-Cologne Water Quality Control Act of 1967 (California Water Code Section 13000 et seq.) requires SWRCB and the nine RWQCBs to adopt water quality criteria to protect state waters, including groundwater. These criteria include the identification of beneficial uses, narrative and numerical water quality standards, and implementation procedures. The Porter-Cologne Water Quality Control Act is the regulation through which the RWQCBs regulate discharges to groundwater.

The Water Quality Control Plan for the Los Angeles Basin (Los Angeles RWQCB, 1994) establishes water quality standards for the Los Angeles Basin, which encompasses the Program area. Water quality standards include designated beneficial uses for surface water and groundwater, and narrative or numeric water quality objectives to protect those beneficial uses. The plan also includes implementation plans describing the actions by the Los Angeles RWQCB and others that are necessary to achieve and maintain the water quality standards.

2.2.2 California Division of Drinking Water

The SWRCB Division of Drinking Water (DDW) regulates public water systems, oversees water recycling projects, permits water treatment devices, and supports and promotes water system security. As part of these responsibilities, DDW reviews and issues water supply permits for public water systems.

2.2.3 California Office of Emergency Services

The State of California requires an owner or operator of a facility to complete and submit a Hazardous Materials Business Plan (HMBP) if the facility handles a hazardous material or mixture containing a hazardous material that has a quantity at any one time during the reporting year equal to or greater than 55 gallons (liquids), 500 pounds (solids), or 200 cubic feet (ft^3) for a compressed gas. When needed, HMBPs are submitted to the designated Certified Unified Program Agency (CUPA). The CUPA for the city of Torrance is the Los Angeles County Fire Department Health Hazardous Materials Division.

2.2.4 California Accidental Release Prevention Program

The purpose of the California Accidental Release Prevention Program (CalARP), California Code of Regulations (CCR), Title 19, Division 2, Chapter 4.5, is to prevent the accidental release of regulated substances, including aqueous ammonia in quantities greater than or equal to 500 pounds. As applicable, a Risk Management Plan (RMP), per CalARP, will need to be prepared. RMPs are regulated by the designated CUPA. The CUPA for the city of Torrance is the Los Angeles County Fire Department Health Hazardous Materials Division.

2.2.5 Above Ground Petroleum Storage Act

The Above Ground Petroleum Storage Act (APSA) applies to facilities that store petroleum in aboveground storage tanks (ASTs), containers, or equipment of 55 gallons or more in shell capacity and have total aboveground petroleum storage capacity of 1,320 gallons or more or has one or more petroleum tanks in an underground area. Facilities that exceed applicable criteria are required to implement a Spill Prevention, Control, and Countermeasure (SPCC) Plan. SPCC Plans are regulated by the designated CUPA. The CUPA for the city of Torrance is the Los Angeles County Fire Department Health Hazardous Materials Division.

2.2.6 Caltrans Encroachment

The California Department of Transportation (Caltrans) issues encroachment permits for construction within Caltrans rights-of-way (ROWs).

2.2.7 California Environmental Quality Act

The California Environmental Quality Act (CEQA) requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible. A public agency must comply with CEQA when it undertakes an activity defined by CEQA as a "project." A project is an activity undertaken by a public agency or a private activity that must receive some discretionary approval (meaning that the agency has the authority to deny the requested permit or approval) from a government agency, which may cause either a direct physical change in the environment or a reasonably foreseeable indirect change in the environment. If the proposed project does not fit within a CEQA Categorical or Statutory Exemption, an initial study (IS) must be conducted by the lead agency to determine whether a project may have a significant effect on the environment. If the IS does not identify a significant impact, the lead agency will prepare a Negative Declaration (ND) or Mitigated Negative Declaration (MND). If the proposed project will have significant impacts on the environment that cannot be mitigated to less than a level of significance, an environmental impact report (EIR) must be prepared.

2.3 Local

2.3.1 Municipal National Pollutant Discharge Elimination System Program

Municipalities are required under Section 402(p) of the CWA to develop programs to monitor and control pollutants in stormwater discharges from their municipal systems. Such control might include regulation of stormwater discharges from industrial and commercial facilities that the municipality determines are contributing pollutants to the municipal storm drain system.

In 2012, the Los Angeles RWQCB adopted Order R4-2012-0175 (later amended R4-2012-0175-0A1), the MS4 Permit for Los Angeles County. The MS4 Permit dictates stormwater and non-stormwater discharge requirements for the Los Angeles County Flood Control District, Los Angeles County, and 84 permittee cities including the stakeholder cities of Torrance, Manhattan Beach, Lomita, and Carson, a city with jurisdiction over certain project components. Alternatively, the Los Angeles RWQCB may require enrollment under the Industrial General Permit (IGP) or may require an individual NPDES permit for the facility.

2.3.2 Los Angeles County Department of Public Health

The Los Angeles County Department of Public Health (LACDPH), under the Drinking Water Program, is responsible for regulating small water systems and wells pursuant to state laws and regulations. LACDPH reviews plans and performs inspections and surveys of all small water systems, including checking the levels of bacteria, chemicals, and other elements within these systems. LACDPH is also involved in work plan approvals for construction and decommissioning of water wells and monitoring wells within the county of Los Angeles.

2.3.3 City Permits

City permits include standard ministerial permits (nondiscretionary), such as encroachment, excavation, and traffic control permits for activities within public roadways and ROWs, and building permits for a new permanent desalter facility.

3. Potential Permits or Approvals and Acquisition Schedule

This section includes a preliminary identification of potential permits or regulatory approvals that may be required before Program components can be constructed. Table 3-1 includes preliminary identification of potential permits or regulatory approvals that may be required for the Program and associated acquisition schedule.

Table 3-1. Preliminary Summary of Environmental Permits/Approvals

Activity	Permit/Approval[a]	Technical Studies	Acquisition Schedule[b]
Project undertaking as a whole (i.e., construction and operation of desalter facility, and associated extraction wells and conveyance pipelines).	CEQA environmental review and public disclosure. An IS/MND would likely be adequate, as it is not anticipated that the Project or any of its aspects would cause a significant effect on the environment.[c]	Construction and operations air emissions calculations, biological reconnaissance field survey and desktop data review, and cultural resources records search of California Historical Resources Information System within 0.5-mile buffer zone. Assumes feasibility study deliverables can be repurposed as water supply and water quality technical studies.	CEQA (IS/MND): 6 to 9 months
Acquisition of SRF financing.	CEQA-Plus environmental review, in lieu of NEPA associated with federal nexus for partial funding of SRF program by EPA. CEQA-Plus would include project CEQA document plus completion of the	Technical studies identified for IS/MND.	CEQA-Plus (IS/MND): 9 to 12 months

Table 3-1. Preliminary Summary of Environmental Permits/Approvals

Activity	Permit/Approval[a]	Technical Studies	Acquisition Schedule[b]
	SRF Program's Evaluation Form for Environmental Review and Federal Coordination, which includes need for specific review and documentation in conformance with federal laws (e.g., CAA, Endangered Species Act, National Historical Preservation Act).[d]		
Development of property for permanent desalter facility located, owned by the City of Torrance, at 1001 Elm Avenue.	City of Torrance. Property has a designated land use of PU. According to the City of Torrance, the parcel has been identified as one that has inconsistent zoning, and a zone change in the near future will classify the parcel to PU to be consistent with the Land Use Designation in the General Plan. The PU zone allows for water district facilities as permissible by right. City of Torrance. Conditional Use Permit: 6 to 9 months City of Torrance, Community Development Department, Building and Safety Division, Building Permit.	Design to support attainment of CUP Design to support Building Permit Application	Zone change: 6 to 12 months CUP: 6 to 9 months Building permit: 4 to 6 months
Operation of public water system.	SWRCB, DDW. Water Supply Permit. LACDPH. Drinking Water Program water systems plan review.	Preliminary Technical Report, per DDW guidance.	Water supply permit: 6 to 9 months Plan review: 6 to 9 months
Construction and operation of treatment plant equipment and power generation equipment, including emergency backup power generation equipment.	SCAQMD. Permit to Construct/Operate for construction and operation of treatment plant equipment and power generation equipment, including emergency backup power generation equipment.	Treatment plant and power generation equipment inventory. Technical evaluation to confirm compliance with SCAQMD's source-specific rules and new source review rules for emission control.	Permit to construct and operate for treatment plant equipment and power generation equipment, including emergency backup power generation equipment: 6 to 12 months
Storage of aqueous ammonia in quantities greater than or equal to 500 pounds.	Los Angeles County Fire Department Health Hazardous Materials Division. CalARP RMP.	RMP. Includes: regulated substances onsite and stationary sources, potential accident factors and consequences of offsite release, emergency response program, local emergency responders, hazard review and analysis, operating procedure, training, maintenance, and incident investigation.	Submit CalARP RMP: 2 to 3 months
Storage and handling of chemicals and fuel, assuming quantities exceed reporting thresholds (55 gallons for liquids, 500 pounds for solids or 200 ft^3 for gas).	Los Angeles County Fire Department Health Hazardous Materials Division. Hazardous materials inventory and associated HMBP documentation.	Hazardous materials storage inventory and HMBP.	File HMBP and inventory: 1 to 2 months
Storage of petroleum in AST, containers, or equipment of 55 gallons or more in shell capacity and having total aboveground petroleum storage capacity of 1,320 gallons or more or	Los Angeles County Fire Department Health Hazardous Materials Division. SPCC Plans	SPCC Plan. Includes: Operating procedures to prevent oil spills; control measures to prevent a spill from reaching navigable waters; and countermeasures to contain, clean up, and mitigate the effects of an oil	Submit SPCC Plan: 2 to 3 months

Table 3-1. Preliminary Summary of Environmental Permits/Approvals

Activity	Permit/Approval[a]	Technical Studies	Acquisition Schedule[b]
one or more petroleum tanks in an underground area.		spill that reaches navigable waters.	
Installation of approximately 7 to 10 new extraction wells within Torrance.	City of Torrance. New water wells within Torrance are conditionally permitted in all zoning districts (with the exception of M-1 and M-2 zones, which permit water wells by right). LACDPH. Drinking Water Program plan review and well permits.	Design to support attainment of CUP. Water use technical study and design to support plan review and well permits.	CUP: 6 to 9 months Plan review and well permits: 6 to 9 months
Discharge of well development and well purging groundwater.	Los Angeles RWQCB. Order No. R4-2013-0095. General NPDES Permit No. CAG994004. WDRs for discharge of groundwater, including groundwater generated from well drilling, construction, or development and purging of wells.	Water quality characterization and review of receiving water limitations.	WDRs: 9 to 12 months
Conveyance pipelines, including brackish water, potable supply, and brine disposal within public roadways and ROW, and railroad crossing.	City encroachment and excavation permits, including traffic control plans, for activities in public roadways and ROW. Caltrans encroachment permits for activities within Caltrans ROW. Caltrans facilities in Program area include Hawthorne Boulevard (SR 107), Western Avenue (SR 213), Artesia Boulevard (SR 91), I-110. Railroad encroachment permit.	Pipeline design sheets and associated traffic control plans.	City encroachment / excavation permits (and traffic control plans): 3 to 6 months Caltrans encroachment permits: 3 to 6 months
Stormwater and non-stormwater discharge (runoff) from facility.	Los Angeles RWQCB. MS4 Permit, State Water Board Order WQ 2015-0075. Alternatively, the Los Angeles RWQCB may require enrollment under the IGP or may require an individual NPDES permit for the facility.	LID plan for onsite stormwater retention.	Existing MS4 permit is already in effect. Comply with City of Torrance LID requirement for onsite stormwater retention.
Soil disturbance of one or more acres. Applicable to all project soil disturbance, including desalter facility and conveyance pipeline construction.	SWRCB and Los Angeles RWQCB. Water Quality Order 2012-0006-DWQ (General Construction Permit).	SWPPP drawings including BMP placement identification.	SWPPP preparation and NOI filing: 1 to 2 months

[a] State agency CEQA review is required before state agencies can issue discretionary permits.

[b] The estimated total acquisition duration is 18 to 24 months following selection of a defined Project and development of a complete Project description.

[c] The ultimate decision to proceed with an MND (and not an EIR) should be made following selection of proposed Project.

[d] Applicable only if Program receives federal funds via the SRF.

Notes:

BMP = best management practice

CUP = Conditional Use Permit

I-110 = Interstate 110

LID = low-impact development

MS4 = Municipal Separate Storm Sewer Systems

No. = number

NOI = Notice of Intent

PU = Public Use

SR = State Route

SRF = State Revolving Fund

SWPPP = Stormwater Pollution Prevention Plan

4. Permitting Approach

Following selection of the proposed Project, the potential permits and approvals identified should be reviewed for applicability or gaps. Early consultation with regulatory agencies is recommended to further identify and refine the requisite permits or regulatory approvals required for Program construction and operation.

Several key approval and permitting items and approaches are described in this section.

4.1 Land Use

Coordination with the City of Torrance on status and timing to address inconsistent zoning at the proposed desalter property, and a zone change to PU to be consistent with the land use designation in the General Plan should be clarified early in the Project review process. The proposed zone change to PU would need to be included in the Project-specific CEQA evaluation.

4.2 California Environmental Quality Act

Pursuant to CEQA, WRD would be the lead agency for approving projects associated with the Program. At selection of the proposed Project, an IS would be prepared to determine whether the Project may have a significant effect on the environment. Based on the *Environmental Review Plan* included in this Feasibility Study, it is anticipated that the IS would not identify substantial evidence that the Project or any of its aspects would cause a significant effect on the environment. Hence, WRD could prepare an MND. An MND is a short document that describes the proposed Project, presents findings related to environmental conditions, includes a copy of the IS (which documents the reasons to support the findings), and includes mitigation measures, if any, included in the Project to avoid potentially significant effects.

4.3 Other Permits and Approvals

Opportunities to expedite the schedule and maximize cost efficiencies should be considered following selection of the proposed Project. For example, WDRs for discharge of well development and well purging of groundwater may take time to acquire. Alternate discharge opportunities, such as to the sanitary sewer in instances where there is an adjacent manhole, may be appropriate. Prior to discharge to the sanitary sewer, a sewer discharge permit would be needed from the applicable sewer service provider. Similarly, discharge of well purge water to a temporary storage tank, such as a Baker tank, and transport via vacuum truck to the Joint Water Pollution Control Plant may be appropriate depending on selected well locations.

5. References

California Regional Water Quality Control Board, Los Angeles Region (4) (Los Angeles RWQCB). 1994. *Water Quality Control Plan, Los Angeles Region. Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties.* June 13.

Appendix H
Project Costs and Funding Plan

JACOBS

Technical Memorandum

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Subject **Project Costs and Funding Plan**

Project Name Regional Brackish Water Reclamation Program Feasibility Study

Date May 14, 2019, Finalized March 26, 2021

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1. Background

In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids has been trapped in the Gage, Silverado, Lynwood, and Lower San Pedro (Sunnyside) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To more fully use the West Coast Basin, WRD has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to treat the trapped saline plume for beneficial use. Program goals include treatment of the saline plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process.

As a part of the Program, WRD has initiated a regional planning study to evaluate the feasibility of remediating treating the saline plume with seven additional stakeholders (known as the Stakeholder Group). The Stakeholder Group has expressed interest in treating the saline plume, receiving the treated water, or both as part of the Program. The members of the Stakeholder Group either pump, hold water rights, or have other key roles in supporting the basin operations.

The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

The purpose of this technical memorandum (TM) is to summarize the results of the Project Financing Options and Cost of Water Analysis for the Regional Brackish Water Reclamation Program Feasibility Study.

2. Cost of Water Analysis

This section provides details and a summary of the cost of water for each of the six potential Projects. It assumes that the Projects will be constructed using a traditional design-bid-build basis and that all developmental costs are included in the cost estimates.

2.1 Project Costs

2.1.1 Cost Basis and Assumptions

Jacobs' Conceptual and Parametric Engineering System (CPES) was used to generate the treatment plant and piping portions of the Project costs. CPES uses parametric engineering algorithms based on the successful implementation of previous projects to provide detailed and accurate cost estimates for projects early in their lifespans, as follows:

- Finite plume volume:
  - As detailed in the *Potential Projects and Recommended Short List Technical Memorandum* of this Feasibility Study, the plume contains approximately 375,000 acre-feet (AF) of saline water. In combination with the existing Goldsworthy and Brewer Desalters, it is assumed that the treatment durations will be 20 to 30, 17 to 30, and 14 to 30 years for the Projects that extract 12,500, 16,000, and 20,000 AFY, respectively (extraction and treatment 350 days per year). Thus, for example, the range of average operating costs for the 12,500-AFY Projects includes the cost of treatment plus well water extraction for 20 to 30 years and well water extraction and chlorination for the remaining 10 to 0 years, respectively.
- Capital cost assumptions:
  - Based upon recent information on Southern California projects, each 2,000-AFY extraction well was assumed to have an installed capital cost of $2 million.
  - Well water, product water, and brine transmission pipelines were sized for a velocity of approximately 7 feet per second (fps).
  - Duty and standby equipment was included for chemical and water transmission pumps and ancillary equipment. No standby reverse-osmosis (RO) trains or air strippers are included, as the Projects are not required to meet their design capacity 100 percent of the time.
  - Installed equipment costs include the following markups:
    - 12 percent for contractor overhead
    - 10 percent for contractor profit
    - 3 percent for contractor mobilization bonds and insurance
    - Non-construction costs of 2 percent for permitting, 8 percent for engineering, 8 percent for services during construction, and 2 percent for Project commissioning and startup
    - 30 percent overall contingency, as this is a Class IV cost estimate based on an approximately 10 percent level of design
- Operations and maintenance (O&M) cost assumptions:
  - O&M details and assumptions are provided in the *Facilities and Operation Maintenance Plan Technical Memorandum* of this Feasibility Study.
  - Costs for brine disposal are detailed in the *Brine Discharge Evaluation Technical Memorandum* of this Feasibility Study. Project costs reflect discharge of the brine to the sanitary sewer.

2.1.2 12,500-AFY Centralized Project 18 Capital Cost Summary

As an example, Table 4-1 provides capital cost details in 2018 dollars of the 12,500-AFY Centralized Project 18.

Table 4-1. Capital Cost of Project

Item	Quantity	Capital cost ($millions)
2,000-AFY extraction wells	Eight (one standby)	16.0
Well water piping	3.2 miles total	10.5
Treatment plant		
RO	Three skids and trains each, including feed pumps and turbochargers Also includes CIP and neutralization systems	34.3
Air strippers	Two	2.7
Underground clearwell, 1-hour storage	One	3.5
Chemicals	Five chemicals One tank and two pumps (one standby) each	8.1
Product water pumps	Four (one standby)	8.7
Product water piping [a]	6 miles total	11.0
Brine connection to sewer		17.5
Subtotal Construction Cost		**112.3**
Permitting, Engineering, Services during Construction		27
Total		**139**

[a] This piping is for a delivery to Manhattan Beach. All other product water piping will be placed into the existing Torrance distribution system piping adjacent to the Project site.

Notes:

CIP = clean-in-place

2.1.3 Projects Cost Summary

Table 4-2 summarizes capital and total annual O&M costs in 2018 dollars for each of the six potential Projects. Because the individual items within the annual O&M costs have different durations, the individual O&M costs are presented separately in Table 4-1.

Table 4-2. Capital and Annual Operations and Maintenance Costs

Project Alternative	Capital Cost ($millions)	Annual O&M Costs ($millions)			
		Well Energy and Maintenance[a] ($)	Treatment Plant(s)[b] ($)	Brine Disposal[b] ($)	Total Annual O&M ($)
Project 18	139	1.2	6.8	0.48	8.5
Project 19	180	1.2	7.8	0.48	9.5
Project 41	165	1.5	8.2	0.60	10.3
Project 42	203	1.5	9.0	0.60	11.1
Project 43	185	1.9	9.6	0.75	12.3
Project 44	227	1.9	10.6	0.75	13.3

[a] These costs are assumed to occur every year of the 30-year study period.

[b] These costs are assumed to occur only for the following range: 20 to 30 years for Projects 18 and 19; 17 to 30 years for Projects 41 and 42; and 14 to 30 years for Projects 43 and 44.

The cost of water analysis was evaluated on the basis of these costs and the following assumptions:

- Project design expected to be completed in fall 2020
- Construction schedule – 2 years starting in 2022 and ending in 2023
- Years of operation – 30 years (2024 to 2053)

- Year of cost estimate – 2018
- Year of lifecycle cost (LCC) estimates – 2018
- Discount rate – 4 percent
- Inflation rate – 3 percent
- O&M escalation rate – 3 percent
- Replenishment cost - $339/AF (2019 dollars, not net present value (NPV) as displayed below in Table 4-3)
- RO recovery rate – 85 percent
- Gallons per AF – 325,851
- Well annual maintenance cost of $75,000 per well
- It is assumed that the wells will need to have a pressure of 150 pound) per square inch gauge (psig) to lift the groundwater from the aquifer and deliver it to the Project at a 50- to 60-psig feed pressure, which is necessary for cartridge filtration and proper RO high-pressure pump suction pressure

Using these assumptions and the costs shown in Table 4-2, an LCC analysis was developed. The NPV of the total costs (in 2018 dollars) for each of the six potential Projects is shown in Table 4-3. The NPV calculation in the analysis uses an end-of-year expenditure convention.

Table 4-3. WRD Desalter Project Lifecycle Cost Analysis Summary

Project Alternative	Feed Capacity		NPV Total LCCs ($)	NPV Total LCCs ($millions)	Cost per 1000 Gallons ($)	Cost per AF ($)	NPV Replenishment Cost per AF [a] ($)	NPV Total Cost per AF ($)
	AFY	mgd						
Project 18	12,500	11.2	286,429,679	286 - 341	2.87 – 3.41	934 – 1,111	235	1,168 – 1,345
Project 19	12,500	11.2	342,512,791	343 - 404	3.43 – 4.04	1,117 – 1,318	235	1,351 – 1,552
Project 41	16,000	14.3	324,007,708	324 - 411	2.54 – 3.22	827 – 1,048	235	1,062 – 1,283
Project 42	16,000	14.3	371,568,011	372 - 466	2.91 – 3.65	949 – 1,190	235	1,183 – 1,424
Project 43	20,000	17.9	349,801,993	350 - 477	2.19 – 2.98	713 - 973	235	948 – 1,207
Project 44	20,000	17.9	402,302,302	402 - 542	2.52 – 3.39	821 – 1,105	235	1,055 – 1,339

[a] Annualized replenishment cost
Note:
mgd = million gallons per day

Based on the results shown in Table 4-3, Project 19 has the highest cost per AF of water, while Project 43 has the lowest cost per AF of water. Thus, on the basis of cost per AF of water, Project 43 seems to be the best option. In general, the larger capacity Projects are more economical from a cost per AF of water standpoint, but they require the highest initial capital investment.

3. Project Financing Options

This section summarizes the potential financing options available to the Stakeholder Group from the private financial sector, including municipal borrowing. Each of the financial options discussed in this section are assumed to be a potential source of funding for any of the six potential Projects currently being reviewed as part of this Feasibility Study. None are assumed to specifically apply to only one these potential Projects.

3.1 Public-Private Partnerships

If the Stakeholder Group was unable to secure any funding from a state or federal agency (per the discussion in this section), they could partner with a private entity for funding. Several private equity investment organizations and groups have shown increased interest in providing financing as part of a Public-Private Partnership (P3) structure to capital projects in the water and wastewater industries. The size of the project would determine the level of interest from private investors. The interest rate for capital equity financing is likely to be noticeably higher than for municipal revenue bond financing (discussed in Section 3.3). This is because the sources of money available to private equity firms typically have higher interest rates (taxable rates) than tax-exempt options available to municipal borrowers, and the return that private equity firms need to show for their equity investments in transactions such as that needed to invest in any of these projects is typically higher than municipal borrowing rates. But, as detailed in the *Value for Money (VfM) TM* included in this Feasibility Study, there can be risk transfers to the private sector that can offset the higher cost of capital.

Banks, insurers, and pension funds are also sources of private financing for public infrastructure. Just as in the case of the private equity financing, the potential for attracting these types of investors would depend on the size of the project. Additionally, these private funding sources would likely have higher interest rates (taxable rates) compared to the tax-exempt options available to municipal borrowers.

The California Infrastructure Finance Act allows P3s for projects that are fee-producing and do not include state funds, and the P3 contract length cannot exceed 35 years. The act also blocks the use of the state revolving funds for projects that go the P3 route.

3.2 Green Bonds

Green bonds are another possible source of private financing. A green bond is typically a municipal bond whose proceeds are to be used for mitigating an environmental impact or, perhaps, improving resiliency or sustainability. They are typically used for projects whose objectives include

- Pollution prevention and control
- Protection of watersheds and coastal environments
- Sustainable drinking water and wastewater infrastructure
- Adaptation to climate change

Because of its broad definition, green bonds are sometimes associated with “self-labeling.” However, there are guidelines for determining the “greenness” of these bonds. These guidelines are referred to as the Green Bond Principles (GBP), and their aim is to promote integrity in the green bond market. Additionally, issuers of these green bonds can obtain external input in the form of consultant reviews, specialized auditors, and external green assessments, as well ratings by qualified third parties to help in the determination of accurate labeling and certification and verification that the appropriate green, sustainability objectives are met by the capital projects being financed. Green bonds that include this external certification provide an added assurance to investors that their funds are being invested in projects in alignment with sustainability investment objectives (ICMA, 2017).

3.3 Municipal Revenue Bonds

Revenue bonds could be issued through the traditional bond market to construct the Project. Revenue bonds would be secured by the revenues of the bond holder. Typically, bonds have a 20-year term and an interest rate of around 4 percent for public agencies, depending on their credit rating. The bond holder would also have to establish a reserve fund equal to one annual debt service payment and pay an estimated bond issuance fee of 1 to 2 percent.

3.4 Enhanced Infrastructure Financing District

Approved by Governor Brown in September 2014, Senate Bill (SB) 628 authorizes the creation of Enhanced Infrastructure Financing Districts (EIFDs) to finance public capital facilities or other specified projects of communitywide significance. EIFDs are separate government entities, formed through a Joint Power Authority (JPA) consisting of cooperating cities, counties, and special districts. The cooperating cities, counties, and special districts establish the EIFD by adopting a resolution of intention that states the following:

- Boundaries of the district
- Type of public facilities and development proposed to be financed

- Need for the district
- Goals the district proposes to achieve

The boundaries may include multiple jurisdictions, matching a tributary or watershed.

The establishment of an EIFD does not require voter approval; however, there is a 55 percent voter approval requirement to authorize bonds. The timeline for tax increments under an EIFD is 45 years.

The new EIFD requires that the individual members of the JPA work together to make financing plans that combine a range of permitted funding sources, including tax increment bonds, that are the responsibility of all participants. Each participant must agree to the amount of tax increment that they will contribute, which allows funding flexibility. Community facilities bonds, California's Proposition 1 Water Bond funds, federal and state grants, fees from developer agreements, and hotel and sales taxes may be used. School district and community college district money may not be included.

An EIFD receives the incremental growth in property tax revenues, or tax increment, of taxing agencies (cities, counties, and special districts, but not schools) that consent. An EIFD may finance the purchase, construction, expansion, or rehabilitation of a wide variety of public infrastructure and private facilities, including:

- Flood control levies and dams, retention basins, and drainage channels
- Sewage treatment plants, water reclamation plants, and interceptor pipes
- Facilities for the collection and treatment of water for urban uses

An EIFD may not be used to finance routine maintenance, repair work, or the costs of an ongoing operation, or for providing services of any kind.

4. Local, State, and Federal Grant and Loan Options

This section summarizes and provides an analysis of the potential local, state, and federal grant and loan funding options that are available to offset the development costs for each of the six potential Projects. The analysis of each funding option includes the eligibility requirements, as well as any limitations. Each of the grant options summarized and analyzed in this section are assumed to be a potential source of funding for any of the six potential Projects currently being reviewed as part of this Feasibility Study. None are assumed to specifically apply to only one the potential Projects.

4.1 Local Grant Options

4.1.1 Local Resources Program Funding

The Local Resources Program (LRP) is a program funded by the Metropolitan Water District of Southern California (MWD). The LRP provides funding for the development of water recycling, groundwater recovery, and seawater desalination supplies that offsets an existing demand or prevents a new demand on MWD's imported water deliveries either through direct replacement of imported water or increased regional groundwater production.

The LRP is open to public and private water agencies within MWD's service area. Applications have to be made through the applicant's MWD member agency – in this case, through the WBMWD, which is part of the Stakeholder Group who pumps and wholesales potable water within the district and is an MWD member agency. Early coordination is strongly encouraged.

New water recycling, groundwater recovery, and seawater desalination projects are eligible for funding, provided they include construction of new substantive treatment or distribution facilities. Eligibility of the LRP for the expansion of an existing project may be determined on a case by case basis. For an expansion project to be eligible for funding, an agency would need to be committed to producing water exceeding the existing facility annual production AF.

The program strongly encourages early coordination, and the funding is based on three incentive payment structures:

- Option 1: Sliding scale incentives up to $340/AF over 25 years
- Option 2: Sliding scale incentives up to $475/AF over 15 years
- Option 3: Fixed incentive up to $305/AF over 25 years

Applications must indicate an option.

Applications are accepted on an open and continuous basis until the target yield of 170,000 AF per year is fully subscribed. Applications must be submitted prior to the start of construction, and must include the following documents:

- A supporting letter from a member agency
- LRP application for the project according to application guidelines
- California Environmental Quality Act documents
- Permits – either obtained or in process

4.1.2 Future Supply Actions Funding Program

Future Supply Actions (FSA) is another MWD funding program that is focused on removing barriers to the development of groundwater, recycling, seawater desalination, and stormwater supplies. Although the FSA is currently not funded for 2019, future funding opportunities are anticipated over the next 2 years; as such, this program could be considered as another potential source of funding for any of the six potential Projects.

4.2 State Grant Options

4.2.1 California State Water Resources Control Board: Proposition 1 Groundwater Sustainability Program

This is a program supported by the Water, Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1). It is a matching grant program for the planning, feasibility, and implementation of projects that prevent or clean up contamination of an aquifer (SWRCB, 2019). For planning projects, the maximum award is $2 million. For implementation projects, the maximum grant is $50 million. The program also allows additional funding for the implementation of drinking water treatment for Disadvantaged Communities (DACs) or Economically Distressed Areas (EDAs), for a maximum grant of $5 million. To be eligible, the applicant must be a public agency; public utility; federally recognized Indian tribe; nonprofit; or a city, county, or town government. The applicant is required to provide a minimum cost share of 50 percent of the total non-DAC or EDA project cost. Other state funds (regardless of the issuing state agencies) cannot be used for the required match funds (SWRCB, 2018).

The State Water Resources Control Board (SWRCB), the agency that administers the program, is currently evaluating Round 2 projects (SWRCB, 2019). The SWRCB expects to open the Round 3 application process sometime in 2020.

4.2.2 Integrated Regional Water Management

The Integrated Regional Water Management (IRWM) Implementation Grant Program provides funding for implementation projects that meet the intent of Proposition 1, Chapter 7. The California Department of Water Resources (DWR) plans to award grants on a competitive basis in at least two funding rounds. Approximately $222 million in grant funding is being made available for implementation projects, with approximately $23.6 million being made available for projects that provide benefits to DACs. As required by legislation (Water Code Section 79742[d]), at least 10 percent of authorized funds will be reserved for projects that directly benefit DACs, with the minimum 10 percent requirement applied to each funding area. Of the $98 million allocated to the Los Angeles Funding Area under Proposition 1 IRWM Implementation Grant Funds, $68.6 million is currently available for disbursement.

To be eligible, the applicant must be a public agency; public utility; federally recognized Indian tribe; nonprofit; or a city, county, or town government. Eligible projects must already have been included in an adopted IRWM Plan.

The applicant is required to provide a minimum cost share of 50 percent of the total project cost. An applicant may request the local cost share requirement be waived or reduced for projects that directly benefit one or more DACs, EDAs, or both.

4.2.3 State Revolving Fund Loans

State Revolving Fund (SRF) loans are typically offered for terms of up to 20 years, although longer terms can be arranged in some circumstances. They typically are offered at below-market rates. The SRF program provides funds to a wide variety of eligible projects and borrowers and is compatible with other funding sources. The program has no maximum financing limits, though amounts offered will depend on the available funding and the applicant's ability to repay. Repayment begins 1 year after completion of construction (DWR, 2018).

In recent years, the SRF programs in some states, including California, have been over-subscribed, meaning that they have more eligible projects than funds available to loan, making qualification a highly competitive process.

4.2.4 Water Desalination Grant Program

Desalination Grants are funded by Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002; and Proposition 1, the Water Quality, Supply, and Infrastructure Improvement Act of 2014. Proposition 50 provided $50 million for grants to desalination of ocean or brackish water, while Proposition 1 allocates $100 million for desalination projects. The objective of the Water Desalination Program is to use grant funds to facilitate the use of desalinated water to meet the water resource needs of the state. The focus of the program is on the development of potable water for municipal uses. The program funds four types of desalination projects: construction, Feasibility Study, environmental documentation, and design pilot.

Applications are reviewed on a continuous basis, and the reviewed projects (Continuous Application Process [CAP]) are expected to be released on a quarterly basis until funds are exhausted. Based on the latest applications received, funding from both Propositions 50 and 1 is expected to be exhausted; however, there is a possibility that the program could receive funding from other sources.

4.3 Federal Grant Options

4.3.1 U.S. Bureau of Reclamation: WaterSMART Desalination Construction Projects

A funding opportunity under the Water Infrastructure Improvements for the Nation (WIIN) Act, the Desalination Construction Project funding program, is available for sponsors of ocean and brackish water desalination projects to request cost-shared funding for the planning, design, or construction, or some combination of these, of those projects. Recipients must provide at least 75 percent of the total project costs. Eligible entities include states, departments of a state, subdivisions of a state, or public agencies, and must be located in the Western United States (U.S.). A Feasibility Study must have been completed and submitted to the Bureau of Reclamation (Reclamation). Up to $12 million is available. Two to six awards are expected.

4.3.2 U.S. Bureau of Reclamation: WaterSMART Title XVI Water Reclamation and Reuse Program

A funding opportunity under the WIIN Act, the Title XVI Water Reclamation and Reuse Project funding program, is available for sponsors of projects eligible under Section 4009(c) to request cost-shared funding for the planning, design, or construction, or some combination of these, of those projects. Recipients must provide at least 75 percent of the total project costs. Eligible entities include states, departments of a state, subdivisions of a state, or public agencies, and must be located in the Western

U.S. A Title XVI Feasibility Study must have been completed and submitted to Reclamation. Up to $20 million is available. Four to eight awards are expected.

4.3.3 U.S. Bureau of Reclamation: Desalination and Water Purification Research Program Pitch to Pilot for Fiscal Year 2019

Reclamation launched a novel “pitch to pilot” funding program on April 30, 2019. The program seeks new innovative technologies or processes for desalination and water purification. Top applicants will pitch their ideas to reviewers for the chance to test through a pilot demonstration. Reclamation’s goal is “…to address a critical need to reduce the costs, energy requirements, and environmental impacts for treating unusable water” (Reclamation, 2019b).

Reclamation sees this as an opportunity to take a new approach from the laboratory to a real-world demonstration, providing products that serve the water treatment community and attract commercial interests. Specifically, Reclamation is seeking:

- A less energy-intensive way than current processes and technologies to treat brackish groundwater at the pilot scale
- To reduce the high cost, energy usage, and environmental impacts of concentrate management for inland desalination at the pilot scale
- To improve efficiency of treatment without increasing the total cost and energy usage of current systems for desalination pretreatment
- To address costs, energy usage, and environmental impacts of seawater desalination, including intakes and outfalls

Reclamation anticipates awarding four to six agreements with up to $150,000 available per agreement through its Desalination and Water Purification Research Program. Though not required, applicants are encouraged to provide a non-federal cost share.

To be eligible, applicants can be:

- Individuals or entrepreneurs
- Institutions of higher education
- Commercial or industrial organizations
- Private entities
- State and local government entities
- Federally funded research and development centers
- Tribal governments and organizations
- Nonprofit organizations

4.3.4 Water Infrastructure Finance and Innovation Act

The Water Infrastructure Finance and Innovation Act of 2014 (WIFIA) established a federal credit program administered by the U.S. Environmental Protection Agency (EPA) (EPA, 2019a). The WIFIA program accelerates investment in water and wastewater infrastructure of national and regional significance by offering loans to creditworthy borrowers for up to 49 percent of eligible project costs.

For each year that Congress appropriates funds for WIFIA subsidies, EPA publishes a Notice of Funding Availability (NOFA) that provides interested entities with WIFIA application information. In each NOFA, EPA identifies additional considerations for project prioritization (for example, repairing aging infrastructure and addressing drinking water contamination). The NOFA invites entities to submit a letter that validates the eligibility of the entity and project, provides preliminary engineering assessments and prospective borrower information, and evaluates the proposed project against the NOFA’s selection criteria. For the selected projects, prospective borrowers will be invited to formally apply to EPA within 1 year of the notice their selection. In the application, selected prospective borrowers provide EPA with materials necessary to underwrite the proposed WIFIA assistance and to develop, through negotiation, individual loan agreements between the applicant and EPA.

WIFIA loans have distinct benefits that are not readily available in the capital markets. The WIFIA program can act as a patient investor and offer credit assistance with extended maturities due to the federal government's long-term investment horizon. It can offer borrowers the advantage of developing customized terms, including sculpted repayment terms to match the specific needs of a project. Finally, the WIFIA program lends at a low, fixed interest rate equal to the Treasury rate for a comparable maturity.

The WIFIA program is intended to complement existing funding resources rather than supplant them. All projects that receive WIFIA credit assistance must be co-financed with other sources of funding, including tax-exempt or taxable bonds, loans, grants, and equity.

4.3.4.1 Eligibility

Eligible borrowers include:

- Corporations
- Partnerships
- Joint ventures
- Trusts
- Federal, state, or local government entity, agency, or instrumentality
- Tribal government

4.3.4.2 Eligible Projects

Wastewater projects that are eligible for the Clean Water SRF include:

- Drinking water projects that are eligible for the Drinking Water SRF
- Projects that enhance energy efficiency
- Projects for repair, rehabilitation, or replacement of treatment works, community water systems, and aging distribution or waste collection facility
- A brackish or seawater desalination facility, including recharge project, recycling project, or alternative water supply to reduce aquifer depletion
- The acquisition of real property
- A combination of eligible drinking water or wastewater projects

For a project to be eligible for WIFIA credit assistance, the project's eligible costs must be at least $20 million. This threshold is lower for projects serving small communities. Small community projects must be reasonably anticipated to total at least $5 million. The statute defines projects in small communities as drinking water and wastewater projects that serve a community of not more than 25,000 individuals.

Eligible projects carried out by private entities must be publicly sponsored. To satisfy this requirement, the prospective borrower must demonstrate that it has consulted with and gained the support of the affected state, local, or tribal government in which the project is located. The prospective borrower can show support by including a certified letter signed by the following:

- Supporting state, tribal, or municipal department, or similar agency
- Governor, mayor, or other similar designated authority
- Statute or local ordinance
- Any other means by which government approval can be evidenced

Projects applying for WIFIA credit assistance must demonstrate a reasonable assurance of repayment of the credit instrument over the term of the requested assistance.

4.3.4.3 Eligible Project Costs

Eligible project costs are those associated with the following activities, as defined in the statute:

- Development-phase activities, including planning, feasibility analysis (including any related analysis necessary to carry out an eligible project), revenue forecasting, environmental review, permitting, preliminary engineering and design work, and other preconstruction activities
- Construction, reconstruction, rehabilitation, and replacement activities
- The acquisition of real property or an interest in real property (including water rights, land relating to the project, and improvements to land), environmental mitigation (including acquisitions that would mitigate the environmental impacts of water resource infrastructure projects otherwise eligible for WIFIA credit assistance), construction contingencies, and acquisition of equipment
- Capitalized interest necessary to meet market requirements, reasonably required reserve funds, capital issuance expenses, and other carrying costs during construction; capitalized interest on WIFIA credit assistance may not be included as an eligible project cost

Additionally, indirect costs allocable to the development, oversight, or management of a project are generally eligible, subject to a federally negotiated cost rate, as well as fees charged by the WIFIA program.

Projects receiving WIFIA credit assistance must comply with all relevant federal laws and regulations. The WIFIA program is currently in its third year of operation. Because it has been deemed a successful addition to federal funding support in the water industry, the budget for the Program has been increased each year. For the current (Year 3) cycle, the EPA budget will enable Treasury loans of $6 billion to eligible applicants, resulting in funding for more than $12 billion in infrastructure when the 51 percent non-WIFIA matching funds are included (EPA, 2019b).

EPA released the fiscal year 2019 NOFA to solicit letters of interest for WIFIA loans on April 5, 2019.

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Appendix I
Project Delivery Plan

Technical Memorandum

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Subject	**Project Delivery Analysis**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 15, 2019
Prepared by	Leofwin Clark, Brown and Caldwell Jonathon Johnson, Brown and Caldwell
Reviewed by	Pat Tangora, P.E., Brown and Caldwell
Reference	152586.008

1. Introduction and Purpose

1.1 Introduction

This Technical Memorandum (TM) presents the findings of a Project Delivery Analysis performed for potential delivery methods for the new brackish water reclamation facility projects that have been identified in the broader feasibility study. The analysis includes the following scope elements:

- An overview of applicable delivery methods for the size and types of projects anticipated to be components of the Regional Brackish Water Reclamation Program (Program)
- A summary of current best practices and conventional wisdom, including nomenclature, for each anticipated relevant delivery model
- A summary of the California statute and Water Replenishment District of Southern California (WRD) procurement practice that affects the various delivery model options that can be implemented by WRD
- A summary of the WRD-specific issues, risks, experience, and potential stakeholder concerns that impact the determination of a delivery method
- An initial, high-level strengths and weaknesses assessment for each scope element comprising the brackish water reclamation facility projects being considered in the feasibility study in relation to the available delivery models
- Based on this evaluation of delivery model strengths and weaknesses, an initial recommendation of delivery models to avoid (or eliminate) or to emphasize (or elevate in consideration) in the future

1.2 Background

The WRD is responsible for managing and replenishing both the West Coast and Central groundwater basins. To fully use the West Coast Basin, WRD has initiated a Program to evaluate ways to remediate a trapped saline plume. Program goals include treating the plume to produce potable water and discharging waste streams generated (mostly high-salinity brine) in the treatment process. The Program includes the analysis of numerous different "Projects" at a number of potential sites, each consisting of various combinations of scope components to:

- Extract the water from the plume
- Treat the water to potable standards
- Convey the treated potable water to the Program stakeholders
- Manage the brine stream via conveyance to existing treatment facilities (or to ocean outfalls)

The potential delivery methods may impact WRD and the Stakeholder Group in numerous noneconomic aspects of the Program. These include:

- Schedule considerations
- Permitting processes
- Performance accountability
- Control and oversight of various Project scope components at various stages of planning, design, and construction

In an overall characterization, the selection of a given delivery method for a given Program scope component will largely define the risk allocation that may be retained or transferred to a designer, builder, and optional operator. These noneconomic considerations are the primary focus of the TM.

The Program also includes the calculation of the economics of each Project, encompassing a summation of the anticipated cost of each of the scope components. These potential costs, and the resulting economic analysis, may be significantly impacted by the procurement and delivery method with which the Projects are implemented, especially given the potential to include private financing as a funding source and to include private operations and maintenance (O&M) and repair in the delivery scope. These economic considerations are closely aligned with the delivery methods identified in this TM, but are considered in detail in the accompanying *Value for Money Analysis TM*.

In considering both the noneconomic and economic factors of potential delivery methods, consideration is included for interface with – or delivery by – seven additional stakeholders (known as the Stakeholder Group). The Stakeholder Group has expressed interest in treating the saline plume, receiving the treated water, or both, as part of the Program. The members of the Stakeholder Group either pump, hold water rights, or have other key roles in supporting the basin operations.

The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

2. Overview of Applicable Delivery Methods

Procurement methods and their resulting delivery models take numerous forms, ranging from standard design-bid-build (DBB) techniques, through construction management-at-risk (CMAR), to turnkey approaches with significant risk transfer, including many variants of design-build (DB). While many of these methods have historically been referred to as "alternative" project delivery, widespread industry acceptance has shifted them to the mainstream. As a result, and given the fundamental premise of collaborative engagement between Owners and their stakeholders, planners, engineers, operators, and constructors, "collaborative delivery" is used as a term-of-art to encapsulate the full spectrum of options beyond traditional DBB.

The spectrum of collaborative methodologies also can encompass variations that include operations scope and private financing participation. For example, methodologies that include O&M support are often designated as design-build-operate (DBO). Models that include funding support via private equity and financing (often in conjunction with O&M, as well) are often designated as public-private partnerships (P3s).

Funding options and related value for money (VfM) analyses can also be considered in parallel with the delivery model analyses. Recognizing that DB methodologies are fundamental to any P3 approach, the intent is to identify the best delivery methods for design and construction and apply O&M and P3 concepts as enabling or value-added improvements to the preferred approach.

Another consideration in assessing the collaborative delivery spectrum is permissibility under applicable state and local statutes. As the Program includes projects currently defined only at an early feasibility phase, it is recommended that the Stakeholder Group consider all potential options, only eliminating from consideration those that are clearly prohibited. As such, the approach to this initial Project Delivery Analysis is to identify the best model. Should a preferred delivery model be in conflict with current statute (or, more likely, require interpretation of a statute's applicability and specific requirements), early legal review is recommended. Upon legal review, the preferred model may need to be adapted as-needed to comply – or the Program may opt to pursue legal or procurement policy relief via other means.

The spectrum of available options recommended for consideration is illustrated on Figure 1.

(Note that delivery model graphics are based on those published by the Water Design-Build Council [WDBC] in the Fourth Edition of the Water and Wastewater Design-Build Handbook *and are used with permission by Jacobs and Brown and Caldwell as full members of the WDBC.)*

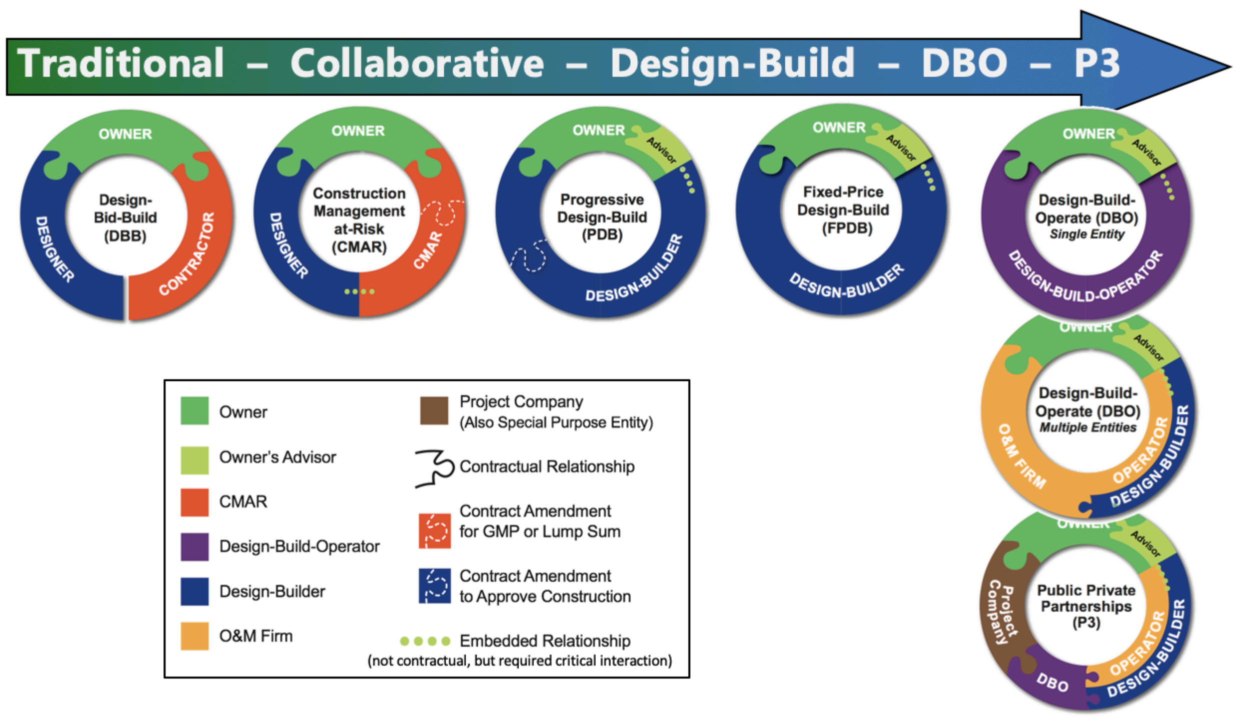

Figure 1. The Project Delivery Method Spectrum

The project delivery and procurement methods shown on Figure 1 have generally evolved from the traditional DBB approach as the baseline most commonly used by public entities. In recent decades, the various collaborative delivery methodologies have emerged as viable alternatives to traditional delivery. These alternatives to DBB seek to better allocate risk and responsibility, save time, and support a selection methodology beyond low-bid capital price. The potential improvement to traditional delivery is supported by redefined contractual relationships. These relationships are shown on Figure 1 via two forms:

1) Formal Contractual Relationships (illustrated with the puzzle piece) indicate firm relationship agreements executed between the given entities (dotted puzzle lines refer to the substantive contract amendments that are required to lock in a guaranteed price for construction).
2) Embedded Relationships (illustrated with the dotted green line) represent the collaborative connections required, but not formally contracted, to make the given model a success.

Each of the traditional and collaborative project delivery methods has its own attributes that generally differ in terms of:

- Allocation of risks and responsibilities
- Scheduling and schedule certainty
- Ownership
- Performance guarantees
- Procurement complexity

In practice, the Stakeholder Group may opt for a combination of delivery methods across various components of the Program. Discussions follow of the four primary delivery methods identified on Figure 1.

2.1 Traditional Two-Contract Methods

Traditional public works contracting is fundamentally based on a two-contract approach: one for the professional services related to architecture, design, and engineering; and a second related to the physical construction of a facility according to the plans developed under the previous professional services contract. This approach evolved to create a distinct separation between design and construction and remains the predominant public works contracting methodology today, although, in some states where alternative methods are allowed, DB methods are arguably close to becoming the preferred approach.

2.1.1 Design-Bid-Build

DBB has historically been the most common approach to development of public infrastructure projects. The DBB process has also been used extensively by the private sector to procure new facilities. For the sake of comparison, DBB is considered the baseline contract delivery model for public entities (Owners).

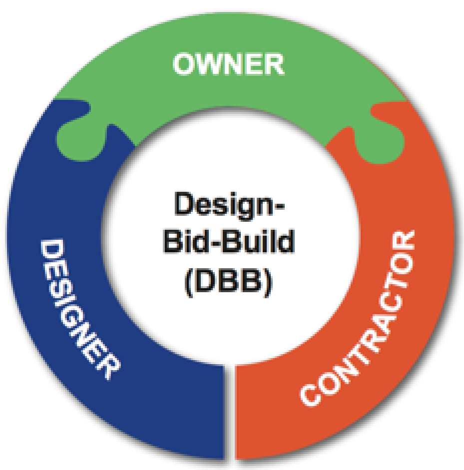

Figure 2. Design-Bid-Build Process

A typical DBB project involves the Owner engaging one or more engineering firms to develop a detailed design and specifications, and to assist with obtaining local, state, and federal approvals for the project (Figure 2). The Owner then uses the detailed design and specifications package as part of a tender package to obtain bids from contractors. The contractor selected through the bidding process is subsequently engaged to construct the facility in accordance with their bid price and schedule. Typically, the contractor is paid monthly progress payments, and the Owner applies holdbacks on payments (for example, retainage) in accordance with governing state or local law.

Table 1 lists the advantages and disadvantages of DBB.

Table 1. Advantages and Disadvantages of Design-Bid-Build

Advantages to Owner	Disadvantages to Owner
• Well-understood and time-tested process and procedures. • Ability to select design consultants by qualifications and cost in the traditional manner. Limited at-risk exposure to local professional firms. • Bids to full plans and specifications. • Full going-in construction price known at bid time. • Fully accepted and viable under applicable procurement statutes	• Design limited to Standard of Care, limiting performance risk transfer potential. • Linear process takes time. • Little or no designer or contractor collaboration. • Predesigned approach may not support best potential construction technologies and best practices. • Relies on engineer's estimates until very late in the project. • Hard bids subject to design omissions, resulting change orders. • Limited opportunity to select contractor on qualifications and past performance in addition to price. • Separate contracts for design and construction creates multiple points of contact for Owner and does not align business interests. • Not readily conducive to integration of a lifecycle evaluation component or a performance-based operations commitment. • Not consistent with the required permitting and approval process for a major wet weather project (e.g., integration of design, construction, and operations components required for the permitting process).

Typically, on a DBB project, the design definition and permitting phases must be completed before a project can be released for the detailed design for construction. This sequence leads to a longer overall delivery schedule. However, because approvals are completed prior to bidding, this approach reduces the Owner's exposure to post-bid permitting delays or unexpected changes in permit conditions.

Roles in a DDB project are normally very clearly defined. Design and a Standard of Care risk lies with the design team. Construction and scheduling risks lie with the contractor. Operations risk rests with the Owner. However, contractors and operators may not have significant input into the design, which can contribute to change orders. Claims during construction are common, and the requirement for some redesign during construction exists, typically at the Owner's cost. In addition, design performance or lifecycle responsibility and risk is not typically transferable using DDB delivery.

2.1.2 Construction Management At-Risk

CMAR, referred to in some geographies at General Contractor/Construction Manager (GC/CM), is also considered a traditional delivery model, albeit an improved approach where an intentional overlap is created between the engineer and the contractor, allowing the contractor to bring construction insight to bear as early as practical in the design process (Figure 3). Sometimes referred to as "design-build-light," this methodology maintains two separate contracts between the Owner and the design and CMAR firms, similar to DBB, but encourages collaboration during design, since the contractor is hired early in the design development process to reduce risk once the contractor proceeds to construction in the field.

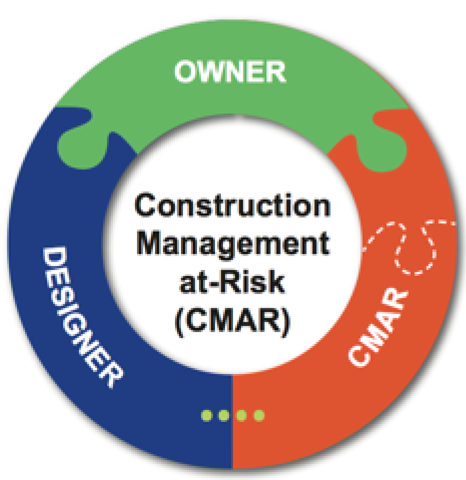

Figure 3. Construction Management At-Risk

While in conformance to most traditional procurement processes (where the engineer is selected using traditional professional services criteria), this method introduces the concept of contractor selection without a hard bid of the construction cost. Instead, contractors are generally selected based on their qualifications in combination with their proposed scope of services and fee for service prior to construction, as well as their fee and overhead costs for construction services. The ultimate construction cost is developed during the design period, typically in an open-book fashion, and ultimately agreed upon as a guaranteed price (GP). The GP can be implemented at the Owner's discretion, as a guaranteed maximum price (GMP) or as a lump sum (LS) prior to authorizing the start of construction.

A GMP approach is delivered on an open book basis where actual construction costs are transparent to the Owner. Project costs exceeding the GMP are the CMAR's responsibilities, and savings from underspending the GMP revert to the Owner, although a shared savings incentive is often used to split the savings in some ratio with the CMAR. The GMP option requires administrative resources to track actual construction costs, but provides assurance to the Owner that any excessive contingency or other unspent costs will be returned, at least in part.

An LS approach proceeds to construction without further auditing of actual construction costs incurred by the CMAR, and any underrun or overrun relative to the LS accrues to the CMAR. The LS option reduces administrative burden and simplifies the construction phase, but with the recognition that the CMAR can earn additional profit for underrunning expected costs.

Where agreement on a GP cannot be reached or construction pricing competitiveness cannot be verified, CMAR contracts almost always contain a provision to convert the construction scope to a hard bid process. This is commonly known as the contractual "off-ramp."

While promoting collaboration early in the design process, the formal contract vehicles with separate agreements between the Owner and engineer and the Owner and contractors are essentially unchanged compared to traditional DBB delivery. During construction delivery, traditional practices for managing contractor change orders, requests for information (RFIs) from the designer, and verification of construction performance remain unchanged.

Table 2 lists the advantages and disadvantages of CMAR.

Table 2. Advantages and Disadvantages of Construction Management At-Risk

Advantages to Owner	Disadvantages to Owner
• Relies on proven, accepted method for selecting professional engineering services based on qualifications and price. • Integrates constructability earlier in the design process. • Provides contractor-led estimates earlier and allows scope revision during design to meet project budget. • Can reduce overall project risk and contingency. • Can reduce design misunderstandings and resulting potential for change orders. • Allows qualifications and past performance to be considered when selecting a contractor. • Allows permitting process to be integrated into design and construction planning.	• Design limited to Standard of Care, limiting performance risk transfer potential. • Relies on engineer's estimate for initial cost characterization. • Creates a "forced marriage" between designer and contractor that may – or may not – work. • Final construction scope still subject to change order potential. • Added cost to Owner for contractor's preconstruction phase services (although may be offset with construction savings due to early collaboration). • Requires selection of contractor based on fees without knowing full construction price. • Separate contracts for design and construction create multiple points of contact for Owner and does not align business interests. • Does not inherently allow support performance risk transfer - design obligation is traditional Standard of Care, and construction obligation is to build according to the specified design. • Not readily conducive to integration of a lifecycle approach or a performance-based operations commitment.

2.2 Single-Contract Design-Build

Under a DB structure, the Owner enters into a single contract with a design-builder (a single company or a consortium of entities acting together as one entity, such as a Joint Venture [JV]). Generally, the design-builder has the responsibility of designing and building a project that meets Owner-prescribed performance standards, and the Owner then pays the design-builder based on certain construction and performance milestones being achieved.

In practice, DB can be procured using a number of different methods, tailored to meet procurement statutes and practice, as well as to align with project complexity and the level of design completion anticipated prior to the procurement. DB models also support performance risk transfer for both design and construction delivery, as well as provide a basis for O&M and financing approaches.

The various forms of DB differ largely in the type of pricing requested of proposers and in the degree of solution definition developed for the project in advance of a procurement and subsequently provided to the design-builder in the request for qualifications (RFQ) and request for proposal (RFP). For this Program's purposes, two fundamental DB models are considered, as discussed in the following subsections.

2.2.1 Progressive Design-Build

In a Progressive Design-Build (PDB) procurement, a design-builder is selected based primarily on qualifications and, where local practice requires it, limited pricing information generally similar to the CMAR model, with an added component of cost for design and preconstruction services (Figure 4). As the design-builder develops the design, a construction cost estimate is progressively developed, often in conjunction with the 30 and 60 percent levels of design detail. Once the design is well advanced (beyond 60 percent and often up to 90 percent), a GP is defined for approval by the Owner. (As with CMAR, the Owner has the option to implement the GP as a GMP or LS). If the design-builder and the Owner cannot reach agreement on an acceptable GP, the Owner can use the completed design as the basis for a hard construction bid procurement or a fixed-price DB procurement.

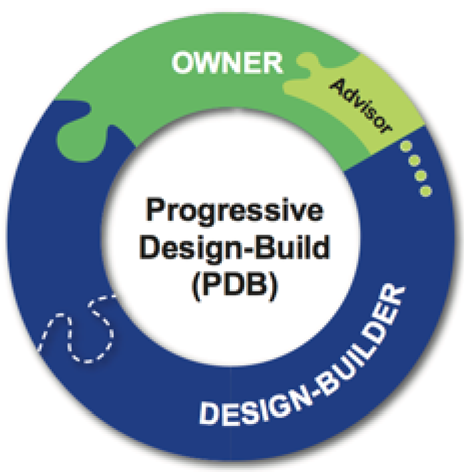

Figure 4. Progressive Design-Build

PDB procurements are often preferred when a project lacks definition or final permitting, or when an Owner prefers to remain involved in the design process while leveraging the schedule, collaboration, and contractual advantages provided by a DB approach. This model is also valuable when regulatory permitting requires well-developed design solutions, or when an Owner believes that they can lower cost by participating in design decisions and managing risk progressively through the project definition phase.

Owners do not generally use the progressive procurement method when a project's definition is well advanced prior to the procurement or when an LS construction price is preferred (or required) to select a design-builder.

Table 3 lists the advantages and disadvantages of PDB.

Table 3. Advantages and Disadvantages of Progressive Design-Build

Advantages to Owner	Disadvantages to Owner
• Maximum control over project design, construction, and O&M lifecycle costs because final contract is not signed until a large portion of the design is complete. • Single, straightforward, and inexpensive procurement process can be completed in a short time frame. • Increased marketplace interest due to relatively low proposal preparation cost. • Allows selection of designer and contractor based on past performance, qualifications, and ability to work as a single-entity team with aligned interests for project success. • Provides progressively accurate contractor estimates of total project costs from earliest point in project through GP definition. • Provides maximum opportunity for designer, contractor, and Owner collaboration to define scope, meet schedule and budget, and tailor subcontracting plan. • Provides on off-ramp to hard-bid construction if GP is not competitive or cannot be agreed upon. • No contractor-initiated change orders. • Requires little or no design to be completed by Owner in advance of procurement, and provides maximum flexibility in a final determination of project viability for economic and noneconomic factors. • Provides a performance risk transfer mechanism that can be implemented in conjunction with long-term operations commitments. • Single contract and point of contact with Owner.	• Requires selection based on fee; full construction cost is not known at the time of initial contract. • Existing project design investment may not be of value or use to design-builder. • May not be as fast to deliver as other DB methods due to potential for extended design and estimate development period, including involvement of numerous stakeholders in the design process. • May not be perceived as being competitive for construction pricing, particularly self-performed work that is not bid out as subcontracted scope. • Requires significant Owner staff involvement and resources during design. • May limit local and small subconsultant participation due to at-risk nature of the work.

2.2.2 Fixed-Price Design-Build

In the Fixed-Price Design-Build (FPDB) process, the RFQ and RFP generally include a conceptual design as a minimum and a 30 percent design (sometimes referred to as a “bridging” design) as a maximum. Requirements for a prescriptive approach rely on these predesign documents as required templates for the design-builder (Figure 5).

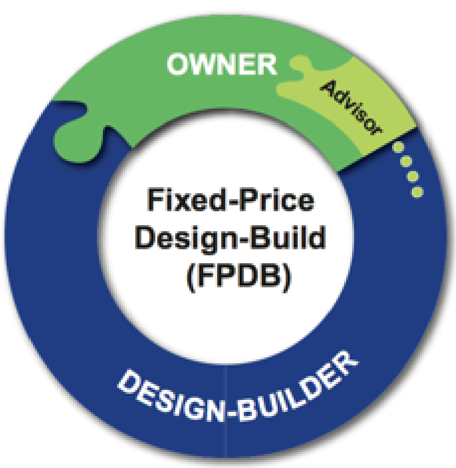

Figure 5. Fixed-Price Design-Build

Requirements for a performance-based approach are stated as measurable performance objectives of the completed project rather than the specific approaches or processes the design-builder should follow to achieve those objectives.

FPDB is often considered as a highly competitive contract delivery model given its industry-recognized success in supporting large, complex projects.

A performance-based procurement gives a design-builder the flexibility to propose how they will meet the Owner’s objectives, while requiring proposers to provide an LS, fixed price for completion of the project. This attribute of FPDB creates a “design competition” that may result in innovative or unanticipated solutions. Alternatively, the Owner may ask for a “target price” for construction that establishes a not-to-exceed construction price basis, while allowing the Owner to collaborate on and adjust scope during detailed design definition. In this case, the target LS can be adjusted after award, but only as directed via Owner-approved scope changes. Except for these explicitly approved Owner changes, the design-builder must conform to their originally proposed price. Thus, this option provides some confirmation of a set price for the project.

Performance-based procurements are often preferred when an Owner has a clear vision for how a facility must perform, or has limited resources, time, or interest in the specific method for gaining required performance. This model is used to prompt innovative and cost-effective solutions through what is essentially a design competition, typically in combination with a need to accelerate schedule.

Table 4 lists the advantages and disadvantages of FPDB.

Table 4. Advantages and Disadvantages of Fixed-Price Design-Build

Advantages to Owner	Disadvantages to Owner
• Maximum potential for DB cost savings through design innovation during competitive procurement. • Maximum schedule acceleration opportunity. • Maximum transfer of design-related performance risk to design-builder. • Perceived as competitive construction pricing, providing full contract cost at bid time. • Allows selection of designer and contractor based on past performance, qualifications, and ability to work as a single-entity team with aligned interests for project success. • No contractor-initiated change orders. • Provides a performance risk transfer mechanism that can be implemented in conjunction with long-term operations commitments. • Can create a design competition that results in innovative solutions. • Single contract and point of contact with Owner.	• If lifecycle cost is not analyzed or operations not included in scope, may result in higher O&M costs or undesirable project features. • Upfront design work by Owner and consultant required to define the project in advance of a procurement process, sometimes resulting in increased effort and time to prepare an RFP. • Proposal evaluation and selection is relatively complex. • Limited ability to predict what will ultimately be proposed. • LS pricing may include excess risk and contingency cost due to undefined project scope. • Limited opportunity for Owner and design-builder collaboration on design during procurement process. • Limited ability for Owner to adjust proposed design, scope without resulting in Owner-initiated change orders and resulting price adjustments. • Being overly prescriptive may have the effect of retaining risk for the Owner. • May limit local and small subconsultant participation due to at-risk nature of the work.

In a prescriptive FPDB procurement, the RFQ and RFP typically include at least a 30 percent design completed by an Owner's consultant prior to the procurement, sometimes referred to as "bridging documents." Requirements are stated in terms of specific approaches or processes the design-builder must follow.

Prescriptive procurements are often preferred when Owners are very clear on their preferences and want to use DB to accelerate the schedule while allowing selection of a design-builder based on a combination of qualifications and an LS price. While a design-builder may offer a variation or alternative concept to the bridging documents, procurement procedures are often established to require Owner review and approval of these exceptions or alternative technical concepts in advance of the proposal submittal. With this method, the LS price in the design-builder's proposal is only adjusted for specific Owner-initiated scope changes, generally due to unforeseen conditions or a change in law or regulatory practice. Overly prescriptive approaches may have the effect of retaining risk for the Owner, as the design-builder can make a case for having to implement a solution not entirely within its control or discretion.

2.2.3 Design-Build-Operate

In a DBO approach, a long-term partnership exists between the Owner and the DBO entity, whereby the latter builds the necessary infrastructure and subsequently operates it to deliver the service. DBO contracts are typically performance-based and have terms of 10 to 20 years. The Owner normally retains control over the project through ultimate ownership of the asset (Figure 6).

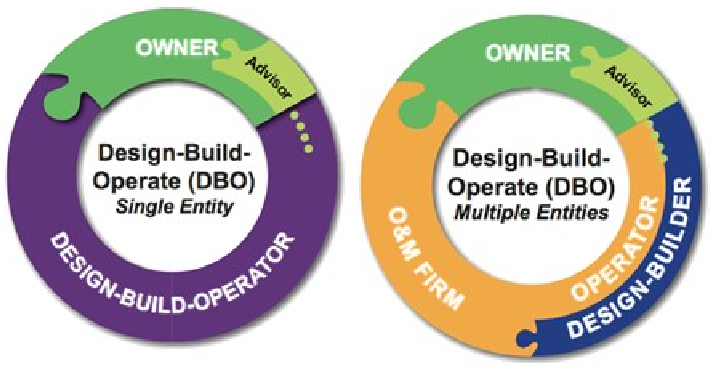

Figure 6. Design-Build-Operate

The DBO approach involves shared risks, benefits, decision making, and responsibilities. One of the main drivers for considering a DBO model for infrastructure procurement is that it encourages the entity to optimize the tradeoffs between initial construction costs and longer-term maintenance and rehabilitation costs because the entity is responsible for both. For the Owner, a DBO model can be used to reduce resource requirements and, where a design-build-finance-operate (DBFO) contract is used, the amount of capital needed at the beginning of a project. However, it is critical that the DBO agreement incorporate clauses regarding useful asset life and repair of damages at the hand-back.

DBO projects may be procured under either the prescriptive- or performance-based fixed-price methods described or, although less common, as a PDB with an operations component.

Table 5 lists the advantages and disadvantages of DBO.

Table 5. Advantages and Disadvantages of Design-Build-Operate

Advantages to Owner	Disadvantages to Owner
• Opportunity to include long-term operations and lifecycle cost. • Provides for numerous turnkey delivery options. • May provide method for obtaining project financing not otherwise possible.	• Requires long-term (10 years or more) commitment to contract mechanism and future payments. • Can be complex to implement and controversial. • While legal in most states, may encounter public employee union resistance.

The initial capital cost of the infrastructure for a DBO can be paid for by the Owner up front during the construction process (as would be done in a DBB model), or the capital can be amortized and paid for over the term of the DBO agreement, resulting in a DBFO agreement. As P3s have emerged in the water sector, the DBFO model has been included under the P3 umbrella.

2.3 Public-Private Partnership

A public-private partnership, often referred to as P3, typically involves a form of collaborative delivery with financing support, combined with a performance commitment and some level of responsibility for O&M of a capital works project. P3s almost always embed collaborative delivery for the design and construction of a project. P3s also typically expand the collaboration model by including long-term operations, maintenance, repair, and capital renewal.

Currently, there is no uniformly accepted definition of P3 in the water and wastewater market sector. For example, water and wastewater P3s may – or may not – include financing or long-term operations. Most commonly, the private sector design, builds, finances, and provides some form of O&M; and a public entity owns the infrastructure.

As public agencies look to broaden their collaborative-delivery options for water and wastewater projects, the evolving P3 model may be suited to meet specific needs under the right conditions, including:

- Obtaining all, or a portion, of the funding from alternative financing sources using a combination of private equity and debt that is typically repaid by the public Owner after construction is complete
- Promoting development of innovative projects that would otherwise fall outside a public entity's capabilities

- Leveraging the value of existing infrastructure assets to help fund economic development initiatives or resolve budget challenges
- Increasing accountability, and efficiency, and optimizing assets, through the use of private resources and expertise
- Allocating a portion of the delivery and performance risks to private entities, with the public interest and performance secured through strong contractual control of the future repayment stream
- Providing flexibility in project structuring and governance
- Supporting a business case to offset the potential added cost of private funds in return for added performance commitments and risk transfer
- Accessing unique technology solutions by allowing design flexibility in conjunction with appropriate performance guarantees
- Providing a mechanism for rate stability by providing price certainty for an extended term of operations, maintenance, and capital renewal

Generally, water-related P3 projects fall under two models: DBFO, where a shorter-term financing component is focused on the capital works; and a design-build-operate-finance-and maintain (DBOFM) model, where the longer-term capital repayment is tied to the operations period, which includes maintenance and repair of a facility.

3. Applicable California Statute and Practice

3.1 Design-Bid-Build

The DBB project delivery method conforms with California statutes, and its practice is accepted throughout California.

3.2 Construction Management At-Risk

Although recent California legislation, Senate Bill (SB) 914, signed into law in 2018, expanded eligibility of using CMAR under the California Public Contract Code (PCC) Section 20146 to “County-dependent” entities, a CMAR delivery approach for this Project may not be allowed for entities such as WRD (a Special District) due to the PCC’s current definition of “public entity” for CMAR projects:

- PCC Section 20146. (a) “A county, with approval of the board of supervisors, or a public entity, with approval of its governing body, may utilize construction manager at-risk.”
- “’Public entity’ means a public entity of which the members of the county board of supervisors make up the members of the governing body of that public entity.”

It may be possible to conduct a detailed legal review and look for special interpretation of the state PCC for the WRD’s ability to use CMAR; however, such a process may bring cost and schedule implications.

3.3 Design-Build

Current DB codes are based on the DB law adopted pursuant to SB 785 and located in PCC Sections 22160-22169 (SB 785).

DB project delivery is available to local agencies, such as WRD and public-entity stakeholders. PCC Section 22161(f) defines local agencies as follows:

> *(1) A city, county, or city and county.*
>
> *(2) A special district that operates wastewater facilities, solid waste management facilities, water recycling facilities, or fire protection facilities.*

(3) Any transit district, included transit district, municipal operator, included municipal operator, any consolidated agency, as described in Section 132353.1 of the Public Utility Code, any joint powers authority formed to provide transit service, any county transportation commission created pursuant to Section 130050 of the Public Utilities Code, or any other local or regional agency, responsible for the construction of transit projects.

The types of projects for which local agencies may use the DB method are defined in PCC Section 20175.2:

"…construction of a building or buildings and improvements directly related to the construction of a building or buildings, county sanitation wastewater treatment facilities, and park and recreational facilities, but does not include the construction of other infrastructure, including but not limited to streets and highways, public rail transit, or water resources facilities and infrastructure."

3.4 Design-Build-Operate

The award of a contract for DBO services is now expressly prohibited, except for operations during a training or transition period of typically no more than a year beyond Substantial Completion (PCC Section 22164 [a] [2]). SB 785 clearly limits contract awards to DB. As a result, if a city or agency desires to award a contract that includes an operation component after a new facility is constructed, it must seek other contracting authority, such as under the Infrastructure Financing Act applicable to fee-producing infrastructure facilities (Government Code Section 5956-5956.10) or the Energy Conservation Contract statutes (Government Code Section 4217.10-4217.18.) or the P3 statute noted herein.

3.5 Public-Private Partnerships

Current statutory authority in California does allow for P3s for municipal facilities and environmental projects (water, wastewater treatment, stormwater, flood mitigation). The authority that allows P3s in California is found under the Infrastructure Financing Act applicable to fee-producing infrastructure facilities (Government Code Section 5956-5956.10) or the Energy Conservation Contract statutes (Government Code Section 4217.10-4217.18).

3.6 Summary of Allowable Delivery Models

The following heat map illustrates the ability of each of the Stakeholder Group entities to deliver the Projects under consideration in the feasibility analysis, assuming the given entity is the contracting authority. Stakeholders with California Charter City status may pass local procurement statues that contradict state statute restrictions on CMAR or DBOs. Counties or agencies with a county-appointed board of directors (versus locally elected boards) may use CMAR. Private entities are assumed to not be subject to public procurement statues, although certain Public Utility Commission requirements may pose additional restrictions in certain cases. As previously noted in Section 1, the Stakeholder Group includes:

- WRD, a special district
- LADWP, a department of a California Charter City
- City of Torrance, a California Charter City
- City of Manhattan Beach, not a California Charter City
- City of Lomita, not a California Charter City
- GSWC, a private entity
- Cal Water, a private entity
- WBMWD, an agency with an elected board of directors.

Note that Table 6 does not presume previous experience with any potential delivery method; therefore, it does not indicate a given stakeholder's *willingness* to use any indicated delivery method.

Green areas represent a clear state statutory authority or ability to implement the method shown.

Yellow areas represent a reasonable assumption that the method shown could be implemented, although the stakeholder may be required to pass specific rules as a California Charter City to implement its own authority for the given delivery method.

Red indicates a prohibition on the model.

Table 6. Stakeholder Heat Map

Delivery Models	WRD	LADWP	Torrance	Manhattan Beach	Lomita	GSWC	Cal Water	WBMWD
Traditional								
DBB								
CMAR	2	1	1	2	2			2
Design-Build								
PDB								
FPDB								
DBO	3	1	1	3	3			3
P3								
DBFO						4	4	
DBOFM						4	4	

Notes:

1. As California Charter Cities, these entities may use these methods if a specific policy or rule authorizing the method is passed by their respective city council.
2. For CMAR, a public entity allowed to use CMAR is defined as a county or an entity with a county-appointed board. Other entities are not specifically allowed to use CMAR.
3. Non-California Charter Cities are subject to state statute that prohibits DBOs.
4. Assumed to be allowed as a business arrangement at a private entity's discretion, but would likely not constitute a P3 under the state statue definition (which applies to public, not private, entities).

4. Entity-Specific Delivery Model Considerations

Issues, risks, experience, and potential Stakeholder Group concerns that impact the determination of a delivery method for any public entity fall into the four general areas discussed in this section. These considerations do not include the specific types or scope of the projects included in this feasibility study. Instead, this initial filter serves to eliminate delivery models that are not applicable for reasons outside of specific project scope, and to elevate potential delivery models because they may offer specific benefits to the Program, regardless of the type of project to which they are applied. The following considerations for WRD exemplify the type of analysis that should be conducted for any of the potential stakeholders that may sponsor or procure projects within the Program

4.1 Previous Experience and Organizational Comfort

WRD's primary project delivery experience is based on the traditional DBB format. Existing procurement policy and practice readily support DBB and appear to be sufficient for WRD's legacy well and conveyance projects. DBB is likely most common to all Program stakeholders.

As WRD and the Program's Stakeholder Group considers the implementation of additional treatment projects, collaborative delivery clearly has a place on the delivery method roster. For example, WRD's primary foray into the non-DBB arena is the Albert Robles Center for Water Recycling & Environmental Learning (ARC, formerly GRIP) project. Procured primarily in 2015, this project used a modified form of PDB with a planned extended commissioning period. While an extensive delivery analysis of this project was not conducted, anecdotal feedback from WRD staff provides two key insights:

1) The DB method is viable for WRD, but experience may dictate some adjustments as to how it is implemented for future projects. The ARC delivery will provide valuable lessons learned for future treatment-related projects.
2) The ARC project was procured prior to widespread acceptance of the progressive method of implementing DB; as a result, some caution was taken in implementing the project according to interpretation of the relative California DB statues in effect at the time.

Based on these two observations, WRD does have existing internal insight to implement a procurement policy development or revision to accommodate a DB approach, if desired. In addition, WRD may encounter more flexibility on the type of DB it chooses to use, as the past several years have seen a significant body of California precedent in implementing the progressive form of DB, even though it is not specifically authorized in the state statute as such (it should be noted that the state statue itself has been revised). While not surveyed at this time, it is likely that other Program stakeholders are likely to fall under similar circumstances.

To be determined as ARC is completed and put into full operation is WRD's experience and preference for third-party operations support. This experience may inform future comfort with extended operations periods (most likely under a P3 format due to restrictions on DBOs within the DB statute); operations by other stakeholder public entities; or avoidance of third-party operations in lieu of developing in-house capabilities.

Beyond the evolving ARC experience, WRD staff have indicated a willingness to explore collaborative delivery methods, albeit with some caution. Specifically, the issue of in-house control over design and performance standards was raised, with a desire to be cognizant of how risk and Owner control is balanced in a fixed-price model.

4.2 Legislative and Policy Authority

Current California statute restricts and may prohibit WRD and Program stakeholders' ability to use CMAR and DBO. For CMAR, there is some precedent elsewhere in California for using a form of delivery that mirrors CMAR in its approach (for example, design-assist contracting used by the City of Roseville). CMAR might also be used under the auspices of an allowed entity (for example, in partnership with a county). However, the potential advantages to WRD for using CMAR are largely aligned with PDB, which, in turn, has several distinct performance risk transfer capabilities not afforded by CMAR. Therefore, using CMAR does not appear to be of particular advantage, even if there was a path to using it in some form.

For DBO, California statute specifically prohibits single-contract, long-term operations combined with design and construction. Therefore, DBO is off the table for WRD, except for short-term operating "tails" to DB contracts in support of extended commissioning and training (often referred to as DB + "little o" [DBo]). However, the P3 pathway does include DBO scope, albeit with some form of financing, so the inclusion of operations as an alternative can fall into the P3 considerations.

4.3 Stakeholder Partnering

At this early stage of feasibility analysis, the definition of the specific location and scope of the Project components is preliminary. As such, the potential to partner with potential stakeholder entities – other cities and agencies – should be considered in the delivery model analysis. Once Projects are better defined and located, the familiarity and comfort level of stakeholder partners with collaborative delivery should be strongly considered. For example, a project located within a city with a strong DB proclivity would have a strong favorability to build upon previous success. Similarly, if a project is to be located and delivered with the support of a stakeholder with no collaborative delivery experiences, traditional delivery for all or some of the scope may be more efficient.

In addition, procurement statue and policy would generally apply to the procuring entity, defined as who is implementing the procurement process and ultimately signing the contract. Subject to legal counsel validation, this provides some flexibility for delivering via the desired approach by designating an entity with the appropriate authorization for the desired delivery methods. Other entities or stakeholders could then presumably participate in the project as third parties with appropriate cooperation agreements in place.

Therefore, delivery model conclusions described here should be considered preliminary, subject to the level and type of stakeholder partnering to be undertaken by WRD as the feasibility study potentially evolves to actual implementation.

4.4 Initial Conclusions

In summarizing these three concerns relative to the availability of various delivery models to WRD, they align as shown in the following heat map. Other stakeholder entities will have their own variations on this assessment.

Green areas represent a high level of acceptability, previous adoption of a given model, or both.

Yellow areas represent the ability to adopt the model, but with limited previous experience or unknown level of acceptability given what jurisdiction the project will be delivered in.

Red indicates a prohibition on the model or an understanding that it is not otherwise acceptable given past experience or preference.

Table 7. Delivery Model Heat Map

Delivery Models	WRD Previous Experience and Comfort	Legislative and Policy Authority	Stakeholder Partnering
Traditional			
DBB	Readily accepted	Readily accepted	Readily accepted
CMAR	No experience, not allowed	Not allowed	Unknown, some entities prohibited
Design-Build			
PDB	Previously used (ARC)	Readily accepted	Allowed, but depends on entity's experience
FPDB	Allowed, but no previous experience	Readily accepted	Allowed, but depends on entity's experience
DBO	No experience, not allowed	Not allowed	Not allowed
P3			
DBFO	Allowed, but no previous experience	Allowed	Allowed, but depends on entity's experience
DBOFM	Allowed, but no previous experience	Allowed	Allowed, but depends on entity's experience

5. Scope-Specific Delivery Model Considerations

An initial, high-level strengths and weaknesses assessment for each scope element comprising the brackish water reclamation facility projects being considered is provided in this section based on the type of work components for each of the six Projects currently being considered.

5.1 Extraction Wells

Extraction wells are typically delivered by specialty contractors who do not generally cross over to broader treatment plant construction (although some may provide conveyance and pumping construction services in support of well installation). To our knowledge, there are a limited number of DB projects that are solely focused on drilling and installing wells or wellhead treatment. Some larger DB projects may encompass wellhead and drilling scope, but these project elements would be generally considered ancillary to the larger treatment plant construction conveyance and pumping scope.

A recent delivery analysis for a seawater intrusion protection program for Soquel Creek Water District concluded that the individual well drilling scope size (small project), diverse geographic locations, and the agency familiarity with bidding these projects out resulted in little benefit in deviating from tried-and-true DBB for these types of projects.

Given this precedent, there is little advantage to delivering these types of projects using collaborative delivery methods. There may be some disadvantage given the potential higher cost and complexity of a collaborative delivery procurement for a relatively simple project, especially given WRD's familiarity with contracting these projects in the traditional manner. Other stakeholder entities may have similar types of in-house project delivery experience that should be retained under the Program.

However, there is no inherent disadvantage in including this type of scope in a broader collaborative delivery procurement if the wells are combined as part of a treatment facility.

5.2 Treatment Facilities

Treatment facilities are the most common type of water-related project to be delivered using collaborate delivery methods. Recent WDBC research has documented that adoption of DB, particularly PDB, is growing at over 10 percent a year in this sector. California is the leading market for DB adoption, and water and wastewater treatment facilities are the primary types of projects for which DB is used.

For the specific types and sizes of treatment being considered in the context of this feasibility study, the treatment facilities may trend toward the smaller size at individual extraction well locations. The potential use of portable or relocatable skid-mounted treatment modules also represent the smaller end of the potential treatment process facility scale, which tends to be delivered via collaborative delivery less often as compared to larger, more complex treatment projects.

However, other than the efficiency of scale for the procurement process, there is no inherent disadvantage to using collaborative delivery for smaller treatment facilities, particularly PDB, which can be efficient to procure (as they do not require significant advance bridging design). Also, DB offers the potential for performance risk transfer, which may be of particular importance to WRD.

DB may become more advantageous as facilities are bundled. Depending on the actual number of treatment sites, delivering them under one DB contract might represent an efficient procurement option with beneficial performance risk transfer. In addition, larger projects tend to be more market-attractive to design-builders.

5.3 Potable Water and Brine Conveyance

Conveyance projects are delivered under a wide mix of collaborative delivery methods. Beyond DBB, CMAR is quite common for conveyance facilities but is not allowed (as discussed) for WRD. DB has been widely used for conveyance facilities, as well, albeit with fewer examples than treatment plant facilities.

There is also a mix of progressive and fixed-price DB examples for conveyance, sometimes within the same program or group of projects.

For this Project, conveyance scope can be considered separately from the treatment scope; in which case, the relative merits of DB over traditional delivery may be less apparent. DB will offer some schedule and coordination benefits, but will provide limited opportunity for innovation or performance risk transfer. However, if combined with the treatment facilities, the delivery of the conveyance scope as part of a DB project might offer significant coordination benefits, both from a schedule coordination and hydraulic system perspective.

5.4 Summary

In summary, the following heat map illustrates the relative applicability for each major scope component of the Projects under consideration in the feasibility analysis, plus a scenario where all Projects are combined into a single procurement.

Green areas represent a high level of acceptability, high potential of a given model to add value to WRD, or both.

Yellow areas represent the ability to apply the model, but with caveats and dependence on what stakeholders may be involved.

Red indicates a prohibition on the model or an understanding that it is not otherwise applicable to this given scope.

Table 8. Scope Component Heat Map

Delivery Models	Extraction Wells	Treatment Facilities	Conveyance and Pumping	Combined Scope
Traditional				
DBB	Most common	Readily accepted	Readily accepted	Readily accepted
CMAR	Not allowed	Not allowed	Unknown, some entities prohibited	Unknown, some entities prohibited
Design-Build				
PDB	Not common	Readily accepted	Readily accepted	Readily accepted
FPDB	Not common	Readily accepted	Readily accepted	Readily accepted
DBO	Not allowed	Not allowed	Not allowed	Not allowed
P3				
DBFO	Not common	Allowed, but scope is too small to be practical	Allowed, not common	Allowed, larger scope more practical
DBOFM	Not common	Allowed, but scope is too small to be practical	Allowed, not common	Allowed, larger scope more practical

The final key aspect of the ultimate delivery model decision is the entity under which a given project will be procured. While this TM is focused on WRD's options, partnerships with various stakeholders can significantly expand potential delivery methods available for the projects under consideration in the feasibility study.

6. Preliminary Conclusions

For the Projects being analyzed as part of this feasibility study, collaborative delivery represents a viable delivery option and should be retained in WRD's tool box going forward. For the purposes of further evaluation and for alignment to the VfM analysis being conducted in parallel to this TM, we recommend grouping the delivery options into the following three categories, with assumptions as noted:

1) **Traditional Delivery.** This option is primarily limited to DBB. CMAR may be an option for some stakeholder jurisdictions but is otherwise assumed not to be allowed.
2) **DB.** This option may include progressive, or fixed-price approaches, or combinations of both. For the purposes of this analysis (and for the VfM analysis) these types of DB are treated equally. Once specific projects and stakeholders are further refined, the differentiation between progressive and fixed-price options can be further refined. DBO is not considered a viable option, unless included in the P3 option with a financing component, described next.
3) **P3.** DB, with or without operations, with a third-party financing component is an option that has potential merits, as defined separately by in the VfM analysis TM.

The favorability for applying these models to the potential Projects identified in the feasibility study align to the heat maps provided herein. The following is also noted:

- **Extraction Wells.** Best suited for DBB unless combined with the larger project scope.
- **Treatment Facilities.** High probability of DB being beneficial, depending on local stakeholders' perspectives, size of project, and level of desired performance risk transfer.
- **Conveyance and Pumping Infrastructure.** Equally attractive to DBB and DB on a stand-alone basis, depending on scope, schedule requirements, and coordination risk with other facilities.
- **Combined Scope.** Highly attractive for the DB option due to increased size and complexity and ability to transfer schedule coordination and performance risk. Final determination will be largely impacted by local stakeholders' preferences and by the results of the VfM analysis, which may shift the recommendation to a P3 model.

7. References

Water Design-Build Council (WDBC). 2016. *Water and Wastewater Design-Build Handbook*. 4th Ed.

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Subject **Value for Money Analysis**

Project Name Regional Brackish Water Reclamation Program Feasibility Study

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1. Introduction

The purpose of this Technical Memorandum (TM) is to summarize the results of the Value for Money (VfM) analysis of the different procurement and technical options selected for detailed evaluation by the Regional Brackish Water Reclamation Program (Program) stakeholders. The technical components comprise Project alternatives that have been crafted as part of this feasibility study to remediate the trapped saline plume in the West Coast Basin, producing potable water and brine waste streams in the treatment process. The VfM analysis was developed to support the Water Replenishment District of Southern California (WRD) and the other seven Program stakeholders, the Stakeholder Group, in selecting an appropriate delivery and financing strategy for the brackish water reclamation Project that will provide significant value to the region.

VfM analysis is a generally accepted best practice that compares the lifecycle costs of traditional public delivery and finance with the costs of collaborative delivery and finance for various procurement methods under consideration. The analysis includes the direct capital and operating costs of the Project, and the monetized risk transfers that result from the delivery and finance options under consideration. The purpose of the VfM analysis, generally, is to determine the most advantageous financing and delivery method on a comparative lifecycle cost basis, including the value of risks shared and retained under various selected delivery methods.

Risk transfers frequently occur because of a transfer of accountability from the public agency to a private partner in a collaborative delivery method; in some circumstances, there is greater risk associated with a collaborative delivery option. Both forms of risk transfer are incorporated into the VfM analysis, as appropriate. Examples of areas where risk transfer may occur include:

- Upfront delivery cost and accountability
- Relative cost of borrowing to deliver the capital facilities and opportunities in some circumstances to keep privately provided capital off the books that determine credit ratings and public borrowing limits
- Ongoing cost and accountability in the operations and maintenance (O&M) phase, including preventive versus (vs.) reactive maintenance practices

It is important to highlight that this VfM analysis is only intended to serve as a focused alternative analysis that compares selected delivery methods for the Program as described herein. It was prepared by Jacobs Engineering Group Inc. (Jacobs) in our role as planning and engineering consultant to WRD as part of the current feasibility studies for the Program, and is not intended to serve as a recommendation or prediction of specific financing terms, which will depend on such factors as financial market conditions at the time the financing is arranged for the Project, WRD's (or other stakeholders') overall financial context, and other factors. Jacobs is not a registered Municipal Advisor per Section 15B of the Exchange Act[1] with respect to the information and material contained in this VfM analysis; WRD's Municipal Advisor could likely provide additional useful input to decisions made in this matter.

A description of all delivery options available to the Program Stakeholder Group and their primary advantages and disadvantages for use in implementing the Program's Project is provided in the accompanying *Project Delivery Analysis TM*, the combination of which constitutes the feasibility study's Project Delivery Plan.

2. Project Delivery Methods Evaluated

As previously noted, a description of the full range of project delivery and finance options is evaluated in the *Project Delivery Analysis TM*, including the primary advantages and disadvantages of each method. Three project delivery options were selected for inclusion in the VfM in consultation with WRD; these options reflect the options of primary interest, given both the financial context and attributes of the remediation project:

1) Traditional
2) Design-Build (DB)
3) Public-Private Partnership (or P3)

The traditional method serves as a baseline representing traditional design-bid-build (DBB) or construction management at risk (CMAR) public delivery methodologies. The DB method offers an alternative method that primarily transfers change order and delay risk during construction to a private partner.

For this VfM analysis, the DB option is intended to reflect variations within the DB delivery approach, including DB and Progressive Design Build (PDB). PDB procurements, for example, provide the Owner the opportunity to remain involved in the design process to help manage costs and make certain the end-product satisfies the objectives for the project while leveraging the schedule, collaboration, and contractual advantages provided by DB models.

The third method, P3 delivery, as defined for this project also allows the Owner to retain ownership over the assets, rate structure, and current operations, but transfers change order and delay risk, as well as performance accountability over the life of the agreement, to a private partner; it also provides alternative (private) financing with expanded capacity, if needed, to supplement the Owner's municipal bonding capabilities. Under the P3 approach, the bidder must arrange financing to cover the capital costs (both soft and hard costs) during design, construction, and the O&M period if necessary.

The procurement methods considered in this VfM analysis are described in more detail in the following sections.

2.1 Traditional Public Delivery

The traditional public sector procurement approach for the Project is DBB, in which the Owner would first contract with an engineering consultant to design the Project components and then tender the construction to the lowest qualified bidder. Following successful startup, the Owner would operate and maintain the Project.

2.2 Design-Build Delivery

Under DB delivery, the design and construction tasks are combined and performed by a single contractor or team instead of being completed by separately contracted teams. There are several permutations

[1] Section 975 of Title IX of the Dodd-Frank Wall Street Reform and Consumer Protection Act amended Section 15B of the Securities Exchange Act of 1934 (Exchange Act) to require municipal advisors to register with the Securities and Exchange Commission, effective October 1, 2010.

within the DB delivery model, as described in the *Project Delivery Analysis TM*. For this VfM analysis, a single DB option is included because the costs and risk transfers for the range of options within the DB category are considered comparable at the level of cost and risk definition currently available.

In the PDB model, as the design-builder develops the design, a construction cost estimate is progressively developed, often in conjunction with the 30 and 60 percent levels of design detail, in close partnership with the Owner, providing the opportunity for deeper engagement in the definition of the Project than would occur in the traditional DBB model. Once the design is well-advanced (beyond 60 percent and often up to 90 percent), a guaranteed maximum price (GMP) is defined for approval by the Owner. If the design-builder and the Owner cannot reach agreement on an acceptable GMP or lump sum, the Owner can use the completed design as the basis for a hard construction bid procurement.

The PDB delivery method can provide both cost and schedule efficiencies. Cost savings can be found through multiple sources, including reduced design effort, minimized construction change orders, and value engineering. Schedule efficiencies are gained through the simultaneous execution of portions of the design and construction work and avoidance of two procurement processes (one for the designer and one for the construction contractor).

Following successful startup, the Owner would operate and maintain the Project.

2.3 Public-Private Partnership Delivery

P3 delivery integrates the design, construction, financing, and operations of the Project under a single contract with a private partner. While some form of P3s result in transfer of the ownership of the assets to a private party, the form of P3 that is assumed for the VfM analysis is a Design-Build-Finance-Operate-Maintain (DBFOM) model, in which the private partner would:

- Work in close collaboration with a public Owner to specify performance outcomes, finance, and design
- Construct the Project to those mutually agreed upon specifications
- Operate and maintain the Project to meet the performance specifications and overall agreed upon lifecycle business plan

The Owner retains ownership and an oversight role, and the facility must be maintained to a specified condition for handback at the end of the agreement. The term of P3 agreements typically mirrors the term of the financing, with 30- to 40-year terms customary.

The private partner is typically compensated for the design, build, financing, operation, and maintenance in the form of a fixed availability payment over the operating period of the project. If performance specifications are not met, reductions in the availability payment to the private partner may occur. This creates ongoing performance accountability and risk-sharing for the life of the agreement. Certain variable commodity per unit costs may be most cost-effectively treated as pass-through costs (such as energy), while performance commitments capping or reducing total unit use may be incorporated to incentivize efficiencies.

At the end of the operation period, handback conditions and their enforcement ensure that (1) the assets are well maintained to maximize their ultimate useful design life, and (2) the plant can be reliably operated by the Owner for a reasonable period after handback before additional investment is required.

3. Project Assumptions

Several estimates and assumptions are used in the creation of the VfM analysis. This section describes the assumptions for the Project duration, construction costs, operating costs, and financing costs for the three procurement methods.

3.1 Project Duration

A 30-year study period has been used to conduct the VfM analysis. Two primary considerations were used in identifying this period. The normal lifespan for major mechanical process equipment is typically 30 years, which is a likely time frame for a private delivery arrangement if a P3 approach is selected. In addition, as detailed later in this TM, 30 years is a reasonable financing time frame for either a public or private delivery option.

3.2 Construction Costs and Duration

The construction costs for the Project alternatives are discussed in this section. The construction costs were developed using Jacobs' Parametric Cost Estimating System (CPES). CPES seamlessly integrates the three main conceptual components of early project planning—facility design, construction cost estimating, and lifecycle cost estimating. It is a proprietary conceptual design and cost estimating tool that generates quick, accurate, and detailed cost estimates at the conceptual stage of infrastructure investment.

CPES modeling was applied consistently across the two engineering alternatives. While the estimates are study-level (AACE International [AACE] Class 4) and, as such, have an accuracy of +50 to -30 percent, the margin of error is consistent across alternatives; therefore, they are reliable for comparison purposes. The construction costs provided herein are in 2019 dollars and do not include cost escalation over the construction duration.

Table 3-1 presents the fully installed capital costs for the engineering options under consideration. Capital cost estimates as defined in this TM are the combination of estimated design and construction costs and other associated upfront costs, such as legal and administrative costs. It was assumed the capital costs would be the same under the three procurement options, except as adjusted by the risk transfer factors described later in this TM.

Table 3-1. Construction Costs

Component	Project 18 – 12,500 AFY ($)	Project 44 – 20,000 AFY ($)
Extraction Wells	16,000,000	28,000,000
Feed Piping	10,519,000	12,348,000
Treatment Plants	61,000,000	102,300,000
Product Piping	10,996,364	14,400,000
Brine Connection	17,400,000	32,400,000
Additional Capital Markup[a]	23,182,636	37,890,000
Total	**139,098,000**	**227,338,000**

[a] Additional capital markup includes: Permitting (2%), Engineering (8%), Services during Construction (8%), and Commissioning and Startup (2%).

Notes:

% = percent

AFY = acre-feet per year

3.3 Operating Costs

This section discusses the expected annual operating costs for each Project alternative. The operating costs are based on Jacobs' operating cost models and anticipated operating requirements for a project of this scale and type, and were applied consistently across all three procurement options.

Table 3-2 presents the annual operating costs for the two engineering alternatives under consideration. The annual operating cost includes major maintenance components. Overhead costs, such as accounting and human resources, that would support the facility are not included.

Table 3-2. Annual Operation and Maintenance Costs

Component	Project 18 – 12,500 AFY ($)	Project 44 – 20,000 AFY ($)
Wells	1,200,000	1,900,000
Treatment Plant	6,800,000	10,600,000
Brine Disposal	480,000	745,000
Total	**8,480,000**	**13,245,000**

Annual operating costs are assumed to be the same for the traditional and DB delivery options. Under both scenarios, the Owner or its partners will be responsible for the operations of the facility. Under the P3 delivery option, the annual operating costs are expected to be approximately 15 percent lower than operating costs for traditional and DB delivery. The lower operating costs are due to expected savings in labor efficiencies and reduced material costs because of bulk purchasing for commodities, such as energy and chemicals, where a private developer could realize even deeper discounts by purchasing in greater volume to meet the needs of multiple projects.

It is assumed that the operating costs will increase at an annual rate of 3.0 percent under each procurement option.

3.4 Financing Costs

This section discusses financing assumptions for the three procurement methods under consideration.

3.4.1 Traditional

Under a traditional delivery, it is assumed the Owner would not be able to secure state or federal funding to pay for the capital cost of the project so would issue municipal bonds for the capital costs. The Owner or stakeholders might pursue low-interest loans through state revolving fund (SRF) or low-interest federal loan programs now available in the water sector. But, since the Owner has not qualified for any such loans for this Project at this point, it is assumed that municipal bonds will be issued to pay for the Project. More detailed discussion of public and private financing options and the opportunity to apply them for this Project is provided in the Task 7 TM.

3.4.1.1 Bond Rate and Term

An average interest rate of 4.50 percent is assumed for the traditional alternative, which is the estimated interest rate for a municipal bond. A term of 30 years is assumed to match the expected facility life. Payment of the debt will be amortized over the 30-year term. For the VfM analysis, a level debt service payment structure is assumed.

3.4.1.2 Issuance Costs

When issuing new municipal bond market debt, the issuer will incur professional fees, such as accounting, legal, financial advisory, and underwriting costs in connection with the sale of the bonds; these costs are typically in the range of 1.0 to 2.0 percent of the total amount borrowed. Issuance costs of 1.5 percent of the capital project costs are assumed for the traditional alternative, to reflect the assumption that municipal debt would be issued to pay for the capital costs.

3.4.2 Design-Build

The financing assumptions for a DB delivery are the same as a traditional delivery.

3.4.3 Public-Private Partnership

3.4.3.1 Borrowing Rate and Term

The capital cost for private finance has traditionally been higher than financing available through the municipal interest rates. For the purposes of this VfM analysis, the weighted average cost of capital (WACC) is assumed to be approximately 6.0 percent. A 30-year term is assumed and is consistent with the estimated service life of most facilities that would be developed. It also is consistent with the term assumed for the traditional public delivery and finance option. A level debt service structure is also assumed for the internalized cost of capital, which would be built into the Owner's payments to the private P3 provider.

3.4.3.2 Issuance Costs

It is assumed that there are no direct issuance costs for the Owner associated with the private delivery and finance option. Since P3 delivery would be a direct negotiated arrangement between the Owner and a private team for the full value of the term, with the private partner expected to provide capital financing, there would be no need for the Owner to hire an underwriting team to sell shares related to financing or secure a credit rating for the transaction.

3.4.3.3 Payment Structure

It is assumed that the Owner will make progress payments to the P3 partner throughout the construction period if the Project proceeds on schedule and on budget. Once the wells and treatment plant are online, fixed availability payments, with certain agreed-upon hard costs escalated for inflation, will begin.
The fixed availability payments will continue for the life of the partnership if the P3 partner continues to meet performance specifications.

4. Risk Transfer and Cost Reduction Opportunities

A preliminary identification and screening of potential risk transfer considerations that would be relevant for the Project was conducted, with associated gains in performance accountability and cost reduction discussed. Specific categories of risk and accountability are most advantageously and cost-effectively transferred to those parties best positioned to manage them. By contrast, making a party accountable for a risk they are not positioned to manage is not cost-effective. For example, making a private partner take the risk on what the per-unit price of electricity will be for 30 years would require an inefficient hedge in their compensation. Commodity risks like this are most efficiently priced on an at-cost pass-through basis. By contrast, transferring the risk of managing the total usage of electricity, a risk the private partner is well positioned to manage, can deliver cost reductions effectively. Putting design and operations risk on the private partner to manage makes sense and reduces overall cost and likelihood of failure, while addressing force majeure risk through the insurance provider is customary. This process of identifying and appropriately allocating risks and accountability on an open book basis is the trademark of an enduring, high-performance P3 agreement.

The risk factors that are relevant in a VfM analysis depend on the nature of the facilities being developed in the planned projects, the procurement and delivery options under consideration, and the financing context of the public agency. A workshop meeting was held with the Jacobs staff involved in developing the engineering solutions to consider the applicability for this VfM analysis of a range of potential risk transfers, including the following:

- **Capital cost** (bid climate uncertainty and change orders; also, appropriateness of design to the capacity of the party operating and maintaining it) – Risk that capital cost will exceed the initial estimate because of higher bids than estimated and change orders during project delivery and execution. Design risk that the capital project as designed can be run and maintained to perform as specified.

- **Bonding rate risk** – Risk that interest rates for borrowed funds will be higher.
- **Operating risk** – Risk that assets will not be properly operated or that operating costs will be higher than projected or forecasted.
- **Maintenance risk** – Risk that assets will be reactively, not proactively maintained, or that maintenance costs will be higher than projected or forecasted.
- **Variable demand risk** – Uncertainty related to the level of demand and resulting revenue.
- **Performance risk** – Uncertainty related to asset performance.
- **Security risk** – Risks related to security considerations for the public delivery entity.
- **Process risk** - Risks associated with higher salinity rates, higher odor, and poorer water quality than expected, which could increase the cost of capital, operating expenses, or both.
- **Technology risk** – Uncertainty related to capability of technologies employed to provide the level of service needed to meet the required outputs. Generally, this is most relevant when a system depends on new or unproven technologies.
- **Credit reduction risk** – Potential additional risk of higher borrowing rates for other capital projects, considering cumulative public debt burden of the current project, plus existing outstanding debt when additional debt is incurred in the future for other capital projects.
- **Existing facility failure prior to completion of new facility**.
- **Siting risk** – Potential risks associated with site selection or the need to select additional replacement sites, which could have schedule and cost impacts.

In addition to potential risks, the team identified basin protection risk as an important consideration. But, because that issue is being addressed in high-level planning that will impact significantly the potential nature of any such risks, it was decided not to attempt to quantify or monetize these considerations as part of this VfM

From this candidate list, the team identified several risks that would be relevant to this Project and added several context- and Project-specific risks, resulting in the following list of relevant risks for inclusion in this VfM analysis:

- Capital cost (bid climate uncertainty and change orders; design risk)
- Operating risk
- Bonding rate risk
- Performance risk
- Technology risk
- Process risk
- Siting risk

Table 4-1 presents a matrix of the risks considered for inclusion in the analysis. The highlighted rows indicate the risks that are relevant for this Project and the rationale for including the risk in the VfM. The method of monetizing the risk transfer is also presented. The method to monetize each risk is based on information gathered for this study and other similar studies conducted by Jacobs for municipal clients and professional judgement from Jacobs staff with experience in addressing similar risks for other projects.

In monetizing financial risks and establishing financing assumptions for this VfM analysis, such as bond rate risk, information gathered about WRD's financial history and context as part of the Task 7 efforts has been used to inform interest rate and term assumptions for traditional and DB options. In monetizing operational risks, such as process risks and performance risks, Jacobs' professional judgement based on experience in planning and operating facilities similar to those included in the options in this study was used.

Process and Performance risks are related to either higher fouling plume water or plume water with substantially different salinity than modeling has predicted. The resulting costs incurred with such risks include additional infrastructure in the form of wells or treatment, additional energy and chemicals related to the desalination of groundwater via reverse osmosis (RO), or both. Quantification of such risks was performed by team member Steve Alt. Steve is a chemical engineer and membrane and desalination technologist with Jacobs.[2]

For some of the identified risks, a range of adjustment factors have been applied to present a “high” and “low” impact of monetized risk to the different procurement options.

The following subsections identify how the risk transfers identified as relevant for this study were monetized for the engineering and procurement options included in this analysis. For each of the identified risks, the cost or impact of the event was estimated, and the risk premium was incorporated into the VfM.

4.1 Capital Cost (Bid Climate and Change Orders)

4.1.1 Traditional

The traditional option would be subjected to market bidding conditions and, during execution, would be subjected to change orders in response to changing conditions, changes in design preferences, and unexpected elements.

Public agencies can experience cost overruns on traditional DBB procurements due to change orders in the 10.0 to 20.0 percent range for major construction projects. The reasons for this condition are widely debated, but theories include:

- Public procurement processes for projects delivered in a DBB method often require selection of the lowest-priced bidder for the initial capital costs of construction without consideration of which provider might provide the greatest lifecycle value over the life of project delivery or competing contractors’ track records with regard to final costs for construction projects they have delivered. This requirement can drive bid prices artificially low, with change orders then used by the private sector to recoup potential losses.
- No at-risk 30-year equity results in inadequate due diligence at the front end of the project, and unnecessary change conditions as a result.
- Overly prescriptive designs may invite improvement post-award, again creating a change condition unnecessarily.

A 10.0 to 15.0 percent factor has been incorporated into this analysis to address the combination of uncertainties related to change orders and initial construction bidding climate for a project of this magnitude.

4.1.2 Design-Build

While a DB delivery could be subject to similar risks as traditional delivery, many are mitigated because of the contract structure of a DB implementation. Under a DB delivery, the risk of change orders is lower due to the teaming arrangement between the design consultant and the contractor. Under a PDB model, the design is developed beyond 60 percent levels, and a GMP is agreed to by the Owner and the DB team, which leaves very limited allowances for change orders. In Jacobs’ experience, there is still some risk, especially as driven by scope changes directed by the client. To account for the lower risk, a 6.0 to 12.0 percent factor has been incorporated into this analysis to address capital cost uncertainties.

[2] Steve Alt has more than 25 years of membrane technology experience in the application, design, startup, commissioning, and pilot testing of membrane processes (microfiltration [MF], ultrafiltration [UF], and RO) on a variety of environmental water and wastewater projects. He has had significant roles in the design of five full-scale groundwater desalination projects to date.

Table 4-1. Risk Matrix for Value for Money Analysis[a]

Risks	Facility			Comments	Method of Monetizing Relevant Risks
	Wells	Pipes	Treatment		
1. Cost Risk	X	x	X	All three cost risks (capital, O&M, interest rate) are relevant to this Project. Increases in capital costs associated with bid climate and change orders could impact the cost of the Project. Operating costs could be higher than estimated and would impact the operator of the facility. Interest rates fluctuate based on market conditions and could increase if securing financing takes longer than initially anticipated.	Risk of change orders and bid climate. Increase CAPEX by 15% for traditional, 12% for DB, 0% for P3. Increase annual O&M escalation by 1% for traditional and DB. Risk of increased interest rate estimated by increased cost of capital by 0.5%.
2. O&M Risk	X		X	For VfM, assume public agency ownership and governance for traditional; modified ownership and governance option for P3.	Assume public ownership for traditional and DB; P3 could decrease annual O&M costs when compared to public sector operation by 15%.
3. Variable Demand Risk				Does not apply.	-
4. Performance Risk	X			Risk involved for performance of wells; if not able to address the plume (extracted salinity too low), may result in additional costs; uncertainty in performance of wells due to geologic and other factors; performance of wells; location of plume could require new location of well – more modeling and monitoring required to better understand the movement of the plume.	Based on professional judgement, an increase in capital cost of 20% for traditional and DB for additional well infrastructure required.
5. Security Risk				Not relevant for delivery models being considered; risk to public health may not be different across delivery models.	-
6. Technology Risk			X	If P3 model, new technology may be adopted more readily to keep costs down (i.e., membrane technology).	Based on professional judgement, a decrease in O&M for P3 option by 10%.
7. Credit Reduction Risk				Currently not aware of future capital expenditure requirements that would make this a relevant risk. AAA bond rating as of June 2018. Outstanding debt of $150-200 million is modest for an agency of this scale, and they have reduced litigation risk substantially in recent years, reducing the likelihood for substantial additional expenditures.	-
8. Process Risk			x	Higher fouling rates due to manganese or other water quality issues would result in higher energy and chemical requirement for RO. Would be rectified by either additional pretreatment (CAPEX) or higher O&M costs over time. In P3, this would be borne by the private team; while in DBB, this would be an added public cost.	See 8a and 8b
			x	8a. Risk of higher salinity than anticipated, assumed to be 1,000 mg/L TDS in average well water.	Increase in treatment plant energy of 7% for traditional and DB.
			x	8b. Risk of odor impacts beyond those anticipated or risk of higher fouling rate than expected.	Additional treatment would be required; increase treatment capital by 30% for traditional and DB;

Table 4-1. Risk Matrix for Value for Money Analysis[a]

Risks	Facility			Comments	Method of Monetizing Relevant Risks
	Wells	Pipes	Treatment		
					also increase treatment O&M by 15% for public operation.
9. Siting Risk	X		x	Risk that community risk cannot be addressed at currently suggested or planned sites and resulting need to select additional replacement sites, which could have schedule and cost impacts.	Assumed siting issues would result in a 1-year delay; increased capital cost by 3% and interest rate by 0.5% for traditional and DB.

[a] Risks identified as relevant for this VfM analysis are shaded in grey.

Notes:

CAPEX = capital expenditure

mg/L = milligram(s) per liter

TDS = total dissolved solids

4.1.3 Public-Private Partnership

Under a P3 delivery, there is a very low risk to the Owner for changes in capital costs. A P3 delivery would incorporate a fixed price for design and construction with very limited exceptions. The fixed price for design and construction would be based on a well-defined scope from the Owner that would be subjected to a thorough due diligence process and resolved by the private partner in collaboration with the P3. The price would be fixed during the procurement process based on the scope covering performance requirements (that is, treatment standards and capacity) and prescriptive requirements (that is, equipment requirements and site layout requirements). If there are cost overruns or changes not driven by the Owner, and not defined in limited change conditions language, the Owner is not responsible for covering these additional costs. The P3 partner would be responsible for covering the cost overruns at their own loss. For the P3 delivery, it is assumed there is no risk of change orders to the Owner.

4.2 Operating Risk

4.2.1 Traditional

During operations for the traditional delivery, there is a risk that operating costs will be higher than expected. This risk could be either higher costs at startup or a higher escalation than expected. The risk of higher costs at startup is not included in the VfM analysis given that the treatment technology used in both engineering alternatives is well-established, and the operating costs are known.

The risk of greater escalation has been included in the VfM analysis and is meant to capture the uncertainties in long-term operations. The cause of the additional escalation could be, for example, lower operating due to membrane fouling, inefficient staffing, or poor preventative maintenance leading to higher reactive maintenance costs. In addition, the higher operating costs can be driven by conflicting interests between the contractor and the long-term operations of the plant. The contractor is selected on a low-bid basis and paid based on completing construction. This creates an incentive to keep construction cost down through lower capital cost, inferior equipment, design modifications, and materials with the potential result of higher expense of long-term operations of the plant.

Over the life of a 30-year operating period, there is also the possibility that key elements of operations, such as labor, chemicals, and energy, may experience price increases higher than typical levels. In collaborative options that include private operations, such as P3, the contract arrangement typically includes some indexed limit to increases in operating costs that are allowed, while with public operation of the facilities, the full risk of such price increases is borne by the public agency and its customers.

To account for these risks in the VfM risk analysis, it is assumed that operating costs will rise at an additional 1 percent per year over the life of the facility.

4.2.2 Design-Build

The DB delivery is assumed to have the same operating cost uncertainty as the traditional delivery.

4.2.3 Public-Private Partnership

The P3 delivery provides a fixed availability payment cost to the Owner inclusive of operations, with a few exceptions. The price that the Owner and the P3 partner agree to at the outset of the contract is typically adjusted only for inflation based on agreed-upon escalators on hard costs, such as the Consumer Price Index or one of the relevant *Engineering News-Record* cost indices, as well as a limited number of other change conditions, such as a change in law. The P3 fixed availability payment might also allow for some of the more variable costs to adjust on an agreed-upon pass-through basis, should, for example, system demand for treated water exceed some specified quantity levels. But, there is typically some indexed upper limit to increases allowed in operating costs.

This shifts a significant portion of the risk for O&M costs and accountability for performance onto the private partner and eliminates the Owner open-ended exposure to O&M costs that the Owner would face under the traditional and DB scenarios. The Owner is not responsible for covering the additional costs if operating costs exceed the baseline set in the contract. The higher operating costs would represent a loss to the P3 partner instead of to the Owner.

Accordingly, it was assumed there was no operating cost risk for the Owner under the P3 delivery business case.

4.3 Bonding Rate Risk

4.3.1 Traditional

Due to the longer design and construction time compared to the other procurement alternatives because of sequential bid and delivery for each stage of Project development, the risk cost of a change to interest rates is included. An additional 0.5 percent is added to the anticipated interest rate. The potential increase in annual debt service payments is included for the term of the loan in the VfM analysis.

4.3.2 Design-Build

The bonding rate risk would be the same as under the traditional alternative, as the Owner would be securing the funding for the Project.

4.3.3 Public-Private Partnership

Because the P3 structure is based on a fixed price for the capital portion of the Project, the private provider would bear the cost of increased capital rates during the Project delivery period.

4.4 Performance Risk

Consideration will be given to whether there is greater likelihood of potential risks associated with the performance of the wells and whether they perform as designed due to geologic or other factors. The performance of the well could require drilling new wells or increased maintenance and rehabilitation.

4.4.1 Traditional

Under the traditional option, the Owner would be responsible for the cost associated with drilling new wells. For this VfM analysis, it was assumed Project costs associated with well infrastructure would increase by 10 to 20 percent.

4.4.2 Design-Build

While a DB delivery could be subject to similar risks as the traditional delivery, many are mitigated because of the contract structure of a DB implementation. Under a DB delivery, the risk of change orders is lower than the traditional model due to the teaming arrangement between the design consultant and the contractor. In Jacobs' experience, there is still some risk, especially as driven by scope changes directed by the client. To account for the lower risk, a 5.0 to 10.0 percent factor has been incorporated into this analysis to address performance risk.

4.4.3 Public-Private Partnership

Because the P3 structure is based on a fixed price for the capital portion of the Project, the private provider would bear the cost of increased capital costs.

4.5 Technology Risk

Consideration will be given to whether there is greater likelihood of selecting new technologies or whether potential risks associated with these technologies would be more likely to be realized under either the public or private delivery options.

4.5.1 Traditional

For this VfM analysis, it was assumed that the Owner would not adopt new technologies; therefore, would not realize a potential reduction in operating costs.

4.5.2 Design-Build

The technology risk would be the same as under the traditional alternative.

4.5.3 Public-Private Partnership

Because the P3 team would design and build the facility, it is assumed they would be equipped to operate and maintain the facility to meet the performance requirements. The P3 team would be more likely to adopt new treatment technologies that are developed over the life of the operating period that would potentially reduce treatment-related operating costs. For this analysis, it was assumed the P3 alternative would reduce treatment O&M by 3 percent. The reduction in cost for the P3 model will appear under the traditional and DB delivery models as a cost.

4.6 Process Risk

The risks associated with treatment process could impact different delivery models. The potential process risks were identified and incorporated as a monetized value in the analysis, as described in this section. The risk associated with higher levels of salinity, higher odor impacts, and higher treatment processes than anticipated could increase both capital and operating costs. Some of the potential risks could be mitigated with additional pretreatment costs or higher operating expenses.

4.6.1 Traditional

Under the traditional alternative, it is assumed that the Owner or other Program stakeholders would operate the treatment plant. Higher salinity levels (assumed to be 1,000 mg/L) were estimated to increase treatment plant energy costs by 7 percent. If water quality constituents were more difficult to remove than expected or if odor impacts were higher than anticipated, additional capital expenses (20-30 percent) and an increase in operation costs (15 percent) would be likely..

4.6.2 Design-Build

The process risks would be the same as under the traditional alternative, as the assets would also be operated by the Owner.

4.6.3 Public-Private Partnership

Because the P3 structure is based on a fixed price for the capital and operating portion of the Project, the private provider would bear the cost of increased capital and operating expenses.

4.7 Siting Risk

Depending on the procurement option selected, there could be risks associated with delaying the Project because of siting or community concerns. Delaying the Project could lead to increased capital costs due to inflation adjustments. A delay in the Project could also impact the final interest rate received on loans under all procurement options, leading to increased borrowing costs.

4.7.1 Traditional

A delay of 1 year is assumed for this delivery method. The delay would result in an increased capital cost of 3 percent and an increased interest rate of 0.5 percent.

4.7.2 Design-Build

The DB alternative would have a smaller level of risk as the traditional alternative because of the assumed shortened design and construction schedule. A delay of 6 months was assumed for this delivery method.

4.7.3 Public-Private Partnership

Because the P3 structure is based on a fixed price for the capital portion of the Project, the private provider would bear the cost of increased capital rates during the Project delivery period.

5. Value for Money Analysis

5.1 Key Inputs

Key inputs to the VfM analysis for the Project are summarized in Table 5-1, based on the relevant risk factors and monetization methodologies described in Section 4. For some of the identified risks, a range of adjustment factors have been applied to present a “high” and “low” impact of monetized risk to the different procurement options. The high scenario represents a reasonable expectation of potential impact based on Jacobs’ professional judgement; the low scenario is included to illustrate the sensitivity of findings with lower assumptions because the full impact may not result for all identified risk transfers.

Table 5-1. Key Inputs for the Value for Money Analysis, Project 18 – 12,500 AFY

	Item	Traditional	DB	P3
Base Assumptions	Discount Rate, %	4.00	4.00	4.00
	Base Capital Cost, $	139,098,000	139,098,000	139,098,000
	Year of Construction	2022	2022	2022
	Term (Years)	30	30	30
	Interest Rate (long-term), %	4.50	4.50	6.50
	Issuance Cost (% of Capital Cost)	1.5	1.5	0.0
	First Year O&M, $	8,480,000	8,480,000	8,480,000
	Escalation Rate O&M, %	3.00	3.00	3.00
Risk Factors	Bid Climate/Change Order Differential, %	10/15	6/12	0
	Contractor Risk Contingency (% of Capital Cost)	0	0	5
	Operating Risk	1.00	1.00	0.00
	Bond Interest Differential, %	0.50	0.50	0.00
	Private O&M, as % of traditional	100	85% for first three years; then 100%	85
	Performance Risk, added well capital, %	10/20	5/10	0
	Technology Risk - Decrease in O&M, %	0	0	3
	Process Risk a - Higher salinity (increased treatment CAPEX), %	0	0	0
	Process Risk b - Higher odor (increased treatment CAPEX), %	20/30	7.5/15	0
	Process Risk c - Water quality (increased treatment CAPEX), %	20/30	7.5/15	0
	Process Risk a - Higher salinity (increased treatment plant energy), %	7	7	0
	Process Risk b - Higher odor or water quality (increased treatment O&M), %	15	15	0

Table 5-1. Key Inputs for the Value for Money Analysis, Project 18 – 12,500 AFY

	Item	Traditional	DB	P3
	Years of construction delay because of siting issues	1	1	0
	Delay Impacts – Inflation, %	3.00	3.00	3.00
	Delay Impacts - Increased Interest Rate Risk, %	0.50	0.50	0.50

5.2 Results Project 18 – 12,500 AFY

This section provides VfM results, which are the total net present value (NPV) of lifecycle costs, including direct capital and operating costs over the 30-year study period. In addition, in accordance with standard methodology, the VfM analysis incorporates the NPV of the risk transfers identified in Section 4. The NPV assumes a discount rate of 4.0 percent. A range of impacts is shown for the traditional and DB delivery options to illustrate the impact of adjusting some of the risk factors; the low end of the range is included to reflect the fact that full impact may not be realized for all risk factors.

As shown on Figure 5-1, the NPV of costs for the P3 option is less than the costs for the traditional and DB options. The lifecycle costs of the traditional and DB options are similar. Figure 5-2 shows a breakdown of the costs into the direct cost and risk transfer components. As shown on Figure 5-2, the primary reasons for the lower NPV for P3 is the risk of increased capital and operating expenses due to process and technology risk, as well as the higher operating costs for the Owner under the traditional and DB delivery options.

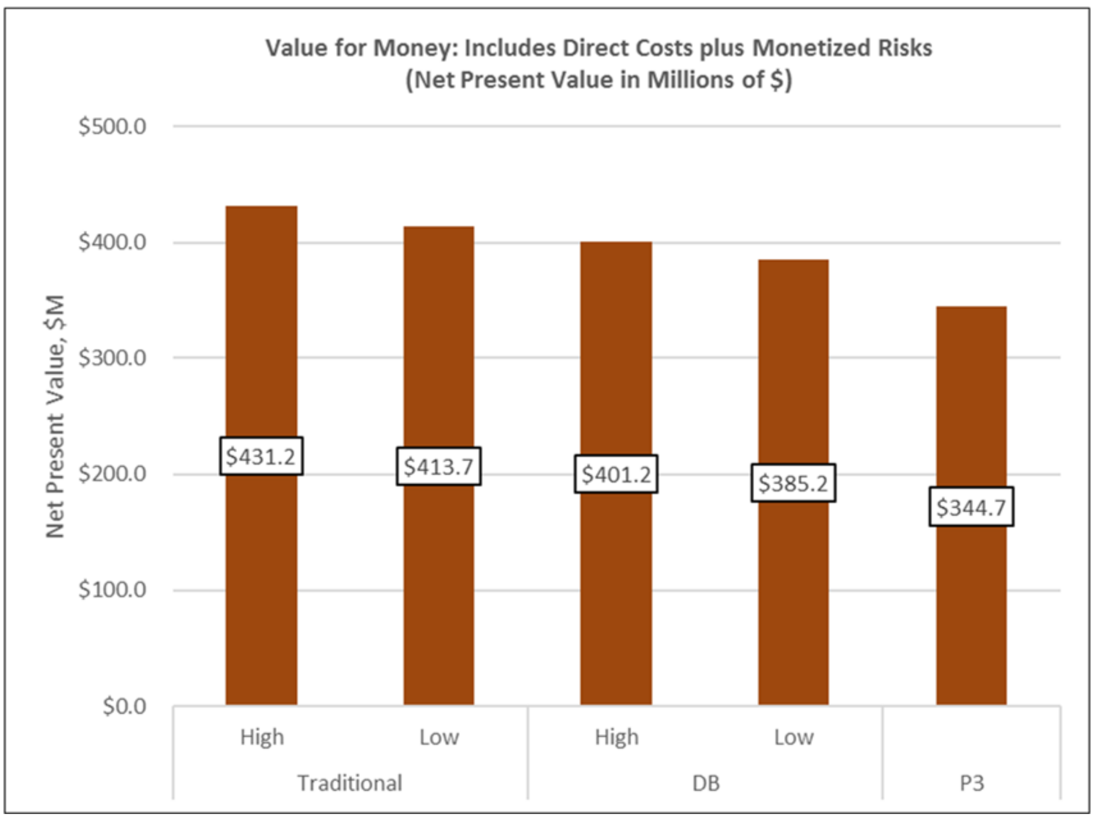

Figure 5-1. Summary of the Net Present Value Results, in Millions of Dollars, Project 18 – 12,500 AFY

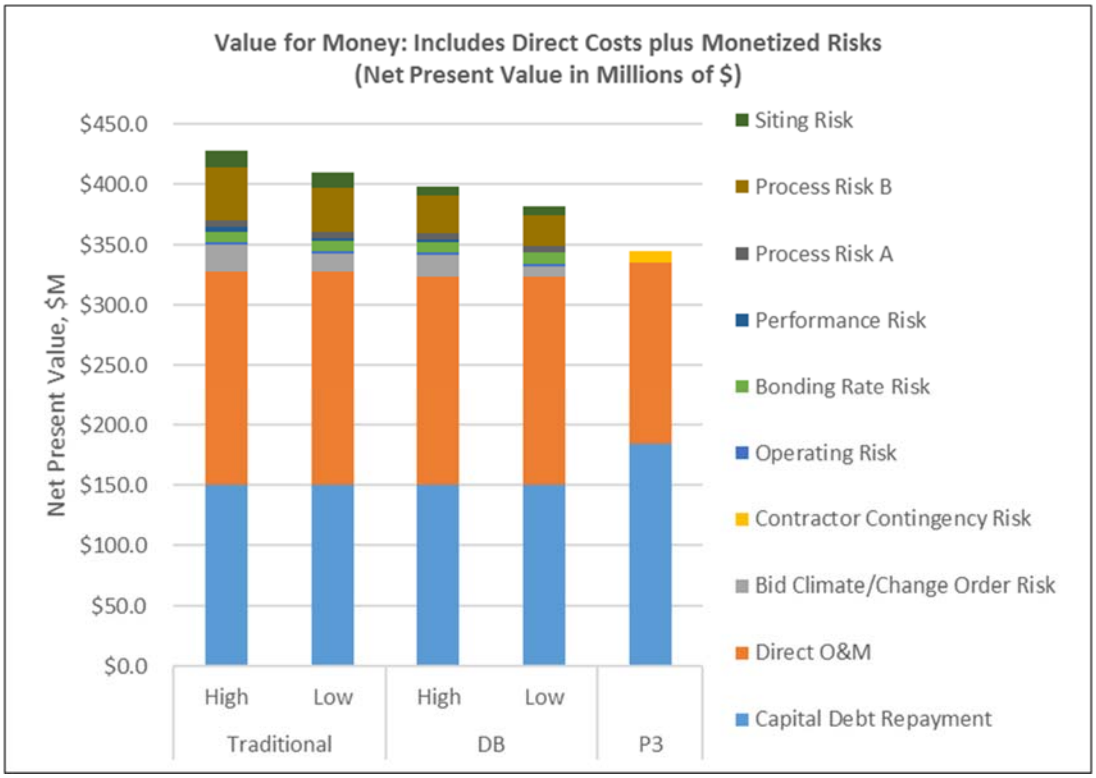

Figure 5-2. Detail of the Net Present Value Results, in Millions of Dollars, Project 18 – 12,500 AFY

As shown in Table 5-2 and on Figure 5-2, the VfM analysis results in an NPV difference of between 7 and 11 percent between the DB and traditional alternatives. The P3 delivery option is approximately 20 percent less than the traditional high alternative and 11 percent less than the DB low option.

Table 5-2. Summary of Net Present Value for Costs and Monetized Risks, Project 18 – 12,500 AFY

Item	Traditional ($million)		DB ($million)		P3 ($million)
	High	Low	High	Low	
Capital Debt Repayment	149.9	149.9	149.9	149.9	184.2
Direct O&M	178.0	178.0	173.9	173.9	151.3
Bid Climate and Change Order Risk	22.5	15.0	18.0	9.0	0.0
Contractor Contingency Risk	0.0	0.0	0.0	0.0	9.2
Operating Risk	1.8	1.8	1.7	1.7	0.0
Bonding Rate Risk	8.9	8.9	8.9	8.9	0.0
Performance Risk	4.1	2.1	2.1	1.0	0.0
Technology Risk	3.4	3.4	3.4	3.4	0.0
Process Risk A	5.0	5.0	5.0	5.0	0.0
Process Risk B	43.8	35.9	31.5	25.6	0.0
Siting Risk	13.7	13.7	6.7	6.7	0.0
Total	431.2	413.7	401.2	385.2	344.7
Change from Traditional, High, %		-4.0%	-7.0%	-10.7%	-20.1%

The cost of water per acre foot (AF) is presented in Table 5-3. The costs include the capital and operating costs over the 30-year period and the monetized risks identified in the VfM analysis. Although replenishment costs were not included in the VfM analysis, they are included in this table to illustrate the fully loaded estimated cost of water; the method for determining the replenishment costs in $/AF is presented in the Task 7 TM.

Table 5-3. Summary of Cost of Water, including Capital, O&M, and Monetized Risks, Project 18 – 12,500 AFY

Item	Traditional ($)		DB ($)		P3 ($)
	High	Low	High	Low	
NPV	431,170,000	413,720,000	401,187,000	385,244,000	344,667,000
$/AF	1,406	1,349	1,308	1,256	1,124
Replenishment Cost ($/AF)	$235	$235	$235	$235	$235
Cost of Water ($/AF)	$1,641	$1,584	$1,543	$1,491	$1,359

5.3 Results Project 44 -20,000 AFY

This section provides VfM results, which are the total NPV of lifecycle costs, including direct capital and operating costs over the 30-year study period. In addition, in accordance with standard methodology, the VfM analysis incorporates the NPV of the risk transfers identified in Section 4. The NPV assumes a discount rate of 4.00 percent.

As shown on Figure 5-3, the NPV of costs for the P3 option is less than for the traditional and DB options. The lifecycle costs of the DB options are less than the traditional option. Figure 5-4 shows a breakdown of the costs into the direct cost and risk transfer components. As shown on Figure 5-4, the primary reason for the lower NPV for P3 and DB delivery is the lower cost of capital for these options. There are more risk transfer costs assigned to these options than to the P3 option, but the costs associated with risks that are retained with the Owner under the traditional and DB options do not outweigh the higher cost of capital associated with the P3 option.

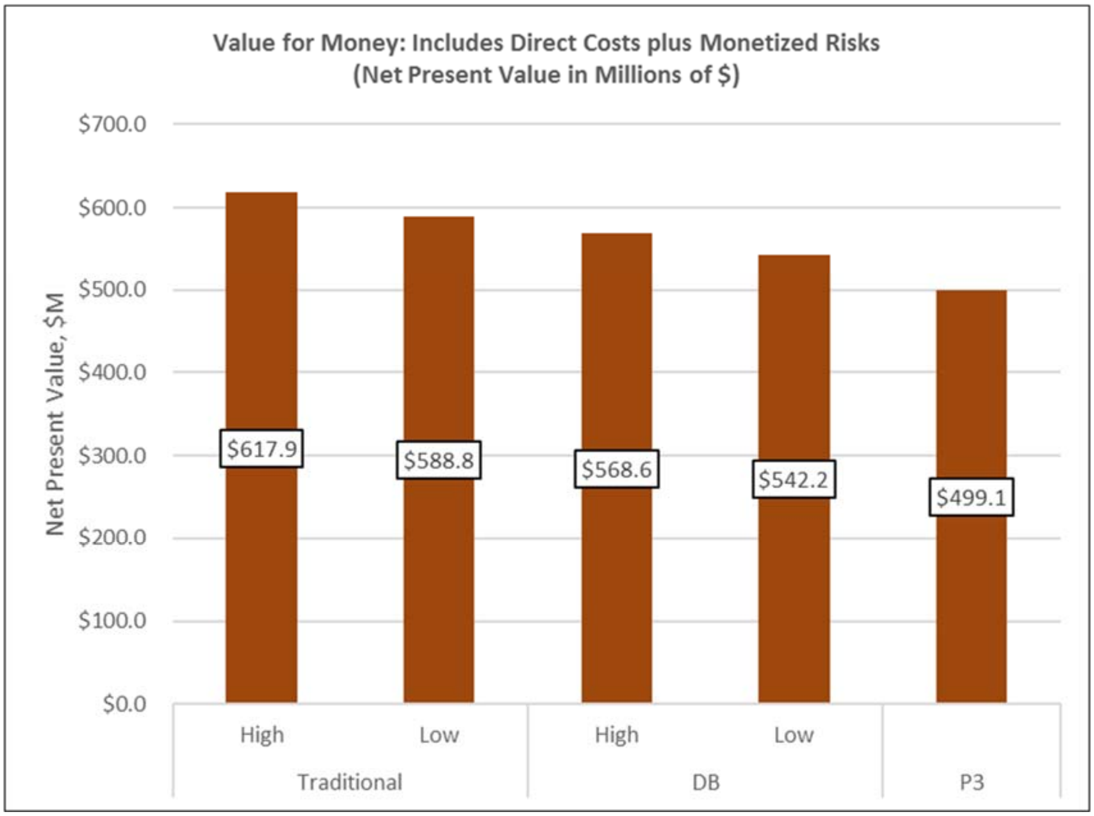

Figure 5-3. Summary of the Net Present Value Results, Project 44 – 20,000 AFY

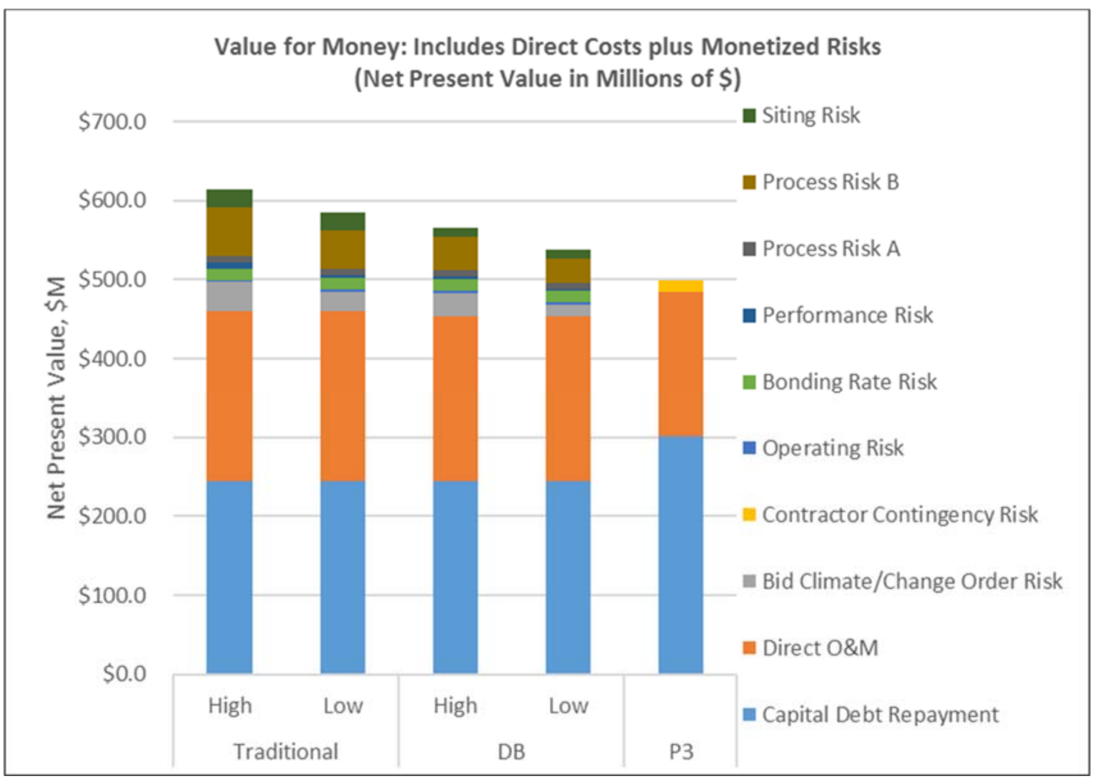

Figure 5-4. Detail of the Net Present Value Results, Project 44 – 20,000 AFY

As shown in Table 5-4 and on Figure 5-4, the VfM analysis results in an NPV difference of between 5 and 12 percent between the DB and traditional alternatives. The P3 delivery option is approximately 19 percent less than the traditional high alternative and 8 percent less than the DB low option.

Table 5-4. Summary of Net Present Value for Costs and Monetized Risks, Project 44 – 20,000 AFY

Item	Traditional ($million)		DB ($million)		P3 ($million)
	High	Low	High	Low	
Capital Debt Repayment	245.0	245.0	$245.0	$245.0	301.0
Direct O&M	215.4	215.4	$209.0	$209.0	183.1
Bid Climate and Change Order Risk	36.7	24.5	$29.4	$14.7	0.0
Contractor Contingency Risk	0.0	0.0	$0.0	$0.0	15.1
Operating Risk	2.2	2.2	$2.1	$2.1	0.0
Bonding Rate Risk	14.6	14.6	$14.6	$14.6	0.0
Performance Risk	7.2	3.6	$3.6	$1.8	0.0
Technology Risk	3.8	3.8	$3.8	$3.8	0.0
Process Risk A	8.3	8.3	$8.4	$8.4	0.0
Process Risk B	62.3	49.1	$41.7	$31.8	0.0
Siting Risk	22.4	22.4	11.0	11.0	0.0
Total	617.9	588.8	568.6	542.2	499.1
Change from Traditional, High, %		-4.7%	-8.0%	-12.3%	-19.2%

The cost of water per AF is presented in Table 5-5. The costs include the capital and operating costs over the 30-year period and the monetized risks identified in the VfM analysis. Although replenishment costs were not included in the VfM analysis, they are included in this table to illustrate the fully loaded estimated cost of water; the method for determining the replenishment costs in $/AF is presented in the Task 7 TM.

Table 5-5. Summary of Cost of Water, including Capital, O&M, and Monetized Risks, Project 44 – 20,000 AFY

Item	Traditional ($)		DB ($)		P3 ($)
	High	Low	High	Low	
NPV	617,925,000	588,829,000	568,590,000	542,161,000	499,143,000
$/AF	1,260	1,201	1,160	1,106	1,018
Replenishment Cost ($/AF)	$235	$235	$235	$235	$235
Total Cost ($/AF)	$1,495	$1,436	$1,395	$1,341	$1,253

6. Findings and Suggested Next Steps

Two engineering alternatives and three procurement options (traditional, DB, and P3) were selected during the preliminary screening processes for inclusion in the VfM analysis to band the range of both technical solutions and delivery models that survived preliminary screening analyses described in the earlier TMs developed for this project. Conceptual cost estimates for the direct capital and operating costs for the engineering solutions have been developed using parametric cost estimating tools and procedures consistent with an AACE Class 4 estimating process. The team identified the relevant risk transfers and associated assumptions for this study, and Jacobs developed a model to calculate the resulting NPV of lifecycle costs, including the risk transfers.

Key results include:

- For both engineering solutions (Project 18 and Project 44), the traditional and DB delivery options result in a higher NPV of costs than the P3 option in the VfM analysis. The results for these two options are close to each other, with the DB option roughly 8 percent lower in NPV than the traditional option in both cases.
- The NPV of cost results for the P3 (DBFOM) option are notably lower than for the other two delivery options, primarily because the risk transfers and operating cost efficiencies provided by this delivery method are substantial and appear to outweigh the higher cost of capital for the private delivery option. For both the 12,500-AFY and 20,000-AFY options, the NPV of costs for P3 are approximately 20 percent lower than for the traditional delivery option.
- A sensitivity analysis was conducted that reduced many of the risk monetization factors in half for the traditional and DB delivery options to see whether the ranking of the options would be affected by assuming lower risk transfer costs, since the full estimated impact of some of the risk transfers may not occur. The resulting low case narrowed the spread in costs among the three delivery options but did not change the order of the options. The low sensitivity analysis case for the DB option is within 8 to 11 percent of the costs for the P3 option, depending on which of the engineering options is evaluated.

The VfM results for all options are well within the current level of cost estimating accuracy at this stage of analysis (+50 to -30 percent). But, since the same methods were used to develop the underlying cost estimates for the three delivery options, the results suggest that further consideration of the collaborative delivery and finance options (DB and P3) may be worthwhile.

Given the results of the VfM analysis, some of the next steps stakeholders should consider as they continue planning toward implementation of this Project include:

- Have a dialogue among the Program Stakeholder Group regarding the delivery and finance decisions for this Project, including the individual stakeholders' management teams and Municipal Advisors, on the findings of the VfM analysis and other related findings and recommendations made in other TMs in this report. For example, as the Stakeholder Group considers the path forward for selecting a delivery method, it is recommended that they consider which of the benefits of the delivery options described in *Project Delivery Analysis TM* and evaluated in this VfM TM are most important to them. As just a few examples, they should consider what is the relative importance of benefits, such as:
  - Opportunity to use traditional municipal financing and draw upon WRD's or other stakeholder's strong credit rating, as maximized in the traditional and DB delivery options.
  - Opportunity to maintain input to the selection of specific technical solutions and approaches, as maximized in the DB family of delivery options, especially PDB delivery approaches.
  - Opportunity to transfer operation-period risks to other parties, as maximized in the P3 type of delivery model, as illustrated in this VfM through the DBFOM form of P3 delivery and finance.
- Reduce the number of engineering options to allow focused attention on a recommended technical solution.
- Refine the cost estimates and the analysis of the risk transfer opportunities for the recommended technical solution to determine whether the relationships among the delivery options shown in this VfM analysis are confirmed or changed with further, more refined evaluation and consideration.
- Develop a more detailed Project implementation plan for the delivery and finance option selected by the Stakeholder Group. For example, if the stakeholder decides to implement a traditional DBB or CMAR approach, this would include development of plans for municipal financing for the Project and development of a request for proposal (RFP) or request for qualifications (RFQ) to initiate the process of selecting a design engineer for the Project. If the stakeholders decide to implement a DB or P3 approach, next steps would include development of a request for expressions of interest, an RFQ, or an RFP from private delivery teams for one or more of those delivery models.

Appendix J
Project Entitlements and Acquisition Plan

JACOBS

Technical Memorandum

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Subject	**Project Entitlements and Acquisition Plan**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 30, 2019

1. Introduction

The Water Replenishment District of Southern California (WRD) is responsible for managing and replenishing both the West Coast and Central groundwater basins. In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, Lynwood, and Lower San Pedro (equivalent to Sunnyside) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To fully utilize the West Coast Basin, WRD has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. Program goals include treatment of the saline plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process.

The feasibility study will evaluate the following components: where to extract the plume water, where and how to treat the plume water, how to convey the treated potable water to the Program Stakeholders, and how to manage the brine waste stream. The feasibility study includes the analysis of numerous “Projects,” consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of these components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed as dollars per acre foot (AF) of treated water.

As a part of the Program, WRD has initiated a regional planning study to evaluate the feasibility of remediating the saline plume with seven additional stakeholders (known as the Stakeholder Group). The Stakeholder Group has expressed interest in treating the saline plume, receiving the treated water, or both as part of the Program. The members of the Stakeholder Group either pump, hold water rights, or have other key roles in supporting the basin operations.

The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

The purpose of Task 3 is to identify the key legal entitlements and easements needed for implementation of the preferred Project alternatives and next steps. Various engineering support services will be needed for acquisition of Project entitlements, which will be used for the development of the conceptual project design, environmental review, and permitting. A key component for the acquisition of various Project entitlements is the understanding of the charters of participating agencies, strategies to build consensus among stakeholders, and securing legal entitlements for the Program.

The purpose of this Technical Memorandum (TM) is to provide the Project Entitlement Acquisition Plan (PEAP) to:

- Identify each participating stakeholder's governance structure and limitations for developing the governance concepts
- Investigate easements and rights-of-way (ROW) for the location of extraction wells, and the preferred pipeline routes for product water delivery and brine discharge
- Explore the power supply arrangement and plan for the treatment facility operations

This TM is organized to include the following sections

- Section 1 – Introduction
- Section 2 – Summary of Potential Projects and New Infrastructure Locations
- Section 3 – Water Rights and Facilities Operation
- Section 4 – Stakeholder Charters, Roles and Responsibilities, and Governance Concepts
- Section 5 – Potential Options for Partnership and Governance
- Section 6 – Conclusions and Recommendations

2. Summary of Potential Projects and New Infrastructure Locations

2.1 Selection of Potential Projects

Based on the discussions at Workshop Number (No.) 3, held at WRD headquarters on March 20, 2019, the preferred Projects include six distinct Projects that will be carried forward in the Program feasibility assessment study. The characteristics of these potential Projects for further evaluation are shown in Table 2-1. Projects were developed by combining options for saline water extraction and treatment volume, water collection and treatment, brine disposal, and delivery and conveyance for various components of each Project.

Table 2-1. List of Potential Projects for Further Evaluation

Potential Project - General Description		Extraction Wells	Treatment Locations				Total New Extraction, AFY	Total Existing Extraction (Goldsworthy and Brewer), AFY	Water Delivery Locations and Amount, AFY						Total New Product Delivery, AFY
			Elm and Faysmith (Torrance)	Wellhead Treatment	Goldsworthy and Brewer	JWPCP			Torrance	Golden State Water	Manhattan Beach	LADWP	Cal Water	Lomita	
18	Spread Across Stakeholders via interties with New Pipeline to Manhattan Beach (12,500 AFY)	7 new wells	12,500	-	7,300	-	12,500	7,300	3,872	850	944	2,597	1,417	944	10,625
19	Spread Across Stakeholders via interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (12,500 AFY)	10 new wells	10,500	2,000	7,300	-	12,500	7,300	3,872	850	944	2,597	1,417	944	10,625
41	Spread Across Stakeholders via interties with New Pipeline to Manhattan Beach (16,000 AFY)	9 new wells	16,500	-	7,300	-	16,000	7,300	3,900	900	1,700	2,900	2,900	1,300	13,600
42	Spread Across Stakeholders via interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (16,000 AFY)	12 new wells	14,500	2,000	7,300	-	16,000	7,300	3,900	900	1,700	2,900	2,900	1,300	13,600
43	Spread Across Stakeholders via interties with New Pipeline to Manhattan Beach (20,000 AFY)	11 new wells	20,000	-	7,300	-	20,000	7,300	4,500	900	1,700	4,200	4,200	1,500	17,000
44	Spread Across Stakeholders via interties with New Pipeline to Manhattan Beach and Portable Wellhead Treatment (20,000 AFY)	14 new wells	18,000	2,000	7,300	-	20,000	7,300	4,500	900	1,700	4,200	4,200	1,500	17,000

Notes:

- = not applicable

AFY = acre-foot (feet) per year

JWPCP = Joint Water Pollution Control Plant

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2.2 Components of Projects and their Locations

Each preferred potential Project consists of the following project components:

- Brackish water extraction from various plume areas
- Brackish water treatment plant and wellhead treatment units
- Conveyance of:
  - Brackish water to the treatment plant for treatment
  - Treated product water conveyed to purveyors and off-takers
- Brine disposal
- Groundwater replenishment

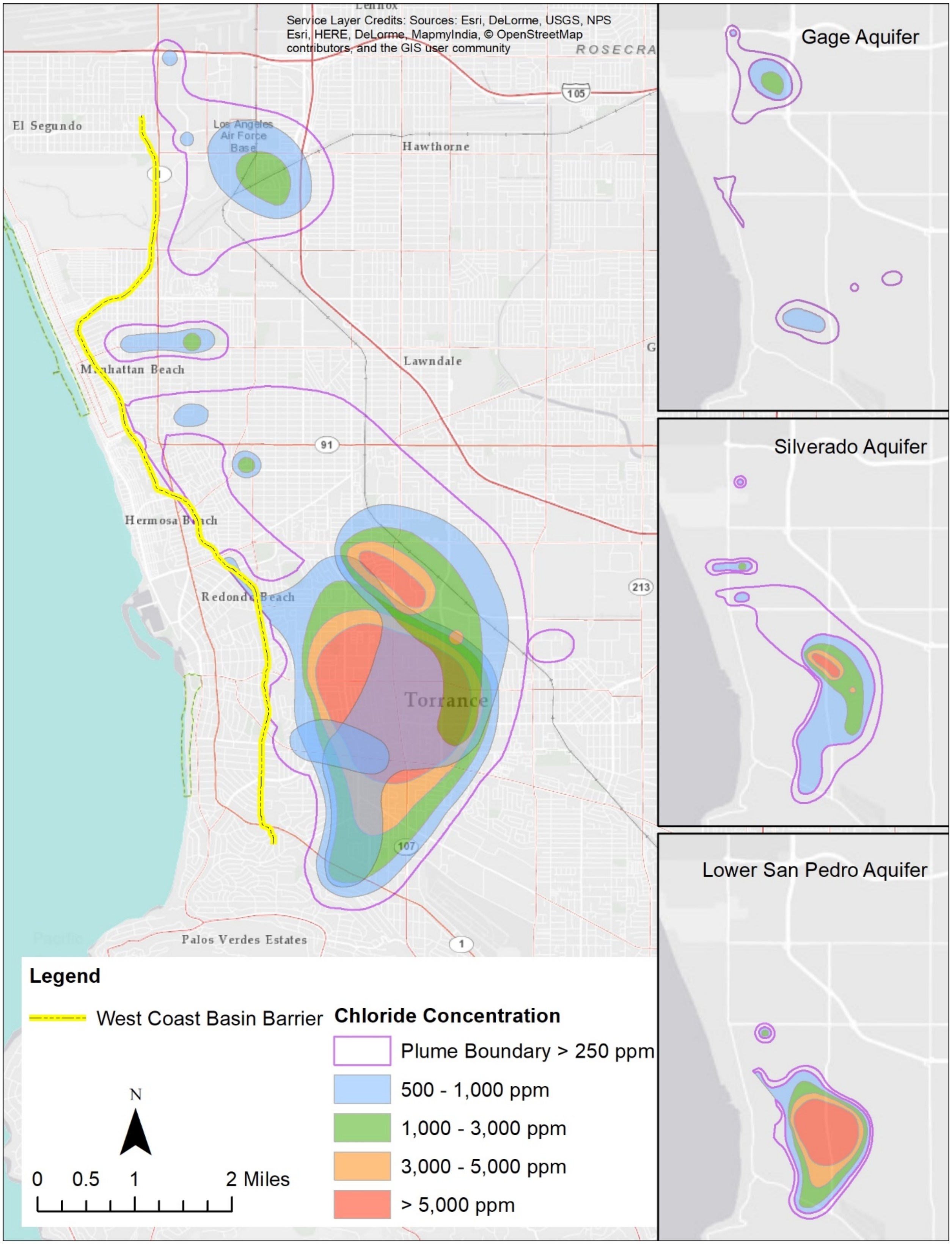
This section provides a summary of the location of the centralized treatment plant and the components of each Project, which will help understand and define the needs and limitations for the roles and responsibilities of stakeholders, their service areas, and the stakeholder charters for evaluation of potential governance structure for executing the Program successfully. Specifically, this review is meant to understand the location of the facilities and the stakeholder (with their jurisdictional area) that may be involved in the implementation of the proposed Projects. The answers to the following set of questions will help identify the roles and responsibilities of the stakeholders and other agencies under this Program:

- Who are the current owners of the sites considered for the centralized treatment plant and the potential properties identified for the portable wellhead treatment unit(s)?
- Where are these sites located with respect to the jurisdictional areas of the stakeholders?
- Based on the locations of the Project components, who has the legal authority to implement the Project components?
- Which agencies are responsible for the replenishment of the groundwater basins, and management of collection systems and water reclamation facilities for brine management?
- Which stakeholder(s) may own, operate, and maintain the facility or the components of the Projects?

2.2.1 Location of Treatment Facility

Figure 2-1 shows the location of the saline plume in Gage, Silverado, and Lower San Pedro aquifers. It can be seen from this figure that most of the saline plume lies under Torrance's service area. Small patches of the saline plume exist between Hermosa Beach and El Segundo and Hawthorne. To capture of the largest portion of the saline plume, the proposed centralized treatment facility will be located between Elm and Faysmith Avenues in Torrance. The location of the treatment facility at this site is suitable, as the saline plume is slowly migrating eastward towards this location. The migration of the plume is due to the pressure gradients induced from injection at the West Coast Basin Barrier system near the Pacific Ocean coastline. The extraction wells would extract water from the leading edge of the plume area. A concept-level design and layout for a 20,000-AFY facility on half of the 2-acre Elm and Faysmith site is presented in the *Conceptual System Design and Program Requirements (CSDPR)* TM. Figure 2-2 shows the location of the plant site. The proposed routing of the conveyance piping from the extraction wells to the proposed treatment facility and conveyance of the brine waste stream and treated product water are discussed in this section.

In addition to the centralized treatment facility that will remediate the majority of the plume area, some Projects include a portable wellhead treatment unit that will allow desalting of small patches of the plume, including the northern section of the Gage and Silverado aquifers. Three suggested locations for the portable treatment unit are described in this section.



Note:
ppm = part(s) per million

Figure 2-1. Saline Plume in Aquifers: Gage, Silverado, and Lower San Pedro

Figure 2-2. Location of the Proposed Centralized Treatment Facility in Torrance

2.2.1.1 Locations of Portable Treatment Unit

The portable treatment unit can be placed near the Oceangate property in Hawthorne, the Peck Reservoir area near Manhattan Beach, and the existing Sepulveda 2 well property in Torrance. Extracting the saline plume at these locations in addition to extraction wells feeding the Elm and Faysmith centralized treatment will allow the majority of the plume to be treated. The Manhattan Beach location is close to an area of the West Coast Barrier that is currently being enhanced with additional injection and monitoring wells by the Los Angeles County Department of Public Works. Therefore, this should be the last treatment site that the potable system would be placed to allow the provision for completion of this effort to protect the groundwater basin from seawater intrusion.

2.2.1.2 Alternative Locations for the Centralized Treatment Plant and Siting Extraction Wells for Targeting Northern Plume

The selection of the Elm and Faysmith site for the centralized treatment plant was based on suggestions of the Program stakeholders. The property at Elm and Faysmith is large enough for a 20,000-AFY treatment plant, and is reasonably close to the areas offered by the stakeholders for new extraction wells.

Potential alternative locations for the centralized treatment plant were investigated. Similarly, potential alternative properties for well extraction sites in proximity to the northernmost saline plume in the Gage Aquifer were explored. For these evaluations, a desktop analysis was performed using available aerial images from Google Earth™. Following the desktop analysis, a field investigation was conducted that included driving to the locations to assess site conditions.

Figure 2-3 shows a map of four properties, larger than 1 acre, that were evaluated as potential alternative locations for the centralized treatment facility (Appendix A provides details). Each site is larger than the 1 acre necessary for a 20,000-AFY treatment plant. The sites are located east of the plume and within 2 miles of the Elm Avenue and Faysmith property. If any of these sites are considered in the future, analysis of ROW and easements will need to be conducted to evaluate the ownership and potential governance considerations.

Table 2-2 presents the ownership of these alternative locations for the centralized treatment plant. To get the easements from the property owners, the next step would be to determine whether there are any current plans for development of the properties. The property owners should be contacted, and an appraisal prepared, and then an attorney would need to prepare an easement agreement. A typical time frame of such activities may take from 3 to 6 months. In a worst-case scenario, eminent domain action could be undertaken.

Table 2-2. Proposed Alternative Desalter Plant Locations

Proposed Alternative Desalter Plant	Property Information (Size in AC[a], Parcel Number, Land Use, and Assessed Value[b])	Property Ownership	Distance from: Elm Plant (miles)[a]; East of Plume (miles)[a]	Comments
Property 1	33.8 7352-015-005 Vacant Land $11,918,356	Torrance Black Beauty LLC	1.0 Within boundary	Includes a small, private property with horses and stables. Location is in proximity to an industrial plant, the Torrance Refining Company.
Property 2	7.8 7352-012-017 Vacant Land $2,929,013	Torrance Refining Company LLC	1.0 Within boundary	The vacant land includes a ChargePoint charging station, small facilities, and power lines. Location is in proximity to an industrial plant, the Torrance Refining Company. The site is adjacent to an active City of Torrance waste hauler facility and the closed Torrance Municipal Dump[c].
Property 3	4.1 4090-021-032 Commercial/Industrial $3,256,578	St Paul Fire and Marine Insurance Company, Comstock Crosser and Associate Dev Co.	1.5 0.5	Property is advertised for sale and includes an abandoned parking lot that is fenced off from the neighboring commercial property. Property 3 is directly across the street from an industrial plant, the Torrance Refining Company.
Property 4	8.9 7348-020-003, 7348-020-004, 7348-020-007, 7348-020-008, 7348-020-009, 7348-020-010 Commercial/Industrial $21,880,000	Bridge Point South Pay LLC	1.9 1.8	Includes abandoned buildings and parking lot where the buildings are covered in graffiti and contain broken glass windows. Sign within the property limits indicates hazardous materials were previously onsite. Sign exterior of property references that the property is for sale. Current owner is the Bridge Point South Pay LLC. Neighboring areas include residential area, commercial area, as well as two covered landfills. A portion of the site appears to be an archived Superfund site (Azko Coatings, Inc.).[d]

[a] Approximate acreage and distance based on desktop analysis

[b] Source: Los Angeles County Office of the Assessor, 2019

[c] Source: Los Angeles County Public Works, 2019a

[d] Source: Homefacts.com, 2019

Notes:

AC = acre(s)

Other properties were also investigated but eliminated from further assessments, and are not shown on the map. The rationale for eliminating those sites were (1) construction was being conducted at the site, or (2) the current use of the site was not compatible with the proposed treatment facility (for example, some sites were found to be close to landfill sites and stormwater sumps).

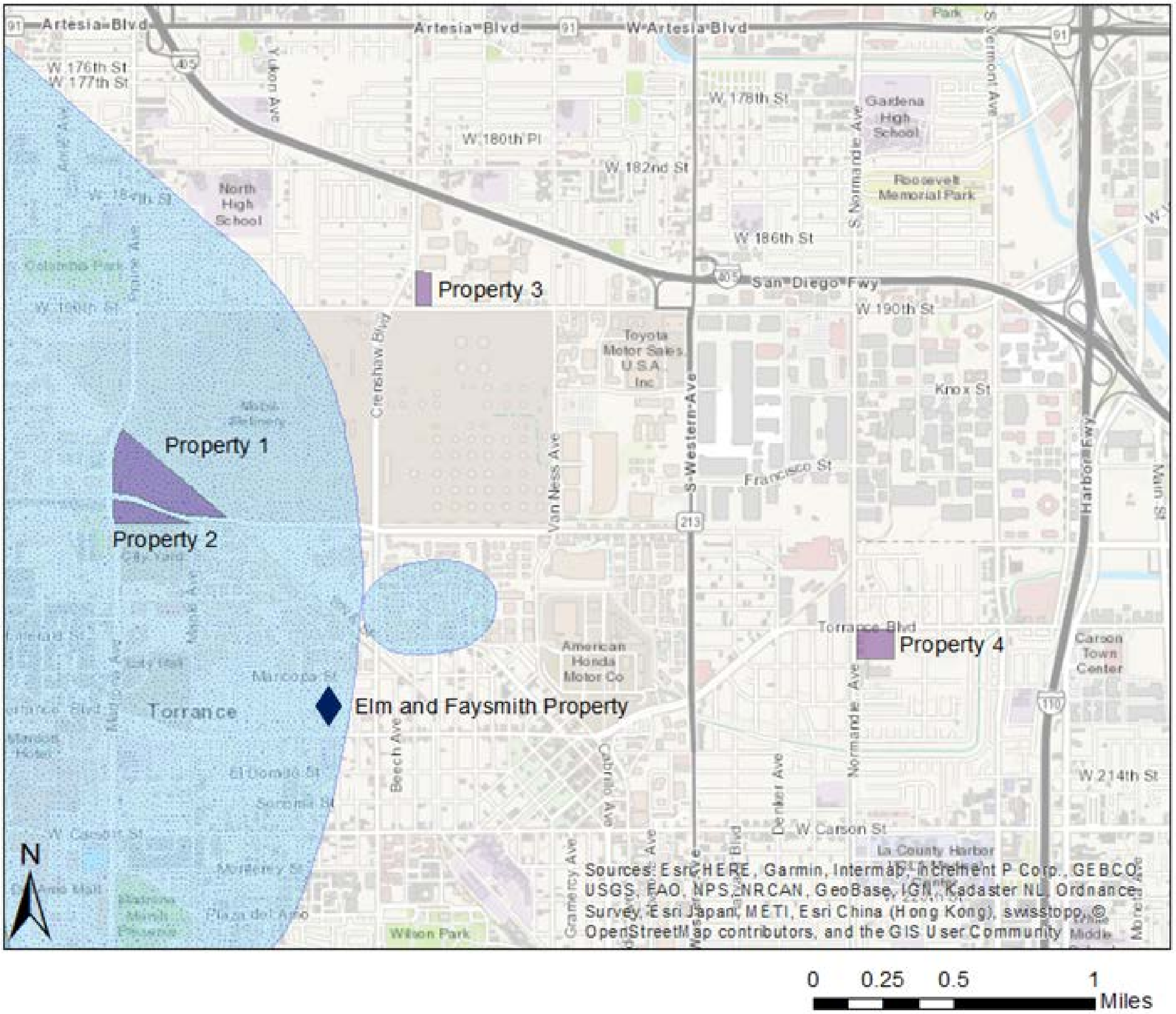


Figure 2-3. Alternative Properties for the Centralized Desalter Plant

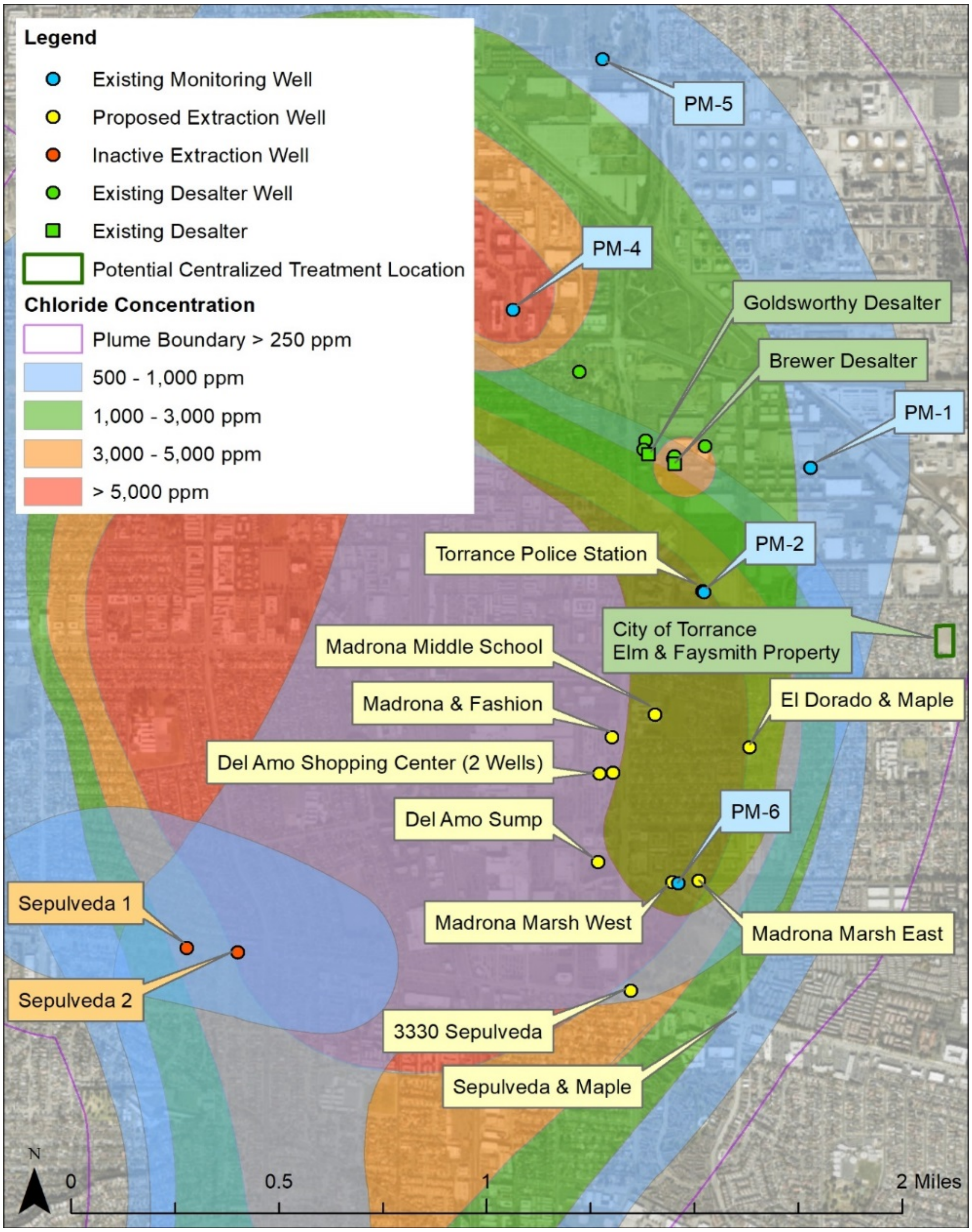
2.2.2 Extraction Wells and Conveyance Layout

2.2.2.1 Location of Extraction Wells and Property Ownership

The City of Torrance suggested 10 properties as proposed locations for new extraction wells for the Program that could treat the majority of the saline plume and feed a centralized treatment facility. Figure 2-4 shows the proposed 10 properties for placing extraction wells and the location of the centralized treatment facility. This figure also shows the locations of existing desalters, their associated extraction wells, as well as inactive extraction wells, including the Sepulveda 1 and Sepulveda 2 wells that were considered in the CSDPR. Note that well Sepulveda 2 is included in Projects 19, 42, and 44 as a suggested site for the portable wellhead treatment unit.

The *Brackish Water Extraction Conveyance Piping Route Analysis* TM (an appendix of the CSDPR) presents the evaluation of easements and jurisdictional rights associated with the proposed 10 new extraction well sites. Table 2-3 presents the ownership of these sites. Six out of 10 properties are owned by the City of Torrance, and the remaining four properties are owned by others. Based on the proposed extraction well locations and property ownership information provided by the Los Angeles County Office of the Assessor, it appears that easements may be required for extraction wells at the Del Amo Sump, Del Amo Shopping Center, Madrona and Fashion Streets, and the Madrona Middle School, as these properties are not owned by the City of Torrance.

To get the easements from the owners of these properties, the next step would be to determine whether there are any current plans for development of the properties. The property owners should be contacted and an appraisal prepared, and then an attorney would need to prepare an easement agreement. A typical time frame of such activities may take from 3 to 6 months. In a worst-case scenario, eminent domain action could be undertaken.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID

Figure 2-4. Regional Map with the Location of Monitoring Wells, Potential Extraction Wells, One Potential Treatment Plant Location (Elm and Faysmith Property), along with an Overlay of Saline Plumes in the Gage, Silverado, and Lower San Pedro Aquifers.

Table 2-3. Proposed Extraction Wells Property Ownership

Proposed Extraction Well Location	Property Information[a]	Property Ownership[a]	Potential Next Steps
3330 Sepulveda	Madrona Marsh Preserve, Assessor's ID No. 7359-002-903	Owned by the City of Torrance	None
Sepulveda and Maple Streets	Madrona Marsh Preserve, Assessor's ID No. 7359-002-903		
Madrona Marsh West (shown as Monterey Street on Figure 2-1)	Madrona Marsh Nature Center (3201 Plaza Del Amo), Assessor's ID No. 7359-030-900		
Madrona Marsh East (shown as 3201 Plaza Del Amo on Figure 2-1)	Madrona Marsh Nature Center (3201 Plaza Del Amo), Assessor's ID No. 7359-030-900		
El Dorado and Maple Streets	Maple Sump, Assessor's ID No. 7362-003-900		
Torrance Police Station	3300 Civic Center Drive, Assessor's ID No. 7353-001-914		
Del Amo Sump (shown as 21735 Madrona Avenue on Figure 2-1)	Assessor's ID No. 7366-019-086	Property is owned by Torrance Company (property type is listed as vacant land, and assessed value is listed as $21,324)	Real estate firm or the City of Torrance should contact the property owners and prepare an appraisal, and then the City of Torrance attorney will need to prepare an easement agreement
Del Amo Shopping Center (2 wells)	21515 Madrona Avenue, Assessor's ID No. 7366-019-051, owned by Madrona F and F LLC	Property type is listed as vacant land, and the assessed value is listed as $5,700,364	
Madrona and Fashion Streets	21405 Madrona Avenue, Assessor's ID No. 7366-019-146, owned by Madrona F and F LLC	Property type is listed as a commercial/industrial area, and the assessed value is listed as $16,121,804	
Madrona Middle School (shown as Madrona Avenue and Opal Street on Figure 2-1)	Madrona Middle School (21364 Madrona Avenue), Assessor's ID No. 7362-004-900	Owned by Torrance Unified School District	

[a] Source: Los Angeles County Office of the Assessor, 2019

Notes:

ID = identification

2.2.2.2 Conveyance for Source Water Delivery to the Centralized Plant and Piping Route

The *Brackish Water Extraction Conveyance Piping Route Analysis* TM also examined the proposed conveyance piping routes from the new extraction wells to the proposed centralized treatment facility at the City of Torrance Elm and Faysmith property. Based on the desktop analysis of the available aerial images from Google Earth™ and data from the Los Angeles County Geographic Information System (GIS) data portal, it was found that all conveyance piping from the extraction wells to the proposed Project will be located in the city's street ROW, and no easements will be required for constructing the pipelines.

2.2.3 Product Water Delivery

One of the goals of the Project is to deliver product water to all of the Program stakeholders. As part of this Feasibility Study, a conveyance and distribution system analysis for delivery of the product water produced by the centralized treatment plant was performed. Delivery alternatives were evaluated to identify the pipeline routing, connection points, and the ROW analysis. One of the stakeholders, the City of Torrance, has distribution system interties with all other stakeholders, with the exception of Manhattan Beach. Since the Elm and Faysmith treatment location is in the Torrance area, the plan is to pump the product water into the Torrance distribution system within a block or two of the Elm and Faysmith site, and deliver the water to the other stakeholders via the existing interties. Delivery of the product water from the treatment facility to Manhattan Beach requires a new, dedicated pipeline. The product water conveyance system analysis examined the new conveyance equipment and routing. The proposed piping alignment extends entirely within the public ROW within the cities of Torrance and Manhattan Beach. No easements will be required.

2.2.4 Conveyance Piping Routes for Brine Line

The options for brine waste management include: (1) discharge to the existing Los Angeles County Sanitation Districts' (LACSD's) collection system (sewer system); (2) construct a dedicated brine line to the outfall of either LACSD's JWPCP or the City of Los Angeles' Hyperion Water Reclamation Plant. The *Dedicated Brine Line Route Analysis* TM presents the evaluation of a proposed route for the dedicated brine line from the treatment facility to the JWPCP effluent tunnel and outfall system. Based on the analysis conducted under Task 1F, the proposed brine line from the proposed treatment facility to the JWPCP will be located in the city street ROW. Trenchless crossings and permits are required at one railroad and two highway crossings. Easements will also be required for the crossing of Interstate 110 (I-110). Geotechnical analysis, detailed survey, and utility investigations will need to be performed during design of the conveyance routes for the brine line. The exact route in the city ROW will need to be determined to minimize conflicts with the utility infrastructure and to avoid traffic disruption within the proposed ROW.

2.2.5 Power Supply Needs for the Treatment Plant Operations

The *Power Supply Plan* (PSP) presents the evaluation of power supply options and power supply needs. The goal of the PSP is to analyze and recommend the most applicable and feasible, environmentally efficient, cost-effective, and long-term equipment configurations to meet the electric power demand loads for running the brackish reclaimed water facility. The assessment provides a screening of power options, including conventional generation and renewable energy that meets the needs of the overall energy strategy in comparison to the baseline purchased electricity. A methodical evaluation of power generating facility selection began with the establishment of the Project baseline for the amount of purchased electricity required from the utility provider for each of the new water treatment facility projects. The PSP details the extent of the transmission infrastructure that may be required, and provides a review of purchased power from Southern California Edison (SCE), a community choice aggregation (CCA), or a wholesale market broker. Based on the evaluation of the power requirements for the Project components for each of the projects, it appears that each of the facilities will require new electrical service, which creates necessary coordination with SCE for transmission line easements.

3. Water Rights and Facilities Operation

3.1 Water Rights of Stakeholders

The West Coast Basin has total adjudicated rights of 64,468.25 AFY, which is based on historical use and not the safe yield of the basin. The adjudication is based on a physical solution that includes artificial replenishment through two injection barriers using a combination of imported and recycled water supply to create an operational yield to allow production higher than the natural safe yield.

Groundwater extractions from the West Coast Basin are governed primarily by the legal requirements of the existing Judgment, water consumption demands, and water supplies from the local water purveyors for the areas overlying the West Coast Basin. The Judgment contains provisions that allow for limited flexibility in the management of the West Coast Basin. Carryover of unpumped water is allowed from one administrative year to the next, up to 100 percent of the adjudicated right. However, the amount of available carryover is reduced by the amount of stored water held by the party. A reduction of this type, however, will not cause the amount of carryover to be less than 20 percent of a party's total adjudicated rights. Adjudicated rights or carryover can be leased or sold by parties to the Judgment or their successors.

Overextraction in the basin is limited to 10 percent, or 2 AF, whichever is greater. Overproduction must be made up the following year by reduced pumping (WRD, 2009).

Each year, adjudicated rights are transferred between parties through sales and leases. Allowable extraction in each year for each party depends on adjudicated rights, net carryover, leases, and storage. Table 3-1 shows the groundwater rights of the stakeholder purveyors, along with leased pumping in 2017.

Table 3-1. Stakeholder Water Rights Accounting in the West Coast Basin

Stakeholder	Adjudicated Rights (AFY)	Net Carryover 2015-2016[a] (AFY)	Leases (with Flex)[b] (AFY)	Leases (without Flex)[b] (AFY)	Storage[c] (AFY)	Allowable Extraction[d] (AFY)
Cal Water – Hawthorne Lease	0.00	475.79	1,882.00	0.00	0.00	2,357.79
Cal Water – Hermosa Redondo	4,070.00	4,070.00	0.00	0.00	0.00	8,140.00
Cal Water – Dominguez	10,417.45	10,417.45	0.00	0.00	0.00	20,834.90
GSWC[e]	7,502.24	3,164.57	0.00	0.00	3,300.00	10,008.81
City of Lomita	1,352.00	770.70	-250.00	0.00	0.00	1,872.70
City of Los Angeles	1,503.00	1,503.00	0.00	0.00	0.00	3,006.00
City of Manhattan Beach	1,131.20	1,284.24	950.00	0.00	0.00	3.365.44
City of Torrance	5,638.86	0.0	0.0	0.0	5,638.86	11,277.72

[a]Net Carryover is the sum of all carryover from the previous year less the amount of carryover conversion for 2017.

[b]Lease with flex includes carryover provisions. Refer to Watermaster Report 2017 for information concerning leases (WRD, 2017).

[c]Storage includes Carryover Conversion for Administrative Year 2016-2017.

[d]Allowable Extraction = Adjudicated Rights + Net Carryover + Leases + Storage.

[e]Includes 3,959 AF of increased extraction accounted for in Allowable Extraction (pursuant to Section IV(K) of the Central Basin Judgment).

3.2 Existing Groundwater Adjudication and Operation of Facilities

As discussed in Section 3.1, there are provisions for transferring adjudication rights, overproduction amounts, carryover, and storage; however, WRD and the other stakeholders have agreed to operate the facility within the total adjudicated rights of 64,468.25 AFY. The use of individual stakeholder water rights will be determined as the Program advances and the entities involved in Project implementation are established.

4. Stakeholder Charters, Roles and Responsibilities, and Project Governance Concepts

4.1 Stakeholder Charters, Roles, and Responsibilities

To develop potential governance concepts, a review of each stakeholder's charter, roles and responsibilities, and governance concepts within their service areas was conducted. Table 4-1 captures the information on stakeholders' charters, along with the governance structure of the agencies, which is necessary to understand the authority of each stakeholder to work within or outside the jurisdictional boundaries and help define the type of roles and responsibilities they can potentially take on in this Program.

Table 4-1. Stakeholder Charters, Roles and Responsibilities, and Example Facilities

Stakeholder	Charter	Roles/Responsibilities and Example of Existing Collaborative Projects
WRD	• WRD is enabled under the California Water Code to purchase and recharge additional water to make up this annual overdraft, which is known as artificial replenishment or managed aquifer recharge (MAR). WRD has the authority to levy a replenishment assessment on all pumping within the District to raise the monies necessary to purchase or manufacture the artificial replenishment water and to fund projects and programs necessary for replenishment and groundwater quality activities. • A five-member Board establishes policy for the WRD. The Board members are elected by the public, each representing the cities and unincorporated areas within their respective divisions, and serve a 4-year term. • The City of Torrance is responsible for O&M of the Robert W. Goldsworthy Desalter (also known as the Torrance desalter) treatment plant under contract with WRD.	• WRD is the largest groundwater agency in the State of California, managing and protecting local groundwater resources for 4 million residents. • WRD is responsible for managing and replenishing both the West Coast and Central groundwater basins. • WRD's service area covers a 420-square-mile region of southern Los Angeles County, the most populated county in the United States. The 43 cities in the service area, including a portion of the City of Los Angeles, use about 250,000 AF (82 billion gallons) of groundwater annually, which accounts for approximately half of the region's (i.e., WRD's service area) water supply. • WRD ensures that a reliable supply of high-quality groundwater is available through the use of recycled water and stormwater capture. WRD is responsible for monitoring and testing groundwater throughout the region using effective management principles. • Since 2002, WRD has been operating the Robert W. Goldsworthy Desalter, to remove brackish groundwater from a saline plume in the Torrance area that was stranded inland of the WCB Barrier after the barrier was put into operation in the 1950s and 1960s. Product water from the Goldsworthy Desalter is delivered for potable use to the City of Torrance's water distribution system. Since 2001, it has been removing 2.3 MGD of brackish groundwater from the WCB. • The largest component of WRD's WIN program is the ARC (formerly known as the GRIP). The purpose of WIN and the ARC is to fully eliminate the current demand for imported water for groundwater replenishment. ARC will produce 21,000 AF of advanced treated recycled water annually to replenish the Central Basin. • To ensure high-quality water delivered through the distribution system, WRD measures and tracks groundwater levels and water quality conditions, evaluates potential impact of recycled water on groundwater, and identifies potential problems at monitoring wells before recycled water arrives at any downgradient drinking water wells.
LADWP	• The LADWP is a department of the City of Los Angeles, a charter city. LADWP is a local public agency as defined by California Water Code Section 10701(a). LADWP, the largest municipal water and power utility in the nation, was established more than 100 years ago and delivers reliable, safe water and electricity to 4 million residents and businesses in Los Angeles. • Los Angeles City Charter Sections 100-107 legally incorporate the City of Los Angeles as a municipal corporation with all the powers ascribed to charter cities in the Constitution of the State of California. Los Angeles Administrative Code Section 10.1 gives the City the authority to make contracts. • Los Angeles City Charter Sections 600-610 create three proprietary departments in the City, specifically Airports, Harbor, and Water and Power. The proprietary departments are governed by Boards of	• LADWP serves approximately 681,000 water customers and 1.4 million electric customers. • The Los Angeles Aqueducts, local groundwater, and supplemental water purchased from the MWD are the primary sources of water supply for Los Angeles. • LADWP owns and operates the LAAFP that has been operating since 1986. LADWP's treatment capacity at the LAAFP in Sylmar is 600 MGD.

Table 4-1. Stakeholder Charters, Roles and Responsibilities, and Example Facilities

Stakeholder	Charter	Roles/Responsibilities and Example of Existing Collaborative Projects
	Commissioners and manage and control their own assets and funds. Los Angeles City Charter Sections 670-684 define the power and authority of the Board of Water and Commissioners. • As a revenue-producing proprietary department, the LADWP transfers a portion of its annual estimated electric revenues to the City of Los Angeles general fund. LADWP's operations are financed solely by the sale of water and electric services. Capital funds are raised through the sale of bonds. No tax support is received. • A five-member Board of Water and Power Commissioners establishes policy for the LADWP. The Board members are appointed by the Mayor and confirmed by the City Council for 5-year terms.	
City of Torrance	• The City of Torrance is a charter city and operates under a city council-city manager form of government. Under this system, the people elect the City Council, which is the legislative body, consisting of a mayor and six council members.	• The City delivers over 25,000 AF (8.1 billion gallons) of both potable (drinking water) and recycled water supplies to residential, businesses, and industrial customers in Torrance. The City is also responsible for maintenance and repair of 320 miles of distribution pipelines, 2,700 fire hydrants, 7,500 valves, and 26,500 service connections. • The Department of Public Works is responsible for local water supply, the monitoring and maintenance of water quality, planning preventive maintenance and regular maintenance, the operation and repair of the water system and distribution system, and interfacing with the State Health Department and other agencies regarding water quality matters. • The Robert W. Goldsworthy Desalter (also known as the Torrance Desalter) was originally designed with a production capacity of 2,200 AFY of potable quality water for delivery to the City's distribution system. The City of Torrance is responsible for O&M of the treatment plant under contract with WRD. The facility underwent a significant expansion to increase production to a total capacity of 4,800 AFY. Completed in December 2017, this included the addition of one RO system, two new source water wells, and associated conveyance pipelines and pump stations.
City of Manhattan Beach	• The planning and management of potable water supply within the Manhattan Beach area is managed by the City of Manhattan Beach's Board members. • All members of boards or commissions are registered voters and residents of the City of Manhattan Beach. • Decisions on water purchase and distribution for the City are made by the City's Board members.	• The City obtains 85% of its water supply from connections with the MWD's system. • The remaining 15% is obtained from two City-owned wells located in Redondo Beach. • The MWD filters and chlorinates water at a treatment plant before the water reaches Manhattan Beach. • The City maintains water quality for the distributed water.

Table 4-1. Stakeholder Charters, Roles and Responsibilities, and Example Facilities

Stakeholder	Charter	Roles/Responsibilities and Example of Existing Collaborative Projects
City of Lomita	• The planning and management of potable water supply within the City of Lomita area is managed by the City's Board members. • Decisions on water purchase and distribution for the City are made by the City's Board members.	• The City of Lomita's sources of drinking water are local groundwater and surface ("imported") water purchased from WBMWD. WBMWD gets its water from the MWD. The source of water is the Sacramento–San Joaquin River Delta via the State Water Project and the Colorado River beginning at Lake Havasu. MWD supplies the City of Lomita with water treated at the Weymouth Treatment Plant. Most of the water treated at this plant originates in the mountain ranges in seven western states, travels down the Colorado River, and flows through MWD's 242-mile Colorado River Aqueduct. • The water quality of imported water is maintained by the WBMWD. The City of Lomita ensures water quality of groundwater for distribution. The water from WBMWD is treated using conventional treatment methods, which include coagulation, flocculation, sedimentation, and filtration. The water is then disinfected to kill any microorganisms, such as bacteria, and reduce the potential for their regrowth in the distribution pipes.
GSWC	• GSWC is a regulated utility in California and is a wholly owned subsidiary of American States Water Company. • GSWC is an investor-owned public utility company, which owns 39 water systems throughout California regulated by the CPUC. • GSWC, an urban water supplier, is regulated by the U.S. Environmental Protection Agency, the California Department of Public Health, and the California Public Utilities Commission.	• GSWC provides water service to residents across California located within more than 80 communities throughout 10 counties in Northern, Coastal, and Southern California (approximately 255,000 customers). • GSWC monitors and tests for hundreds of contaminants in each of 37 water distribution systems.
Cal Water	• Since 1928, Cal Water has delivered quality water, service, and value to their customers. Cal Water's goal is to provide a reliable supply of water that meets all federal and state water quality standards. • The Board of Directors, elected by the company's stockholders, oversees the management of the company and its business. The Board selects the senior management team that is responsible for operating the company's business, and monitors the performance of senior management.	• Cal Water is the largest subsidiary of the California Water Service Group, which also includes Washington Water Service, New Mexico Water Service, Hawaii Water Service, HWS Utility Services, and CWS Utility Services. As a whole, the Group provides high-quality regulated and nonregulated utility services to approximately 2 million people in 100 communities. • The company provides nonregulated services to private companies and municipalities. The services include production, purchase, storage, treatment, testing, distribution, and sale of water for domestic, industrial, public, and irrigation uses, and for fire protection. The nonregulated services include water system operation, billing, and meter reading services.

Table 4-1. Stakeholder Charters, Roles and Responsibilities, and Example Facilities

Stakeholder	Charter	Roles/Responsibilities and Example of Existing Collaborative Projects
WBMWD	• West Basin's water retail agencies include three private water companies (Cal Water, GSWC, and California American Water Company), four cities (El Segundo, Inglewood, Lomita, and Manhattan Beach), and the Los Angeles County Department of Public Works (Waterworks District #29).	• Wholesale imported water is purchased from MWD to nearly 1 million people in 17 cities and unincorporated areas over a 185-square-mile area southwest of Los Angeles County. • WBMWD sells water produced by the C. Marvin Brewer Desalter at the effective Metropolitan rate. This includes the Metropolitan noninterruptible base rate and an AF equivalent for the capacity charge. The rate for desalter water is $1,060/AF as of January 2016. • WBMWD owns the C. Marvin Brewer Desalter Facility, which began operating in July 1993. The facility was built on a site owned by CWS in Torrance, where it removes chloride from groundwater impacted by seawater intrusion in the West Coast Groundwater Basin. In the early 1990s, WBMWD completed the C. Marvin Brewer Desalter Facility as a demonstration project for removing and treating the brackish water using two existing drinking water wells that were impacted by the seawater intrusion. In 2005, those two wells were replaced with a new, more productive well. This well has the capability to pump 1,600 to 2,400 AFY of brackish groundwater to be treated at the desalting facility for use by WBMWD's retail agency, Cal Water. • WBMWD's Edward C. Little Water Recycling Facility, located in El Segundo, has been in continuous operation since 1995 and has conserved over 170 billion gallons of imported water by serving reliable supplies of recycled water for a wide variety of nonpotable uses.

Sources:

WRD, 2019a,b; City of Torrance, 1947, 2019a, b; Reuters, 2019; Cal Water, 2019; NAWC, 2001; GSWC, 2019a,b; WBMWD, 2019a,b; City of Los Angeles, 2019; American Legal Publishing Corporation, 2019; Government of California, undated; LADWP, 2019; City of Lomita, 2011, 2013; Los Angeles County Public Works, 2019b; City of Manhattan Beach California, undated, 2019a,b

Notes:

% = percent

ARC = Albert Robles Center for Water Recycling & Environmental Learning

Cal Water = California Water Service Company

CPUC = California Public Utilities Commission

CWS = California Water Service

GRIP = Groundwater Reliability Improvement Project

GSWC = Golden State Water Company

LAAFP = Los Angeles Aqueduct Filtration Plant

LADWP = Los Angeles Department of Water and Power

MAR = managed aquifer recharge

MGD = million gallons per day

MWD = Metropolitan Water District of Southern California

O&M = operations and maintenance

RO = reverse osmosis

WCB = West Coast Basin

WIN = Water Independence Now

4.1.1 Evaluation of Projects and Stakeholder Involvement

The location of the physical components and infrastructure associated with the potential Projects is the first step in developing the management structure. The potential Projects presented in Table 2-1 were developed by considering options for location of the Project components and infrastructure associated with potential Projects, such as:

- Location of the centralized treatment facility
- Locations of extraction wells to pump saline water
- Conveyance for delivery of extracted water to the treatment facility
- Brine disposal methods, brine disposal routes, and location
- Delivery of product water (that is, the stakeholder's distribution system and amount of water)

Based on the evaluation of the Project components, the governance for the Project will include the formulation, establishment, and implementation of policies, contracts, and clarification of roles and responsibilities of stakeholders in relation to their charters and services. The governance mechanism will include the political, social, economic, and administrative system(s) in place that influence the Project and water use management. Essentially, the governance mechanism will be evaluated as:

- Who will own, design, build, operate, and maintain the Project
- How will product water be distributed among the stakeholders
- When and how water will be conveyed to the plant
- When and how will product water be conveyed from the plant to the off-takers
- Who has the rights to water
- How will the entire Project will be managed, not only from the prospective of product water deliveries and amount, but also for brine management

The rest of this section provides a summary of the Project components and location of infrastructure, which will help define the possibilities for governance structure.

With the assessment of Project components for all potential six projects, the new centralized brackish water treatment plant will be located on property owned by the City of Torrance at Elm Avenue and Sierra Street, and would distribute water across various stakeholders involved in this Project. Product water will be supplied to all stakeholders; however, the volume of water to each stakeholder depends on the Project.

In addition to the stakeholders, agencies such as the LACSD and MWD may participate to share the roles and responsibilities of the Project.

4.1.2 Project Governance Concepts and Example Projects

The location of the Project components, as well as an understanding of each of the stakeholders' charters, limitations, and water rights, will influence governance concepts for the Program. The governance structure will depend on the rules and roles and responsibilities that may be taken or assigned to stakeholder(s). To execute such governance structure, some limitations may arise, such as an agency may not fulfil the role to implement Project components that are not within the stakeholder's jurisdiction. For example, the wellhead treatment units may be owned and operated by the same stakeholder who owns and operates the centralized treatment facility; alternatively, those wellhead treatment units may be owned and operated by the stakeholder who owns the properties where the well head treatment extraction wells will be situated. To overcome the jurisdictional limits for implementation of the Project plans, regional agencies have the authority to go beyond the boundaries so that they could be considered as owners and operators of the facilities.

The governance structure and configuration can be developed based on two types of Project component needs and services: (1) Projects that use only the centralized treatment facility, and (2) Projects that include wellhead treatment, with potential options for ownership and operations of the facilities and conveyance based on the physical site locations with respect to the agencies' service areas.

The following are two existing examples of governance mechanisms for facilities in the basin that could be considered while developing the governance structure for the Program:

1) **Robert W. Goldsworthy Desalter.** The Goldsworthy Desalter is an existing brackish groundwater treatment facility owned by WRD and operated by the City of Torrance. The location of the Goldsworthy Desalter is shown on Figure 2-2.
2) **C. Marvin Brewer Desalter.** The Brewer Desalter is an existing brackish groundwater treatment facility owned by WBMWD and operated by Cal Water. The facility was built on a site owned by Cal Water and is located in Torrance. The location of the Goldsworthy Desalter is shown on Figure 2-2.

5. Potential Options for Partnership and Governance

In addition to the physical components and infrastructure associated with the potential Projects, an organizational and governance structure will need to be established for successful implementation. Figure 5-1 presents a simplified illustration of the major roles that will need to be filled by stakeholders and others for the Project to proceed. A brief description of the roles and responsibilities follows.

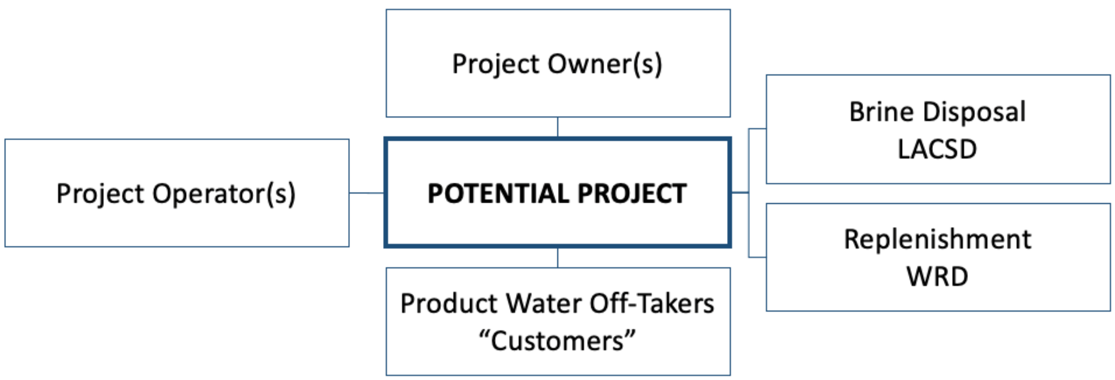


Figure 5-1. Overview of Major Project Roles and Responsibilities

5.1 Major Organizational Roles

5.1.1 Project Owner

The ownership of land and facilities is at the top of the organization chart. This role could be filled by an individual agency or multiple agencies organized as a joint powers authority (JPA). The Project owner generally takes responsibility for Project development, environmental permitting, and Project financing.

5.1.2 Project Operator

The Project operator is the entity or entities responsible for O&M of the facilities and infrastructure. Again, frequently, the owner and the operator are the same stakeholder, but this is not always the case. For example, the Goldsworthy Desalter is owned by WRD and operated by the City of Torrance. There are also examples of projects where portions of a conveyance system may be owned and operated by off-takers, when the facilities are sited within their service areas.

5.1.3 Product Water Off-Taker

An off-taker is a customer for the product water produced and delivered by the Project. Off-takers receive the primary benefits of the Project and, in return, provide the revenue stream(s) needed to cover the costs of financing and operations. In many local projects, the owner and the off-taker are the same stakeholder. Because the potential Projects are likely to serve multiple stakeholders, there may be several off-takers with separate water purchase agreements with the owner entity. There are also examples of off-taker JPAs, with a collective purchase agreement (for example, Bay Area Water Supply & Conservation Agency).

5.1.4 Service Providers

There are two essential service providers to the Project that have already been identified to provide (1) brine disposal services (LACSD), and (2) replenishment water (WRD). These services and others generally result in owner costs that can be passed on to off-takers through the water purchase agreement(s).

5.2 Project Governance

The specific governance requirements for the Program will flow from future decisions regarding Project ownership. While there are many possible ownership possibilities, several general ownership categories can be identified:

1) Existing regional public agency (for example, WRD or WBMWD)
2) Existing local public agency (for example, City of Torrance)
3) Existing private water company (for example, Cal Water)
4) New JPA comprising two or more public off-takers (stakeholders)

Each of these possible ownership entities will have existing or newly established governance structures that will define the initial authorities and control of the Program. Importantly, the existing stakeholders collectively possess the necessary authorities needed to accomplish the implementation of the Program. As the Program develops, stakeholders may benefit from consideration of the following questions when finalizing the ownership and governance structure:

- Is this Project beneficial to the stakeholder or agency and meet their goals and mission?
- Does it meet the regional goals and benefits for water supply reliability?
- With the unused water rights, can the agencies supply water to neighboring utilities?
- Is it possible for the stakeholder’s or agency’s policy to accommodate the need of the Project?
- What are the opportunities for financing, owning, operating, and maintaining the facility?
- How should cost sharing be determined?
- What type of contractual agreements are needed to cover all elements of the Project?
- How will regulatory requirements be met?

Based on interviews with the Stakeholder Group and a review of the Project components, several of the stakeholders could potentially fulfill all of the functions needed for the Project, presuming the facilities or the conveyance, or both, are within their service areas. Agencies also have identified available land within their service areas that could offer additional locations for siting extraction wells as the saline plume shifts over time. Depending on the service area, the agencies could also provide treatment for constituents other than chlorides, should additional treatment prove cost-effective. Finally, there may be other mechanisms to design, build, operate, and maintain the treatment project in conjunction with the project stakeholders and other agencies, such as LACSD and MWD.

As the functional governance structure is developed, a number of institutional agreements and contracts will need to be prepared. They will likely include:

- Water purchase agreements
- Intake and discharge agreements
- Site options and site leases
- Easements and ROW required for the preferred product water pipeline route
- Power supply agreements for the facility operations

6. Conclusions and Recommendations for Next Steps

After reviewing the legal authorities and rights of the potential Project participants, as well as having discussions with individual members of the Stakeholder Group, it appears that there are no institutional barriers to the successful implementation of any of the potential Projects presented in this TM. The examples provided by the Goldsworthy and Brewer projects further demonstrate the feasibility of project structures that are already in place. At this stage in the Program's development, no specific recommendations for governance structure are provided, pending further discussions among Stakeholder Group members and others. This Program is not limited to the agencies who have been identified as stakeholders for this Project; others, such as MWD and LACSD, could also participate in the Project, depending on the needs to fulfill the regional objectives. Continued outreach with key stakeholders within the groundwater basin and the public, together with ongoing coordination with regulatory agencies, will help support the success of the Program.

6.1 Recommendations for Next Steps

With the input of stakeholders, an assessment matrix can be developed, consisting of the following:

- Location of Project components and jurisdictional areas
- Stakeholder governance structure, roles and responsibilities, and limitations
- Projected roles and responsibilities for the implementation of the Program

Such a matrix will help define roles and responsibilities and potential governance options for the preferred Projects. Apart from providing an overview of the agencies and Program needs, the matrix will help identify the stakeholder's capacity and mechanism to shape the governance structure(s) for the Project.

As a next step, a workshop with WRD and other stakeholders is recommended to further refine and fine tune the potential governance options that will have the greatest potential of moving forward. A timeline of the Project execution can also be developed. Following the workshop, the details of the governance structure should be worked out, which will include the role of the owner, operator, off-takers of product water, and service providers, as well as coordination among other sectors and potential stakeholders of the Program.

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Appendix A
Alternative Treatment Plant Locations and Extraction Well Sites for Northern Plume

Technical Memorandum

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Subject	**Alternative Desalter Plant Locations and Extraction Well Sites for Northern Plume**
Project Name	Regional Brackish Water Reclamation Program Feasibility Study
Date	May 30, 2019

1. Introduction

The Water Replenishment District of Southern California (WRD) is responsible for managing and replenishing both the West Coast and Central groundwater basins. In the West Coast Basin, a significant plume of saline groundwater (saline plume) with elevated total dissolved solids (TDS) has been trapped in the Gage, Silverado, Lynwood, and Lower San Pedro (equivalent to Sunnyside) aquifers because of historical seawater intrusion and the subsequent implementation of two injection barriers. To fully use the West Coast Basin, WRD has initiated a Regional Brackish Water Reclamation Program (Program) to evaluate ways to remediate the trapped saline plume. Program goals include treatment of the saline plume to produce potable water and discharge of waste streams generated (mostly high-salinity brine) in the treatment process.

The feasibility study will evaluate the following components:

- Where to extract the plume water
- Where and how to treat the plume water
- How to convey the treated potable water to Program stakeholders
- How to manage the brine waste stream

The feasibility study includes the analysis of numerous "Projects," consisting of various combinations of components, and the calculation of the economics of each Project. The economics include a summation of the cost of each of these components and the cost of the water necessary to replenish the extracted high-salinity plume water, expressed as dollars per acre foot (AF) of treated water.

As a part of the Program, WRD has initiated a regional planning study to evaluate the feasibility of remediating the saline plume with seven additional stakeholders (known as the Stakeholder Group). The Stakeholder Group has expressed interest in treating the saline plume, receiving the treated water, or both as part of the Program. The members of the Stakeholder Group either pump, hold water rights, or have other key roles in supporting the basin operations.

The Stakeholder Group consists of the following parties:

- WRD
- Los Angeles Department of Water and Power (LADWP)
- City of Torrance
- City of Manhattan Beach
- City of Lomita
- Golden State Water Company (GSWC)
- California Water Service Company (Cal Water)
- West Basin Municipal Water District (WBMWD)

The proposed centralized desalter facility is currently planned to be located at the Elm Avenue and Faysmith property in Torrance. This site is a park located within a residential housing area. Due to concerns with permitting of this site, WRD requested that alternate sites within the Project area be investigated.

WRD also requested that additional sites within the northernmost saline plume area (in Gage Aquifer) be evaluated for placing extraction wells and wellhead treatment units.

The purpose of this Technical Memorandum (TM) is to evaluate the alternative locations for the centralized desalter plant from the Elm Avenue property originally considered, as well as additional properties for siting extraction wells to target the northernmost saline plume. The TM includes the following sections:

- Section 1 – Introduction
- Section 2 – Alternative Locations for the Proposed Centralized Desalter Plant
- Section 3 – Proposed Portable Treatment Site Location for Saline Plume in Manhattan Beach
- Section 4 – Additional Locations for Siting Extraction Wells for the Northernmost Saline Plume
- Section 5 – Conclusions and Recommendations

2. Alternative Locations for the Proposed Centralized Desalter Plant

This section summarizes the alternative locations for the previously proposed desalter facility at Elm Avenue and Faysmith property in Torrance. For evaluating feasible locations for siting the treatment plant, a desktop analysis was performed using available aerial images from Google Earth™. Following the desktop analysis, a field investigation was performed, including driving through the locations to assess whether the properties were different than shown on Google Earth™, including further development of the site or change in its use or access.

Figure 2-1 displays the four properties larger than 1 acre in size that were evaluated as potential alternative locations for the centralized desalter plant. The sites are east of the plume and within 2 miles of the Elm Avenue and Faysmith property originally selected. In addition to these four sites, several other properties were investigated, but in general, those properties are not shown because (1) the properties were within a residential area, (2) construction was being conducted on the site, or (3) the current use of the site was not compatible with the proposed desalter facility (for example, some sites that appeared to be vacant from aerial images were determined to be closed landfills and stormwater sumps).

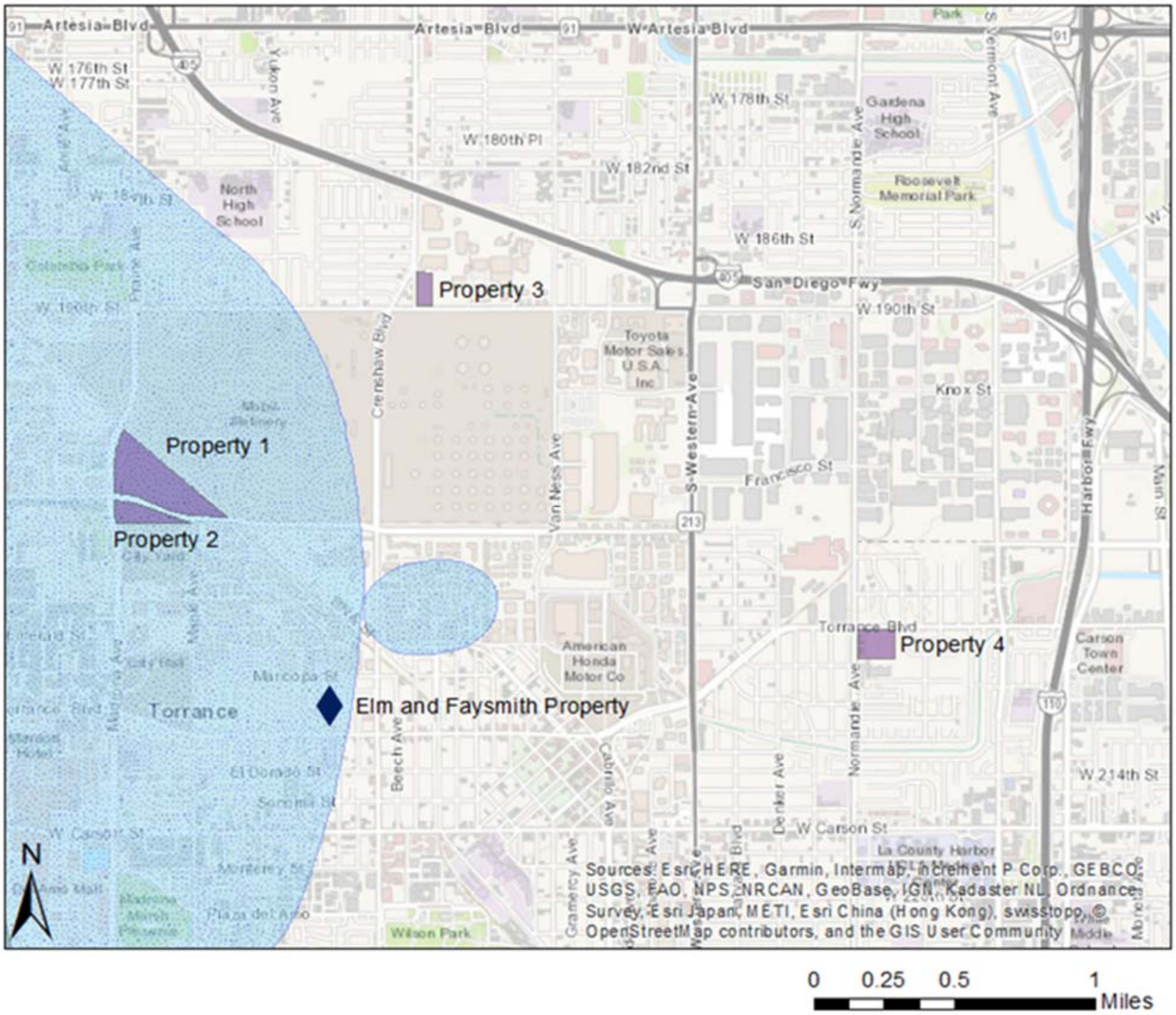

Figure 2-1. Location of Alternative Properties for the Proposed Centralized Desalter Plant

Table 2-1 lists the properties of each proposed alternative location, including size, parcel number, current assessed value, and distance from the saline plume and the location of the Elm Ave and Faysmith property originally considered for the desalter plant. Figures 2-2 through Figure 2-5 show the site images of Property 1 through Property 4, respectively.

Table 2-1. Proposed Alternative Desalter Plant Locations

Property	Size (AC) [a]	Distance from Elm Plant (miles) [a]	Distance East of Plume (miles) [a]	Parcel Number, Land Use, Property Owner, and Assessed Value[b]	Comments
Property 1	33.8	1.0	Within boundary	7352-015-005 Vacant Land Torrance Black Beauty LLC $11,918,356	Includes a small, private property with horses and stables. Location is in proximity to an industrial plant, the Torrance Refining Company.
Property 2	7.8	1.0	Within boundary	7352-012-017 Vacant Land Torrance Refining Company LLC $2,929,013	The vacant land includes a ChargePoint charging station, small facilities, and power lines. Location is in proximity to an industrial plant, the Torrance Refining Company. The site is adjacent to an active City of Torrance waste hauler facility and the closed Torrance Municipal Dump[c].
Property 3	4.1	1.5	0.5	4090-021-032 Commercial/Industrial St Paul Fire and Marine Insurance Company, Comstock Crosser and Associate Dev Co. $3,256,578	Property is advertised for sale and includes an abandoned parking lot that is fenced off from the neighboring commercial property. Property 3 is directly across the street from an industrial plant, the Torrance Refining Company.
Property 4	8.9	1.9	1.8	7348-020-003, 7348-020-004, 7348-020-007, 7348-020-008, 7348-020-009, 7348-020-010 Commercial/Industrial Bridge Point South Pay LLC $21,880,000	Includes abandoned buildings and parking lot where the buildings are covered in graffiti and contain broken glass windows. Sign within the property limits indicates hazardous materials were previously onsite. Sign exterior of property references that the property is for sale. Current owner is the Bridge Point South Pay LLC. Neighboring areas include residential area, commercial area, as well as two covered landfills. A portion of the site appears to be an archived Superfund site (Azko Coatings, Inc.).[d]

[a] Approximate acreage and distance based on desktop analysis.

[b] Source: Los Angeles County Office of the Assessor, 2019

[c] Source: Los Angeles County Public Works, 2019

[d] Source: Homefacts.com, 2019

Figure 2-2. Property 1

Figure 2-3. Property 2 (Source: Google Earth)

Figure 2-4. Property 3

Figure 2-5. Property 4

Of the four properties identified, Properties 3 and 4 have previously been built upon and urbanized, while Properties 1 and 2 appear to be vacant land. Property 4 extends approximately 2 miles or more from the Elm Property site originally selected, whereas Properties 1, 2, and 3 are within 2 miles of the original desalter plant location. Properties 1, 2, and 3 are near an existing industrial plant, Torrance Refining Company. Properties 3 and 4 are abandoned commercial/industrial sites that are currently for sale.

3. Proposed Portable Treatment Site Location for Saline Plume in Manhattan Beach

In relation to the saline plume in Manhattan Beach, there is one school property at 1200 N. Meadows Avenue, Meadows Avenue Elementary School, considered for placing the portable treatment system. Based on a desktop analysis, the surface area of the green space at Meadows Avenue Elementary School is approximately 1.5 acres. It is estimated that a 6,500-square-foot (ft^2) area will be needed for the portable treatment unit. Considering the area need for the extraction well, portable treatment system, and treatment equipment, Meadows Avenue Elementary School's green space can be used.

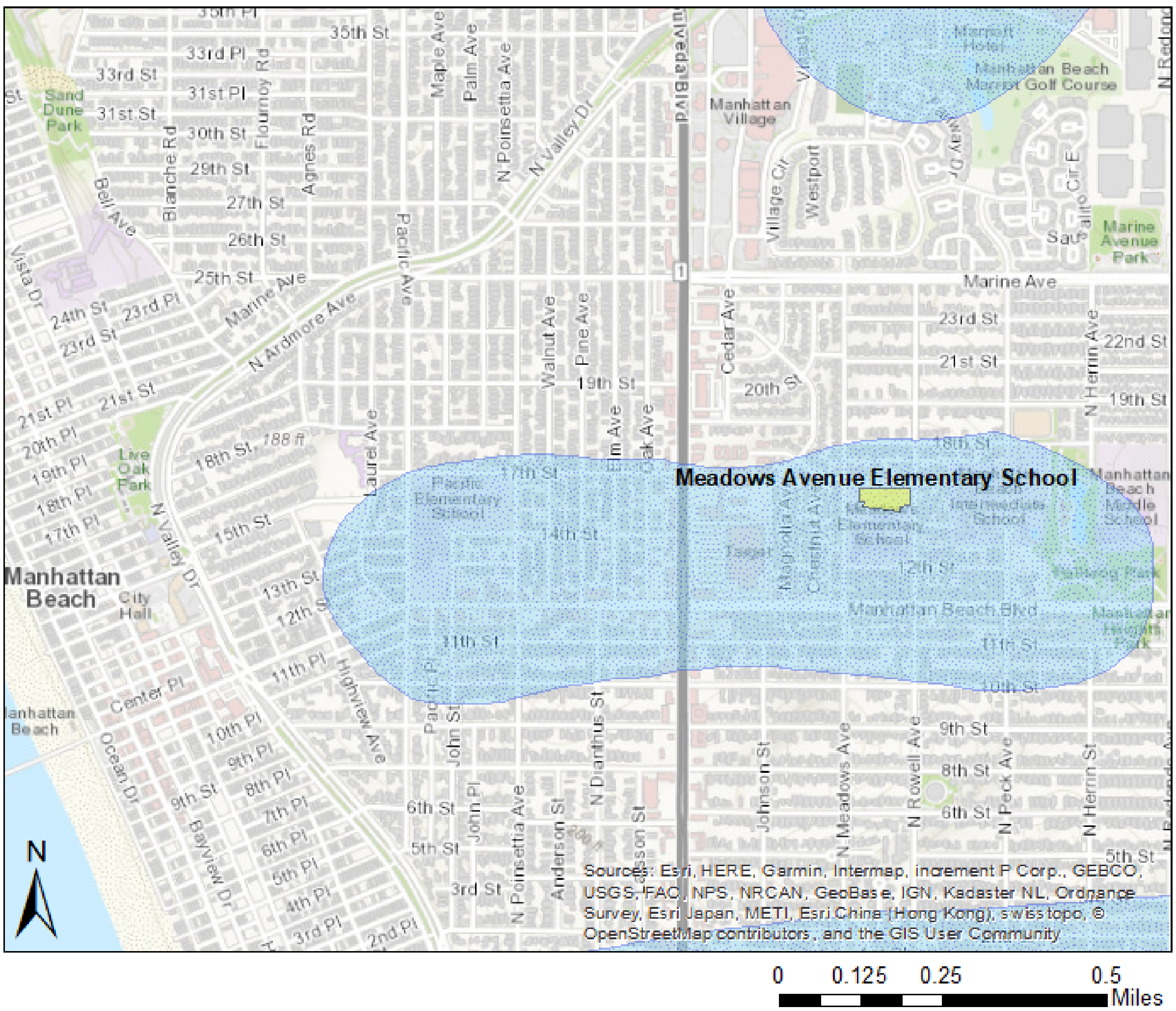

Figure 3-1. Proposed Location for Placement of Portable Treatment System in Manhattan Beach

4. Additional Locations for Siting Extraction Wells for the Northernmost Saline Plume

For placing the extraction wells to target the extraction of the northernmost saline plume, three recreational parks are considered. Those include Glasgow Park, which is segmented by W. 135th Street into northern and southern sections, as well as Hollyglen Park. All three sites are owned by the City of Hawthorne.

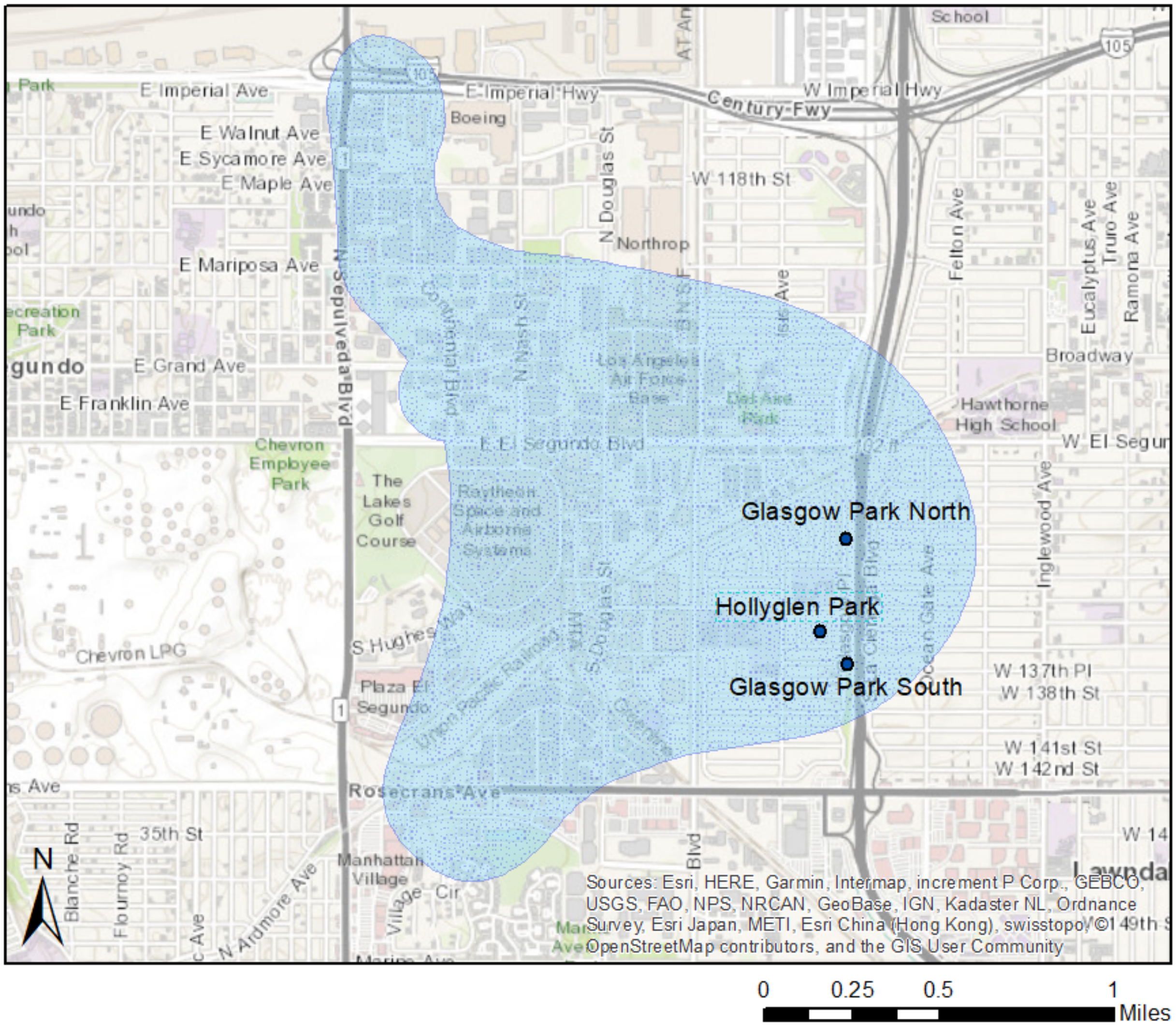

Figure 4-1. Proposed Extraction Well Sites for Northernmost Saline Plume

Table 4-1 provides information on these park sites that can be used for siting the extraction wells near the eastern edge of the northernmost saline plume.

Table 4-1. Proposed Locations for Placing Extraction Well Sites in the Northernmost Saline Plume Area

Land Use	Comments [a]
Glasgow Park (North)	The segment of Glasgow Park that lies north of W. 135th Street and runs along I-405. Neighborhood residential area and Juan Cabrillo Elementary School.
Glasgow Park (South)	The segment of Glasgow Park that lies south of W. 135th Street and runs along I-405. Neighborhood residential area.
Hollyglen Park	Holly Glen Park located near Juan Cabrillo Elementary School and Peter Burnett Elementary School includes some impervious area within the square block it encompasses and neighbors a residential area.

[a] Commentary based on desktop analysis

Notes:

I-405 = Interstate 405

5. Conclusions and Recommendations

Based on the assessment conducted to site the centralized treatment plant at four additional properties , the following can be noted:

- Properties 1, 2, and 3 are in proximity of an existing industrial plant, Torrance Refining Company.
- Property 4 is an abandoned commercial/industrial site and is the largest site that does not encompass a private property in use.
- Property 1, although the largest, includes a private property with horse stables.
- Properties 3 and 4 are currently for sale.
- Property 4 is furthest from the existing Elm Avenue and Faysmith site and the leading edge of the saline plume and would require a longer conveyance pipeline from the well extraction sites to the plant.

It is recommended that these sites be evaluated further to determine suitability for the placement of the centralized desalter plant. It is recommended that a Phase 1 environmental site assessment be conducted for each site to determine the potential presence of any contamination.

Meadows Avenue Elementary school contains 1.5 acres of green space where 6,500 ft^2 may be available for use for the portable treatment system site for the median saline plume located in Manhattan Beach.

The additional locations for well extraction sites in relation to the northernmost saline plume include Glasgow Park (North and South) and Hollyglen Park. Those are located at the eastern edge of the northernmost saline plume. Glasgow Park is next to the I-405 freeway and would cause the least disruption to the surrounding residential areas.

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