PREPARED FOR: PALMDALE WATER DISTRICT





Final Report

Program Priorities and Implementation Plan Table of Contents | February 2024

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1.0 Introduction

Stantec was retained by the Palmdale Water District (PWD) to provide program management services for its regional water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV) or Program. Using advanced treatment processes including microfiltration, reverse osmosis (RO), and ultraviolet light with advanced oxidation, Pure Water AV will further purify tertiary treated (Title 22) wastewater to produce water that will meet all applicable state and federal drinking water standards and regulations. This purified water will be injected into the local groundwater aquifer, thereby supplementing PWD's existing water supplies. Pure Water AV is intended to provide safe and reliable drinking water for Antelope Valley.

As part of the program management services contract, several planning studies have been completed to better define the Pure Water AV Program. This document provides a summary of major project components and identifies drivers, risks, and critical milestones necessary to fully implement the Program, based on current, available information. The findings and conclusions within this document may updated as additional information on the program becomes available.

1.1 Program Background and Drivers

PWD has been providing water service to its customers since 1918 when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the Antelope Valley groundwater basin has been in an overdraft condition since the 1930s, resulting in land subsidence. In 1973, Palmdale Irrigation District changed its name to Palmdale Water District (PWD). In 2012, the Palmdale Recycled Water Authority (PRWA), comprised of members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area for landscape irrigation. PRWA manages the distribution of recycled water, designing and constructing support facilities and financing efforts.

PWD has conducted a number of studies that date back to as early as the 1990s to evaluate the water resources necessary to meet future water demands. Concepts evaluated to date include using recycled water for landscape irrigation, discharging into existing sand and gravel pits where the recycled water would replenish the groundwater basin naturally, and groundwater recharge (GWR) through the use of recharge basins (i.e., Palmdale Regional Groundwater Recharge and Recovery Project). Based on the Littlerock Creek Groundwater Recharge and Recovery Project Feasibility Study (Kennedy Jenks, 2015), the average infiltration rate was expected to be 9.4 feet per day (fpd) in the northern region and 12 fpd in the southern region for the proposed sites. A series of subsequent pilot studies showed less than half of the original estimated recharge volume was realized, which challenged the feasibility of this alternative and prompted PWD to investigate other sources and approaches to augment existing water supplies.

1.2 Study Background and Objectives

Following the pilot studies for surface spreading, PWD hired Stantec to conduct a feasibility study on other potable reuse alternatives including indirect and direct potable reuse. The study concluded that indirect potable reuse by groundwater augmentation via direct injection is the most economical alternative for potable reuse and can be implemented based on existing regulations. The objective of this report is to define the Program and describe strategies for its successful implementation.

1.3 Study Area

PWD is located within the City of Palmdale, in Los Angeles County, CA. PWD provides service to an area of approximately 40 square miles to the City of Palmdale and unincorporated areas in Los Angeles County as shown in Figure 1-1. The service area is located in the Antelope Valley Groundwater Basin (AVGB) within the Lahontan Region. Covering parts of Kern, Los Angeles, and San Bernardino counties, the AVGB is located at the western end of the Mojave Desert in southern California. It is topographically closed with respect to surface water outlets and was formed by alluvial deposits filling a structural depression resulting from tectonic activity in the area. The AVGB is bounded on the northwest by the Tehachapi Mountains and the Garlock Fault Zone on the north and east by a series of low hills, ridges, and buttes, and on the south by the San Gabriel Mountains and the San Andreas Fault Zone. Groundwater flow is confined to the AVGB, except at the far northeastern end, where a small amount of groundwater flows into the Fremont Valley Basin. Figure 1-2 shows a regional map of the AVGB.

The entire PWD service area is designated as a large, disadvantaged community by the California State Water Resources Control Board (SWRCB), with a calculated median household income of \$55,129. According to the Census Bureau, 15.8% of Palmdale residents live below the federal poverty line, 80% identify as people of color, and 47% speak a language other than English at home. The Environmental Protection Agency (EPA) Environmental Justice indices show Palmdale as above the US 90th percentile for multiple pollutants and above the US 80th percentile for multiple socioeconomic characteristics.



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Figure 1-1. Pure Water Antelope Valley Program Area



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Figure 1-2. Antelope Valley Groundwater Basin

1.4 Report Structure and Content

- + **Section 1** Introduction: Provides the Program background and drivers as well as study background and objectives.
- + **Section 2** Study Approach: Describes the overall approach to the initial planning efforts of the Program.
- Section 3 Program Components and Locations: Describes key project components including the advanced water purification facility, conveyance infrastructure and groundwater injections wells.
- Section 4 Funding Strategy: Provides an overview of the potential funding sources and associated funding requirements recommended for the Program.
- Section 5 Project Component Packaging and Delivery Methods: Provides recommendations for the delivery of Program components.
- + Section 6 Economic Impact Assessment: Provides an overview of the economic impacts of the Program on the surrounding communities.
- Section 7 Regulatory Approval Approach: Describes the actions that will be taken to achieve regulatory approval along with continuous regulatory engagement.
- Section 8 Public Outreach Strategy: Describes the overall public outreach approach of the Program.
- + **Section 9** Environmental Studies and Permit Requirements: Provides an overview of the anticipated environmental and permitting requirements for the Program.
- + **Section 10** Cost Estimates: Provides a summary of the estimated capital cost, the estimated operation and maintenance cost, and net present value analysis.
- + **Section 11** Master Program Schedule: Provides an overview of the Program schedule components.

1.5 Acknowledgements

This document and its content were developed in close collaboration with PWD staff. We would like to thank them for their guidance, participation, and contributions including meeting attendance, document review, response to questions, and data inquiries throughout the development of this document.

2.0 Plan Approach

The Program Priorities and Implementation Plan (PPIP) is meant to be the framework to guide the implementation of the Pure Water AV Program in a cost-effective manner, using an expedited schedule, all while producing high-quality deliverables for the Program. Prior to project implementation, a multi-step approach was developed, as shown in **Figure 2-1**, to evaluate major project components, define project objectives, and provide a comprehensive implementation plan to PWD. The following subsections describe the approach used for each major task undertaken in developing the PPIP. Details on the results and recommendations from each task are provided in subsequent sections.



Figure 2-1. Program Priorities and Implementation Plan Approach

2.1 Review Prior Studies and Identify Knowledge Gaps

PWD has been planning for the use of recycled water within its service area for over twelve years. Significant progress towards implementing expanded use of recycled water has been made through various planning efforts including planning studies, environmental impact assessments and feasibility studies. PWD provided data and reports, including regulatory documents, master plans, environmental reports, groundwater modeling projects, existing and future wells characterization, plans and process information for the Los Angeles County Sanitation District (LACSD) 20 Palmdale Water Reclamation Plant (PWRP), as well as annual operating budgets and other financial information. The timeline for major studies and/or milestones that led to the Pure Water AV Program are shown in **Figure 2-2**.

To assess data gaps between the existing information available versus the information necessary for full Program implementation, data made available and previously prepared reports provided by PWD were reviewed and summarized into a Rapid Program Readiness Assessment Technical Memorandum (TM) (**Appendix A.1**). The assessment was used to evaluate and identify additional studies, data and/or analyses needed to supplement the existing studies. The findings and data gaps of these prior work efforts are discussed in more detail within this report. The workplan developed for the Pure Water AV Program is anticipated to fill the major data gaps and thereby pave the way for successful implementation of the Program.

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Figure 2-2. Important Milestones Leading to Pure Water AV

2.2 Establish Project Definition

The tertiary effluent characteristics and available flow, treatment capacity and process configuration, as well as location of treatment, conveyance, and injection well infrastructure, have to be established to define the project to a point where subsequent tasks can occur. As part of this effort, the available tertiary effluent flow and characteristics from the PWRP were reviewed to confirm the capacity of the full-scale advanced water purification facility (AWPF).

To determine the process configuration and treatment/conveyance infrastructure, potable reuse alternatives for the Program were also evaluated and the most suitable alternative was recommended. Defining the process configuration also helps develop the Program cost as well as funding and regulatory approval strategies.

Additionally, preliminary siting of major project components was undertaken with the intent of minimizing the project footprint, assessing procurement/use feasibility, and estimating the cost of land acquisition, as well as examining the potential to reduce conveyance costs. Additional consideration in the analysis was to select a site for the full-scale AWPF that would not restrict future expansion. Based on this analysis, the full-scale Pure Water AV AWPF will be located approximately 1,100 ft north of the intersection of 25th Street E and Avenue Q, approximately 0.5 miles from PWD headquarters.

2.3 Develop Brine Management Strategy

Reverse osmosis is a key treatment component of the AWPF and is important for salinity management and for its ability to reject pathogens and trace constituents. However, RO treatment generates a continuous brine (waste) stream for disposal, which is a planning consideration for inland systems where ocean disposal of the brine is not available. Given that Pure Water AV is located in an arid inland region, brine management is a key issue for the overall cost, conceptual viability, and operability of the project. An evaluation of brine management options to provide a cost-effective strategy for Pure Water AV was conducted and summarized in **Appendix A.4**. From this analysis, the use of brine evaporation ponds was recommended.

To reduce the footprint and the cost of constructing evaporation ponds, it is important to minimize, to the extent reasonable, the generated brine volume. Thus, selecting the highest practical RO recovery is an important strategy to reduce brine (**Figure 2-3**). This impacts the overall facility's footprint, cost of

construction, and annual operations and maintenance. The chemistry of the RO concentrate was also considered, such as saturation levels of common scaling compounds, including silica, calcium carbonate and calcium phosphate, which were analyzed using scaling models. The results were first used to establish a minimum target RO recovery as a baseline. High recovery targets using advanced secondary RO systems, such as closed-circuit desalination RO (CCRO) and flow reversal RO (FRRO), were evaluated to perform a cost-benefit analysis and compare with the baseline scenario. Passive evaporation ponds were designed per the outcome of the analysis to accommodate the projected brine discharge with different recovery scenarios. Cost of the alternatives was analyzed to determine optimal mix of high-recovery RO systems and brine disposal concepts. To better define the process feasibility, design criteria, and system costs for the full-scale facilities, the Pure Water AV demonstration plant will test high-recovery RO systems in connection with brine management.



Figure 2-3. Approach to Analyze Brine Management Alternatives

The demonstration plant will also evaluate another brine management solution provided by Capture6, which is a novel technology for carbon dioxide removal via direct air capture (DAC). It utilizes RO brine to generate a solvent to extract carbon dioxide from the atmosphere. In aqueous form, the carbon dioxide is converted to carbonate which makes it stable for long-term storage. Such conversion also allows precise calculation of carbon dioxide removed, which is important to secure federal and corporate incentives for carbon removal. By realizing the ancillary benefit of DAC, additional treatment of the brine through the Capture6 process may become viable and would eliminate the need for evaporation ponds. Through data collected from testing and operations of Capture6's technology, PWD will determine the final strategy for brine management of the full-scale AWPF.

2.4 Assess Funding Sources and Requirements

The implementation costs for Pure Water AV Program are substantial and include a significant construction cost component. There are, however, a number of relevant and available federal, state, and local funding programs that have the potential to provide assistance with funding. The initial steps in

developing a funding strategy are to identify funding opportunities available, evaluate for relevance to the Pure Water AV Program, and assess for likelihood of procurement success. Based on the identified funding sources, a preliminary strategy for phasing the Pure Water AV Program and schedule for application preparation, submission, and compliance has been developed to target funding opportunities well suited for the Program, as detailed in Section 4.0. As more funding programs are identified, this assessment process is sufficiently flexible to allow for updating with future funding opportunities.

2.5 Select Delivery Methods and Packaging for Program Components

A key consideration for the Pure Water AV Program is the program component delivery method assessment, which considers the complexity, time constraints and risk of each Program component and identifies a suitable approach for Program implementation. The project delivery methods available and utilized in the water/wastewater marketplace range from traditional Design-Bid-Build (DBB) to Alternative Project Delivery (APD) methods such as Design-Build (DB), Progressive Design-Build (PDB), and Construction Management at Risk (CMAR). The project delivery method selected for a particular project is dependent upon a number of factors, such as legality of the delivery method for the entity in question, the goals of the project, the project schedule, and cost.



Figure 2-4. Drivers for Delivery Method Selection

A workshop was held on June 14, 2022 with PWD staff to discuss the key project drivers and selection criteria, merits of different delivery methods, and assist PWD in selecting methods for each Program component. A summary of the recommendations based on the outcome of the workshop is provided in **Section 5.0**.

2.6 Assess Economic Impact of the Program

An economic impact analysis is utilized to capture the multiplier effects resulting from the direct impact of a project (such as investment in materials, jobs, etc.), and to estimate the indirect impacts (on industries supporting the project) and induced impacts (due to the increased economic activity) of a project. The inputs for such an analysis include construction costs, estimated fulltime equivalent employees, operations costs, and approximate salaries for jobs created during different phases of a project's life cycle. The economic impact assessment for the Pure Water AV Program will give PWD and its stakeholders insight into the overall economic effects of the Program on the surrounding communities to better understand added benefits of the project.

2.7 Develop Regulatory Approval Strategy

Identifying permitting requirements and obtaining timely regulatory approvals are key for successful Program implementation. These approvals have to be coordinated with appropriate deadlines for funding applications. Preparing an initial permitting matrix will help identify a list of required permits throughout the duration of the project along with continuous regulatory engagement, as major project facilities become operational. Major known regulatory approvals include waste discharge requirements, brine discharge permit, and Title 22 Engineering report.

2.8 Initiate Groundwater Modeling Efforts

Groundwater modeling is a key component for the Pure Water AV Program to better understand groundwater flow directions and gradients. Information developed will be used to confirm travel times and provide confidence in the use of groundwater recharge by direct injection. Existing general groundwater models that adequately represent the project area without significant modification were not available for this effort. Thus, a project-specific groundwater flow, particle track and solute transport model was required to reproduce groundwater flow conditions, injected water flow directions, dilution rates, and travel times to nearby pumping wells. This information was used to evaluate alternate injection wellfield and monitoring network designs that meet regulatory requirements. Groundwater modeling work began immediately after the start of the project and will continue through the pilot testing for groundwater injection and groundwater monitoring phase, while utilizing the data from the field to update the model concurrently.

To obtain regulatory approval for groundwater injection, the response retention time must be two months at minimum. Starting at two months, for each month of retention time underground, one log removal value (LRV) of virus can be granted to the project, thus potentially obtaining from two to six LRVs. The regulations require that travel time needs to be adjusted based on the accuracy of the method used to estimate groundwater injection. For example, the use of Darcy's law to estimate travel time, qualifies for 25% response time credit. Similarly, numerical groundwater flow and transport models can receive a 50% travel time credit. The later methodology was applied for the Pure Water AV Program to evaluate the injection sites and maximize the time credit. Site-specific data was used to evaluate the feasibility of direct injection for the Pure Water AV Program and estimate the minimum travel time from the injection well sites to the potable water extraction wells.

2.9 Develop Public Outreach Strategy

Building on PWD's existing outreach activities and leveraging the prior efforts for the groundwater recharge and recovery efforts, a new public outreach strategy was developed to assist the Program in moving towards successful implementation by gaining stakeholder and public acceptance. Public outreach activities will include a programmatic communications plan and talking points, content for the dedicated Pure Water AV website, newsletter and social media, in-person tour development and support, virtual tours, and community meetings.

2.10 Strategize Approach to Environmental Studies and Clearances

It is critical to identify all environmental documentation, permits, and clearances required prior to project implementation and the strategy for their procurement. This will assist with identifying the appropriate California Environmental Quality Act (CEQA) processes for the project along with initial studies including air quality, biological resources, cultural resources, noise, water resources, traffic, and Cortese list (i.e., Hazardous Waste and Substances Sites List). Documenting environmental investigations, including field surveys, provides a focus on environmental issues that may present a fatal flaw to successful regulatory permitting or that could become major schedule constraints.

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3.0 Potable Reuse Alternatives

The regulatory framework governing potable reuse was assessed to determine requirements that specifically pertain to the alternative scenarios under consideration for PWD in terms of both indirect and direct potable reuse applications (IPR/DPR). After analyzing the benefits and drawbacks for each potable reuse alternative, a final recommendation was made (**Appendix A.3**).

From the IPR alternatives analyzed, only GWR by direct injection and surface water augmentation (SWA) were judged viable. DPR regulations are under development in California and are expected to be formalized by the end of 2023. As such, the two forms of DPR, (1) raw water augmentation (RWA) and (2) treated water augmentation (TWA) were evaluated. The alternatives considered in this analysis are illustrated in **Figure 3-1**.



Figure 3-1. Evaluated Potable Reuse Alternatives

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The benefits and challenges for all potable reuse alternatives considered in the analysis are summarized in **Table 3-1** below.

Table 3-1.	Potable	Reuse	Alternatives	– Advantage	s and	Challenges
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Criteria	GWR via subsurface injection	SWA	DPR (RWA/TWA)
Advantages	 Increases groundwater supply for drinking water use Lower costs (capital, O&M) Small footprint Less treatment processes, less complexity Well established statewide 	 Increases surface water supply for drinking water Small footprint Relatively new to the state, but current projects are actively pursuing this alternative Potential capital costs comparable to GWR via direct injection, but more stringent regulations may require additional planning effort (e.g., CTR compliance) 	 Adds additional source of water supply, increases drought resiliency Can be used when IPR alternative(s) cannot meet the dilution and/or retention time requirements (RWA) Can add a source of water directly into the distribution system (TWA)
Challenges	 Studies and modeling required to determine if groundwater flow and hydrogeology parameters are adequate to meet retention time and dilution requirements Must meet BPOs limits 	 Modeling required to determine if reservoir volume and flows are adequate to meet required dilution Studies and modeling required to determine if hydrology parameters are adequate to meet retention time requirements AWPF treated water must comply with CTR, unless a mixing zone (dilution factor) is studied and approved by the RWQCB 	 Most expensive alternative (capital, O&M, permitting, monitoring, reporting, etc.) Largest treatment footprint Most treatment processes, increases operational complexity New to the state (regulations have not been finalized, no permitted projects) More intensive, broad, and higher frequency monitoring required Requires higher degree of inter-agency coordination, technical, financial, and management capacity (more efforts for source control, sewershed monitoring, faster response to failure) More frequent reporting (monthly versus annually)

Key:

AWPF = advanced water purification facility CTR = California Toxics Rule DPR = direct potable reuse GWR = groundwater recharge IPR = indirect potable reuse O&M = operations and maintenance RWA = raw water augmentation RWQCB = Regional Water Quality Control Board SWA = surface water augmentation TWA = treated water augmentation

From the alternatives presented herein and based on an evaluation of the advantages and challenges described above, GWR via direct injection provides the most straightforward and economical implementation of potable reuse. In a GWR application, retention time of water in the ground provides

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additional treatment, pathogen abatement, chemical dilution, and an environmental buffer to reduce the treatment infrastructure. Because of its simplicity compared to the other potable reuse options and the number of similar projects implemented in the State of California, the permitting process for GWR via direct injection is straightforward. This IPR application has been regulated for almost a decade and this approach is well established in California, with many water utilities employing it.

Overall, any potable reuse project will decrease PWD's reliance on water imported from other institutions and associated infrastructure. In the case of GWR, the project will add a reliable source of water to the public while also potentially working as storage to offset long-term drought or water supply variations. This will diversify the region's long-term water supply source and increase PWD's groundwater pumping rights. Additionally, the safe yield of the AVGB may be increased if the stored groundwater is not fully utilized each year, although this is not guaranteed. GWR via direct injection would be subject to routine monitoring and reduction requirements to meet Title 22 California Code of Regulations (CCR) mandates and Salt and Nutrient Management Plan (SNMP) limits, which will improve the water quality by providing highly purified water.

Using GWR via direct injection, the AWPF facility, using the planned processes, will meet all Title 22 water quality goals based on the current PWRP tertiary effluent water quality. The only factor that could affect this alternative's implementation is the theoretical retention time that the aquifer provides. However, preliminary results of the groundwater modeling indicate that groundwater injection is a viable option, as discussed further in **Section 4.4**. Additional data gathering and modeling may be performed to increase the confidence of the model and the resulting travel and retention times.

4.0 Program Components

The following section summarizes the components of the Pure Water AV Program, including:

- + Tertiary effluent source water from the PWRP
- + The full-scale AWPF
- + Conveyance lines including tertiary effluent to the AWPF, product water from the AWPF to the injection wells, and RO brine to the brine ponds
- + Injection wells located adjacent to the AWPF
- + Brine ponds

An overview map of the major Program components is presented in Figure 4-1.



Figure 4-1 Pure Water AV Program Components

4.1 Source Water

The Pure Water AV Program includes the design of a 4.75 MGD AWPF, where the product water will be used for groundwater recharge via direct injection into the AVGB. The feed water to the AWPF will be disinfected tertiary effluent from the PWRP. This section provides a summary of the tertiary effluent flow, water quality, treatment design implications, and contractual arrangements and commitments, all of which can be found in more detail in **Appendix A.2**.

4.1.1 Contractual Arrangements/Commitments

PWD has an agreement with LACSD for the sale and purchase of up 4.75 MGD (5,325 AFY [acre feet per year]) of recycled water from PWRP, of which 3.6 MGD (4,000 AFY) is currently allocated for groundwater recharge and 1.2 MGD (1,325 AFY) for non-potable (purple pipe) reuse (LACSD/PWD, 2016). The agreement states that PWD may request a permanent increase to the allotment of recycled water if additional permanent supplies of recycled water become available at the PWRP. In addition, PWD must meet certain milestones toward completion of the recharge project to continue to receive its recharge allotment. The LACSD/PWD agreement was amended in 2019 to grant a two-year extension in reaching the milestones for the intended recharge use and non-potable projects. The intended recharge use defined in the document was groundwater recharge with a blend of recycled water and imported water from the SWP, while the non-potable project referred to direct reuse of recycled water for irrigation. The implementation of the Pure Water AV Program will require an amendment to the agreement to account for changes, such as milestones and method for recycled water use.

Per the agreement amended in 2019, water quality provided by LACSD must conform to disinfected tertiary recycled water Title 22 regulations. The PWRP uses a nitrification/denitrification process to reduce total nitrogen levels in the recycled water. The agreement outlines there is no minimum mandatory volume of recycled water that PWD must take from PWRP but to maintain the allotment established under the agreement, PWD must pay a minimum payment each year. This minimum payment was detailed in the agreement in terms of equivalent AFY for each year of the contract. PWD and LACSD are currently updating the agreement to address the minimum water quality requirements expected for the Pure Water AV Program.

4.1.2 Tertiary Effluent Location

The wastewater generated from the City of Palmdale's service area is collected and treated by LACSD's 14 and 20 districts. Wastewater conveyance is provided via gravity flow, through a network of 104 miles of trunk sewers (Carollo, 2015). The collected wastewater is treated in two water reclamation facilities: the PWRP and the Lancaster Water Reclamation Plant (LWRP). Although a portion of the City of Palmdale's generated wastewater is treated at the LWRP, the first phase of implementation of the Pure Water AV Program will be only using feed water from PWRP and the focus of this PPIP is PWD's service area. Future expansion of the Program may consider additional water from LWRP, subject to future agreements between the agencies that have jurisdiction over the recycled water.

PWRP, operated by LACSD District No. 20, provides primary, secondary, and tertiary treatment for wastewater with a maximum daily design capacity of 12 MGD. The plant is located at 39300 30th Street

East, Palmdale, California, 93550, northeast from PWD's headquarters (**Figure 4-2**). LACSD adds chloramines to tertiary effluent from the PWRP for disinfection and control of biogrowth in the recycled water distribution system.

The City of Palmdale and PWD established the PRWA through a joint agreement to manage recycled water that is generated within the Palmdale area. The joint powers authority manages non-potable reuse projects for a recycled water distribution system for landscape irrigation within the Palmdale area. **Figure 4-2** shows the existing PRWA recycled water system, which also includes a Recycled Water Backbone System. This conveyance system is in development with a portion of the system having already been constructed by the City of Lancaster, the City of Palmdale, and Los Angeles County Waterworks District No. 40. After full implementation, the system can move recycled water between the LWRP and PWRP and could be utilized to facilitate expansion of the Pure Water AV Program, if agreements are reached between the agencies.



Figure 4-2. Existing PRWA Recycled Water System

4.1.3 Variability in Tertiary Effluent Flows and Equalization Needs

The PWRP has a design capacity of 12 MGD, however the average tertiary effluent flow produced is 8.3 MGD. Several treatment processes at the AWPF require a near-constant feed flow. Therefore, the flow data from 2017 to 2021 was assessed to determine if PWRP can consistently provide at least 4.75 MGD of feed water to the AWPF and if not, what equalization volume would be needed to maintain a constant feed flow to the AWPF.

The assessment used hourly effluent flow data for one week in September for each year from 2017 to 2021. As shown in **Figure 4-3**, results indicate that the diurnal pattern of PWRP's effluent flow is very stable, ranging from 7.1 MGD to 9.2 MGD, and averaging 8.3 MGD. Therefore, there is sufficient minimum tertiary effluent available throughout the day to sustain treatment of 4.75 MGD of tertiary effluent at the AWPF.



Figure 4-3. Diurnal Pattern of the PWRP Effluent Flows with One-Week Hourly Data from September of 2017, 2018, 2019, 2020, and 2021

Further assessment of hourly flows throughout the year is recommended, but if the trend from this analysis is consistent for other months, it may be possible to convey tertiary effluent to the AWPF directly from the PWRP without equalization at the AWPF.

Seasonal flow variability was assessed using PWRP's daily tertiary effluent flowrates from 2017-2021. Based on this information, the probability plot shown in **Figure 4-4** was prepared to show the flows available for groundwater injection. As illustrated, the historical daily tertiary effluent flow in the past five years was at least 5 MGD 99.8% of the time. Therefore, the plant is expected to be able to consistently provide a flow of 4.75 MGD of tertiary water to the AWPF.



Figure 4-4. Seasonal Variability Probability of the PWRP Tertiary Effluent Flows Minus City of Palmdale Recycled Water Flows

4.1.4 Tertiary Effluent Water Quality and Treatment Design Implications

The PWRP tertiary effluent water quality impacts the design and performance of the downstream AWPF. Various key water quality parameters were analyzed in relation to the proposed AWPF treatment processes to provide a good understanding of the effects these processes may have in reducing contaminant concentrations and the impacts that the water contaminants may have on system performance.

In California, indirect potable reuse projects must meet the regulatory requirements and monitor contaminants at frequencies listed in Articles 5.1, 5.2 and 5.3 of the Water Recycling Criteria, Title 22, Division 4, Chapter 3 of the California Code of Regulations (Title 22 CCR). Indirect potable reuse regulatory requirements include the SNMP, EPA, and State of California drinking water primary and secondary maximum contaminant levels (MCLs) and action levels (ALs), as well as California's

notification levels (NLs). In addition, the final effluent must meet the water quality objectives (WQOs) prescribed in AVGB's SNMP for groundwater.

PWRP's tertiary effluent's water quality was analyzed in relation to these drinking water and potable reuse standards to better understand the influent water quality to the AWPF and its ability to meet these limits in the final effluent. A few constituents were identified as possible challenges for the implementation of the AWPF, either due to their concentrations found in the PWRP tertiary effluent, or to the lack of existing data from the tertiary effluent. These compounds are listed in **Table 4-1** along with possible solutions for implementation at the AWPF.

Table 4-1. Potentially Challenging Compounds for the Implementation at the AWPF

Compound	Reason for Possible Challenge to AWPF Implementation	Possible Solution
NDMA	Low limit (CTR), NL	Source control at PWRP; high UV doses
Chlorine residuals	High variability in concentrations	Impacts operational logic in the AWPF to stabilize chlorine residuals in the AWPF'S feed water
Key: AWPF = advanced water CTR = California Toxics F NDMA = N-nitrosodimeth NL = notification level PWRP = Palmdale Water UV = ultraviolet	purification facility Rule ylamine Reclamation Plant	

4.2 Advanced Water Purification Facility

The Pure Water AV AWPF will be designed to treat 4.75 MGD of disinfected tertiary effluent from PWRP. After treatment, approximately 4.25 MGD of purified product water will be used for GWR via direct injection. The following subsections summarize the process train, preliminary design criteria, and phasing of the planned AWPF.

4.2.1 Process Train and Preliminary Design Criteria

The treatment train of the Pure Water AV AWPF will consist of membrane filtration (MF), RO and advanced oxidation process (UV/AOP), as shown in **Figure 4-5**. The feedwater to the MF system will be dosed with chloramines to control biofouling on the MF and RO membranes. Following the chloramines addition, the flow will be filtered through Automatic Backwashing Strainers (ABS) to remove any large particles present in the feed water that may damage the MF membranes. The MF process will polish the feed water (tertiary effluent from PWRP) as a pretreatment step for the RO process by removal of virtually all solids. It will also provide pathogen removal credits of four logs for both *Cryptosporidium* and *Giardia*. Credits are not granted for virus removal through MF treatment. The integrity of the membranes will be assessed to establish LRV credits based on daily pressure decay tests (PDT) and continuous turbidity monitoring from individual MF units.

In a conventional RO system, MF filtrate (i.e., RO feed water) is pressurized by a high-pressure RO feed pump and fed to the RO vessels, which contain the membranes. The feed flow passes through the first stage, where the concentrate flow is separated from the permeate. The concentrate from Stage 1 is used as the feed flow for Stage 2. The permeate streams are typically combined and the resultant concentrate flow is only produced from the final stage. Higher recoveries can be achieved by adding a third stage. Because the feed water to each subsequent phase is the concentrate from the prior stage, later stages have increased salinity levels in the feedwater and may require more frequent membrane replacement due to more frequent cleanings associated with higher scaling potential of the feedwater.

In California, use of RO process is mandatory for GWR via direct injection. It provides removal of dissolved constituents – including inorganic salts, total organic carbon (TOC), nitrate, metals, and trace organic contaminants – while also serving as a barrier for pathogens. Depending on the feed concentrations, typically 1.5-2.0 log credits each for virus, *Giardia*, and *Cryptosporidium* are provided when using online conductivity and/or TOC as surrogates.

Percent recovery for RO systems contemplated is important in that higher recoveries increase product water volumes and reduce the volume of brine to be disposed of. Conventional RO technology can typically achieve up to 90% recovery, beyond which some form of novel secondary RO system is required. Based on PWRP's tertiary effluent water quality, recoveries between 92-96% may be achievable with adequate pH adjustment and anti-scalant dosing, with a maximum theoretical recovery of around 94% based on scaling model. Achieving a recovery of greater than 90% would require a high recovery RO system that uses novel flow patterns (e.g., Closed Circuit RO, CCRO or Pulse-Flow RO, PFRO). A High Efficiency RO (HERO)-type process with much more extensive pre-conditioning is required to reach recoveries greater than 96%.



Figure 4-5. Process Flow Diagram of the Pure Water AV AWPF

For the Pure Water AV AWPF, a conventional 2-stage RO will be used as the primary RO system. To increase the recovery, either a third stage will be added or a high-recovery system such as CCRO or PFRO will be deployed to treat the brine from the second stage of the primary RO system. The preferred pathway will be identified after testing at the demonstration facility (described in **Section 7.1**).

The CCRO process relies on the use of a recirculation loop that decouples cross-flow velocity from the flow rate through the system. In a recirculation loop, feedwater enters the system during the closed-circuit desalination mode, producing permeate and recirculating concentrate. As more product water is produced and brine is recirculated, the brine concentration increases. When the recovery set point is achieved, the system transitions to plug-flow desalination mode, and the brine is purged from the system. Due to the continuous recirculation, the CCRO is not limited by minimum cross-flow velocity, and recovery can theoretically be maximized up to the solubility limit. Based on scaling models around 94% recovery can be achieved through a CCRO system for the Pure Water AV AWPF. However, the CCRO process is energy-intensive and requires more frequent membrane cleanings than conventional RO, thereby resulting in high operations and maintenance cost.

The last treatment process prior to product water stabilization is UV/AOP. In California, the use of the AOP process is mandatory for GWR via direct injection. During this process, an oxidant is injected into the water; common oxidants are sodium hypochlorite and hydrogen peroxide. The water is then irradiated with a high dose of UV light. The combination of oxidant and UV light results in the formation of hydroxyl radicals. UV/AOP (as opposed to ozone based AOP processes) is commonly employed in potable reuse applications due to its ability to photolyze certain compounds, most specifically NDMA. In addition, the UV/AOP process has a high efficiency in inactivating pathogens, including *Cryptosporidium, Giardia*, and viruses. Finally, the AOP process oxidizes many types of harmful contaminants present in the water, including alkenes and aromatics, due to the creation of hydroxyl radicals. The full-scale AWPF will utilize UV/AOP with free chlorine as an oxidant. After the three main treatment processes, the product water will be stabilized through calcite contactors that add alkalinity and calcium hardness as the water passes through them. Carbon dioxide (CO₂) may also be added upfront of the contactors to aid calcite dissolution into the water. Alternatively, other acids can also be used.

4.2.2 Capacity and Phasing

The first step in the Pure Water AV program is to build the Demonstration Facility that has a capacity of approximately 200 gpm. The demonstration facility is expected to come online in 2025. The Demonstration Facility will not be a production facility. It will provide valuable insight into the design and construction of the full-scale facilities. Phase-1 of the full-scale facilities will be rated to treat approximately 4.75 MGD and is anticipated to come online by 2030 (**Figure 4-6**).



Figure 4-6. Summary of Capacity and Phasing

There are various opportunities to expand treatment capacity if additional sources of influent water become available through agreements with other agencies. One such opportunity could be with the City of Palmdale who has an agreement with LACSD for 1.8 MGD of recycled water (Recycled Water Facilities Master Plan, 2015) that was transferred to PRWA for use in urban irrigation and construction. If an agreement is reached between the City of Palmdale and PWD, some of this water could be treated at the Pure Water AV AWPF to expand the groundwater recharge program. In addition, future agreements with LACSD to purchase tertiary effluent from LWRP may also lead to further expansion of Pure Water AV by up to 5 MGD, for a total Phase-2 capacity of up to 10 MGD. Consideration of this future scenario would also require expansion of the recycled backbone conveyance system to connect LWRP with the existing PWD recycled water system.

4.3 Conveyance Infrastructure

As shown in **Figure 4-1**, three major conveyance pipelines are required for the full-scale Pure Water AV Program. These include:

- + Source Water to the AWPF Approximately 7,700 linear feet (LF) of 18-inch diameter pipe will convey tertiary feed water from the PWRP to the new AWPF, which will be located on an undeveloped 15-acre parcel just east of PWD headquarters. The existing temporary recycled water pump station at PWRP will need to be replaced to convey the source water to both the recycled water system and to the new full-scale facility. A new recycled water pump station is required and. There is an opportunity to reduce the required length of the new pipeline by utilizing the existing 24-inch recycled water pipeline currently used to deliver treated water for irrigation. However, further analyses are required to assess the condition and spare capacity of this pipeline.
- Product Water from the AWPF Advanced treated water from the AWPF will be conveyed by approximately 500 LF of 16-inch diameter pipeline to two new injection wells, located at the AWPF site. This pipeline will be within the site boundaries of the AWPF.
- + RO Brine to Evaporation Ponds The brine produced from the RO process at the AWPF will need to be conveyed to the evaporation ponds located northeast of the AWPF. Although the pressure in the RO brine line is expected to be high enough to convey the brine without any additional pumps, this assumption will be confirmed during the conceptual design of the

full-scale AWPF. Approximately 17,000 LF of 6-inch diameter pipeline will be required to convey up to 0.45 MGD of brine flow. PVC piping is a preferred material for this smaller-diameter pipe as it is smooth and chemically inert, which helps mitigate issues with precipitate formation and pipe corrosion, respectively. Additional details on anticipated brine volume and characteristics can be found in the brine management strategy TM (**Appendix A.4**).

4.4 Injection Wells

Product water from the AWPF will be injected into the groundwater basin using injection wells. Groundwater modeling was conducted using available data to assess the travel times and feasibility of groundwater recharge via direct/subsurface injection.

First, a local scale hydrogeologic conceptual model (HCM) was developed using hydrogeologic data and information from the other Antelope Valley numerical groundwater models. The HCM informed a preliminary assessment of injection feasibility and confirmed that the underground retention times were favorable compared to Title 22 IPR regulatory requirements. For a subsurface groundwater augmentation IPR project, Title 22 Regulations require injected treated water to have an underground retention time of at least two months. Analytical estimates receive a 25 percent retention time credit, and numerical model estimates receive a 50 percent retention time credit.

A numerical groundwater flow and particle tracking model was then developed primarily to estimate underground retention times of purified water in the saturated zone between the injection and extraction wells. The model was also used to confirm injection feasibility and evaluate conceptual injection well and monitor well locations. A conservative analysis was conducted to develop reasonable estimates of the shortest underground retention times. Key assumptions include: (1) injection wells would be located within the boundaries of the new AWPF site, and (2) future pumping rates in the six closest PWD pumping wells would be increased to extract all purified water. **Figure 4-7** presents the results from the groundwater modeling. Using a simulated injection rate of 1,750 gallons per minute (GPM) and two injection wells (total of 5 MGD) on the AWPF property, the model results indicate favorable simulated (two years) and credited (one year) underground retention times compared to Title 22 IPR regulations. Credited underground retention time reflects the 50 percent reduction applied to results from a numerical groundwater flow model. Title 22 IPR regulations require a minimum two-month underground retention time and also allow for up to six months of log virus reduction credit. The model results of one year credited underground retention time exceeds the two-month requirement and exceeds the six months to qualify for the maximum log virus reduction credit.

Model results also indicate that operating injection wells on the treatment facility properties would result in manageable groundwater level rise, indicating that these locations are conceptually feasible. Title 22 IPR regulations also require monitoring of purified water flow in at least two monitor wells to demonstrate effective underground treatment and ensure a safe water supply. Model results indicate that one of these monitor wells could be located on the full-scale treatment facility property and one would be located between the injection and pumping wells.



Figure 4-7. Groundwater Particle Travel Time

The results of the conservative modeling analysis indicate favorable underground retention times compared to Title 22 IPR regulations. Based on the particle travel time presented in **Figure 4-7**, the shortest simulated and credited travel time was 2.1 years and one year, respectively. Model results also indicate that operating injection wells on the treatment facility property would result in manageable groundwater level rise, indicating that the assumed location is conceptually feasible. The construction of the injection wells will include drilling wells, and installation of well screens, injection pumps and equipment. Title 22 IPR regulations also require monitoring of purified water flow in at least two monitoring wells to demonstrate effective underground treatment and ensure a safe water supply. Model results indicate that one of these monitoring wells could be located on the full-scale treatment facility property and one would be located between the injection and extraction wells.

Although results were generally favorable, important data gaps that reduce model confidence include: (1) uncertainty on the presence of preferential rapid flow paths between the injection and pumping wells, (2) injection capacity of wells located on the full-scale and demonstration facility properties, and (3) uncertainty on effective porosity. To improve model confidence, supplemental hydrogeologic characterization in the project area is recommended. Refer to **Appendix A.8** for more details about the groundwater modeling study.

Funding Strategy | February 2024

5.0 Funding Strategy

A comprehensive funding plan assessment was developed, which considered federal and state funding opportunities, in addition to exploring alternative financing mechanisms to supplement state and federal funding, using bonds, public-public partnerships, and public-private partnerships. The funding sources are anticipated to include grants and low-interest loans across federal, state, and local levels. The full funding plan report for the Program is attached in Appendix D. The assessment showed that combining multiple complementary funding programs can be optimized to match the Pure Water AV Program Schedule, as some funding opportunities are better suited for funding different phases of the project. A funding strategy for phasing the proposed project is provided in **Table 5-1**. Application preparation, submission, and compliance varies by funding program. State and federal funding is vital to the viability of this project. For all of these programs, PWD will work with individual funding entities to coordinate different sources and thereby avoid overlap or duplicate in terms of activities, costs, or commitment of key personnel. The full funding plan report for the Program is attached in **Appendix A.5**.

Projects receiving funding and financing assistance from government sources must comply with relevant laws and regulations, including environmental compliance requirements, labor regulations, and other compliance requirements. Federal requirements differ from state requirements and may occasionally conflict. Complying has cost implications for the funding recipient and in certain instances, funding made available through a program does not justify the level of effort associated with compliance systems and activities.

There are three areas of funding compliance for PWD to consider:

- 1. Funding eligibility
- 2. Representations and warranties priorly included in grant or loan agreements
- 3. Project implementation compliance and reporting

Funding Strategy | February 2024

Phase					
Program	Planning	Design	Construction	Status	Maximum cost coverage
CA Prop 1 IRWM Round 2 DAC			•	Awarded \$450K awarded for demonstration facility conservation garden	50% of costs, up to 100% for DACs. No award maximum.
CA Prop 1 IRWM Round 2 Implementation			•	Awarded \$587K offered by IRWM region in 2/2023 for demonstration facility influent pipeline	50% of costs, up to 100% for DACs. No award maximum.
USBR Title XVI Desalination and Recycling- Planning	•	•		Awarded \$715K awarded in 9/2023 for planning and design activities of the full-scale facility occurring between 10/2023- 10/2025.	50% of planning and design costs as federal cost share, up to \$1M.
CA SGC Community Resilience Centers [Demonstration Facility]		•	•	Submitted \$10.0M requested for construction of demonstration facility and transition to community resilience center	100% of costs, up to \$10.0M
CA OPR ICARP Regional Resilience [Demonstration Facility]			•	Submitted \$3.0M requested for construction of demonstration facility and transition to community resilience center	100% of costs, up to \$3.0M
CA DWR Urban Community Drought Relief		•	•	Submitted, Not Awarded \$13.1M requested for demonstration facility, submitted 12/2022.	75% for non-DACs, 100% for DACs. Requested 76% cost coverage. No award maximum.
CA DWR Urban Community Drought Relief		•	•	Submitted, Not Awarded \$11.4M requested for extraction well 36/37, submitted 12/2022.	75% for non-DACs, 100% for DACs. Requested 87% cost coverage. No award maximum.
USBR WaterSMART Drought Resiliency Projects		•	•	Submitted, Not Awarded \$5.0M requested for extraction well 36/37, submitted 6/2022. Application will be resubmitted in 10/2023.	50% of costs as federal cost share, up to \$5M.

Table 5-1. Funding Strategy by Project Phase

Funding Strategy | February 2024

		Phase)		
Program	Planning	Design	Construction	Status	Maximum cost coverage
US EPA WIFIA Loan	•	•	•	In Progress Letter of interest accepted 12/2022, invited to apply. PWD will submit a request for a loan for 49% of project costs in Fall 2023.	49% of planning, design, and construction costs as low- interest loan, allows up to 80% federal cost share. No maximum loan amount.
US EPA Climate Pollution Reduction Grant			•	In Progress PWD intends to collaborate with the County to submit an application for this program in April 2024.	100% of implementation costs, with awards ranging from \$2.0M - \$500.0 M
CA SWB Water Recycling Funding Program Construction			•	Forecasted PWD intends to request \$15.0M for construction of full-scale facility in FY24 after full-scale design has begun.	35% of construction costs, up to \$15M.
USBR Title XVI Reuse & Recycling Construction			•	Forecasted PWD intends to request \$30.0M for construction of full-scale facility in FY24.	25% of construction costs as federal share, up to \$30M.
US FEMA Building Resilient Infrastructure and Communities			•	Forecasted PWD intends to request up to \$50.0M for construction of full-scale facility in FY23.	90% of costs as federal cost share, up to \$50M
Revenue Bonds	As	s Need	ed	Forecasted PWD intends to issue revenue bonds to finance as needed.	N/A
CA Clean Water State Revolving Fund Loan		N/A		Ineligible PWD is unable to qualify for SRF loan funds due to existing bond coverage requirements.	N/A

Key:

CA = California DAC = Disadvantaged Community DWR = Department of Water Resources FEMA = Federal Emergency Management Agency EPA = Environmental Protection Agency IRWM = Integrated Regional Water Management K = Thousands of Dollars M = Millions of Dollars OPR ICARP = Office of Planning and Research Integrated Climate Adaptation and Resiliency Program SGC = Strategic Growth Council SRF = State Revolving Fund USBR = US Bureau of Reclamation WIFIA = Water Infrastructure Finance and Innovation Act Program Component Packaging and Delivery Methods | February 2024

6.0 Program Component Packaging and Delivery Methods

The selection of the delivery methods for the different major Program components was based on PWD's key priorities and drivers as well as PWD's contractual requirements and constraints. PWD's contractual requirements are described in **Section 4.1.1**. This section provides an overview of the implementation phasing of the Program components as well as a description of the recommended delivery method and timeline for the design packages. For more details, refer to the Delivery Methods Assessment TM in **Appendix A.6**.

Based upon the nature of the new facilities planned, and in consultation with PWD staff, it was recommended to deliver the Pure Water AV Program in four separate packages including:

- 1. Demonstration Facility
- 2. Conveyance Pipelines (tertiary effluent, AWPF product water, and RO brine)
- 3. Injection Wells
- 4. AWPF and Brine Ponds

The following four delivery methods were evaluated for the Pure Water AV Program using key criteria identified by PWD staff:

- 1. Conventional Design-Bid-Build;
- 2. Construction Manager at Risk;
- 3. Fixed-price Design Build; and
- 4. Progressive Design-Build.

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The delivery methods were analyzed in relation to project risk allocation, owner involvement, and major equipment procurement. PWD staff identified cost certainty as the most important criterion for PWD to minimize rate changes to customers and maintain a level of integrity for its stakeholders. **Table 6-1** below lists the recommended delivery methods for each of the Program packages, as well as the reasoning behind the selection. Construction schedule details are included in the Master Program Schedule presented in **Section 11**.

There are statutory legal requirements to consider in the selection of any project delivery method. PWD, as an independent special district formed under the California Water Code Division 11 has the authority to establish its own rules and regulations. Per PWD's rules and regulations, its Board may authorize to establish new contract mechanisms for different procurement and delivery methods.

Table 6-1. Program	Packages'	Recommended	Delivery	Methods
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Program Package	Delivery Method	Details
1. Demonstration Facility	DBB	The demonstration facility consists of pre-packed OEM vendor systems. Due to the relatively straightforward nature of the facility, it is recommended to deliver this package using DBB.
2. Conveyance Pipelines	DBB	Because of their routine approach to design and construction, this package's components did not drive the schedule. Therefore, design and construction can be staged. DBB is recommended as the appropriate delivery method.
3. Injection Wells	DBB	Similar to conveyance pipelines, injection well designs are also straightforward and because staging of design and construction is not expected to impact the schedule, DBB was selected as the appropriate delivery method.
4. AWPF and Brine Ponds	PDB	Because of the complexity surrounding the AWPF, an early start of the construction activities is crucial to maintain the overall Program schedule. Additionally, it is important for PWD to obtain a cost estimate at different design levels and adjust the design accordingly to meet the construction cost. Based on this, PDB is recommended for the delivery of this package.

Key:

AWPF = advanced water purification facility

DBB = design bid build

OEM = original equipment manufacturer

PDB = progressive design build

PWD = Palmdale Water District

Economic Impact Assessment | February 2024

7.0 Economic Impact Assessment

The potential economic impacts of the Pure Water AV Program include direct impacts (such as investment in materials, jobs, etc.), indirect impacts (on industries supporting the project) and induced impacts (due to the increased economic activity) arising from the construction and operation of the final facilities. An economic impact analysis was conducted to measure these impacts. The inputs for the analysis included construction costs, estimated full-time equivalent employees and approximate salaries for jobs created during different phases of the Program. The analysis accounts for the construction period and ongoing operations through the projected life of 20+ years. The economic analysis for the Pure Water AV Program focused on the effects the new facilities may have to Los Angeles County's economy, with a particular emphasis on the following economic indicators: output, value added/gross domestic product, labor income, and jobs. For the full analysis, refer to Appendix A.7. The overall economic impacts of the Project could total about \$79.8 million annually during the anticipated 3-year construction period, and \$9.3 million annually once the facilities are operational. The regional economic multiplier from the construction phase of the Program is 0.78, and 0.69 for the operations phase. This means that for every \$1 spent during construction on the project, an additional \$0.78 could be generated in the Los Angeles County economy. For every \$1 spent during the operational life of the Pure Water AV Program, \$0.69 could be generated in the Los Angeles County economy. During the construction phase, about 269 constructionrelated support and induced jobs are expected to be created, bringing economic benefits to the community through labor income and economic output from onsite construction as well as supply chain services and induced jobs. Operation of the facilities will require approximately four full-time jobs annually over the estimated 50-year life of the Program. In addition to these direct jobs, indirect and induced jobs related to operations and maintenance (O&M) services could create 19 additional jobs, earning approximately \$1.3 million more in labor income within Los Angeles County per year (in 2022 dollars).
8.0 Regulatory Approval Approach

The production and use of recycled water is supervised by state and local regulatory agencies, including Lahontan Regional Water Quality Control Board (RWQCB), the State Water Resources Control Board Division of Drinking Water (DDW), and the Department of Environmental Health (DEH). The Pure Water AV Program will pursue a groundwater recharge permit and a waste discharge permit from the RWQCB, pursuant to the applicable compliance requirements. The key activities for regulatory approval are provided in the following section.

8.1 Demonstration Testing

One of the key Program features that will be instrumental in attaining regulatory approval is the Pure Water AV Demonstration Facility (Demonstration Facility). Data from monitoring and testing at this facility will be used to procure regulatory acceptance by engaging regulators and generating at the Demonstration Facility the required data for validation and permitting. In addition, this facility will be used to optimize the full-scale design, provide a training ground for PWD operators, and promote public outreach.

The Demonstration Facility will be located adjacent to PWD's headquarters and will utilize tertiary treated water from PWRP, which will be fed from a tertiary recycled water pipeline. At a minimum, the facility will employ a treatment train consisting of MF, primary RO, high recovery RO, and UV/AOP, with the objective of achieving the treatment level required by groundwater recharge via direct injection. A process flow diagram for the Demonstration Facility is presented in **Figure 8-1** below.



Figure 8-1. Demonstration Facility Process Flow Diagram

The design is intended to promote public engagement by adopting an open design. 3D renderings for the Demonstration Facility are presented in **Figure 8-2**.



Figure 8-2. Demonstration Facility 3D Rendering (Left – Conservation Garden, Right – Front of Facility)

Major objectives of the Demonstration Facility include the following:

- + Demonstrate that the treatment train can meet regulatory requirements regarding both chemical and pathogen constituents.
- + Inform and optimize the treatment processes for the full-scale design.
- + Test recoveries for different RO technologies.
- + Engage the public via tours, educational opportunities, and public events.
- + Facilitate operator training of advanced treatment processes.

The Conceptual Design Report (**Appendix A.9**) was developed for the Demonstration Facility and includes a detailed description of the facility, the project delivery method, applicable regulations, water quality information, process description, control strategies, design guidelines, a cost estimate, and information pertaining to public outreach. After completion of testing to guide full-scale design, PWD plans to continue operating the facility and use it as a learning center for public outreach and a training center for water and conservation education. The schedule of the design, construction, and startup of the Demonstration Facility is illustrated in **Figure 8-3**.



Figure 8-3. Demonstration Facility Timeline

Extensive testing and water quality monitoring will be performed at the Demonstration Facility to assess regulatory compliance, operations and treatment performance, and to inform design criteria for the full-scale facility. The results from these sampling events will also be compared to other reuse facilities. Once all systems are optimized, special tests will be performed at the Demonstration Facility to investigate compliance with potable reuse regulations. It is anticipated that testing and monitoring of the Demonstration Facility will require up to twelve months, as shown in **Table 8-1**. The initial three months will be used for baseline testing to establish baseline conditions, while the remaining nine months will be designated for optimization of key operational parameters.

Table 8-1. Testing and Monitoring	Schedule for the	Demonstration Facility
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T = -1-		Month										
Task	1	2	3	4	5	6	7	8	9	10	11	12
MF												
Phase 1: Low flux												
Phase 2: Medium flux												
Phase 3: High flux												
Primary RO												
Baseline Testing												
Normal Operations												
Secondary Conventional RO												
Baseline Testing												
 Recovery Evaluation/Optimization Testing 												
Secondary CCRO												
Baseline Testing: Overall Recovery												
 Recovery Evaluation/Optimization Testing: Overall Recovery 												
UV/AOP												
Routine Testing												
Phase 1: Verify UV Dose												
Phase 2: Determine optimized UV dose and free chlorine dose setpoints												
Routine Monitoring												

8.2 Independent Advisory Panel and Regulatory Engagement

An Independent Advisory Panel (IAP) has been engaged under the framework of the National Water Research Institute (NWRI), which includes a team of academics and industry experts with relevant water augmentation experience. The IAP will evaluate the technical, scientific, and regulatory aspects of the Demonstration facility, approve the test plan, and provide input during demonstration testing and ultimately, the Pure Water AV Program. The following workshops and meetings are scheduled to better inform and prepare the IAP.

- 1. **Introductory Meeting**: present an overview of the project and determine what information the IAP needs in advance of Workshop 1. The introductory meeting was conducted on December 21, 2022.
- 2. **Workshop 1**: present the project alternatives, groundwater modeling results, demonstration facility, and associated test plan to the IAP. Workshop 1 was conducted on March 2, 2023.
- 3. **Update Meeting**: solicit input on technical and/or regulatory hurdles midway through the demonstration testing. This meeting will be scheduled in accordance with demonstration testing.
- 4. **Workshop 2**: Review the preliminary results of the demonstration facility and final groundwater modeling results. Workshop 2 will be scheduled once results from the demonstration facility are available.

Direction and recommendations received from the IAP in each of the meetings/workshops will be incorporated into the project as appropriate.

Additionally, PWD has hired an independent consultant to review the testing results and project costs and the performance data from the Capture6 demonstration facility. Using the data from the independent consultant, a separate IAP will provide recommendations on the full scale Capture6 carbon removal technology. The IAP will primarily assist PWD to assess the technical feasibility of integrating Capture6's technology into Pure Water AV and review the economic viability of the carbon capture portion of the project. The following workshops and meetings are scheduled to better inform and prepare the IAP for review of the Capture6 facility.

- Introductory Meeting: present an overview of the project and determine what information the IAP needs in advance of Workshop 1. The introductory meeting will be conducted on October 17th, 2023.
- Workshop 1: Review conceptual design of Capture6's demonstration facility and framework of testing and monitoring plan. This meeting will be scheduled within the fourth quarter of 2023.
- 3. **Update Meeting**: solicit input on performance data midway through the brine management demonstration testing. This meeting will be scheduled in accordance with the brine management demonstration testing.
- 4. **Workshop 2**: Review operational and water quality performance data from the demonstration facility. Workshop 2 will be scheduled after results from the brine management demonstration facility are available.

8.3 Title 22 Engineering Report

The Title 22 Engineering Report describes how the final, full-scale facility will comply with the California Code of Regulations, Title 22 requirements. The Title 22 Engineering Report must be approved by the DDW. At a minimum, the engineering report shall: identify all project participants, describe applicable rules and regulations, describe the source wastewater, describe the recycled water treatment processes and operations, present plant reliability features, describe all supplemental water supplies, present the proposed monitoring and reporting program, and present a contingency plan to prevent discharge of off-specification water.

Development of the Draft Title 22 Engineering Report will begin near completion of the 60% full-scale design and is expected to take approximately 6 months to complete, including internal review. Once completed, the draft will be submitted to DDW to review and provide comments. The review and revision process is expected to take 3 to 6 months.

The Preliminary Final Title 22 Engineering Report will be prepared during the DDW review cycle as revisions are made in response to comments from DDW. The preliminary final report is expected to be submitted approximately 6 months after the submittal of the draft report. The submittal of the preliminary final report will be followed by a public hearing with DDW.

The Final Title 22 Engineering Report will be prepared and submitted to DDW after the public hearing, incorporating any additional feedback from the hearing. Once submitted, it may take 1 to 3 months to receive the Conditional Approval Letter from DDW.

8.4 Waste Discharge Requirements/Water Recycling Requirements (WDR/WRR) Permit

The Report of Waste Discharge (ROWD) package includes general information about the facility, the type of discharge, the location of the facility, and the reason for filing. Information about completion of CEQA requirements must be included, and any completed CEQA documents should be enclosed. A complete characterization of the discharge must be provided, which includes information about flows, discharge concentrations of constituents, best managements practices, and disposal methods, among others. The ROWD package will be prepared in parallel to the preparation of the Preliminary Final Title 22 Engineering Report to capture feedback from DDW. The timing of the submittal of the ROWD will be similar to that of the Preliminary Final Title 22 Engineering Report. The ROWD, along with the Conditional Approval Letter, will inform the RWQCB's preparation of the WDR/WRR permit. Once the draft WDR/WRR permit is received, there will be a courtesy review period, followed by a public comment period.

8.5 Operation Optimization Plan

The Operation Optimization Plan (OOP) describes the operations, maintenance, analytical methods, monitoring, and reporting necessary to meet the requirements set by Article 5.2 (Indirect Potable Reuse: Groundwater Replenishment – Subsurface Application) of the Title 22 regulations. The draft OOP must be submitted to and accepted by DDW and the RWQCB prior to operation of the facility. Preparation of

the draft OOP may take 6 to 9 months, including internal review cycles and DDW review. An amended OOP may be requested by the regulatory agencies that incorporates feedback on the draft OOP as well as full-scale startup testing results. The final OOP is typically prepared and submitted within the first 90 days of operation.

Per the recycled water regulations, after the first year of operation, an updated OOP must be submitted within six months that incorporates any changes in operational procedures that were made to optimize treatment processes. The updated OOP is not included in this schedule.

8.6 Tracer Study Workplan

The Tracer Study Workplan will include details such as rationale for tracer selection, the tracer injection protocol, proposed sampling methods, and other sampling details. The Tracer Study Workplan may take approximately 3 months to prepare, including internal review and DDW review and approval. The tracer study should be initiated prior to the end of the third month of operation. A tracer study report should be prepared upon completion of the study.

8.7 UV/AOP Performance Test

UV/AOP performance testing must be completed during commissioning to demonstrate the system meets required treatment criteria (i.e., minimum 0.5-log removal of 1.4-dioxane). The test protocol should be completed and approved by DDW prior to the end of construction. Once performance testing is completed, a test report is prepared and submitted to DDW for approval. Typically, completion of the UV/AOP performance testing is shortly followed by the DDW inspection to receive approval for injection.

Public Outreach Strategy | February 2024

9.0 Public Outreach Strategy

Public outreach to communities that may receive the new purified recycled water and/or be impacted by the construction of the Program is a vital component for PWD. Therefore, a Public Outreach Plan (**Appendix A.10**) was prepared to assist PWD with informing the local communities about the Program, respectfully seek their input, and start building trusting relationships. The Public Outreach Plan is an audience-driven plan and "living" document, meaning that the outreach activities outlined are tailored to the various audiences that need to be informed about the Program, and such activities will be reviewed and revised on a periodic basis. It is essential that these efforts be broad, equitable, and inclusive, encompassing diverse audiences and ensuring all communities have access to Program information and opportunities for participation and involvement.

Water recycling agencies across the nation often face negative public opinion about potable reuse projects because the product water was once municipal wastewater. Linked to this are the existing concerns about the water quality of the public drinking water supply. A sense of mistrust can be highly prevalent in some communities, particularly in areas that have experienced systemic challenges with water service. Moreover, the communication of technical information may require audiences to learn new vocabulary and assimilate new information in short amounts of time. Different communication methods and networks may be required to promptly reach all the population groups.

Various opportunities to aid in building understanding, momentum, visibility, and support for the Pure Water AV Program include:

- + The increased popularity of environmental awareness and support,
- + Numerous successful potable reuse projects throughout California and the U.S., and
- + Heightened public awareness of limited or constrained water supplies.

Additionally, PWD plans to approach outreach on a more local level and work directly within the communities to create the opportunity for more innovative and community-oriented strategies. Virtual engagement offers a different way of communication that can expand the outreach Program engagement through the development of additional tools that can serve virtual audiences. The already established relationships with key project stakeholders can also be utilized to connect to communities in a more collaborative approach. Utilizing these opportunities to better engage with the public contributes directly to the overall success of the Program.

The key messages and overarching themes for public outreach to help focus communication efforts and frame the conversation around the Pure Water AV Program are:

- 1. The Palmdale Water District has embarked on the Pure Water AV, which will use advanced technology to purify wastewater that has already been treated to levels consistent with pretreatment required by the advanced water treatment systems envisioned.
- The purified water will be a local, reliable, and sustainable source that will help ensure water supply reliability for the region.

3. Once operational, PWD will be conducting testing at its 200 GPM Advanced Purification Demonstration Facility in 2025, which will provide data for a full-scale water purification plant and Program. The Demonstration Facility will also serve as a central component of the potable reuse outreach program by offering guided tours of the treatment process, tasting opportunities for tour participants, interactive educational displays, a native garden to provide examples of low water use landscaping, and a community room available for public functions. Environmental Studies and Permit Requirements | February 2024

10.0 Environmental Studies and Permit Requirements

As a discretionary action of a governmental agency that will have direct and reasonably foreseeable indirect impacts on the environment, Pure Water AV will be subject to review under CEQA. In compliance with CEQA (Public Resources Code Section 21000 et seq., and state CEQA Guidelines, Title 14 CCR Section 15000 et seq.), PWD will prepare an Initial Study (IS) to address the impacts of construction and operation of the Program. The IS will identify the site-specific impacts, evaluate their potential significance, and determine the appropriate document needed to comply with CEQA. If the information reviewed and contained in the IS supports a determination that the proposed project will not have a significant environmental impact with mitigation measures incorporated into the project, a Mitigated Negative Declaration (MND) will be the appropriate CEQA document. If potentially significant unmitigable impacts are identified, PWD will prepare an Environmental Impact Report to further evaluate project alternatives and additional mitigation measures. The CEQA process will include distribution of the environmental document for review and comment by relevant responsible, trustee, and interested agencies, Native American tribes, environmental organizations, and the public. It is assumed that the CEQA process will approximately follow the schedule shown in **Figure 10-1**.





In further compliance with CEQA and Assembly Bill 52 (AB52), PWD will consult with relevant California Native American tribes and consider tribal cultural resources potentially impacted by the project. By requiring consideration of tribal cultural resources early in the CEQA process, the legislature intended to ensure that local and tribal governments, public agencies, and project proponents will have information available early in the project planning process to identify and address potential adverse impacts to tribal cultural resources. PWD will outreach to the Native American Heritage Commission to obtain a tribal contact list. Individual letters to each tribe on the contact list will be sent to outline the proposed project and invite tribal representatives to consult with PWD.

Based on initial biological and cultural investigations of the project site, no significant cultural or biological resources were identified at the project site. The site is currently vacant and graded with a scattering of Joshua trees and drainages running through the area. More detailed investigations as described within this section will be completed once the project site has been officially procured and further details of the project are established, prior to ground disturbing activities.

In addition to the above-mentioned environmental studies, PWD will pursue and acquire the applicable permits for implementation of the Pure Water AV Program. **Table 10-1** summarizes the anticipated permits that will be pursued and respective stakeholders. This list may not be exhaustive of all applicable permits for the project, and a more detailed assessment will be developed during final design to identify all applicable permits and regulatory requirements.

Environmental Studies and Permit Requirements | February 2024

Table 10-1. Potential Permit Requirements for Pure Water AV

Permit/Approval	Stakeholders
National Pollutant Discharge Elimination System (NPDES) and Construction Stormwater Pollution Prevention Plan (SWPPP) permit	State Water Resource Control Board (State Water Board)
Indirect Potable Reuse Permit	State Water Resources Control Board Division of Drinking Water (DDW)
Waste Discharge & Water Recycling Requirements / User Water Recycling Permit/ Title 22 Engineering Report / operations and optimization plan (OOP)	Lahontan RWQCB
Sewer Discharge Permit	Los Angeles County, LACSD
Cross Connection & Water Pollution Control Program Compliance	Los Angeles County Department of Public Health
Fire Protection System Permit/Plan Check	Los Angeles County Fire Department
Hazardous Materials Review/Field Inspection Spill Prevention Control and Countermeasure Plan (SPCC) Certified Unified Program Agency (CUPA) Permit	Los Angeles County Fire Department
Fire Protection System Permit/Plan Check	City of Palmdale
Easement Encroachment/Haul Route Permit	City of Palmdale
Offsite Utilities, Roadway, Street Use, and Landscape	City of Palmdale Public Works
Construction Permits Demolition Stockpile After Hours Construction Oversize Load Right-Of-Way Sign Roadway Closure (Temp Traffic Control Plan) Dewatering Boring Fugitive Dust Control	City of Palmdale CalTrans (for transportation permits of oversize/overweight vehicles on State Highway System)
Standard Urban Storm Water Mitigation Plan (SUSMP)	Los Angeles County Public Works
Flood Control Permit	Los Angeles County Department of Public Works Flood Control District
Dust Control Plan (depending on acreage and volume of earthwork) Construction and operations permit	Antelope Valley AQMD

 (γ)

Key: AQMD = Air Quality Management District OOP = Operations and Optimization Plan

Cost Estimates | February 2024

11.0 Cost Estimates

The following section describes the preliminary cost assessment performed for the full-scale facilities of the Pure Water AV Program. Cost estimating details include the capital cost estimate, operation and maintenance cost estimate, and net present value analysis.

11.1 Capital Cost Estimate

The five major Program components considered in the capital cost estimate includes:

- + Conveyance Lines
- + The New AWPF
- + Groundwater Injection Wells
- + Brine Conveyance
- + Brine Evaporation Ponds

Each of these are briefly discussed in the following subsections:

- Conveyance: Approximately 7,700 linear feet (LF) of 18-inch diameter pipe will be utilized to convey tertiary feed water from the PWRP to the new AWPF, currently located on an undeveloped 15-acre parcel just east of PWD headquarters.
- + Treatment: The AWPF will treat 4.75 mgd of tertiary effluent and will consist of MF, Primary RO, Secondary RO, and UV system along with ancillary facilities, such as break tanks, transfer pumps, chemical pump skids. Equipment for the AWPF will be housed in a pre-engineered metal building and a separate operations and laboratory building will also be constructed adjacent to the AWPF.
- Product Water Distribution: Advanced treated purified product water from the AWPF will be conveyed by approximately 500 LF of 16-inch diameter pipelines to two new injection wells, located at the AWPF site.
- Disposal Conveyance: The brine from the RO system will be conveyed by approximately 17,000 LF of 6-inch diameter pipelines to new evaporation ponds to facilitate brine disposal at a nearby location.
- Brine Evaporation Ponds: Up to 113 acres of new evaporation ponds will be constructed to dispose RO brine.

After the required residence time (groundwater travel time) as stipulated by the DDW, groundwater will be extracted downgradient using existing municipal wells owned by PWD to supply potable water to the service area. **Table 11-1** provides a summary of the construction costs, which includes the following cost components:

- + Equipment includes process equipment and associated tanks or pumps.
- + Conveyance includes pipelines, pumps and injection wells.
- + **Buildings** includes pre-engineering buildings for equipment and storage and associated concrete foundations.
- + Brine Evaporation Ponds includes liners, ramps and flood control improvements.
- + **Sitework and Installation** includes demolition, earthwork, yard piping, installation and electrical and instrumentation and control (I&C) work.
- + Mobilization assumed at five percent of the construction subtotal.
- Other Contract Costs includes five percent design contingency, 9.5 percent sales tax of equipment and materials, 30 percent contractor markups and overheads, and 25 percent construction contingencies.
- + Non-Contract Costs includes Engineering/ESDC/PM/CM costs, land acquisition and permitting.

Parameter	Cost (2022\$)	Notes
Equipment	\$14,463,000	
Conveyance	\$13,115,000	
Buildings	\$20,825,000	
Brine Evaporation Ponds	\$16,836,000	
Sitework and Installation	\$15,808,000	
Subtotal	\$81,047,000	
Mobilization	\$4,060,000	5% of subtotal
Subtotal with Mobilization	\$85,107,000	
Contract Cost Allowances	\$36,050,000	includes design contingencies, sales tax, contractor markups and overheads
Contract Cost	\$121,157,000	
Construction Contingencies	\$30,290,000	25% of contract cost
Field Cost	\$151,447,000	
Non-Contract Costs	\$44,990,000	includes engineering, ESDC, PM, CM, land acquisition costs and permitting
TOTAL CONSTRUCTION COST	\$196,500,000	

Key:

CM = construction management

ESDC = engineering services during construction

PM = project management

Cost Estimates | February 2024

Detailed cost estimates are provided in **Appendix A.11**. All cost estimates are presented in 2022 dollars but once the project schedule is finalized, costs will be escalated to the midpoint of construction. The estimates were prepared in accordance with the criteria established by the Association for the Advancement of Cost Engineering (AACE) for a Class 5 cost estimate. According to AACE, Class 5 estimates are "generally prepared based on very limited information, and subsequently have wide accuracy ranges. Typical accuracy ranges for Class 5 estimates are -20 percent to -50 percent on the low side, and +30 percent to +100 percent on the high side, depending on the technological, geographical, and geological complexity of the project, appropriate reference information, and other risks."¹

11.2 Operations and Maintenance Cost Estimate

The operation and maintenance costs include power, chemicals, and consumables for each treatment process at the AWPF, major equipment replacement, labor, brine disposal, tertiary effluent water purchase and contingency. **Table 11-2** provides a breakdown of the O&M costs. The cost components include:

- Power assumed at \$0.18/kWh and included power demand for treatment equipment and conveyance based on pumping demand.
- Chemicals assumed for process chemicals including MF (sodium hypochlorite, citric acid, hydrochloric acid, sodium bisulfite, ammonium sulfate), RO (sulfuric acid, antiscalant, citric acid, caustic), UV/AOP (sodium hypochlorite), stabilization (lime, carbon dioxide) and residual disinfectant (sodium hypochlorite)
- + Maintenance assumed at three percent of equipment costs
- + Major Equipment Replacement estimated at five percent of equipment costs
- + Labor estimated at \$150/hr (based on experience from other AWPF facilities)
- + **Disposal** brine ponds salt disposal costs assumed at \$243/cubic yards (based on quotes from dredging companies and disposal rates for resource conservation and recovery act (RCRA waste)
- Surface water treatment estimated at \$270/acre-feet (AF) (based on 5-year historical treatment cost data from PWD)
- + Tertiary water purchase estimated at \$150/AF (based on contract agreement with LACSD)
- + Contingency assumed at 15 percent of O&M subtotal

¹ (2005) AACE International Recommended Practice No. 18R-97, Cost Estimate Classification System – As Applied In Engineering, Procurement, And Construction For The Process Industries, TCM Framework: 7.3 – Cost Estimating and Budgeting

Cost Estimates | February 2024

Parameter	Cost (2022\$)	Notes
Power, \$/yr	\$753,000	
Chemicals, \$/yr	\$611,000	
Maintenance, \$/yr	\$592,000	
Major Equipment Replacement, \$/yr	\$561,000	5% of equipment cost
Labor, \$/yr	\$1,752,000	
Disposal, \$/yr	\$1,070,000	Salt disposal from ponds
O&M Subtotal	\$5,339,000	
O&M Contingency	\$801,000	15% of subtotal of O&M cost estimate
Water Purchase	\$799,000	\$150/AF: Based on agreement with LACSD
Total O&M Cost	\$6,140,000	

Table 11-2. Operations and Maintenance Cost Summary

Key:

LACSD = Los Angeles County Sanitation District

O&M = operations and maintenance

Detailed operations and maintenance cost estimates are provided in Appendix A.11.

11.3 Net Present Value

The net present value was calculated for a 25-year term and 5 percent interest rate, using 2022 dollars. This analysis showed NPV of \$235,435,000, which translates to a unit cost for product water at \$1,982/AF.

Risk and Mitigation Summary | February 2024

12.0 Risk and Mitigation Summary

The following potential risks and associated mitigation strategies that have been identified to date for the Pure Water AV Program are presented in **Table 12-1**. Potential risks, and recommended mitigation strategies associated with the program will be continually assessed throughout the project life cycle.

Table 1	2-1.	Risk	Assessment
---------	------	------	------------

Program Item	Risk	Mitigation
Financing	Financing rates are higher than anticipated.	Stantec is continually working with PWD to secure additional sources of funding as they become available to help finance Pure Water AV. Funding opportunities will continually be explored through construction of the program to minimize project costs and the impact to PWD rate payers.
Demonstration Facility Water Quality Results	Demonstration water quality results are less favorable than expected.	During demonstration testing, adjustments and optimizations will be made to each of the processes to confirm final water quality results are within acceptable regulatory limits. All water quality test results from the demonstration testing will be carefully reviewed by an independent advisory panel of experts (IAP). Recommendations from the IAP will be incorporated into the design of the full-scale facilities.
Brine Management Approach	Viability of Capture6 technology for brine management.	The Capture6 technology will be tested alongside the AWP demonstration facility to confirm its applicability and viability for full-scale brine management. The test results from the brine management demonstration testing will be reviewed by an independent consultant as well as an independent advisory panel. If the results and recommendations from the IAP are unfavorable, PWD will still move forward with the project using brine ponds for brine management
Injection Wells	Reduced groundwater modeling confidence due to uncertainty of travel times, injection capacity, and uncertainty of effective porosity	To date, groundwater modeling efforts have been based on desktop studies using available site hydrogeological data. To improve confidence in the model results, it is recommended to perform field studies to better inform the hydrogeological model. Field studies to include design and construction of a full-scale injection well, construction of monitoring wells, installation of data loggers on existing potable water extraction wells and tracer testing. Potable water would be utilized to test the capacity of the injection well and data collected would be reviewed by an independent advisory panel. Additional field testing will be completed as needed and the hydrogeological model will be updated.
Construction Costs	Construction costs may be higher than originally estimated.	Updated construction costs will be provided to PWD throughout the various stages of design to increase confidence in the final construction costs and allow PWD time to secure more funding if needed.
Environmental Permitting	Environmental issues may arise during initial investigations that result in more mitigation than expected.	It is assumed a Mitigated Negative Declaration (MND) will be the appropriate CEQA document. If potentially significant unmitigable impacts are identified, PWD will prepare an Environmental Impact Report to further evaluate project alternatives and additional mitigation measures. Cost and time impacts will be evaluated at that time.
Public Outreach	Limited public acceptance of the program.	PWD will continue public outreach efforts throughout the life of the project planning and construction. A Pure Water AV website has been set-up to keep the public and stakeholders up to date on program activities. Documents produced as part of the program will be available for public and stakeholder review on the Pure Water AV website. Public tours of the demonstration facility will be held and will provide an opportunity for public and stakeholder engagement and learning.

Master Program Schedule | February 2024

13.0 Master Program Schedule

The recommended project implementation schedule is presented in **Figure 12-1** and includes phases for engineering, procurement and bidding, construction, and commissioning activities for various project components. It is anticipated that preliminary design and CEQA tasks will be completed in 2024 and 2025, with design and construction of facilities to follow through 2029. The critical path schedule will consist of the AWPF construction and well drilling and equipping tasks, while other infrastructure design and construction will occur in parallel. Under this schedule, the treatment facility and conveyance infrastructure will be operational by mid-2029.

The current schedule is based on the use of brine ponds for brine disposal. As previously discussed, the Capture6 technology will be evaluated at the demonstration facility as an alternative brine management solution, which may eliminate the need for brine ponds. However, initial results from the demonstration facility will not be available until 2026. Waiting for these results to determine an optimum brine management strategy would extend the overall Program schedule by over one year, as presented in an alternative schedule (**Figure 12-2**).

These project schedules are a snapshot in time of what is known at the time of this report being written. The program schedule is driven by many factors including obtaining additional funding, permitting, demonstration performance results, design activities and constructions schedules. Both program schedules will be updated periodically as more data becomes available and until an optimum brine management strategy is selected.

Master Program Schedule | February 2024

Brine Management with Brine Ponds

	2023	2024	2025		2026		20	27	1	2028			2029
Key activities	Q1 Q2 Q3 Q4 0	Q1 Q2 Q3 Q4	Q1 Q2 Q3	Q4	Q1 Q2 Q3	Q4	Q1 Q2	Q3 Q4	Q1 -	Q2 Q3	Q4	Q1	Q2 Q3 Q4
Demonstration Facility								1.1					
Engineering and Design													
Bidding and Award													
Construction & Commissioning			1-1				_						
Testing and Operation						-	_		-	_			-
Environmental Studies & Permiting													
AB52/CEQA Tribal Consultation			A										
Environmental Technical Studies													
CEQA Document				1			_	_			-	_	
Title 22 Engineering Report						1					-		
RWQC8 WDR/WRR Permit													
Operation Optimization Plan													
Tracer Study Workplan													
UV/AOP Performance Test													
DDW Inspection													
Hydrogeologic Investigation Program													
Design													
Spinner Logging					100								
Testing Well Installation													
Testing													
Geochemical Evaluations													
AWPF and Brine Ponds (Progressive Design Build)													
Conceptual Design			1000										
PDB Entity Selection													
Design			1.1.1	1		1							-
Construction & Commissioning						1 1			1				
Conveyance Pipelines (Design Bid Build)													
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Construction & Commissioning												1	
Injection Wells (Design Bid Build)													
Desian													
Contractor Selection			1										
Construction & Commissioning										1			

Figure 12-1. Pure Water Antelope Valley Baseline Implementation Schedule

Master Program Schedule | February 2024

Brine Management with Capture 6

the set	2023	2024	2025	2026	2027	2028	2029	2030
Key activities	Q1 Q2 Q3 Q4 Q1	Q2 Q3 Q4 Q1	Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3
Demonstration Facility				CINERAL				
Engineering and Design								
Bidding and Award								
Construction & Commissioning		1						
Testing and Operation								
Environmental Studies & Permiting								1
AB52/CEQA Tribal Consultation								
Technical Studies								
CEQA Document								
Title 22 Engineering Report								
RWQC8 WDR/WRR Permit	· · · · · · · · · ·							
Operation Optimization Plan								1
Tracer Study Workplan								
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Conceptual Design								
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Construction & Commissioning								
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Construction & Commissioning								
Injection Wells (Design Bid Build)								
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Construction & Commissioning								
Brine Management (Capture 6)								
Design							/	
Contractor Selection								
Construction & Commissioning	Street Stre	and the second sec						

Figure 12-2. Pure Water Antelope Valley Extended Implementation Schedule

APPENDIX A.1 Rapid Program Readiness TM

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Rapid Program Readiness Assessment – Pure Water Antelope Valley

Technical Memorandum

May 2023

Prepared for: Palmdale Water District

Prepared by: Stantec Team

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APPENDIX A

Prior Studies

Abbreviations May 2023

Abbreviations

AFY	acre feet per year
AWPF	advanced water purification facility
EIR	Environmental Impact Report
GWR	groundwater recharge
IPR	indirect potable reuse
IRWM	Antelope Valley Integrated Regional Water Management Plan
LACSD	Los Angeles County Sanitation District
No.	Number
PRWA	Palmdale Recycled Water Authority
Pure Water AV	Pure Water Antelope Valley
PWD	Palmdale Water District
PWRP	Palmdale Water Reclamation Plant
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board
SNMP	Salt and Nutrient Management Plan
SWA	surface water augmentation
SWP	State Water Project
SWRP	Strategic Water Resource Plan
TDS	total dissolved solids
ТМ	technical memorandum
WRP	Water Reclamation Plant

Abbreviations May 2023

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Introduction May 2023

1.0 Introduction

Stantec Consulting Services Inc. (Stantec) was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional recycled water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). As part of that effort, several planning studies are underway for successful implementation of Pure Water AV. This technical memorandum [™] provides an overview of the studies completed prior to Pure Water AV and identifies additional studies or analyses needed to supplement the existing studies.

1.1 Program Background and Drivers

PWD has been providing water service to its customers since 1918, when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the groundwater basin has been in overdraft since the 1930s, resulting in land subsidence. In 1973, Palmdale Irrigation District changed its name to Palmdale Water District.

PWD has conducted a number of studies that date back to as early as the 1990s to evaluate the water resources necessary to meet future water supply demands. Concepts evaluated to date include using recycled water for landscape irrigation, discharging into Palmdale Lake, and discharging into existing sand and gravel pits to replenish the groundwater basin. In 2012, the Palmdale Recycled Water Authority (PRWA), comprising members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area. PRWA manages the distribution of recycled water and the design and construction of support facilities, and finances the efforts.

PWD has been exploring different concepts of groundwater banking, storage, and extraction. As part of that effort, PWD has conducted a series of pilot studies to determine the infiltration rates. Less than favorable results from the pilot studies led PWD to evaluate the feasibility of surface water augmentation and/or groundwater recharge via direct injection – two different forms of indirect potable reuse (IPR). Stantec was retained by PWD to conduct a feasibility study on IPR. Based on the results of the IPR feasibility study, PWD decided to pursue the concept further. Using tertiary effluent from the Los Angeles County Sanitation Districts' (LACSD) Palmdale Water Reclamation Plant (PWRP), PWD plans to produce potable quality water for groundwater recharge via direct injection.

1.2 Study Background and Objectives

The PWD has been planning for the use of recycled water within its service area for more than 12 years. The 2010 Strategic Water Resource Study (RMC, 2010) outlined a set of guiding objectives and steps to expand the available water supply, including recycled water, to supplement the projected water demand by 2035. Since then, PWD has made significant progress towards implementing expanded use of recycled water through various planning efforts, including planning studies, environmental impact assessments, and feasibility studies (**Figure 1**). The objective of this TM is to review and summarize the findings from the previous studies/projects and identify knowledge gaps for efficient program execution of Pure Water AV. In addition, regulations, guidelines, and water purchase agreements that are relevant to

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Pure Water AV were also reviewed. The timeline for major studies and/or milestones that led to Pure Water AV are shown on **Figure 1**. The listed documents have been provided for reference in **Appendix A**.



Figure 1. Major Studies and Milestones that Led to Pure Water Antelope Valley

Planning Reports May 2023

2.0 Planning Reports

Stantec reviewed several planning reports to determine their relevance to Pure Water AV. These are discussed in the following sections.

2.1 Master Plans

The Master Plan reports reviewed include:

- City of Palmdale Sewer Master Plan Final Report (RMC, 2009)
- Strategic Water Resource Plan (RMC, 2010)
- Recycled Water Facilities Master Plan (Carollo, 2015)
- Water Distribution System Master Plan (MWH, 2016)

Of the four reports listed above, Stantec determined that the Strategic Water Resource Plan (RMC, 2010) and the Recycled Water Facilities Master Plan (Carollo, 2015) were relevant to Pure Water AV. The key findings from these two documents are summarized in the following sub-sections.

2.1.1 STRATEGIC WATER RESOURCE PLAN

The Strategic Water Resource Plan (SWRP) (RMC, 2010) aimed to establish guiding objectives and identify necessary steps to meet the projected future demand for PWD for the next 25 years, which was expected to double by 2035. The study considered different water supplies available to PWD, including groundwater, imported water, local runoff, recycled water, conservation, and water banking. The SWRP evaluated different strategies for water resource management and made several recommendations with an outlined implementation plan to increase available water supply to PWD. These recommendations included maximizing the use of recycled water within PWD's service area, developing a non-potable distribution system to deliver tertiary water for irrigation and other industrial/commercial uses, and pursuing a recycled water exchange program with nearby agriculture customers in lieu of groundwater pumping. The study also recommended securing recycled water agreements, conducting further research into recycled water use for groundwater recharge, and using surface spreading facilities to percolate untreated State Water Project (SWP) water and aquifer storage recovery wells to inject potable water. PWD is currently working to update the SWRP, which is scheduled to be published by the end of 2023. The SWRP laid the foundation for Pure Water AV by identifying research on recycled water supplies.

2.1.2 RECYCLED WATER FACILITIES MASTER PLAN

After an agreement between the City of Palmdale and PWD, PRWA was established to manage recycled water that is generated within the Palmdale area. PRWA's Recycled Water Facilities Master Plan described the existing and planned facilities, conducted a market assessment for recycled water, and

Planning Reports May 2023

performed an alternative analysis for recycled water use in the region. The report noted that 10,430-acre feet year per year (AFY) of tertiary treated recycled water could be available for use within the PRWA area.

Alternatives were evaluated to identify the most effective approach for reuse. These alternatives assumed different levels of recharge and locations for recharge (Upper Amargosa Creek versus Littlerock Creek). The results showed that the alternative with eastern direct use and full recharge at Littlerock Creek resulted in the highest benefits. Thus, this alternative was recommended based on its ability to provide recycled water to the direct use market, while also incorporating the use of recycled water for groundwater recharge (GWR). The outcome of this study demonstrated that groundwater recharge with recycled water was a favorable alternative, which is the direction taken by Pure Water AV.

2.2 Antelope Valley Regional Reports

Three reports have been produced for the Antelope Valley that are relevant to Pure Water AV. The Antelope Valley Watermaster Annual Report (Todd Groundwater, 2020) summarized the state of the Antelope Valley Basin, including changes in production/extraction and production rights, and reported on water levels trends and storage volume/capacity.

The Antelope Valley Integrated Regional Water Management Plan (IRWM) (Antelope Valley Service Districts, 2019) reviewed all aspects of water resources in the region by considering a broader range of resource management issues, competing water demands, new approaches to ensure water supply reliability, and new ways of financing. The report established specific aspects or "standards" for IRWM to be eligible for grant programs.

The 2014 Salt and Nutrient Management Plan (SNMP) (LACSD/LACDPW, 2014) was a collaborative effort to manage salts and nutrients from all sources and ensure water quality objectives for the Antelope Valley Basin. Water quality assessment included baseline water quality and current assimilative capacity, which is the difference between water goals for the basin and baseline water quality. The results indicated that overall groundwater quality in the basin is stable and below the water quality management goals. On the sub-basin level, cases of water quality exceedances of management goals were found for some naturally occurring constituents, such as arsenic, boron, fluoride, and total dissolved solids (TDS). Monitoring programs at 32 municipal water supply wells was proposed to track the water quality in the basin. The results from existing monitoring programs were to be downloaded at the State Water Resource Control Board's Geotracker Groundwater Ambient Monitoring and Assessment database. The SNMP indicated good water quality and stable trends within the groundwater basin, which will continue to be able to support designated beneficial uses.

Agreement for Purchase and Sale of Recycled Water May 2023

3.0 Agreement for Purchase and Sale of Recycled Water

PWD has an agreement with LACSD Number (No.) 20 for the sale and purchase of recycled water from the Palmdale Water Reclamation Plant (WRP). The agreement (LACSD/PWD, 2016) allocated 4,000 AFY for groundwater recharge and 1,325 AFY for purple pipe reuse. The agreement also stated that PWD may request a permanent increase to its allotment if additional permanent supplies of recycled water become available at the Palmdale WRP. In addition, PWD must meet certain milestones toward completion of the recharge project to continue to receive its recharge allotment.

Per the agreement, water quality provided by LACSD must conform to disinfected tertiary recycled water Title 22 regulations. The Palmdale WRP uses a nitrification/denitrification process to reduce total nitrogen levels in the recycled water. Further Regional Water Quality Control Board (RWQCB) requirements to meet more stringent water quality targets may be undertaken by PWD at its discretion and expense. The agreement outlines that there is no minimum mandatory volume that PWD must withdraw from the Palmdale WRP; but in order to maintain the allotment established under the agreement, PWD must pay a minimum payment each year. This minimum payment was detailed in the agreement in terms of equivalent AFY for each year of contract.

The LACSD/PWD agreement contract was amended in 2019 at PWD's request. The amendment granted a two-year extension in reaching the milestones for the Recharge Project and Purple Line Projects (LACSD/PWD, 2016), due to project delays not caused by PWD and not within PWD's control.

Agreement for Purchase and Sale of Recycled Water May 2023

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Major Milestone Studies May 2023

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4.0 Major Milestone Studies

Stantec reviewed several "major milestone" studies relevant to Pure Water AV. These are discussed in detail below.

4.1 Littlerock Creek Groundwater Recharge and Recovery Project Feasibility Study

The Littlerock Creek Groundwater Recharge and Recovery Project Feasibility Study (Kennedy Jenks, 2015) investigated the feasibility of a groundwater banking, storage, and extraction program via spreading grounds. The analysis included infrastructure needs for new spreading grounds and recovery facilities to replenish recycled water and surplus SWP water during wet years. An optimization analysis showed that WRP's provision of 25% of the projected water demand resulted in an optimal water supply mix. Initially, 10 preliminary alternatives were considered for the proposed recharge sites and pipelines. These sites included run-of-river for recharge (only SWP water) and pipeline delivery for off-stream recharge at various locations. The outcomes of the study showed that the best alternative was off-stream recharge within the Lancaster Basin.

A economic analysis was conducted to compare the recommended project with two alternatives for water supply strategies, with and without water banking. The water banking without recycled water alternative required additional SWP water, whereas the no water banking alternative considered additional water purchase to meet the future supply needs. In summary, the study identified a potential spreading site for groundwater recharge and detailed the implementation plan for the recommended project. This led PWD to conduct pilot spreading ground testing, which showed that the selected recharge site had less than half of the original estimated recharge volume, and prompted PWD to investigate groundwater recharge via direct injection and/or surface water augmentation (SWA) for Pure Water AV.

4.2 Recycled Water Desalination Brine: Evaporation Basins Concept Evaluation

The Recycled Water Desalination Brine: Evaporation Basins Concept Evaluation (Pace, 2015), prepared for LACSD, investigated implementation of evaporation basins for reverse osmosis (RO) brine. The study evaluated practical loss in performance of evaporation basins by characterizing seasonal effects, precipitation, types of salts, and retardation of evaporation with increasing salinity. In addition, the study summarized other potential challenges, such as manual removal of slurry when crusting of salts occurs on the top layer. The study noted that no large permanent solar evaporation ponds have been permitted in two decades due to environmental regulations to preclude potential impacts on bird populations from high selenium concentrations and RWQCB waste discharge requirements. However, such a system was installed recently at Sycuan Casino in San Diego County on Tribal land. The biggest obstacle to implementing evaporation ponds was found to be retardation of evaporation with increasing salinity, with very high anticipated retardation when water reaches a TDS concentration of 30%. The outcomes of the

Major Milestone Studies May 2023

study inform the brine management effort of Pure Water AV and highlight the challenges with solar evaporation in terms of low efficiency at high TDS conditions.

4.3 Hydrogeological Evaluation

A hydrogeological evaluation conducted by Geoconsultants (2019) for PWD evaluated the nearby groundwater in order to select potential locations for future groundwater injection wells for replenishment of the regional aquifer system. The study boundary was by 90th Street East on the west, 120th Street East on the east, Avenue J on the south, and Avenue L-8 on the south. The study surveyed numerous wells located within and in the vicinity of the study area, with purported production of up to 2,300 gallons per minute.

Based on evaluation of several factors, including total thickness of saturated alluvium, total net alluvial production section, and electrotelluric sounding, the location designated as ETS-2 (southeast corner of 90th Street East and Avenue J) was concluded to be the most promising location for groundwater injection and storage. Another location, ETS-24 (southeast corner of 100th Street East and Avenue K) also met the criteria for a suitable site; however, the proximity of this location to several wells in the immediate vicinity made the location less desirable for groundwater injection and storage. The study recommended test drilling in the vicinity of ETS-2 with mud-rotary methods to a minimum "target" depth of 800 feet, and that deeper penetration should only be considered if the granitic basement has not been penetrated. The outcome of the study identified potential sites for direct groundwater injection, which informs the groundwater modeling and planning efforts of Pure Water AV.

4.4 Well Rehabilitation Prioritization Program

The Well Rehabilitation Prioritization Program (Kyle Groundwater, 2020) provided PWD with decisionmaking means relative to well maintenance and well replacement projects designed to optimize and maintain water production capacity. The study identified wells that are in most need of rehabilitation, wells that offer low-cost operation, and ones that should be operated to failure while planning for replacement.

The PWD well field was generally found to be in poor condition, primarily due to the use of inferior construction material and poor design elements. From the wells analyzed, seven were found structurally unsound and deemed unsuitable candidates for well rehabilitation efforts. Thus, these wells were recommended for replacement. For the remaining 15 wells, the report summarized the rehabilitation and/or repair effort needed, proposed prioritization rank and timeline for repair, and estimated cost of rehabilitation. The study revealed the status of the PWD wells and helped identify potential wells for tracer study and future implementation of groundwater injection by giving insight into the condition of the active PWD well field.

4.5 Recycled Water Alternatives Evaluation – Surface Water and Groundwater Augmentation Feasibility Study

The Recycled Water Alternatives Evaluation – Surface Water and Groundwater Augmentation Feasibility Study (Stantec, 2021) evaluated the feasibility of PWD utilizing recycled water for SWA and/or GWR via

Major Milestone Studies May 2023

direct injection. As mentioned earlier, PWD conducted a series of pilot studies to determine infiltration rates and determine the feasibility of groundwater banking and storage via spreading grounds (Kennedy Jenks, 2015). Less than favorable outcomes from the pilot studies led PWD to evaluate the feasibility of SWA and/or GWR via direct injection.

The regulatory requirements, infrastructure requirements, and initial costs were assessed for SWA and GWR via direct injection. The study recommended an advanced water purification facility (AWPF) with a treatment train consisting of low-pressure membrane filtration, RO, ultraviolet/advanced oxidation process, and chlorination to achieve the required pathogen log reduction for both SWA and GWR via direct injection. The SWA option would use Palmdale Lake. Further analysis with a computation fluid dynamics model would be required to predict mixing during different times of the year and the best location to add the advanced purified water. The conveyance and alignment required to transport water to Palmdale Lake from the two potential AWPF sites recommended by PWD was assessed in the report. For the GWR option, a minimum of 2,640 feet of distance between new groundwater injection wells and existing active production wells was recommended to be conservative in meeting the two-month required time until a tracer study can establish more accurate travel time. Considering both travel time and proximity to AWPF sites to minimize conveyance, two potential groundwater injection sites were identified. Subsequent analysis with tracer study and groundwater modeling was recommended to inform a decision on final well locations.

The study also discussed brine disposal alternatives, including deep well injection, connecting to nearby brine lines and evaporation ponds. Evaporation ponds was the recommended option from these alternatives, because of the expensive permitting and uncertainty issues with deep well injection and the extensive pipeline required for conveyance to the nearest brine line. The study recommended solar evaporation ponds to minimize operations cost, however, in-depth further analysis was suggested as future study to evaluate and compare different technologies.

In summary, this feasibility study began the initial planning stages for the implementation of Pure Water AV.

Major Milestone Studies May 2023

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Environmental Impact Studies May 2023

5.0 Environmental Impact Studies

Stantec reviewed two environmental studies relevant to Pure Water AV, which are discussed below.

5.1 Palmdale Regional Groundwater Recharge and Recovery Project Final Environmental Impact Report

The Palmdale Regional Groundwater Recharge and Recovery Project Final Environmental impact Report (EIR) (Helix, 2016) was prepared in accordance with the California Environmental Quality Act for the implementation of PWD's Palmdale Groundwater Recharge and Recovery Project. The proposed project was the use of new spreading grounds to recharge raw SWP water and recycled water from PWRP, with a recharge capacity of 50,000 to 52,000 AFY. The report analyzed direct impacts that would occur from the implementation of the proposed project, level of impact significance, recommended mitigation measures to avoid or reduce significant impacts, and level of significance after mitigation measures are implemented.

The major categories analyzed included air quality, biological resources, cultural and paleontological resources, geology and soils, greenhouse gas emissions, hydrology and water quality, and noise. For each significant impact identified, implementation measures were recommended. The study found that all project-specific significant impacts would be reduced to below a level of significance following the implementation of the mitigation measures outlined in the report. The EIR also concluded that project-related impacts combined with impacts from other projects in the study area would not result in significant and unmitigable cumulative impacts.

Two off-site alternatives for the location of the spreading grounds and a 'No project' alternative were considered and compared with the proposed project alternative. The outcome of the study showed that the proposed groundwater recharge project had no significant and unmitigable impacts. This study will inform the environmental impact assessment tasks of Pure Water AV.

5.2 Littlerock Reservoir Sediment Removal Project Final Environmental Impact Report

The Littlerock Reservoir Sediment Removal Project Final EIR (PWD/Aspen, 2017) evaluated the environmental impacts of the Littlerock Reservoir Sediment Removal Project, which aimed to restore the Littlerock Reservoir to 1992 water storage and flood control capacity through annual sediment removal and to preserve habitat for the Arroyo toad through construction of a grade control structure. The proposed project entailed removing sediments by truck annually to restore the reservoir's design storage capacity. Two alternatives were analyzed: a reduced sediment removal intensity alternative and 'No action/project' alternative. The alternative with reduced sediment removal intensity was found to be the environmentally superior alternative, particularly considering the reduction in air quality emissions on the environment compared to the proposed project.
Environmental Impact Studies May 2023

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Water Reclamation Plant Regulations May 2023

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6.0 Water Reclamation Plant Regulations

6.1 Palmdale Water Reclamation Plant

In compliance with the reporting requirements of RWQCB Order No. R6V-2011-0012, Palmdale WRP submits quarterly and annual monitoring reports detailing water quality analysis, methods, violations, and corrective actions, among other components. The order describes the water discharge requirements and water recycling requirements for PWRP, including monitoring, reporting, and water quality guidelines. RWQCB order No. R6V-2012-0002 describes the master water recycling requirements and waste discharge requirements of PWRP and details program requirements for reuse of disinfected tertiary water (RWQCB Lahontan, 2012).

6.2 Lancaster Water Reclamation Plant

In compliance with the reporting requirements of RWQCB Order No. R6V-2011-0012, Lancaster WRP submits quarterly and annual monitoring reports detailing water quality analysis, methods, violations, and corrective actions, among other components. RWQCB Order No. R6V-2006-0051 provides the water discharge requirements for Lancaster WRP and summarizes the treatment train, water quality, and proposed four storage reservoirs, based on alternatives evaluated (RWQCB Lahontan, 2006).

Water Reclamation Plant Regulations May 2023

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Miscellaneous Studies May 2023

7.0 Miscellaneous Studies

The following discusses additional information reviewed by Stantec that is relevant to Pure Water AV.

7.1 Nitrate Delineation Report

The Nitrate Delineation Report (Geomatrix, 2004) was conducted to assess the lateral and vertical extent of nitrate-impacted groundwater at Palmdale WRP and its vicinity. Compliance with the treated wastewater discharge regulations for land application and agricultural reuse include monitoring and reporting groundwater quality at nearby monitoring and agricultural supply wells. The objectives of the study included evaluation of background nitrate concentrations in the vicinity of the Palmdale WRP and groundwater upgradient of the planned effluent management site, and assessment of 16 exploratory boring wells. The outcome of the study informs future groundwater water quality monitoring analysis and liner selection for evaporation ponds to minimize the potential flux of nitrogen if evaporation ponds are to be implemented for brine management in Pure Water AV.

7.2 Engineering Report for Distribution and Use of Recycled Water

The Engineering Report for Distribution and Use of Recycled Water (Antelope Valley Engineering, 2012) summarized the City of Palmdale's recycled water production, water transmission and distribution facilities, and water reuse areas, and fulfilled the Title 22 requirements for reporting. **A similar report will be produced for Pure Water AV**.

7.3 Local Hazard Mitigation Plan

The 2021 PWD Local Hazard Mitigation Plan (HDR, 2021) reviewed long-term risks to people and property, including natural or anthropogenic, man-made, and technological hazards, and discussed reduction measures. The study outlined the planning process, hazard characterization and profiles, mitigation strategies, and monitoring and evaluation.

Miscellaneous Studies May 2023

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Summary May 2023

8.0 Summary

Selected studies (and associated key findings) that were found to be most relevant to Pure Water AV are presented in **Table 1**. Based on these studies, the following next major steps on Pure Water AV have been identified for successful and timely implementation of the program:

- 1. Groundwater Modeling
- 2. Funding Strategy and Applications
- 3. AWPF Planning
- 4. Environmental Studies
- 5. Regulatory Compliance (demonstration facility design and engagement with regulators)
- 6. Public Outreach

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These tasks are currently underway and discussed further in the Program Priorities and Implementation Plan; they are expected to fill a majority of the knowledge gaps identified in the various prior studies summarized in this TM.

Summary May 2023

Table 1. Summary of Selec	cted Studies with Hig	h Significance to Pu	re Water Antelope
Valley		_	

Studies	Significance to Study
Recycled Water Facilities Master Plan, 2015	The outcome of this study demonstrated that groundwater recharge with recycled water was a favorable alternative, which is the direction taken by Pure Water AV.
Littlerock Creek Groundwater recharge and Recovery Project Feasibility Study, 2015	The study identified a potential spreading site for groundwater recharge and detailed the implementation plan for the recommended project. This led PWD to conduct pilot spreading ground testing, which showed that the selected recharge site had less than of half the estimated recharge volume and prompted PWD to investigate groundwater recharge via direct injection and/or surface water augmentation for Pure Water AV.
Evaporation Basins Concept Evaluation, 2015	The outcomes of the study inform the brine management effort of Pure Water AV and highlight the challenges with solar evaporation in terms low efficiency at high TDS conditions.
Palmdale Regional Groundwater Recharge and Recovery Project: EIR, 2016	The outcome of the study showed that the proposed groundwater recharge project had no significant and unmitigable impacts. This study will inform the environmental impact assessment tasks of Pure Water AV.
Agreement for Purchase and Sale of Recycled Water, 2016	This purchase agreement between PWD and LACSD for tertiary water detailed the recycled water available to PWD and conditions for the purchase.
Hydrogeological Evaluation, 2019	This evaluation identified potential sites for direct groundwater injection, which will inform the groundwater modeling and planning efforts of Pure Water AV.
Well Rehabilitation Prioritization Program, 2020	This program revealed the status of the PWD wells and helped identify potential wells for tracer study and future implementation of groundwater injection by providing insight into the condition of the active PWD well field.
Recycled Water Alternatives Evaluation, 2021	The feasibility study began the initial planning stages for the implementation of Pure Water AV, including analysis of the AWPF treatment train required and comparison of direct groundwater injection and surface water augmentation.

Key:

AWPF = advanced water purification facility EIR = Environmental impact Report LACSD = Los Angeles County Sanitation District Pure Water AV = Pure Water Antelope Valley PWD = Palmdale Water District TDS = total dissolved solids

Additional study areas identified in prior TMs but not included in the planned/budgeted work for Pure Water AV are listed below.

- A tracer study was recommended to determine the retention time in the groundwater basin and obtain the response time credit according to the recycled water regulations (Stantec, 2021). A tracer study will be conducted if deemed necessary based on the groundwater modeling efforts.
- Groundwater test drilling and evaluation were recommended as the next steps to establish successful completion of a groundwater injection well (Geoconsultants, 2019). A full-scale pilot testing for groundwater injection will be considered as part of the future phase of Pure Water AV, after the AWPF is fully operational.

Summary May 2023

- Pilot/full-scale testing of an evaporation pond strategy for brine management was recommended to characterize evaporation retardation at high TDS conditions (Pace, 2015). The current scope of Pure Water AV includes the use of evaporation pond models to simulate retardation rates, but a pilot study was not included. Hence, pilot testing of evaporation ponds could be added as an optional task for the Demonstration Facility.
- A computation fluid dynamics model was recommended to predict mixing during different times of the year and identify the best location to add the advanced treated water (Stantec, 2021). This study will be needed for Pure Water AV only if SWA is deemed necessary for potable reuse.

The studies identified above may be beneficial to Pure Water AV, but are not required for program implementation. In summary, the review of prior studies showed that the proposed work for Pure Water AV is expected to fill all the major anticipated knowledge gaps for the successful implementation of Pure Water AV.

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APPENDIX A

Prior Studies

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Prior Studies May 2023

Appendix A Prior Studies

- Appendix A1 LACSD No. 14 Lancaster Four New Storage Reservoirs: Waste Discharge Requirements
- Appendix A2 City of Palmdale Sewer Master Plan Final Report
- Appendix A3 Strategic Water Resource Plan
- Appendix A4 LACSD No. 2 Palmdale: Waste discharge requirements and water recycling requirements
- Appendix A5 LACSD No. 14 Lancaster Revised monitoring and reporting Program
- Appendix A6 LACSD No. 2 Palmdale: Master Water Recycling Requirements and Waste Discharge Requirements
- Appendix A7 Engineering Report for Distribution and Use of Recycled Water
- Appendix A8 Salt and Nutrient Management Plan (SNMP) for the Antelope Valley
- Appendix A9 Nitrate delineation report
- Appendix A10 Palmdale Recycled Water Authority: Recycled water facilities Master Plan
- Appendix A11 Littlerock Creek Groundwater Recharge and Recovery Project Feasibility Study
- Appendix A12 Recycled water desalination brine: Evaporation Basins Concept Evaluation
- Appendix A13 Palmdale Regional Groundwater Recharge and Recovery Project: Final Environmental Impact Report
- Appendix A14 Agreement for purchase and sale of recycled water between LASAN and Palmdale water district
- Appendix A15 2016 Water System Master Plan
- Appendix A16 Littlerock Reservoir Sediment Removal Project: Final Environmental Impact Report
- Appendix A17 Antelope Valley Integrated Regional Water Management Plan (IRWM)
- Appendix A18 Hydrogeological Evaluation: Proposed ground water recharge project Antelope Valley
- Appendix A19 Amendment to the recycled water sale and purchase agreement
- Appendix A20 Palmdale WRP Annual Monitoring Report 2021

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- Appendix A21 Lancaster WRP Annual Monitoring Report 2021
- Appendix A22 Recycled Water Alternatives Evaluation -Surface Water and Groundwater Augmentation Feasibility Study
- Appendix A23 Draft 2021 Local hazard Mitigation Plan
- Appendix A24 Antelope Valley Watermaster 2020 Annual Report
- Appendix A25 Palmdale WRP Quarterly Monitoring Report 3rd Quarter 2021
- Appendix A26 Lancaster WRP Quarterly Monitoring Report 3rd Quarter 2021
- Appendix A27 Well rehabilitation prioritization program
- Appendix A28 Palmdale WRP Quarterly Monitoring Report 4th Quarter 2021
- Appendix A29 Lancaster WRP Quarterly Monitoring Report 4th Quarter 2021

APPENDIX A.2 Tertiary Water Requirements TM

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Tertiary Water Requirements – Pure Water Antelope Valley

Draft Technical Memorandum

May 2023

Prepared for: Palmdale Water District

Prepared by: Stantec Team

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Executive Summary May 2023

Executive Summary

Stantec Consulting Services Inc. was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). The objective of Pure Water AV is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection (project). As part of that effort, several planning studies are underway for successful implementation of Pure Water AV, which includes the design of a 5 million gallon per day (MGD) Advanced Water Purification Facility (AWPF). The AWPF will receive tertiary effluent from the Sanitation Districts of Los Angeles County's (LACSD) Palmdale Water Reclamation Plant (PWRP). The product water produced at the AWPF could be used for groundwater replenishment, via direct injection into the Antelope Valley Groundwater Basin, or other forms of potable reuse.

The focus of this technical memorandum is to characterize available quantity and key water quality parameters of the PWRP's tertiary effluent for years 2017 through 2021, with an emphasis on Pure Water AV regulatory compliance implications and impacts to the downstream treatment processes of the AWPF.

LACSD has committed to provide PWD 5 MGD of tertiary effluent from the PWRP to the AWPF. At a 5 MGD capacity, the quantity of flow from PWRP eliminates or minimizes the need for an equalization basin between the PWRP and AWPF. Thus, the tertiary effluent water can be conveyed directly from the PWRP with minimal storage. Additionally, the limited diurnal and seasonal variabilities of the PWRP effluent flows further confirm the lack of need for an equalization basin. LACSD can continue to supply a small amount of tertiary effluent (historical daily maximum of 0.4 MGD) for recycled water uses to Palmdale Recycled Water Authority.

At a minimum, the AWPF will employ a treatment train consisting of membrane filtration (MF), reverse osmosis (RO), and ultraviolet light advanced oxidation process (UV/AOP). The RO process can reject more than 99.5% of ion concentrations in the water, while UV/AOP can eliminate and oxidize harmful chemicals such as nitrosamines and 1,4-dioxane.

Historical water quality characteristics of PWRP's tertiary effluent show that only total dissolved solids would have to be removed at the AWPF for the product water to meet the Salt and Nutrient Management Plan water quality goals for the Antelope Valley Groundwater Basin. Additionally, the processes employed at the AWPF will most likely be able to meet the Water Quality Objectives laid out in the Region's Basin Plan for Lake Palmdale and Little Rock Reservoir given PWRP's current tertiary effluent quality. Other important water quality parameters for potable reuse projects, such as total organic carbon, total nitrogen, constituents with federal- and state-regulated maximum contaminant levels, among many others, presented typical levels for tertiary effluent from a nitrified water reclamation plant and, therefore, should comply with their limits at the AWPF product water.

Disinfection of the tertiary effluent at the PWRP is achieved using chloramines, and the final chlorine residual concentrations are relatively variable. Chloramines will be needed upstream of MF at the AWPF; but given the variability of the influent chloramine concentrations to the AWPF, a good control logic will be necessary to adjust dosing based on the residuals present. Chloramine concentration is also an important factor in N-nitrosodimethylamine (NDMA) formation. High NDMA concentrations were detected in the PWRP tertiary



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effluent. This level of NDMA can be mitigated, but will require either treatment using a high UV dose at the AWPF or formation of control strategies at the PWRP, such as lower polymer and/or chloramine dosing.

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Abbreviations

afy	acre-feet per year
AL	action level
AOP	advanced oxidation process
AWPF	advanced water purification facility
BAC	biological activated carbon
BDCM	bromodichloromethane
BPO	Basin Plan Objective
CCR	California Code of Regulations
Cl ₂	chlorine
CTR	California Toxics Rule
DBCM	dibromochloromethane
DBP	disinfection byproducts
DPR	direct potable reuse
EPA	Environmental Protection Agency
GWR	groundwater replenishment
IPR	indirect potable reuse
LACSD	Los Angeles County Sanitation Districts'
MCL	maximum contaminant level
MF	membrane filtration
MGD	million gallons per day
MRL	method reporting limit
ND	non-detected
NDEA	N-nitrosodiethylamine
NDMA	N-nitrosodimethylamine
NDPA	N-nitrosodi-n-propylamine
ng/L	nanograms per liter
NL	notification level



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No.	Number
PAS	Palmdale Agricultural Site
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutane sulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PHHxS	perfluorohexane sulfonic acid
pMCL	primary maximum contaminant level
project	Augmentation of groundwater supplies with advanced treated wastewater via direct subsurface injection
PRWA	Palmdale Recycled Water Authority
Pure Water AV	Pure Water Antelope Valley
PWD	Palmdale Water District
PWRP	Palmdale Water Reclamation Plant
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board
sMCL	secondary maximum contaminant level
SNMP	Salt and Nutrient Management Plan
SRS	Storage Reservoir Site
Stantec	Stantec Consulting Services Inc.
SWA	surface water augmentation
TDS	total dissolved solids
THMs	trihalomethane
TKN	total Kjeldahl nitrogen
ТМ	technical memorandum
TN	total nitrogen
тос	total organic carbon
TTHMs	total trihalomethane
UV	ultraviolet

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UV/AOP ultraviolet light advanced oxidation process

WQO water quality objective

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1.0 Introduction

Stantec Consulting Services Inc. (Stantec) was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional recycled water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). The objective of Pure Water AV is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection (project). As part of that effort, several planning studies are underway for successful implementation of Pure Water AV. This technical memorandum (TM) characterizes the quality and quantity of tertiary effluent from the Palmdale Water Reclamation Plant (PWRP), with an emphasis on Pure Water AV regulatory compliance implications and impacts to the downstream treatment processes of PWD's planned advanced water purification facility (AWPF).

1.1 Program Background and Drivers

PWD has been providing water service to its customers since 1918, when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the groundwater basin has been in overdraft since the 1930s, resulting in land subsidence. Up until 1973, PWD was formerly known as Palmdale Irrigation District.

PWD has conducted a few studies that date back to as early as the 1990s to evaluate the water resources necessary to meet future water supply demands. Concepts evaluated to date include using recycled water for landscape irrigation, discharging into Palmdale Lake, and discharging into existing sand and gravel pits to replenish the groundwater basin. In 2012, the Palmdale Recycled Water Authority (PRWA), comprising members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area. PRWA manages the distribution of recycled water and the design and construction of support facilities, and finances the efforts.

PWD has been exploring different concepts of groundwater banking, storage, and extraction. As part of that effort, PWD has conducted a series of pilot studies to determine the infiltration rates and storage capacity. Less than favorable results from the pilot studies led PWD to evaluate the feasibility of surface water augmentation and/or groundwater recharge via direct injection – two different forms of indirect potable reuse (IPR). Stantec was retained by PWD to conduct a feasibility study on IPR. Based on the results of the IPR feasibility study, PWD decided to pursue the concept further. Using tertiary effluent from the Los Angeles County Sanitation Districts' (LACSD) PWRP, PWD plans to produce potable quality water for groundwater recharge via direct injection.

1.2 Study Background and Objectives

PWD has an agreement to purchase 5,325 acre-feet per year (afy) of tertiary effluent from the PWRP. Current flows at PWRP indicate that the plant can provide up to 5 million gallons per day (MGD) of tertiary effluent for potable reuse. PWD has been evaluating the utilization of this tertiary effluent under different water reuse alternatives to expand its water portfolio and meet its future water supply needs. In order to meet that goal, PWD is planning the design of a 5 MGD AWPF that will be built near the PWRP. The

1.1

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product water from the AWPF will likely be injected into the Antelope Valley Groundwater Basin, referred to as groundwater replenishment (GWR) via subsurface injection – a form of indirect potable reuse (IPR). Other alternatives being considered include surface water augmentation (SWA) – another type of IPR – using Lake Palmdale or Little Rock Reservoir, and direct potable reuse (DPR) options, such as raw water augmentation and treated water augmentation.

The purpose of this TM is to evaluate the quality and quantity of tertiary effluent from PWRP, which will be the feed water for the future AWPF. The goals in characterizing variability in key water quality and operational parameters are to assess potential issues with regulatory compliance and determine impacts to the downstream treatment processes of the AWPF, as well as treatment design criteria of those processes.

The objectives of this TM are to:

- Evaluate PWRP's historical influent and effluent flows, in addition to tertiary water quality characteristics, to determine diurnal and seasonal variability
- Assess key tertiary water quality constituents for meeting the potable reuse regulatory requirements, including the:
 - Salt and Nutrient Management Plan (SNMP) water quality goals
 - Basin Plan water quality objectives (WQO) for the Lahontan Regional Water Quality Control Board (RWQCB)
 - Environmental Protection Agency (EPA) and State of California drinking water primary and secondary maximum contaminant levels (MCL) and action levels (AL)
 - California's Notification Levels (NL)
- Identify and analyze other important water quality parameters to optimize the treatment train performance of the future AWPF and implement a water quality monitoring plan
- Recommend potential process improvements for the PWRP that are mutually beneficial for PWD and LACSD

1.3 Technical Memorandum Structure and Content

This TM consists of seven sections:

- Section 1 Introduction Provides program background, drivers, and objectives.
- Section 2 Background Describes the PWRP treatment train, current uses of PWRP effluent, and potable reuse water quality regulatory limits.
- Section 3 PWRP Flows and Effluent Water Quality Describes the analyses conducted with historical PWRP tertiary effluent flows and water quality characteristics for years 2017 through

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2021. This section also highlights the potential tertiary effluent water quality impacts to downstream AWPF and proposed improvements.

- Section 4 Data Gaps Provides recommendations for operational and water quality
 performance monitoring in the PWRP and AWPF based on findings from tertiary water quality
 analysis, and includes a list of constituents to be monitored in the pilot phase of the AWPF. This
 section also identifies challenges for AWPF implementation.
- Section 5 Key Findings and Recommendations Summarizes pertinent findings and recommendations, including equalization tank volume and proposed process improvements at the PWRP.
- Section 6 References Provides a list of references used in the TM.

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2.0 Background

This section describes the PWRP and current uses of its effluent. It also introduces the concepts and regulatory requirements regarding water quality for potable reuse projects.

2.1 Palmdale Water Reclamation Plant Treatment Train Overview

PWRP currently provides primary, secondary, and tertiary wastewater treatment and has a maximum daily design capacity of 12 MGD. The plant is located at 39300 30th Street East, Palmdale, California, 93550. The plant's service area includes portions of the City of Palmdale and nearby unincorporated areas of Los Angeles County, and is located in the Antelope Valley, which is within the Lahontan RWQCB's jurisdiction.

The primary treatment at PWRP consists of bar screens and grit removal, followed by primary clarification. Secondary treatment includes activated sludge with anoxic and aerated zones that provide nitrification and partial denitrification, followed by secondary clarification. A secondary flow equalization basin with approximately 1.8 million gallons of capacity is located downstream of the secondary clarifiers to provide a more stable flow to the tertiary treatment process. Tertiary treatment is achieved by cloth-media filtration and disinfection using chloramines.

Secondary sludge undergoes dissolved air flotation, and the thickened waste sludge is combined with primary sludge before entering anaerobic digesters. The digested biosolids are dewatered via centrifugation and ultimately hauled offsite. Figure 1 on the following page presents the PWRP treatment train schematic.

2.2 Current Uses of Palmdale Water Reclamation Plant's Effluent

LACSD has been delivering the majority of PWRP's tertiary effluent as recycled water for irrigation of crops at a site ("Agricultural Site") leased from Los Angeles World Airports. Smaller amounts of recycled water are conveyed to the PRWA for landscape irrigation, such as at McAdam Park and authorized reuse sites receiving hauled recycled water. When tertiary recycled water production exceeds the agronomic rates needed by the Agricultural Site, LACSD routes the recycled water to Reservoir Number (No.) 1 and No. 2 at the Palmdale Storage Reservoir Site (SRS). Stored recycled water is utilized by the Agricultural Site during spring and summer months, when the irrigation demands exceed PWRP's recycled water production. Figure 2 shows the location of PWRP, McAdam Park, the Agricultural Site, and the SRS.

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Figure 1. Palmdale Recycled Water Authority Treatment Train Schematic



Figure 2. Locations of Palmdale Recycled Water Authority, Agricultural Site, McAdam Park (City of Palmdale use), and Storage Reservoir Site

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2.3 Proposed Process Improvements at Palmdale Water Reclamation Plant

The presence of NDMA in the tertiary effluent of the PWRP is due to NDMA precursors present in the wastewater, potentially from the cationic polymer used and chloramine used as the disinfectant. NDMA levels in the tertiary effluent water were observed up to 1,200 nanograms per liter (ng/L), which will require a significant ultraviolet (UV) dose in the ultraviolet light advanced oxidation process (UV/AOP) to lower the NDMA concentrations to below the California NL of 10 ng/L. High UV dosages for the UV/AOP process require significant energy usage; thus, reducing NDMA formation at the PWRP may be the most cost-effective strategy to mitigate high energy consumption from the UV/AOP process. An evaluation could consider lowering the concentrations of NDMA precursors by either changing the polymer used at the PWRP or lowering its dose and optimizing the chloramine dose. However, optimizing the chloramine dose could adversely impact the disinfection efficacy for PWRP and increase the final effluent pathogen concentrations. Therefore, this latter strategy should be performed more carefully if pursued.

In order to implement a successful lower chloramine dosing to the filtered effluent, the current and stable treatment of organics and nutrients by PWRP is crucial. Biological treatment upsets will lead to different organic and nutrient loading at the end of the treatment line, which will impact the chloramine consumption. Therefore, stable and consistent treatment of organics and nutrients by PWRP is important for the viability of the overall reuse program.

In 2021, industrial flows represented approximately 1.4% of the flow to the PRWA. Effluent discharges from this wastewater treatment plant are regulated under the LACSD's industrial waste pretreatment program, which is subject to the EPA's "General Pretreatment Regulations for Existing and New Sources," 40 Code of Federal Regulations 403. Under this program, LACSD has adopted the Wastewater Ordinance, which provides the legal authority to enforce its local requirements as well as all appropriate state and federal regulations. This pretreatment program and ordinance require that treatment plants comply with effluent discharge requirements and industrial users to be responsible for pretreatment and monitoring requirements to meet effluent limits. Another integral part of this pretreatment program is source control, which was established to protect the wastewater collection system and to ensure the quality of the recycled water produced from water recycled plants and any subsequent advanced treatment system listed under this program.

2.4 Potable Reuse Water Quality Regulatory Limits

Potable reuse projects in California must meet the regulatory requirements and monitor compounds at frequencies listed in Title 22 of the California Code of Regulations (CCR). Title 22 CCR specifies that potable reuse projects must comply with federal and state drinking water regulations, such as MCLs and ALs. The projects must also monitor for NLs and, in the event a constituent exceeds the NL, the responsible party must take actions, such as communicating with the customers and consumers.

If GWR is pursued for Pure Water AV, this alternative would augment the Antelope Valley Groundwater Basin with flow from the AWPF. Projects aiming for GWR must also comply with the Basin Plan Objectives (BPO) for the affected groundwater basin (Antelope Valley Groundwater Basin within the

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Lahontan Region), as described in the Basin Plan of the Region. The Lahontan Region Basin Plan does not have any specific BPOs for the Antelope Valley Groundwater Basin. However, the Lahontan RWQCB has approved and published an SNMP that is specific to the Antelope Valley (LACSD, 2014). The SNMP was developed to manage salts, nutrients, and other constituents in the Antelope Valley Groundwater Basin to ensure the beneficial uses of the groundwater basin are protected. The SNMP water quality management goals are meant to serve as a management and planning tool for groundwater quality, rather than as a basis for regulatory or discharge limits. A list of the constituents and goals of the SNMP is shown in Table 1.

Table 1. Salt and Nutrient Management Plan Water Quality Goals for the	Antelope	Valley
Groundwater Basin		

Constituent Units		Water Quality Management Goals		
Arsenic	µg/L	10 ¹		
Boron	mg/L	0.7 ² – 1 ³		
Chloride	mg/L	238/250/500 ⁴		
Fluoride	mg/L	1 ² -2 ¹		
Nitrate as Nitrogen	mg/L	10 ¹		
Total Dissolved Solids	mg/L	450/500/1000 ⁵		

Source: Los Angeles County Department of Public Works and LACSD, 2014 Notes:

¹ Municipal and Domestic Supply (MUN) Water Quality Objective which is based on the Title 22 California Code of Regulations drinking water primary maximum contaminant level

² Based on the agricultural supply beneficial use threshold

³ Based on California's Notification Level

⁴ Recommended (based on agricultural supply beneficial use threshold), upper (based on maximum contaminant level), and short-term values, respectively

⁵ Recommended (based on agricultural supply beneficial use threshold), upper, and short-term total dissolved solids values, respectively.

Key:

µg/L = micrograms per liter

mg/L = milligrams per liter

If SWA is the selected potable reuse alternative for Pure Water AV, the AWPF would provide flows to a local surface water body and augment the raw water for the Leslie O'Carter Water Treatment Plant. The Basin Plan has established WQOs for key surface water bodies within the Antelope Valley Hydrological Unit that would be considered under an SWA scenario, namely Lake Palmdale and Little Rock Reservoir.

Figure 3 depicts the locations of Lake Palmdale and Little Rock Reservoir. An average yield of approximately 3,000 afy of local surface water from the Little Rock Reservoir that is conveyed to Palmdale Lake via the Palmdale Ditch is treated at the Leslie O'Carter Water Treatment Plant. Parameters with WQOs established in the Basin Plan for Lake Palmdale and Little Rock Reservoir are listed in Table 2 as average and 90th percentile concentrations.

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Figure 3. Locations of Lake Palmdale (1) and Little Rock Reservoir (2)

Table 2. Summary of Water	Quality Objectives for	Surface Waters in	the Antelope Valley
Hydrological Unit within th	e Lahontan Region		

	Objectives						
Surface Waters	Parameter	Boron, mg/L	Chloride, mg/L	Fluoride, mg/L	Nitrate, mg/L as Nitrogen	Sulfate, mg/L	TDS, mg/L
Lake Palmdale	Average	0.13	50	0.8	-	100	460
	90 th percentile	0.15	68	1	-	121	585
Little Rock Reservoir	Average	0.03	12.5	0.29	0.4	16.5	176
	90 th percentile	0.05	20	0.38	0.7	19	180

Source: RWQCB Lahontan Region, 1995

Key:

mg/L = milligrams per liter

TDS = total dissolved solids

Potable reuse projects employing inland surface waters in the State of California, such as SWA reuse projects, must also meet the California Toxics Rule (CTR) limits. Further details on the overall regulatory requirements for the different potable reuse options are in the Alternative Analysis TM, an appendix to the Program Priorities and Implementation Plan.

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3.0 Palmdale Water Reclamation Plant Flows and Effluent Water Quality

This section describes the available feed water flows and quality from PWRP for the future AWPF. The focus is on gathering information aimed at characterizing variability in key water quality and operational parameters used to define treatment design criteria and assess regulatory compliance.

3.1 Available Flows for Potable Reuse

Although PWRP has a 12-MGD design capacity, the average flows of tertiary effluent exiting the plant are lower. Since PWD is planning to construct a 5-MGD AWPF, assessment of the diurnal and seasonal variabilities of PWRP's effluent flows are necessary to ensure the Pure Water AV needs will be met. The AWPF will need to operate continuously without having its processes offline due to low influent flow.

In order to understand the diurnal variation, LACSD provided hourly effluent flow data for one week in September for each year from 2017 to 2021. The diurnal flow, represented by the hourly flow data, is illustrated in Figure 4. LACSD also provided daily average flow data for PWRP's tertiary effluent from 2017 to 2021. The effluent flows are subcategorized as effluent to PRWA (e.g., for McAdams Park and other authorized reuse sites), effluent to PAS, and effluent to SRS, as previously described. Table 3 summarizes the daily average plant effluent flow and its uses.

The diurnal effluent flow from the PWRP ranges from 7.1 MGD to 9.2 MGD, with an average of 8.3 MGD, as shown in Figure 4. The limited fluctuation in the diurnal pattern of the effluent flow from the PWRP indicates that the existing secondary effluent equalization basin may be able to provide at least 5 MGD of effluent flow at all times as influent to the AWPF, and the need for an equalization basin between the PWRP and the AWPF may not be necessary. If the trend from this analysis of September data (2017-2021) is consistent for other months, it may be possible to convey tertiary effluent to the AWPF directly from the PWRP with minimal storage, such as using a wet well upstream of the membrane filtration (MF) process at the AWPF. Further assessment of hourly flows throughout the year is recommended in conjunction with sizing of a wet well or equalization tank that provides the feedwater to the AWPF.

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Figure 4. Diurnal Pattern of Palmdale Water Reclamation Plant Effluent Flows with One-Week Hourly Data from September 2017, 2018, 2019, 2020, and 2021

Table 3. Summary of Daily A	Average Flow Data for Palmdale	Water Reclamation Plant's
Effluent		

Description	Flow (in MGD)		
	Total Plant Effluent	Effluent to City of Palmdale	
Maximum	11.9	0.4	
Minimum	3.5	0	
Average	8.2	0.1	
Median	8.2	0.04	
Std	0.55	0.08	
RSD	7%	110%	
Count	1826	1826	

Key:

MGD = million gallons per day

PWRP = Palmdale Water Reclamation Plant

RSD = Relative Standard Deviation

Std = Standard Deviation

The daily total plant effluent flow is more variable over time, ranging from 3.5 MGD to 11.9 MGD, and averaging 8.2 MGD. Of the daily values assessed, representing the period from 2017 through 2021, there were only two occurrences during which the total plant effluent flow was below 5 MGD: 3.5 MGD in April 2020 and 4.6 MGD in June 2018. No information was available regarding these events, but the low
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number of occurrences does not support the need for an equalization tank between the two plants. The daily average flow conveyed to the City of Palmdale is minimal, compared to the total plant effluent flow, with a range of 0 MGD to 0.4 MGD, and an average of 0.1 MGD.

Recycled water (tertiary water) is also being sent to the PAS and Storage (Reservoirs No. 1 and No. 2). These two end uses of the recycled water have an even higher variability in their demand than the total effluent flow, and the cumulative flows to these users can be higher than the total effluent flow from PWRP at times, which can be misleading. During spring and summer months, the effluent flow to storage is low while the flow to the PAS is high, because the majority of the effluent flow is sent to the PAS to fulfill irrigation needs during the hotter, drier months. During fall and winter, when it is colder and wetter, demand at the PAS drops and excess effluent flow is sent to the Reservoirs No. 1 and No. 2. Additionally, water from storage is sent to the PAS when higher volumes of water are needed during spring and summer months. The combined flows from both PWRP and storage to the PAS explain the occurrence of higher flow to the PAS than the total effluent flow. This relationship is illustrated in Figure 5. Communications with LACSD indicated that the 5 MGD to Pure Water AV takes priority over demands to satisfy water demands from the PAS and Storage Site.



• Effluent Total Plant Flow • Effluent Total to Storage • Effluent Total to Agricultural Site

Figure 5. Historical Allocations of Tertiary Effluent Water from Palmdale Water Reclamation Plant

In order to provide consistent, adequate feed flow to the AWPF, some of the effluent for the current recycled water users will have to be redirected to the AWPF. The PRWA's use of recycled water for

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irrigation will be prioritized along with the Pure Water AV. Preliminary communications with LACSD have indicated that the agency will have other water sources for the PAS during peak demand periods. Therefore, the available average flow for the AWPF will range from 3.1 MGD to 11.5 MGD after subtracting out the historical daily effluent flow that was conveyed to the PRWA. These calculated available flows for potable reuse were charted in a probability plot in Figure 6.



Figure 6. Seasonal Variability Probability of Palmdale Water Reclamation Plant Tertiary Effluent Flows (Plant Effluent Flows Minus City of Palmdale Recycled Water Flows)

Figure 6 illustrates that historical daily PWRP tertiary effluent flow in the past five years was at least 5 MGD for 99.8% of the time. Therefore, the plant is expected to be able to consistently provide a tertiary effluent flow of 5 MGD to the AWPF.

3.2 Tertiary Effluent Water Quality and Variability

The tertiary effluent from PWRP will be the feed water to the future AWPF. Water quality parameters that are relevant for the implementation of a successful AWPF and for potable reuse were analyzed in the

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PWRP tertiary effluent. Some of these parameters are relevant for compliance, while others are important for operations and design of the unit processes at the AWPF.

While PWRP's tertiary effluent values were compared to drinking water and potable reuse standards, it is important to emphasize that these limits have no meaning for the tertiary effluent; the values are used merely for understanding the influent water quality to the AWPF and its ability to meet these limits in the final effluent by way of further advanced treatment.

The SNMP water quality goals for the seven constituents previously provided in Table 2 were used to compare the PWRP tertiary effluent water quality, as shown in Table 4. This comparison was used to evaluate which of them could be a challenge for the AWPF to meet the regulatory limits. The statistics presented are calculated from historical water quality data from 2017 through 2021 provided by LACSD.

Table 4. Comparison Between the Salt and Nutrient Management Plan Water Quality Goals and Palmdale Water Reclamation Plant Tertiary Effluent Water Quality

Constituent	Unito	SNMP Water	2017-2021 PWRP Tertiary Effluent Water				
Constituent	Units	Quality Goal	Average	Min	Max	Count	
Arsenic	µg/L	10	0.5	0.26	0.61	10	
Boron	mg/L	0.7 - 1		0.29		1	
Chloride	mg/L	238/250/500	145	107	180	20	
Chromium, total	µg/L	50	0.8	0.39	1.22	10	
Fluoride	mg/L	1 - 2	NA	NA	NA	0	
Nitrate	mg/L as N	10	2.6	0.9	8.9	62	
Total Dissolved Solids	ma/L	450/500/1000	471	406	536	21	

Source: Los Angeles County Department of Public Works and LACSD, 2014

Notes:

Meets SNMP water quality goal

Exceeds SNMP water quality goal, but treatment by MF-RO-AOP is expected to address this

Key:

 $\mu g/L = micrograms per liter$

AOP = advanced oxidation process Max = maximum MF = membrane filtration mg/L = milligrams per liter Min = minimum

N = Nitrogen

NA = data not available

PWRP = Palmdale Water Reclamation Plant

RO = reverse osmosis

SNMP = Salt and Nutrient Management Plan

Overall, the levels of constituents in the PWRP effluent are lower than the respective SNMP goal for all constituents, except for total dissolved solids (TDS). The AWPF is expected to employ low-pressure MF as pretreatment, reverse osmosis (RO), and ultraviolet coupled with UV/AOP. RO is highly effective in rejecting salts and ions, at rates above 99%, including for TDS. Therefore, even though the tertiary effluent TDS concentrations are higher than the recommended value of 450 mg/L, the RO process employed at the AWPF will reduce the concentrations to well below this value, and TDS is expected to remain below this value even after post-conditioning. No water quality data was available for fluoride; thus, no comparison was made for this constituent.

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Since SWA is one potable reuse alternative being considered, the tertiary effluent from the PWRP was compared to the WQOs established in the Basin Plan. The average and 90th percentile of the available data from 2017 through 2021 are summarized in Table 5.

Table 5. Comparison Between the Water Quality Objectives for Water Bodies in the
Antelope Valley Within the Lahontan Region and Palmdale Water Reclamation Plant's
Tertiary Effluent

Analyte Units		Lake Palmdale WQOs		Little Rock Reservoir WQOs		2017-2021 PWRP Tertiary Effluent Water		
Analyte	Onits	Average	90th Percentile	Average	90th Percentile	Average	90th Percentile	Count
Boron	mg/L	0.13	0.15	0.03	0.05	0.29	-	1
Chloride	mg/L	50	68	12.5	20	145	173	20
Fluoride	mg/L	0.8	1	0.29	0.38	NA	NA	0
Nitrate	mg/L as N	-	-	0.4	0.7	2.6	5.4	62
Sulfate	mg/L	100	121	16.5	19	67.3	78.4	20
Total Dissolved Solids	mg/L	460	585	176	180	471	522	21

Source: RWQCB Lahontan Region, 1995 Note:

Exceeds WQO, but treatment by MF-RO-AOP is expected to address this

Key: AOP = advanced oxidation process

MF = membrane filtration

mg/L = milligrams per liter

N = Nitrogen

NA = data not available PWRP = Palmdale Water Reclamation Plant

RO = reverse osmosis

WQO = water quality objective

The WQOs for Lake Palmdale and Little Rock Reservoirs are very stringent, especially for Little Rock Reservoir, as presented in Table 5. Comparing historical PWRP tertiary effluent water quality average and 90th percentile values with the WQOs for both reservoirs indicates that further treatment would be required to meet most of the WQOs. For Lake Palmdale, the tertiary effluent levels are below the WQOs for sulfate, there are no stated WQOs for nitrate, and data was not available for PWRP tertiary effluent fluoride levels. RO treatment will be employed at the AWPF, and its rejection rates differ for the constituents shown in Table 5, and they also depend on the RO configuration. Conventional RO systems at a recovery of approximately 85% reject ions such as chloride, fluoride, and others at typically 99.5% or higher. The only constituent that could be problematic regarding the WQOs for the AWPF is boron, given its low limits, especially for Little Rock Reservoir, and because RO rejection of boron is around 50%. However, since there is only one data point for boron collected at the tertiary effluent of PWRP, no definitive conclusions can be made. Additionally, other forms of RO can be employed to increase the rejection, such as using 2- or 3-pass RO, which increases the overall energy usage and costs and

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reduces the recovery of the RO permeate. No data was available for tertiary effluent fluoride levels, but given that RO removes around 99.5% of the concentrations of ions, it is expected that the RO process can bring its levels to below the limit.

In addition to the site-specific water quality limits or goals for Antelope Valley's water bodies and groundwater, all potable reuse projects must meet the limits imposed by CCR Title 22, which combines the MCLs for inorganic and organic chemicals, radionuclides, and disinfection byproducts (DBP), as well as ALs for copper and lead under the Lead and Copper Rule.

Table 6 through Table 8 list these regulatory limits and compare them to PWRP's tertiary effluent data. Table 6 summarizes the inorganic constituents with primary MCLs (pMCL), Table 7 lists the two compounds with ALs, and Table 8 focuses on the DBPs. Statistics on PWRP's tertiary effluent data were calculated based on available data from 2017 through 2021. For compounds that had non-detected (ND) values and numerical results, the method reporting limit (MRL) was used as the ND value for average calculations.

Currently, the tertiary effluent values from PWRP are all below the MCL values for their respective constituent MCLs and copper and lead AL values. As such, no issues are anticipated for the AWPF to meet these limits, particularly considering the further treatment provided by the AWPF (i.e., rejection of metals by RO). Table 8 compares PWRP's tertiary effluent data for DBPs to their MCLs from 2017 through 2021.

Total trihalomethanes (TTHMs) and the five haloacetic acids are DBPs resulting from reactions of free chlorine and organics present in the wastewater. The maximum values for these two categories of DBPs were well below their MCLs and, therefore, will not be an issue for the implementation of the AWPF. No data was available for bromate and chlorite, but their concentrations are expected to be below their MRLs as they are typically formed as byproducts of treatment with ozone and chlorine dioxide, respectively, although they have been found in wastewater and drinking water as a result from old chlorine stocks (Asami et. al., 2009).

The remaining categories of the pMCLs are organics and radionuclides. Trace organic contaminants (especially highly soluble ones) are pretty commonly found in wastewater, but tend to be addressed by RO and UV/AOP in the AWPF. The few organic compounds that had available data for the PWRP tertiary effluent were all below their MRLs. Assessment of trace organics and their removal through the advanced treatment processes will be a focus of the demonstration testing. No radionuclide data was available for PWRP's tertiary effluent. Therefore, these parameters are not summarized in a table. A comprehensive list of regulated drinking water parameters with their MCLs can be found in Appendices A and B.

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Table 6. Comparis	on Betwe	en Enviror	mental Protection Agency Primary Maximum	
Contaminant Leve	ls for Ino	rganic Che	micals and Palmdale Water Reclamation Plant	ťs
Tertiary Effluent W	Vater Qua	lity		

Constituent	Unito	MCI	2017-2021	Vater				
Constituent	Units	MCL	Average	Minimum	Maximum	Count		
Aluminum	mg/L	1		ND		1		
Antimony	µg/L	6		ND		10		
Arsenic	µg/L	50		ND		10		
Asbestos	MFL	7		NA		0		
Barium	µg/L	1,000		22.5		1		
Beryllium	µg/L	4		ND		10		
Cadmium	µg/L	5		ND		10		
Chromium, Total	µg/L	50	0.8	0.39	1.22	10		
Cyanide	µg/L	150		ND				
Fluoride	mg/L	2		NA		0		
Mercury	µg/L	2	0.0013	0.0005	0.0028	12		
Nickel	µg/L	100	1.2	0.84	1.55	10		
Nitrate (as N)	mg-N/L	10	2.6	0.91	8.9	62		
Nitrite (as N)	mg-N/L	1	0.1	0.03	0.42	60		
Nitrate + Nitrite ¹	mg-N/L	10	2.7	1.1	8.9	60		
Perchlorate	µg/L	6		NA		0		
Selenium	µg/L	50		ND		10		
Thallium	µg/L	2		ND		10		

Notes:

¹ Nitrate + nitrite values were calculated. Meets MCL

Key:

μg/L = microgram per liter AOP = advanced oxidation process MCL = maximum contaminant level

MF = membrane filtration

MFL = million fibers per liter

mg/L = milligrams per liter mg-N/L = milligrams per liter as Nitrogen

NA = data not available

ND = non-detected

PWRP = Palmdale Recycled Water Plant

RO = reverse osmosis

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Table 7. Comparison Between Environmental Protection Agency Action Levels for Lead and Copper and Palmdale Water Reclamation Plant's Tertiary Effluent Water Quality

Constituent	Unito	MCI	2017-20	21 PWRP Te	rtiary Effluen	nt Water
Constituent	Units	WCL	Average	Minimum	Maximum	Count
Copper	µg/L	1,300	1.7	1.11	3.43	10
Lead	µg/L	15	0.1	0.04	0.33	10
Notes:						

Meets AL Key: µg/L = microgram per liter AL = action level AOP = advanced oxidation process MCL = maximum contaminant level MF = membrane filtration PWRP = Palmdale Water Reclamation Plant RO = reverse osmosis

Table 8. Comparison Between Environmental Protection Agency Primary MaximumContaminant Levels for Disinfection Byproducts and Palmdale Water Reclamation Plant'sTertiary Effluent

Ogenetitusent	11	MO	2017-2021 PWRP Tertiary Effluent Water			
Constituent	Units	MCL	Average	Minimum	Maximum	Count
Total Trihalomethanes	µg/L	80	7.9	2.4	15.9	20
Bromodichloromethane	µg/L		1.5	0.5	3.4	20
Bromoform	µg/L			ND		20
Chloroform	µg/L		6.2	2.4	12	20
Dibromochloromethane	µg/L		0.51*	<0.5	0.62	20
Haloacetic Acids (five)	µg/L	60	19.5	15	26	20
Monochloroacetic Acid	µg/L		2.4*	<2.0	4.9	20
Dichloroacetic Acid	µg/L		NA	NA	NA	NA
Trichloroacetic Acid	µg/L		5.0	2.8	9.6	20
Monobromoacetic Acid	µg/L		1.0*	<1.0	1.1	20
Dibromoacetic Acid	µg/L			20		
Bromate	mg/L	0.01	NA	NA	NA	NA
Chlorite	mg/L	1	NA	NA	NA	NA

Notes:

* Average was calculated using the MRL for the samples with concentrations <MRL

Meets MCL

Key:

AOP = advanced oxidation process

MF = membrane filtration

mg/L = milligram per liter

MRL = method reporting limit NA = data not available

NA = data not avalla

ND = non-detected

pMCL = primary maximum contaminant level

RO = reverse osmosis

µg/L = micrograms per liter

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Even though secondary MCLs (sMCLs) are technically non-reinforced, aesthetic-based drinking water limits, potable reuse projects should meet them. The sMCLs and their comparison to the PWRP's tertiary effluent data from 2017 through 2021 are presented in Table 9.

Table 9. Comparison Between Environmental Protection Agency Secondary MaximumContaminant Levels and Palmdale Water Reclamation Plant's Tertiary Effluent WaterQuality

Constituent	Unito	aMCI	2017-2021 PWRP Tertiary Effluent Water			
Constituent	Units	SIVICL	Average	Minimum	Maximum	Count
Aluminum	mg/L	0.2		ND		1
Chloride	mg/L	250	145	107	180	20
Color	units	15		NA		0
Copper	mg/L	1.0	0.002	0.001	0.003	10
Foaming Agents (MBAS)	mg/L	0.5	0.10*	<0.10	0.11	21
Iron	mg/L	0.3		1		
Manganese	mg/L	0.05		1		
Methyl-ted-butyl ether	mg/L	0.005		10		
Odor—Threshold	Units	3		NA		0
рН	-	6.5-8.5	7.1	6.3	7.8	261
Silver	mg/L	0.1		ND		10
Sulfate	mg/L	250	67.3	49.4	78.7	20
Total Dissolved Solids	mg/L	500	471	406	536	21
Thiobencarb	mg/L	0.001		NA		0
Turbidity	Units	5	0.68	0.45	0.89	857
Zinc	mg/L	5.0	0.09	0.07	0.11	10

Notes:

* Averages were calculated using the MRL for the samples with concentrations <MRL

Meets MCL

Exceeds MCL but treatment by MF-RO-AOP is expected to address this

Key:

MBAS = methylene blue active substance mg/L = milligram per liter MRL = method reporting limit NA = data not available ND = non-detected PWRP = Palmdale Water Reclamation Plant sMCL = secondary maximum contaminant level

PWRP tertiary effluent data on color, fluoride, odor, and thiobencarb were not available. The concentrations of the other constituents of PWRP's tertiary effluent were well below the designated sMCLs for drinking water and potable reuse. Some of these compounds have more stringent WQOs, including fluoride, sulfate, and TDS, and associated ALs, such as copper.

The PWRP's tertiary effluent constituents with NLs have limited to no data available for analysis. Table 10 presents only the NL compounds that had available data from PWRP's tertiary effluent, from 2017 through 2021, and compares these values to the California NLs. The full NL list is presented in Appendix C.

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Table 10. Comparison Between	the California Notification Levels and Palmdale Water
Reclamation Plant's Tertiary Eff	fluent Water Quality

Constituent	Unite	Linite CA		2017-2021 PWRP Tertiary Effluent Water			
Constituent	Units	NL	Average	Minimum	Maximum	Count	
Naphthalene	µg/L	17		ND		10	
N-Nitrosodimethylamine (NDMA)	ng/L	10	532	46	1,200	24	
N-Nitrosodi-n-propylamine (NDPA)	ng/L	10	ND			20	
Perfluorobutane Sulfonic Acid (PFBS)	ng/L	500	2.6*	<2.0	3.1	4	
Perfluorooctane Sulfonate (PFOS)	ng/L	6.5	2.0*	<2.0	2.1	5	
Perfluorooctanoic Acid (PFOA)	ng/L	5.1	6.9	4.8	8.2	5	
Vanadium	mg/L	0.05		0.003		1	

Notes:

* Average was calculated using the MRL for the samples with concentrations <MRL

Meets NL

Exceeds NL but treatment by MF-RO-AOP is expected to address this

Key: µg/L = microgram per liter CA = California mg/L = milligram per liter ND = non-detected ng/L = nanogram per liter NL = notification level PWRP = Palmdale Water Reclamation Plant

Naphthalene and N-nitrosodi-n-propylamine (NDPA) were not detected in any of the samples collected from the PWRP tertiary effluent in that five-year analysis period. The MRL for NDPA was higher than the NL (data not shown), thus additional monitoring may be needed for this constituent in the pilot facility, using a method with a lower MRL. Vanadium, perfluorooctane sulfonate (PFOS), and perfluorobutane sulfonic acid (PFBS) were detected at least once in the tertiary effluent, but the overall concentrations are lower than their respective NLs.

NDMA is a DBP from chloramination and ozonation. This nitrosamine is a probable human carcinogen and overall the main reason that UV is employed at AWPFs downstream of RO. Historical tertiary effluent NDMA concentrations from 2017 through 2021 reached up to 1,200 ng/L, as seen in Table 10, which is roughly two orders of magnitude greater than the NL for this chemical. NDMA is only moderately rejected by RO (~50%), but it is highly susceptible to photolysis and, therefore, the UV process can reduce its concentration to below the NL. More on NDMA is discussed under the treatment sections.

Per- and polyfluoroalkyl substances (PFAS), also known as "forever chemicals," are gaining a lot of attention lately; three of these PFAS have corresponding NLs, including perfluorooctanoic acid (PFOA), PFOS, and PFBS, and the process of developing an NL has been initiated for perfluorohexane sulfonic acid (PFHxS). The EPA's Fifth Unregulated Contaminant Monitoring Rule includes 29 PFAS compounds and will generate significant occurrence data through mandatory monitoring of treated drinking water for public water systems serving at least 3,300 customers (2023-2025). While PFOS levels in the tertiary effluent are below the NL and show little variability, and PFBS concentrations were all well below its NL, the average PFOA concentration is above its NL. No data was available for PFHxS. The RO process

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serves as an effective barrier for a variety of trace contaminants, such as PFAS. Rejection of PFAS compounds by RO is typically high (>95%), which will allow the AWPF to meet the NL for PFOA.

PWRP's tertiary effluent database from 2017 through 2021 was also compared to the CTR chemicals and their limits, since SWA is one of the potable reuse possibilities for PWD. The list has human health criteria limits for 92 of the total 126 compounds. Of the 92 compounds, only one was not sampled from the PWRP tertiary effluent (asbestos), and only three compounds were above or very close to the CTR limit, as listed in Table 11. The full CTR list is presented in Appendix D.

Table 11. California Toxics Rule Detected Components, Limits, and Associated Palmdale Water Reclamation Plant Tertiary Effluent Data

Constituent	Unito	CTR	2017-2021 PWRP Tertiary Effluent Water			
Constituent	Units	Limit	Average	Minimum	Maximum	Count
Dibromochloromethane (DBCM)	µg/L	0.41	0.51*	<0.5	0.62	20
Bromodichloromethane (BDCM)	µg/L	0.56	1.5	<0.5	3.4	20
N-nitrosodimethylamine (NDMA)	ng/L	0.69	532	46	1200	24

Notes:

* Average was calculated using the MRL of 0.5 μ g/L for DBCM for the samples with ND as result.

PWRP tertiary effluent does not need to meet any of the CTR limits in this table.

Exceeds NL, but treatment by MF-RO-AOP is expected to address this

Exceeds CTR, and treatment by MF-RO-AOP may not be sufficient

Key:

Hg/L = microgram per liter AOP = advanced oxidation process CTR = California Toxics Rule MF = membrane filtration MRL = method reporting limit ND = non-detected NL = notification level ng/L = nanogram per liter PWRP = Palmdale Water Reclamation Plant RO = reverse osmosis

The compounds dibromochloromethane (DBCM) and bromodichloromethane (BDCM) are trihalomethanes and are included in TTHM results, along with bromoform and chloroform. These two compounds are a common issue in potable reuse projects pursuing SWA due to their very low CTR limits.

Given that the MRL used for the trihalomethanes (THMs) detection is 0.5 μ g/L, DBCM was detected only three times out of 20 samples. Because the CTR limit is below the MRL, it is not possible to know if the number of DBCM exceedances were the same or above the number of detects. RO has a fair rejection of THMs (~50%), and the final concentrations at the AWPF are expected to be ND.

BDCM's average was about three times the CTR limit. Since RO rejection is only moderate for THMs, BDCM might still be an issue for the AWPF. There are actions that PWD can take, such as further treatment at the AWPF and/or regulatory actions. THMs are volatile compounds and, therefore, they can be removed by treatment processes using the air-water interface, such as cascade aeration and air stripping. Alternatively, the use of a mixing zone can be pursued with the RWQCB. The designation of a mixing zone would require the discharger to meet the CTR criteria within or at the defined boundary of the mixing zone, rather than at the end of the discharge pipe. Further details on the mixing zone are

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discussed in the Alternative Analysis TM. This regulatory approach might be the most cost-effective for PWD if SWA is pursued. A possible action at PWRP to decrease BDCM concentrations is the use of preformed chloramines, where chloramines would be formed in a side stream using water with low organic concentration, and then injected into the process flow upstream of the cloth filters.

Since THMs are formed from the chlorination of waters containing organics, they can also be formed during UV/AOP if the oxidant used is free chlorine. Due to the low organic content after RO, measured as total organic carbon (TOC), it is unlikely that BDCM will be formed at a significant concentration. Since increased contact time leads to increased THM concentrations, the best strategy to confirm if they could reform after UV/AOP would be to perform formation potential tests. In these tests, a sample from UV/AOP effluent is dosed with a high concentration of chlorine or other disinfectant, and the water is analyzed for TTHMs or other DBPs at several time intervals. These tests could be performed at the pilot for a preliminary understanding of the potential for DBP reformation post UV/AOP. NDMA was previously discussed and more information on it is presented under the UV/AOP subsection.

Finally, other important parameters for potable reuse are total nitrogen (TN), which is the sum of ammonia, organic nitrogen, nitrate, and nitrite, and TOC. The sum of ammonia and organic nitrogen is also known as total Kjeldahl nitrogen (TKN). Therefore, TN can be calculated as the sum of TKN, nitrate, and nitrite. Statistical analysis on TN and TOC of PWRP's tertiary effluent is summarized in Table 12, with data available from 2017 through 2021. As aforementioned, these limits have no meaning for or impact on PWRP's tertiary effluent; the comparison is merely for understanding the AWPF's ability to meet the limit based on its feed water.

 Table 12. Constituents Important for Potable Reuse Applications, Limits, and Associated

 Palmdale Water Reclamation Plant Tertiary Effluent Data

O an a ditu a nt	11	Potable	2017-20	21 PWRP Te	ertiary Efflue	nt Water
Constituent	Units	Reuse Limit	Average	Minimum	Maximum	Count
Total Nitrogen*	mg/L	10	6.3	2.8	9.9	60
Total Organic Carbon	mg/L	0.5	6.1	5.3	7.8	25

Notes:

* Calculated Meets potable reuse limit

Exceeds potable reuse limit but treatment by MF-RO-AOP is expected to address this

Key:

mg/L = milligrams per liter

PWRP = Palmdale Water Reclamation Plant

The PWRP's tertiary effluent TOC values are consistent with effluents that undergo biological treatment with long solids retention time, such as in fully nitrified plants. RO rejection of TOC is usually around 99%, bringing the constituent's level in the AWPF product water to below 0.1 mg/L.

The maximum TN concentration found in the past five years at PWRP's tertiary effluent was right below the 10-mg/L limit for potable reuse projects. To understand the ability of the RO system to remove TN, the different constituents of TN must be separated. For example, while nitrate, nitrite, and free ammonia are moderately to well rejected by RO (80-90% range in conventional RO systems), combined (or total)

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ammonia, such as in the form of chloramines, is only fairly rejected (~50%). The different nitrogen species are further dissected in Table 13.

Table 13. Summary of Nitro	ogen Specie	s in Palmdale	Water Recla	mation	Plan	t's Tertiary
Effluent from 2017 to 2021	-					-
		00/ = 0				

		2017-2021 PWRP Tertiary Effluent Water					
Constituent	Units	Average	Minimum	Maximum	90 th Percentile	Count	
Total Ammonia	mg/L as N	1.9	0.7	5.3	3.2	62	
Total Kjeldahl Nitrogen	mg/L as N	3.5	1.3	7.5	5.0	62	
Nitrate	mg/L as N	2.6	0.9	8.9	5.4	62	
Nitrite	mg/L as N	0.10	0.03	0.40	0.30	60	
Nitrate + Nitrite*	mg/L as N	2.7	1.1	8.9	5.5	62	
Total Nitrogen*	mg/L as N	6.3	2.7	13.1	9.9	60	

Note:

mg/L as N = milligrams per liter as Nitrogen

PWRP = Palmdale Water Reclamation Plant

The concentrations of the nitrogen species in PWRP's tertiary effluent are consistent with treatment plants employing nitrification-denitrification during secondary treatment. The final ammonia effluent concentrations (total ammonia) are due to the chloramines addition.

The TKN values (fair RO rejection) are similar to the nitrate + nitrite values (high RO rejection). Therefore, the maximum TN concentrations at the AWPF effluent are expected to be well below the potable reuse limit and this constituent should not be an issue for the AWPF. Other key parameters to assess wastewater treatment plant performance are listed in Table 14.

Table 14. Sum	mary of Key Wastewater Parameters in Palmdale Water Reclamation
Plant's Tertiary	/ Effluent

Constituent	Unite	2017-2021 PWRP Tertiary Effluent Water				
Constituent	Units	Average	Minimum	Maximum	Count	
Biochemical Oxygen Demand	mg/L	<3.2	<3.0	<4.9	61	
Chemical Oxygen Demand	mg/L	<22.7	<7.5	<30.6	61	
Turbidity	NTU	0.7	0.4	0.9	857	

Key:

mg/L = milligrams per liter

NTU = Nephelometric Turbidity Units

PWRP = Palmdale Water Reclamation Plant

Biochemical oxygen demand and chemical oxygen demand are within typical limits for wastewater plants with good biological treatment. The turbidity values in PWRP's tertiary effluent are relatively low numbers considering the filtration process is accomplished by cloth filters.

^{*} Calculated

Key:

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3.3 Potential Tertiary Effluent Water Quality Impacts to Downstream Advanced Water Purification Facility and Proposed Improvements

Key water quality parameters that have an impact on the design and performance of the downstream AWPF treatment processes are assessed in this section. The section describes the impacts of the characteristics of the PWRP tertiary effluent water on the design of the AWPF downstream processes.

3.3.1 MEMBRANE FILTRATION AND REVERSE OSMOSIS SYSTEM

To avoid biofouling on the MF and RO membranes, it is common practice to add chloramines before the MF system. Typical doses range from 1.0 to 5.0 mg/L as chlorine (Cl₂). Chloramines are typically added after the cloth media filters at the PWRP to provide final disinfection and maintain disinfectant residual through downstream conveyance, as previously seen in Figure 1. The monthly minimum, maximum, and average results for 2021 and the daily average total chlorine residuals for April 2021 are shown in Figure 7 and Figure 8, respectively.



Figure 7. Palmdale Water Reclamation Plant Tertiary Effluent Monthly Average, Maximum, and Minimum Chlorine Residuals (2021)

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Figure 8. Daily Average Palmdale Water Reclamation Plant Tertiary Effluent Chlorine Residuals (April 2021)

The chloramine residual in PWRP's tertiary effluent is quite variable. This may require control logic for the chloramine addition system upstream of MF to maintain a consistent chloramine concentration for the MF and RO systems. As seen in the figures above, the maximum average concentrations go below 1.0 mg/L as Cl₂ and go over 5.0 mg/L as Cl₂, which is the recommended and commonly employed range of chloramines for biofouling control on RO membranes. Moreover, the hourly average, or even instantaneous concentrations are not known, and could be even more variable, potentially with concentrations higher than the recommended upper range. With higher chloramine dosage comes potential issues with bromamine formation, which is harmful to RO membranes. No bromide data was available for analysis, but it has been requested. The demonstration testing will be crucial to understand the chloramine dosage and potential bromamine formation.

Several other water quality parameters (organics and inorganics) are important for the design of RO systems, such as for fouling and scaling potential, and to understand their performance. These constituents are presented in Table 15, along with PWRP's tertiary effluent data analysis from 2017 through 2021. Per discussions of the scaling models for the Brine Analysis TM, calcium, phosphate, and silica are expected to be key compounds governing inorganic scaling and the requirements for RO post-conditioning to achieve the desired high recoveries. The TM also provides an analysis of the major ion chemistry, which shows good electroneutrality and balance between measured and calculated TDS. In addition, organic and colloidal particles are important for fouling potential in reuse RO systems. Data for constituents, such as phosphorous and silica, were limited and, therefore, should be monitored in the pilot phase of the AWPF to obtain more data. An initial analysis of the major ion chemistry on the future RO

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feed water shows good electroneutrality and balance between measured and calculated TDS, although not clearly depicted in Table 15.

-		2017-2021 PWRP Tertiary Effluent Water				•
Constituent	Units	Minimum	Maximum	Average	90th Percentile	Count
Aluminum	µg/L			ND		1
Ammonia	mg/L as N	0.65	5.27	1.93	3.21	62
Barium	µg/L		2	22.5		1
Boron	µg/L			290		1
Calcium	mg/L	24.5	39.5	33.5	39.1	20
Chloride	mg/L	107	180	145.1	172.9	20
Iron	µg/L			40		1
Magnesium	mg/L	5.8	12.9	9.3	12.1	21
Manganese	µg/L		2	20.7		1
Nitrate	mg/L as N	0.91	8.9	2.62	5.44	62
Nitrite	mg/L as N	0.03	0.4	0.1	0.3	60
рН	-	6.3	7.8	7.1	7.4	261
Phosphorous	mg/L		1	.89		2
Potassium	mg/L		1	5.9		1
Silica		20.3	21.1	20.7	-	2
Sodium	mg/L	95.3	139	118.2	133.7	20
Sulfate	mg/L	49.4	78.7	67.3	78.4	20
Total Dissolved Solids	mg/L	406	536	471	522	21
Temperature	°C	14.5	30.1	23.0	27.5	261
Total Organic Carbon	mg/L	5.26	7.78	6.08	6.87	25
Total Alkalinity	mg/L	65	127	97.2	126.5	10

Table 15. Key Water Quality Parameters	(Organics and Inorganics) for Reverse Os	mosis
System Performance		

Key:

°C = degrees Celsius µg/L = microgram per liter

mg/L = milligram per liter

N = Nitrogen

 \bigcirc

ND = non-detected

PWRP = Palmdale Water Reclamation Plant

3.3.2 ULTRAVIOLET/ADVANCED OXIDATION PROCESS SYSTEM

The effectiveness of the UV/AOP process comes from the combination of the applied UV dose and the concentration of the oxidant in the water (e.g., free chlorine). Often, the UV dose is controlled by the influent and the target effluent NDMA concentrations. The NL in California for NDMA in drinking water is

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10 ng/L, and applying a safety factor, a target final NDMA value of 5 ng/L is appropriate when designing the UV system. Other nitrosamines also have California NLs, but are not as ubiquitous as NDMA or are not present in such high concentrations as NDMA in wastewater.

Historical tertiary effluent NDMA concentrations from 2017 through 2021 averaged 532 ng/L and reached up to 1,200 ng/L; further statistics are provided in Table 16, based on detection per EPA method 1625B. In all sampling events, NDMA concentrations in the tertiary effluent exceeded the California NL, as shown in Figure 9. NDMA is a DBP known to be formed upon chloramination or ozonation. In the case of PWRP, NDMA is most likely formed during the chloramination after the cloth media filters. Another important factor for NDMA formation is the presence of NDMA precursors in the water. PWRP has the capability to apply a cationic polymer upstream of the secondary clarifiers, as shown in Figure 1, which is a known NDMA precursor.

 Table 16. Palmdale Water Reclamation Plant's Tertiary Effluent N-nitrosodimethylamine

 Statistics (2017-2021)

Average	Minimum	Maximum	90th Percentile	Count
532	46	1,200	1,150	24



Figure 9. N-nitrosodimethylamine Concentrations in Palmdale Water Reclamation Plant's Tertiary Effluent Water

Since NDMA is only moderately rejected by RO (~50%), the UV doses would still be significant to reduce NDMA to below the NL. To decrease the highest NDMA concentration to 5 ng/L, more than 2-log removal would be required. Alternatively, NDMA concentrations could be potentially lowered by evaluating

Palmdale Water Reclamation Plant Flows and Effluent Water Quality May 2023

potential NDMA precursors, including reducing and/or switching the cationic polymer usage at the PWRP. Moreover, the chloramine dosing in the disinfection process could be evaluated to understand if it could be lowered without impacting the disinfection performance requirements (e.g., coliform, concentration time).

Chloramines in the feed water (i.e., RO permeate) will impact UV performance in that chloramines increase the UV absorbance at 254 nanometer wavelength, which, in turn, decreases the UV transmittance, a crucial factor in UV dose efficiency. Additionally, chloramines compete with free chlorine in the advanced oxidation process (AOP) system when free chlorine is used as the oxidant. This competition leads to increased free chlorine doses in order to achieve and overcome breakpoint chlorination.

Per the potable reuse regulations, 1,4-dioxane is used as an indicator of the UV/AOP effectiveness, requiring demonstration of a 0.5-log removal through the UV/AOP system. 1,4-dioxane is also a regulated constituent with a NL of 1 μ g/L, and commonly present in wastewater because of its mobility in the aqueous environment. This constituent was not monitored in the PWRP effluent and will be evaluated during the demonstration facility testing.

If free chlorine is used as the AOP oxidant, bromide should be monitored in the UV/AOP feed water and bromate in the UV/AOP effluent. A recent case of bromate formation after UV/AOP using free chlorine as the oxidant has linked the formation to high bromide concentrations in the UV/AOP feed water. These two compounds were not monitored in the PWRP effluent and will be evaluated during the demonstration facility testing.

Nitrite in the feed water to UV/AOP consumes free chlorine, and increases its demand, consuming chlorine at about five times its concentration. Nitrite also consumes ozone. The secondary process at PWRP aims for complete nitrification (i.e., the ammonia is oxidized to nitrate). The events where tertiary effluent nitrite was above 0.2 mg/L as N could have been the result of ammonia breakthrough events that can occur during high loading periods, especially during colder winter months. Since the average nitrite concentration in the tertiary effluent was 0.1 mg/L as N, nitrite should not pose a concern to the implementation of the AWPF. Moreover, even though the maximum nitrite concentrations in PWRP's tertiary effluent reached 0.4 mg/L, RO will remove >99%, bringing its concentration in the UV/AOP feed to below detection.

3.3.3 OZONE AND/OR OZONE/BIOLOGICAL ACTIVATED CARBON SYSTEM

Ozonation can also lead to NDMA formation, as previously mentioned. If ozonation is employed at the AWPF, NDMA concentrations could increase to levels higher than the ones found in the PWRP tertiary effluent. Biological activated carbon (BAC), when placed downstream of the ozone, usually decreases NDMA concentrations. But since it is a biological process and not a physical or chemical one, the levels of reduction are not consistent throughout different plants; thus, site-specific piloting would be required to provide insight into the expected removal of NDMA. In general, the combination of ozone and BAC has a net neutral effect on the formation of NDMA, but can often reduce available NDMA precursors, preventing further formation or reformation by downstream processes. The ozone/BAC process is required for the Pure Water AV AWPF if a DPR alternative is pursued.

Palmdale Water Reclamation Plant Flows and Effluent Water Quality May 2023

Bromate is another DBP formed from ozonation, in the presence of bromide. Since none of these analytes were monitored in the PWRP tertiary effluent, it is not possible to predict if bromate could be an issue if ozone is employed at the AWPF. Ozone is usually dosed in wastewater as a ratio with TOC. A high TOC concentration in the feed water will then require a high ozone dose to match the desired ozone-to-TOC ratio. If nitrite is present, it should also be accounted for in the dosing controls, since it consumes ozone, as previously noted.

Data Gaps May 2023

4.0 Data Gaps

To better understand the feed water quality to the AWPF, this section describes the recommendations for operational and water quality performance monitoring in the PWRP and AWPF. Constituents in PWRP's tertiary effluent with limited data or that are present in high concentrations should be monitored in the pilot phase of the AWPF. This preliminary list of constituents could be included in the future pilot phase test plan.

4.1 Relevant Water Quality Data

A few constituents that are important to understand the implementation of the AWPF and its potential challenges were mentioned throughout the text. These constituents are:

- Boron
- Bromide
- Bromate
- Chlorite
- Fluoride
- N-nitrosodiethylamine (NDEA)
- 1,4-dioxane
- Phosphorous
- Silica

These parameters should be monitored in the pilot AWPF influent and effluent to: (1) observe their removal throughout the AWPF and associate the removal with treatment process performance; and (2) assess compliance of the product water. A few compounds that are important for the design of RO systems, such as phosphorous and silica, had limited data; additional information on those compounds could inform the modeling and designing phases.

Moreover, several other compounds with MCLs and/or NLs were not sampled. Even though they are not expected to be an issue for the AWPF, based on the industry's experience on GWR and the minimum required treatment processes, they should be sampled at the AWPF influent and effluent for the same reasons mentioned above.

Data Gaps May 2023

4.2 Operational Parameters

The following operational parameters monitoring gaps were identified:

- Hourly effluent flows to PRWA: The hourly flows to PRWA are not known, but they could have a significant impact on the available flows to the AWPF.
- More frequent (e.g., hourly) chloramine residual monitoring at the plant effluent: the high variability of effluent chlorine has a direct impact on the operations of the AWPF. A tight control logic of the chloramine dosing in the MF feed water would be needed to provide a constant dose. Even though the maximum daily or monthly average chloramine residual found in the presented data was below 5 mg/L as Cl₂, utilizing this variable influent water quality leaves no room for optimization during piloting. The recommended chloramine dosing range for MF and RO operations is between 1 and 5 mg/L as Cl₂, as aforementioned. While higher doses have the potential to decrease biofouling rates, it uses more chemical, increasing chemical costs, and reduces the UV transmittance at the UV/AOP feed water, increasing energy consumption as well. This further highlights the need to monitor chlorine dosing and residual in the piloting phase.

A possible solution is to optimize the chloramine dosing at the AWPF. For that to happen, PWRP must ensure stable secondary and tertiary treatment processes, which will, in turn, maintain consistent effluent water quality so no extra chloramines need to be dosed. Another solution for PWD is to draw the water to the AWPF before the chloramination point. The more stable chloramine dosing would probably aid in the minimization of NDMA formation.

4.3 Challenges for Advanced Water Purification Facility Implementation

During this analysis, a few constituents were identified as possible challenges for the implementation of the AWPF. Some were due to the concentrations found in PWRP tertiary effluent and others were for lack of existing data from PWRP tertiary effluent. These compounds are listed in Table 17, along with clarification of the potential challenges.

Data Gaps May 2023

Table 17. Compound Reason for Possible Challenge to Advanced Water Purification Facility Implementation, Type of Reuse, and Potential Solution

Compound	Reason for Possible Challenge to AWPF Implementation	Type of Reuse	Potential Solution
Boron	Low limit (WQOs for surface water) and moderate RO rejection of boron	SWA (Basin Plan WQOs compliance)	Employing 2- or 3-ASs RO
BDCM	Low limit (CTR) and moderate RO rejection of trihalomethanes	SWA (CTR compliance)	Adding more treatment or optimization at AWPF
NDMA	Low limit (CTR), NL	SWA (CTR compliance) or GWR (NL compliance)	Source control at PWRP; high UV doses for AOP
Chloramine residuals in tertiary effluent	High variability in concentrations	Any	Impacts operational logic at the AWPF to stabilize chloramine concentrations in the AWPF'S feed water

Key: AOP = advanced oxidation process

AWPF = advanced water purification facility BDCM = bromodichloromethane

CTR = California Toxics Rule GWR = groundwater replenishment

NDMA = N-nitrosodimethylamine

NL = notification level

RO = reverse osmosis

SWA = surface water augmentation

UV = ultraviolet

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WQO = water quality objective

Key Findings and Recommendations May 2023

5.0 Key Findings and Recommendations

This section summarizes the key results and recommendations that would better prepare PWD and LACSD to utilize the tertiary effluent water from the PWRP to produce potable water. These findings and recommendations will provide guidance on the design of the future AWPF to meet regulatory requirements and avoid potential downstream treatment issues.

5.1 Equalization Tank Volume

Historical diurnal and seasonal variabilities of the PWRP effluent flows from 2017 to 2021 were assessed to determine that the plant could sufficiently and consistently provide at least 5 MGD to the future AWPF. The daily average plant effluent flow that is available for the AWPF ranges from 3.1 MGD to 11.5 MGD, with an average of 8.3 MGD, when considering the worst-case scenario of 0.4 MGD maximum daily average flow sent to the PRWA. A probability plot showed that the plant has produced at least 5 MGD of tertiary effluent for 99.8% of the time in the past five years.

No information on the hourly flow to PRWA was available and, therefore, no definitive conclusions can be made in the hourly available flow for the AWPF. More information is necessary to assess this issue. Nonetheless, minimal equalization should be required at the headworks of the AWPF to provide constant influent flow.

References May 2023

6.0 References

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- Regional Water Quality Control Board (RWQCB) Lahontan Region. 1995. Water Quality Control Plan for the Lahontan Region. Available at: https://www.waterboards.ca.gov/lahontan/water_issues/programs/basin_plan/references.html.

APPENDIX A

Primary MCLS for Organic Chemicals

Appendix A – Primary MCLS for Organic Chemicals May 2023

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Appendix A Primary MCLS for Organic Chemicals

Constituent	MCL (mg/L)			
Volatile Organic	Chemicals			
Benzene 0.001				
Carbon Tetrachloride CTC	0.0005			
1,2-Dichlorobenzene	0.6			
1,4-Dichlorobenzene	0.005			
1,1 -Dichloroethane	0.005			
1,2-Dichloroethane	0.0005			
1,1-Dichloroethene	0.006			
Cis-1,2-Dichloroethylene	0.006			
Trans-I,2-Dichloroethylene	0.01			
Dichloromethane	0.005			
1,2-Dichloropropane	0.005			
1,3-Dichloropropene	0.0005			
Ethylbenzene	0.3			
Methyl-tert-butyl-ether (MTBE)	0.013			
Monochlorobenzene	0.07			
Styrene	0.1			
1,1,2,2-Tetrachloroethane	0.001			
Tetrachloroethylene PCE	0.005			
Toluene	0.15			
1,2,4-Trichlorobenzene	0.005			
1,1,1 -Trichloroethane	0.2			
1,1,2-Trichloroethane	0.005			
Trichloroethylene TCE	0.005			
Trichlorofluoromethane	0.15			
1,1,2-Trichloro-1,2,2-Trifluoroethane	1.2			
Vinyl Chloride	0.0005			
Xylenes m,p	1.75**			
Non-Volatile synthetic O	rganic Chemicals			
Alachlor	0.002			
Atrazine	0.001			
Bentazon	0.018			
Benzo(a)pyrene	0.0002			
Carbofuran	0.018			
Chlordane	0.0001			
2,4-D	0.07			
Dalapon	0.2			
1,2-Dibromo-3-chloropropane (DBCP)	0.0002			
Di(2-ethylhexyl)adipate	0.4			

Appendix A – Primary MCLS for Organic Chemicals May 2023

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Di(2-ethylhexyl)phthalate	0.004
Dinoseb	0.007
Diquat	0.02
Endothall	0.1
Endrin	0.002
Ethylene Dibromide (EDB)	0.00005
Glyphosate	0.7
Heptachlor	0.00001
Heptachlor Epoxide	0.00001
Hexachlorobenzene	0.05
Hexachlorocyclopentadiene	0.05
Lindane	0.0002
Methoxychlor	0.03
Molinate	0.02
Oxamyl	0.05
Pentachlorophenol	0.001
Picloram	0.5
Polychlorinated Biphenyls	0.0005
Simazine	0.004
Thiobencarb	0.07
Toxaphene	0.003
2,3,7,8-TCDD (Dioxin)	3x10⁻ ⁸
2,4,5-TP (Silvex)	0.05

APPENDIX B

Radionuclides

Appendix B – Radionuclides May 2023

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Appendix B Radionuclides

Constituent	Units	sMCL
Gross alpha particle activity	pCi/L	15
Gross beta particle activity	pCi/L	50
Radium-226 + Radium-228	pCi/L	5
Strontium-90	pCi/L	8
Tritium	pCi/L	20,000

APPENDIX C

California Notification Level List

Appendix C – California Notification Level List May 2023

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Appendix C California Notification Level List

Constituent	MCL (mg/L)
Boron	1
n-Butylbenzene	0.26
sec-Butylbenzene	0.26
tert-Butylbenzene	0.26
Carbon disulfide	0.16
Chlorate	0.8
2-Chlorotoluene	0.14
4-Chlorotoluene	0.14
Diazinon	0.0012
Dichlorodifluoromethane Freon 12	1
1,4-Dioxane	0.001
Ethylene	14
Formaldehyde	0.1
HMX	0.35
Isopropylbenzene	0.77
Manganese	0.5
Methyl isobutyl ketone (MIBK)	0.12
Naphthalene	0.017
N-Nitrosodiethylamine (NDEA)	0.00001
N-Nitrosodimethylamine (NDMA)	0.00001
N-Nitrosodi-n-propylamine (NDPA)	0.00001
Perfluorooctanoic acid (PFOA)	0.00001
Perfluorobutanesulfonic acid (PFBS)	0.0005
Perfluorooctanoic acid PFOA	0.0000051
Perfluorooctanesulfonic acid (PFOS)	0.0000065
Propachlor	0.09
n-Propylbenzene	0.26
RDX	0.0003
Tertiary butyl alcohol (TBA)	0.012
1,2,4-Trimethylbenzene	0.33
1,3,5-Trimethylbenzene	0.33
2,4,6-Trinitrotoluene (TNT)	0.001
Vanadium	0.05

APPENDIX D

California Toxics Rule List

Appendix D – California Toxics Rule List May 2023

Appendix D California Toxics Rule List

Constituent	Units	CTR Limit
Antimony	µg/L	14
Arsenic	µg/L	N/A
Beryllium	µg/L	n
Cadmium	µg/L	n
Chromium (III)	µg/L	n
Chromium (VI)	µg/L	n
Copper	µg/L	1,300
Lead	µg/L	n
Mercury	µg/L	0.05
Nickel	µg/L	610
Selenium	µg/L	n
Silver	µg/L	N/A
Thallium	µg/L	1.7
Zinc	µg/L	N/A
Cyanide	mg/L	0.7
Asbestos	MFL	7
Asbestos (<10 µm)	MFL	N/A
Asbestos (0.5 to 10 µm)	MFL	N/A
2,3,7,8-TCDD	pg/L	0.013
Acrolein	µg/L	320
Acrylonitrile	µg/L	0.059
Benzene	µg/L	1.2
Bromoform	µg/L	4.3
Carbon tetrachloride	µg/L	0.25
Chlorobenzene	µg/L	680
Dibromochloromethane	µg/L	0.41
Chloroethane	µg/L	N/A
2-Chloroethyl vinyl ether	µg/L	N/A
Chloroform	µg/L	Reserved
Bromodichloromethane	µg/L	0.56
1,1-Dichloroethane	µg/L	N/A ³
1,2-Dichloroethane	µg/L	0.38
1,1-Dichloroethene	µg/L	0.057
1,2-Dichloropropane	µg/L	0.52
1,3-Dichloropropene, Total	µg/L	10
Ethylbenzene	µg/L	3,100
Bromomethane	µg/L	48
Chloromethane	µg/L	n

Appendix D – California Toxics Rule List May 2023

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Methylene chloride	µg/L	4.7
1,1,2,2-Tetrachloroethane	µg/L	0.17
Tetrachloroethene/Tetrachloroehtylene (PCE)	µg/L	0.8
Toluene	µg/L	6,800
1,2-Trans-Dichloroethylene	µg/L	700
1,1,1-Trichloroethane	µg/L	n
1,1,2-Trichloroethane	µg/L	0.6
Trichloroethene	µg/L	2.7
Vinyl chloride	µg/L	2
2-Chlorophenol	µg/L	120
2,4-Dichlorophenol	µg/L	93
2,4-Dimethylphenol	µg/L	540
2-Methyl-4,6-dinitrophenol	µg/L	13.4
2,4-Dinitrophenol	µg/L	70
2-Nitrophenol	µg/L	N/A
4-Nitrophenol	µg/L	N/A
4-Chloro-3-methylphenol	µg/L	N/A
Pentachlorophenol	µg/L	0.28
Phenol	µg/L	21,000
2,4,6-Trichlorophenol	µg/L	2.1
Acenaphthene	µg/L	1,200
Acenaphthylene	µg/L	N/A
Anthracene	µg/L	9,600
Benzidine	µg/L	0.00012
Benzo (a) anthracene	µg/L	0.0044
Benzo (a) pyrene	µg/L	0.0044
Benzo (b) fluoranthene	µg/L	0.0044
Benzo (g,h,i) perylene	µg/L	N/A
Benzo (k) fluoranthene	µg/L	0.0044
Bis(2-chloroethoxy)methane	μg/L	N/A
Bis(2-chloroethyl)ether	µg/L	0.031
Bis(2-chloroisopropyl)ether	µg/L	1,400
Bis(2-ethylhexyl)phthalate	µg/L	1.8
4-Bromophenyl phenyl ether	µg/L	N/A
Butyl benzyl phthalate	µg/L	3,000
2-Chloronaphthalene	µg/L	1,700
4-Chlorophenyl phenyl ether	µg/L	N/A
Chrysene	µg/L	0.0044
Dibenzo (a,h) anthracene	µg/L	0.0044
1,2-Dichlorobenzene	µg/L	2,700
1,3-Dichlorobenzene	µg/L	400
1,4-Dichlorobenzene	µg/L	400
3,3'-Dichlorobenzidine	μg/L	0.04

Appendix D – California Toxics Rule List May 2023

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Diethyl phthalate	μg/L	23,000
Dimethyl phthalate	µg/L	313,000
Di-n-butyl phthalate	µg/L	2,700
2,4-Dinitrotoluene	µg/L	0.11
2,6-Dinitrotoluene	µg/L	N/A
Di-n-octyl phthalate	µg/L	N/A
1,2-Diphenylhydrazine/Azobenzene	µg/L	0.04
Fluoranthene	µg/L	300
Fluorene	µg/L	1,300
Hexachlorobenzene	µg/L	0.00075
Hexachlorobutadiene	µg/L	0.44
Hexachlorocyclopentadiene	µg/L	240
Hexachloroethane	µg/L	1.9
Indeno (1,2,3-cd) pyrene	µg/L	0.0044
Isophorone	µg/L	8.4
Naphthalene	µg/L	N/A
Nitrobenzene	µg/L	17
N-Nitrosodimethylamine	µg/L	0.00069
N-Nitrosodi-n-propylamine	µg/L	0.005
N-Nitrosodiphenylamine	µg/L	5
Phenanthrene	µg/L	N/A
Pyrene	µg/L	960
1,2,4-Trichlorobenzene	µg/L	N/A
Aldrin	µg/L	0.00013
alpha-BHC	µg/L	0.0039
beta-BHC	µg/L	0.014
gamma-BHC	µg/L	0.019
delta-BHC	µg/L	N/A
Chlordane	µg/L	0.00057
4,4-DDT	µg/L	0.00059
4,4-DDE	µg/L	0.00059
4,4-DDD	µg/L	0.00083
Dieldrin	µg/L	0.00014
Endosulfan I	µg/L	110
Endosulfan II	µg/L	110
Endosulfan sulfate	µg/L	110
Endrin	µg/L	0.76
Endrin aldehyde	µg/L	0.76
Heptachlor	µg/L	0.00021
Heptachlor epoxide	µg/L	0.0001
PCBs, Total	µg/L	0.00017
PCB Aroclor 1016	µg/L	N/A
PCB Aroclor 1221	µg/L	N/A

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Appendix D – California Toxics Rule List May 2023

PCB Aroclor 1232	µg/L	
PCB Aroclor 1242	µg/L	
PCB Aroclor 1248	µg/L	
PCB Aroclor 1254	µg/L	
PCB Aroclor 1260	µg/L	
Toxaphene	µg/L	0.00073

Note:

n: EPA is not promulgating human health criteria for these contaminants. However, permit authorities should address these contaminants in NPDES permit actions using the State's existing narrative criteria for toxics.

Key:

N/A = Not available/Not applicable

APPENDIX A.3 Potable Reuse Alternatives Analysis TM

3


Potable Reuse Alternatives Analysis – Pure Water Antelope Valley

Draft Technical Memorandum

May 2023

Prepared for: Palmdale Water District

Prepared by: Stantec Team Table of Contents May 2023

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Executive Summary May 2023

Executive Summary

Stantec Consulting Services Inc. was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). The objective of Pure Water AV is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection (project).

PWD is planning to expand its portfolio of drinking water sources by the addition of recycled water while continuing to ensure safe drinking water for its customers. Currently, one type of potable reuse is regulated – indirect potable reuse (IPR). Direct potable reuse (DPR) is expected to be regulated in 2023. Therefore, both alternatives are investigated in this technical memorandum (TM).

IPR projects involve the addition of an environmental buffer, such as groundwater and reservoirs/lakes, after the water purification. This type of potable reuse requires fewer treatment processes, resulting in less energy consumption, as well as lower capital costs. IPR also requires lower pathogen removal, lower monitoring frequency of chemicals, and is generally less restrictive. IPR projects are well established in California, providing a safe and economical alternative to increase PWD's water portfolio. However, the requirements for the environmental buffer (i.e., certain retention times and/or dilution factors) and/or water quality limits can impact the feasibility of implementing IPR projects.

DPR does not require an environmental buffer between the water purification and the water distribution. The purified water is either sent to a drinking water treatment plant or straight to the distribution system. This lack of buffering comes with requirements for further treatment (i.e., more energy consumption, higher capital costs), higher removal of pathogens limits, higher frequency of chemical monitoring, higher frequency of reporting, and more stringent source control plan, among other requirements. While the requirements are not yet finalized in California, DPR represents a resilient and drought-proof water source that could be employed by PWD to meet its water needs.

Both potable reuse alternatives will be investigated in this TM, and the key regulatory requirements are highlighted for each. The benefits and challenges will also be explored in order to understand the implications for PWD. Recommendations from this analysis are listed in the final section of this TM.

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Abbreviations

afy	acre-feet per year
AOP	advanced oxidation process
AWPF	advanced water purification facility
AWTO	advanced water treatment operator
BAC	biological activated carbon
BDCM	bromodichloromethane
BPO	Basin Plan Objective
СТ	contact time
CTR	California Toxics Rule
DBCM	dibromochloromethane
DBP	disinfection by-product
DDW	Division of Drinking Water
DPR	direct potable reuse
EBCT	empty bed contact time
ESB	engineered storage buffer
FAT	full advanced treatment
GWR	groundwater recharge
HRT	hydraulic retention time
IPR	indirect potable reuse
LACSD	Los Angeles County Sanitation District
LRV	log removal value
MBR	membrane bioreactor
MCL	maximum contaminant level
MF	membrane filtration
mgd	million gallons per day
mg/L	milligrams per liter
MUN	Municipal and Domestic Supply



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NDMA	N-nitrosodimethylamine
NL	notification level
O ₃	ozone
O&M	operations and maintenance
PRWA	Palmdale Recycled Water Authority
Pure Water AV	Pure Water Antelope Valley
PWD	Palmdale Water District
PWRP	Palmdale Water Reclamation Plant
RO	reverse osmosis
RWA	raw water augmentation
RWQCB	Regional Water Quality Control Board
SIP	State Implementation Policy
SNMP	Salt and Nutrients Management Plan
Stantec	Stantec Consulting Services Inc.
State	State of California
SWA	surface water augmentation
SWP	State Water Project
SWRCB	State Water Resources Control Board
SWTP	surface water treatment plant
TDS	total dissolved solids
ТМ	technical memorandum
ТОС	total organic carbon
TWA	treated water augmentation
UV	ultraviolet
UV/AOP	ultraviolet/advanced oxidation process
V/G/C	viruses, Giardia cysts, and Cryptosporidium oocysts

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1.0 Introduction

Stantec Consulting Services Inc. (Stantec) was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional recycled water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). As part of that effort, several planning studies are underway for successful implementation of the Pure Water AV. This technical memorandum (TM) summarizes the regulatory requirements associated with potable reuse options; potential potable reuse alternatives for Pure Water AV; and key findings and recommendations.

1.1 Program Background and Drivers

PWD has been providing water service to its customers since 1918, when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the groundwater basin has been in overdraft since the 1930s, resulting in land subsidence. In 1973, Palmdale Irrigation District changed its name to Palmdale Water District.

PWD has conducted a number of studies that date back to as early as the 1990s to evaluate the water resources necessary to meet future water supply demands. Concepts evaluated to date include using recycled water for landscape irrigation, discharging into Palmdale Lake, and discharging into existing sand and gravel pits to replenish the groundwater basin. In 2012, the Palmdale Recycled Water Authority (PRWA), comprising members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area. PRWA manages the distribution of recycled water and the design and construction of support facilities, and finances the efforts.

PWD has been exploring different concepts of groundwater banking, storage, and extraction. As part of that effort, PWD has conducted a series of pilot studies to determine the infiltration rates. Less than favorable results from the pilot studies led PWD to evaluate the feasibility of surface water augmentation (SWA) and/or groundwater recharge (GWR) via direct injection – two different forms of indirect potable reuse (IPR). Stantec was retained by PWD to conduct a feasibility study on IPR. Based on the results of the IPR feasibility study, PWD decided to pursue the concept further. Using tertiary effluent from the Los Angeles County Sanitation Districts' (LACSD) Palmdale Water Reclamation Plant (PWRP), PWD plans to produce potable quality water for groundwater recharge via direct injection.

1.2 Study Background and Objectives

PWD is in search of alternative water sources to increase its water supply and decrease dependency on water imported from the State Water Project (SWP). Currently, Palmdale's water needs are met by a combination of groundwater, local surface water, and imported water from the SWP.

Surface water from Little Rock Dam Reservoir is conveyed to Palmdale Lake via the Palmdale Ditch, and is then treated at the Leslie O' Carter Water Treatment Plant. Even though PWD has rights of circa 4,000 acre-feet per year (afy) of surface water from Little Rock Reservoir, only approximately 3,000 afy are available due to sediment buildup behind the dam.

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SWP water is available via a turnout to Lake Palmdale from the East Branch of the California Aqueduct. PWD estimates a long-term average annual flow of around 10,900 afy (corresponding to a 51% delivery capability) from the SWP based on the *The State Water Project Final Delivery Capability Report 2021* published by the California Department of Water Resources estimating long-term average reliability of the SWP (DWR, 2021). The true long-term average will be higher, as it would be a blend of receivable contracted water transfers through 2035, with a higher rate of reliability.

PWD has signed an agreement to purchase 5,325 afy (4.7 million gallons per day [mgd]) of tertiary effluent from PWRP, owned and operated by LACSD. Current flows at PWRP indicate that the plant can provide 4.7 mgd of tertiary effluent for potable reuse and may be capable of providing up to 10 mgd.

To increase its water source portfolio and meet its future water needs, PWD has been evaluating the utilization of this tertiary effluent under different water reuse alternatives. To meet that goal, PWD is planning the design of an advanced water purification facility (AWPF) that will be built near the PWRP. The purified water treated at the AWPF will likely be injected into the Antelope Valley Groundwater Basin as an IPR project (GWR via subsurface injection). Other alternatives still being considered include SWA using Lake Palmdale or Little Rock Reservoir and direct potable reuse (DPR) alternatives, such as raw water augmentation (RWA) and treated water augmentation (TWA). As noted above, this TM presents the key regulatory requirements for IPR with direct injection GWR, and for the other alternatives stated earlier. This evaluation of the regulatory requirements, along with the tertiary water requirements, will inform the selection of the type of potable reuse adopted by PWD and the corresponding treatment processes employed at the AWPF.

1.2.1 STUDY AREA

The study area is located in the City of Palmdale, within Los Angeles County, California. Figure 1 illustrates key features of the Pure Water AV such as the PWRP, the proposed AWPF site, Lake Palmdale, the Leslie O' Carter Surface Water Treatment Plant (SWTP), PWD's headquarters, and the Little Rock Reservoir.

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Figure 1. Study Area and Key Facilities

1.2.2 STUDY OBJECTIVES

One objective of this TM is to establish the potable reuse regulatory requirements for a number of alternative scenarios. This includes the type of treatment employed as well as facilities locations and process configurations. Each potable reuse alternative is presented with a brief description of key regulatory requirements for project implementation.

Current IPR alternatives are GWR, by either surface spreading or by direct injection, and SWA. GWR by direct injection and SWA will be evaluated in this TM. Previous studies conducted by PWD indicated a



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lack of storage in the aquifer and concern with treating a growing list of constituents of emerging concern (e.g., perfluoroalkyl acids) and, thus, GWR via surface spreading with a blend of tertiary (20%) and raw water from SWP (80%) was not assessed in this analysis.

Although DPR regulations are under development in the State of California (State), the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) has publicly released multiple drafts of the regulations to date, as well as reports of recommendations and discussion points with the State-appointed expert review panel. The DPR regulations are expected to be formalized by the end of 2023. As such, the two forms of DPR, RWA, and TWA are evaluated in this analysis. The current available alternatives for potable reuse are illustrated in Figure 2.



Note: Full advanced treatment is the minimum requirement for treatment in direct potable reuse projects Figure 2. Potable Reuse Alternatives

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1.3 Technical Memorandum Structure and Content

This study assesses current (IPR) requirements and potential future (DPR) requirements for potable reuse alternatives, both in a generalized manner (Section 2), and as may specifically apply to PWD (Section 3). Key findings and recommendations are listed in Section 4, and are based on the discussion, review, and assessment performed in the previous sections.

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2.0 Key Regulatory Requirements

This section reviews the different forms of potable reuse, along with the purpose and key regulatory requirements of each. Key requirements for IPR are identified in Section 2.1; those for DPR are identified in Section 2.2; and a global summary is provided for all forms of potable reuse in Section 2.3.

2.1 Indirect Potable Reuse

IPR via GWR was the first potable reuse alternative to be formally regulated by DDW in 2014. Regulations for IPR via SWA were adopted by the SWRCB in 2018. In IPR projects, there is an environmental buffer (e.g., groundwater aquifer, surface water reservoir/lake) placed in between the recycled water and the drinking water facility (e.g., drinking water well or SWTP) that provides:

- Further treatment/attenuation of both chemical contaminants and pathogens;
- Minimum dilutions of the treated recycled water with raw water sources; and
- Provisions for rapid response times in the case of any upstream IPR treatment failure.

In general, longer retention times provide increased pathogen removal attributed to the environmental buffer. If the retention time is too short, the project may not qualify as IPR. The minimum hydraulic retention time (HRT) for IPR projects is two months. The pathogen log removal value (LRV) criteria are discussed under each subsection.

GWR can be further categorized as surface spreading and subsurface/direct injection. In the case of surface spreading, only tertiary treated water is required, but must be blended with other water sources at an initial recycled water contribution of 20%. The recycled water (and potentially other blended sources) is applied at spreading grounds and percolates through the underlying soil layers until it reaches the groundwater aquifer. This type of GWR is not assessed in this study, since prior evaluation by PWD deemed the selected location of surface spreading unable to achieve the desired storage required. The other two types of IPR, GWR via subsurface injection and SWA, are described in the following subsections.

2.1.1 GROUNDWATER REPLENISHMENT VIA SUBSURFACE INJECTION

GWR via subsurface injection consists of purified water from an AWPF directly injected into the saturated zone of an aquifer via an injection well. Many projects in the State use this alternative to augment groundwater resources used as drinking water supplies (Monterey Pure Water) and/or to create a barrier for preventing saltwater intrusion (Orange County Water District's Groundwater Replenishment System) into the groundwater sources.

From a regulatory perspective, this is the best-defined type of reuse, as discussed in this TM. Potable reuse projects in the State must demonstrate specific LRVs for viruses, Giardia cysts, and Cryptosporidium oocysts (V/G/C). For GWR via subsurface injection, the required LRVs are 12/10/10

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(V/G/C). These LRVs must be earned through at least three treatment processes, where each provides at least one LRV; but no more than six LRVs can be gained from any treatment process. Since the environmental buffer is described as "further treatment," it can also provide virus LRVs to the project, as long as the minimum travel time from the injection point to the groundwater well for water extraction is greater than two months. Starting at two months, for each month of retention time underground, one LRV of virus can be granted to the project, thus varying from two to six LRVs. The LRV accreditation also depends on the method used to estimate the theoretical retention time. For example, numerical modeling is worth 0.25 or 0.5 LRV for each month, while tracer studies using added tracer grants the full one LRV per month underground.

As with pathogen control, chemicals must also be monitored throughout the AWPF. The IPR project must meet all drinking water standards, including primary and secondary maximum contaminant levels (MCL) or action levels (e.g., copper and lead) established by the United States Environmental Protection Agency, as well as monitor and potentially establish mitigation plans for chemicals with notification levels (NL) established by DDW. The total nitrogen must be below 10 milligrams per liter (mg/L) as N and the total organic carbon (TOC) must be less than 0.5 mg/L.

In GWR projects, the purified water must also comply with the Basin Plan Objectives (BPO) for the affected groundwater basin, which, in this case, is the Antelope Valley Groundwater Basin, in the Lahontan Region. These BPOs are established by the Region's Basin Plan, defined by the Regional Water Quality Control Board (RWQCB), and are usually for salts and minerals.

The Lahontan Region Basin Plan does not have any specific BPOs for the Antelope Valley Groundwater Basin. However, the RWQCB has published a Salt and Nutrient Management Plan (SNMP) that is specific to the Antelope Valley. The SNMP was developed to manage salts, nutrients, and other constituents in the Antelope Valley Groundwater Basin to ensure the beneficial uses of the groundwater basin are protected. The SNMP water quality management goals are meant to serve as a management and planning tool for groundwater quality and not to serve as a basis for regulatory or discharge limits. A list of the constituents of the SNMP and the goals for the Antelope Valley are shown in Table 1.

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Table 1. Salt and Nutrient Management Plan Water Quality Goals for Antelope Valley Groundwater Basin

Constituent	Units	SNMP Water Quality Goal
Arsenic	µg/L	10 (1)
Boron	mg/L	0.7 ⁽²⁾ - 1 ⁽³⁾
Chloride	mg/L	238/250/500 (4)
Chromium, total	µg/L	50 ⁽¹⁾
Fluoride	mg/L	1 ⁽²⁾ - 2 ⁽¹⁾
Nitrate	mg/L as N	10 (1)
TDS	mg/L	450/500/1000 (5)

Notes:

¹ Municipal and Domestic Supply (MUN) Water Quality Objective which is based on the Title 22 CCR drinking water primary MCL

² Based on the agricultural supply beneficial use threshold

³ Based on California's Notification Level

⁴ Recommended (based on agricultural supply beneficial use threshold), upper (based on MCL), and short-term values, respectively. Recommended (based on agricultural supply beneficial use threshold), upper, and short-term TDS values, respectively.

Key:

µg/L = micrograms per liter

CCR = California Code of Regulations

MCL = Maximum Contaminant Level

mg/L = milligrams per liter

N = Nitrogen

SNMP = Salt and Nutrient Management Plan

TDS = total dissolved solids

From a treatment process perspective, GWR with direct injection regulations requires reverse osmosis (RO) and an advanced oxidation process (AOP), which is usually an oxidant combined with ultraviolet light (UV), referred to as UV/AOP. The combination of these treatment technologies is called full advanced treatment (FAT). Low-pressure membrane filtration (MF), whether micro- or ultrafiltration, is usually employed before RO as a pretreatment to protect the RO membranes from larger particles. Further treatment can also be employed, but is not required, as long as the required pathogen LRVs and chemical control requirements are met. The typical treatment train associated with GWR via subsurface injection is shown in Figure 3.



Figure 3. Treatment Processes Required for Groundwater Recharge Via Subsurface Injection

Table 2 summari	Benefits	sε	UV/AOP	rocess. Hi	igher LRVs are
de <mark>יחמה גדיפטיבי</mark> ז סו	 4-log path Cryptospo Provides present in 	hogen æ red o <i>ridium</i> control aga n the transr	it for Giardia and inst bio-sloughing an mission system	nd ARBs	
Rem rel Mechanism	<u>Challenges</u> • Requires monitorir	research o Ig	n acceptable indirec	ct integrity	

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	MF	RO	UV/AOP	GW	Total	Required
Virus (V)	0	1.5	6	2 – 6*	7.5 – 13.5	12
Giardia (G)	4	1.5	6	0	11.5	10
Cryptosporidium (C)	4	1.5	6	0	11.5	10

Table 2. Summary of Log Removal Values for Treatment Processes Employed in Groundwater Recharge Via Direct Injection

Note:

* Dependent on travel time underground and method used for estimating the theoretical retention time Key:

GW = groundwater

GWR = groundwater recharge

LRV = log removal value MF = membrane filtration

RO = reverse osmosis

UV/AOP = ultraviolet/advanced oxidation process

MF is commonly used as a pretreatment in front of RO to protect membranes from fouling. RO is required because it is currently the most cost-effective technology to reduce TOC concentrations to below 0.5 mg/L, while also rejecting a series of other constituents. UV/AOP is deployed after RO for two reasons: (1) the UV treatment component is a germicide (disinfectant) and also photolyzes harmful compounds such as N-nitrosodimethylamine (NDMA), and (2) the hydroxyl radicals from the AOP component oxidize many trace organics that can be evaluated by the removal of 1,4-dioxane. NDMA is a probable human carcinogen and disinfection byproduct (DBP) from ozonation and chloramination, with an NL of 10 ng/L.

2.1.2 SURFACE WATER AUGMENTATION

SWA consists of purified water from an AWPF conveyed to a water reservoir, that is, in turn, used as the source water for a downstream SWTP. The reservoir serves as an environmental buffer that provides both dilution and response time in case of a treatment failure and further treatment to pathogens and chemicals. Since the adoption of the SWA regulations in late 2018, no SWA project is fully operational, but several utilities are pursuing this type of IPR and are currently undergoing the permitting process



Figure 4. Treatment Processes Required for Surface Water Augmentation

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When the reservoir provides at least 100:1 dilution and above 180 days of retention time, no extra LRVs are needed beyond the 12/10/10. Dilution is considered as the volume of recycled water delivered to a surface water reservoir within any 24-hour period. Within this same dilution, but at a retention time between 120 and 180 days, the LRV criteria is still 12/10/10, but additional evaluation and information about the reservoir and its operation will be assessed and undergo approval by DDW. For projects operating at a retention time between 60 and 120 days with a minimum dilution rate of 100:1, an additional 1/1/1 will be required in addition to the DDW evaluation and approval of using the reservoir. Projects with less than 60 days of retention time do not qualify as IPR and will need to comply with DPR requirements. If greater than a 100:1 blend ratio, a minimum of two treatment processes, each providing at least one LRV and a maximum of six LRVs, must be employed at the AWPF.

With dilution ratios between 10:1 and 100:1, extra 1/1/1 LRV requirements (V/G/C) are added to each retention time bracket scenario to compensate for the lower dilution. The same logic presented before for the mean theoretical HRT is applied: for HRT of at least 180 days, no additional measures are required; for retention times between 120 and 180 days, no extra LRVs are needed, but the reservoir and its operation will need to be evaluated and approved by DDW prior to project implementation; for retention times between 60 and 120 days, another 1/1/1 LRVs are needed to compensate for the lower retention time as well, and the reservoir will also need to undergo DDW's evaluation and approval. Retention times below 60 days disqualify the project as IPR. If between a 100:1 and 10:1 blend ratio, a minimum of three treatment processes, each providing at least one LRV and a maximum of six LRVs, must be employed at the AWPF.

Beyond the minimal retention time of 60 days, the minimal dilution rate for a project to be qualified as SWA is 10:1. Should the reservoir be unable to provide a dilution rate above 10:1, the project is ineligible to be considered SWA, and it must undergo DPR permitting.

SWTPs can be granted up to 4/3/2 LRVs for V/G/C, which can be combined with the LRVs earned at the AWPF, since the water in the reservoir will undergo final treatment the SWTP prior to entering the drinking water distribution system. This would decrease the number of LRVs needed throughout the AWPF. Table 3 summarizes the LRV requirements under the different dilution rates and retention times in the reservoir, and the minimum LRVs needed at the AWPF.

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Table 3. Summary of Log Removal Value Requirements for Surface Water Augmentation	on
Projects Under Different Dilution and Retention Time Scenarios	

Dilution	Theoretical Retention Time (days) Required		Minimum Required for AWPF (Assumes 4/3/2 LRVs provided by the SWTP)	
1% by volume of recycled	≥ 180	12/10/10	8/7/8	
water delivered to the reservoir during any 24-hour	< 180, > 120	12/10/10*	8/7/8*	
period (100:1)	< 120, ≥ 60	13/11/11*	≥ 9/8/9*	
10% by volume of recycled water delivered to the	≥ 180	13/11/11	9/8/9	
reservoir during any 24-hour	< 180, > 120	13/11/11*	9/8/9*	
period (10:1)	< 120, ≥ 60	14/12/12*	≥ 10/9/10*	

Note:

*DDW may change requirements after reservoir evaluation.

Key: < = less than > = greater than ≥ = greater than or equal to AWPF = advanced water purification facility DDW = Division of Drinking Water LRV = log removal value SWA = surface water augmentation SWTP = surface water treatment plant

SWA projects must meet all the chemical drinking water standards previously mentioned for GWR via direct injection projects, with one difference: since there is no groundwater involved, there is no requirement for the purified water to meet the groundwater BPOs. However, surface waters in California require that any surface discharge (e.g., discharge of the purified water) must comply with the chemicals and concentrations listed in the California Toxics Rule (CTR), which are typically very stringent.

Lake Palmdale would likely be the reservoir used for the SWA IPR scenario, although Little Rock Reservoir is also a possibility in case extra storage volume or retention time is needed. These two reservoirs are part of the Antelope Valley Hydrological Unit, also in the Lahontan Region. Both Lake Palmdale and Little Rock Reservoir are categorized as municipal and domestic supply (MUN) beneficial use. Water bodies designated as MUN have the following uses: "uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply" (RWQCB, 1995). Since the CTR is applied to "all waters assigned any aquatic life or human health use classifications in the *Water Quality Control Plans for the Basin Plans adopted by the State Water Resources Control Board*," both water bodies must meet the CTR limits.

In general, the CTR limits must be met at the end of the discharge pipe (i.e., at the purified water). The SWRCB has established the State Implementation Policy (SIP), which sets forth procedures on how the federal CTR receiving standards are to be applied in regulating discharges to California's surface waters. Under the SIP, all CTR receiving water standards must be met at the end of the discharge pipe, unless a mixing zone is authorized by the RWQCB pursuant to provisions of the SIP. For that to be approved, a dilution or mixing zone study must be performed by the RWQCB, and if the study has demonstrated that

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there is sufficient assimilative capacity in the receiving water, the dilution factor can then be applied. This dilution factor is a multiplier "applied in the calculation of final effluent limitations at the point of initial discharge (i.e., 'end-of-pipe'), to account for the dilution that will take place in the receiving water" (EPA, 2000).

2.2 Direct Potable Reuse

Draft DPR regulations were first released in 2021, and the final version is expected by the end of 2023. Therefore, DPR is being considered as an alternative for PWD to evaluate. The key difference in shifting from IPR to DPR is that the environmental buffer between the municipal wastewater and drinking water is reduced or eliminated. As such, the regulations are focused on achieving greater contaminant reduction through treatment and ensuring greater process reliability to compensate for the loss of response time resulting from eliminating an environmental buffer. The DPR regulations do not differentiate between RWA and TWA; however, they will be addressed separately in the following sections.

2.2.1 RAW WATER AUGMENTATION

In RWA, the treated water from the AWPF is sent to a source water aqueduct or directly to the headworks of a SWTP for further treatment before being distributed to customers by the public water system. Therefore, there is very little to no environmental buffer between the AWPF and the SWTP.

Section 2.1 outlined the minimum retention time and dilution requirements by the environmental buffer to qualify a potable reuse project as IPR. These retention time and/or dilution requirements are critical for further pathogen attenuation and mitigation of chemicals/toxins. When they cannot be met (i.e., the dilution provided by the reservoir is below 10:1, and/or the retention time provided by the groundwater or reservoir is under 60 days), one way to continue with the potable reuse project is to increase the level of treatment in compliance with DPR requirements, under the RWA category. Since the reservoir/ groundwater cannot provide the time or dilution required for pathogen attenuation and chemical mitigation, these strategies must be replaced by further treatment and more stringent reliability features, such as response time and redundancy. Another approach for RWA is intentionally planning for the purified water to be conveyed to the SWTP or to its upstream pipelines.

Due to the lack of a buffer and/or lower dilution and/or detention times required by IPR, more rigorous treatment and higher LRVs are required for pathogen control to ensure public health safety when DPR is employed. It is expected that the final DPR regulations will require 20/14/15 LRVs for V/G/C, which must be provided throughout the AWPF and SWTP in the case of RWA. For DPR, at least four different treatment processes will be required at the AWPF, each one granting at least one pathogen LRV. In all cases, no more than six LRVs can be granted to the same unit process. Moreover, the treatment processes employed will have to be of at least three different mechanisms: chemical disinfection (e.g., ozone [O₃]), physical separation (e.g., RO), and UV disinfection.

Whereas 4/3/2 from the SWTP are granted for SWA, a DPR project has to demonstrate all pathogen LRVs using pre-validated technologies (e.g., O₃ or chlorine disinfection residual concentration multiplied by the contact time [CT]) to obtain the SWTP LRVs. In general, SWTPs using conventional treatment

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processes would receive 2/0.5/0 for V/G/C, based on the chlorine disinfection process. These LRVs could be increased if O_3 is used for primary disinfection or if membrane filtration is used.

The higher LRVs and the higher minimum number of treatment processes will require unit processes beyond the FAT system. Treatment with O₃ and biologically activated carbon (BAC) will be required upstream of RO for DPR projects per the draft regulations unless the purified recycled water is less than 10% of the source drinking water. A summary of the processes and their LRVs for each pathogen is presented in Table 4, while Figure 5 illustrates the treatment processes required. Based on the current status of regulation development, there are no further requirements for the processes, as long as the minimum LRVs are met.



Table 4. Summary of Pathogen Log Removal Values for Direct Potable Reuse

highest level) certified operator w removaled to be one site at all times for at least the first year of the project. Provides no chemical control Does not increase treatment robustness

Several requirements will be put in place related to the different treatment processes for an improved control of chemicals. For example, when O₃ and BAC are employed, the following operational parameters must be applied to indicate a 1-log reduction of formaldehyde: an O_3 :TOC ratio above 1.0 and an empty

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bed contact time (EBCT) of at least 15 minutes for the BAC process. EBCT is the time the water takes to go through the BAC bed.

A comprehensive monitoring plan will be required throughout the entire process (i.e., from the feed to the wastewater treatment plant until the finished water – the latter at a higher frequency than in IPR applications). A summary of the monitoring frequencies, locations, and the analytes for is provided in Table 5.

	Weekly	Monthly	Quarterly
Wastewater feed	-	MCLs (primary and secondary); NLs; priority toxic pollutants; State Boar-specific chemicals; acetone; methanol; methyl ethyl ketone; N,N-dimethylacetamide (DMAc); treatment byproducts and precursors	Chemicals from industrial sources, nonindustrial sources of pharmaceuticals, personal care products, and household hazardous substances; chemicals known to cause cancer or reproductive toxicity
Post UV/AOP	-	MCLs (primary and secondary); NLs; priority toxic pollutants; State Boar-specific chemicals; acetone; methanol; methyl ethyl ketone; N,N-dimethylacetamide (DMAc); treatment byproducts and precursors	Chemicals from industrial sources, nonindustrial sources of pharmaceuticals, personal care products, and household hazardous substances; chemicals known to cause cancer or reproductive toxicity
Finished water (on distribution system)	Nitrate, nitrite, perchlorate, lead	MCLs (primary and secondary); NLs; priority toxic pollutants; State Boar-specific chemicals; acetone; methanol; methyl ethyl ketone; N,N-dimethylacetamide (DMAc); treatment byproducts and precursors	Chemicals from industrial sources, nonindustrial sources of pharmaceuticals, personal care products, and household hazardous substances; chemicals known to cause cancer or reproductive toxicity
Kev:	I	N = Nitrogen	

Table 5. Summary of Required Monitoring for Reuse

AOP = advanced oxidation process

N = Nitrogen NL = notification level

MCL = maximum contaminant level

NL = notification le UV = ultraviolet

Another important aspect of chemical control in DPR projects is the ability for the system to provide attenuation of chemical peaks. Chemical peaks could be caused by unintended chemical spills in the sewershed or other events that could exponentially increase the concentration of chemicals in the wastewater treatment plant that go untreated or barely treated. Per the current draft DPR regulations, adequate retention time and continuous mixing of the flow from the point of entry of the wastewater treatment plant until the drinking water distribution system must be provided through treatment, storage, and conveyance. This "length" that the flow travels must be sufficient to attenuate a one-hour chemical peak by a factor of 10 (i.e., in order to provide this one-hour peak attenuation, the total travel time must be at least 10 hours with continuous longitudinal mixing).

The chemical peak issue can be observed by the RO permeate TOC levels. Even though the potable reuse regulations require final TOC concentrations to be under 0.5 mg/L, typical RO permeate TOC concentrations in potable reuse plants are under 0.1 mg/L. RO permeate TOC concentrations above this

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0.1 mg/L level, monitored every five minutes by online TOC monitors, will trigger different actions, as summarized in Table 6.

Table 6. Reverse Osmosis Permeate Total Organic Carbon Concentrations andRespective Actions

-	TOC Trigger		Action			
> 0.1 mg/L for more	e than 24 hours		Perform a five-day total trihalomethane formation potential study			
> 0.15 mg/L for mo	ore than 5 days a	at RO permeate	Perform conductivity profile to identify underperforming vessel or element			
> 0.25 mg/L at RO	permeate		Collect samples to investigate peak			
> 0.5 mg/L prior to	distribution		Automatically discontinue delivery of water to distribution system			
Key: > = greater than mg/L = milligrams per liter RO = reverse osmosis TOC = total organic carbon MF Benefils UV/AOP The best strategy to prevent key element for the implementat.or.c.c.si MF 4-ldg pathogen credit for Giardia and Cryptosporidium • Cryptosporidium • control Important role in DPR. Beyo pretreatment and concernent for chen iccs die of local community crectors MF • UV/AOP equired for IPR, such as industrial Cryptosporidium • equired for IPR, such as industrial Ogests • equired for IPR, such as industrial • Provides control against bio-sloughing and Adscredue • equired for IPR, such as industrial • equired for IPR, such as industrial • equired for IPR, such as industrial • prevides control against bio-sloughing and Adscredue • equired for IPR, such as industrial<						
In TW (2010) er	BAC	OTT THE AVAIL rides no with emical Be	RO IC UV/AOP inking water 4-ldg pathogen@redit for Giardia and Dive blending with			
ot % rc op * * > > ra		xe on disrbu .	Cryptosporidium Provides control against bio-sloughing and ARES required for this present in the transmission system			
OZONE	BAC	<u>Removal Mechanism</u> Ch	RO ar AOP tegrity Water			
		→				

Note: O₃/BAC is only required for projects contributing to more than 10% of the total drinking water source supply. **Figure 6. Treatment Processes Required for Treated Water Augmentation**

The latest draft DPR regulations do not differentiate TWA requirements from RWA requirements in all aspects (i.e., pathogen control, chemical control, source control, monitoring, etc.). The only technical difference is that the SWTP pathogen LRVs cannot be applied to TWA projects, since the purified water does not go through an SWTP before entering the distribution system. Since there is no buffer or further treatment after the AWPF (i.e., no SWTP downstream and no environmental buffer, such as reservoir or

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groundwater), the monitoring requirements and triggers are exceptionally important for the success of the project and for public health protection.

2.3 Summary

Table 7 summarizes key regulatory requirements for the different potable reuse alternatives.

Criteria	GWR via Subsurface	SWA	DPR (RWA/TWA)
Treatment Required	RO + UV/AOP	RO + UV/AOP	Ozone/BAC + RO + UV/AOP
Pathogen Control	 12-log enteric virus 10-log <i>Giardia</i> 10-log <i>Cryptosporidium</i> 	 12 to 14-log enteric virus 10 to 12-log <i>Giardia</i> 10 to 12-log <i>Cryptosporidium</i> 	 20-log enteric virus 14-log <i>Giardia</i> 15-log <i>Cryptosporidium</i>
Minimum Number of Treatment Processes	 3, each one providing a minimum LRV of 1 	 2 when the dilution is at least 100:1 3 when the dilution is between 10:1 and 100:1 Each process must provide a minimum LRV of 1 	 4, each one providing a minimum LRV of 1 3 different mechanisms (1 physical separation, 1 chemical disinfection, and UV disinfection)
Chemical Control	 Maximum TOC of 0.5 mg/L Must meet all current drinking water standards for quarterly monitoring (MCLs, NLs, etc.) <u>Must meet</u> <u>Groundwater Basin</u> <u>Plan Water Quality</u> <u>Objectives</u> 	 Maximum TOC of 0.5 mg/L Must meet all current drinking water standards for quarterly monitoring (MCLs, NLs, etc.) Must meet California Toxics Rule limits 	 Maximum TOC of 0.5 mg/L; additional, more stringent TOC thresholds with response actions Must meet all current drinking water standards for <u>monthly</u> monitoring (MCLs, NLs, etc.) 10-fold reduction of one- hour chemical spike Continuous monitoring of nitrate and nitrite in RO permeate Stringent source control program

Table 1. Summary of Key Regulatory Requirements for Potable Reuse Alternatives

Key Regulatory Requirements May 2023

Criteria	GWR via Subsurface Injection	SWA	DPR (RWA/TWA)
Environmental Buffer	 Minimum aquifer retention time of 2 months Ideally >6 months retention time to achieve maximum virus LRVs from soil aquifer treatment 	 Initial minimum reservoir hydraulic retention time of 6 months; potential to reduce to 2 months with additional pathogen control Minimum reservoir dilution of 100:1; with potential to reduce to 10:1 with additional pathogen control 	 Use of an environmental buffer is not necessary, but if an IPR project does not comply with the dilution (i.e., <10:1) and/or retention time (i.e., <2 months) requirements, it will be classified as DPR An engineered storage buffer can be used for blending and/or diversion of off spec water
Additional Monitoring	 Quarterly sampling in recycled water and downgradient monitoring wells for priority pollutants, unregulated chemicals, and NLs 	 Quarterly sampling in recycled water for priority pollutants, unregulated chemicals, and NLs 24 months of monthly sampling for MCLs, TOC, nitrogen, and others at multiple locations in reservoir to be augmented. Additional monthly monitoring for at least first 24 months of operations. 	 Monitoring required in feed water, directly after oxidation process, and finished water as described in Table 5.
Key: > = greater than < = less than AOP = advanced oxi BAC = biological acti	dation process vated carbon	MCL = maximum contan mg/L = milligram per liter NL = notification level RO = reverse osmosis SWA = surface water au	ninant level r igmentation

DPR = direct potable reuse DPR = direct potable reuse

GWR = groundwater recharge IPR = indirect potable reuse

LRV = log removal value

SWA = surface water augmentation SWA = surface water augmentation TOC = total organic carbon TWA = treated water augmentation UV = ultraviolet

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3.0 Potential Potable Reuse Alternatives

The main advantages and challenges for each potable reuse alternative evaluated for the Pure Water AV are discussed in the following subsections and summarized in the last subsection.

3.1 Groundwater Replenishment Via Subsurface Injection

GWR via subsurface injection is a viable alternative for PWD to pursue, and likely the most feasible as well, due to its established performance and reduced regulatory requirements as compared to the other alternatives presented here. Groundwater modeling is necessary to determine if the retention time within the aquifer is higher than 60 days (or 120 days based on modeling, since regulations only allow half credit for retention time for modeled results). If the modeled retention time is less than two months, either a lower flow of purified water can be injected into the subsurface to increase the retention time, or the project can become classified as 'DPR,' while leveraging the benefit of the retention time in the groundwater basin to attenuate chemical peaks and failure response time. In the event the groundwater retention time is above the minimum, but not long enough to provide the maximum virus LRVs (six), additional treatment processes may be required. A relatively simple treatment process to add in IPR applications is free chlorine disinfection downstream of UV/AOP, which is commonly employed in AWPFs and drinking water facilities. Table 8 summarizes the possible LRVs for the treatment train for GWR via direct injection.

	MF	RO ⁽¹⁾	UV/ AOP	Env. Buffer	Required	Total	Free Cl ₂ (3)	Total
Virus	0	1.5–2.5	6	2-6 ⁽²⁾	12	7.5–13.5	0–6	13.5–20.5
Giardia	4	1.5–2.5	6	0	10	11.5	0–1	11.5 –12.5
Cryptosporidium	4	1.5–2.5	6	0	10	11.5	0	11.5

Table 8. Log Removal Value Requirements for Groundwater Recharge Via Direct Injection

Notes:

¹ RO LRVs depend on surrogate used.

² Environmental buffer (groundwater) LRVs can vary from 2 to 6, depending on the time the water spends underground. Starting at 2 months, 1 LRV is granted for every month underground.

³ 6 virus LRVs and 1 Giardia LRV can be granted Free chlorine LRVs depending on the concentration, contact time, and approach. Key:

AOP = advanced oxidation process

GWR = groundwater recharge

LRV = log removal value

MF = membrane filtration

RO = reverse osmosis

UV = ultraviolet

3.1.1 BENEFITS

In a GWR application, the capacity of the groundwater for further treatment, pathogen abatement, and chemical dilution are beneficially exploited. The use of groundwater as a further treatment decreases additional treatment infrastructure, the need for a greater footprint at the AWPF, etc. Due to the relatively

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low number of treatment processes required, GWR via direct injection may have the lowest costs among the potable reuse alternatives considered. That applies to both capital as well as operations and maintenance (O&M) costs.

Because of its simplicity compared to the other potable reuse alternatives, the permitting process for GWR via direct injection is straightforward. Since this IPR application has been regulated for almost a decade and considering that this alternative is well established in California, with many water utilities employing it, PWD can benefit from the lessons learned from these utilities.

Overall, any potable reuse project will decrease PWD's reliance on water imported from other institutions and associated infrastructure. In the case of GWR, the project will add a reliable source of water to PWD's allocation in the adjudicated groundwater basin, while also potentially working as storage to offset long-term drought or water supply variations.

3.1.2 CHALLENGES

GWR via subsurface injection projects must comply with water quality goals imposed by the SNMP that are specific to the Antelope Valley. Table 9 summarizes the SNMP water quality goals, along with statistical analyses of PWRP's tertiary effluent data from 2017 to 2021. More details on the tertiary effluent data analyses are presented in the Tertiary Water Requirements TM, part of the Program Priorities and Implementation Plan.

Table 9. Salt and Nutrients Management Plan Water Quality Goals for Antelope ValleyGroundwater Basin and Statistical Analysis for Palmdale Water Reclamation Plant'sTertiary Effluent from 2017 to 2021

Constituent	Units	SNMP Water Quality Goal	Average	Minimum	Maximum	Count
Arsenic	µg/L	10 ⁽¹⁾	0.5	0.26	0.61	10
Boron	mg/L	0.7 ⁽²⁾ - 1 ⁽³⁾	0.3	0.29	0.29	1
Chloride	mg/L	238/250/500 (4)	145	107	180	20
Chromium, total	µg/L	50 ⁽¹⁾	0.8	0.39	1.22	10
Fluoride	mg/L	1 ⁽²⁾ - 2 ⁽¹⁾	NA	NA	NA	0
Nitrate	mg/L as N	10 (1)	2.6	0.9	8.9	62
TDS	mg/L	450/500/1000 ⁽⁵⁾	471	406	536	21

Notes:

¹ Municipal and Domestic Supply (MUN) Water Quality Objective, which is based on the Title 22 CCR drinking water primary MCL

² Based on the agricultural supply beneficial use threshold

³ Based on California's Notification Level

⁴ Recommended (based on agricultural supply beneficial use threshold), upper (based on MCL), and short-term values, respectively.

⁵ Recommended (based on agricultural supply beneficial use threshold), upper, and short-term TDS values, respectively.

Key:

µg/L = micrograms per liter

CCR = California Code of Regulations

mg/L = milligrams per liter

MCL = maximum contaminant level

N = Nitrogen NA = not applicable

SNMP = Salt and Nutrient Management Plan

TDS = total dissolved solids

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Upon RO treatment, the concentrations of all constituents in Table 9 will decrease by more than 95%, lowering the total dissolved solids concentrations to below the SNMP limits and providing potential long-term benefits to the groundwater basin water quality. However, a big challenge for potable reuse projects employing RO is brine disposal. Facilities with proximity to the ocean usually opt for ocean discharge, complying with the discharge limits and regulations in accordance with the California Ocean Plan. For inland facilities, conveying the brine to an ocean outfall or even a brine line can be cost-prohibitive, requiring the facility to manage the brine differently.

There are currently many options for brine treatment and/or disposal for inland facilities. Some of them include further treating the RO concentrate to minimize the brine flow, such as with additional RO systems (e.g., closed-circuit RO). Another option is deep-well injection, which requires several geological studies, constant monitoring, and rigorous permitting requirements. A common and viable option is the use of brine or evaporation ponds to dry the brine. This is especially pertinent for PWD, due to the elevated temperatures in the region that facilitate evaporation and to the available land space for the ponds. If brine ponds are chosen, it is recommended that liners are used in the ponds prior to brine discharge to protect the groundwater quality. Once the liquid in the brine is evaporated, the resulting salts can be physically removed and hauled to a landfill for disposal. The Brine Management Strategy TM, prepared by the Stantec Team as part of these programmatic efforts, covers this topic in-depth.

3.2 Surface Water Augmentation

For the SWA scenario, Lake Palmdale is being considered as the primary reservoir due to its proximity to the SWTP and PWRP. Little Rock Reservoir could also be used as back-up or if increased retention time is required, but it is farther from both plants, resulting in higher pumping and conveyance costs, and its flow is ultimately conveyed to Lake Palmdale.

The volume of Lake Palmdale is 4,189 acre-feet (~1.37 billion gallons). Given that Leslie O' Carter SWTP has a 35-mgd capacity, the theoretical retention time would be 39 days when using the full capacity, which is below the minimum 60 days. However, the plant does not operate at full capacity. The plant's flow ranges from 10 to 20 mgd, with an annual average flow of 18.7 mgd (PWD, n.d.). Using the upper limit to be conservative, the HRT is approximately 68 days, which is above the minimum of 60 days. Additionally, 22.8 mgd is the maximum flow that can be withdrawn from Lake Palmdale by Leslie O' Carter SWTP to keep the HRT at 60 days or more while the reservoir is at full capacity.

Given the plant's capacity is larger than the 22.8 mgd flow, using SWA with Lake Palmdale would derate the SWTP, potentially lowering future supply options. Additionally, annual maintenance of the shoreline and dock requires the lake to lower its capacity to between 3,250 and 3,500 acre-feet for approximately one month, which would further restrict the plant capacity during this timeframe. Furthermore, PWD receives a 39% groundwater return flow credit for use of SWP when available, and this credit would be limited as a result of the SWTP derating. Alternatively the reservoir and Leslie Carter SWTP could be used in a DPR alternative to leverage the natural attenuation and retention time in the reservoir.

The dilution factor for Lake Palmdale can be calculated by using a 24-hour volume average fed to the reservoir compared to its entire volume. The AWPF is planned for a 5-mgd capacity, although not the entirety of flow will be converted to purified water (e.g., RO concentrate generated during the RO

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process). Using 5 million gallons as a conservative feed to the reservoir in 24 hours, the reservoir would provide a dilution factor of 273:1. Therefore, Lake Palmdale would need 13/11/11 LRVs for V/G/C in a SWA project.

Little Rock Reservoir's capacity is 3,500 acre-feet (~1.1 billion gallons). Given its flow allocation to PWD of 3,000 afy (~2.7 mgd) and assuming no change to that flow, the estimated retention time would be above 400 days. The dilution factor can be calculated using conservative flow of 5 mgd from the proposed AWPF to the entire reservoir volume, which results in 220:1. Thus, 12/10/10 LRVs would be needed for Little Rock Reservoir in an SWA application. This dilution and overall capacity of Pure Water AV via SWA at Little Rock Reservoir may also be impacted by annual maintenance for sediment removal, which typically occurs during dry months (May through September). The impacts of maintenance should be considered in more detail if SWA is pursued further.

The retention times presented above were calculated assuming the reservoir behaves like a continuously stirred tank reactor, which is not the reality. Hydrodynamic modeling and tracer tests are needed to determine the dilution factor and retention time. The modeling and/or tracer test would additionally identify the diffusion patterns throughout Lake Palmdale and Little Rock Reservoir to investigate if the path the water takes or diffuses through is enough to reach the retention time. The dilution and retention time modeling results would also dictate if there is need for further treatment at the AWPF beyond FAT. Refer to Table 3 for a summary of LRV requirements dependent on dilution factor and retention time.

The LRV requirements for the SWA alternative are summarized in Table 10 for Lake Palmdale and Table 11 for Little Rock Reservoir.

	MF	RO ⁽¹⁾	UV/ AOP	SWTP (2)	Free Cl _{2 (3)}	Required	Total ⁽³⁾	
Virus	0	1.5–2.5	6	4	0-6	13	11.5–18.5	
Giardia	4	1.5–2.5	6	3	0-1	11	14.5–16.5	
Cryptosporidium	4	1.5-2.5	6	2	0	11	13.5–14.5	

Table 10. Log Removal Value Requirements for Surface Water Augmentation Using LakePalmdale as the Reservoir

Notes:

¹ RO LRVs can range depending on surrogate

² The SWTP (Leslie O' Carter Water Treatment Plant) is assumed to comply with the SWTR 4/3/2 requirements.

³ The total required LRVs will depend on the dilution factor (between 10:1 and 100:1 and \geq 100:1) and retention time (between 60 and 180 days and \geq 180 days).

⁴ 6 virus LRVs and 1 Giardia LRV can be granted free chlorine LRVs depending on the concentration, contact time, and approach.

Key:

 \geq = greater than or equal to

AOP = advanced oxidation process

LRV = log removal value

MF = membrane filtration RO = reverse osmosis

RO – Teverse Ostitosis SW/TD – ourfood water trootr

SWTP = surface water treatment plant SWTR = Surface Water Treatment Rules

UV = ultraviolet

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	MF	RO ⁽¹⁾	UV/ AOP	SWTP (2)	Free Cl _{2 (3)}	Required	Total ⁽³⁾
Virus	0	1.5–2.5	6	4	0-6	12	11.5–12.5
Giardia	4	1.5–2.5	6	3	0-1	10	14.5–15.5
Cryptosporidium	4	1.5–2.5	6	2	0	10	13.5–14.5

Table 2. Log Removal Value Requirements for Surface Water Augmentation Using Little Rock Reservoir as the Reservoir

Notes:

¹ RO LRVs can range depending on surrogate

² The SWTP (Leslie O' Carter Water Treatment Plant) is assumed to comply with the SWTR 4/3/2 requirements.

³ The total required LRVs will depend on the dilution factor (between 10:1 and 100:1 and ≥ 100:1) and retention time (between 60 and 180 days and ≥180 days).

⁴ 6 virus LRVs and 1 Giardia LRV can be granted free chlorine LRVs depending on the concentration, contact time, and approach.

Key:

 \geq = greater than or equal to

AOP = advanced oxidation process

LRV = log removal value

MF = membrane filtration

RO = reverse osmosis

SWTP = surface water treatment plant

SWTR = Surface Water Treatment Rules

UV = ultraviolet

The benefits and challenges associated with these alternatives are reviewed in the following subsections.

3.2.1 BENEFITS

As with the GWR and groundwater, the ability of the reservoir for further treatment (e.g., from sunlight), dilution, and response time in case of failure would be beneficially exploited in an SWA application. For PWD, based on an initial assessment, SWA using Palmdale Lake appears to be a viable alternative. Lake Palmdale is within a close distance from the proposed AWPF site, and is located next to Leslie O' Carter SWTP, which uses the reservoir water for drinking water treatment and distribution. Little Rock Reservoir is farther, but is also a feasible option, since it likely provides further dilution and retention time, as well as storage.

In the case the maximum LRVs are provided by each treatment process, including the SWTP, for the three different pathogens, and the dilution factor and retention times estimates are confirmed, only FAT at the AWPF would be required to meet the LRV requirements. In that case, the treatment costs for project implementation could be the same as the ones required for GWR, or even less, in the event the GWR alternative requires further LRVs from free chlorine disinfection. The same logic is valid for footprint needs at the AWPF.

SWA is relatively new in California, but there are currently a handful of projects pursuing this alternative, which could help facilitate the project implementation for PWD, since knowledge could be shared and applied to the future AWPF. Although SWA projects involve compliance with more regulatory requirements and monitoring than the IPR alternative (e.g., monthly sampling and monitoring of the reservoir before and during the beginning of operations), they are significantly less than those associated



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with DPR projects. Besides providing a reliable and drought-proof source of water for Palmdale, the reservoir can also serve as storage for treated water, increasing the volume of the reservoir(s) mentioned.

3.2.2 CHALLENGES

If the modeling results show a lower retention time or less dilution, the project would become classified as DPR and further treatment beyond the processes mentioned will be necessary to achieve the required pathogen LRVs. Additionally, the retention time below 180 days could trigger DDW to request additional studies or even higher LRVs, as previously mentioned.

Even though the AWPF treatment costs may be similar to the GWR treatment alternative for the SWA alternative, pumping and operating costs of Surface Water Treatment Rules would be higher than for GWR, and it is likely these costs would offset any potential savings in AWPF treatment costs.

Additionally, surface discharges must comply with CTR limits at the end of the discharge pipe, unless a mixing zone is approved by the RWQCB, as previously explained. Out of the 126 compounds listed at the CTR, 92 have CTR limits with human health criteria. Some of these compounds with human health criteria have their maximum discharge limits stipulated by CTR as low as or even lower than their methods reporting limits. Examples that are usually problematic for potable reuse projects are NDMA, and the trihalomethanes dibromochloromethane (DBCM) and bromodichloromethane (BDCM), among others. CTR limits for compounds that could be an issue for PWD are summarized in Table 12, along with tertiary effluent data from PWRP from 2017 to 2021.

Table 12. Summary of California Toxics Rule Compounds Within Palmdale WaterReclamation Plant's Tertiary Effluent and Statistical Analysis for Palmdale WaterReclamation Plant's Tertiary Effluent from 2017 to 2021

Compound	Units	CTR Limit	Minimum	Maximum	Average	Count
DBCM	µg/L	0.41	0.13	0.62	0.38	20
BDCM	µg/L	0.56	0.5	3.4	1.5	20
NDMA	ng/L	0.69	46	1200	532	24

Key:

µg/L = micrograms per liter

BDCM = dibromochloromethane

CTR = California Toxics Rule

DBCM = bromodichloromethane

NDMA = N-nitrosodimethylamine

The average DBCM and BDCM results from PWRP's tertiary effluent are either above or very close to their CTR limits. It is anticipated that these two compounds will be, to a large extent, rejected by RO, and that the final concentrations would be below the CTR limit. More details are provided in the Tertiary Water Requirements TM.

UV/AOP is usually designed to reduce NDMA concentrations to 5 ng/L, which is below its NL but above the CTR limit. NDMA is of particular concern due to its ability to reform after UV/AOP. Formation potential tests are recommended at the purified water to understand the potential of DBPs, including DBCM and

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BDCM, to form at the purified water. The final discharge limits will dictate the design and planning for the treatment processes at the AWPF if SWA is chosen as the potable reuse alternative. RO concentrate management would be a challenge for PWD in all reuse scenarios.

As aforementioned, implementing SWA with Lake Palmdale could limit the maximum flow that the Leslie O' Carter SWTP could treat to provide a minimum of 60 days of HRT to below its capacity, which could potentially lower future supply options to PWD.

Finally, the additional monitoring (when compared to the groundwater injection alternative) that is required for the reservoir will increase costs related to laboratory analyses and labor for sampling and reporting. However, it is still significantly less sampling, monitoring, and costs when compared to DPR projects.

3.3 Raw Water Augmentation

In the case that either the aquifer or reservoir retention time requirements of two months are not met for the GWR or SWA alternatives, the program could still move forward, but would be characterized as a DPR project with an increased set of requirements. RWA could also be pursued by conveying the AWPF purified water to the headworks of the SWTP for further treatment and potential pathogen LRVs. However, utilization of the environmental buffer (groundwater or reservoir) would help to alleviate certain key aspects in the DPR draft regulations, including failure response time, peak chemical attenuation and, potentially, dilution. Additionally, less SWP would be used, impacting the 39% groundwater return flow credit for use of SWP.

Currently, the SWTP LRVs accounted for in DPR projects per the draft regulations are 2/0.5/0, unless the project demonstrates all pathogen LRVs using pre-validated technologies to obtain higher LRVs. The SWTP LRVs can be applied in the scenarios using a reservoir and the conveyance leading to a SWTP (i.e., it cannot be applied in the DPR scenario aiming for groundwater replenishment under 60 days of retention time underground). Table 13 summarizes the estimated LRVs expected from unit processes at DPR facilities and the required LRVs.

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Table 13. Summary of Anticipated Pathogen Removal Log Removal Values for Direc	Ł
Potable Reuse	

Process	Virus	Giardia	Cryptosporidium
Ozone	6	6	1
BAC	-	-	-
MF	0	4	4
RO	1.5-2.5	1.5-2.5	1.5-2.5
UV/AOP	6	6	6
Free Chlorine Disinfection ⁽¹⁾	0-6	0-1	0
SWTP ⁽²⁾	2	0.5	0
DPR Minimum Required	20	14	15
Total	19.5-20.5	18.5-19.5	12.5-13.5

Notes:

¹ 6 virus LRVs and 1 Giardia LRV can be granted free chlorine LRVs depending on the concentration, contact time, and approach.

² SWTP LRVs can be increased to 4/3/2 by demonstrating the use of pre-validated technologies.

Key:

AOP = advanced oxidation process

BAC = biological activated carbon

DPR = direct potable reuse

LRV = log removal value

MF = membrane filtration RO = reverse osmosis SWTP = surface water treatment plant UV = ultraviolet

Table 13 shows a deficit of 0.5 to 2.5 LRVs compared to what is needed to comply with the minimum LRVs for virus and Cryptosporidium, respectively, if the minimum LRVs are granted for each unit process. As mentioned before, if the number of required pathogen LRVs is not met, challenge tests or monitoring alternatives can be proposed to increase the LRVs for some of the treatment processes. For example, recent studies using strontium as a surrogate with RO potentially increased the LRVs to 3 for V/G/C, but 2.5 is more commonly employed after challenge tests. Another example is increasing the O₃ dose or CT to achieve additional Cryptosporidium LRVs.

Alternatively, LRVs from Long Term 2 Enhanced Surface Water Treatment Rule-validated RO cartridge filters could be pursued at the AWPF, once the filters were already in place at the plant. For that to be gualified, the cartridge filter pore size must be a maximum of 1 micrometer, and its integrity must be confirmed by direct integrity tests. Up to 2 or 2.5 Cryptosporidium LRVs can be granted for individual filters or filters in series, respectively. This is based on the removal efficiency demonstrated during challenge testing with a 1.0 and 0.5-log factor of safety, respectively.

In the event the higher LRVs cannot be granted, or when they are still not enough to meet the minimum criteria with the processes shown in Table 13, further treatment must be employed. Example of LRVs from other treatment processes that could be employed for RWA are summarized in Table 14.

Table 14. Pathogen Removal Log Removal Values for Further Treatment Processes **Employed for Raw Water Augmentation**

Process	Virus	Giardia	Cryptosporidium
MBR	1-2.5	2.5-4	2.5-4
CIO ₂ Disinfection	4	3	1
UV Disinfection	0	4	4
RO cartridge filters (LT2 validated)	0	0	0-2.5
Kev	MBR	= membrane bioreac	tor

 CIO_2 = chlorine dioxide

LT2 = Long Term 2 Enhanced Surface Water Treatment Rule

MBR = membrane bioreactor

RO = reverse osmosis

UV = ultraviolet

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From the options in Table 14, UV and/or chlorine dioxide disinfection would be simpler and more inexpensive due to their ease of implementation and relatively small footprint. LRVs from membrane bioreactor (MBR) would require either more footprint at the AWPF for further biological treatment or retrofitting of the PWRP to accommodate the MBR as the secondary treatment technology.

The benefits and challenges associated with RWA are discussed in the following subsections.

3.3.1 BENEFITS

When the selected environmental buffer(s) cannot provide the required storage volume and associated retention time, additional treatment processes for the AWPF may be warranted. Treating water to a DPR level represents one approach that allows for the maximization of recycled water use. This alternative also would lead to a decrease in PWD's reliance on imported water, while ensuring public health safety to its customers.

3.3.2 CHALLENGES

Additional monitoring is required for DPR projects, beyond those already in place for IPR. These additional monitoring requirements are:

- Perform feed water quality monitoring for at least two years before the operation of the project for all regulated and non-regulated chemicals of interest, as shown in Table 5.
- Establish an enhanced source control program, such as implementing qualitative risk assessment for chemicals discharge to the collection system and monitoring of the sewershed online for chemical peaks.
- Provide a 10-fold reduction of one-hour chemical spikes.
- Monitor post-oxidation and finished water quality for the same chemical categories as IPR, but monthly instead of quarterly, among many others.

While IPR projects must report annually to the SWRCB and RWQCB regarding their project's compliance, DPR projects must do the same reporting monthly. The increased monitoring and reporting will significantly increase the overall cost of the project due to cost of monitoring equipment and maintenance, higher costs for chemical analyses, labor for plant O&M, as well as resources dedicated to reporting. Also, since DPR projects require more treatment processes than IPR, capital and O&M costs, as well as footprint, are larger.

A brine management plan would be necessary to dispose of the RO concentrate, as with the other alternatives. The difference is that if O₃/BAC is placed upstream of RO, the RO concentrate brine quality is significantly better than without O₃/BAC pretreatment. However, the concentrations of salts would very likely be the same, and the addition of a liner at the bottom of the brine ponds would still be required to protect the groundwater quality.

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DPR systems require more coordinated planning and contingency plans to meet certain response time requirements in the event of a failure to meet pathogen and/or chemical control requirements. Therefore, planning, regulating, designing, and operating a DPR facility is far more complex and involving than IPR projects, which results in significantly higher costs to the facilities.

3.4 Treated Water Augmentation

In the case of TWA, the AWPF purified water would be sent directly to the distribution system. DPR projects are the most challenging among the alternatives presented due to the high pathogen LRVs required, the complex chemical and source control planning, and the regulatory involvement. They are also the most expensive due to the number of treatment processes employed and the sampling and regulatory approach, among others.

3.4.1 BENEFITS

The benefits of a TWA application are the same as the RWA, except that the purified water can be available for the consumers in a shorter amount of time and with greater flexibility relative to where the purified water can be incorporated.

3.4.2 CHALLENGES

The challenges for a TWA project are similar to those for a RWA project, except that the SWTP LRVs cannot be accounted for in the TWA application. This results in the need for additional treatment processes, such as the ones presented in Table 14, and/or challenge tests or alternative monitoring practices to increase the LRVs of existing treatment processes.

3.5 Summary

A summary of the benefits and challenges discussed for all potable reuse alternatives discussed is presented in Table 15.

Criteria	GWR via Subsurface Injection	SWA	DPR (RWA/TWA)
Advantages	 Increases groundwater supply for drinking water use Lower costs (capital, O&M) Small footprint Fewer treatment processes, less complexity 	 Increases surface water supply for drinking water Small footprint Relatively new to the State, but current projects are actively pursuing this alternative Potential capital costs comparable to GWR via direct injection, but 	 Adds another source of water or increases volume of existing PWD water supply, making it more resilient to future droughts Can be used when IPR alternative(s) cannot meet the dilution and/or retention time requirements (RWA) Can add a source of water directly into the distribution system (TWA)

Table 15. Potable Reuse Alternatives Advantages and Challenges

Potential Potable Reuse Alternatives May 2023

	Well established state-wide	more stringent regulations may require additional planning effort (e.g., CTR compliance)	
Challenges	 Studies and modeling required to determine if groundwater flow and hydrogeology parameters are adequate to meet retention time and dilution requirements Must meet BPOs limits 	 Modeling required to determine if reservoir volume and flows are adequate to meet required dilution Studies and modeling required to determine if hydrology parameters are adequate to meet retention time requirements AWPF treated water must comply with CTR, unless a mixing zone (dilution factor) is studied and approved by the RWQCB 	 Most expensive alternative (capital, O&M, permitting, monitoring, reporting) Largest treatment footprint Most treatment processes, operational complexity New to the State (regulations have not been finalized, no permitted projects) More intensive, broad, and higher frequency monitoring required Requires higher degree of inter-agency coordination, technical, financial, and management capacity (more efforts for source control, sewershed monitoring, faster response to failure) More frequent reporting (monthly versus annually)

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Key: AWPF = advanced water purification facility

BPO = Basin Plan Objectives CTR = California Toxics Rule

DPR = direct potable reuse GWR = groundwater recharge IPR = indirect potable reuse O&M = operations and maintenance

RWA = raw water augmentation RWQCB = Regional Water Quality Control Board SWA = surface water augmentation TWA = treated water augmentation

Key Findings and Recommendations May 2023

4.0 Key Findings and Recommendations

Each potable reuse alternative has its benefits and challenges. The feasibility of the most economical alternative (i.e., GWR via direct injection) depends on favorable characteristics in the groundwater aquifer. Ongoing groundwater modeling efforts will determine the aquifer's suitability. SWA may require a similar amount of treatment as GWR, although additional planning efforts and, potentially, conveyance costs would be incurred to utilize Lake Palmdale or Little Rock Reservoir. DPR alternatives incur additional cost in the form of increased effort and investment in treatment, monitoring, and reporting. In these early stages of planning and assessment, PWD can potentially pivot from one alternative to another in the event the groundwater modeling results are not desirable. These pros and cons must be taken into consideration before moving forward with a final decision.

PWRP's tertiary effluent water quality and the final water reuse quality goals must also be taken into consideration when choosing the treatment processes at the AWPF. Even though DPR projects tend to have more stringent limits for chemicals, some limits for IPR, such as CTR (applying to SWA), can hinder the implementation of such projects, or require further treatment that ultimately results in increased capital and O&M costs.

From the alternatives presented herein, GWR via direct injection provides the most straightforward and economical implementation. The main challenges for this alternative are the modeled travel time and SNMP limits (Table 1 and Table 9). As discussed earlier, all goals will be met at the AWPF purified water based on the current PWRP tertiary effluent water quality and on the processes that will be employed at the AWPF – mainly due to RO. The only factor that could affect this alternative's implementation is the theoretical retention time that the aquifer provides. Therefore, the decision about the feasibility of this alternative can be made only after the groundwater modeling results are available.

As a backup alternative, preliminary estimates of dilution factor(s) and retention time(s) from both reservoirs (Lake Palmdale and Littler Rock Reservoir) indicate SWA is feasible and that further treatment beyond FAT may not be required. However, hydraulic modeling and tracer tests would be necessary to confirm these preliminary estimates. Additionally, studies such as disinfection byproducts formation potential in the purified water may be necessary to evaluate potential limitations in meeting CTR limits.

References May 2023

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APPENDIX A.4 Brine Management Strategy TM

3



Brine Management Strategy – Pure Water Antelope Valley

Final Technical Memorandum

May 2023

Prepared for: Palmdale Water District

Prepared by: Stantec Team

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Executive Summary May 2023

Executive Summary

Stantec Consulting Services Inc. was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). The objective of Pure Water AV is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection.

The reverse osmosis (RO) process is important in the reuse treatment train for salinity management (especially in arid regions) and for its ability to reject pathogens and trace constituents. However, it generates a continuous brine stream for disposal, which is a planning consideration that looms particularly large for inland systems. This technical memorandum describes the proposed brine management strategy for Pure Water Antelope Valley (Pure Water AV). Pure Water AV will include RO treatment as part of its advanced water purification facility (AWPF).

A planning-level analysis of RO system options is presented based on scaling models and array performance models. Conventional RO technology can serve as the primary RO system on its own, up to approximately 90% recovery. Higher recoveries often require some form of novel secondary RO system. Recoveries between 92% and 96% may be achievable with adequate pH adjustment and antiscalant dosing, with a likely theoretical scaling limit of around 94%. This would likely require secondary RO systems that use novel flow patterns (e.g., closed circuit RO [CCRO] or pulse flow RO [PFRO]). A high efficiency RO (HERO)-type process with more extensive pre-conditioning is required to reach recoveries greater than 96%. For each option, capital and operating costs that vary with RO recovery were calculated based on vendor quotes and performance models.

In addition to the analysis of the RO system options, a planning-level analysis of evaporation pond options is presented based on a general flow-balance model for pond sizing. This model accounts for evaporation loss across the pond surface each month, along with required storage for months with lower evaporation rates. A linear relationship was found between brine flow and required pond footprint, and various potential options were provided for pond layout, including one redundant cell.

A brine management planning baseline is generally established for full conventional RO treatment at 90% recovery, which requires approximately 113 acres of evaporation ponds for the first phase of the AWPF treating 4.75 million gallons per day (MGD) of influent. This planning baseline gives a unit cost of \$880/acrefoot (AF) for the combined cost of RO treatment and brine disposal. This baseline pond area would increase to approximately 246 acres for potential buildout to 10 MGD, with a similar unit cost of \$880/AF.

This baseline was used to evaluate the viability of emerging RO and brine management technologies. Cost curves were developed to demonstrate the relative capital and operations and maintenance (O&M) costs of the high recovery options and to compare to baseline. Secondary RO systems, such as CCRO and PFRO, could be viable in the 92% to 96% recovery range. This would achieve total RO and brine disposal costs in the range of \$580 to \$800/AF by reducing the evaporation pond required to the 47- to 91-acre range. These options are worthy of further study at the Pure Water Demonstration Plant, because of the potentially significant cost savings they could generate for the program. The high capital and operating costs of a HERO-type system make it more expensive than the planning baseline and not worthy of study at the Demonstration



Executive Summary May 2023

Plant. The optimum recovery is the highest achievable value without HERO, likely around 94%. Notably, the shape of the cost curves, and the resultant costs for RO treatment and brine disposal on a unit volume basis, are similar for potential buildout to 10 MGD.

In addition, some potentially viable, low-energy technologies exist that could improve the performance of the evaporation ponds (e.g., solar-powered mixers). Pond enhancements that can improve throughput efficiency and reduce pond size should be considered for full-scale implementation. The Demonstration Plant offers an important opportunity for brine management studies. Both low-energy pond enhancements, and potentially viable alternative disposal methods such as the Capture6 process to beneficially reuse brine for direct air capture of carbon dioxide, can be tested at demonstration scale.

Abbreviations May 2023

Abbreviations

AF	acre-foot
AWPF	advanced water purification facility
СС	closed circuit
CCRO	closed circuit reverse osmosis
FRRO	flow reversal reverse osmosis
ft/s	feet per second
gfd	gallons per square feet per day
HDPE	high-density polyethylene
HERO	high efficiency reverse osmosis
IL	Illinois
IPR	indirect potable reuse
LACSD	Los Angeles County Sanitation Districts
LAWA	Los Angeles World Airports
LRV	log removal values
MF	membrane filtration
MGD	million gallons per day
mg/L	milligrams per liter
ОН	Ohio
OPCC	Opinion of Probable Construction Cost
PFRO	pulse flow reverse osmosis
PRWA	Palmdale Recycled Water Authority
psi	pounds per square inch
Pure Water AV	Pure Water Antelope Valley
PWD	Palmdale Water District
PWRP	Palmdale Water Reclamation Plant
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board

Abbreviations May 2023

Stantec	Stantec Consulting Services Inc.
TDS	total dissolved solids
ТМ	technical memorandum
ТХ	Texas
WRCC	Western Regional Climate Center
WRP	water reclamation plant
ZLD	zero liquid discharge

Introduction May 2023

1.0 Introduction

Stantec Consulting Services Inc. (Stantec) was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional recycled water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). As part of that effort, several planning studies are underway for successful implementation of Pure Water AV. This technical memorandum (TM) describes the proposed brine management strategy for Pure Water AV.

1.1 Program Background and Drivers

PWD has been providing water service to its customers since 1918, when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the groundwater basin has been in overdraft since the 1930s, resulting in land subsidence and driving interest in improved sustainability. In 1973, Palmdale Irrigation District changed its name to Palmdale Water District.

PWD has conducted several studies that date back to as early as the 1990s to evaluate the water resources necessary to meet future water supply demands. Concepts evaluated to date include using recycled water for landscape irrigation, discharging into Palmdale Lake, and discharging into existing sand and gravel pits to replenish the groundwater basin. In 2012, the Palmdale Recycled Water Authority (PRWA), comprising members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area. PRWA manages the distribution of recycled water and the design and construction of support facilities, and finances the efforts.

PWD has been exploring different concepts of groundwater banking, storage, and extraction. As part of that effort, PWD has conducted a series of pilot studies to determine the infiltration rates. Less than favorable results from the pilot studies led PWD to evaluate the feasibility of surface water augmentation and/or groundwater recharge via direct injection – two different forms of indirect potable reuse (IPR). Stantec was retained by PWD to conduct a feasibility study on IPR. Based on the results of the IPR feasibility study, PWD decided to pursue the concept further. Using tertiary effluent from the Los Angeles County Sanitation Districts' (LACSD) Palmdale Water Reclamation Plant (PWRP), PWD plans to produce potable quality water for groundwater recharge via direct injection. Additionally, one of the major components of Pure Water AV is the implementation of the advanced water purification facility (AWPF), which is projected to include a treatment train consisting of membrane filtration (MF), reverse osmosis (RO), and ultraviolet-advanced oxidation process.

1.2 Study Background and Objectives

This TM, which summarizes the brine management strategy for Pure Water AV, includes an analysis of RO systems and evaporation ponds; an evaluation of the economic model and cost curves for RO treatment and brine disposal; and recommendations for demonstration testing and full-scale facility planning. The objective of Pure Water AV is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection (project).

Introduction May 2023

There are several ongoing planning studies for the implementation of the Pure Water AV program. As an inland reuse project, a critical planning component is the management of RO brine discharge, which may represent a substantial cost to project. The RO process is important for salinity management (especially in arid regions) and for its ability to reject pathogens and trace constituents. From a public health standpoint, it is one of the most important barriers in the reuse treatment train. However, it generates a continuous brine stream for disposal, which is a planning consideration that looms particularly large for inland systems.

The objective of this study is to develop an optimum brine management strategy that results in reduction of the footprint and the cost of brine disposal facilities by decreasing generated brine volume. Baseline analysis is presented to establish planning-level design criteria and costs of conventional RO treatment and evaporation ponds for brine management. In addition, emerging technologies that are potentially applicable for this program are evaluated for higher-recovery RO systems and alternative brine disposal options. An economic model is used to compare these alternatives to the baseline and quantify the tradeoffs between higher RO costs and lower brine disposal costs as RO recovery increases.

1.3 Technical Memorandum Structure and Content

This TM is divided into the following sections:

- Section 1 Introduction Provides the program background and drivers and study background and objectives.
- Section 2 Study Approach Describes key water quality and economic assumptions that are
 relevant to brine management planning and the overall approach used to develop the brine
 management strategy.
- Section 3 Reverse Osmosis System Analysis Contains an analysis of conventional and enhanced RO system options, leading to planning-level sizing and arrangement for RO systems at various recoveries.
- Section 4 Evaporation Pond Analysis Presents an analysis of evaporation ponds, leading to planning-level sizing and arrangement for brine disposal facilities at various recoveries.
- Section 5 Planning Baseline and Cost Curves Provides the overall economic model and cost curves for RO treatment and brine disposal as a function of design recovery.
- Section 6 Program and Demonstration Testing Recommendations Summarizes recommendations for demonstration testing and full-scale AWPF planning.
- Section 7 References Provides a list of references used in the TM.

Study Approach May 2023

2.0 Study Approach

2.1 Advanced Water Purification Facility Capacity and Location

In the first phase of the project, the objective of the PWRP is to treat and reuse 4.75 million gallons per day (MGD) of the tertiary water available from PWRP for potable reuse. Based on the Feasibility Study (Stantec, 2021), this 4.75 MGD feed to the AWPF would yield a 4.52 MGD feed to the RO process, and this 4.52 MGD RO feed rate is used in this study. The available flow is expected to increase to around 10 MGD in the future, by sourcing additional tertiary water from the Lancaster Water Reclamation Plant (WRP). Future expansions to facilitate the use of water from Lancaster WRP would require significant piping and pumping facilities due to the location of this plant. While this study is based on a 4.52 MGD RO feed for the first phase of AWPF implementation, the tradeoffs identified between RO and brine disposal costs provide useful insights for planning future phases of Pure Water AV as well. The additional brine pond acreage required for the full expansion to the 10 MGD plant has also been evaluated for future expansion considerations.

The location of the full-scale AWPF is currently planned to be on 25th Street and in the vicinity of Avenue P10, on an area that is approximately 14.8 acres and less than 8,000 feet away from the PWRP. PWD is in the process of procuring the site for the full-scale AWPF. The evaporation ponds are planned to be located around this area as well.

The final location has not yet been determined. Figure 1 shows the proposed AWPF location, and the old oxidation ponds of LACSD, which were initially considered for placing the brine ponds. The availability of the old oxidation pond site is still to be confirmed, and other sites are being explored in the vicinity of the proposed AWPF location.

Study Approach May 2023

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Figure 1. Proposed Location for Advanced Water Purification Facility Site

Study Approach May 2023

2.2 Water Quality

Historical effluent data from PWRP was analyzed for the period ranging from January 2017 to December 2021, to evaluate the projected feed quality to the AWPF. The minimum, average, and maximum values were used as inputs for RO modeling. Electroneutrality analysis showed that positively and negatively charged ions were well balanced (within 10%), and there was good agreement between calculated and measured total dissolved solids (TDS), which indicates that these water chemistry profiles are reasonable and complete. The feed water quality is summarized in Table 1.

	Palmdale WRP	Palmdale WRP	Palmdale WRP	
Parameter	Effluent - Minimum	Effluent - Average	Effluent - Maximum	
	mg/L	mg/L	mg/L	
Cations		·		
Calcium	24.5	34.1	39.5	
Magnesium	5.8	9.0	12.9	
Sodium	95.3	119	139	
Potassium	15.9	15.9	15.9	
Iron	0.04	0.04	0.04	
Manganese	0.0207	0.0207	0.0207	
Aluminum	0.01	0.01	0.01	
Barium	0.0225	0.0225	0.0225	
Ammonia as Nitrogen	0.65	1.91	5.27	
Total Cations (meq/L)	6.3	8.2	9.9	
Anions				
Bicarbonate	79	118	154	
Carbonate	0.007	0.070	0.449	
Chloride	107	146	180	
Sulfate	49.4	68.6	78.7	
Nitrate as Nitrogen	0.9	2.6	8.9	
Phosphate ¹	1.9	1.9	1.9	
Total Anions (meq/L)	5.5	7.7	9.9	
General				
pH (pH units)	6.3	7.1	7.8	
Alkalinity as CaCO ₃	65	97	127	
Temperature (°C)	14.5	23	30.1	
Silica ¹	20.3	20.7	21.1	
Calculated TDS	401	539	658	
Measured TDS	406	475	536	
Total organic carbon ²	5.3	6.1	7.8	

Table 1. Summary of Historical Tertiary Water Quality

Notes:

¹ Based on additional analysis conducted in July 2022

² From Tertiary Water Requirements Technical Memorandum draft (September 2022)

Key:

°C = degrees Celsius

 $CaCO_3 = calcium carbonate$

meq/L = milliequivalents per liter

mg/L = milligrams per liter

TDS = total dissolved solids

WRP = Water Reclamation Plant

Study Approach May 2023

The water quality data showed that the disinfected tertiary water is high quality water, with TDS generally ranging from 400-600 milligrams per liter (mg/L). This relatively low TDS compared to other reuse systems in arid regions means that very high RO recoveries may be theoretically possible. The water quality profiles in Table 1 were used as feed water quality to project RO performance. There will be an MF treatment step before RO at the AWPF; however, MF treatment will mainly remove suspended solids. Major ion chemistry and trace dissolved constituents based on historical influent data can therefore be used for RO modeling, as further described in Section 3.

Historical data for silica and phosphate were not available; therefore, additional sampling was conducted to estimate concentrations of these constituents, and the results have been included in all the analysis conducted for this TM. Silica and phosphate are key constituents in projecting RO performance, and the limited data available limits the interpretation of the modeling results herein. Variability in silica and phosphate levels will be further assessed at the Demonstration Plant, but obtaining data even before completion of the testing plan at the Demonstration Plant is important from a scheduling standpoint to inform the full-scale design studies. Frequent monitoring of these key constituents at the Demonstration Plant will better inform the analysis on achievable maximum recovery.

2.3 Approach for Brine Management

This study is based on a stepwise planning process for brine disposal that has been applied to other RO brine disposal planning efforts in California and Arizona (Adelman et al., 2021). The study approach is summarized in the following steps:

- Start with full RO treatment at typical brackish-water recovery in the 75% to 85% range.
- Reduce RO brine flow by considering partial RO treatment and increasing RO recovery to typical limits for conventional systems based on cross-flow velocity. Partial RO treatment was not a suitable option for this project due to full treatment required for pathogen / log reduction values.
- Size evaporation ponds for the resultant brine flow at conventional recovery limits.
- Establish a planning baseline based on conventional RO and evaporation pond technology and calculate the baseline cost per AF produced for RO equipment plus brine disposal.
- Use a scaling model to identify the fundamental solubility-based limits for RO recovery.
- Evaluate advanced RO technology options and alternative brine disposal methods relative to this baseline by sizing RO systems for different recovery targets and scaling evaporation pond size to the total brine flow.
- Develop cost estimates for different RO recovery scenarios to determine the optimum recovery target for Pure Water AV.

A key variable in this approach is the RO recovery. For a given RO feed rate (fixed at 4.52 MGD in this study), increasing the RO recovery will produce a greater share of product water and a smaller share of brine.

Study Approach May 2023

2.4 Economic Analysis

The fundamental questions in this study include:

- What is a plausible baseline cost for conventional RO treatment and brine disposal?
- For potential RO and brine management alternatives, how does their cost compare to the planning baseline?
- When RO recovery is increased, how do the marginal benefits (i.e., reduced brine disposal cost, increased recoverable water) compare to the marginal costs (i.e., increased costs for RO equipment, energy, and chemical feeds)?

An economic model is well-suited to address these questions of relative costs and tradeoffs. Developing cost curves for various RO recovery alternatives requires accounting for important costs and putting them into comparable terms.

This economic evaluation considered all costs that may vary with RO recovery to quantify tradeoffs between higher RO treatment costs and lower brine disposal costs as RO recovery increases. Costs that are factored into this analysis include:

- RO capital costs Treatment system equipment procurement, including membrane arrays and associated pumps, cartridge filters, instruments, tanks, etc. RO equipment tends to increase in cost for systems able to achieve higher recovery. Balance-of-plant costs (e.g., structural features and major process piping) were excluded, because they would be similar for any RO recovery, so RO equipment cost captures the key capital cost changes at variable recovery.
- RO operating costs Energy and continuous chemical dosing. RO operating costs also tend to
 increase at higher recovery, due to greater conditioning requirements, additional pumping for
 advanced RO systems, and higher osmotic pressure. Labor costs are excluded because, although
 the frequency of cleaning and membrane replacement may increase at higher recovery, the total staff
 required to operate the plant would remain similar. In addition, because clean-in-place and membrane
 replacement take place on the time scale of months and years, respectively, the cost of cleaning
 chemicals and membrane elements is small compared to costs of power and continuous chemical
 feeds. Therefore, energy and continuous chemical feeds capture most of the changes in operating
 costs at variable recovery.
- Evaporation pond capital costs Opinion of Probable Construction Cost (OPCC) for the ponds, including land cost per acre, conveyance, earthwork, high-density polyethylene (HDPE) liner, and flood control improvements. This cost scales more or less directly with pond size.
- Evaporation pond operating costs Excavation and disposal of precipitated salts and liner from individual pond cells at the end of the liner life. Evaporation ponds are a passive system and have relatively few operating costs on a continuous basis.

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Total costs for RO treatment plus brine disposal were reported in dollars per AF of product water. Capital costs were annualized assuming a 20-year period and 4% discount rate, which reflect typical assumptions for an amortization period and time value of money over that period. Note that the discount rate is distinct from a short-run cost escalation factor, which was not used in this analysis because it does not affect *marginal* costs. Annualized capital costs were added to operating costs to give total annualized costs, and this total was divided by total annual production to give cost per AF produced.

Reverse Osmosis System Analysis May 2023

3.0 Reverse Osmosis System Analysis

The RO treatment step will help improve the effluent quality for downstream application by rejecting salts, pathogens, and trace contaminants. Considering the goal of achieving log removal value (LRV) credit for the RO process (as confirmed by online surrogates like conductivity or total organic carbon), the RO system must be capable of handling 100% of the 4.52 to 10 MGD MF effluent (i.e., without bypass).

This section details the sizing and configuration rationale for an RO system to achieve the highest recovery feasible while maintaining a reasonable flux distribution through the RO membranes and minimizing the disposal costs associated with brine management. First, a base case analysis was conducted to evaluate a plausible Primary RO system with conventional technology. Thereafter, scaling models were used to define the maximum theoretical recovery based on solubility limits. The outcome of this analysis was then used to model the secondary RO system required to achieve the maximum recovery considering solubility limits. Various RO technologies were evaluated for applicability to this project, and potential RO arrangements were developed at various recoveries for the economic model.

3.1 Conventional Primary Reverse Osmosis Model

Design criteria were evaluated for a full-scale RO system with feed flow of 4.52 MGD. Analysis was carried out for 90% recovery (higher than typical conventional RO recoveries that range from 80%-85%), because a conventional RO system capable of operation at this design point would (with some modifications) be adequate for lower recoveries as well. Some conventional RO systems operate at greater than 90% (e.g., Water Replenishment District's Leo J. Vander Lans AWPF and Padre Dam Pilot) but 90% recovery is a conservative upper limit for conventional RO systems. An RO configuration with 6+1 skids, 3 stages each, and a 12:6:3 pressure vessel array resulted in reasonable flux and flow distribution. Each pressure vessel was assumed to include 7 elements, 40 inches in length, and an active area of 400 square feet per element. This arrangement resulted in an average flux of 11.5 gallons per square feet per day (gfd), which is within the typical range of 9 to 14 gfd for conventional RO treating MF/ultrafiltration effluent in potable reuse systems.

To verify the array configuration, the RO arrangement was simulated using the Integrated Membrane Solutions Design (IMSDesign®) software platform by Hydranautics. The Hydranautics ESPA [Energy-Saving Polymide] membranes (ESPA2-LD) with an active area of 400 square feet was selected, and to model a realistic fouling-induced flux reduction through a membrane, a constant flux decline of 10% per year over the lifetime of the membrane was used. Salt passage increase was also assumed to be 10% per year. The staging arrangements of the RO are illustrated in Figure 2.

The operating window of the RO system was evaluated by varying the feed water quality, water temperature, and membrane age. The variation in feed water quality was defined as high, medium, and low – corresponding to the historical maximum, average, and minimum concentrations of soluble salts and metals observed in RO feed. As mentioned earlier, any removal ahead of RO through MF was neglected for conservatism by assuming tertiary effluent feed water quality for RO feed. To simulate flux decline over time, three membrane ages – 0, 3.5, and 7 years – were considered. Using various

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combinations of these governing factors, seven scenarios were identified to define the operating envelope of the RO system, as shown in Table 2.



Figure 2. Schematic of RO Stages

Scenario	Water Temperature	Water Quality	Membrane Age (years)	Objective
Scenario 1	Low	High	7	Highest feed pump pressure
Scenario 2	High	High	7	Highest TDS in permeate
Scenario 3	Low	High	0	Highest TDS in brine
Scenario 4	High	High	0	Size booster
Scenario 5	Medium	Medium	3.5	Typical average operation
Scenario 6	High	Low	0	Lowest pump pressure
Scenario 7	Low	Low	0	Lowest TDS in permeate

Table 2. Critical Scenarios Developed to Model the RO Process Train

Key:

TDS = total dissolved solids

As the results for booster sizing show, the system required a maximum 50 pounds per square inch (psi) booster pump between the second stage and third stage. The model also showed the maximum feed pressure required was 212 psi. Overall, the results showed that the proposed conventional RO arrangement at 90% recovery was feasible for planning purposes. Selected critical performance parameters, including specific energy and average flux, for the different scenarios are summarized in Table 3. The specific energy ranged from 0.89-2.24 kilowatt-hours per kilogallon (within the typical range for reuse RO systems), and reasonable fluxes and recoveries at each stage were achieved across the range of water quality, temperature, and membrane age conditions. Refer to Appendix A for the complete Hydranautics model output.

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Parametera	Scenario						
Farameters	1	2	3	4	5	6	7
Specific energy, kwh/kgal-perm	2.24	1.45	1.26	0.89	1.26	0.82	1.2
Average flux, gfd	11.3	11.1	11.1	10.8	11.2	11.2	11.4
Feed pressure, psi	212	133	114	78	115	71	108
Booster size, psi	50						
Feed TDS	690	690	690	690	538	417	417
TDS of RO permeate	25.8	41.3	16.1	27.2	17.1	12.33	7.50
TDS of RO concentrate	6719	6575	6804	6668	5360	4099	4114

Table 3. Summary of Results from RO Modeling

Key:

gfd = gallons per square foot per day

kgal = kilogallon

kwh = kilowatt-hour

psi = pounds per square inch

RO = reverse osmosis

TDS = total dissolved solids

This conventional RO analysis produced insights for other potential recoveries as well:

- >90% Recovery would begin to run into limits with low cross-flow velocity. The minimum cross-flow velocity on the feed-concentrate side is approximately 0.1 feet per second (ft/s) at 90%, which is close to typical design limits of 0.08 to 0.1 ft/s and higher recovery would reduce cross-flow velocity even more. Therefore, 90% recovery is a reasonable planning-level limit for conventional RO. Somewhat higher recoveries up to around 92% may be achievable with conventional RO, but system-specific testing would be recommended to achieve this.
- <90% Recovery would be achievable with similarly sized skids as were analyzed for the design envelope above and would represent less critical design cases. Three-stage RO would be selected at 85%, while only two stages would be needed at 75% or 80%.

3.2 Scaling Analysis

At high RO recovery conditions, scaling may be exacerbated, because ions in the RO feed are concentrated into smaller and smaller volumes of brine and therefore begin to reach the solubility limits for sparingly soluble salts. To characterize the RO scaling regime and levels of antiscalant required, the Avista AdvisorCi® online chemical dosing platform was used. The AdvisorCi model has been shown in recent studies to accurately predict scaling for RO recoveries >90% (James et al., 2022). Additional scenarios, as presented in Table 4, were developed to model the scaling potential at 90% RO recovery. The maximum and minimum tertiary effluent water quality parameters summarized in Section 2 were used to project feed water. The antiscalant type assumed for analysis was the Vitec 4000 from Avista, which is a recommended product for high recovery applications where silica is present. The scenarios developed to characterize and analyze antiscalant dosages are included in Table 4.

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Scenarios of Antiscalant Dose	Water Quality	Temperature	рН	Reason
Scaling Scenario S1	Maximum	High	Maximum (7.8)	High antiscalant dose
Scaling Scenario S2	Minimum	Low	Minimum (6.3)	Low antiscalant dose

The results showed that the recommended antiscalant dose was in the 2-3 mg/L range, considering the low and high dose conditions. To achieve this dose, the daily requirement for antiscalant addition required is in the range of 80-90 pounds per day for the Phase 1 AWPF feed rate.

The modeling results of Scenario S1 showed that the saturation index for calcium phosphate $(Ca_3(PO_4)_2)$ was the highest at 80%. Scenario 2, with low pH and TDS, showed that all categories were below 8% of the product limit, with the exception of silicate (SiO_2) , which showed 79% of the product limit.

The results indicate that calcium phosphate is the controlling parameter, considering the maximum water quality and feed pH of 7.8. The low solubility of calcium phosphate at high pH results in higher scaling propensity on RO membranes (Malki and Abbas, 2013), and this is often of particular concern for potable reuse applications (Adelman et al., 2017). Therefore, the results show that pH adjustment may be necessary, when considering maximum concentrations and maximum pH in feed water. The saturation index observed for scenarios 1 and 2 are shown in Figure 3 and Figure 4, respectively. Refer to Table 5 for the summary of scaling model results.



Figure 3. Saturation Index Results for Scenario S1

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Figure 4. Saturation Index Results for Scenario S2

Scenario	Antiscalant Dose (mg/L)	Daily Requirement (Ibs/day)	Saturation Index Exceeded Product Limit?	Compound with Highest Saturation Index
Scenario S1	2.45	92.15	No	Ca ₃ (PO ₄) ₂
Scenario S2	2.39	90.1	No	SiO ₂

Key:

lbs/day = pounds per day

mg/L = milligrams per liter

RO = reverse osmosis

Utilizing pH adjustment to lower the feed pH would allow more than 90% recovery at maximum water quality scenarios, without exceeding any of the product limits. Additional runs were performed to investigate the maximum RO recovery that would result in all compounds being within their product limit, using sulfuric acid to adjust feed pH. The highest recovery observed with all parameters below their product limits was 94% at feed pH of 6.9 (Figure 5). To achieve this feed pH, about 25 mg/L of sulfuric acid dose is needed, which would require chemical addition of 66 gallons per day of 93% sulfuric acid. After pH adjustment, the primary drivers for scaling shift to silicate and calcium carbonate precipitation potential, while calcium phosphate (Ca₃(PO₄)₂) and barium sulfate (BaSO₄) showed the next highest saturation index.

While pH adjustment allows higher RO recovery, the additional cost associated with chemical consumptions should also be considered. In addition, lower feed pH also means more chemical consumption downstream for the post-stabilization step, where reagents such as caustic and calcium chloride are used to adjust pH and alkalinity of product water. On the other hand, higher RO recovery can significantly reduce the capital and operational cost of brine management, as further detailed in Section 5.2. Overall, the highest theoretical recovery based on feed conditioning with acid and antiscalant and fundamental solubility limits appears to be around 94%, considering maximum (worst-case) feed water quality. Further reductions in pH do not affect BaSO₄ solubility and worsen silica solubility. Therefore, additional acid dosing would not further increase recovery, and increasing from 94% to 96% would be expected to lead to silica scaling in this model. Some advanced RO systems (as discussed in the next

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section) at least claim to delay silica scaling beyond typical solubility limits, but further testing would be required to validate this claim.

As mentioned earlier, there was limited data on key scaling constituents (i.e., silica and phosphate). Demonstration testing would be beneficial for any RO system to be designed for >90% recovery, and especially in a case where a more extensive dataset is needed for key drivers of scaling. The demonstration scale results will be very important to give a more thorough data set for key drivers of scaling like phosphate and silica; to account for the contributions of biofouling and colloidal particles which may be important to overall fouling in a reuse application; and to understand the scaling regime and maximum theoretical recovery independent of any particular vendor system. Nevertheless, the scaling models presented here show that recoveries in the 92%-96% range may be theoretically achievable, with a most likely maximum recovery around 94%.



Figure 5. Saturation Index Results at 94% RO Recovery and Feed pH of 6.9

3.3 Secondary Reverse Osmosis System Options

Secondary RO may be required to achieve higher than 90% RO recovery and further minimize the brine produced. The analysis above showed that around 94% RO recovery could be achieved by dosing acid and antiscalant before fundamental solubility limits are reached. For these target recoveries, secondary RO systems were considered that utilize novel flow patterns or flow-based mechanisms to either maintain high cross-flow velocity, even at very low net brine flow rates, or otherwise reduce the induction times for nucleation of scale forming minerals that precipitate onto the membrane and cause scaling. A further incremental increase in recovery beyond about 94% would require further pre-treatment or conditioning steps. This is because of the impacts of silica, whose precipitation is exacerbated with decreasing pH.

Various commercially available advanced RO technologies were evaluated, as shown in Table 6, and the following advanced secondary systems were considered potentially viable for Pure Water AV: (1) HERO; (2) PFRO; (3) closed circuit reverse osmosis (CCRO); and (4) flow reversal reverse osmosis (FRRO).

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Vendor	System Name	Technical Concept	Potential Recovery	Installation References	Applicability
Desalitec (now part of DuPont)	CCRO	High cross-flow velocity is achieved even with low net concentrate flow using a feed- concentrate loop.	~92-96% (solubility limit)	Many commercial/industrial First installation - 2009, Israel Large installations in IL and OH Piloted for East County AWPF	Could serve as a Stage 3 Secondary RO system or as the Primary RO system
IDE	PFRO	High local velocity is achieved using pulsed flow on the feed-concentrate side over the time scale of minutes, which interferes with nucleation of crystals.	~92-96% (solubility limit)	Several successful recent pilots, in Israel and for reuse systems in CA and TX	Could serve as a Stage 3 Secondary RO system
Rotec	FRRO	Banks of vessels take turns serving as the various stages, ensuring that no single vessel experiences too low velocity or too high brine strength.	~92-96% (solubility limit)	Largest installation at Singapore PUB; selected for SWIFT and to be studied for Pure Water San Diego Phase 2	Would serve as the Primary three- stage RO system
Aquatech (leading OEM)	HERO	Divalent cations are removed and pH is raised to >10 to prevent silica scale.	~96-98%	60+ installations, mostly commercial/industrial	Could serve as a Stage 3 Recovery RO system with significant treatment of Stage 2 brine
Veolia	OPUS	Multiple pre-treatment processes ahead of RO to reduce the hardness, metals and suspended solids. Process operates at an elevated pH.	~99%	Mostly in mining, oil & gas, power, and industrial wastewater reuse	Less applicable – significant equipment would be required for pretreatment, including chemical softening, ultrafiltration, and IX softening
veolia	HPD	Uses evaporation and crystallization technology to recover water and byproducts, and reduce effluent volume.	~99%	Mostly in mining, oil & gas, power, and industrial wastewater reuse	Less applicable – significant equipment would be required for brine treatment, e.g., thermal evaporators or crystallizers

Table 6. Summary of Advanced RO System Options

Key:

AWPF = advanced water purification facility CA = California

CCRO = closed circuit reverse osmosis

FRRO = flow reversal reverse osmosis

HERO = high efficiency reverse osmosis IDE = IDE Water Technologies

IL = Illinois

IX = ion exchange

OEM = original equipment manufacturer OH = Ohio OPUS = optimized pretreatment and unique separation PFRO = pulse flow reverse osmosis PUB = Public Utilities Board RO = reverse osmosis TX = Texas

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The HERO process is a treatment system that is specially designed to handle high amounts of silica. The system is often used in zero liquid discharge (ZLD) or near-ZLD treatment applications because high recoveries can be achieved beyond solubility-based limits. The typical process includes removal of all divalent cations by softening and ion exchange; carbon dioxide removal and sodium hydroxide dosing to raise pH; followed by RO membrane treatment. Once the divalent cations are removed and the silica is solubilized at high-pH conditions, very little scale will form, even at high recoveries. However, the pre-treatment required increases the complexity of the operations and cost for chemicals and energy.

Unlike HERO, which relies on removal of ions to achieve recoveries beyond solubility-based limits, other secondary RO system options use novel flow arrangements to avoid the issues with low concentrate flow and low cross-flow velocities at high recovery in conventional systems. These systems are theoretically able to reach fundamental solubility-based recovery limits.

- **PFRO**. The PFRO operates by alternating between two modes: production and flushing. During production mode, the brine line is closed, and all the feed flow passes to the permeate side, also known as dead-end filtration. During the flushing mode, the permeate valve is closed and the brine valve is open, enabling the brine to discharge at high velocity. Cycling between the two modes over the time scale of minutes creates short and rapid pulses which discharge at high shear force and interferes with the nucleation of precipitate crystals. This process claims to be effective in reducing silica scaling.
- CCRO. Similar to PFRO, the CCRO system also alternates between two modes of operation: closed circuit (CC) at 100% recovery and plug flow (PF) or flushing mode at 15%-30% recovery. The system achieves high recovery by recirculating concentrate in CC mode until the target recovery is achieved. This allows good cross-flow velocity to be maintained independent of recovery. After achieving a desired recovery percentage, brine is purged from the system in PF mode and replaced with fresh feed without stopping the flow of pressurized feed or permeate. The duration of PF mode is usually around one minute, and CC mode varies usually from three to 12 minutes, depending on recovery.
- FRRO. This system is similar to conventional RO, but with a novel arrangement of valving that divides the pressure vessel array into various "banks," and each "bank" is rotated among the Stages 1, 2, and 3 positions in the array. This way, no element experiences too much time exposed to low cross-flow velocity or excessive brine strength, and some natural cleaning of scale happens as Stage 3 elements rotate back to Stage 1.

To predict the system requirements of a potential secondary RO system, a preliminary model was built using DuPont's WAVE water treatment design software. Only CCRO was modeled in this TM, because the modeling platform for CCRO is publicly available and this system is anticipated to show relatively higher specific energy compared to the other secondary systems due to recirculation of pressurized feedwater. The primary purpose of the model was to estimate the power requirements for a secondary RO system and use output in the subsequent economic model described in Section 3.4. Initially IMSDesign® and Advisor® software was used to simulate a two-stage conventional RO system with 79% overall recovery by modifying the models described in the previous section. The output for concentrate water quality was used as input to the secondary RO model, with 112.5 gallons per minute of feed flow per train to six parallel trains. The secondary RO recovery was altered to target an overall system

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recovery of 92% and 94%, by adjusting the duration of the CC mode (100% recovery). The secondary RO skid included six vessels with seven elements per vessel. The PF feed ratio was set at 109% for all the recovery scenarios. The major results are summarized in Table 7 and the complete modeling results are presented in Appendix A.

Devenetor	Overall Syst	em Recovery
Farameter	92%	94%
Secondary RO recovery (%)	63.6%	73.4%
CC sequency duration (min)	3.50	5.48
PF sequence duration (min)	1.87	1.85
Net product (gpm/train)	71.5	82.5
Average flux (gfd)	6.1	7.1
Feed pressure (psi)	73 - 84	73 - 98
Average NDP (psi)	37	39
Specific energy consumption (kwh/kgal)	3.4	3.6
Secondary RO Feed TDS (mg/L)	2,545	2,545
Secondary RO Permeate TDS (mg/L)	324	373
Secondary RO Brine TDS (mg/L)	6,408	8,511

Table 7. Summary of Secondary RO Results

Key:

CC = closed circuit gfd = gallons per square foot per day kgal = kilogallon kwh = kilowatt hour mg/L = milligrams per liter NDP = net driving pressure PF = plug flow psi = pounds per square inch RO = reverse osmosis TDS = total dissolved solids

The modeling results confirmed that combining a two-stage conventional RO with a secondary RO to target overall recovery of 92%-94% was feasible. The results of the secondary RO model showed that recovery in the secondary RO ranged from 64%-73%, and specific energy consumption ranged from 3.4-3.6 kwh/kgal, which is used as input to analyze the O&M cost in Section 5.2.

3.4 Reverse Osmosis System Arrangement for Economic Model

RO system sizing and arrangements for the economic model were developed based on the insights from the Primary and Secondary RO analysis with array and scaling models:

- The AWPF must treat 100% of the flow by RO based on LRV considerations, so partial RO treatment is not viable.
- A conventional RO system can be designed up to 80% recovery with a two-stage system, and up to 90% recovery with a three-stage system. The baseline design for conventional RO consists of a three-stage system with a 12:6:3 pressure vessel array.

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- Increased doses of acid and antiscalant are required to achieve >90% recovery by controlling calcium phosphate scale, and fundamental solubility limits exist around 94% recovery. At recoveries greater than 90%, a conventional array would begin running into design limits for crossflow velocity, so advanced Secondary RO systems would be used for operation around 92%-96% recovery. The arrangement would use a conventional Primary RO system for Stages 1 and 2 (12:6 pressure vessel array), feeding a Secondary RO system in the Stage 3 position with the equivalent of approximately three pressure vessels per train.
- Above 94%-96% recovery, the HERO process would be needed, and additional softening of divalent cations along with high pH to control silica would enable the RO to operate up to 98% recovery. The switch to HERO is most likely required around the 94% recovery solubility limits. Because of the uncertainty in this limit and the potential ability of different Secondary RO systems to delay silica scaling, cases were evaluated for both Primary and Secondary RO and HERO at 96% recovery.

The resulting RO arrangements for the economic model are shown in Table 8. This table includes specific energy from the RO array models and chemical doses from the scaling models as the basis for the operating costs, and the annualized equipment cost (at 4% discount rate over 20 years) based on vendor quotes as the basis for the capital cost. All cost estimates presented in this TM are based on 2020 U.S. dollars. Additional annualized capital and operating costs specific to the extra treatment steps in the HERO system are also included.

Recovery =	75%	80%	85%	90%	92%	94% 96		% 98%	
RO System	Two- Prima	Stage iry RO	Three Prima	-Stage ry RO	Two-Sta + Se	age Primary condary RO	RO	ŀ	IERO
RO Product (MGD)	3.39	3.62	3.84	4.07	4.16	4.25	4.3	34	4.43
Brine Flow (MGD)	1.13	0.90	0.68	0.45	0.36	0.27	0.1	8	0.09
Annualized Capex (\$/MGD)	\$44	,000	\$52	,000	\$61,0 \$69,	00 (CCRO) t 000 (PFRO)	0	\$1	81,000
Energy (kWh/kgal)	1.6	1.5	1.4	1.3	1.6	1.6 1.7 1.8		1 Prir	.3 for nary RO
Feed pH			diustmont		7.4	7.1	6.2		
Acid (mg/L)		по рп А		Justment		16	71		
Antiscalant (mg/L)	2.7	2.7	2.6	2.3	2.1			2.7	
HERO O&M (\$M/yr)								C,	\$1.92

 Table 8. Reverse Osmosis Arrangements for Economic Model and Cost Curves, Phase 1

Key:

\$ = U.S. dollars

\$M = million U.S. dollars

CCRO = closed circuit reverse osmosis HERO = high efficiency reverse osmosis

kWh = kilowatt hour

mg/L = milligrams per liter

MGD = million gallons per day

PFRO = pulse flow reverse osmosis

RO = reverse osmosis

yr = year

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3.5 Capital and Operations & Maintenance Costs

Equipment costs for the RO system were based on the following vendor data:

- A typical equipment cost of \$600,000 per MGD permeate capacity for two-stage conventional RO, which is on the low end of the typical range for RO equipment (Rickenbach and Kocher, 2016) and consistent with Stantec's experience.
- Quotes of \$2.9M and \$2.85M from H2OInnovation and Wigen, respectively, for three-stage conventional RO with the proposed 12:6:3 array design and 90% recovery. This equates to around \$712,000 per MGD of permeate capacity, on the high end of the typical range for conventional RO as expected for three-stage systems.
- Total costs of \$3.5M to \$4.0M for Primary RO with Secondary CCRO/PFRO, based on typical cost data from Desalitech and quotes from IDE, respectively. This equates to between approximately \$834,000 to \$937,000 per MGD permeate capacity for this style of RO system. Because of the variation between these two estimates, they are expected to capture the range of equipment costs for advanced RO systems with novel flow arrays and allow for the economic modeling of the feasibility of these systems. Pricing was not provided for FRRO during this study, but it will likely be in the same order of magnitude as the other systems.
- Quote of \$10M for capital cost and operating cost of \$6 per 1000 gal treated from Aquatech for the HERO system, including the RO equipment itself plus lime-soda softening, ion exchange, and decarbonation. The capital cost is equivalent to \$2.5M per MGD permeate capacity and the operating cost is equivalent to \$1.92M per year for the Phase 1 AWPF.

Operating costs included both power and chemicals. Power costs were calculated based on specific energy per unit volume of permeate under average conditions using a unit price of \$0.18 per kilowatt-hour for electricity. Chemical costs were based on total doses of acid and antiscalant per the models shown in Appendix A, with costs of \$33.57/gallon for 100% antiscalant and \$2.08/gallon for 93% sulfuric acid.

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4.0 Evaporation Pond Analysis

Passive solar HDPE-lined evaporation ponds are the most common method of brine disposal for inland facilities. These ponds are characterized by their shallow liquid depth, which allows for the rapid evaporation of effluent discharged into the ponds. As passive systems, they are often the cheapest brine disposal facilities from an operational standpoint.

Evaporation ponds were sized at four different RO recoveries, and potential layouts and footprints of pond facilities were developed. The four sizing cases allowed for the development of a relationship between brine flow and required pond size for any recovery. Pond enhancement technologies and alternative brine disposal methods were considered. Finally, capital and operating cost inputs were developed for the economic model.

4.1 Pond Sizing

4.1.1 EVAPORATION RATE

The design and sizing of evaporation ponds depends on the regional climate characteristics where the ponds are located. For arid climates, evaporation rates are expected to be higher. Factors such as average precipitation, monthly average pan evaporation, and seasonal temperatures affect the rate at which effluent evaporates from the disposal ponds. Average total precipitation and evaporation data from the Western Regional Climate Center was used for this analysis. Table 9 and Table 10 summarize the average total precipitation (WRCC, 2016) and pan evaporation (WRCC, 2022) for the project area.

Month	Average Total Precipitation (inches)
January	1.13
February	0.76
March	0.62
April	0.40
Мау	0.05
June	0.03
July	0.07
August	0.11
September	0.17
October	0.20
November	0.84
December	0.67
Annual Average	5.05

Fable 9. Average Total Precipitation	(1934-2016) for Pal	mdale, California
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Month	Mojave ¹	Beaumont Pumping Plant ²
January		2.90
February	4.65	
March	6.45	
April	9.97	
May	13.59	
June	15.33	
July	17.21	
August	16.00	
September	11.83	
October	8.28	
November	4.76	
December	3.52	
Annual Average		114.49

Table 10. California Monthly Average Pan Evaporation Rates in Inches, for Recording Locations Closest to Project Site

Notes:

¹ Closest available recording station based on distance to project site.

² Second closest available recording station based on distance and included to supplement the January monthly pan evaporation for erroneous data point.

4.1.2 SOLIDS PRECIPITATION RATE

As the water from the effluent evaporates, salts and minerals found in the brine effluent are precipitated as solids, which accumulate at the bottom of the pond and must be removed (by dredging) periodically to prevent reductions in available pond volume. Expected solids precipitation rates for this facility are summarized in Table 11. Rates of solids precipitation increase with the increasing salinity of the concentrate, with higher accumulation rates per year noted for 96% recovery, compared to the 90% recovery scenario.

Table 11. Preliminary	v Solids Precipitation	on Rates for Differen	t RO Recovery Rate

RO Recovery	Feed TDS (mg/L)	Brine TDS (mg/L)	Solids Precipitation Rate (ft/year)			
90%	707	6620	0.003			
92%			0.0035 ¹			
94%	740	11100	0.004			
96%			0.0045 ¹			

Note:

¹ Values based on federal government studies on brine desalting, calculated via interpolation between known brine salinity values for 90% recovery and 96% recovery (Office of Saline Water, 1970).

Key:

ft/year = feet per year

mg/L = milligrams per liter

RO = reverse osmosis

TDS = total dissolved solids

4.1.3 POND STORAGE CAPACITY

Evaporation pond sizing is determined by calculating the minimum water surface area required to maintain a volumetric balance between the detention of brine effluent, the evaporation of water from the

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brine effluent, and the accumulation of precipitated solids at the bottom of the pond. The minimum surface area will allow brine effluent liquids to evaporate faster than the brine effluent can reach the maximum volume capacity based on daily flows determined by the RO percent recovery. The expected volumes of brine effluent for the proposed RO systems based on RO percent recoveries ranging from 90% to 96% are shown in Table 12.

RO Recovery	Brine Effluent Flowrate (MGD)
90%	0.45
92%	0.36
94%	0.27
96%	0.18
Note: Beend on a total AM/DE f	and flow of 4 E2 MCD

Table 12. Volume of E	xpected Brine	Effluent for	Different	RO	Percent	Recovery	/ Rates
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Note: Based on a total AWPF feed flow of 4.52 MGD.

Key:

AWPF = advanced water purification facility

MGD = million gallons per day

RO = reverse osmosis

Minimum storage requirements for an evaporation pond generally vary seasonally as evaporation rates increase in the summer months due to higher temperatures and an increase in daylight hours. Evaporation and solids precipitation rates were used to determine the minimum water surface area required to meet the brine effluent flow rates. Detailed descriptions and calculations for evaporative and solids precipitation factors are presented in Appendix B. Expected monthly storage volume requirements for each RO percent recovery are shown in Figure 6.



Figure 6. Minimum Monthly Storage Volumes Needed for Evaporative Ponds Based on Expected Climate and Evaporation Rates at the Project Site

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4.1.4 AREA REQUIREMENTS

Minimum water surface area requirements were calculated based on the monthly storage volume needs outlined in the previous section (Section 4.1.3). Detailed calculations are available in Appendix B.

4.1.4.1 Current Area Requirements

Area requirements have been calculated for a design RO feed flow of 4.52 MGD. Four different RO recoveries have been evaluated ranging from 90% to 96%, in 2% intervals. Higher land requirements are expected for lower RO recovery percentages. Results are summarized in Table 13. The minimum water surface area acreage shown in Table 13 does not include supporting features required for construction of the ponds.

RO Recovery	Minimum Water Surface Area (acres)	
90%	81	
92%	65	
94%	49	
96%	33	

Table 13. Minimum Water Surface Area for Evaporation Ponds at Different Recoveries

Note: Based on a total AWPF feed flow of 4.52 MGD

Key: MGD = million gallons per day AWPF = advanced water purification facility RO = reverse osmosis

4.1.4.2 Future Operating Area Requirements

The available flow is expected to increase from 4.75 MGD to around 10 MGD in the future. While pond sizing and layout options in this TM are only provided for the current expected flows, the maximum potential area requirement for a flowrate of 10 MGD has been provided to inform future land acquisition efforts.

A 90% RO recovery has been used for this analysis; higher recovery rates result in lower land acquisition requirements. The expected area required for the ponds is 180 acres, as shown in Table 14. Maximum area requirements are assumed to not include the use of enhancement technologies.

Parameter	Value
RO Recovery (%)	90%
Brine Effluent Flowrate (MGD)	1.0
Minimum Water Surface Area (acres)	180

Key:

MGD = million gallons per day

RO = reverse osmosis

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4.1.4.3 Pond Sizing Assumptions

Total land area requirements for evaporation ponds are typically larger than the minimum water surface area required to meet the monthly storage volume needs. Land area requirements include supporting features such as embankment side slopes, access roads, and redundancy to achieve the desired pond dimensions and function. The geometric characteristics assumptions used to estimate the total land area requirements are summarized in Table 15.

Parameter	Value
RO Recovery (%)	90-96
Solids Precipitation Rate (ft-solids/yr)	0.003-0.0045
Pond Redundancy	N+1
Freeboard (ft)	2
Pond Maximum Depth (ft)	6
Maximum Aspect Ratio (L:W)	3
Berm/Road Side Slope	3H:1V
Berm/Road Top Width (ft)	15
Keen NL material and	and a second second

Table 15. D	Desian Assum	ptions for Ev	vaporation Pon	d Sizina

Key:	N = referenced number
ft = feet	RO = reverse osmosis
H = horizontal	V = vertical
L:W = length to width ratio	yr = year

Evaporation pond area requirements vary depending on the expected RO percent recovery. Three preliminary layout options created using the assumptions listed in Table 15 were evaluated for area and layout optimization to achieve this facility's evaporation pond goals. Descriptions and discussion of the layouts evaluated for Options 1 through 3 are shown in Section 4.4.3. For higher recovery scenarios, the salinity of the brine conveyed will be substantially higher than the baseline 90% scenario, and brine conveyance scaling considerations should be more concertedly managed with increasing RO recovery.

4.2 Effluent Conveyance

Brine effluent requires conveyance from the main plant facility to the evaporation pond effluent disposal site. New pipelines will need to be constructed to convey the brine effluent to the evaporation pond site. It is assumed that the residual brine pressure from the RO system (at least 75 psi in the scenarios in Appendix B) will be sufficient to convey the brine to the evaporation ponds without any additional pumping. The quantity and size of pipe, as well as the need for additional pumping, will depend on the selected site.

It is anticipated that a 6-inch plastic main pipe will be required for brine flow up to 0.45 MGD. Plastic piping is a reasonable choice for smaller-diameter brine lines, because the plastic surface is smooth and chemically inert, which helps mitigate issues with precipitate formation and pipe corrosion. In addition, the

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cost of several miles of brine conveyance pipe was built into each evaporation pond OPCC and the resultant unit cost. By scaling this unit cost for future pond options, this builds in the assumption that additional brine conveyance lines would need to be built for future phases. This assumption is reasonable given the uncertainty in facility siting, and is conservative compared to assuming that a single common brine line could serve all phases.

4.3 Enhancement Technologies

In some cases, land area requirement reductions are possible with the use of enhancement technologies and alternative brine disposal management strategies. Low-energy enhancement technologies are implemented when increases in evaporation rates can reduce the land footprint of passive solar evaporation systems. High-energy evaporation and alternative brine disposal management strategies are used in cases where land acquisition presents significant challenges and pond area must be minimized.

Enhancement technologies and alternative strategies were evaluated for viability of implementation for this program. Technologies and strategies evaluated included the following:

- Low-Energy Pond Enhancements. Various technologies exist to enhance the throughput of passive solar evaporation processes and reduce their required footprint. These technologies are often at least theoretically viable because of their minimal energy input, which is mainly intended to increase airwater contact rather than directly evaporate the brine. Low-energy enhancement technologies include misters, SolarBee® mixers, Wind-Aided Intensified Evaporation®, EcoVAP® panels, and Brine Solutions® halophilic microorganisms.
- **High-Energy Evaporation.** Brine can also be concentrated and evaporated through direct heating by systems such as thermal brine concentrators and crystallizers. These may be viable at a commercial scale, but their capital and energy costs at the municipal scale are often prohibitive. A crystallizer process for the Pure Water AV system would require several megawatts of connected load.
- Alternative Disposal Methods. In some cases, brine can be disposed of via sewers, deep-well injection, and evaporation at thermal power facilities. These are not practical for Pure Water AV: sewer disposal is generally limited to small quantities of brine, and both deep-well injection and power facility disposal require the local availability of the relevant facilities. A practical form of alternative disposal would likely require some benefit to be realized from the brine.

Evaluation criteria for the technologies and strategies included cost, geographic availability, and energy requirements. Refer to Appendix B for a full summary of the evaluation. As shown in Appendix B, the alternative strategies evaluation resulted in two low-energy enhancement solutions identified as viable options for the location and conditions of the proposed evaporation ponds: SolarBee Mixers and Brine Solutions bioaugmentation. Capture6® was also identified as a potential disposal alternative.

4.3.1 LOW-ENERGY POND ENHANCEMENTS

SolarBee Mixers are floating reservoir mixers that achieve high volumes of circulation through solar power, which help increase the evaporation rate of brine effluent. The SolarBee Mixer supplier, IXOM

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Watercare Technology, uses materials which are corrosion resistant for brine applications. SolarBee Mixers are easy to implement and have shown success in the Southern California climate, as demonstrated by the existing installations at Lake Palmdale. Additional power input is not required due to the use of solar energy to power the system. Previous installations of the SolarBee technology have yielded up to a 20%-22% increase in evaporation efficiency.

Brine Solutions, from Clear Creek Environmental, uses halophilic micro-organisms chosen based on brine characteristics to increase the efficiency of evaporation. The Brine Solutions microbial culture increases in effectiveness as salinity increases and requires no energy input or additional equipment. Due to the specialization of halophilic microorganisms, the efficiency is unique to each application.

4.3.2 ALTERNATIVE BRINE DISPOSAL METHODS

Capture6 is a novel process for direct air capture (DAC) of carbon dioxide. It is a brine utilization process that takes waste brine as a process input, and it consists of several treatment steps to generate sodium hydroxide from the brine and capture atmospheric carbon dioxide. In aqueous form, the carbon dioxide is converted to carbonate which makes it stable for long-term storage. By realizing the ancillary benefit of DAC, additional treatment of the brine through the Capture6 process may become viable. This makes it potentially useful as a disposal method from the standpoint of the AWPF.

4.3.3 VIABLE TECHNOLOGY COMPARISON

Design considerations for both evaporation enhancement strategies are summarized in Table 16. Additional brine disposal options described in Appendix B are not considered viable at this time, either because of limited installation track record at the required scale (e.g., for Wind-Aided Intensive Evaporation) or excessive energy costs (e.g., for thermal brine concentration).

Design Parameter	SolarBee Mixers	Brine Solutions Halophilic Microorganisms	Capture6
Power Requirements	 Solar powered; no external power requirements 	No power requirements	External power required
Installation	 Procured in units for easy installation Pilot testing not available 	 Brine ponds seeded with halophilic microorganisms Pilot testing available for site-specific microbiology 	 Process train with multiple steps Pilot testing available
Pretreatment	None	May require pretreatment, as determined by brine composition evaluation	 Multiple treatment steps produce NaOH This feeds into DAC of carbon dioxide
O&M	 Additional O&M costs associated with solar system and motors 	Regular testing and sampling required	 Power and chemicals Ancillary benefit of DAC realized
Adaptability	 Scales readily with pond size 	 Theoretically scalable Salinity requirements may restrict applicability 	Theoretically scalable to larger brine flows

Table 16. Evaluation of Design Considerations for Potentially Viable Technologies

Key:

O&M = operations and maintenance

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4.4 Evaporation Pond Arrangement for Economic Model

Evaporation pond sizing was developed based on the area requirements and geometric assumptions stated above.

4.4.1 INITIAL SIZING

In order to calculate the total area requirements including supporting features required for the construction of the ponds for the initial RO feed flow of 4.52 MGD, layout options have been selected for analysis. The minimum water surface areas required to achieve the evaporative volumetric balance are discussed in Section 4.1.4. Area requirements accounting for roads, berms, side slopes, and other geometric parameters for each layout option and RO percent recovery (also shown in Table 19 through Table 23) are summarized in Table 17. Detailed option descriptions, area requirements, and layout assumptions for each option are shown in Section 4.4.3.

RO Recovery	Option 1b (Retrofitted Existing Ponds)	Option 2	Option 3
90%	108.0	113.0	102.4
92%	90.0	91.1	82.6
94%	72.0	69.2	62.8
96%	54.0	47.2	42.9

Table 17. Area Requirements for Different RO Percent Recoveries

Key:

RO = reverse osmosis

Figure 7 graphically represents Table 17, and shows that the higher RO percent recovery leads to lower area requirements; however, these cost savings can be offset by higher operational costs to run the plant at the higher recovery percentages. The linear relationship between brine flow rate and pond size is apparent from this graph. Note that Figure 7 does not include Option 1b, because this represents a retrofit to existing ponds rather than optimized land requirement layouts.
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Figure 7. Area Requirements for Different RO Percent Recoveries

The resulting sizing and arrangement for the evaporation ponds at various RO recoveries is shown in Table 18. This information can be used to provide cost comparisons for the various recovery levels in the economic model in Section 5.2. This table used the linear relationship visible in Figure 7 to calculate brine pond size at any recovery, based on the following function:

$$A_{Pond} [acre] = Q_{Brine} [gpm] x \frac{0.35 \ acre}{gpm \ brine} + 3 \ acre$$

Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
Brine (MGD)	1.13	0.90	0.68	0.45	0.36	0.27	0.18	0.09
Brine (gpm)	785	628	471	314	251	188	126	63
Layout Area (acres)	278	223	168	113	91	69	47	25

Table 18. Evaporation Pond at Various RO Recoveries, Phase 1

Key:

gpm = gallons per minute

MGD = million gallons per day

RO = reverse osmosis

As shown in Table 18, the required minimum operating area and volume for a pond for 1 MGD of brine flow was consistent with the other sizing scenarios in its linear relationship to total brine flow. Therefore, the linear brine sizing function was used to estimate total pond sizing for various RO recoveries in a potential 10 MGD buildout scenario, as shown in Table 19.

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Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
Brine (MGD)	2.50	2.00	1.50	1.00	0.80	0.60	0.40	0.20
Brine (gpm)	1736	1389	1042	694	556	417	278	139
Layout Area (acres)	611	489	368	246	197	149	100	52

Table 19. Evaporation Pond Size at Various RO Recoveries, Future 10 MGD

Key:

gpm = gallons per minute

MGD = million gallons per day

RO = reverse osmosis

4.4.2 POTENTIAL SITE LOCATIONS

Figure 8, below, identifies the potential areas under consideration for pond development. A majority of the area shown is currently owned by Los Angeles World Airports (LAWA). Leasing or negotiations with LAWA are required by PWD to acquire the potential land. Three location options were evaluated for this study.

- Option 1: Repurposing the LACSD's former oxidation ponds
- **Option 2:** New property with ponds utilizing the maximum 3:1 aspect ratio in a north-south orientation
- Option 3: New property with ponds that minimize berm/road area placed in an east-west orientation



Note: Locations for consideration shown in light and dark blue shading. Figure 8. Locations Under Consideration for Proposed Ponds at PWRP Facility

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4.4.3 PRELIMINARY POND LAYOUT OPTIONS

Evaporation pond area requirements vary depending on the expected RO percent recovery. Three layouts were evaluated for area and layout optimization to achieve this facility's evaporation pond goals.

4.4.3.1 Option 1 – LACSD's Former Oxidation Ponds

Option 1 is based on the retrofit and repurposing of existing oxidation ponds owned and operated by PWRP. The plant currently has six existing oxidation ponds. Pond 2 and Pond 3 are located east of the main facility campus and are being considered for emergency plant flow storage and solar energy production use, respectively, and have not been evaluated for conversion to evaporative ponds. The remaining Ponds 4 through 7 are located northeast of the intersection of 40th Street East and East Avenue P. The area corresponding to Ponds 4, 5 and 6 is currently being considered for solar energy production. The locations of the existing ponds are shown in Figure 9.

If Ponds 4 through 6 are not used for solar energy production, they may be able to be used as evaporation ponds. Each pond has an area of 34 acres, for a total available water surface area of 136 acres, and a total land area availability of 144 acres, with an average depth of 9.8 feet. The ponds are laid in a grid configuration.



Figure 9. Location of Existing Ponds at PWRP Facility

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Option 1 has two configurations: Layout 1aand Layout 1b. Layout 1a utilizes the ponds in their existing 2x2 grid format, without altering the size of each individual pond. Layout 1b includes modifications to the existing ponds, where a berm is added to split each existing pond into two smaller equivalently sized ponds. This modification results in eight ponds each with a water surface area of 16.6 acres, which allows for greater operational flexibility and a smaller footprint, while still achieving an N+1 redundancy. Schematics for Layout 1a and Layout 1b are shown in Figure 10.

Existing Pond 6 Existing Pond 7	(16.6 ac)	(16.6 ac)
(34 ac)	Existing Pond 6b (16.6 ac)	Existing Pond 7b (16.6 ac)
Existing Pond 5	Existing Pond 4a (16.6 ac)	Existing Pond 5a (16.6 ac)
(34 ac)	Existing Pond 4b (16.6 ac)	Existing Pond 5b (16.6 ac)
	Existing Pond 7 (34 ac) Existing Pond 5 (34 ac)	Existing Pond 7 (34 ac) Existing Pond 6b (16.6 ac) Existing Pond 6b (16.6 ac) Existing Pond 4a (16.6 ac) Existing Pond 4a (16.6 ac) Existing Pond 4a (16.6 ac)

Note: Existing pond with no modifications (left) and existing pond with new berms (right)

Figure 10. Existing Oxidation Ponds and Configuration for Layout 1a and Layout 1b

Based on the increased operational and land use flexibility, Layouts 1a and 1b have different land requirements. Land area and retrofit requirements for Layout 1a are summarized in Table 20 and shown graphically in Figure 11. Land area and retrofit requirements for Layout 1b are summarized in Table 21 and shown graphically in Figure 12. The specific ponds to be retrofitted are shown for clarity only. Additional operational coordination with AWPF staff is required to determine which ponds provide the most flexibility for the facility and interfere the least with planned improvements.

Notably, higher RO recovery rates require less area. In some cases, the reduction is sufficient to limit the impact to a fewer number of ponds needing conversion to meet the minimum disposal requirements, including redundancy. Per discussions with PWD, the goal is to keep the brine ponds to only two of the existing oxidation ponds for this option. Layout 1a requires a 96% RO recovery rate in order to limit the impact to repurposing oxidation ponds as requested, while Layout 1b requires only a 94% RO recovery rate to achieve the same.

Due to the additional operational flexibility and the significant reduction in land area requirements, the remaining evaluation was completed using Layout 1b.

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Table 20. Acreage and Retrofit Requirements at Different Recoveries for Layout 1a

Characteristic	90% Recovery	92% Recovery	94% Recovery	96% Recovery
Minimum Water Surface Area (acres)	81	65	49	33
Pond Acreage Used (acres)	144	144	108	72
Number of Ponds in Use	4 of 4	4 of 4	3 of 4	2 of 4
Number of Existing Ponds Requiring Retrofit	4 of 4	4 of 4	3 of 4	2 of 4



Figure 11. Water Surface Area Requirements for Layout 1a for 90% to 96% Recovery

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Table 21. Acreage and Retrofit Requirements for Different Recoveries for Layout 1b

Characteristic	90% Recovery	92% Recovery	94% Recovery	96% Recovery
Minimum Water Surface Area (acres)	81	65	49	33
Pond Acreage Used (acres)	108	90	72	54
Number of Ponds in Use	6 of 8	5 of 8	4 of 8	3 of 8
Number of Existing Ponds Requiring Retrofit	3 of 4	3 of 4	2 of 4	2 of 4



Figure 12. Water Surface Area Requirements for Layout 1b for 90% to 96% Recovery

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4.4.3.2 Option 2 – Narrow Ponds Oriented North-South

Option 2 assumes the evaporation ponds will be constructed on newly acquired land. The size and orientation of the individual ponds is intended to implement a maximum aspect ratio of 3:1 (length to width). An N+1 redundancy scheme has been used to allow ponds to be taken offline for maintenance while still achieving the maximum surface area needed for evaporation. The Layout 2 schematic shown in Figure 13 is representative of the pond sizing and orientation that may be achieved for the stated assumptions. True pond orientation and shape may vary depending on land acquisition limitations.

Proposed	Proposed	Proposed	Proposed
Pond 1	Pond 2	Pond 3	Pond 4
Fully	Fully	Fully	N+1
Utilized	Utilized	Utilized	

Figure 13. Representative Schematic of Evaporation Pond Option 2

The minimum area required to achieve the parameters outlined for Option 2 depends on the expected brine effluent flowrate, which is based on the percent RO recovery. Land area requirements also include access roads, berms, and side slopes. A summary of the expected land requirements associated with Option 2 for different RO recovery percentages is shown in Table 22. The relative reduction in land requirements based on an increase in RO recovery is illustrated in Figure 14.

Table 22. Land Red	quirements for La	yout 2 Based on	Different RO Recover	y Percentages
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Characteristic	90% Recovery	92% Recovery	94% Recovery	96% Recovery
Minimum Water Surface Area (acres)	81	65	49	33
Layout Area Requirement (acres) ¹	113.0	91.2	69.2	47.2

Note:

¹ Layout area requirements include area allocations for access roads, berms, and side slopes.

Key: RO = reverse osmosis

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90% Recovery Land Requirement: 113.0 Acres				
92% Recovery Land Requirement: 91.2 /	Acres			
94% Recovery Land Requirement: 69.2 /	Acres			
96% Recovery Land Requirement: 47.2 Acres				

Figure 14. Relative Land Area Requirements for Option 2 at Different Recoveries

4.4.3.3 Option 3 – Wide Ponds Oriented East-West

Option 3 assumes the evaporation ponds will be constructed on newly acquired land. The size and orientation of the individual ponds is intended to achieve the low land area requirements for an N+1 redundancy scheme, which allows for ponds to be taken offline for maintenance while still achieving the maximum surface area needed for evaporation. This scheme maximizes the sharing of access roads between ponds to reduce land requirements. The Layout 3 schematic shown in Figure 15 is representative of the pond sizing and orientation that may be achieved for the stated assumptions. True pond orientation and shape may vary depending on land acquisition limitations.

Proposed Pond 1	Proposed Pond 2
Fully Utilized	Fully Utilized
Proposed Pond 3	Proposed Pond 4
Fully Utilized	Fully Utilized
Proposed Pond 5	Proposed Pond 6
Fully Utilized	N+1 Redundancy

Figure 15. Representative Schematic of Evaporation Pond Option 3

The minimum area required to achieve the parameters outlined for Layout 3 depends on the expected brine effluent flowrate, which is based on the percent RO recovery. Land area requirements also include access roads, berms, and side slopes. A summary of the expected land requirements associated with

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Layout 3 for different RO recovery percentages is shown in Table 23. The relative reduction in land requirements based on an increase in RO recovery is illustrated in Figure 16.

Table 23. Land Requirements for Layout 3 Based on Different RO Recovery Percentages

Characteristic	90% Recovery	92% Recovery	94% Recovery	96% Recovery
Minimum Water Surface Area (acres)	81	65	49	33
Layout Area Requirement (acres) ¹	102.4	82.6	62.8	42.9

Note:

¹ Layout area requirements include area allocations for access roads, berms, and side slopes.

Key: RO = reverse osmosis

90% Recovery Land Requirement: 102.	4 Acres	
92% Recovery Land Requirement: 82.6	Acres	
94% Recovery Land Requirement: 62.8	Acres	
96% Recovery Land Requirement: 42.9 Acres		

Figure 16. Relative Land Area Requirements for Layout 3 at Different Recoveries

4.5 Capital and Operations & Maintenance Costs

An OPCC (Appendix C) was developed for the 90% RO recovery rate as a baseline condition. This estimate determined the approximate quantities of materials, labor, and equipment for the major components necessary for scope items, including:

- Land acquisition at \$47,000/acre
- Conveyance piping from AWPF site
- Earthwork and placement of HDPE liners
- Flood control improvements

Class IV project construction and capital costs were developed for each layout. Option 1 - Layouts 1A and 1B were the most economical, with an estimated \$32M of project construction and capital costs. The retrofitting of two existing oxidation ponds eliminates a substantial amount of earthwork and requires less flood control improvements, but results in more lining and requires more conveyance facilities. Because

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the two existing oxidation ponds provide insufficient area and storage volume for the quantity of brine produced with a 90% RO recovery rate, 58 acres of greenfield evaporation ponds are needed. The resulting construction cost savings (relative to Options 2 and 3) is approximately \$1M. Options 2 and 3 project construction and capital were estimated to be \$33M. While land acquisition and liner costs for these completely greenfield alternatives are assumed to be lower, the earthwork and flood control improvement costs result in higher total project costs than the Option 1 alternatives.

Also included in Appendix C are two OPCCs for the repurposing of two of LACSD's ponds and the greenfield construction of an equivalent area (72 acres). Estimated total capital cost of two repurposed oxidation ponds is \$13.5M and results in about 72 acres of usable area. For an equivalent area of greenfield pond construction, the estimated total capital cost is \$21.9M. As seen by the difference between these two estimates, the potential total savings of repurposing the existing LACSD ponds is \$8.4M. However, to completely realize these savings, the RO recovery rates would need to be at least 94%. Lower RO recovery rates result in the need for more evaporation area than can be provided by the two existing oxidation ponds. In other words, the cost savings that can be realized by repurposing the existing oxidation ponds ranges from \$1M on the low end (90% RO recovery rate) to \$8.4M on the high end (94% recovery rate).

Based on the 90% RO recovery rate greenfield total project costs, a unit cost of \$300,000 per acre was used to scale with brine flow in a roughly linear fashion. This unit cost was selected as the baseline for the economic evaluation, as future program expansions would eventually require greenfield construction of brine evaporation ponds. Particularly for lower recovery cases and larger ponds, capital costs are the dominant cost of passive solar evaporation, and the most important cost that varies directly with total brine flow rate and therefore with RO recovery.

For this analysis, it was assumed that at the end of the approximately 20-year life cycle of the HDPE liners, each pond cell will be taken offline for the removal of all solids and replacement of the liner. This operation would be staggered so that the other pond cells could remain online while the redundant pond cell was offline for solids cleanout. Alternative lining systems can be designed with roller-compacted concrete and UV protection to last up to ~40 years and allow for some scraping of salts without replacing the liner. While such a liner system could be considered for final design of the ponds, the 20-year HDPE lining system assumed here is considered more likely.

In any case, while capital costs for passive evaporation ponds are strongly dependent on pond area, operating costs mainly reflect the periodic removal of solids and are more dependent on total salt loading to the system. On a mass basis, this total salt load is roughly independent of RO recovery, because it reflects virtually all of the TDS in the influent ending up in the RO concentrate. Solids accumulation at the bottom of the ponds is expected to range from 0.1 ft (based on the precipitation rates in Table 11) to 0.5 ft (the design allowance). Using the conservative 0.5 ft depth of solids, an annual equivalent of 4,400 cy/yr of salt disposal would be needed. The pond operating cost was based on an estimated cost of about \$200 per cubic yard, based on a quote of \$4.35M for excavation and hazardous disposal of precipitated solids and HDPE lining from one pond cell for the 90% case. Because the collection and shipment of this salt waste is subject to some uncertainty, it warrants further study to refine program cost estimates.

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5.0 Planning Baseline and Cost Curves

5.1 Planning Baseline

The recommended planning baseline is conventional RO at 90% recovery, using 6+1 RO trains in a 12:6:3 array configuration and Stage 3 boosters. This would require 4.52 MGD RO feed to produce 4.07 MGD product, with 0.45 MGD brine for disposal. A total of 113 acres of evaporation ponds in a six-cell configuration would be built to dispose of this brine.

This planning baseline is achievable with familiar and mature technology and would cost approximately \$880/AF for RO treatment plus brine disposal. Potential improvements in RO technology and alternatives for brine disposal can be compared to this baseline cost to determine their viability.

5.2 Cost Curves

The cost per unit volume treated was calculated as a function of recovery, as shown in Table 24. Full calculations are provided in Appendix D. Figure 17 shows cost curves assuming a solubility-based recovery limit at 94%, with HERO required for 96% recovery. Cost curves were also developed as shown in Figure 18 for the more optimistic case in which 96% recovery turns out to be viable with CCRO or PFRO before the HERO process is required. Each graph also includes a cost curve showing the effect of a pond enhancement that reduces area by 20%.

Cost curves were also generated for potential expansion to 10 MGD, as shown in Figure 19. Because the economic analysis was conducted on a unit volume basis, the overall costs as well as the shape of the curve were similar at each recovery. This shows that the economic analysis presented here is scalable to different RO and brine flows and not highly specific to the first phase of the AWPF.

Finally, a sensitivity analysis was carried out by varying several key assumptions, to ensure that the insights from the cost curves robust even with uncertainty in some of the input values (particularly evaporation pond related costs). One alternative cost curve was generated assuming 50% higher construction cost per unit area of pond. Compared to the base model, this curve is steeper at lower recoveries reflecting the large influence of pond area for high brine flows, and the cost of water increases overall (e.g., from \$880/AF to \$1,200/AF at the 90% recovery planning baseline). However, the optimum point on this curve is the same, and maximizing RO recovery is still beneficial at the program level. In addition, at increased evaporation pond cost, HERO-like systems may be more viable – a 50% increase in the cost per unit area of evaporation ponds brings the HERO alternative costs to around the planning baseline level, although the solubility-based limit for non-HERO systems remains the optimum point. A second alternative cost curve was generated using a lower annual volume of solids removal from the ponds, reflecting the solids precipitation rates in Table 11 instead of the conservative 0.5 ft depth assumption. This alternative curve simply shifts the total cost of water down at every recovery. For both alternatives in this sensitivity analysis, the optimum point and the magnitude of the total cost of RO treatment plus brine disposal remain similar. This indicates that the model is robust.

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Recovery =	75%	80%	85%	90%	92%	94%	96% (CCRO/ PFRO)	96% (HERO)	98%
Pond Capital (\$M/yr)	\$6.11	\$4.90	\$3.69	\$2.48	\$2.00	\$1.52	\$1.03	\$1.03	\$0.55
Pond O&M (\$M/yr)	\$0.88	\$0.88	\$0.88	\$0.88	\$0.88	\$0.88	\$0.88	\$0.88	\$0.88
Pond Cost (\$M/yr)	\$6.99	\$5.78	\$4.57	\$3.36	\$2.88	\$2.40	\$1.91	\$1.91	\$1.43
Pond Cost (\$/AF)	\$1,839	\$1,426	\$1,061	\$737	\$618	\$503	\$393	\$393	\$288
RO Capital (\$M/yr)	\$0.15	\$0.16	\$0.20	\$0.21	\$0.29	\$0.29	\$0.30	\$0.79	\$0.80
RO Energy (\$M/yr)	\$0.36	\$0.36	\$0.35	\$0.35	\$0.44	\$0.47	\$0.51	\$0.37	\$0.38
RO Chems (\$M/yr)	\$0.13	\$0.13	\$0.13	\$0.11	\$0.11	\$0.13	\$0.28	\$0.13	\$0.13
HERO Cost (\$M/yr)								\$1.92	\$1.92
RO Cost (\$M/yr)	\$0.64	\$0.65	\$0.68	\$0.67	\$0.84	\$0.90	\$1.09	\$3.20	\$3.23
RO Cost (\$/AF)	\$167	\$159	\$158	\$147	\$180	\$189	\$224	\$658	\$650
RO + Pond (\$/AF)	\$2,006	\$1,585	\$1,219	\$884	\$797	\$692	\$617	\$1,044	\$930

Table 24. Cost Per Unit Volume Treated as a Function of Recovery

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Key: \$/AF = dollars per acre-foot \$M/year = millions of dollars per year CCRO = closed circuit reverse osmosis

Chems = chemicals

HERO = high efficiency reverse osmosis O&M = operations and maintenance PFRO = pulse flow reverse osmosis

RO = reverse osmosis

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Figure 18. Cost Curves for RO Plus Brine Disposal with CCRO/PFRO Up to 96%

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Figure 19. Cost Curves with CCRO/PFRO up to 94%, Future 10 MGD



Figure 20. Sensitivity Analysis – Higher Pond Cost and Lower Disposal Volume Cases

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5.3 Cost Curve Implications

The cost per acre-foot produced is extremely high in the typical brackish water RO range from 75%-85% recovery – the RO and brine disposal costs alone are more expensive than many other sources of water, before even accounting for additional treatment and conveyance costs. At the 90% recovery planning baseline, RO plus brine disposal costs are reduced to around \$880/AF assuming passive ponds for both the initial AWPF and the future 10 mgd phase, and \$780/AF for enhanced ponds.

The lowest point on the cost curves is at whatever recovery can be achieved based on fundamental solubility limits before HERO is required – up to this point, the cost of increased RO system complexity is more than outweighed by the savings from smaller evaporation ponds. However, achieving the highest recoveries is more expensive because of the significant jump in cost for HERO compared to other Secondary RO alternatives. The curve suggests that the optimum Pure Water AV brine recovery for the AWPF is in the range of 92% to 96%, at whatever turns out to be the highest sustainable recovery before a HERO-type system is required.

Pond enhancements also represent a potentially notable source of cost savings, on the order of \$100/AF at the 90% recovery planning baseline and \$40/AF to \$80/AF in the 92% to 96% recovery range. The magnitude of savings from enhanced evaporation ponds decreases at increasing RO recovery. This is because the total acreage of ponds changes a lot as a function of brine volume for disposal, while a 20% increase in throughput achieved by pond enhancements represents a smaller and smaller decrease in gross area as recovery increases.

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6.0 Program and Demo Study Recommendations

6.1 Planning Baseline and Alternatives

Based on the analysis performed during this study, the combined RO and brine management cost per acre-foot produced is summarized for various system options in Figure 21.



Figure 21. Cost Per Unit Volume Based on Stepwise Analysis

Conventional RO at 90% recovery with passive, unenhanced evaporation represents a prudent planning baseline for the program, with an RO and brine disposal cost of around \$880/AF. Recovery of 90% is achievable with familiar, proven technology, and planning around this baseline ensures that sufficient land will be acquired to support evaporative disposal of brine. This baseline cost on a unit volume basis is similar for both initial AWPF implementation as well as potential future 10 MGD buildout.

The scaling models presented in this TM show that fundamental solubility-based recovery limits appear to be in the 92% to 96% range (most likely value ~94%) for RO pre-conditioning with pH control and antiscalant dosing. For recoveries greater than this, a HERO-type process would be required, with softening of divalent cations and high pH operation to ensure silica solubility. The significant increase in the level of treatment – which would include lime-soda softening, ion exchange, and decarbonation, before Stage 3 RO – increases the cost of RO more than it decreases the cost of evaporation ponds, and HERO is predicted to cost more than the planning baseline, even at 98% recovery. Therefore, HERO is not currently viable for the program and not recommended for the Demonstration Plant.

Program and Demo Study Recommendations May 2023

6.2 Permitting Requirements

Stantec contacted the Regional Water Quality Control Board (RWQCB) for the Lahontan region, who confirmed that they would be the key agency for permitting the evaporation ponds. Refer to Appendix E for notes from this call. RO brine is considered a "designated waste," and disposing of brine via passive solar evaporation triggers "lined surface impoundment" requirements per Title 27 of the California Code of Regulations. Key regulatory criteria for the RWQCB include the following:

- Lining: Title 27 is proscriptive with respect to liner requirements. The regulations specify the maximum hydraulic conductivity that must be achieved by a clay liner, and note that "engineered alternatives" (e.g. geosynthetic liners) may be used. Lining must be installed by a qualified contractor.
- **Stormwater:** The pond must have 2 ft minimum freeboard, and the designer must provide a volume calculation for the 100-year storm. The project sponsor needs either an Industrial Stormwater permit or a Notice of Non-Applicability for full capture of site stormwater.
- **Monitoring:** Monitoring wells will be required to sample both the vadose zone and groundwater. The District will also need to periodically sample and report water quality for the influent brine.
- **Financial Assurance:** Permitting a lined surface impoundment requires financial assurance for potential closure costs. A Memorandum of Understanding or some other agreement may be needed between the District and the RWQCB.

RWQCB noted that very deep impoundments may be considered jurisdictional dams under the oversight of the Division of Safety of Dams. A "wide and shallow" pond design philosophy that keeps their depth well under 30 ft helps avoid this designation. In addition, the particular parcels chosen for siting the ponds may be subject to local zoning requirements.

The District can keep the RWQCB updated about the status of the project and the anticipated timeline for final siting, final design, and construction of the evaporation ponds. The formal regulatory process requires submission of a Notice of Intent (Form 200) along with stamped design drawings and qualifications for the liner installer, and a meeting with RWQCB will be scheduled around this time.

The RWQCB noted that two lined surface impoundments are permitted as evaporation ponds in the Antelope Valley area for mining operations. Data on these existing sites is available in the State's Geotracker system, and this can be a useful reference when preparing submittals for permitting.

6.3 Demonstration Plant RO Studies

Increasing RO recovery up to 92% to 96% is theoretically possible based on solubility limits and could be achieved with advanced non-HERO Secondary RO systems that reach fundamental solubility limits by using novel flow patterns and limiting scaling of silica in particular. This would reduce the RO and brine disposal cost to \$580-\$800/AF depending on the actual recovery that proves achievable. Such Secondary RO systems – including CCRO, PFRO, and FRRO – would be worthy of further study at the

Program and Demo Study Recommendations May 2023

Demonstration Plant because of the potential cost savings for the program. At a minimum, it is recommended that the Demonstration Plant include a common Primary RO system producing Stage 2 concentrate to be treated by parallel conventional and advanced arrays in the Secondary RO position. Both CCRO and PFRO could be tested as Secondary RO systems, and this setup would allow for useful side-by-side comparisons between conventional RO and arrays with novel flow patterns. An additional standalone FRRO train could also be considered for the Demonstration Plant to test an additional potentially viable technology. Given the importance of brine minimization and affordable high-recovery RO options for the current practice of inland water reuse, grant funding may be available to support such studies.

The Demonstration Plant RO systems would be tested in the 90% to 96% recovery range to observe fundamental solubility-based scaling limits, and cross-flow velocity would also be monitored. Studies at the Demonstration Plant would lead to a better understanding of the actual scaling regime; confirm the maximum sustainable recovery for RO operation; offer insight into O&M items, such as chemical and cleaning costs; and provide an opportunity for demonstration of novel RO technologies with limited track records of installation. If the Demonstration Plant shows that a recovery on the higher end of the range (e.g., 94%) is sustainable as a design point, procurement of an advanced RO system like CCRO, PFRO, or FRRO at full scale likely will be required. However, if the maximum recovery observed at the Demonstration Plant ends up on the lower end of the range (e.g., 92%), a conventional RO system carefully designed for adequate cross-flow velocity may be the optimal choice. Either way, the highest sustainable recovery that can be achieved without extensive HERO-like pretreatment is the likely optimal design point for the full-scale facility.

6.4 Demonstration Plant Brine Studies

The brine produced at the demonstration facility provides an important opportunity to conduct further studies. For example, evaporation pan tests could be used to check the derating factor for brine evaporation rates compared to clean water. Brine from the demonstration facility could also be used as influent for alternative brine disposal systems or technologies intended to improve evaporation.

Enhancement of evaporation ponds may allow greater throughput of brine per unit area. The magnitude of potential savings from pond enhancements gets smaller at higher recovery, so achieving 92% to 96% RO recovery is considered the highest priority for the program and for demonstration testing. However, achieving improved evaporation pond performance remains a worthwhile goal with the potential for cost savings in the \$40/AF to \$100/AF range. At a minimum, potentially viable pond enhancement technologies, such as mixers and bioaugmentation, are worthy of further consideration for full-scale design. The Capture6 system is also worthy of further study, potentially at demonstration scale, to determine whether it can serve as an effective alternative disposal method for brine by realizing the additional potential benefits of using brine as a process input for DAC of carbon dioxide. Grant funding may also be available to add evaporation enhancement studies to the Demonstration Plant, given the importance of this topic for inland RO systems.

References May 2023

7.0 References

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APPENDIX A

RO Calculations and Models

APPENDIX A

RO CALCULATIONS AND MODELS

Appendix A1 – Conventional Primary RO model output

Appendix A2 – Scaling analysis model output

Appendix A3 – Secondary RO model outputs

Appendix A1 – Conventional Primary RO model output

Palmdale Regional Water Augmentation Program

RO Flow Balance and Array Sizing - Full Scale Concept

RO Skid Arrangement

			_
Total Feed =	4.52	4.52	mgd MF filtrate
Recovery =	90%	94%	
Product =	4.07	4.25	mgd total
Deire e	0.45	0.27	mgd total
Brine =	314	188	gpm total

RO Skids =	6	
Feed =	0.75	mgd per RO skid

Array Sizing - Conventional

Feed =	523.1	gpm per RO skid	Elements =	7	per vessel
Stage 1 =	12	vessels	Area =	400	sf per element
Stage 2 =	6	vessels	Element Length =	3.33	ft
Stage 3 =	3	vessels	Feed Spacer Thickness =	34	mil

	Feed	Recovery	Permeate	Concentrate	Elements	Elements Element Area (ft ²)		Avg Flux	Flow	per Vessel	(gpm)	Cross-Flow Velocity (ft/s)			
	(gpm)	(%)	(gpm)	(gpm)	(number)	Surface	Cross-Section	(gfd)	Feed	Perm	Conc	Max	Avg	Min	
Stage 1	523.1	57%	298.2	225.0	84	33600	4.1	12.8	43.6	24.8	18.7	0.29	0.20	0.12	
Stage 2	225.0	50%	112.5	112.5	42	16800	2.0	9.6	37.5	18.7	18.7	0.25	0.18	0.12	
Stage 3	112.5	54%	60.7	51.7	21	8400	1.0	10.4	37.5	20.2	17.2	0.25	0.18	0.11	
Overall	523.1	90%	471.4	51.7	147	58800		11.5							

Array Sizing - Conventional Primary RO plus Advanced Recovery RO

					_
Feed =	523.1	gpm per RO skid	Elements =	7	per vessel
Stage 1 =	12	vessels	Area =	400	sf per element
Stage 2 =	6	vessels	Element Length =	3.33	ft
		-	Feed Spacer Thickness =	34	mil

	Feed	Recovery	Permeate	Concentrate	Elements	Element Area (ft ²)		Avg Flux	Flow	per Vessel	(gpm)	Cross-F	Cross-Flow Velocity (ft/s)		
	(gpm)	(%)	(gpm)	(gpm)	(number)	Surface	Cross-Section	(gfd)	Feed	Perm	Conc	Max	Avg	Min	
Stage 1	523.1	57%	298.2	225.0	84	33600	4.1	12.8	43.6	24.8	18.7	0.29	0.20	0.12	
Stage 2	225.0	50%	112.5	112.5	42	16800	2.0	9.6	37.5	18.7	18.7	0.25	0.18	0.12	
Overall	523.1	79%	410.7	112.5	126	50400		11.7							



	Feed	Recovery	Permeate	Concentrate	Elements	Element	Element Area (ft ²)		Flow per Vessel (gpm)			Cross-Flow Velocity (ft/s)			
	(gpm)	(%)	(gpm)	(gpm)	(number)	Surface	Cross-Section	(gfd)	Feed	Perm	Conc	Max	Avg	Min	
CCD Mode	111.0	100%	111.0	0.0	42	16800	2.0	9.5	38.5	18.5	20.0	0.25	0.19	0.13	
PFD Mode	120.0	0%	0.0	120.0	42	16800	2.0	0.0	20.0	0.0	20.0	0.13	0.13	0.13	
Net (CCRO)	113.3	73.51%	83.3	30.0	42	16800	2.0	7.1							
Overall System	523.1	94%	493.9	30.0											

Flush and CIP Sizing







							Boo	ster Pu	ımp						
Project	name			PRWAP B	Brine Ma	nagem	ent-Max								Page : 1/4
Calcula	ted by			Yam	nrot A.				Permeate	e flow/train				0.678	mgd
HP Pun	np flow					522	.92 gpm		Total pro	duct flow				4.07	mgd
Feed pr	essure					21	1.8 psi		Number	of trains				6	
Feed te	mperatur	е				1	4.5 °C(58.′	1°F)	Raw wat	er flow/train				0.753	mgd
Feed wa	ater pH					7	.80		Permeate	e recovery				90.00	%
Chem d	lose, mg/	l, -				N	one		Element	age				7.0	years
Specific	energy					2	.24 kwh/kg	al	Flux decl	ine %, per y	ear			10.0	
Pass N	DP					18	8.1 psi		Fouling fa	actor				0.48	
Average	e flux rate	;				1	1.5 gfd		SP increa	ase, per yea	r			10.0	%
									Inter-stag	ge pipe loss				3.000	psi
									Feed typ	е				Waste MF	/UF
Pass -	Perm.	Flow /	Vessel	Flux	DP	Flux	Beta	Sta	gewise Pr	essure	Perm.	E	ement	Elemen	t PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boost	Conc	TDS		Туре	Quantity	/ Elem #
	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l				
1-1	283.4	43.6	20	12.1	13.4	12.7	1.14	0	0	198.4	9.4	ES	PA2-LD	84	12 x 7N
1-2	122.5	40	19.5	10.5	12	11.2	1.13	0	0	183.3	30	ES	PA2-LD	42	6 x 7M
1-3	65.4	39.1	17.3	11.2	11.1	12.4	1.14	0	50	219.2	89	ES	PA2-LD	21	3 x 7M
lon (mg/)				Raw M	/ater	Feed Water	Pern	neate	Concentrate 1	Concentra	ate 2	Concentr	ate 3	

lon (mg/l)	Raw Water	Feed Water	Water	Concentrate 1	Concentrate 2	Concentrate 3
Hardness, as CaCO3	151.62	151.62	0.137	330.7	675.9	1527.8
Са	39.50	39.50	0.036	86.2	176.1	398.0
Mg	12.90	12.90	0.012	28.1	57.5	130.0
Na	139.00	139.00	6.505	300.5	606.4	1342.8
к	15.90	15.90	0.842	34.3	69.2	152.7
NH4	6.78	6.78	0.504	14.5	28.9	62.2
Ва	0.023	0.023	0.000	0.1	0.1	0.2
Sr	0.000	0.000	0.000	0.0	0.0	0.0
Н	0.00	0.00	0.000	0.0	0.0	0.0
CO3	0.55	0.55	0.001	2.9	13.2	75.2
HCO3	154.00	154.00	6.376	330.4	659.1	1423.8
SO4	78.70	78.70	0.461	171.5	350.1	789.5
CI	180.00	180.00	4.180	390.9	794.2	1777.3
F	0.00	0.00	0.000	0.0	0.0	0.0
NO3	39.41	39.41	6.364	83.2	162.2	339.7
PO4	1.90	1.90	0.011	4.1	8.5	19.1
ОН	0.00	0.00	0.000	0.0	0.0	0.0
SiO2	21.10	21.10	0.510	45.8	93.1	208.2
В	0.00	0.00	0.000	0.0	0.0	0.0
CO2	4.19	4.19	4.19	4.19	4.19	4.19
NH3	0.11	0.11	0.11	0.11	0.11	0.11
TDS	689.76	689.76	25.80	1492.52	3018.38	6718.62
PH	7.80	7.80	6.46	8.11	8.39	8.70

Saturations	Raw Water	Feed Water	Concentrate	Limits
CaSO4 / ksp * 100, %	1	1	24	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	85	85	1192	10000
SiO2 saturation, %	19	19	137	140
CaF2 / ksp * 100, %	0	0	0	50000
Ca3(PO4)2 saturation index	0.5	0.5	2.6	2.4
CCPP, mg/l	-0.29	-0.29	625.12	850
Langelier saturation index	-0.28	-0.28	2.49	2.8
Ionic strength	0.01	0.01	0.12	
Osmotic pressure, psi	5.9	5.9	57.1	

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warrantes may result in different pricing than previously quoted. Version : 2.231.90 %





Booster Pump Management-Max

Project	name		PR	WAP Brin	e Mar	nagem	ent-Max							Pa	age : 2/4
Calcula	ated by			Yamro	A.				Permeat	e flow/trair	1			0.678	mgd
HP Pur	mp flow					5	22.92 gpn	n	Total pro	oduct flow				4.07	mgd
Feed p	ressure						211.8 psi		Number	of trains				6	
Feed te	emperature	Э					14.5 °C(58.1°F)	Raw wat	ter flow/trai	n			0.753	mgd
Feed w	/ater pH						7.80		Permeat	e recovery				90.00	%
Chem	dose, mg/l	, -					None		Element	age				7.0	years
Specifi	c energy						2.24 kwł	n/kgal	Flux dec	line %, per	year			10.0	
Pass N	IDP						188.1 psi		Fouling f	factor				0.48	
Averag	e flux rate						11.5 gfd		SP incre	ase, per ye	ear			10.0	%
									Inter-sta	ge pipe los	s			3.000	psi
									Feed typ	e			W	aste MF/L	JF
Pass -	Perm.	Flow / V	'essel	Flux	DP	Flux	Beta	Stage	ewise Pres	ssure	Perm.	Eleme	ent E	Element	PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boost	Conc	TDS	Туре	e c	Quantity	Elem #
•	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l				
1-1	283.4	43.6	20	12.1 ·	3.4	12.7	1.14	0	0	198.4	9.4	ESPA2	-LD	84	12 x 7M
1-2	122.5	40	19.5	10.5	12	11.2	1.13	0	0	183.3	30	ESPA2	-LD	42	6 x 7M
1-3	65.4	39.1	17.3	11.2 [·]	1.1	12.4	1.14	0	50	219.2	89	ESPA2	-LD	21	3 x 7M
							Permeat	Permeate							
Pass -	Element	Feed	Pressure	e Conc	1	NDP	e Water	Water	Beta		Permeat	e (Stagew	ise cumu	lative)	
Stage	no.	Pressure	Drop	Osmo			Flow	Flux		TDS	Ca	Mg	Na	CI	
		psi	psi	psi		psi	gpm	gfd							
1-1	1	211.8	2.81	6.5	2	204.6	3.5	12.7	1.08	5.9	0.008	0.003	1.466	0.932	
1-1	2	209	2.48	7.1	2	200.9	3.5	12.5	1.08	6.3	0.008	0.003	1.564	0.994	
1-1	3	206.5	2.18	7.8		198	3.4	12.3	1.09	6.7	0.009	0.003	1.673	1.064	
1-1	4	204.3	1.88	8.7	1	95.2	3.4	12.1	1.1	7.2	0.01	0.003	1.798	1.144	
1-1	5	202.4	1.61	9.7	1	92.5	3.3	12	1.11	7.8	0.011	0.003	1.945	1.237	
1-1	6	200.8	1.35	11	1	89.9	3.3	11.8	1.13	8.5	0.011	0.004	2.121	1.35	
1-1	7	199.5	1.11	12.8	1	87.1	3.2	11.6	1.14	9.4	0.013	0.004	2.337	1.488	
1-2	1	195.4	2.47	14.1		181	3.1	11.2	1.08	18.1	0.025	0.008	4.55	2.905	
1-2	2	192.9	2.2	15.3	1	77.3	3	10.9	1.08	19.5	0.027	0.009	4.886	3.121	
1-2	3	190.7	1.94	16.7	1	73.9	3	10.7	1.09	21	0.029	0.009	5.26	3.361	
1-2	4	188.7	1.69	18.3	1	70.6	2.9	10.5	1.09	22.7	0.031	0.01	5.691	3.638	
1-2	5	187.1	1.46	20.3	1	67.2	2.9	10.3	1.1	24.7	0.034	0.011	6.196	3.963	
1-2	6	185.6	1.24	22.8	1	63.6	2.8	10	1.11	27.1	0.037	0.012	6.8	4.352	
1-2	7	184.4	1.04	25.8	1	59.7	2.7	9.8	1.13	30	0.041	0.013	7.536	4.827	
1-3	1	230.3	2.4	28.9	2	202.3	3.4	12.4	1.09	46	0.064	0.021	11.682	7.511	
1-3	2	227.9	2.1	31.6	1	96.8	3.3	12	1.09	50.9	0.071	0.023	12.819	8.247	
1-3	3	225.8	1.81	34.9	1	91.8	3.2	11.6	1.1	56.1	0.078	0.025	14.114	9.086	
1-3	4	224	1.55	38.9	1	86.5	3.1	11.3	1.11	62.1	0.087	0.028	15.656	10.086	

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1-3

1-3

1-3

5

6

7

222.5

221.1

220.1

1.31

1.09

0.89

43.8

49.8

57.3

180.6

174

166.2

3

2.9

2.8

10.9

10.4

9.9

1.12

1.13

1.14

69.5

78.6

89

0.097

0.11

0.126

0.032

0.036

0.041

17.536

19.878

22.582

11.308

12.833

14.598



Booster Pump

Project name	PRWAP Brine Management-Max		Page : 3/4
Calculated by	Yamrot A.	Permeate flow/train	0.678 mgd
HP Pump flow	522.92 gpm	Total product flow	4.07 mgd
Feed pressure	211.8 psi	Number of trains	6
Feed temperature	14.5 °C(58.1°F)	Raw water flow/train	0.753 mgd
Feed water pH	7.80	Permeate recovery	90.00 %
Chem dose, mg/l, -	None	Element age	7.0 years
Specific energy	2.24 kwh/kgal	Flux decline %, per year	10.0
Pass NDP	188.1 psi	Fouling factor	0.48
Average flux rate	11.5 gfd	SP increase, per year	10.0 %
		Inter-stage pipe loss	3.000 psi
		Feed type	Waste MF/UF

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

Concentrate saturation of Ca3(PO4)2 saturation index (2.65) is higher than limit 2.4.

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.

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warranties may result in different pricing than previously quoted. Version : 2.231.90 %





Stream No.	Flow (gpm)	Pressure (psi)	TDS (mg/l)	рН	Econd (µs/cm)
1	523	0	690	7.80	1252
2	523	212	690	7.80	1252
3	240	198	1493	8.11	2458
4	117	183	3018	8.39	4629
5	117	230	3018	8.39	4625
6	51.9	219	6719	8.70	9663
7	283	0	9.36	6.01	14.8
8	122	0	30.0	6.52	46.4
9	65.4	0	89.0	6.99	138
10	471	0	25.8	6.46	40.0

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							Boos	ster Pu	ump						
Project	name			PRWAP E	Brine Ma	nagem	nent-Max								Page : 1/4
Calcula	ted by			Yam	rot A.				Permea	ate flow/train				0.678	mgd
HP Pun	np flow					522	2.92 gpm		Total product flow					4.07	mgd
Feed pr	ressure					13	33.3 psi		Numbe	r of trains				6	
Feed te	mperatur	е				:	30.1 °C(86.2	°F)	Raw wa	ater flow/train				0.753	mgd
Feed w	ater pH					7	7.80		Permea	ate recovery				90.00	%
Chem c	lose, mg/l	l, -				N	one		Elemen	t age				7.0	years
Specific	energy						1.45 kwh/kga	al	Flux de	cline %, per ye	ar			10.0	
Pass N	DP					1(09.7 psi		Fouling	factor				0.48	
Average	e flux rate	•					11.5 gfd		SP incr	ease, per year				10.0	%
									Inter-sta	age pipe loss				3.000	psi
									Feed ty	ре				Waste MI	F/UF
Pass -	Perm.	Flow /	Vessel	Flux	DP	Flux	Beta	Sta	igewise F	Pressure	Perm.	E	lement	Elemer	t PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boos	st Conc	TDS		Туре	Quantit	y Elem #
	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l				
1-1	292.7	43.6	19.2	12.5	13.1	13.6	1.15	0	0	120.2	15	ES	PA2-LD	84	12 x 7M
1-2	113.7	38.4	19.5	9.7	11.4	10.9	1.11	0	0	105.8	53.6	ES	PA2-LD	42	6 x 7M
1-3	64.8	38.9	17.3	11.1	10.9	13.1	1.13	0	50	141.8	142.6	ES	PA2-LD	21	3 x 7M
lon (mg/)				Raw W	/ater	Feed Water	Pern W	neate ater	Concentrate 1	Concent	rate 2	Concentra	ate 3	
Hardnes	s, as CaCO	D3			1	51.62	151.62		0.228	344.2		679.1	1	525.8	
Са						39.50	39.50		0.059	89.7		176.9		397.5	
Mg						12.90	12.90		0.019	29.3		57.8		129.8	

• •	00100	00100	0.000	0011		00110
Mg	12.90	12.90	0.019	29.3	57.8	129.8
Na	139.00	139.00	10.613	310.8	600.4	1304.4
к	15.90	15.90	1.371	35.5	68.3	147.8
NH4	6.78	6.78	0.796	14.9	28.1	58.0
Ва	0.023	0.023	0.000	0.1	0.1	0.2
Sr	0.000	0.000	0.000	0.0	0.0	0.0
Н	0.00	0.00	0.000	0.0	0.0	0.0
CO3	0.77	0.77	0.003	4.4	18.0	97.9
HCO3	154.00	154.00	10.480	342.7	649.5	1372.1
SO4	78.70	78.70	0.767	178.4	351.1	786.1
CI	180.00	180.00	6.912	405.6	792.2	1751.2
F	0.00	0.00	0.000	0.0	0.0	0.0
NO3	39.41	39.41	10.034	84.6	154.3	306.1
PO4	1.90	1.90	0.019	4.3	8.5	19.0
ОН	0.02	0.02	0.001	0.0	0.1	0.1
SiO2	21.10	21.10	0.842	47.5	92.8	205.0
В	0.00	0.00	0.000	0.0	0.0	0.0
CO2	3.34	3.34	3.34	3.34	3.34	3.34
NH3	0.33	0.33	0.33	0.33	0.33	0.33
TDS	689.98	689.98	41.92	1547.72	2997.99	6575.08
Hq	7.80	7.80	6.67	8.13	8.39	8.68

Saturations	Raw Water	Feed Water	Concentrate	Limits
CaSO4 / ksp * 100, %	1	1	21	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	85	85	1198	10000
SiO2 saturation, %	14	14	105	140
CaF2 / ksp * 100, %	0	0	0	50000
Ca3(PO4)2 saturation index	0.8	0.8	2.9	2.4
CCPP, mg/l	-0.29	-0.29	604.21	850
Langelier saturation index	0.02	0.02	2.76	2.8
Ionic strength	0.01	0.01	0.12	
Osmotic pressure, psi	6.2	6.2	58.7	

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							Bo	oster Pun	np						
Project	name		PR	RWAP B	rine M	anagem	ent-Max							Pa	age : 2/4
Calcula	ated by			Yam	rot A.				Permeat	e flow/trair	ı			0.678	mgd
HP Pur	np flow					5	22.92 gpr	n	Total product flow					4.07	mgd
Feed p	ressure						133.3 psi		Number of trains					6	
Feed te	emperature	9					30.1 °C(86.2°F)	Raw wat	Raw water flow/train 0.					mgd
Feed w	ater pH						7.80		Permeate recovery					90.00	%
Chem of	dose, mg/l,	, -					None		Element	ent age 7.0					years
Specifi	c energy						1.45 kwl	n/kgal	Flux dec	Flux decline %, per year 10					
Pass N	DP					109.7 psi			Fouling	factor				0.48	
Averag	e flux rate						11.5 gfd		SP incre	ase, per ye	ear			10.0	%
									Inter-sta	ge pipe los	S			3.000	psi
									Feed typ	e			W	aste MF/L	JF
Pass -	Perm.	Flow / V	'essel	Flux	DP	Flux	Beta	Stage	ewise Pres	ssure	Perm.	Eleme	ent E	lement	PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boost	Conc	TDS	Туре	e (Juantity	Elem #
	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l				
1-1	292.7	43.6	19.2	12.5	13.1	13.6	1.15	0	0	120.2	15	ESPA2	-LD	84	12 x 7M
1-2	113.7	38.4	19.5	9.7	11.4	10.9	1.11	0	0	105.8	53.6	ESPA2	-LD	42	6 x 7M
1-3	64.8	38.9	17.3	11.1	10.9	13.1	1.13	0	50	141.8	142.6	ESPA2	-LD	21	3 x 7M
							Permeat	Permeate							
Pass -	Element	Feed	Pressure	e Co	nc	NDP	e Water	Water	Beta		Permeat	e (Stagew	vise cumu	lative)	
Stage	no.	Pressure	Drop	Osr	no.		Flow	Flux		TDS	Ca	Mg	Na	CI	
Ũ		psi	psi	ps	si	psi	gpm	gfd				Ū			
1-1	1	133.3	2.81	6.	9	126	3.8	13.6	1.08	8.9	0.012	0.004	2.221	1.42	
1-1	2	130.5	2.46	7.	6	122.1	3.7	13.2	1.09	9.7	0.013	0.004	2.394	1.532	
1-1	3	128	2.14	8.	4	119.1	3.6	12.8	1.1	10.4	0.014	0.005	2.585	1.654	
1-1	4	125.9	1.84	9.	4	116.3	3.5	12.5	1.11	11.3	0.015	0.005	2.803	1.795	
1-1	5	124.1	1.55	10	.5	113.5	3.4	12.2	1.12	12.3	0.017	0.005	3.059	1.96	
1-1	6	122.5	1.29	1:	2	110.8	3.3	11.9	1.13	13.5	0.018	0.006	3.366	2.159	
1-1	7	121.2	1.05	13	.9	108	3.2	11.6	1.15	15	0.02	0.007	3.746	2.404	
1-2	1	117.2	2.33	15	.3	101.8	3	10.9	1.08	31.4	0.043	0.014	7.913	5.1	
1-2	2	114.8	2.07	16	.6	98.1	2.9	10.5	1.08	34.2	0.047	0.015	8.565	5.524	
1-2	3	112.8	1.82	18	.1	94.8	2.8	10.1	1.09	37.1	0.051	0.017	9.287	5.993	
1-2	4	110.9	1.6	19	.8	91.5	2.7	9.8	1.09	40.3	0.056	0.018	10.11	6.529	
1-2	5	109.3	1.38	21	.8	88.1	2.6	9.4	1.1	44.1	0.061	0.02	11.062	7.151	
1-2	6	108	1.19	24	.2	84.7	2.5	9	1.1	48.4	0.067	0.022	12.18	7.881	
1-2	7	106.8	1.01	2	7	81	2.4	8.6	1.11	53.6	0.075	0.024	13.51	8.752	
1-3	1	152.8	2.38	30	.3	123.6	3.6	13.1	1.09	69.1	0.099	0.032	17.618	11.49	
1-3	2	150.4	2.06	33	.3	117.9	3.4	12.4	1.1	77.3	0.11	0.036	19.6	12.794	
1-3	3	148.3	1.77	36	.9	112.7	3.3	11.8	1.1	86.3	0.123	0.04	21.859	14.283	
1-3	4	146.5	1.51	41	.2	107.1	3.1	11.2	1.11	96.7	0.138	0.045	24.552	16.063	
1-3	5	145	1.27	46	.1	101.1	2.9	10.5	1.12	109.4	0.157	0.051	27.825	18.231	
1-3	6	143.8	1.06	53	2	94.5	2.7	9.8	1.12	124.9	0.181	0.059	31.86	20.913	
1-3	7	142.7	0.87	59	9	87.1	2.5	9	1.13	142.6	0.208	0.068	36.489	24.001	

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Booster Pump

Project name	PRWAP Brine Management-Max		Page : 3/4
Calculated by	Yamrot A.	Permeate flow/train	0.678 mgd
HP Pump flow	522.92 gpm	Total product flow	4.07 mgd
Feed pressure	133.3 psi	Number of trains	6
Feed temperature	30.1 °C(86.2°F)	Raw water flow/train	0.753 mgd
Feed water pH	7.80	Permeate recovery	90.00 %
Chem dose, mg/l, -	None	Element age	7.0 years
Specific energy	1.45 kwh/kgal	Flux decline %, per year	10.0
Pass NDP	109.7 psi	Fouling factor	0.48
Average flux rate	11.5 gfd	SP increase, per year	10.0 %
		Inter-stage pipe loss	3.000 psi
		Feed type	Waste MF/UF

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

Concentrate saturation of Ca3(PO4)2 saturation index (2.94) is higher than limit 2.4.

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.

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Stream No.	Flow (gpm)	Pressure (psi)	TDS (mg/l)	рН	Econd (µs/cm)
1	523	0	690	7.80	1257
2	523	133	690	7.80	1257
3	230	120	1548	8.13	2548
4	117	106	2998	8.39	4628
5	117	153	2998	8.39	4616
6	51.9	142	6575	8.68	9547
7	293	0	15.0	6.22	23.6
8	114	0	53.6	6.77	83.2
9	64.8	0	143	7.20	223
10	471	0	41.9	6.67	65.3

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							Boos	ster Pu	ump					
Project	name			PRWAP E	Brine Ma	nagem	ent-Max							Page : 1/4
Calcula	ted by			Yam	rot A.				Permea	ate flow/train			0.678	mgd
HP Pun	np flow					522	2.92 gpm		Total pr	oduct flow			4.07	mgd
Feed pr	essure					11	14.3 psi		Numbe	r of trains			6	
Feed te	mperatur	е					14.5 °C(58.1	°F)	Raw wa	ater flow/train			0.753	mgd
Feed wa	ater pH					7	7.80		Permea	ate recovery			90.00	%
Chem d	ose, mg/	, -				N	one		Elemen	it age			0.0	years
Specific	energy						1.26 kwh/kga	al	Flux de	cline %, per ye	ar		10.0	
Pass N	ЭР					ę	91.4 psi		Fouling	factor			1.00	
Average	e flux rate	•					11.5 gfd		SP incr	ease, per year			10.0	%
									Inter-sta	age pipe loss			3.000	psi
									Feed ty	pe			Waste MF	/UF
Pass -	Perm.	Flow /	Vessel	Flux	DP	Flux	Beta	Sta	igewise F	Pressure	Perm.	Element	Elemen	t PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boos	st Conc	TDS	Туре	Quantity	/ Elem #
	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l			
1-1	296.4	43.6	18.9	12.7	13	13.9	1.15	0	0	101.3	5.5 I	ESPA2-LD	84	12 x 7M
1-2	109.7	37.8	19.5	9.4	11.2	10.7	1.11	0	0	87.1	21.2 I	ESPA2-LD	42	6 x 7M
1-3	65.1	39	17.3	11.2	10.9	13.5	1.13	0	50	123.2	55.5 I	ESPA2-LD	21	3 x 7M
lon (mg/l)				Raw W	/ater	Feed Water	Pern W	neate ater	Concentrate 1	Concentrate 2	Concentr	ate 3	
Hardnes	s, as CaCO	03			1	51.62	151.62	2	0.085	349.8	677	2	1523.6	
Ca						39.50	39.50	1	0.022	91.1	176	4	396.9	
Mg						12.90	12.90)	0.007	29.8	57	6	129.6	

Mg	12.90	12.90	0.007	29.8	57.6	129.6
Na	139.00	139.00	4.051	318.9	612.5	1360.9
к	15.90	15.90	0.525	36.4	69.9	155.1
NH4	6.78	6.78	0.313	15.5	29.4	64.0
Ва	0.023	0.023	0.000	0.1	0.1	0.2
Sr	0.000	0.000	0.000	0.0	0.0	0.0
н	0.00	0.00	0.001	0.0	0.0	0.0
CO3	0.55	0.55	0.000	3.3	13.6	78.7
HCO3	154.00	154.00	3.944	354.3	669.2	1454.9
SO4	78.70	78.70	0.283	181.4	351.0	788.7
CI	180.00	180.00	2.576	414.1	798.8	1786.4
F	0.00	0.00	0.000	0.0	0.0	0.0
NO3	39.41	39.41	4.038	89.1	167.5	359.7
PO4	1.90	1.90	0.007	4.4	8.5	19.0
ОН	0.00	0.00	0.000	0.0	0.0	0.0
SiO2	21.10	21.10	0.315	48.5	93.6	209.3
В	0.00	0.00	0.000	0.0	0.0	0.0
CO2	4.19	4.19	4.19	4.19	4.19	4.19
NH3	0.11	0.11	0.11	0.11	0.11	0.11
TDS	689.76	689.76	16.08	1586.89	3048.25	6803.50
pH	7.80	7.80	6.25	8.14	8.40	8.71

Saturations	Raw Water	Feed Water	Concentrate	Limits
CaSO4 / ksp * 100, %	1	1	23	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	85	85	1179	10000
SiO2 saturation, %	19	19	137	140
CaF2 / ksp * 100, %	0	0	0	50000
Ca3(PO4)2 saturation index	0.5	0.5	2.6	2.4
CCPP, mg/l	-0.29	-0.29	636.21	850
Langelier saturation index	-0.28	-0.28	2.50	2.8
Ionic strength	0.01	0.01	0.13	
Osmotic pressure, psi	5.9	5.9	57.8	

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						Bo	oster Pun	ıp						
Project	name		PR	WAP Brine	Managem	ent-Max							Pa	age : 2/4
Calculated by Yamrot A. HP Pump flow Feed pressure Feed temperature Feed water pH Chem dose, mg/l, - Specific energy Pass NDP Average flux rate			A.	522.92 gpm 114.3 psi 14.5 °C(58.1°F) 7.80 None 1.26 kwh/kgal 91.4 psi 11.5 gfd			Permeate flow/train Total product flow Number of trains Raw water flow/train Permeate recovery Element age Flux decline %, per year Fouling factor SP increase, per year				0.678 4.07 6 0.753 90.00 10.0 1.00 10.0	ngd mgd mgd % years		
								Inter-sta	ge pipe los	S			3.000	psi
Pass Parm Flow / Vassal Flux DE						Rota	Story	Feed typ	e	Borm	Elomo	vot E	aste MF/L	
Fass - Stane	Ferm.	Flow / V	Conc	Flux D	Max	Dela	Porm	Boost	Conc		Type	ווו ב ה (Elem #
Olage	apm	apm	apm	gfd p	si gfd		psi	psi	psi	ma/l	Турс	, (suanny	
1-1	296.4	43.6	18.9	12.7 1	3 13.9	1.15	0	0	101.3	5.5	ESPA2	-LD	84	12 x 7M
1-2	109.7	37.8	19.5	9.4 11	.2 10.7	1.11	0	0	87.1	21.2	ESPA2	-LD	42	6 x 7M
1-3	65.1	39	17.3	11.2 10	.9 13.5	1.13	0	50	123.2	55.5	ESPA2	-LD	21	3 x 7M
Dooo	Element	Food	Brocours	Cono	מחא	Permeat	Permeate	Poto		Dormoot	o (Storow		lativa)	
Fd55 -	Element	Brocouro			NDF	Flow	Flux	Dela	TDS	Co	e (Slayew	No	ci	
Slaye	110.	nsi	nsi	nsi	nsi	apm	afd		103	Ca	ivig	INd	CI	
1-1	1	114.3	2.81	6.6	107	3.9	13.9	1.09	3.2	0.004	0.001	0.796	0.503	
1-1	2	111.5	2.45	7.3	103.4	3.7	13.4	1.09	3.5	0.005	0.002	0.861	0.544	
1-1	3	109.1	2.12	8	100.4	3.6	13.1	1.1	3.7	0.005	0.002	0.933	0.59	
1-1	4	107	1.82	9	97.6	3.5	12.7	1.11	4.1	0.005	0.002	1.017	0.642	
1-1	5	105.1	1.53	10.2	94.9	3.4	12.3	1.12	4.5	0.006	0.002	1.115	0.705	
1-1	6	103.6	1.27	11.6	92.1	3.3	11.9	1.13	4.9	0.007	0.002	1.234	0.78	
1-1	7	102.3	1.03	13.5	89.3	3.2	11.6	1.15	5.5	0.007	0.002	1.381	0.873	
1-2	1	98.3	2.28	14.9	83.1	3	10.7	1.08	12.1	0.017	0.005	3.047	1.93	
1-2	2	96	2.02	16.2	79.5	2.9	10.3	1.08	13.2	0.018	0.006	3.314	2.099	
1-2	3	94	1.78	17.6	76.3	2.7	9.8	1.08	14.4	0.02	0.006	3.609	2.287	
1-2	4	92.2	1.56	19.3	73.1	2.6	9.4	1.09	15.7	0.021	0.007	3.946	2.501	
1-2	5	90.7	1.36	21.2	69.8	2.5	9	1.09	17.3	0.024	0.008	4.335	2.749	
1-2	6	89.3	1.17	23.4	66.5	2.4	8.5	1.1	19.1	0.026	0.008	4.789	3.038	
1-2	7	88.1	1	26	63	2.2	8.1	1.11	21.2	0.029	0.009	5.327	3.38	
1-3	1	134.1	2.39	29.4	105.7	3.7	13.5	1.09	25.5	0.035	0.012	6.452	4.105	
1-3	2	131.7	2.06	32.5	99.9	3.5	12.7	1.1	28.8	0.04	0.013	7.239	4.607	
1-3	3	129.7	1.77	36.1	94.6	3.3	12	1.1	32.4	0.045	0.015	8.144	5.185	
1-3	4	127.9	1.5	40.3	89	3.1	11.3	1.11	36.7	0.051	0.017	9.23	5.88	
1-3	5	126.4	1.26	45.3	83	2.9	10.4	1.12	41.9	0.058	0.019	10.558	6.729	
1-3	6	125.1	1.05	51.2	76.4	2.7	9.6	1.12	48.4	0.067	0.022	12.203	7.783	
1-3	7	124.1	0.87	57.9	69.2	2.4	8.6	1.13	55.5	0.077	0.025	14.045	8.965	

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Booster Pump

Project name	PRWAP Brine Management-Max		Page : 3/4
Calculated by	Yamrot A.	Permeate flow/train	0.678 mgd
HP Pump flow	522.92 gpm	Total product flow	4.07 mgd
Feed pressure	114.3 psi	Number of trains	6
Feed temperature	14.5 °C(58.1°F)	Raw water flow/train	0.753 mgd
Feed water pH	7.80	Permeate recovery	90.00 %
Chem dose, mg/l, -	None	Element age	0.0 years
Specific energy	1.26 kwh/kgal	Flux decline %, per year	10.0
Pass NDP	91.4 psi	Fouling factor	1.00
Average flux rate	11.5 gfd	SP increase, per year	10.0 %
		Inter-stage pipe loss	3.000 psi
		Feed type	Waste MF/UF

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

Concentrate saturation of Ca3(PO4)2 saturation index (2.65) is higher than limit 2.4.

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.

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warranties may result in different pricing than previously quoted. Version : 2.231.90 %





Stream No.	Flow (gpm)	Pressure (psi)	TDS (mg/l)	рН	Econd (µs/cm)
1	523	0	690	7.80	1252
2	523	114	690	7.80	1252
3	227	101	1587	8.14	2591
4	117	87.1	3048	8.40	4664
5	117	134	3048	8.40	4659
6	52.0	123	6804	8.71	9751
7	296	0	5.52	5.78	9.10
8	110	0	21.2	6.37	32.8
9	65.1	0	55.5	6.78	86.0
10	471	0	16.1	6.25	25.1

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Booster Pump															
Project	name	ame PRWAP Brine Management-Max								Page : 1/4					
Calculat	ted by			Yam	rot A.				Permea	ate flow/train				0.678	mgd
HP Pum	np flow					522	2.92 gpm		Total p	roduct flow				4.07	mgd
Feed pr	essure					7	77.5 psi		Numbe	r of trains				6	-
Feed te	mperatur	е				3	30.0 °C(86.0	°F)	Raw wa	ater flow/train				0.753	mgd
Feed wa	ater pH					7	7.80		Permea	ate recovery				90.00	%
Chem d	ose, mg/l	, -				N	one		Elemer	nt age				0.0	years
Specific	energy					().89 kwh/kga	d	Flux de	cline %, per ye	ar			10.0	
Pass NI	DР					Ę	55.2 psi		Fouling	factor				1.00	
Average	e flux rate						1.5 gfd		SP incr	ease, per year				10.0	%
									Inter-st	age pipe loss				3.000	psi
									Feed ty	rpe				Waste MF	/UF
Pass -	Perm.	Flow /	Vessel	Flux	DP	Flux	Beta	Sta	igewise F	Pressure	Perm.	E	lement	Elemen	t PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boos	st Conc	TDS		Туре	Quantity	/ Elem #
-	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l				
1-1	315.3	43.6	17.3	13.5	12.5	15.7	1.16	0	0	65	8.9	ES	PA2-LD	84	12 x 7M
1-2	91.6	34.6	19.4	7.9	10	10	1.1	0	0	52	44.3	ES	PA2-LD	42	6 x 7M
1-3	64.3	38.8	17.3	11	10.5	15.2	1.11	0	50	88.5	92.3	ES	PA2-LD	21	3 x 7M
								Pern	neate						
lon (mg/l)				Raw W	/ater	Feed Water	W	ater	Concentrate 1	Concen	trate 2	Concentra	ate 3	
Hardnes	s, as CaCC	03			1	51.62	151.62		0.146	381.5		681.9	1	523.7	
Ca Ma						39.50	39.50		0.038	99.4		58.0		120.6	
Na					1	39.00	139.00		6.882	346.4		610.5	1	335.8	

pH	7.80	7.80	6.48	8.17	8.39	8.68
TDS	689.98	689.98	27.20	1720.19	3039.16	6668.42
NH3	0.33	0.33	0.33	0.33	0.33	0.33
CO2	3.35	3.35	3.35	3.35	3.35	3.35
В	0.00	0.00	0.000	0.0	0.0	0.0
SiO2	21.10	21.10	0.539	52.8	93.8	207.4
ОН	0.02	0.02	0.001	0.0	0.1	0.1
PO4	1.90	1.90	0.012	4.8	8.5	19.0
NO3	39.41	39.41	6.698	95.7	162.4	335.8
F	0.00	0.00	0.000	0.0	0.0	0.0
CI	180.00	180.00	4.409	450.9	800.4	1770.6
SO4	78.70	78.70	0.486	197.8	353.1	787.2
HCO3	154.00	154.00	6.725	378.2	657.8	1375.2
CO3	0.77	0.77	0.001	5.4	18.5	98.5
н	0.00	0.00	0.000	0.0	0.0	0.0
Sr	0.000	0.000	0.000	0.0	0.0	0.0
Ва	0.023	0.023	0.000	0.1	0.1	0.2
NH4	6.78	6.78	0.510	16.7	28.8	60.2
к	15.90	15.90	0.891	39.6	69.6	151.9
Na	139.00	139.00	6.882	346.4	610.5	1335.8
IVIG	12.90	12.90	0.012	32.5	58.0	129.6

Saturations	Raw Water	Feed Water	Concentrate	Limits
CaSO4 / ksp * 100, %	1	1	21	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	85	85	1187	10000
SiO2 saturation, %	14	14	106	140
CaF2 / ksp * 100, %	0	0	0	50000
Ca3(PO4)2 saturation index	0.8	0.8	2.9	2.4
CCPP, mg/l	-0.29	-0.29	605.02	850
Langelier saturation index	0.02	0.02	2.75	2.8
Ionic strength	0.01	0.01	0.12	
Osmotic pressure, psi	6.2	6.2	59.6	

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							Bo	oster Pun	ıp						
Project	name		PR	WAP Br	ine M	anagem	ent-Max							Pa	age : 2/4
Calcula	ted by			Yamr	ot A.				Permeat	e flow/trair	ı			0.678	mgd
HP Pur	np flow					5	22.92 gpr	n	Total product flow					4.07	mgd
Feed p	ressure						77.5 psi		Number of trains					6	•
Feed te	emperature	9					30.0 °C(86.0°F)	Raw wat	ter flow/trai	n			0.753	mgd
Feed w	ater pH						7.80		Permeate recovery					90.00	%
Chem of	dose, mg/l	, -					None		Element age					0.0	years
Specific	c energy						0.89 kwl	h/kgal	Flux decline %, per year					10.0	
Pass N	DP						55.2 psi		Fouling factor					1.00	
Averag	e flux rate						11.5 gfd		SP incre	ase, per ye	ear			10.0	%
									Inter-sta	ge pipe los	S			3.000	psi
									Feed typ	e			W	aste MF/L	JF
Pass -	Perm.	Flow / V	/essel	Flux	DP	Flux	Beta	Stage	ewise Pres	ssure	Perm.	Eleme	ent E	Iement	PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boost	Conc	TDS	Туре	e C	Quantity	Elem #
-	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l			-	
1-1	315.3	43.6	17.3	13.5	12.5	15.7	1.16	0	0	65	8.9	ESPA2	-LD	84	12 x 7M
1-2	91.6	34.6	19.4	7.9	10	10	1.1	0	0	52	44.3	ESPA2	-LD	42	6 x 7M
1-3	64.3	38.8	17.3	11	10.5	15.2	1.11	0	50	88.5	92.3	ESPA2	-LD	21	3 x 7M
							Pormoat	Pormosto							
Pass -	Element	Feed	Pressure	e Con	C	NDP	e Water	Water	Beta		Permeat	e (Stagew	vise cumu	lative)	
Stage	no.	Pressure	, Drop	Osm	0.		Flow	Flux		TDS	Ca	Mg	Na	CI	
Ũ		psi	psi	psi		psi	gpm	gfd				0			
1-1	1	77.5	2.81	7.1		69.9	4.4	15.7	1.1	4.6	0.006	0.002	1.143	0.724	
1-1	2	74.7	2.41	7.9)	66	4.1	14.8	1.1	5.1	0.007	0.002	1.261	0.799	
1-1	3	72.3	2.05	8.8	;	62.9	3.9	14.1	1.11	5.6	0.008	0.002	1.392	0.882	
1-1	4	70.2	1.72	10		60	3.7	13.5	1.12	6.2	0.008	0.003	1.545	0.979	
1-1	5	68.5	1.42	11.4	4	57.2	3.6	12.8	1.13	6.9	0.009	0.003	1.727	1.095	
1-1	6	67.1	1.16	13.	2	54.3	3.4	12.2	1.15	7.8	0.011	0.003	1.951	1.238	
1-1	7	65.9	0.92	15.	5	51.2	3.2	11.4	1.16	8.9	0.012	0.004	2.232	1.417	
1-2	1	62	2.01	17.	1	45	2.8	10	1.08	23.5	0.032	0.011	5.928	3.774	
1-2	2	60	1.78	18.	5	41.5	2.6	9.2	1.1	26.1	0.036	0.012	6.568	4.183	
1-2	3	58.2	1.57	20		38.3	2.4	8.5	1.1	28.9	0.04	0.013	7.273	4.633	
1-2	4	56.6	1.38	21.	7	35.2	2.2	7.8	1.1	32.1	0.044	0.014	8.07	5.144	
1-2	5	55.3	1.22	23.	5	32.2	2	7.1	1.1	35.7	0.049	0.016	8.977	5.725	
1-2	6	54	1.08	25.4	4	29.2	1.8	6.5	1.08	39.7	0.055	0.018	10.01	6.388	
1-2	7	53	0.95	27.4	4	26.3	1.6	5.8	1.08	44.3	0.061	0.02	11.188	7.145	
1-3	1	99	2.37	31.3	3	69	4.2	15.2	1.11	36.3	0.051	0.017	9.256	5.939	
1-3	2	96.6	2	35		62.7	3.8	13.7	1.11	42.3	0.059	0.019	10.707	6.874	
1-3	3	94.6	1.68	39.2	2	56.9	3.5	12.4	1.11	49.1	0.069	0.022	12.408	7.971	
1-3	4	93	1.41	43.9	9	50.9	3.1	11.1	1.1	57.2	0.08	0.026	14.483	9.311	
1-3	5	91.5	1.18	49.	1	44.6	2.7	9.7	1.11	67.2	0.095	0.031	17.036	10.963	
1-3	6	90.4	0.99	54.	5	38.2	2.3	8.2	1.11	79.1	0.112	0.037	20.094	12.944	
1-3	7	89.4	0.83	60.	1	31.8	1.9	6.8	1.1	92.3	0.131	0.043	23.521	15.168	

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Booster Pump

Project name	PRWAP Brine Manageme	ent-Max			Page : 3/4
Calculated by	Yamrot A.		Permeate flow/train	0.678	mgd
HP Pump flow	5	22.92 gpm	Total product flow	4.07	mgd
Feed pressure		77.5 psi	Number of trains	6	
Feed temperature		30.0 °C(86.0°F)	Raw water flow/train	0.753	mgd
Feed water pH		7.80	Permeate recovery	90.00	%
Chem dose, mg/l, -		None	Element age	0.0	years
Specific energy		0.89 kwh/kgal	Flux decline %, per year	10.0	
Pass NDP		55.2 psi	Fouling factor	1.00	
Average flux rate		11.5 gfd	SP increase, per year	10.0	%
			Inter-stage pipe loss	3.000	psi
			Feed type	Waste M	F/UF

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

Concentrate saturation of Ca3(PO4)2 saturation index (2.94) is higher than limit 2.4.

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.





Stream No.	Flow (gpm)	Pressure (psi)	TDS (mg/l)	рН	Econd (µs/cm)
1	523	0	690	7.80	1257
2	523	77.5	690	7.80	1257
3	208	65.0	1720	8.17	2800
4	116	52.0	3039	8.39	4681
5	116	99.0	3039	8.39	4669
6	52.0	88.5	6668	8.68	9669
7	315	0	8.93	5.99	14.3
8	91.6	0	44.3	6.69	68.7
9	64.3	0	92.3	7.01	144
10	471	0	27.2	6.48	42.4





							Boos	ster Pu	ump					
Project r	name			PRWAP E	Brine Ma	nagem	ent-Avg							Page : 1/4
Calculat	ed by			Chi	nmay				Permea	te flow/train			0.678	mgd
HP Pum	p flow					522	2.92 gpm		Total pr	oduct flow			4.07	mgd
Feed pre	essure					11	15.2 psi		Numbe	r of trains			6	
Feed ter	nperatur	e				2	23.1 °C(73.6	ΰ°F)	Raw wa	ater flow/train			0.753	mgd
Feed wa	iter pH					7	7.10		Permea	te recovery			90.00	%
Chem de	ose, mg/l	, -				N	one		Elemen	t age			3.5	years
Specific	energy					1	I.26 kwh/kga	al	Flux de	cline %, per ye	ar		10.0	
Pass ND	P					9	94.5 psi		Fouling	factor			0.69	
Average flux rate						1	1.5 gfd		SP incr	ease, per year			10.0	%
									Inter-sta	age pipe loss			3.000	psi
									Feed ty	ре			Waste MF	F/UF
Pass -	Perm.	Flow /	Vessel	Flux	DP	Flux	Beta	Sta	igewise F	ressure	Perm.	Element	Elemen	t PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boos	t Conc	TDS	Туре	Quantit	y Elem #
	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l			
1-1	292.5	43.6	19.2	12.5	13.1	13.6	1.15	0	0	102.1	6.2	ESPA2-LD	84	12 x 7M
1-2	112	38.4	19.8	9.6	11.5	10.8	1.11	0	0	87.6	22.2	ESPA2-LD	42	6 x 7M
1-3	66.6	39.6	17.4	11.4	11.2	13.4	1.13	0	47	120.4	56.3	ESPA2-LD	21	3 x 7M
					Raw W	lator	Feed Water	Pern	neate	Concentrate 1	Concentrate	2 Concen	trate 3	
Hardness	, as CaCC	03			1	22.16	122.16	6	0.091	277.0	53	8.3	1226.7	

ion (mg/i)	Raw water	Feed water	water	Concentrate 1	Concentrate 2	Concentrate 3
Hardness, as CaCO3	122.16	122.16	0.091	277.0	538.3	1226.7
Са	34.11	34.11	0.025	77.3	150.3	342.5
Mg	9.00	9.00	0.007	20.4	39.7	90.4
Na	119.29	119.29	4.602	268.4	516.1	1157.1
к	15.90	15.90	0.695	35.7	68.6	153.5
NH4	2.45	2.45	0.149	5.5	10.4	22.7
Ва	0.023	0.023	0.000	0.1	0.1	0.2
Sr	0.000	0.000	0.000	0.0	0.0	0.0
Н	0.00	0.00	0.002	0.0	0.0	0.0
CO3	0.10	0.10	0.000	0.6	2.4	14.3
HCO3	118.00	118.00	5.192	265.4	512.7	1134.4
SO4	68.63	68.63	0.428	155.4	301.6	685.8
СІ	146.42	146.42	3.615	330.4	637.8	1438.6
F	0.00	0.00	0.000	0.0	0.0	0.0
NO3	11.46	11.46	1.959	25.0	46.2	97.4
PO4	1.90	1.90	0.012	4.3	8.4	19.0
ОН	0.00	0.00	0.000	0.0	0.0	0.0
SiO2	20.70	20.70	0.424	46.8	90.4	204.2
В	0.00	0.00	0.000	0.0	0.0	0.0
CO2	14.09	14.09	14.09	14.09	14.09	14.09
NH3	0.01	0.01	0.01	0.01	0.01	0.01
TDS	547.98	547.98	17.11	1235.38	2384.70	5360.10
pH	7.10	7.10	5.78	7.43	7.70	8.02

Saturations	Raw Water	Feed Water	Concentrate	Limits
CaSO4 / ksp * 100, %	1	1	19	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	89	89	1246	10000
SiO2 saturation, %	17	17	148	140
CaF2 / ksp * 100, %	0	0	0	50000
Ca3(PO4)2 saturation index	-0.2	-0.2	2.1	2.4
CCPP, mg/l	-24.84	-24.84	452.83	850
Langelier saturation index	-0.98	-0.98	1.82	2.8
Ionic strength	0.01	0.01	0.10	
Osmotic pressure, psi	4.8	4.8	47.1	



Project name PRWAP Brine Ma				anagem	ent-Avg		-					Pa	age : 2/4		
Calcula	ted by			Chi	nmay				Permeat	e flow/train	I			0.678	mgd
HP Pur	np flow					5	22.92 gpr	n	Total pro	oduct flow				4.07	mgd
Feed p	ressure						115.2 psi		Number of trains					6	-
Feed te	emperature	9					23.1 °C((73.6°F)	Raw wat	ter flow/trai	n			0.753	mgd
Feed w	ater pH						7.10	. ,	Permeat	e recovery				90.00	%
Chem o	dose, mg/l,	-					None		Element age					3.5	years
Specific	c energy						1.26 kwl	h/kgal	Flux dec	line %, per	year			10.0	
Pass N	DP						94.5 psi	0	Fouling f	factor				0.69	
Averag	e flux rate						11.5 gfd		SP incre	ase, per ye	ear			10.0	%
Ũ							U		Inter-sta	ge pipe los	S			3.000	psi
									Feed type			Waste MF/UF			
Pass -	Perm.	Flow / V	essel	Flux	DP	Flux	Beta	Stage	ewise Pres	ssure	Perm.	Eleme	ent	Element	PV# x
Stage	Flow	Flow Feed Conc				Max		Perm.	Boost	Conc	TDS	Туре	e	Quantity	Elem #
0	apm	apm	apm	gfd	psi	gfd		psi	psi	psi	ma/l				
1-1	292.5	43.6	19.2	12.5	13.1	13.6	1.15	0	0	102.1	6.2	ESPA2	-I D	84	12 x 7M
1-2	112	38.4	19.8	9.6	11.5	10.8	1.11	0	0	87.6	22.2	ESPA2	-LD	42	6 x 7M
1-3	66.6	39.6	17.4	11.4	11.2	13.4	1.13	0	47	120.4	56.3	ESPA2	-LD	21	3 x 7M
-						-	Pormoat	Pormosto		-		-			-
Pass -	Element	Feed	Pressure	e Co	nc	NDP	e Water	Water	Beta		Permeat	e (Stagewise cur		ulative)	
Stage	no.	Pressure	Drop	Osn	no.		Flow	Flux		TDS	Ca	Mg	Na	CI	
		psi	psi	ps	si	psi	gpm	gfd							
1-1	1	115.2	2.81	5.	3	109	3.8	13.6	1.08	3.6	0.005	0.001	0.977	0.763	
1-1	2	112.4	2.46	5.	9	105.6	3.7	13.2	1.09	3.8	0.005	0.001	1.005	0.784	
1-1	3	109.9	2.14	6.	5	102.7	3.6	12.8	1.1	4.2	0.006	0.002	1.117	0.872	
1-1	4	107.8	1.83	7.	2	100.1	3.5	12.5	1.11	4.6	0.007	0.002	1.229	0.959	
1-1	5	105.9	1.55	8.	2	97.5	3.4	12.2	1.12	5.1	0.007	0.002	1.351	1.055	
1-1	6	104.4	1.29	9.	3	95.1	3.3	11.9	1.13	5.6	0.008	0.002	1.493	1.167	
1-1	7	103.1	1.05	10	.9	92.6	3.2	11.5	1.15	6.2	0.009	0.002	1.665	5 1.301	
1-2	1	99	2.34	11	.9	86.7	3	10.8	1.08	13.2	0.019	0.005	3.543	2.773	
1-2	2	96.7	2.08	12	.9	83.4	2.9	10.4	1.08	14.3	0.021	0.006	3.824	2.994	
1-2	3	94.6	1.83	14	1	80.4	2.8	10	1.08	15.4	0.023	0.006	4.139	3.241	
1-2	4	92.8	1.61	15	.4	77.4	2.7	9.6	1.09	16.8	0.025	0.006	4.496	3.522	
1-2	5	91.2	1.4	16	.9	74.5	2.6	9.2	1.09	18.3	0.027	0.007	4.907	3.845	
1-2	6	89.8	1.21	18	.8	71.5	2.5	8.8	1.1	20.1	0.03	0.008	5.386	4.221	
1-2	7	88.6	1.03	20	.9	68.4	2.3	8.4	1.11	22.2	0.033	0.009	5.951	4.666	
1-3	1	131.6	2.44	23	.3	108.5	3.7	13.4	1.09	27.1	0.04	0.011	7.309	5.745	
1-3	2	129.1	2.11	25	.8	103.7	3.5	12.7	1.1	30.1	0.045	0.012	8.095	6.365	
1-3	3	127	1.81	28	.7	99	3.4	12.1	1.1	33.5	0.05	0.013	9.013	7.089	
1-3	4	125.2	1.54	32	.1	94.2	3.2	11.5	1.11	37.6	0.056	0.015	10.113	7.958	
1-3	5	123.6	1.29	36	.2	89	3	10.8	1.12	42.5	0.064	0.017	11.455	9.018	
1-3	6	122.4	1.07	41	.1	83.3	2.8	10.1	1.13	48.6	0.073	0.019	13.117	10.333	

Booster Pump

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warranties may result in different pricing than previously quoted. Version : 2.231.90 %

1-3

7

121.3

0.88

47

76.9

2.6

9.3

1.13

56.3

0.085

0.022 15.211

11.991



Booster Pump

Project name	PRWAP Brine Management-Avg		Page : 3/4
Calculated by	Chinmay	Permeate flow/train	0.678 mgd
HP Pump flow	522.92 gpm	Total product flow	4.07 mgd
Feed pressure	115.2 psi	Number of trains	6
Feed temperature	23.1 °C(73.6°F)	Raw water flow/train	0.753 mgd
Feed water pH	7.10	Permeate recovery	90.00 %
Chem dose, mg/l, -	None	Element age	3.5 years
Specific energy	1.26 kwh/kgal	Flux decline %, per year	10.0
Pass NDP	94.5 psi	Fouling factor	0.69
Average flux rate	11.5 gfd	SP increase, per year	10.0 %
		Inter-stage pipe loss	3.000 psi
		Feed type	Waste MF/UF

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

Concentrate saturation of SiO2 (148.35 %) is higher than limit 140 %.

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.



Project name PRWAP Brine Management-Avg Page : 4/4 Temperature : 23.1 °C Element age, P1 : 3.5 years

Stream No.	Flow (gpm)	Pressure (psi)	TDS (mg/l)	рН	Econd (µs/cm)
1	523	0	548	7.10	976
2	523	115	548	7.10	976
3	231	102	1235	7.43	2089
4	119	87.6	2385	7.70	3750
5	119	132	2385	7.70	3748
6	52.1	120	5360	8.02	7839
7	292	0	6.23	5.34	11.3
8	112	0	22.2	5.89	34.9
9	66.6	0	56.3	6.29	88.2
10	471	0	17.1	5.78	27.3





							Boos	ster Pu	ump					
Project	name			PRWAP E	Brine Ma	nagem	nent-Low							Page : 1/4
Calcula	ted by			Ch	inmay				Permea	ate flow/train			0.678	mgd
HP Pun	np flow					522	2.92 gpm		Total p	roduct flow			4.07	mgd
Feed pr	essure					-	70.5 psi		Numbe	r of trains			6	-
Feed te	mperatur	е				÷	30.1 °C(86.2	°F)	Raw wa	ater flow/train			0.753	mgd
Feed wa	ater pH					(5.30		Permea	ate recovery			90.00	%
Chem d	lose, mg/l	l, -				N	one		Elemer	nt age			0.0	years
Specific	energy					(0.82 kwh/kga	al	Flux de	cline %, per ye	ar		10.0	
Pass N	DP					ę	53.7 psi		Fouling	factor			1.00	
Average	Average flux rate						11.5 gfd		SP incr	ease, per year			10.0	%
									Inter-st	age pipe loss			3.000	psi
									Feed ty	/pe			Waste MF	F/UF
Pass -	Perm.	Flow /	Vessel	Flux	DP	Flux	Beta	Sta	igewise I	Pressure	Perm.	Element	Elemen	t PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boos	st Conc	TDS	Туре	Quantit	y Elem #
	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l			
1-1	301.7	43.6	18.5	12.9	12.8	14.8	1.15	0	0	57.7	4.9 E	SPA2-LD	84	12 x 7N
1-2	96.2	36.9	20.9	8.2	11.1	10	1.1	0	0	43.5	18.8 E	SPA2-LD	42	6 x 7M
1-3	73.3	41.7	17.3	12.6	11.6	15.7	1.14	0	47	75.9	34.5 E	SPA2-LD	21	3 x 7M
lon (mg/l)				Raw W	/ater	Feed Water	Pern W	neate ater	Concentrate 1	Concentrate 2	Concentra	ite 3	
Hardnes	s, as CaCO	D 3				85.02	85.02	2	0.055	200.8	355.0		856.4	
Ca						24.50	24.50)	0.016	57.9	102.3		246.8	
Mg					1	5.80	5.80)	0.004	13.7	24.2	1	58.4	

naluliess, as Cacos	00.UZ	05.02	0.055	200.0	355.0	000.4
Са	24.50	24.50	0.016	57.9	102.3	246.8
Mg	5.80	5.80	0.004	13.7	24.2	58.4
Na	95.30	95.30	3.217	223.4	391.3	931.3
К	15.90	15.90	0.608	37.2	65.1	154.7
NH4	0.84	0.84	0.045	2.0	3.4	7.8
Ва	0.023	0.023	0.000	0.1	0.1	0.2
Sr	0.000	0.000	0.000	0.0	0.0	0.0
Н	0.00	0.00	0.012	0.0	0.0	0.0
CO3	0.01	0.01	0.000	0.1	0.2	1.7
HCO3	79.00	79.00	2.976	186.3	323.4	775.5
SO4	49.40	49.40	0.263	116.6	205.8	495.5
CI	107.00	107.00	2.259	251.6	442.2	1057.9
F	0.00	0.00	0.000	0.0	0.0	0.0
NO3	17.08	17.08	2.526	38.9	65.9	149.2
PO4	1.90	1.90	0.010	4.5	7.9	19.1
ОН	0.00	0.00	0.000	0.0	0.0	0.0
SiO2	20.30	20.30	0.406	47.7	83.9	200.9
В	0.00	0.00	0.000	0.0	0.0	0.0
CO2	55.48	55.48	55.48	55.48	55.48	55.48
NH3	0.00	0.00	0.00	0.00	0.00	0.00
TDS	417.05	417.05	12.33	979.94	1715.73	4099.18
рН	6.30	6.30	4.91	6.65	6.88	7.23

Saturations	Raw Water	Feed Water	Concentrate	Limits
CaSO4 / ksp * 100, %	1	1	12	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	82	82	1157	10000
SiO2 saturation, %	15	15	148	140
CaF2 / ksp * 100, %	0	0	0	50000
Ca3(PO4)2 saturation index	-1.5	-1.5	1.2	2.4
CCPP, mg/l	-110.38	-110.38	214.86	850
Langelier saturation index	-1.96	-1.96	0.87	2.8
Ionic strength	0.01	0.01	0.08	
Osmotic pressure, psi	3.7	3.7	36.6	



							Bo	oster Pun	np						
Project	name		PR	RWAP B	rine M	anagem	ent-Low							Pa	age : 2/4
Calcula	ated by			Chi	nmay				Permeat	e flow/trair	n			0.678	mgd
HP Pur	np flow					5	22.92 gpr	n	Total pro	duct flow				4.07	mgd
Feed p	ressure						70.5 psi		Number of trains					6	
Feed te	emperature	9					30.1 °C(86.2°F)	Raw water flow/train					0.753	mgd
Feed w	ater pH						6.30		Permeat	e recovery				90.00	%
Chem of	dose, mg/l,	, -					None		Element	age				0.0	years
Specifi	c energy						0.82 kwl	n/kgal	Flux dec	line %, per	' year			10.0	
Pass N	DP						53.7 psi		Fouling f	actor				1.00	
Averag	e flux rate						11.5 gfd		SP incre	ase, per ye	ear			10.0	%
									Inter-sta	ge pipe los	S			3.000	psi
									Feed typ	e			W	aste MF/L	JF
Pass -	Perm.	Flow / V	'essel	Flux	DP	Flux	Beta	Stage	ewise Pres	sure	Perm.	Eleme	nt E	Element	PV# x
Stage	Flow	Feed	Conc			Max		Perm.	Boost	Conc	TDS	Туре	e C	Juantity	Elem #
	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l				
1-1	301.7	43.6	18.5	12.9	12.8	14.8	1.15	0	0	57.7	4.9	ESPA2-	-LD	84	12 x 7M
1-2	96.2	36.9	20.9	8.2	11.1	10	1.1	0	0	43.5	18.8	ESPA2	-LD	42	6 x 7M
1-3	73.3	41.7	17.3	12.6	11.6	15.7	1.14	0	47	75.9	34.5	ESPA2-	-LD	21	3 x 7M
							Permeat	Permeate							
Pass -	Element	Feed	Pressure	e Co	nc	NDP	e Water	Water	Beta		Permeat	e (Stagew	ise cumu	lative)	
Stage	no.	Pressure	Drop	Osr	no.		Flow	Flux		TDS	Ca	Mg	Na	CI	
Ũ		psi	psi	ps	si	psi	gpm	gfd				U			
1-1	1	70.5	2.81	4.	1	65.3	4.1	14.8	1.09	3.2	0.004	0.001	0.817	0.57	
1-1	2	67.7	2.43	4.	6	62.1	3.9	14	1.1	3.3	0.004	0.001	0.86	0.601	
1-1	3	65.2	2.09	5.	1	59.4	3.7	13.4	1.1	3.5	0.004	0.001	0.903	0.631	
1-1	4	63.1	1.78	5.	7	56.9	3.6	12.9	1.11	3.7	0.005	0.001	0.946	0.66	
1-1	5	61.4	1.49	6.	5	54.6	3.4	12.3	1.12	4	0.005	0.001	1.03	0.719	
1-1	6	59.9	1.23	7.	5	52.3	3.3	11.8	1.14	4.4	0.006	0.001	1.133	0.792	
1-1	7	58.7	0.99	8.	8	50.1	3.1	11.3	1.15	4.9	0.006	0.001	1.261	0.882	
1-2	1	54.7	2.2	9.	5	44.5	2.8	10	1.07	11	0.014	0.003	2.864	2.005	
1-2	2	52.5	1.96	10	.3	41.7	2.6	9.4	1.07	12	0.015	0.004	3.117	2.182	
1-2	3	50.5	1.75	11	.1	39	2.4	8.8	1.08	13.1	0.017	0.004	3.397	2.379	
1-2	4	48.7	1.55	12	2	36.5	2.3	8.2	1.08	14.3	0.018	0.004	3.709	2.598	
1-2	5	47.2	1.37	1:	3	34.1	2.1	7.6	1.08	15.6	0.02	0.005	4.058	2.843	
1-2	6	45.8	1.22	14	.1	31.7	2	7.1	1.08	17.1	0.022	0.005	4.449	3.118	
1-2	7	44.6	1.07	15	.3	29.4	1.8	6.6	1.1	18.8	0.024	0.006	4.891	3.429	
1-3	1	87.5	2.64	17	.2	70.1	4.4	15.7	1.1	15.2	0.02	0.005	3.977	2.795	
1-3	2	84.9	2.25	19	.3	65.7	4.1	14.7	1.11	17.1	0.022	0.005	4.466	3.139	
1-3	3	82.6	1.9	21	.7	61.4	3.8	13.7	1.11	19.3	0.025	0.006	5.047	3.548	
1-3	4	80.8	1.59	24	.6	57	3.5	12.7	1.12	22	0.029	0.007	5.751	4.045	
1-3	5	79.2	1.31	27	.9	52.4	3.2	11.6	1.13	25.3	0.033	0.008	6.615	4.654	
1-3	6	77.8	1.08	31	.9	47.5	2.9	10.5	1.13	29.3	0.038	0.009	7.693	5.416	
1-3	7	76.8	0.88	36	.6	42.2	2.6	9.3	1.14	34.5	0.045	0.011	9.051	6.376	

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warrantees may result in different pricing than previously quoted. Version : 2.231.90 %



Booster Pump

Project name	PRWAP Brine Management-Low		Page : 3/
Calculated by	Chinmay	Permeate flow/train	0.678 mgd
HP Pump flow	522.92 gpm	Total product flow	4.07 mgd
Feed pressure	70.5 psi	Number of trains	6
Feed temperature	30.1 °C(86.2°F)	Raw water flow/train	0.753 mgd
Feed water pH	6.30	Permeate recovery	90.00 %
Chem dose, mg/l, -	None	Element age	0.0 years
Specific energy	0.82 kwh/kgal	Flux decline %, per year	10.0
Pass NDP	53.7 psi	Fouling factor	1.00
Average flux rate	11.5 gfd	SP increase, per year	10.0 %
		Inter-stage pipe loss	3.000 psi
		Feed type	Waste MF/UF

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

Concentrate saturation of SiO2 (148.17 %) is higher than limit 140 %.

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.





Stream No.	Flow (gpm)	Pressure (psi)	TDS (mg/l)	рН	Econd (µs/cm)
1	523	0	417	6.30	735
2	523	70.5	417	6.30	735
3	221	57.7	980	6.65	1689
4	125	43.5	1716	6.88	2769
5	125	87.5	1716	6.88	2768
6	51.9	75.9	4099	7.23	6065
7	302	0	4.87	4.50	18.3
8	96.2	0	18.8	5.09	31.5
9	73.3	0	34.5	5.35	54.3
10	471	0	12.3	4.91	23.1

Scenario 7



Created on: 9/15/2022 11:51:01

							Во	oster Pu	ump						
Project	name			PRWAP E	Brine Ma	nagemer	nt-Low						F	Page : 1/4	
Calculat	ted by			Chi	inmay				Permeate	flow/train			0.678 m	ngd	
HP Pum	np flow					522.92 gpm			Total prod	uct flow			4.07 mgd		
Feed pr	essure					107.	9 psi		Number of	trains			6		
Feed te	mperatur	е				14.	5 °C(58	8.1°F)	Raw water	flow/train			0.753 m	ngd	
Feed wa	ater pH					6.3	0		Permeate	recovery			90.00 %	, 0	
Chem d	ose, mg/	I, -				Non	е		Element a	ge			0.0 years		
Specific energy				1.19 kwh/kgal			Flux decline %, per year				10.0				
Pass NI	DР					90.	3 psi		Fouling fac	ctor			1.00		
Average	e flux rate)				11.	5 gfd		SP increas	se, per yea	r		10.0	%	
									Inter-stage	pipe loss			3.000 p	si	
									Feed type				Waste MF/L	JF	
Pass -	Perm.	Flow /	Vessel	Flux	DP	Flux	Beta	Sta	gewise Pres	ssure	Perm.	Element	Element	PV# x	
Stage	Flow	Feed	Conc			Max		Perm.	Boost	Conc	TDS	Туре	Quantity	Elem #	
	gpm	gpm	gpm	gfd	psi	gfd		psi	psi	psi	mg/l				
1-1	288.7	43.6	19.5	12.4	13.2	13.4	1.14	0	0	94.7	3	ESPA2-LD	84	12 x 7M	
1-2	112	39.1	20.4	9.6	11.9	10.7	1.11	0	0	79.8	9.6	ESPA2-LD	42	6 x 7M	
1-3	70.4	40.8	17.4	12.1	11.6	13.8	1.15	0	47	112.2	22.3	ESPA2-LD	21	3 x 7M	
								Perr	neate						

lon (ma/l)	Raw Water	Feed Water	Permeate	Concentrate 1	Concentrate 2	Concentrate 3
Hardness as CaCO3	85.02	85.02	0.033	189.7	363 1	854 0
	24.50	24 50	0.000	54.7	104.6	246.1
Mg	5.80	5.80	0.010	12.9	24.8	58.3
Na	95.30	95 30	1 954	211.6	402.9	930 0
ĸ	15.90	15 90	0.370	35.3	67.1	156.4
NH4	0.84	0.84	0.028	1.9	35	81
Ba	0.023	0.023	0.000	0.1	0.1	0.2
Sr	0.000	0.000	0.000	0.0	0.0	0.0
Н	0.00	0.00	0.020	0.0	0.0	0.0
CO3	0.01	0.01	0.000	0.0	0.2	1.2
HCO3	79.00	79.00	1.800	174.6	333.6	768.0
SO4	49.40	49.40	0.158	110.1	210.7	494.9
CI	107.00	107.00	1.361	238.0	454.1	1062.8
F	0.00	0.00	0.000	0.0	0.0	0.0
NO3	17.08	17.08	1.564	37.3	69.6	157.5
PO4	1.90	1.90	0.006	4.2	8.1	19.0
ОН	0.00	0.00	0.000	0.0	0.0	0.0
SiO2	20.30	20.30	0.245	45.2	86.2	201.8
В	0.00	0.00	0.000	0.0	0.0	0.0
CO2	69.48	69.48	69.48	69.48	69.48	69.48
NH3	0.00	0.00	0.00	0.00	0.00	0.00
TDS	417.05	417.05	7.50	926.00	1765.50	4114.04
pH	6.30	6.30	4.69	6.63	6.89	7.23

Saturations	Raw Water	Feed Water	Concentrate	Limits
CaSO4 / ksp * 100, %	1	1	13	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	82	82	1149	10000
SiO2 saturation, %	19	19	193	140
CaF2 / ksp * 100, %	0	0	0	50000
Ca3(PO4)2 saturation index	-1.8	-1.8	0.9	2.4
CCPP, mg/l	-110.38	-110.38	211.45	850
Langelier saturation index	-2.26	-2.26	0.56	2.8
Ionic strength	0.01	0.01	0.08	
Osmotic pressure, psi	3.5	3.5	34.9	



								-						
Project name PRWAP Brine Management-Low													Pa	age : 2/4
Calcula	ted by			Chinmay	/			Permeat	e flow/train	1			0.678	mgd
HP Pur	np flow				5	522.92 gpr	n	Total pro	duct flow				4.07	mgd
Feed p	ressure					107.9 psi		Number	of trains				6	
Feed te	mperature	Э				14.5 °C(58.1°F)	Raw wat	er flow/trai	n			0.753	mgd
Feed w	ater pH					6.30		Permeat	e recovery				90.00	%
Chem of	lose, mg/l	, -				None		Element	age				0.0	years
Specific	c energy					1.19 kwl	n/kgal	Flux dec	line %, per	year			10.0	
Pass N	DP					90.3 psi		Fouling f	actor				1.00	
Average	e flux rate					11.5 gfd		SP incre	ase, per ye	ear			10.0	%
								Inter-sta	ge pipe los	s			3.000	psi
								Feed typ	e			W	aste MF/L	JF
Pass -	Perm.	Flow / V	'essel	Flux DF	P Flux	Beta	Stage	wise Pres	sure	Perm.	Eleme	nt E	Element	PV# x
Stage	Flow	Feed	Conc		Max		Perm.	Boost	Conc	TDS	Туре	, C	Quantity	Elem #
0	apm	apm	apm	gfd ps	i gfd		psi	psi	psi	ma/l				
1-1	288.7	43.6	19.5	12.4 13.	2 13.4	1.14	0	0	94.7	3	ESPA2	-I D	84	12 x 7M
1-2	112	39.1	20.4	9.6 11.	9 10.7	1.11	0	0	79.8	9.6	ESPA2	-LD	42	6 x 7M
1-3	70.4	40.8	17.4	12.1 11.	6 13.8	1.15	0	47	112.2	22.3	ESPA2	-LD	21	3 x 7M
						D	D							
Pass -	Floment	Food	Prossure	Conc	NDP	Permeat	Water	Beta		Permeat	e (Stadew	ise cumu	lativa)	
Ctore		Dragouro	Drop	Osmo				Deta	TDO	Co	C (Olagew	No		
Slage	no.	Pressure	Biop	osino.		FIOW	FIUX		105	Ca	ivig	ina	CI	
	4	psi 107.0	psi 0.04	psi	psi 100.0	gpm	giù 40.4	4.00	0.4	0.000	0.004	0 554	0.005	
1-1	1	107.9	2.81	3.9	102.9	3.7	13.4	1.08	2.1	0.003	0.001	0.554	0.385	
1-1	2	100.1	2.47	4.3	99.0	3.0	107	1.09	2.2	0.003	0.001	0.577	0.4	
1-1	3	102.0	2.15	4.7	97.1	3.5	12.7	1.1	2.3	0.003	0.001	0.599	0.410	
1-1	4	100.5	1.85	5.3	94.6	3.4	12.3	1.1	2.4	0.003	0.001	0.621	0.432	
1-1	5	98.6	1.57	5.9	92.3	3.3	12	1.11	2.6	0.003	0.001	0.000	0.462	
1-1	0	97	1.31	0.8	90.1	3.3	11.7	1.13	2.0	0.004	0.001	0.72	0.5	
.1 - 1	/	95.7	1.07	7.9	87.9	3.Z	11.4	1.14	3	0.004	0.001	0.789	0.548	
1-2	1	91.7	2.4	8.5	82.3	3	10.7	1.07	6	0.008	0.002	1.549	1.077	
1-2	2	89.3	2.13	9.3	79.4	2.9	10.3	1.08	6.4	0.008	0.002	1.664	1.157	
1-2	3	87.1	1.89	10.1	76.6	2.8	9.9	1.08	6.9	0.009	0.002	1.792	1.246	
1-2	4	85.2	1.66	11	73.9	2.7	9.6	1.09	7.4	0.009	0.002	1.936	1.347	
1-2	5	83.6	1.45	12.1	71.3	2.6	9.2	1.09	8.1	0.01	0.002	2.1	1.461	
1-2	6	82.1	1.26	13.4	68.8	2.5	8.9	1.1	8.8	0.011	0.003	2.289	1.594	
1-2	7	80.9	1.08	15	66.2	2.4	8.6	1.11	9.6	0.012	0.003	2.51	1.748	
1-3	1	123.8	2.55	16.6	106.8	3.8	13.8	1.09	11.1	0.014	0.003	2.901	2.022	
1-3	2	121.2	2.21	18.4	102.7	3.7	13.2	1.1	12.2	0.016	0.004	3.19	2.224	
1-3	3	119	1.9	20.5	98.7	3.5	12.7	1.11	13.5	0.017	0.004	3.529	2.461	

Booster Pump

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warranties may result in different pricing than previously quoted. Version : 2.231.90 %

1-3

1-3

1-3

1-3

4

5

6

7

117.1

115.5

114.2

113.1

1.61

1.35

1.11

0.9

23.1

26.3

30.1

35

94.6

90.2

85.5

80.1

3.4

3.2

3

2.8

12.1

11.6

10.9

10.2

1.11

1.12

1.13

1.15

15.1

17

19.3

22.3

0.019

0.022

0.025

0.029

0.005

0.005

0.006

0.007

3.936

4.432

5.05

5.837

2.745

3.092

3.525

4.076



Booster Pump

Project name	PRWAP Brine Management-Low		Page : 3/4
Calculated by	Chinmay	Permeate flow/train	0.678 mgd
HP Pump flow	522.92 gpm	Total product flow	4.07 mgd
Feed pressure	107.9 psi	Number of trains	6
Feed temperature	14.5 °C(58.1°F)	Raw water flow/train	0.753 mgd
Feed water pH	6.30	Permeate recovery	90.00 %
Chem dose, mg/l, -	None	Element age	0.0 years
Specific energy	1.19 kwh/kgal	Flux decline %, per year	10.0
Pass NDP	90.3 psi	Fouling factor	1.00
Average flux rate	11.5 gfd	SP increase, per year	10.0 %
		Inter-stage pipe loss	3.000 psi
		Feed type	Waste MF/UF

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

Concentrate saturation of SiO2 (193.47 %) is higher than limit 140 %.

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.

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warranties may result in different pricing than previously quoted. Version : 2.231.90 %



Booster Pump



Stream No.	Flow (gpm)	Pressure (psi)	TDS (mg/l)	рН	Econd (µs/cm)
1	523	0	417	6.30	734
2	523	108	417	6.30	734
3	234	94.7	926	6.63	1609
4	122	79.8	1766	6.89	2837
5	122	124	1766	6.89	2837
6	52.1	112	4114	7.23	6088
7	289	0	3.04	4.30	22.1
8	112	0	9.65	4.80	20.2
9	70.4	0	22.3	5.16	36.5
10	471	0	7.50	4.69	18.5

Appendix A2 – Scaling analysis model output

Projection Information	PROJECT PALMDALE BRIN 7.8	IE MANAGEMENT - SCENARIO	DA D S1 - MAX WQ AT MAX PH- Se	13-2022		
	RECOVERY	90.00 %	WATER TYPE	Treated Effluent		
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER	Hydranautics		
	ENGINEER		MEMBRANE MODEL	ESPA4-LD		
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE	Jun-16-2022		

Antiscalant Results Summary

DOSING DATA

	PRIMARY
DOSAGE	2.45 mg/L
PUMP RATE	24.24 ml/min
DAILY REQUIREMENT	92.15 lb/day

RECOMMENDED PRODUCT

PRIMARY

Vitec ™ 4000

SATURATION GRAPH



Saturation Index

PRODUCT USAGE PROJECTION

FRODUCT DOS	AGE						
VITEC ™ 4000							
Daily	92.2 lb	Weekly	645.1 lb	Monthly	2580.2 lb	Yearly	33542.9 lb

NOTES

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Projection Information	PROJECT PALMDALE BRINE MANAGEMENT - SCENARIO S1 - MAX WQ AT MAX PH- 7.8			DATE Sep-13-2022	
	RECOVERY	90.00 %	WATER TYPE	Treated Effluent	
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER	Hydranautics	
	ENGINEER		MEMBRANE MODEL	ESPA4-LD	
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE	Jun-16-2022	

Antiscalant Technical Results Summary

SYSTEM DESIGN



OVERALL SYSTEM 90.00 % RECOVERY

	FLOW (USGPM)	TDS (mg/L)	ECOND (μs/cm)	рН
1	3139.00	703	1184.81	7.80
2	3139.00	703	1184.81	7.80
3	313.90	6708	8849.91	8.85
4	2825.10			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Sodium	139.00	139.00	1337.32
Potassium	15.90	15.90	152.45
Calcium	39.50	39.50	386.31
Magnesium	12.90	12.90	126.15
Iron	0.04	0.04	0.38
Manganese	0.021	0.021	0.200
Barium	0.023	0.023	0.225
Strontium	0.000	0.000	0.000
Aluminum	0.01	0.01	0.10
Ammonium	6.78	6.78	62.87
ANIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Chloride	180.00	180.00	1742.40
Sulfate	78.70	78.70	775.35
Bicarbonate	148.31	148.31	1142.09
Carbonate	1.13	1.13	291.19
Nitrate	39.44	39.44	339.60
Fluoride	0.00	0.00	0.00
Phosphate	1.89	1.89	17.95
Silica	21.10	21.10	204.65

ANTISCALANT DETAILS

	PRIMARY
Antiscalant Selected	Vitec ™ 4000
Dosage	2.45 mg/l
Jsage	92.15 lĎ/day
Fank Concentration	100 %
Pump Rate	24.24 mL/min

SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
CCPP	1.38	1.38	600.48
Calcium Sulfate CaSO ₄	0.01	0.01	0.19
Barium Sulfate BaSO ₄	0.40	0.40	10.64
Strontium Sulfate SrSO ₄	0.00	0.00	0.00
Calcium Phosphate Ca ₃ (PO ₄) ₂	0.74	0.74	23983.69
Calcium Flouride CaF ₂	0.00	0.00	0.00
Silica SiO ₂	0.16	0.16	1.37
Magnesium Hydroxide Mg(OH) ₂	0.00	0.00	0.02
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Langelier Saturation Index (LSI)	0.071	0.071	2.827
Stiff & Davis Index (S&DI)	-0.170	-0.170	2.736
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
pH	7.80	7.80	8.85
Ionic Strength (M)	0.012	0.012	0.112
Temperature (°C)	30.0	30.0	30.0
TDS (mg/L)	702.938	702.938	6708.012

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Projection Information	PROJECT PALMDALE BRIN	ROJECT ALMDALE BRINE MANAGEMENT - SCENARIO S2			DATE Sep-13-2022	
	RECOVERY	90.00 %	WATER TYPE		Treated Effluent	
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics	
	ENGINEER		MEMBRANE MODEL		ESPA2-LD	
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022	

Antiscalant Results Summary

PRIMARY

2.39 mg/L

23.7 ml/min

90.10 lb/day

DOSING DATA

DOSAGE

PUMP RATE

RECOMMENDED PRODUCT

PRIMARY

Vitec ™ 4000

SATURATION GRAPH

DAILY REQUIREMENT



Saturation Index

PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

VITEC ™ 4000							
Daily	90.1 lb	Weekly	630.7 lb	Monthly	2522.7 lb	Yearly	32795.6 lb

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Projection Information	PROJECT PALMDALE BRINE MANAGEMENT - SCENARIO S2			DATE Sep-13-2022	
	RECOVERY	90.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA2-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Technical Results Summary

SYSTEM DESIGN



OVERALL SYSTEM 90.00 % RECOVERY

	FLOW (USGPM)	TDS (mg/L)	ECOND (μs/cm)	рН
1	3139.00	472	544.20	6.30
2	3139.00	472	544.20	6.30
3	313.90	4261	4462.57	7.33
4	2825.10			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Sodium Potassium Calcium Magnesium Iron Manganese Barium Strontium Aluminum Ammonium	95.30 15.90 24.50 5.80 0.04 0.020 0.000 0.000 0.000 0.01 0.83	95.30 15.90 24.50 5.80 0.04 0.020 0.000 0.000 0.000 0.01 0.83	916.88 152.45 239.61 56.72 0.38 0.190 0.000 0.000 0.000 0.10 7.69
ANIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Chloride	161.96	161.96	1567.79
Sulfate	49.40	49.40	486.69
Bicarbonate	37.66	37.66	420.35
Carbonate	0.01	0.01	1.70
Nitrate	3.97	3.97	34.17
Fluoride	0.00	0.00	0.00
Phosphate	1.90	1.90	18.05
Silica	20.30	20.30	196.89

ANTISCALANT DETAILS

Antiscalant Selected Dosage Jsage	PRIMARY Vitec ™ 4000 2.39 mg/l 90.10 lb/day
Tank Concentration Pump Rate	100 % 23.7 mL/min

SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
CCPP	-63.14	-63.14	36.39
Calcium Sulfate CaSO ₄	0.01	0.01	0.15
Barium Sulfate BaSO ₄	0.00	0.00	0.00
Strontium Sulfate SrSO ₄	0.00	0.00	0.00
Calcium Phosphate Ca ₃ (PO ₄) ₂	0.00	0.00	18.73
Calcium Flouride CaF ₂	0.00	0.00	0.00
Silica SiO ₂	0.23	0.23	2.22
Magnesium Hydroxide Mg(OH) ₂	0.00	0.00	0.00
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Langelier Saturation Index (LSI)	-2.492	-2.492	0.357
Stiff & Davis Index (S&DI)	-2.767	-2.767	0.213
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
pH	6.30	6.30	7.33
Ionic Strength (M)	0.007	0.007	0.071
Temperature (°C)	14.5	14.5	14.5
TDS (mg/L)	471.798	471.798	4260.585

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Projection Information	PROJECT PALMDALE BRINE MANAGEMENT -MAX RECOVERY ANALYSIS				DATE Sep-13-2022	
	RECOVERY	94.00 %	WATER TYPE		Treated Effluent	
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics	
	ENGINEER		MEMBRANE MODEL		ESPA4-LD	
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022	

Antiscalant Results Summary

DOSING DATA		ACID DOSING	RECOMMENDED PRODUCT	
	PRIMARY	Р	RIMARY	PRIMARY
DOSAGE	2.19 mg/L	Adjusted pH	6.90	Vitec ™ 4000
PUMP RATE	21.73 ml/min	ACID DOSING	24.96 mg/L	
DAILY REQUIREMENT	82.61 lb/day	DAILY REQUIREMENT	71.60 lb/day	

SATURATION GRAPH





PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

VITEC ™ 4000							
Daily	82.6 lb	Weekly	578.3 lb	Monthly	2313.0 lb	Yearly	30069.6 lb

NOTES

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Projection Information	PROJECT PALMDALE BRINE MANAGEMENT -MAX RECOVERY ANALYSIS				DATE Sep-13-2022	
	RECOVERY	94.00 %	WATER TYPE		Treated Effluent	
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics	
	ENGINEER		MEMBRANE MODEL		ESPA4-LD	
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022	

Antiscalant Technical Results Summary

SYSTEM DESIGN



OVERALL SYSTEM 94.00 % RECOVERY

	FLOW	TDS (mg/L)	ECOND	рН
	(USGPM)		(µs/cm)	
1	3139.00	703	1184.81	7.80
2	3139.00	728	1197.66	6.90
3	188.34	11228	14154.59	8.17
4	2950.66			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Sodium	139.00	139.00	2228.86
Potassium	15.90	15.90	254.08
Calcium	39.50	39.50	643.85
Magnesium	12.90	12.90	210.25
Iron	0.04	0.04	0.64
Manganese	0.021	0.021	0.332
Barium	0.023	0.023	0.375
Strontium	0.000	0.000	0.000
Aluminum	0.01	0.01	0.16
Ammonium	6.78	6.78	104.79
ANIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Chloride	180.00	180.00	2904.00
Sulfate	78.70	102.65	1685.48
Bicarbonate	148.31	119.10	1883.72
Carbonate	1.13	0.06	138.89
Nitrate	39.44	39.44	566.01
Fluoride	0.00	0.00	0.00
Phosphate	1.89	1.89	29.92
Silica	21.10	21.10	341.08

ANTISCALANT DETAILS

Antiscalant Selected Dosage	PRIMARY Vitec ™ 4000 2.19 mg/l 82.61 lb/day
Usage	82.61 lb/day
Tank Concentration	100 %
Pump Rate	21.73 mL/min

SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
CCPP	1.38	-42.23	866.15
Calcium Sulfate CaSO ₄	0.01	0.01	0.51
Barium Sulfate BaSO ₄	0.40	0.52	24.97
Strontium Sulfate SrSO ₄	0.00	0.00	0.00
Calcium Phosphate Ca ₃ (PO ₄) ₂	0.74	0.00	14307.21
Calcium Flouride CaF ₂	0.00	0.00	0.00
Silica SiO ₂	0.16	0.16	2.55
Magnesium Hydroxide Mg(OH) ₂	0.00	0.00	0.00
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Langelier Saturation Index (LSI)	0.071	-0.933	2.425
Stiff & Davis Index (S&DI)	-0.170	-1.172	2.314
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
pH	7.80	6.90	8.17
Ionic Strength (M)	0.012	0.012	0.189
Temperature (°C)	30.0	30.0	30.0
TDS (mg/L)	702.938	727.557	11228.169

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Dosing at 75%

Projection Information	PROJECT PALMDALE BRIN	NE MANAGEMENT - HIGH WQ	0	DATE Sep-13-2022	
	RECOVERY	75.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Results Summary

DOSING DATA		RECOMMENDED PRODUCT
	PRIMARY	PRIMARY
DOSAGE	2.69 mg/L	Vitec ™ 4000
PUMP RATE	26.67 mL/min	
DAILY REQUIREMENT	101.39 lb/day	
		•

SATURATION GRAPH



PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

VITEC ™ 4000 NEAT							
Daily	101.39 lb	Weekly	709.72 lb	Monthly	3041.66 lb	Yearly	36905.48 lb

Notes

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rojection Information	PROJECT PALMDALE BRIN	E MANAGEMENT - HIGH WQ		DATE Sep-13-2022	
	RECOVERY	75.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Technical Results Summary

SYSTEM DESIGN



PRIMARY RECOVERY 75 %

FLOW TDS (mg/L) ECOND рΗ (USGPM) (µs/cm) 1 3139.00 703 1184.81 7.80 2 3139.00 703 1184.81 7.80 3 784.75 2686 4033.28 8.44 4 2354.25

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Sodium	139.00	139.00	534.93
Potassium	15.90	15.90	60.98
Calcium	39.50	39.50	154.52
Magnesium	12.90	12.90	50.46
Iron	0.04	0.04	0.15
Manganese	0.02	0.021	0.080
Barium	0.02	0.023	0.090
Strontium	0.00	0.000	0.000
Aluminum	0.01	0.01	0.04
Ammonium	6.78	6.78	25.15
ANIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Chloride	180.00	180.00	696.96
Sulfate	78.70	78.70	310.14
Bicarbonate	154.00	148.31	535.18
Carbonate	0.50	1.13	37.74
Nitrate	39.44	39.44	135.84
Fluoride	0.00	0.00	0.00
Phosphate	1.89	1.89	7.18
Silica	21.10	21.10	81.86

ANTISCALANT DETAILS

Antiscalant Selected Dosage Usage Tank Concentration	PRIMARY Vitec ™ 4000 2.69 mg/l 101.39 lb/day 100 % 26 67 ml (min
Pump Rate	26.67 mL/min

SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
CCPP	1.38	1.38	133.94
Calcium Sulfate CaSO ₄	0.01	0.01	0.07
Barium Sulfate BaSO ₄	0.40	0.40	3.03
Strontium Sulfate SrSO ₄	0.00	0.00	0.00
Calcium Phosphate Ca ₃ (PO ₄) ₂	0.74	0.74	782.00
Calcium Flouride CaF ₂	0.00	0.00	0.00
Silica SiO ₂	0.16	0.16	0.59
Magnesium Hydroxide Mg(OH) ₂	0.00	0.00	0.00
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Langelier Saturation Index (LSI)	0.071	0.071	1.743
Stiff & Davis Index (S&DI)	-0.170	-0.170	1.609
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
pH	7.80	7.80	8.44
Ionic Strength (M)	0.012	0.012	0.045
Temperature (°C)	30.0	30.0	30.0
TDS (mg/L)	702.94	702.94	2685.99

Dosing at 80%

Projection Information	Djection Information PROJECT PALMDALE BRINE MANAGEMENT - HIGH V		5	DATE Sep-13-2022	
	RECOVERY	80.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Results Summary

DOSING DATA		RECOMMENDED PRODUCT
	PRIMARY	PRIMARY
DOSAGE	2.65 mg/L	Vitec ™ 4000
PUMP RATE	26.25 mL/min	
DAILY REQUIREMENT	99.79 lb/day	
		•

SATURATION GRAPH



PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

VITEC ™ 4000 N	IEAT						
Daily	99.79 lb	Weekly	698.54 lb	Monthly	2993.76 lb	Yearly	36324.29 lb

Notes

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rojection Information	PROJECT PALMDALE BRIN	IE MANAGEMENT - HIGH WQ		DATE Sep-13-2022	
	RECOVERY	80.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Technical Results Summary

SYSTEM DESIGN



PRIMARY RECOVERY

80 %

	FLOW (USGPM)	TDS (mg/L)	ECOND (µs/cm)	рН
1	3139.00	703	1184.81	7.80
2	3139.00	703	1184.81	7.80
3	627.80	3357	4904.05	8.54
4	2511.20			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED FEED	ADJUSTED FEED	CONC. PRIMARY	
Sodium	139.00	139.00	668.66	
Potassium	15.90	15.90	76.22	
Calcium	39.50	39.50	193.16	
Magnesium	12.90	12.90	63.07	
Iron	0.04	0.04	0.19	
Manganese	0.02	0.021	0.100	
Barium	0.02	0.023	0.112	
Strontium	0.00	0.000	0.000	
Aluminum	0.01	0.01	0.05	
Ammonium	6.78	6.78	31.44	
ANIONS (mg/L)	ENTERED FEED	ADJUSTED FEED	CONC. PRIMARY	
Chloride	180.00	180.00	871.20	
Sulfate	78.70	78.70	387.68	
Bicarbonate	154.00	148.31	653.37	
Carbonate	0.50	1.13	63.43	
Nitrate	39.44	39.44	169.80	
Fluoride	0.00	0.00	0.00	
Phosphate	1.89	1.89	8.98	
Silica	21 10	21 10	102.32	

ANTISCALANT DETAILS

Antiscalant Selected Dosage Usage	PRIMARY Vitec ™ 4000 2.65 mg/l 99.79 lb/day
Usage Tank Concontration	99.79 lb/day
Pump Rate	26.25 mL/min

SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
CCPP Calcium Sulfate CaSO ₄ Barium Sulfate BaSO ₄ Strontium Sulfate SrSO ₄ Calcium Phosphate Ca ₃ (PO ₄) ₂ Calcium Flouride CaF ₂ Silica SiO ₂ Magnesium Hydroxide Mg(OH) ₂	1.38 0.01 0.40 0.00 0.74 0.00 0.16 0.00	1.38 0.01 0.40 0.74 0.00 0.74 0.00 0.16 0.00	198.84 0.09 4.14 0.00 1966.71 0.00 0.73 0.00
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Langelier Saturation Index (LSI)	0.071	0.071	2.008
Stiff & Davis Index (S&DI)	-0.170	-0.170	1.889
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
pH	7.80	7.80	8.54
Ionic Strength (M)	0.012	0.012	0.056
Temperature (°C)	30.0	30.0	30.0
TDS (mg/L)	702.94	702.94	3356.84

Dosing at 85%

Projection Information	PROJECT PALMDALE BRINE MANAGEMENT - HIGH WQ			DATE Sep-13-2022	
	RECOVERY	85.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Results Summary

DOSING DATA		RECOMMENDED PRODUCT	
	PRIMARY	PRIMARY	
DOSAGE	2.55 mg/L	Vitec ™ 4000	
PUMP RATE	25.25 mL/min		
DAILY REQUIREMENT	95.99 lb/day		
		I	

SATURATION GRAPH



PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

VITEC ™ 4000 NEAT							
Daily	95.99 lb	Weekly	671.93 lb	Monthly	2879.71 lb	Yearly	34940.51 lb

Notes

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rojection Information	PROJECT PALMDALE BRIN	E MANAGEMENT - HIGH WQ		DATE Sep-13-2022	
	RECOVERY	85.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Technical Results Summary

SYSTEM DESIGN



PRIMARY RECOVERY

85 %

	FLOW (USGPM)	TDS (mg/L)	ECOND (µs/cm)	рН
1	3139.00	703	1184.81	7.80
2	3139.00	703	1184.81	7.80
3	470.85	4475	6285.92	8.67
4	2668.15			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Sodium Potassium Calcium Iron Manganese Barium Strontium Aluminum Ammonium	139.00 15.90 39.50 12.90 0.04 0.02 0.02 0.00 0.01 6.78	139.00 15.90 39.50 12.90 0.04 0.021 0.002 0.000 0.01 6.78	891.55 101.63 257.54 84.10 0.26 0.133 0.150 0.000 0.000 41.91
ANIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Chloride	180.00	180.00	1161.60
Sulfate	78.70	78.70	516.90
Bicarbonate	154.00	148.31	834.76
Carbonate	0.50	1.13	121.54
Nitrate	39.44	39.44	226.40
Fluoride	0.00	0.00	0.00
Phosphate	1.89	1.89	11.97
Silica	21.10	21.10	136.43

ANTISCALANT DETAILS

Antiscalant Selected Dosage Usage Tank Concentration	PRIMARY Vitec ™ 4000 2.55 mg/l 95.99 lb/day 100 %
Pump Rate	25.25 mL/min

SCALING POTENTIAL

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SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
CCPP	1.38	1.38	320.54
Calcium Sulfate CaSO ₄	0.01	0.01	0.12
Barium Sulfate BaSO ₄	0.40	0.40	6.14
Strontium Sulfate SrSO ₄	0.00	0.00	0.00
Calcium Phosphate Ca ₃ (PO ₄) ₂	0.74	0.74	5932.11
Calcium Flouride CaF ₂	0.00	0.00	0.00
Silica SiO ₂	0.16	0.16	0.95
Magnesium Hydroxide Mg(OH) ₂	0.00	0.00	0.01
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Langelier Saturation Index (LSI)	0.071	0.071	2.348
Stiff & Davis Index (S&DI)	-0.170	-0.170	2.245
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
pH	7.80	7.80	8.67
Ionic Strength (M)	0.012	0.012	0.075
Temperature (°C)	30.0	30.0	30.0
TDS (mg/L)	702.94	702.94	4474.60

Dosing at 90%

PROJECT DATE **Projection Information** PALMDALE BRINE MANAGEMENT - HIGH WQ Sep-13-2022 Treated Effluent RECOVERY 90.00 % WATER TYPE Hydranautics CUSTOMER Palmdale MEMBRANE MANUFACTURER ESPA4-LD MEMBRANE MODEL ENGINEER PREPARED BY Yamrot Amha WATER ANALYSIS DATE Jun-16-2022

Antiscalant Results Summary

PRIMARY PRIMARY DOSAGE 2.33 mg/L Vitec ™ 4000 PUMP RATE 23.09 mL/min DAILY REQUIREMENT 87.78 lb/day	DOSING DATA		RECOMMENDED PRODUCT
DOSAGE 2.33 mg/L Vitec ™ 4000 PUMP RATE 23.09 mL/min DAILY REQUIREMENT 87.78 lb/day		PRIMARY	PRIMARY
PUMP RATE 23.09 mL/min DAILY REQUIREMENT 87.78 lb/day	DOSAGE	2.33 mg/L	Vitec ™ 4000
DAILY REQUIREMENT 87.78 lb/day	PUMP RATE	23.09 mL/min	
	DAILY REQUIREMENT	87.78 lb/day	

SATURATION GRAPH



PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

VITEC ™ 4000 N	IEAT						
Daily	87.78 lb	Weekly	614.45 lb	Monthly	2633.37 lb	Yearly	31951.54 lb

Notes

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rojection Information	PROJECT PALMDALE BRIN	E MANAGEMENT - HIGH WQ		DATE Sep-13-2022	
	RECOVERY	90.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Technical Results Summary

SYSTEM DESIGN



PRIMARY RECOVERY

90 %

	FLOW (USGPM)	TDS (mg/L)	ECOND (μs/cm)	рН
1	3139.00	703	1184.81	7.80
2	3139.00	703	1184.81	7.80
3	313.90	6709	8850.58	8.84
4	2825.10			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED FEED	ADJUSTED FEED	CONC. PRIMARY	
Sodium	139.00	139.00	1337.32	
Potassium	15.90	15.90	152.45	
Calcium	39.50	39.50	386.31	
Magnesium	12.90	12.90	126.15	
Iron	0.04	0.04	0.38	
Manganese	0.02	0.021	0.200	
Barium	0.02	0.023	0.225	
Strontium	0.00	0.000	0.000	
Aluminum	0.01	0.01	0.10	
Ammonium	6.78	6.78	62.87	
ANIONS (mg/L)	ENTERED FEED	ADJUSTED FEED	CONC. PRIMARY	
Chloride	180.00	180.00	1742.40	
Sulfate	78.70	78.70	775.35	
Bicarbonate	154.00	148.31	1143.16	
Carbonate	0.50	1.13	291.02	
Nitrate	39.44	39.44	339.60	
Fluoride	0.00	0.00	0.00	
Phosphate	1.89	1.89	17.95	
Silica	21.10	21.10	204.65	

ANTISCALANT DETAILS

Antiscalant Selected Dosage Usage	PRIMARY Vitec ™ 4000 2.33 mg/l 87.78 lb/day
Usage	87.78 lb/day
Tank Concentration	100 %
Pump Rate	23 09 ml /min

SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
CCPP	1.38	1.38	600.66
Calcium Sulfate CaSO ₄	0.01	0.01	0.19
Barium Sulfate BaSO ₄	0.40	0.40	10.64
Strontium Sulfate SrSO ₄	0.00	0.00	0.00
Calcium Phosphate Ca ₃ (PO ₄) ₂	0.74	0.74	23952.95
Calcium Flouride CaF ₂	0.00	0.00	0.00
Silica SiO ₂	0.16	0.16	1.37
Magnesium Hydroxide Mg(OH) ₂	0.00	0.00	0.02
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Langelier Saturation Index (LSI)	0.071	0.071	2.827
Stiff & Davis Index (S&DI)	-0.170	-0.170	2.736
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
pH	7.80	7.80	8.84
lonic Strength (M)	0.012	0.012	0.112
Temperature (°C)	30.0	30.0	30.0
TDS (mg/L)	702.94	702.94	6708.92

Dosing at 92%

PROJECT DATE **Projection Information** PALMDALE BRINE MANAGEMENT - HIGH WQ Sep-13-2022 Treated Effluent RECOVERY 92.00 % WATER TYPE Hydranautics CUSTOMER Palmdale MEMBRANE MANUFACTURER ESPA4-LD MEMBRANE MODEL ENGINEER PREPARED BY Yamrot Amha WATER ANALYSIS DATE Jun-16-2022

Antiscalant Results Summary

DOSING DATA		RECOMMENDED PRODUCT	ACID DOSING	
	PRIMARY	PRIMARY		PRIMARY
DOSAGE	2.08 mg/L	Vitec ™ 4000	Adjusted pH	7.40
PUMP RATE	20.59 mL/min		ACID DOSING	6.4 mg/L H2SO4
DAILY REQUIREMENT	78.27 lb/day		DAILY REQUIREMENT	

SATURATION GRAPH



PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

VITEC ™ 4000 NEAT							
Daily	78.27 lb	Weekly	547.92 lb	Monthly	2348.25 lb	Yearly	28492.08 lb

Notes

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Projection Information	PROJECT PALMDALE BRIN	E MANAGEMENT - HIGH WQ		DATE Sep-13-2022	
	RECOVERY	92.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Technical Results Summary

SYSTEM DESIGN



PRIMARY RECOVERY

92 %

	FLOW (USGPM)	TDS (mg/L)	ECOND (µs/cm)	рН
1	3139.00	703	1184.81	7.80
2	3139.00	709	1189.09	7.40
3	251.12	8400	10907.20	8.54
4	2887.88			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Sodium	139.00	139.00	1671.65
Potassium	15.90	15.90	190.56
Calcium	39.50	39.50	482.89
Magnesium	12.90	12.90	157.69
Iron	0.04	0.04	0.48
Manganese	0.02	0.021	0.249
Barium	0.00	0.023	0.281
Strontium	0.00	0.000	0.000
Aluminum	0.01	0.01	0.12
Ammonium	6.78	6.78	78.59
ANIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Chloride	180.00	180.00	2178.00
Sulfate	78.70	84.99	1046.68
Bicarbonate	154.00	141.28	1502.32
Carbonate	0.50	0.22	221.52
Nitrate	39.44	39.44	424.50
Fluoride	0.00	0.00	0.00
Phosphate	1.89	1.89	22.44
Silica	21.10	21.10	255.81

ANTISCALANT DETAILS

Antiscalant Selected Dosage Usage Tank Concentration	PRIMARY Vitec ™ 4000 2.08 mg/l 78.27 lb/day 100 % 20.50 mJ (min
Pump Rate	20.59 mL/min

SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
CCPP	1.38	-11.04	710.53
Calcium Sulfate CaSO ₄	0.01	0.01	0.29
Barium Sulfate BaSO ₄	0.40	0.43	14.83
Strontium Sulfate SrSO ₄	0.00	0.00	0.00
Calcium Phosphate Ca ₃ (PO ₄) ₂	0.74	0.09	22007.66
Calcium Flouride CaF ₂	0.00	0.00	0.00
Silica SiO ₂	0.16	0.16	1.83
Magnesium Hydroxide Mg(OH) ₂	0.00	0.00	0.01
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Langelier Saturation Index (LSI)	0.071	-0.356	2.656
Stiff & Davis Index (S&DI)	-0.170	-0.596	2.563
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
pH	7.80	7.40	8.54
Ionic Strength (M)	0.012	0.012	0.140
Temperature (°C)	30.0	30.0	30.0
TDS (mg/L)	702.94	709.49	8399.71

Dosing at 94%

PROJECT DATE **Projection Information** PALMDALE BRINE MANAGEMENT - HIGH WQ Sep-13-2022 Treated Effluent RECOVERY 94.00 % WATER TYPE Hydranautics CUSTOMER Palmdale MEMBRANE MANUFACTURER ESPA4-LD MEMBRANE MODEL ENGINEER PREPARED BY Yamrot Amha WATER ANALYSIS DATE Jun-16-2022

Antiscalant Results Summary

DOSING DATA		RECOMMENDED PRODUCT	ACID DOSING	
	PRIMARY	PRIMARY		PRIMARY
DOSAGE	2.08 mg/L	Vitec ™ 4000	Adjusted pH	7.10
PUMP RATE	20.59 mL/min		ACID DOSING	15.6 mg/L H2SO4
DAILY REQUIREMENT	78.27 lb/day		DAILY REQUIREMENT	

SATURATION GRAPH



PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

VITEC ™ 4000 NEAT							
Daily	78.27 lb	Weekly	547.92 lb	Monthly	2348.25 lb	Yearly	28492.08 lb

Notes

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Projection Information	PROJECT PALMDALE BRIN	E MANAGEMENT - HIGH WQ		DATE Sep-13-2022	
	RECOVERY	94.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Technical Results Summary

SYSTEM DESIGN



PRIMARY RECOVERY

94 %

	FLOW (USGPM)	TDS (mg/L)	ECOND (µs/cm)	рН
1	3139.00	703	1184.81	7.80
2	3139.00	719	1193.56	7.10
3	188.34	11214	14047.13	8.37
4	2950.66			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED FEED	ADJUSTED FEED	CONC. PRIMARY	
Sodium	139.00	139.00	2228.86	
Potassium	15.90	15.90	254.08	
Calcium	39.50	39.50	643.85	
Magnesium	12.90	12.90	210.25	
Iron	0.04	0.04	0.64	
Manganese	0.02	0.021	0.332	
Barium	0.02	0.023	0.375	
Strontium	0.00	0.000	0.000	
Aluminum	0.01	0.01	0.16	
Ammonium	6.78	6.78	104.79	
ANIONS (mg/L)	ENTERED FEED	ADJUSTED FEED	CONC. PRIMARY	
Chloride	180.00	180.00	2904.00	
Sulfate	78.70	93.93	1542.41	
Bicarbonate	154.00	130.08	1937.97	
Carbonate	0.50	0.10	222.91	
Nitrate	39.44	39.44	566.01	
Fluoride	0.00	0.00	0.00	
Phosphate	1.89	1.89	29.92	
Silica	21.10	21.10	341.08	

ANTISCALANT DETAILS

ANTISCALANT DETAILS	
Antiscalant Selected Dosage Usage Tank Concentration Pump Rate	PRIMARY Vitec ™ 4000 2.08 mg/l 78.27 lb/day 100 % 20.59 mL/min

SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
CCPP	1.38	-27.08	951.53
Calcium Sulfate CaSO ₄	0.01	0.01	0.45
Barium Sulfate BaSO ₄	0.40	0.47	23.15
Strontium Sulfate SrSO ₄	0.00	0.00	0.00
Calcium Phosphate Ca ₃ (PO ₄) ₂	0.74	0.02	27953.66
Calcium Flouride CaF ₂	0.00	0.00	0.00
Silica SiO ₂	0.16	0.16	2.50
Magnesium Hydroxide Mg(OH) ₂	0.00	0.00	0.00
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Langelier Saturation Index (LSI)	0.071	-0.694	2.658
Stiff & Davis Index (S&DI)	-0.170	-0.933	2.547
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
pH	7.80	7.10	8.37
Ionic Strength (M)	0.012	0.012	0.188
Temperature (°C)	30.0	30.0	30.0
TDS (mg/L)	702.94	718.63	11213.88

Dosing at 96%

PROJECT DATE **Projection Information** PALMDALE BRINE MANAGEMENT - HIGH WQ Sep-13-2022 Treated Effluent RECOVERY 96.00 % WATER TYPE Hydranautics CUSTOMER Palmdale MEMBRANE MANUFACTURER ESPA4-LD MEMBRANE MODEL ENGINEER PREPARED BY Yamrot Amha WATER ANALYSIS DATE Jun-16-2022

Antiscalant Results Summary

DOSING DATA		RECOMMENDED PRODUCT	ACID DOSING	
	PRIMARY	PRIMARY		PRIMARY
DOSAGE	2.08 mg/L	Vitec ™ 4000	Adjusted pH	6.20
PUMP RATE	20.59 mL/min		ACID DOSING	70.9 mg/L H2SO4
DAILY REQUIREMENT	78.27 lb/day		DAILY REQUIREMENT	

SATURATION GRAPH



PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

VITEC ™ 4000 NI	EAT						
Daily	78.27 lb	Weekly	547.92 lb	Monthly	2348.25 lb	Yearly	28492.08 lb

Notes

The information contained herein reflects our current level of technical knowledge and experience. It does not constitute a legal warranty of particular characteristics or of fitness for a specific purpose and, due to the abundance of possible influences, does not exempt the user from making its own examinations and taking appropriate precautionary measures. It shall be the responsibility of the recipient of our products to respect any intellectual property rights and comply with any laws or other provisions.

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Advisor CI Ver. 9.9.0.0-220803 , PID:BrDsT3010923

Projection Information	PROJECT PALMDALE BRIN	E MANAGEMENT - HIGH WQ	DATE I WQ Sep-13-2022		
	RECOVERY	96.00 %	WATER TYPE		Treated Effluent
	CUSTOMER	Palmdale	MEMBRANE MANUFACTURER		Hydranautics
	ENGINEER		MEMBRANE MODEL		ESPA4-LD
	PREPARED BY	Yamrot Amha	WATER ANALYSIS DATE		Jun-16-2022

Antiscalant Technical Results Summary

SYSTEM DESIGN



PRIMARY RECOVERY

96 %

	FLOW (USGPM)	TDS (mg/L)	ECOND (µs/cm)	рН
1	3139.00	688	1184.82	7.80
2	3139.00	760	1218.68	6.20
3	125.56	16583	20161.56	7.64
4	3013.44			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Sodium	139.00	139.00	3343.30
Potassium	15.90	15.90	381.12
Calcium	39.50	39.50	965.77
Magnesium	12.90	12.90	315.37
Iron	0.04	0.04	0.96
Manganese	0.02	0.021	0.499
Barium	0.02	0.023	0.562
Strontium	0.00	0.000	0.000
Aluminum	0.01	0.01	0.24
Ammonium	6.78	6.78	157.18
ANIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Chloride	180.00	180.00	4356.00
Sulfate	78.70	148.11	3647.93
Bicarbonate	154.00	61.35	1907.82
Carbonate	0.50	0.01	51.56
Nitrate	39.44	39.44	849.01
Fluoride	0.00	0.00	0.00
Phosphate	1.89	1.89	44.88
Silica	12.00	12.00	290.97

ANTISCALANT DETAILS

Antiscalant Selected	PRIMARY Vitec ™ 4000 2.08 mg/l 78.27 lb/day
Usage	78.27 lb/day
Tank Concentration	100 %
Pump Rate	20.59 mL/min

SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
CCPP Calcium Sulfate CaSO ₄ Barium Sulfate BaSO ₄ Strontium Sulfate SrSO ₄ Calcium Phosphate Ca ₃ (PO ₄) ₂ Calcium Flouride CaF ₂ Silica SiO ₂ Magnesium Hydroxide Mg(OH) ₂	1.38 0.01 0.40 0.00 0.74 0.00 0.09 0.00	-117.42 0.02 0.74 0.00 0.00 0.00 0.00 0.09 0.00	894.28 1.16 57.90 0.00 4652.42 0.00 2.24 0.00
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
Langelier Saturation Index (LSI)	0.071	-1.930	2.000
Stiff & Davis Index (S&DI)	-0.170	-2.160	1.820
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	PRIMARY
pH	7.80	6.20	7.64
Ionic Strength (M)	0.012	0.012	0.291
Temperature (°C)	30.0	30.0	30.0
TDS (mg/L)	688.38	759.67	16582.85
Appendix A3 – Secondary RO model outputs

Projection Information	PROJECT PALMDALE BRINE MANAGEMENT AVG WQ-79% RECOVERY		DATE Sep-14-2022	
	RECOVERY	79.00 %	WATER TYPE	Treated Effluent
	CUSTOMER	Palmdale Brine Management - low dose	MEMBRANE	Hydranautics
	ENGINEER		MANUFACTURER	Tiyuranautics
	PREPARED BY	Yamrot Amha	MEMBRANE MODEL	ESPA2-LD
			WATER ANALYSIS DATE	Jun-21-2022

Antiscalant Results Summary

DOSING DATA		ACID DOSING		RECOMMENDED PRODUCT
	PRIMARY	P	RIMARY	PRIMARY
DOSAGE	2.42 mg/L	Adjusted pH	6.90	Vitec ™ 4000
PUMP RATE	23.99 ml/min	ACID DOSING	7.01 mg/L	
DAILY REQUIREMENT	91.20 lb/day	DAILY REQUIREMENT	22.21 lb/day	

Saturation Index

SATURATION GRAPH



PRODUCT USAGE PROJECTION

PRODUCT DOSAGE

PRODUCT DOS	DAGE						
VITEC ™ 4000							
Daily	91.2 lb	Weekly	638.4 lb	Monthly	2553.6 lb	Yearly	33196.9 lb

NOTES

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Projection Information	PROJECT PALMDALE BRINE MANAGEMENT AVG WQ-79% RECOVERY		DATE Sep-14-2022	
	RECOVERY	79.00 %	WATER TYPE	Treated Effluent
	CUSTOMER	Palmdale Brine Management - low dose	MEMBRANE	Hydranautics
	ENGINEER		MANUFACTURER	Tyuranautus
	PREPARED BY	Yamrot Amha	MEMBRANE MODEL	ESPA2-LD
			WATER ANALYSIS DATE	Jun-21-2022

Antiscalant Technical Results Summary

SYSTEM DESIGN



OVERALL SYSTEM 79.00 % RECOVERY

	FLOW	TDS (mg/L)	ECOND	рН
	(USGPM)		(µs/cm)	
1	3139.00	587	850.40	7.10
2	3139.00	594	852.35	6.90
3	659.19	2638	3482.12	7.62
4	2479.81			

WATER CHEMISTRY

CATIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Sodium Potassium Calcium Magnesium Iron Manganese Barium Strontium Aluminum Ammonium	119.23 15.87 34.19 8.97 0.06 0.055 0.000 0.000 0.000 0.02 2.45	119.23 15.87 34.19 8.97 0.06 0.055 0.000 0.000 0.000 0.02 2.45	546.23 72.48 159.22 41.79 0.27 0.248 0.000 0.000 0.000 0.08 10.83
ANIONS (mg/L)	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Chloride	173.14	173.14	798.08
Sulfate	68.50	75.23	352.92
Bicarbonate	100.66	90.67	421.42
Carbonate	0.14	0.04	3.59
Nitrate	11.41	11.41	46.79
Fluoride	0.00	0.00	0.00
Phosphate	1.90	1.90	8.60
Silica	20.70	20.70	95.60

ANTISCALANT DETAILS

Antiscalant Selected Dosage Usage Tank Concentration Pump Rate	PRIMARY Vitec ™ 4000 2.42 mg/l 91.20 lb/day 100 % 23.99 mL/min
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SCALING POTENTIAL

SATURATION LEVEL	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
CCPP Calcium Sulfate CaSO ₄ Barium Sulfate BaSO ₄ Strontium Sulfate SrSO ₄ Calcium Phosphate Ca ₃ (PO ₄) ₂ Calcium Flouride CaF ₂ Silica SiO ₂ Magnesium Hydroxide Mg(OH) ₂	-22.54 0.01 0.00 0.00 0.01 0.00 0.19 0.00	-37.30 0.01 0.00 0.00 0.00 0.00 0.19 0.00	54.95 0.09 0.00 24.36 0.00 0.86 0.00
SATURATION INDICES	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
Langelier Saturation Index (LSI)	-0.963	-1.211	0.682
Stiff & Davis Index (S&DI)	-1.243	-1.489	0.516
SYSTEM PARAMETERS	ENTERED	ADJUSTED	CONC.
	FEED	FEED	STAGE 1
pH	7.10	6.90	7.62
Ionic Strength (M)	0.009	0.010	0.045
Temperature (°C)	23.0	23.0	23.0
TDS (mg/L)	587.447	594.444	2638.350

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RO System Flow Diagram



#	Description	Flow	TDS	Pressure
		(gpm)	(mg/L)	(psi)
1	Raw Feed to RO System	112.5	2,545	0.0
2	Net Feed to Pass 1	112.5	2,545	84.2
4	Total Concentrate from Pass 1	41.0	6,410	71.3
6	Net Product from RO System	71.5	324.3	0.0

RO System Overview

Total # of Trains	1	Online =	1	Standby =	0	RO Recovery	63.6 %
System Flow Rate	(gpm)	Net Feed =	112.5	Net Product =	71.5		

Pass		Pass 1
Stream Name		avista output
Water Type		Waste Water (Membrane pretreatment,SDI < 3)
Number of Elements		42
Total Active Area	(m²)	1561
Feed Flow per Pass	(gpm)	112.5
Feed TDS ^a	(mg/L)	2,545
Feed Pressure	(psi)	72.5 - 84.2
Flow Factor Per Stage		0.70
Permeate Flow per Pass	(gpm)	71.5
Pass Average flux	(gfd)	6.1
Permeate TDS ^a	(mg/L)	324.3
Pass Recovery		63.6 %
Average NDP	(psi)	36.9
Specific Energy	(kWh/m³)	0.89
Temperature	(°C)	23.1
рН		7.6
Chemical Dose		-
RO System Recovery		63.6 %
Net RO System Recovery		63.6%

Footnotes:

 $^a\text{Total}$ Dissolved Solids includes ions, SiO_2 and B. It does not include NH_3 and CO_2



CCRO Overview

Pass		Pass 1
Elements per PV	Elements	7
Length Of PV	Elements	7
CC Recovery	(%)	47.62
PF Recovery	(%)	1.00
PF Feed Ratio	(%)	109.00
CC Concentrate Flow	(gpm/pv)	20.00
PF Concentrate Flow	(gpm/pv)	19.62
CC Net Feed Flow	(gpm/pv)	38.18
PF Feed Flow	(gpm/pv)	19.82
Total Cycles		2.91
PF Sequence Duration	(min)	1.87
CC Sequence Duration	(min)	3.50
Complete Cycle Duration	(min)	5.37
CC System Volume	(m³)	0.83

CCRO Sustainability

	Recovery	Concentrate				
		Volume		Value		
Tradional RO	00	59063	kgal/y	185568	\$/y	
CCRO	64	21525	kgal/y	67629	\$/y	
CCRO Savings		37538	kgal/y	117939	\$/y	

At water purchase price 0.52996 $\mbox{\$/m}^3$ and water disposal price 2.61193 $\mbox{\$/m}^3$

RO Flow Table (Stage Level) - Pass 1

					Feed			Concentrate			Permeate			
Stage	Elements	#PV	#Els per PV	Feed Flow	Recirc Flow	Feed Press	Boost Press	Conc Flow	Conc Press	Press Drop	Perm Flow	Avg Flux	Perm Press	Perm TDS
				(gpm)	(gpm)	(psi)	(psi)	(gpm)	(psi)	(psi)	(gpm)	(gfd)	(psi)	(mg/L)
PF	FilmTec™ SOAR 3000i	6	7	118.9	0.0	6.0	10.5	117.7	0.8	5.2	1.19	0.1	0.0	1,967
CC1	FilmTec™ SOAR 3000i	6	7	229.1	0.0	68.0	72.5	120.0	59.6	8.4	109.1	9.4	0.0	263.2
CC Final	FilmTec™ SOAR 3000i	6	7	229.1	0.0	79.7	84.2	120.0	71.3	8.4	109.1	9.4	0.0	361.5

RO Solute Concentrations - Pass 1



Concentrations	(mg/	L as i	ion)
----------------	------	--------	-----	---

			Concentrate		Permeate			
	Feed	PF	CC1	CC Final	PF	CC1	CC Final	Total
NH₄⁺	10.83	10.84	19.16	26.11	9.52	1.68	2.34	2.07
K⁺	72.48	72.57	129.7	178.1	63.72	9.68	13.36	11.91
Na⁺	546.2	546.9	975.9	1,340	476.2	74.38	101.9	91.04
Mg ⁺²	41.79	41.98	78.78	111.7	23.14	1.31	1.86	1.72
Ca+2	159.2	159.9	300.3	425.7	88.14	4.89	6.95	6.45
Sr+2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba ⁺²	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO3 ⁻²	2.42	2.43	7.41	13.40	1.41	0.01	0.02	0.02
HCO₃⁻	409.2	410.1	742.6	1,028	319.8	35.92	50.10	44.98
NO₃⁻	46.79	46.81	71.49	89.41	45.26	19.63	24.57	22.35
F⁻	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CI⁻	798.1	799.1	1,432	1,971	694.7	102.1	141.0	125.8
Br⁻¹	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
504 ⁻²	352.9	354.8	669.7	952.7	165.1	6.63	9.48	9.03
PO4 ⁻³	8.60	8.63	16.11	22.74	5.20	0.38	0.55	0.49
SiO₂	95.60	95.81	176.7	247.7	74.62	6.62	9.33	8.42
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	10.63	10.63	13.54	16.24	10.37	10.61	11.82	11.22
TDSª	2,545	2,550	4,621	6,408	1,967	263.2	361.5	324.3
Cond. µS/cm	3,991	3,999	6,915	9,301	652	465	635	571
рН	7.6	7.6	7.7	7.8	7.6	6.7	6.8	6.8

Footnotes:

aTotal Dissolved Solids includes ions, SiO_2 and B. It does not include NH_3 and CO_2

RO Design Warnings

Design Warning		Limit	Value	Pass	Stage	Element	Product
Pass Average Recovery < Minimum Value	(%)	75.00	63.56	1	-	-	FilmTec™ SOAR 3000i
PF Feed Ratio < Minimum Value	(%)	110.00	109.00	1	-	-	FilmTec™ SOAR 3000i
PF Recovery < Minimum Value	(%)	10.00	1.00	1	-	-	FilmTec™ SOAR 3000i
CC Duration < Minimum Value	(min)	5.00	3.50	1	-	-	FilmTec™ SOAR 3000i

Special Comments

None

RO Flow Table (Element Level) - Pass 1

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WATER APPLICATION VALUE ENGINE WATER SOLUTIONS



Stage	Element	Element Name	Recovery	Feed Flow	Feed Press	Feed TDS	Conc Flow	Perm Flow	Perm Flux	Perm TDS
			(%)	(gpm)	(psi)	(mg/L)	(gpm)	(gpm)	(gfd)	(mg/L)
PF	1	FilmTec™ SOAR 3000i	0.3	19.8	6.0	2,545	19.8	0.05	0.2	1,793
PF	2	FilmTec™ SOAR 3000i	0.2	19.8	5.2	2,547	19.7	0.04	0.2	1,878
PF	3	FilmTec™ SOAR 3000i	0.2	19.7	4.5	2,548	19.7	0.03	0.1	1,965
PF	4	FilmTec™ SOAR 3000i	0.1	19.7	3.8	2,549	19.7	0.03	0.1	2,058
PF	5	FilmTec™ SOAR 3000i	0.1	19.7	3.0	2,550	19.6	0.02	0.1	2,152
PF	6	FilmTec™ SOAR 3000i	0.1	19.6	2.3	2,550	19.6	0.01	0.1	2,257
PF	7	FilmTec™ SOAR 3000i	0.0	19.6	1.5	2,550	19.6	0.01	0.0	2,364
CC1	1	FilmTec™ SOAR 3000i	8.8	38.2	68.0	2,548	34.8	3.35	12.1	165.8
CC1	2	FilmTec™ SOAR 3000i	8.9	34.8	66.3	2,777	31.7	3.08	11.1	193.1
CC1	3	FilmTec™ SOAR 3000i	8.9	31.7	64.8	3,027	28.9	2.82	10.2	225.7
CC1	4	FilmTec™ SOAR 3000i	8.9	28.9	63.5	3,301	26.3	2.58	9.3	264.4
CC1	5	FilmTec™ SOAR 3000i	8.9	26.3	62.3	3,597	24.0	2.34	8.4	310.6
CC1	6	FilmTec™ SOAR 3000i	8.8	24.0	61.3	3,917	21.9	2.11	7.6	365.7
CC1	7	FilmTec™ SOAR 3000i	8.7	21.9	60.4	4,258	20.0	1.90	6.8	431.2
CC Final	1	FilmTec™ SOAR 3000i	9.2	38.2	79.7	3,633	34.7	3.49	12.6	219.9
CC Final	2	FilmTec™ SOAR 3000i	9.1	34.7	78.0	3,977	31.5	3.17	11.4	259.9
CC Final	3	FilmTec™ SOAR 3000i	9.1	31.5	76.5	4,351	28.7	2.86	10.3	308.2
CC Final	4	FilmTec™ SOAR 3000i	9.0	28.6	75.2	4,754	26.1	2.56	9.2	366.6
CC Final	5	FilmTec™ SOAR 3000i	8.8	26.1	74.1	5,184	23.8	2.28	8.2	436.9
CC Final	6	FilmTec™ SOAR 3000i	8.5	23.8	73.1	5,637	21.8	2.02	7.3	521.2
CC Final	7	FilmTec™ SOAR 3000i	8.2	21.8	72.1	6,108	20.0	1.78	6.4	621.2

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Footnotes:

 $^a\text{Total}$ Dissolved Solids includes ions, SiO_2 and B. It does not include NH_3 and CO_2

RO Solubility Warnings

Warning	Pass No
Langelier Saturation Index > 0	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 1 st Pass Conc
рН	7.6	7.8
Langelier Saturation Index	0.75	1.69
Stiff & Davis Stability Index	0.81	1.40
TDSª (mg/l)	2,545	6,410
Ionic Strength (molal)	0.05	0.12
HCO₃⁻ (mg/L)	409.2	1,029
CO ₂ (mg/l)	10.62	16.21
CO ₃ ⁻² (mg/L)	2.42	13.36
CaSO₄ (% saturation)	7.9	32.2
BaSO₄ (% saturation)	0.00	0.00
SrSO₄ (% saturation)	0.00	0.00
CaF ₂ (% saturation)	0.00	0.00
SiO ₂ (% saturation)	78.9	205.1
Mg(OH)₂ (% saturation)	0.00	0.03

Footnotes:

 a Total Dissolved Solids includes ions, SiO₂ and B. It does not include NH₃ and CO₂

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RO System Flow Diagram



#	Description	Flow	TDS	Pressure
		(gpm)	(mg/L)	(psi)
1	Raw Feed to RO System	112.5	2,546	0.0
2	Net Feed to Pass 1	112.5	2,546	98.1
4	Total Concentrate from Pass 1	30.0	8,513	85.3
6	Net Product from RO System	82.5	373.3	0.0

RO System Overview

Total # of Trains	1	Online =	1	Standby =	0	RO Recovery	73.4 %
System Flow Rate	(gpm)	Net Feed =	112.5	Net Product =	82.5		

Pass		Pass 1
Stream Name		avista output
Water Type		Waste Water (Membrane pretreatment,SDI < 3)
Number of Elements		42
Total Active Area	(m²)	1561
Feed Flow per Pass	(gpm)	112.5
Feed TDS ^a	(mg/L)	2,546
Feed Pressure	(psi)	73.0 - 98.1
Flow Factor Per Stage		0.70
Permeate Flow per Pass	(gpm)	82.5
Pass Average flux	(gfd)	7.1
Permeate TDS ^a	(mg/L)	373.3
Pass Recovery		73.3 %
Average NDP	(psi)	39
Specific Energy	(kWh/m³)	0.94
Temperature	(°C)	23.1
рН		7.4
Chemical Dose		-
RO System Recovery		73.3 %
Net RO System Recovery		73.3%

Footnotes:

 $^a\text{Total}$ Dissolved Solids includes ions, SiO_2 and B. It does not include NH_3 and CO_2



CCRO Overview

Pass		Pass 1
Elements per PV	Elements	7
Length Of PV	Elements	7
CC Recovery	(%)	47.83
PF Recovery	(%)	1.00
PF Feed Ratio	(%)	109.00
CC Concentrate Flow	(gpm/pv)	20.00
PF Concentrate Flow	(gpm/pv)	19.78
CC Net Feed Flow	(gpm/pv)	38.33
PF Feed Flow	(gpm/pv)	19.98
Total Cycles		3.99
PF Sequence Duration	(min)	1.85
CC Sequence Duration	(min)	5.48
Complete Cycle Duration	(min)	7.34
CC System Volume	(m³)	0.83

CCRO Sustainability

	Recovery	Concentrate					
		Volume		Value			
Tradional RO	00	59063	kgal/y	185568	\$/y		
CCRO	73	15740	kgal/y	49452	\$/y		
CCRO Savings		43323	kgal/y	136116	\$/y		

At water purchase price 0.52996 $\mbox{\$/m}^3$ and water disposal price 2.61193 $\mbox{\$/m}^3$

RO Flow Table (Stage Level) - Pass 1

					Feed			Concentrate			Permeate			
Stage	Elements	#PV	#Els per PV	Feed Flow	Recirc Flow	Feed Press	Boost Press	Conc Flow	Conc Press	Press Drop	Perm Flow	Avg Flux	Perm Press	Perm TDS
				(gpm)	(gpm)	(psi)	(psi)	(gpm)	(psi)	(psi)	(gpm)	(gfd)	(psi)	(mg/L)
PF	FilmTec™ SOAR 3000i	6	7	119.9	0.0	6.0	10.5	118.7	0.8	5.3	1.20	0.1	0.0	1,964
CC1	FilmTec™ SOAR 3000i	6	7	230.0	0.0	68.5	73.0	120.0	60.0	8.5	110.0	9.4	0.0	261.7
CC Final	FilmTec™ SOAR 3000i	6	7	230.0	0.0	93.6	98.1	120.0	85.3	8.3	110.0	9.4	0.0	470.7

RO Solute Concentrations - Pass 1



Concer	itrations (mg	/L as ion)						
			Concentrate			Pern	neate	
	Feed	PF	CC1	CC Final	PF	CC1	CC Final	Total
NH_4^+	10.83	10.84	19.32	34.32	9.49	1.58	2.94	2.30
K⁺	72.48	72.57	130.2	234.0	63.63	9.64	17.47	13.78
Na⁺	546.2	547.0	979.9	1,761	475.5	74.04	132.4	105.0
Mg ⁺²	41.79	41.98	79.10	151.4	23.04	1.30	2.50	1.98
Ca+2	159.2	159.9	301.5	577.0	87.79	4.88	9.36	7.42
Sr+2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba+2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO3 ⁻²	1.51	1.52	5.20	17.15	0.88	0.01	0.02	0.02
HCO₃⁻	412.0	412.9	751.9	1,375	321.3	35.53	65.87	51.85
NO₃⁻	46.79	46.81	71.76	107.5	45.24	19.58	29.34	24.72
F⁻	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cl⁻	798.1	799.1	1,438	2,594	693.7	101.6	184.8	145.7
Br⁻¹	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
504 ⁻²	352.9	354.8	672.3	1,296	164.2	6.60	12.84	10.29
PO4 ⁻³	8.60	8.64	16.19	30.72	4.87	0.36	0.73	0.56
SiO₂	95.60	95.81	177.4	331.8	74.44	6.58	12.44	9.77
Boron	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO₂	17.22	17.22	19.82	25.47	16.80	17.35	19.72	18.54
TDSª	2,546	2,552	4,643	8,511	1,964	261.7	470.7	373.3
Cond. µS/cm	3,991	3,999	6,941	11,996	823	463	822	655
pН	7.4	7.4	7.6	7.7	7.3	6.5	6.7	6.6

Footnotes:

aTotal Dissolved Solids includes ions, SiO_2 and B. It does not include NH_3 and CO_2

RO Design Warnings

Design Warning		Limit	Value	Pass	Stage	Element	Product
Pass Average Recovery < Minimum Value	(%)	75.00	73.35	1	-	-	FilmTec™ SOAR 3000i
PF Feed Ratio < Minimum Value	(%)	110.00	109.00	1	-	-	FilmTec™ SOAR 3000i
PF Recovery < Minimum Value	(%)	10.00	1.00	1	-	-	FilmTec™ SOAR 3000i

Special Comments

None

RO Flow Table (Element Level) - Pass 1

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WATER APPLICATION VALUE ENGINE WATER SOLUTIONS



Stage	Element	Element Name	Recovery	Feed Flow	Feed Press	Feed TDS	Conc Flow	Perm Flow	Perm Flux	Perm TDS
			(%)	(gpm)	(psi)	(mg/L)	(gpm)	(gpm)	(gfd)	(mg/L)
PF	1	FilmTec™ SOAR 3000i	0.3	20.0	6.0	2,546	19.9	0.05	0.2	1,789
PF	2	FilmTec™ SOAR 3000i	0.2	19.9	5.3	2,548	19.9	0.04	0.2	1,875
PF	3	FilmTec™ SOAR 3000i	0.2	19.9	4.5	2,550	19.9	0.04	0.1	1,963
PF	4	FilmTec™ SOAR 3000i	0.1	19.9	3.8	2,551	19.8	0.03	0.1	2,057
PF	5	FilmTec™ SOAR 3000i	0.1	19.8	3.0	2,552	19.8	0.02	0.1	2,150
PF	6	FilmTec™ SOAR 3000i	0.1	19.8	2.3	2,552	19.8	0.01	0.1	2,258
PF	7	FilmTec™ SOAR 3000i	0.0	19.8	1.5	2,552	19.8	0.01	0.0	2,367
CC1	1	FilmTec™ SOAR 3000i	8.8	38.3	68.5	2,550	35.0	3.38	12.2	164.4
CC1	2	FilmTec™ SOAR 3000i	8.9	35.0	66.8	2,780	31.8	3.11	11.2	191.7
CC1	3	FilmTec™ SOAR 3000i	9.0	31.8	65.3	3,032	29.0	2.85	10.3	224.1
CC1	4	FilmTec™ SOAR 3000i	9.0	29.0	63.9	3,308	26.4	2.60	9.4	262.8
CC1	5	FilmTec™ SOAR 3000i	8.9	26.4	62.8	3,607	24.0	2.36	8.5	309.0
CC1	6	FilmTec™ SOAR 3000i	8.9	24.0	61.7	3,930	21.9	2.13	7.7	364.1
CC1	7	FilmTec™ SOAR 3000i	8.7	21.9	60.8	4,276	20.0	1.91	6.9	429.9
CC Final	1	FilmTec™ SOAR 3000i	9.6	38.3	93.6	4,680	34.7	3.67	13.2	276.5
CC Final	2	FilmTec™ SOAR 3000i	9.5	34.7	91.9	5,146	31.4	3.29	11.8	331.7
CC Final	3	FilmTec™ SOAR 3000i	9.3	31.4	90.5	5,650	28.5	2.92	10.5	399.6
CC Final	4	FilmTec™ SOAR 3000i	9.0	28.5	89.2	6,187	25.9	2.57	9.3	482.6
CC Final	5	FilmTec™ SOAR 3000i	8.7	25.9	88.0	6,752	23.6	2.25	8.1	583.4
CC Final	6	FilmTec™ SOAR 3000i	8.3	23.6	87.0	7,336	21.7	1.95	7.0	704.6
CC Final	7	FilmTec™ SOAR 3000i	7.8	21.7	86.1	7,931	20.0	1.69	6.1	848.0

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Footnotes:

 $^a\text{Total}$ Dissolved Solids includes ions, SiO_2 and B. It does not include NH_3 and CO_2

RO Solubility Warnings

Warning	Pass No
Langelier Saturation Index > 0	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 1 st Pass Conc
рН	7.4	7.7
Langelier Saturation Index	0.54	1.84
Stiff & Davis Stability Index	0.60	1.44
TDSª (mg/l)	2,546	8,513
Ionic Strength (molal)	0.05	0.16
HCO₃⁻ (mg/L)	412.0	1,375
CO₂ (mg/I)	17.22	25.48
CO ₃ ⁻² (mg/L)	1.51	17.15
CaSO₄ (% saturation)	7.9	48.1
BaSO₄ (% saturation)	0.00	0.00
SrSO₄ (% saturation)	0.00	0.00
CaF ₂ (% saturation)	0.00	0.00
SiO ₂ (% saturation)	78.9	275.0
Mg(OH)₂ (% saturation)	0.00	0.02

Footnotes:

 a Total Dissolved Solids includes ions, SiO₂ and B. It does not include NH₃ and CO₂

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APPENDIX B

Brine Pond Calculations and Alternatives Evaluation

APPENDIX **B**

BRINE POND CALCULATIONS AND ALTERNATIVES EVALUATION

Appendix B1 – Passive solar evaporation pond sizing

Appendix B2 – Pond layouts and sizing options

Appendix B3 – Enhancement Technology evaluation table

Appendix B1 – Passive solar evaporation pond sizing

Passive Solar Evaporation Pond Sizing - 90% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 90% Recovery, Phase 1	Updated by & Date:	L.Haug; 06/08/2022
		Reviewer & Review Date:	TBD

Assume 90% RO re	Assume 90% RO recovery with continuous production of brine.											
		Instant.		Monthly								
Treatment Waste	Instant. Flow	Flow		Quantity								
Stream	mgd	gpm	Run Factor	gal	Notes							
RO Brine	0.45	312.5	100.0%	13,687,500	Year-round value.							

Evaporation Rate Conversions	Value	Notes	
Pan Coefficient	1	Not used at this time.	
Brine Derating	0.7	Accounts for lower evaporation rate of brine compared to fresh water (USBR, 2006)	
Factor	•••		
Evaporation	1	No adjustment provided at this time	
Adjustment Factor	Ţ		
Combined Derating	0.7	Translates from Dan to local bring	
Factor	0.7	I ranslates from Pan to local brine	

Evaporation Pond					
Sizing Factors	Value	Units	Notes		
Depth of water	6.64	£+	From below: Total inflow divided by area		
added per year	0.04	11			
Solids Precipitation	0.002	ft	USER 2006 Figure 10.1 see Selids Presin Tab		
Rate	solids/ft				
Solids Precipitation	0.020	ft			
Rate	0.020	solids/yr			
Solids Storage	0.5	f+	No specific guidance found. Kent at 0.5 from go by		
Depth Reservation	0.5				
Required Solids	25.1				
Removal Interval	25.1	yr			
Freeboard	2	ft	Minimum per Los Angeles Region WDR requirements.		

Sizing	Value	Units	Notes
Required Minimum	01	26	*Iterate for stable annual
Surface Area	01	ac	operation
Minimum	17	f+	
Operational Depth	1.7	ιι	
Factor of Safety	50%		Kept from Go-by.
Required	25	£+	
Operational Depth	2.5	ιι	
Required	5 020 105	cf	
Operational Volume	5,550,195	CI	

Section View: Surface area required at lowest water level





Passive Solar Evaporation Pond Sizing - 90% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 90% Recovery, Phase 1	Updated by & Date:	L.Haug; 06/08/2022
		Reviewer & Review Date:	TBD

Assume 90% RO recovery with continuous production of brine.

	Climate Inputs ¹				Volume Needs per Month					Sizin	g	
		Hist.	Adi Fuen Data	A 111	Treatment						Commence	
Time	Cal	Pan	Adj. Evap. Rate	Avg.	Waste	Tractment	Presip	Tetel Inflow	Eveneration	Net Volume	Carryover	Required
Step	Cal. Month	Evap.	in/mo	precip.	volume	Treatment	precip.		Evaporation	Needs	volume	Depth
10101111	lan	2 9	2.03	1 13	13 687 500	1 829 880	332 254	2 162 134	596 881	1 565 253	1 565 253	0.4
2	Feb	4.65	3.255	0.76	13,687,500	1,829,880	223.463	2,102,13	957.068	1 096.275	2 661.528	0.8
- 3	Mar	6.45	4.515	0.62	13,687,500	1.829,880	182.299	2.012.178	1.327,545	684.633	3.346.160	0.9
4	Apr	9.97	6.979	0.4	13.687,500	1.829,880	117,612	1.947,492	2.052.035	-104,544	3.241,617	0.9
5	Mav	13.6	9.513	0.05	13.687,500	1.829,880	14.702	1.844.581	2.797,107	-952.526	2.289.090	0.6
6	Jun	15.3	10.731	0.03	13,687,500	1,829,880	8,821	1.838,701	3,155,236	-1.316,535	972,555	0.3
7	Jul	17.2	12.047	0.07	13,687,500	1,829,880	20,582	1,850,462	3,542,179	-1,691,718	0	0.0
8	Aug	16	11.2	0.11	13,687,500	1,829,880	, 32,343	1,862,223	3,293,136	-1,430,913	0	0.0
9	Sep	11.8	8.281	0.17	13,687,500	1,829,880	49,985	1,879,865	2,434,862	-554,998	0	0.0
10	Oct	8.28	5.796	0.2	13,687,500	1,829,880	58,806	1,888,686	1,704,198	184,488	184,488	0.1
11	Nov	4.76	3.332	0.84	13,687,500	1,829,880	246,985	2,076,865	979,708	1,097,157	1,281,645	0.4
12	Dec	3.52	2.464	0.67	13,687,500	1,829,880	197,000	2,026,880	724,490	1,302,390	2,584,035	0.7
13	Jan	2.9	2.03	1.13	13,687,500	1,829,880	332,254	2,162,134	596,881	1,565,253	4,149,287	1.2
14	Feb	4.65	3.255	0.76	13,687,500	1,829,880	223,463	2,053,342	957,068	1,096,275	5,245,562	1.5
15	Mar	6.45	4.515	0.62	13,687,500	1,829,880	182,299	2,012,178	1,327,545	684,633	5,930,195	1.7
16	Apr	9.97	6.979	0.4	13,687,500	1,829,880	117,612	1,947,492	2,052,035	-104,544	5,825,651	1.7
17	May	13.6	9.513	0.05	13,687,500	1,829,880	14,702	1,844,581	2,797,107	-952,526	4,873,125	1.4
18	Jun	15.3	10.731	0.03	13,687,500	1,829,880	8,821	1,838,701	3,155,236	-1,316,535	3,556,590	1.0
19	Jul	17.2	12.047	0.07	13,687,500	1,829,880	20,582	1,850,462	3,542,179	-1,691,718	1,864,872	0.5
20	Aug	16	11.2	0.11	13,687,500	1,829,880	32,343	1,862,223	3,293,136	-1,430,913	433,959	0.1
21	Sep	11.8	8.281	0.17	13,687,500	1,829,880	49,985	1,879,865	2,434,862	-554,998	0	0.0
22	Oct	8.28	5.796	0.2	13,687,500	1,829,880	58,806	1,888,686	1,704,198	184,488	184,488	0.1
23	Nov	4.76	3.332	0.84	13,687,500	1,829,880	246,985	2,076,865	979,708	1,097,157	1,281,645	0.4
24	Dec	3.52	2.464	0.67	13,687,500	1,829,880	197,000	2,026,880	724,490	1,302,390	2,584,035	0.7
25	Jan	2.9	2.03	1.13	13,687,500	1,829,880	332,254	2,162,134	596,881	1,565,253	4,149,287	1.2
26	Feb	4.65	3.255	0.76	13,687,500	1,829,880	223,463	2,053,342	957,068	1,096,275	5,245,562	1.5
27	Mar	6.45	4.515	0.62	13,687,500	1,829,880	182,299	2,012,178	1,327,545	684,633	5,930,195	1.7
28	Apr	9.97	6.979	0.4	13,687,500	1,829,880	117,612	1,947,492	2,052,035	-104,544	5,825,651	1.7
29	May	13.6	9.513	0.05	13,687,500	1,829,880	14,702	1,844,581	2,797,107	-952,526	4,873,125	1.4
30	Jun	15.3	10.731	0.03	13,687,500	1,829,880	8,821	1,838,701	3,155,236	-1,316,535	3,556,590	1.0
31	Jul	17.2	12.047	0.07	13,687,500	1,829,880	20,582	1,850,462	3,542,179	-1,691,718	1,864,872	0.5
32	Aug	16	11.2	0.11	13,687,500	1,829,880	32,343	1,862,223	3,293,136	-1,430,913	433,959	0.1
33	Sep	11.8	8.281	0.17	13,687,500	1,829,880	49,985	1,879,865	2,434,862	-554,998	U	0.0
34	Oct	8.28	5.796	0.2	13,687,500	1,829,880	58,806	1,888,686	1,704,198	184,488	184,488	0.1
35	Nov	4.76	3.332	0.84	13,687,500	1,829,880	246,985	2,076,865	979,708	1,097,157	1,281,645	0.4
30	Dec	3.52	2.464	0.67	13,687,500	1,829,880	197,000	2,026,880	724,490	1,302,390	2,584,035	0.7
کر 20	Jan	2.9	2.05	1.13	13,087,500	1,829,880	332,234	2,102,134	590,881	1,505,255	4,149,207	1.2
30 20	Feb	4.05	5.255	0.70	13,087,300	1,823,000	102 200	2,055,542	957,000	1,090,275	5,245,502	1.5
35	lVidi Apr	0.45	4.515	0.02	13,007,300	1,823,000	117 612	2,012,170	2,527,545	104 544	2,220,122	1./ 1.7
40	Арі	12.6	0.575	0.4	12 687 500	1,029,000	1/,012	1,541,452	2,032,033	-104,344	,020,001 1072 125	1./
41	lun	15.0	10 731	0.03	12 687 500	1 879 880	<u>14,702</u> 8 821	1 838 701	2,757,107	-332,320	2 556 590	1.4
43		17.2	12 047	0.03	12 687 500	1 879 880	20,521	1 850 462	2 542 179	-1 691 718	1 864 872	0.5
44	Διισ	16	11.2	0.07	13,007,500	1 829 880	20,002	1 862 223	3,342,1,5	-1 430 913	433 959	0.5
45	Sen	11.8	8,281	0.17	13,687,500	1 829,880	49 985	1 879 865	2 434 862	-554 998	-33,333	0.0
46	Oct	8.28	5.796	0.2	13 687,500	1 829,880	58.806	1 888.686	1 704,198	184.488	184.488	0.1
47	Nov	4.76	3.332	0.84	13 687,500	1 829,880	246.985	2 076.865	979,708	1 097.157	1 281.645	0.4
48	Dec	3.52	2.464	0.67	13.687,500	1.829,880	197.000	2.026.880	724,490	1.302.390	2.584.035	0.7
49	lan	2.9	2.03	1.13	13.687,500	1.829,880	332.254	2.162.134	596,881	1.565.253	4.149.287	1.2
50	Feb	4.65	3.255	0.76	13.687,500	1.829,880	223,463	2.053,342	957.068	1.096.275	5.245.562	1.5
51	Mar	6.45	4.515	0.62	13.687,500	1.829,880	182,299	2.012,178	1.327,545	684,633	5.930,195	1.7
52	Apr	9.97	6.979	0.4	13,687,500	1,829,880	117,612	1.947,492	2,052,035	-104,544	5.825,651	1.7
53	May	13.6	9.513	0.05	13,687,500	1,829,880	14,702	1,844,581	2,797,107	-952,526	4,873,125	1.4
54	Jun	15.3	10.731	0.03	13,687,500	1,829,880	8,821	1,838,701	3,155,236	-1,316,535	3,556,590	1.0
55	Jul	17.2	12.047	0.07	13,687,500	1.829,880	20,582	1,850,462	3,542,179	-1.691,718	1,864,872	0.5
56	Aug	16	11.2	0.11	13,687,500	1,829,880	32,343	1,862,223	3,293,136	-1,430,913	433,959	0.1
57	Sep	11.8	8.281	0.17	13,687,500	1,829,880	49,985	1,879,865	2,434,862	-554,998	0	0.0
58	Oct	8.28	5.796	0.2	13,687,500	1,829,880	58,806	1,888,686	1,704,198	184,488	184,488	0.1
59	Nov	4.76	3.332	0.84	13,687,500	1,829,880	246,985	2,076,865	979,708	1,097,157	1,281,645	0.4
60	Dec	3.52	2.464	0.67	13.687,500	1.829,880	197,000	2.026,880	724,490	1.302,390	2.584,035	0.7
						,=,==;===		_,,	,	Maximum	5 930 195	1.7

Notes: 1. Evaporation data was collected from ADEQ Engineering Bulletin No. 11. Precipitation data was collected from Buckeye, AZ.

See ADEQ Data tab

https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca6627

2. Pan evaporation data **has not** been adjusted by an evaporation adjustment factor, and by a brine/TDS factor.

3. This is annual average data, not worst case storm event.

4. Carryover volume is calcuated by the difference between evaporation and inflow by month, and previous volume balance.

Passive Solar Evaporation Pond Sizing - 92% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 92% Recovery, Phase 1	Updated by & Date:	L.Haug; 08/12/2022
		Reviewer & Review Date:	TBD

Assume 92% RO recovery with continuous production of brine.								
		Instant.		Monthly				
Treatment Waste	Instant. Flow	Flow		Quantity				
Stream	mgd	gpm	Run Factor	gal	Notes			
RO Brine	0.3616	251.1	100.0%	10,998,667	Year-round value.			

Evaporation Rate Conversions	Value	Notes			
Pan Coefficient	1	Not used at this time.			
Brine Derating	0.7	Accounts for lower evaporation rate of bring compared to fresh water (LISBR 2006)			
Factor	0.7				
Evaporation	1	No adjustment provided at this time			
Adjustment Factor	L	no aujustment provided, at this time.			
Combined Derating	0.7	Translates from Dan to local bring			
Factor	0.7	I ranslates from Pan to local brine			

Evaporation Pond				
Sizing Factors	Value	Units	Notes	
Depth of water	6.65	£4	From below: Total inflow divided by area	
added per year	0.05	11	FIGHT below. Total IIIIlow divided by area	
Solids Precipitation	0.0025	ft	USPR 2006 Figure 10.1, see Selids Presin, Tab	
Rate	0.0035	solids/ft	USBK 2000, Figure 10.1, see Solius Frecip. Tab.	
Solids Precipitation	0.022	ft		
Rate	0.023	solids/yr		
Solids Storage	0.5	f+	No specific guidance found. Kent at 0.5 from go by	
Depth Reservation	0.5	11	No specific guidance found. Rept at 0.5 from go-by.	
Required Solids	21 F			
Removal Interval	21.5	yı		
Freeboard	2	ft	Minimum per Los Angeles Region WDR requirements.	

Sizing	Value	Units	Notes
Required Minimum	6F	20	*Iterate for stable annual
Surface Area	60	ac	operation
Minimum	17	f+	
Operational Depth	1.7	ιι	
Factor of Safety	50%		Kept from Go-by.
Required	2 5	f+	
Operational Depth	2.5	ιι	
Required	4 770 726	cf	
Operational Volume	4,770,720	CI	

Section View: Surface area required at lowest water level





Passive Solar Evaporation Pond Sizing - 92% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 92% Recovery, Phase 1	Updated by & Date:	L.Haug; 08/12/2022
		Reviewer & Review Date:	TBD

Assume 92% RO recovery with continuous production of brine.

Ind. Org. Ind. Co., App. Co., App., App., App.,<	Climate Inputs ¹				Volume Needs per Month						Sizin	g	
Time Part Adj. Leva José Value Precise Telational Precise Telational Comparison Ref Volume Value Dept Month Munc 10/mo. 10/mo.<			Hist.			Treatment							
Sing Link Problem Prob	Time		Pan	Adj. Evap. Rate	Avg.	Waste	Tracturent	Duccin	Total Inflow	Europetion	Net Volume	Carryover	Required
Banda Banda Data Banda <thdata banda<="" th=""> Data Banda Data Ba</thdata>	Step	Cal. Month	Evap.	in/mo	Precip.	Volume	Treatment	Precip.		Evaporation	Needs	Volume	Deptn
Serie 4.05 3.255 0.073 0.089,207 1.089,701 1.081,701	10101111	lan	2.9	2.03	1 13	10 998 667	1 470 410	266 624	1 737 033	478 979	1 258 055	1 258 055	0.4
Sper 6.45 4.515 0.02 1.0298.667 1.470.110 145.529 1.055.341 155.351 2.001.154 10 5.094 13.6 5.513 0.031 0.038.067 1.470.410 17.398 1.487.207 2.248.529 170.231 1.038.1028.067 1.470.410 17.771 1.477.82 2.531.79 1.04 1.2 1.04 1.038.067 1.470.410 15.517 1.486.920 2.248.549 1.355.57 0 0 0 5 May 1.6 1.12 0.201 0.988.667 1.470.410 1.515.171 1.486.920 2.248.549 1.338.00 0	2	Feb	4.65	3.255	0.76	10,998,667	1 470.410	179.322	1 649.732	768,017	881.715	2 139.770	0.8
ser 997 649 10.98667 1.470.010 1.958 1.564.990 1.646.695 81.995 2.002.448 5 Sum 153 1.071 0.03 1.998 4.2207 2.242.92 7.242.95	- 3	Mar	6.45	4.515	0.62	10,998.667	1.470.410	146.289	1.616.699	1.065.314	551.385	2,100,77	1.0
S New 136 0.513 0.038 0.038.057 1.470.010 1.178 1.482.207 2.244.50 1.86.467 0.33 0 mit 172 17.34 0.031 0.038.657 1.470.010 1.57.348 5.51.79 1.036.491 0.032.056 1.470.010 0.53.551 1.465.021 1.55.550 1.45.261 0.03	4	Apr	9.97	6.979	0.4	10,998.667	1.470.410	94.380	1.564.790	1.646.695	-81.905	2,609.249	0.9
LE 153 10721 0073 1077418 233129 1054419 722.271 0.30 SM 172 10771 008667 1470410 2531146 233129 105441 Seg 118 2811 011 0098667 1470410 05311 146524 2442460 113220 0 0 Seg 118 2811 0111 009867 1470410 03121 05522 1455264 1302561 130264 0 0 0 IO Ct 8.32 0481 0398667 1470410 938.981 166087 783.911 1971157 121777 12 0 <th0< th=""> <th1< th=""> <th0< th=""> <</th0<></th1<></th0<>	5	Mav	13.6	9.513	0.05	10,998.667	1.470.410	11.798	1.482.207	2,244,592	-762.385	1.846.865	0.7
2 11 2 11 10 <th10< th=""> 10 10 10<td>6</td><td>Jun</td><td>15.3</td><td>10.731</td><td>0.03</td><td>10,998,667</td><td>1.470,410</td><td>7,079</td><td>1.477,488</td><td>2.531,979</td><td>-1.054,491</td><td>792,374</td><td>0.3</td></th10<>	6	Jun	15.3	10.731	0.03	10,998,667	1.470,410	7,079	1.477,488	2.531,979	-1.054,491	792,374	0.3
B Sug 13 11.2 0.11 10.996,677 1.470,410 25.955 1.695,364 2.642,404 1.446,276 0 0 0 10 0t.1 8.283 5.796 0.2 10.998,667 1.470,410 47.130 1.515,501 3.533,002 4.43,300 0 0.0 11 Nu 4.76 3.532 0.84 1.098,667 1.470,410 1.58,105 1.563,288 8.24,21 1.03,24,55 0.6 13 nz 2.0 2.03 1.13 1.098,667 1.470,410 1.564,270 3.646,01 8.81,81 1.077,116 2.075,570 0.7 14 ref 4.55 0.62 1.098,667 1.470,410 1.942,737 8.643,733 3.37,621 1.2 1.13,142 1.5 15 Mar 6.5 3.10,093 4.684,21 1.7 1.442,207 2.444,921 1.47,1442 1.55,170 1.664,655 3.1,008 4.68,211 1.1 16 1.10 1.039,86,6	7	Jul	17.2	12.047	0.07	10,998,667	1,470,410	16,517	1,486,926	2,842,490	-1,355,563	0	0.0
9 9 113 8.281 0.07 10.998.667 1.470.410 40.112 1.511.607 1.571.607.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607 1.571.607	8	Aug		11.2	0.11	10,998,667	1,470,410	25,955	1,496,364	2,642,640	-1,146,276	0	0.0
10 10 12 15 16 16 17 17 16 16 11 12 15 16 16 16 16 17 17 17 17 17 17 17 17 17<	9	Sep	11.8	8.281	0.17	10,998,667	1,470,410	40,112	1,510,521	1,953,902	-443,380	0	0.0
11 Nov 4.76 3.32 0.84 10.998,667 1.470,410 198,198 1.666,668 781,658 882,423 1.02,4456 0.47 13 no 2.9 2.03 1.13 10.998,667 1.470,410 1268,649 981,33 1.047,110 2.075,514 53,357,677 1.2 14 Peb 4.65 3.255 0.76 1.0988,667 1.470,410 146,281 1.616,691 1.655,314 53,355,477 1.2 16 Apr 9.97 6.978 0.4 1.0988,667 1.470,410 1.478,481 1.462,202 762,435 3.926,437 1.4 19 no 1.3 10.0731 0.03 1.0988,667 1.470,410 1.178,482 2.542,490 -1.355,50 1.468,242 -1.365,563 1.264,243 -1.365,263 1.264,243 -1.365,263 1.264,243 -1.362,263 0.50 0.00 0.00 0.00 0.00 0.00 1.362,566 1.470,410 1.51,10,11 1.30,998,667 1.470,410 1.51,1	10	Oct	8.28	5.796	0.2	10,998,667	1,470,410	47,190	1,517,600	1,367,566	150,034	150,034	0.1
12 Ccc 3.52 2.464 0.67 1.0.998,667 1.470,410 158,087 1.262,486 931,381 1.047,116 2.075,727 0.77 14 lebe 4.65 3.755 0.76 1.0.998,667 1.470,410 175,322 1.646,059 1.045,314 3.133,324 1.55 15 Mar 6.45 4.515 0.62 1.470,410 146,289 1.646,695 1.646,695 4.680,231 1.7 17 May 13.6 0.51 0.098,667 1.470,410 114,828 1.646,695 4.680,821 1.7 18 Jun 1.35 0.731 0.038,667 1.470,410 1.470,410 1.545,768 1.553,563 1.515,382 0.50 20 Aug 1.511 1.680,296 2.442,400 1.145,756 1.50,343 150,034 0.01 21 Dett S.796 0.21 1.0.98,667 1.470,410 1.511,750 1.525,563 1.553,563 1.553,563 1.553,563 1.553,563 1.553,	11	Nov	4.76	3.332	0.84	10,998,667	1,470,410	198,198	1,668,608	786,185	882,423	1,032,456	0.4
13 10. 2.9 2.03 1.13 10.998,667 1.470.410 179.22 1.548,057 3.37.627 1.22 13 Mar 6.45 4.515 0.62 1.0998,667 1.470.410 143.22 1.646,292 1.646,292 1.646,292 1.646,292 1.646,292 1.646,292 1.624,341 5.1385 4.770,726 1.7 14 Mar 15.3 10.731 0.03 10.998,667 1.470,410 1.142 1.244,592 7.624,852 7.624,852 7.624,852 7.624,852 7.62,842,490 1.2054,91 2.871,946 1.0 1.353,302 1.436,276 37.0107 0.0 1.353,302 1.436,276 37.0107 0.0 <td< td=""><td>12</td><td>Dec</td><td>3.52</td><td>2.464</td><td>0.67</td><td>10,998,667</td><td>1,470,410</td><td>158,087</td><td>1,628,496</td><td>581,381</td><td>1,047,116</td><td>2,079,572</td><td>0.7</td></td<>	12	Dec	3.52	2.464	0.67	10,998,667	1,470,410	158,087	1,628,496	581,381	1,047,116	2,079,572	0.7
114 Eebe 4.65 3.255 0.76 1.0.998,667 1.470,410 179,322 1.546,720 1.065,314 551,384 4.710,362 1.7 15 bar 6.979 0.4 1.0998,667 1.470,410 1.629 1.055,314 551,384 4.770,726 1.7 17 May 13.6 9.513 0.05 1.0.998,667 1.470,410 1.708 1.482,207 2.244,592 7.62,385 3.926,437 1.4 18 Jun 15.3 1.0.731 0.03 1.0.998,667 1.470,410 7.007 1.477,448 2.542,490 1.355,563 1.516,382 0.5 20 Ctt 8.28 1.71 1.0.998,667 1.470,410 4.0113 1.515,003 1.567,566 150,034 1.50,034 0.0 0.0 0.0 0.2 0.058,667 1.470,410 1.58,195 1.628,496 1.357,566 150,034 0.03 1.50,344 0.13,275 0.7 1.073,402 1.552 0.7 1.039,8667 1.470,410 1.58,195 1.628,496 3.256,57 3.70,701 1.7 1.28,1952 1.433,20 </td <td>13</td> <td>Jan</td> <td>2.9</td> <td>2.03</td> <td>1.13</td> <td>10,998,667</td> <td>1,470,410</td> <td>266,624</td> <td>1,737,033</td> <td>478,979</td> <td>1,258,055</td> <td>3,337,627</td> <td>1.2</td>	13	Jan	2.9	2.03	1.13	10,998,667	1,470,410	266,624	1,737,033	478,979	1,258,055	3,337,627	1.2
	14	Feb	4.65	3.255	0.76	10,998,667	1,470,410	179,322	1,649,732	768,017	881,715	4,219,342	1.5
16 Apr 9.97 6.979 0.41 10.998.667 1.470.410 91.864 720 2.244.92 76.238 3.926.41 17 May 13.6 9.513 0.05 10.998.667 1.470.410 7.079 1.477.488 2.531.979 -1.054.491 2.847.946 1.0 19 Jul 17.2 12.047 0.07 10.998.667 1.470.410 15.0521 1.495.262 2.842.490 -1.452.563 1.516.382 0.5 20 Aug 1 12.047 0.07 10.998.667 1.470.410 40.112 1.510.521 1.953.021 4.43.380 0 0 0 0 0 0.0 1.367.566 1.50.341 150.314 1.03.43.80 0 0 0 0 0.0 1.367.566 1.03.44.33.80 0 0 0 0 0 0.0 1.367.566 1.50.34 1.50.34.30.44.33.80 0 0 0 0.0 1.02.45.56 1.25.05.51 3.337.627 1.2 2.37.44.33.80	15	Mar	6.45	4.515	0.62	10,998,667	1,470,410	146,289	1,616,699	1,065,314	551,385	4,770,726	1.7
17 May 13.6 9.513 0.005 1.0.998.667 1.470.410 7.079 1.477.482 2.531.97 1.054.491 2.871.97 18 Jun 17.2 12.047 0.07 10.998.667 1.470.410 7.079 1.477.482 2.531.97 1.054.491 2.871.491 19 Jul 17.2 12.047 0.07 10.998.667 1.470.410 2.555 1.496.344 2.642.490 -1.355.563 1.516.382 0.5 21 Sep 1.48 3.281 0.17 1.998.667 1.470.410 471.112 1.515.760 1.56.565 150.034 150.034 0.0 22 Oct 8.28 5.756 0.21 1.998.667 1.470.410 155.807 1.528.496 581.58 82.473 1.032.460 4 24 Dec 3.52 2.464 0.67 1.998.667 1.470.410 158.97 1.528.496 551.38 837.71 2.2 2.432.3 1.032.471.16 2.197.527 7.60.71 83.473 1.032.198 1.077.116 2.197.526 1.337.50 1.21 1.335.977 <td< td=""><td>16</td><td>Apr</td><td>9.97</td><td>6.979</td><td>0.4</td><td>10,998,667</td><td>1,470,410</td><td>94,380</td><td>1,564,790</td><td>1,646,695</td><td>-81,905</td><td>4,688,821</td><td>1.7</td></td<>	16	Apr	9.97	6.979	0.4	10,998,667	1,470,410	94,380	1,564,790	1,646,695	-81,905	4,688,821	1.7
18 Jun 15.3 10.731 0.003 10.998.667 1.470.410 7.079 1.477.488 2.531.979 -1.085.563 1.265.563 1.561.97 4.682.662 2.842.900 -1.355.563 1.565.882 0.55 20 Aug 16 11.2 0.11 10.998.667 1.470.410 25,955 1.466.364 2.642.640 -1.166.276 370.107 0.1 21 bce A.8 5.796 0.2 1.098.667 1.470.410 156.061 1.367.566 150.034 150.034 0.10.034 0.03 150.034 150.034 0.10.79.72 0.7 25 bc A.4 0.67 1.470.410 158.081 1.67.133 0.471.162.079.72 1.7 25 bc Abs 3.255 0.76 1.098.667 1.470.410 146.289 1.661.599 1.065.314 581.381 1.07.115.77 1.72 1.28.477 0.276.383 3.76.27 1.22 1.470.410 1.707.11 1.470.410 1.779.148.207 2.244.592 7.2	17	May	13.6	9.513	0.05	10,998,667	1,470,410	11,798	1,482,207	2,244,592	-762,385	3,926,437	1.4
15 101 17.2 12.047 0.07 10.998.667 1.470.410 25.571 1.486.246 2.442.490 -1.355.561 1.561.6276 370.107 0.1 12 lep 11.8 8.281 0.17 10.998.667 1.470.410 40.112 1.515.621 1.953.902 -443.380 0 0.0 22 Oct 8.28 5.796 0.2 10.998.667 1.470.410 158.186 186.08 786.185 882.423 1.032.456 0.4 24 Dec 3.52 2.464 0.67 10.998.667 1.470.410 158.087 1.628.963 3.375.27 1.2 25 les 4.55 3.255 0.76 10.998.667 1.470.410 146.299 1.645.991 1.644.691 3.81.94 7.70.72 1.7 26 Feb 4.55 3.751 0.05 1.998.667 1.470.410 146.299 1.645.991 1.644.691 3.81.994 4.88.21 1.7 27 Mar 6.45 <t< td=""><td>18</td><td>Jun</td><td>15.3</td><td>10.731</td><td>0.03</td><td>10,998,667</td><td>1,470,410</td><td>7,079</td><td>1,477,488</td><td>2,531,979</td><td>-1,054,491</td><td>2,871,946</td><td>1.0</td></t<>	18	Jun	15.3	10.731	0.03	10,998,667	1,470,410	7,079	1,477,488	2,531,979	-1,054,491	2,871,946	1.0
20 Aug 16 11.2 0.11 10.998,667 1.470,410 25,955 1.496,364 2,64,2640 -1.146,276 370,107 0.1 21 bcs 1.8 8.281 0.17 10.998,667 1.470,410 47,100 1.517,600 1.367,566 150,034 150,034 150,034 150,034 150,034 150,034 10,998,667 1.470,410 158,188 1,668,608 786,185 882,423 1.032,456 0.4 10,998,667 1.470,410 156,804 10,471,162 0.079,572 0.7 25 ac 4.64 4.515 0.62 1.0,998,667 1.470,410 146,289 1.616,599 1.055,314 51,338 1.770,26 1.7 28 hay 9.97 6.979 0.4 10.998,667 1.470,410 1.564,790 1.664,695 31,305 4.688,821 1.7 29 May 3.6 9.513 0.05 10.998,667 1.470,410 1.561,790 1.664,695 31,300 0.06 31,401 <	19	Jul	17.2	12.047	0.07	10,998,667	1,470,410	16,517	1,486,926	2,842,490	-1,355,563	1,516,382	0.5
21 Bep 11.8 8.281 0.17 10.998,667 1.470,410 40,112 1510,521 1.953,902 -443,380 0 0 0.03 22 Oct 8.28 5.766 0.2 1.098,667 1.470,410 198,198 1.668,608 786,185 882,423 1.032,455 0.44 24 Occ 3.52 2.464 0.67 1.0998,667 1.470,410 158,087 1.528,496 581,381 1.047,116 2.075,572 0.7 25 Jan 2.9 2.03 1.13 1.0398,667 1.470,410 1462,891 1.051,699 1.055,314 5.313,87,172 1.7 28 Apr 9.97 6.979 0.4 1.0998,667 1.470,410 142,820 1.064,695 81,905 4,688,821 1.7 28 Apr 9.57 0.07 10.998,667 1.470,410 142,207 7.02,883 3.926,437 1.4 30 Jun 17.2 0.07 10.998,667 1.470,410 <td< td=""><td>20</td><td>Aug</td><td>16</td><td>11.2</td><td>0.11</td><td>10,998,667</td><td>1,470,410</td><td>25,955</td><td>1,496,364</td><td>2,642,640</td><td>-1,146,276</td><td>370,107</td><td>0.1</td></td<>	20	Aug	16	11.2	0.11	10,998,667	1,470,410	25,955	1,496,364	2,642,640	-1,146,276	370,107	0.1
122 Oct 8.28 5.796 0.2 10.998,667 1.470,410 471,100 1.517,600 1.367,566 150,034 1032,456 0.4 24 Dec 3.32 0.54 1.0998,667 1.470,410 158,087 1,628,496 581,381 1.047,116 2,079,572 0.7 25 Jan 2.9 2.03 1.13 10.998,667 1,470,410 1464,732 768,017 881,715 4,219,342 1.5 27 Mar 6.45 4.515 0.62 1.0998,667 1,470,410 144,283 1.616,693 1.666,695 81,905 4.688,821 1.7 28 Apr 9.37 6.979 0.4 10.998,667 1,470,410 1.708 1,482,207 2,244,952 -762,385 3.326,437 1.4 30 Jun 15.3 1.0.731 0.03 10.998,667 1,470,410 7.079 1,477,488 2,531,979 -1.054,491 2,871,940 -1.355,563 1,516,382 0.53 3.24,040 -1.365,086	21	Sep	11.8	8.281	0.17	10,998,667	1,470,410	40,112	1,510,521	1,953,902	-443,380	0	0.0
23 Nov. 4.76 3.32 0.84 10.998,667 1.470,410 198,188 1,668,608 786,185 88,2423 1.032,456 0.4 24 Dec 3.52 2.464 0.67 10.998,667 1.470,410 158,087 1.628,496 581,381 1.047,116 2.079,572 0.7 25 Ian 2.9 2.03 1.13 10.998,667 1.470,410 177,033 478,979 1.258,055 3.337,627 1.2 27 Mar 6.45 4.515 0.62 1.0470,410 1462,289 1.616,699 1.065,314 53,338,477 4.219,342 1.5 28 Apr 9.37 6.979 0.4 10.998,667 1.470,410 1142,829 1.616,699 1.287,346 1.00 30 Jun 1.53 10.031 10.998,667 1.470,410 1.51,131 1.486,226 762,385 3.226,437 1.4 31 Jul 1.2 0.011 1.098,667 1.470,410 1.51,1151 1.486	22	Oct	8.28	5.796	0.2	10,998,667	1,470,410	47,190	1,517,600	1,367,566	150,034	150,034	0.1
24 Dec 3.52 2.464 0.67 1.0998,667 1.470,410 156,807 1.628,496 581,381 1.047,116 2.079,572 0.7 25 Jan 2.9 2.03 1.13 10.998,667 1.470,410 126,624 1.737,033 478,979 1.258,055 3.337,627 1.2 26 Feb 4.65 3.255 0.76 1.0988,667 1.470,410 1492,322 1.664,99 1.065,314 551,385 4.770,726 1.7 28 Apr 9.97 6.779 0.4 1.0988,667 1.470,410 1.564,790 1.664,695 31,900 4,688,321 1.7 29 May 13.6 9.513 0.051 10.998,667 1.470,410 15,517 1.486,926 2.842,490 -1.355,63 1.516,382 0.5 3.24,196 1.3 1.382 1.31 1.0988,667 1.470,410 15,517 1.469,292 2.842,490 -1.355,563 1.516,382 0.0 0.0 31 Jul 1.2 0.11 10.998,667 1.470,410 15,10,21	23	Nov	4.76	3.332	0.84	10,998,667	1,470,410	198,198	1,668,608	786,185	882,423	1,032,456	0.4
25 2.03 1.13 10.998,667 1.470,410 266,624 1.737,033 478,979 1.280,055 3.337,627 1.2 26 Feb 4.65 3.255 0.76 10.998,667 1.470,410 179,322 1.649,732 768,017 881,715 4.219,342 1.5 27 Mar 6.45 4.515 0.62 10.998,667 1.470,410 943,80 1,564,790 1.646,695 81,905 4,688,821 1.7 29 May 13.6 9.513 0.03 10.998,667 1.470,410 7,079 1.442,207 2.244,208 -1,355,563 1.516,382 0.5 32 Jug 16 1.12 0.11 1.998,667 1.470,410 1.517,512 1.953,902 -443,380 0 0 0 33 Sep 118 8.281 0.77 1.470,410 15,162,040 1.452,763 7.010 1 3.500,27 443,380 0 0 0 0 0 0 0 0.50	24	Dec	3.52	2.464	0.67	10,998,667	1,470,410	158,087	1,628,496	581,381	1,047,116	2,079,572	0.7
26 Feb 4.65 3.255 0.76 1.0998,667 1.470,410 146,289 1.616,699 1.065,314 51,385 4.707,726 1.7 28 Apr 9.97 6.679 0.4 10,998,667 1.470,410 14,289 1.616,699 1.065,314 51,385 4,707,726 1.7 29 May 13.6 9.513 0.05 1.0988,667 1.470,410 1.77 1.648,920 2.244,592 -762,385 3.326,437 1.4 30 Jun 15.3 10.731 0.03 10.998,667 1.470,410 1.517,1486,926 2.842,490 -1,355,563 1.516,322 0.5 31 Jul 1.2 0.11 10.998,667 1.470,410 2,512,793 -1,462,76 370,107 0.1 33 Leg 1.8 8.211 0.01 1.998,667 1.470,410 451,10.521 1.953,902 -443,380 0 0 0 0 3.370,107 0.1 3.3562 1.033 Leg 1.470,410	25	Jan	2.9	2.03	1.13	10,998,667	1,470,410	266,624	1,737,033	478,979	1,258,055	3,337,627	1.2
22 Mar 6.45 4.515 0.62 10.998,667 1.470,410 146,289 1,065,314 551,385 4,770,726 1.7 28 Apr 9.97 6.979 0.4 10,998,667 1.470,410 94,380 1,564,790 1,666,695 -81,995 4,688,821 1.7 30 Jun 15.3 10.731 0.03 10,998,667 1.470,410 7,079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 31 Jul 172 12.047 0.01 10,998,667 1.470,410 25,955 1,496,364 2,642,400 1,146,276 370,107 0.1 33 Sep 11.8 8.281 0.07 10.998,667 1.470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.40 34 Oct 3.32 0.84 10,998,667 1.470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.40 35 Nov 4.76 3.332 <td>26</td> <td>Feb</td> <td>4.65</td> <td>3.255</td> <td>0.76</td> <td>10,998,667</td> <td>1,470,410</td> <td>179,322</td> <td>1,649,732</td> <td>768,017</td> <td>881,715</td> <td>4,219,342</td> <td>1.5</td>	26	Feb	4.65	3.255	0.76	10,998,667	1,470,410	179,322	1,649,732	768,017	881,715	4,219,342	1.5
28 Apr 9.97 6.979 0.4 10,998,667 1.470,410 94,380 1,564,695 -81,905 4,688,821 1.7 29 May 13.6 9.513 0.05 10,998,667 1.470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 31 Juu 17.2 12.047 0.07 10,998,667 1.470,410 16,517 1,486,226 2,482,490 -1,355,563 1,516,382 0.5 32 Aug 16 11.2 0.11 10,998,667 1,470,410 47,109 1,517,600 1,367,566 150,034 0.00 0.0 34 Oct 8.28 5.796 0.2 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 0.4 0.4 0.4 0.4 0.4 1,032,456 1.4 0.4 1,528,466 581,381 1,047,116 2,079,72 0.7 37 Jan 6.5 3.255 0.667<	27	Mar	6.45	4.515	0.62	10,998,667	1,470,410	146,289	1,616,699	1,065,314	551,385	4,770,726	1.7
129 May 13.6 9.513 0.05 1.0.998.667 1.470.410 17.79 1.477.488 2.531.979 -762.385 3.926.437 1.4 30 Jun 17.2 12.047 0.07 10.998.667 1.470.410 16.511 1.486.926 2.842.490 -1,355.563 1.516.382 0.5 32 Aug 16 11.2 0.11 10.998.667 1.470.410 25.955 1.496.364 2.642.640 -1,146.276 370.107 0.1 33 Sep 11.8 8.281 0.17 10.998.667 1.470.410 47.190 1.517.600 1.367.566 150.034 150.034 0.1 34 Oct 8.28 2.046 0.67 1.0998.667 1.470.410 158.081 1.668.608 786.185 882.423 1.032.456 0.4 37 Jan 2.998.667 1.470.410 158.081 1.668.608 786.187 883.423 1.032.456 0.453 37 Jan 1.998.667 1.470.410 179.322 1.649.732 768.017 881.715 4.219.342 1.5	28	Apr	9.97	6.979	0.4	10,998,667	1,470,410	94,380	1,564,790	1,646,695	-81,905	4,688,821	1.7
30 Jun 15.3 10.731 0.03 10.998.667 1.470.410 7.079 1.477.488 2.531.979 -1.054.941 2.871.946 1.0 31 Jul 17.2 12.047 0.07 10.998.667 1.470.410 16.517 1.486.926 2.842.490 -1.355.563 1.516.382 0.0 33 Sep 11.8 8.281 0.17 10.998.667 1.470.410 40.112 1.510.521 1.953.902 -443.380 0 0.0 34 Oct 8.28 5.796 0.2 10.998.667 1.470.410 198.1668.608 766.185 882.423 1.032.456 0.4 35 Nov 4.76 3.332 0.84 10.998.667 1.470.410 198.168.802 766.185 882.423 1.032.456 0.4 36 Dec 3.52 2.64 0.67 10.998.667 1.470.410 173.22 1.649.732 768.017 881.715 4.219.342 1.5 37 Jan 2.9 2.03 1.13 10.998.667 1.470.410 173.922 1.649.732 768.017 881.715 4.219.342 1.5 1.7 4.498.790	29	May	13.6	9.513	0.05	10,998,667	1,470,410	11,798	1,482,207	2,244,592	-762,385	3,926,437	1.4
31 Jul 17.2 12.047 0.07 10.998,667 1.470,410 16.517 1.486,926 2.842,490 -1.355,563 1.516,382 0.51 33 Sep 11.8 8.281 0.17 10.998,667 1.470,410 40.112 1.510,521 1.953,902 -443,380 0 0.00 34 Oct 8.281 0.17 10.998,667 1.470,410 198,198 1.686,608 786,185 882,423 1.032,456 0.4 35 Nov 4.76 3.332 0.84 10.998,667 1.470,410 158,087 1.628,496 786,183 882,423 1.032,456 0.4 36 0.52 2.464 0.67 1.999,8667 1.470,410 179,322 1.684,799 1.258,055 3,337,627 1.2 37 Jan 2.9 2.03 1.13 10.998,667 1.470,410 146,229 1.661,912 881,818 81,715 4,219,342 1.5 39 Mar 6.45 4.553 0.62 1.998,667 1.470,410 1.798 1.482,207 2.445,92 .762,385 <td< td=""><td>30</td><td>Jun</td><td>15.3</td><td>10.731</td><td>0.03</td><td>10,998,667</td><td>1,470,410</td><td>7,079</td><td>1,477,488</td><td>2,531,979</td><td>-1,054,491</td><td>2,871,946</td><td>1.0</td></td<>	30	Jun	15.3	10.731	0.03	10,998,667	1,470,410	7,079	1,477,488	2,531,979	-1,054,491	2,871,946	1.0
32 Aug 16 1.1.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 33 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,515,200 1,367,566 150,034 150,034 10.1 35 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 36 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 37 Jan 2.9 2.03 1.13 10,998,667 1,470,410 179,322 1,649,792 766,017 881,715 4,219,342 1.5 39 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,289 1,516,790 1,646,695 -81,905 4,688,821 1.7 40 Apr 9.97 6.979 0.4 10,998,667 1,470,410 1,564,700 1,64	31	Jul	17.2	12.047	0.07	10,998,667	1,470,410	16,517	1,486,926	2,842,490	-1,355,563	1,516,382	0.5
33 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,517,500 1,367,566 150,034 150,034 0.0 34 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,500 1,367,566 150,034 150,034 0.1 35 Nov 4.76 3.332 0.84 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 7/ Jan 2.9 2.03 1.13 10,998,667 1,470,410 1266,624 1,737,033 478,979 1,258,055 3,337,627 1.2 38 Feb 4.65 3.255 0.76 10,998,667 1,470,410 146,289 1,616,699 1,065,314 551,385 4,770,726 1.7 40 Apr 9.97 6.979 0.4 10,998,667 1,470,410 11,788 1,482,207 2,244,592 -762,385 3,926,437 1.4 42 Jun 15.3 10.731 0.03 10,998,667 1,470,410 1,517 1,486,262 2,842,490 -1,355,563 1,516,382 0.50	32	Aug	16	11.2	0.11	10,998,667	1,470,410	25,955	1,496,364	2,642,640	-1,146,276	370,107	0.1
34 Oct 8.28 5.796 0.2 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.41 35 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.47 36 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 37 Jan 2.9 2.03 1.13 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 39 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,299 1,065,314 551,385 4,707,726 1.7 40 Apr 9.97 6.579 0.4 10,998,667 1,470,410 7.079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 42 Jun 15.3 10.71 10,998,667 1,470,410 7.495,561 1,264,491 2,471,946	33	Sep	11.8	8.281	0.17	10,998,667	1,470,410	40,112	1,510,521	1,953,902	-443,380	0	0.0
35 Nov 4.76 3.32 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 36 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 37 Jan 2.9 2.03 1.13 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 38 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,289 1,661,699 1,065,314 551,385 4,770,726 1.7 40 Apr 9.97 6.979 0.4 10,998,667 1,470,410 1,778,207 2,244,592 -762,385 3,926,437 1.4 41 May 13.6 1.031 0.071 10,998,667 1,470,410 767,188 2,531,979 -1,054,491 2,871,946 1.0 43 Jul 17.2 12.047	34	Oct	8.28	5.796	0.2	10,998,667	1,470,410	47,190	1,517,600	1,367,566	150,034	150,034	0.1
Bore 3.52 2.464 0.67 10.998,667 1.470,410 158,87 1,628,496 581,381 1,047,116 2,079,572 0.7 37 Jan 2.9 2.03 1.13 10.998,667 1,470,410 266,624 1,737,033 478,979 1,258,055 3,337,627 1.2 38 Feb 4.65 3.255 0.76 10.998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 40 Apr 9.97 6.979 0.4 10.998,667 1,470,410 14,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 41 May 13.6 9.513 0.05 10,998,667 1,470,410 7,079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 43 Jul 17.2 12.047 0.07 10,998,667 1,470,410 2,5955 1,496,364 2,642,640 -1,162,76 370,107 0.1 44 Aug 16 1.1.2 0.11 10,998,667 1,470,410 451,515,050 1,316,302	35	Nov	4.76	3.332	0.84	10,998,667	1,470,410	198,198	1,668,608	786,185	882,423	1,032,456	0.4
37 Jan 2.9 2.03 1.13 10.998,667 1,470,410 266,624 1,737,033 478,979 1,258,055 3,337,627 1.2 38 Feb 4.65 3.255 0.76 10.998,667 1,470,410 146,282 1,649,732 768,017 881,715 4,219,342 1.5 39 Mar 6.45 4.515 0.62 10.998,667 1,470,410 146,283 1,564,790 1,646,695 -81,905 4,688,821 1.7 41 May 13.6 9.513 0.05 10.998,667 1,470,410 17,79 1,477,488 2,511,979 -762,385 3,926,437 1.4 42 Jun 15.3 10.731 0.03 10.998,667 1,470,410 7,079 1,477,488 2,511,979 -1,054,491 2,871,946 1.0 44 Jug 16 1.12 0.11 10.998,667 1,470,410 25,955 1,496,364 2,642,400 -1,345,276 370,107 0.1 45 Sep 11.8 8.281 0.17 10.998,667 1,470,410 49,132 1,5563 1,50,34 150,034 150,034 150,034	36	Dec	3.52	2.464	0.67	10,998,667	1,470,410	158,087	1,628,496	581,381	1,047,116	2,079,572	0.7
38 Feb 4.65 3.255 0.76 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 39 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,289 1,616,699 1,065,314 551,385 4,770,726 1.7 40 Apr 9.97 6.979 0.4 10,998,667 1,470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 42 Jun 15.3 10.731 0.03 10,998,667 1,470,410 15,517 1,486,926 2,842,490 -1,355,563 1,516,382 0.5 44 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,60 -1,146,276 370,107 0.1 45 Sep 11.8 8.281 0.17 10,998,667 1,470,410 17,910 1,517,500 1,367,566 150,034 150,034 150,034 150,034 150,034	37	Jan	2.9	2.03	1.13	10,998,667	1,470,410	266,624	1,737,033	478,979	1,258,055	3,337,627	1.2
39 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,289 1,615,699 1,065,314 551,385 4,7/0,7/26 1.7 40 Apr 9.97 6.979 0.4 10,998,667 1,470,410 94,380 1,564,790 1,646,695 -81,905 4,688,821 1.7 41 May 13.6 9.513 0.05 10,998,667 1,470,410 7,079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 43 Jul 17.2 12.047 0.07 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 45 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,515,221 1,963,902 -443,380 0 0.0 46 Oct 8.28 5.796 0.2 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.44 Dec 3.52 <td>38</td> <td>Feb</td> <td>4.65</td> <td>3.255</td> <td>0.76</td> <td>10,998,667</td> <td>1,470,410</td> <td>179,322</td> <td>1,649,732</td> <td>768,017</td> <td>881,715</td> <td>4,219,342</td> <td>1.5</td>	38	Feb	4.65	3.255	0.76	10,998,667	1,470,410	179,322	1,649,732	768,017	881,715	4,219,342	1.5
40 Apr 9.97 6.979 0.4 10,998,667 1,470,410 94,380 1,564,790 1,646,695 -81,905 4,688,821 1.7 41 May 13.6 9.513 0.05 10,998,667 1,470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 42 Jun 15.3 10.731 0.03 10,998,667 1,470,410 16,517 1,486,926 2,842,490 -1,355,563 1,516,382 0.55 44 Aug 16 1.1.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 45 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,517,600 1,367,566 150,034 150,034 0.0 0.0 46 Oct 8.28 5.796 0.2 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 47 Nov 4.76 3.332 0.84 10,998,667 1,470,410 158,0	39	Mar	6.45	4.515	0.62	10,998,667	1,470,410	146,289	1,616,699	1,065,314	551,385	4,770,726	1.7
41 May 13.6 9.513 0.05 10,998,667 1,470,410 11,98 1,482,207 2,244,992 -7.62,385 3,926,437 1.4 42 Jun 15.3 10.731 0.03 10,998,667 1,470,410 7,079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 43 Jul 17.2 12.047 0.07 10,998,667 1,470,410 25,955 1,486,926 2,842,490 -1,355,563 1,516,382 0.5 44 Aug 16 11.2 0.11 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -443,380 0 0.00 46 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1 47 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 48 Dec 3.52 2.464 0.67 10,998,667 1,470,410 178,273 768,017 881,715 4,219,342 1.5 <t< td=""><td>40</td><td>Apr</td><td>9.97</td><td>6.979</td><td>0.4</td><td>10,998,667</td><td>1,470,410</td><td>94,380</td><td>1,564,790</td><td>1,646,695</td><td>-81,905</td><td>4,688,821</td><td>1.7</td></t<>	40	Apr	9.97	6.979	0.4	10,998,667	1,470,410	94,380	1,564,790	1,646,695	-81,905	4,688,821	1.7
42 Jun 15.3 10.731 0.03 10,998,667 1,470,410 7,079 1,477,488 2,51,979 -1,054,491 2,871,946 1.0 43 Jul 17.2 12.047 0.07 10,998,667 1,470,410 16,517 1,486,926 2,842,490 -1,355,563 1,516,382 0.5 44 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 45 Sep 11.8 8.281 0.17 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.0 46 Oct 8.28 5.796 0.2 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 48 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 49 Jan 2.9 2.03 1.13 10,998,667 1,470,410 179,322 1,649,732	41	May	13.6	9.513	0.05	10,998,667	1,470,410	11,798	1,482,207	2,244,592	-762,385	3,926,437	1.4
43 Jul 17.2 12.047 0.07 10,998,667 1,470,410 16,517 1,486,926 2,842,490 -1,355,563 1,516,382 0.5 44 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 45 Sep 11.8 8.281 0.17 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1 46 Oct 8.28 5.796 0.2 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 47 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 48 Dec 3.52 2.464 0.67 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 50 Feb 4.65 3.255 0.76 10,998,667 1,470,410 179,322 1,669,732 768,017 881,715 4,219,342	42	Jun	15.3	10./31	0.03	10,998,667	1,470,410	7,079	1,477,488	2,531,979	-1,054,491	2,871,946	1.0
44 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,495,364 2,642,640 -1,146,276 370,107 0.1 45 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -443,380 0 0.0 46 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1 47 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 48 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 49 Jan 2.9 2.03 1.13 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 51 Mar 6.45 3.255 0.62 10,998,667 1,470,410 146,289 1,616,699 1,646,695 -81,905 4,688,821 1.7	43	Jul	17.2	12.04/	0.07	10,998,667	1,470,410	16,517	1,486,926	2,842,490	-1,355,563	1,516,382	0.5
45 Sep 11.8 8.281 0.1/ 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -443,380 0 0.0 46 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1 47 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 48 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 49 Jan 2.9 2.03 1.13 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 51 Mar 6.45 4.515 0.62 10,998,667 1,470,410 94,380 1,564,790 1,646,695 -81,905 4,688,821 1.7 52 Apr 9.97 6.979 0.4 10,998,667 1,470,410 94,380 1,564,790 1,646,	44	Aug	10	11.2	0.11	10,998,667	1,470,410	25,955	1,496,364	2,642,640	-1,146,276	370,107	0.1
46 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 150,034 0.1 47 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 48 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 49 Jan 2.9 2.03 1.13 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 50 Feb 4.65 3.255 0.76 10,998,667 1,470,410 146,289 1,616,699 1,065,314 551,385 4,770,726 1.7 51 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,289 1,616,699 1,065,314 551,385 4,770,726 1.7 52 Apr 9.97 6.979 0.4 10,998,667 1,470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437	45	Sep	11.8	8.281	0.17	10,998,667	1,470,410	40,112	1,510,521	1,953,902	-443,380	150.024	0.0
47 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,088,008 786,165 882,423 1,032,450 0.4 48 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 49 Jan 2.9 2.03 1.13 10,998,667 1,470,410 266,624 1,737,033 478,979 1,258,055 3,337,627 1.2 50 Feb 4.65 3.255 0.76 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 51 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,289 1,616,699 1,065,314 551,385 4,770,726 1.7 52 Apr 9.97 6.979 0.4 10,998,667 1,470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 54 Jun 15.3 10.731 0.03 10,998,667 1,470,410 70,79 1,4	40	Oct	8.28	5./90	0.2	10,998,667	1,470,410	47,190	1,517,600	1,367,566	150,034	150,034	0.1
48 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,075,572 0.7 49 Jan 2.9 2.03 1.13 10,998,667 1,470,410 266,624 1,737,033 478,979 1,258,055 3,337,627 1.2 50 Feb 4.65 3.255 0.76 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 51 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,289 1,616,699 1,065,314 551,385 4,770,726 1.7 52 Apr 9.97 6.979 0.4 10,998,667 1,470,410 94,380 1,564,790 1,646,695 -81,905 4,688,821 1.7 53 May 13.6 9.513 0.05 10,998,667 1,470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 54 Jun 15.3 10.731 0.03 10,998,667 1,470,410 70,79 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 <td>4/</td> <td>Nov</td> <td>4.76</td> <td>3.332</td> <td>0.84</td> <td>10,998,667</td> <td>1,470,410</td> <td>198,198</td> <td>1,668,608</td> <td>/86,185</td> <td>882,423</td> <td>1,032,450</td> <td>0.4</td>	4/	Nov	4.76	3.332	0.84	10,998,667	1,470,410	198,198	1,668,608	/86,185	882,423	1,032,450	0.4
49 Jan 2.9 2.03 1.13 10,998,667 1,470,410 200,024 1,757,033 476,979 1,250,055 5,357,027 1.2 50 Feb 4.65 3.255 0.76 10,998,667 1,470,410 179,322 1,649,732 768,017 881,715 4,219,342 1.5 51 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,289 1,616,699 1,065,314 551,385 4,770,726 1.7 52 Apr 9.97 6.979 0.4 10,998,667 1,470,410 94,380 1,564,790 1,646,695 -81,905 4,688,821 1.7 53 May 13.6 9.513 0.05 10,998,667 1,470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 54 Jun 15.3 10.731 0.03 10,998,667 1,470,410 7079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 55 Jul 17.2 12.047 0.07 10,998,667 1,470,410 25,955 1,496,364	4ð 40	Dec	3.52	2.404	0.67	10,998,007	1,470,410	158,087	1,628,490	581,381	1,047,110	2,0/9,5/2	0.7
50 Feb 4.65 3.255 0.76 10,998,667 1,470,410 179,322 1,049,732 706,017 861,713 4,219,342 1.3 51 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,289 1,616,699 1,065,314 551,385 4,770,726 1.7 52 Apr 9.97 6.979 0.4 10,998,667 1,470,410 94,380 1,564,790 1,646,695 -81,905 4,688,821 1.7 53 May 13.6 9.513 0.05 10,998,667 1,470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 54 Jun 15.3 10.731 0.03 10,998,667 1,470,410 7,079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 55 Jul 17.2 12.047 0.07 10,998,667 1,470,410 16,517 1,486,926 2,842,490 -1,355,563 1,516,382 0.5 56 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1<	49	Jan	2.9	2.05	1.15	10,998,007	1,470,410	200,024	1,/3/,033	4/8,3/3	1,258,055	3,337,027	1.2
S1 Mar 6.45 4.515 0.62 10,998,667 1,470,410 146,285 1,616,095 1,005,514 551,365 4,770,720 1.7 52 Apr 9.97 6.979 0.4 10,998,667 1,470,410 94,380 1,564,790 1,646,695 -81,905 4,688,821 1.7 53 May 13.6 9.513 0.05 10,998,667 1,470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 54 Jun 15.3 10.731 0.03 10,998,667 1,470,410 7,079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 55 Jul 17.2 12.047 0.07 10,998,667 1,470,410 16,517 1,486,926 2,842,490 -1,355,563 1,516,382 0.5 56 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 57 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -443,380 0 0.0	50	Feb	4.65	3.255	0.76	10,998,007	1,470,410	1/9,322	1,649,732	1 065 214	881,/15	4,219,342	1.5
S2 Apr 9.97 6.979 0.4 10,998,667 1,470,410 94,380 1,504,790 1,040,095 -81,905 4,088,021 1.7 53 May 13.6 9.513 0.05 10,998,667 1,470,410 11,798 1,482,207 2,244,592 -762,385 3,926,437 1.4 54 Jun 15.3 10.731 0.03 10,998,667 1,470,410 7,079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 55 Jul 17.2 12.047 0.07 10,998,667 1,470,410 16,517 1,486,926 2,842,490 -1,355,563 1,516,382 0.5 56 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 57 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -443,380 0 0.00 58 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1	52	Mar	0.45	4.515	0.62	10,998,007	1,470,410	140,203	1,010,099	1,005,314	551,385 21.005	4,//0,/20	1.7
53 May 13.6 9.513 0.05 10,998,667 1,470,410 11,798 1,482,207 2,244,392 -762,365 5,920,437 1.4 54 Jun 15.3 10.731 0.03 10,998,667 1,470,410 7,079 1,477,488 2,531,979 -1,054,491 2,871,946 1.0 55 Jul 17.2 12.047 0.07 10,998,667 1,470,410 16,517 1,486,926 2,842,490 -1,355,563 1,516,382 0.5 56 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 57 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -443,380 0 0.0 58 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1 59 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668	52		12.57	0.5/5	0.4	10,998,007	1,470,410	94,300 11 700	1,504,730	1,040,095	-01,505	4,000,021	1./
54 Jun 15.3 10.731 0.03 10,998,667 1,470,410 7,079 1,477,468 2,331,375 -1,034,491 2,071,940 1.0 55 Jul 17.2 12.047 0.07 10,998,667 1,470,410 16,517 1,486,926 2,842,490 -1,355,563 1,516,382 0.5 56 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 57 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -443,380 0 0.0 58 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1 59 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 60 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7 <	53	lvidy	15.0	9.515	0.03	10,998,007	1,470,410	11,730 7 070	1,402,207	2,244,332	-/02,305	3,920,437	1.4
55 Jul 17.2 12.047 0.07 10,998,667 1,470,410 10,517 1,486,926 2,642,490 -1,555,565 1,510,522 0.5 56 Aug 16 11.2 0.11 10,998,667 1,470,410 25,955 1,496,364 2,642,640 -1,146,276 370,107 0.1 57 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -443,380 0 0.0 58 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1 59 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 60 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7	54		17.3	12 047	0.03	10,998,007	1,470,410	16 517	1,477,400	2,251,373	-1,U34,491	2,0/1,340	1.0
S6 Aug I6 I1.2 0.11 10,998,667 1,470,410 25,955 1,490,504 2,042,040 -1,140,276 570,107 0.11 57 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -443,380 0 0.0 58 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1 59 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 60 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7	55		17.2	11.2	0.07	10,998,007	1,470,410	75 025	1,480,920	2,842,490	-1,355,505	1,510,302	0.5
57 Sep 11.8 8.281 0.17 10,998,667 1,470,410 40,112 1,510,521 1,953,902 -445,580 0 0.0 58 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,367,566 150,034 150,034 0.1 59 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 60 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7	50	Aug	11.0	±1.2 0 201	0.11	10,998,007	1,470,410	20,500 40 112	1,490,304	2,042,040	-1,140,270	370,107	0.1
58 Oct 8.28 5.796 0.2 10,998,667 1,470,410 47,190 1,517,600 1,507,500 150,054 150,054 0.1 59 Nov 4.76 3.332 0.84 10,998,667 1,470,410 198,198 1,668,608 786,185 882,423 1,032,456 0.4 60 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7	50	Sep	0.28	ō.∠o⊥ 5 796	0.17	10,998,007	1,470,410	40,112	1,510,521	1,903,902	-443,300	150.034	0.0
59 Nov 4.76 5.352 0.64 10,998,667 1,470,410 156,156 1,006,006 760,165 662,425 1,052,450 0.4 60 Dec 3.52 2.464 0.67 10,998,667 1,470,410 158,087 1,628,496 581,381 1,047,116 2,079,572 0.7	50	Nov	0.20	2 332	0.2	10,998,007	1,470,410	102 108	1,517,000	796 185	120,034	1 022 //56	0.1
00 Dec 3.52 2.404 0.0/ 10,338,00/ 1,470,410 138,00/ 1,026,490 301,501 1,047,110 2,079,572 0.7	60		2.52	3.332 2.464	0.64	10,990,007	1,470,410	150,150	1 670 106	F01 221	1 047 116	2,032,430	0.4
	00	Dec	3.52	2.404	0.07	10,998,007	1,470,410	120,007	1,020,490	201,201	1,047,110	2,0/9,3/2	17

Notes: 1. Evaporation data was collected from ADEQ Engineering Bulletin No. 11. Precipitation data was collected from Buckeye, AZ.

See ADEQ Data tab

https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca6627

2. Pan evaporation data **has not** been adjusted by an evaporation adjustment factor, and by a brine/TDS factor.

3. This is annual average data, not worst case storm event.

4. Carryover volume is calcuated by the difference between evaporation and inflow by month, and previous volume balance.

Passive Solar Evaporation Pond Sizing - 94% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 94% Recovery, Phase 1	Updated by & Date:	L.Haug; 08/12/2022
		Reviewer & Review Date:	TBD

Assume 94% RO recovery with continuous production of brine.							
		Instant.		Monthly			
Treatment Waste	Instant. Flow	Flow		Quantity			
Stream	mgd	gpm	Run Factor	gal	Notes		
RO Brine	0.2712	188.3	100.0%	8,249,000	Year-round value.		

Evaporation Rate Conversions	Value	Notes
Pan Coefficient	1	Not used at this time.
Brine Derating Factor	0.7	Accounts for lower evaporation rate of brine compared to fresh water (USBR, 2006)
Evaporation Adjustment Factor	1	No adjustment provided, at this time.
Combined Derating Factor	0.7	Translates from Pan to local brine

Evaporation Pond						
Sizing Factors	Value	Units	Notes			
Depth of water	6.62	£4	From balow: Total inflow divided by area			
added per year	0.02	11	FIGHT below. Total IIIIlow divided by area			
Solids Precipitation	0.004	ft	USER 2006 Figure 10.1, see Selids Presin, Tab			
Rate	0.004 solids/		JSBR 2000, Figure 10.1, see Solius Frecip. Tab.			
Solids Precipitation	0.026	ft				
Rate	0.026	solids/yr				
Solids Storage	0.5	£4	No specific guidance found. Kent at 0.5 from go by			
Depth Reservation	0.5	11	No specific guidance found. Rept at 0.5 from go-by.			
Required Solids	19.0					
Removal Interval	18.9	yı				
Freeboard	2	ft	Minimum per Los Angeles Region WDR requirements.			

Sizing	Value	Units	Notes
Required Minimum	40	20	*Iterate for stable annual
Surface Area	49	ac	operation
Minimum	17	f+	
Operational Depth	1.7	ιι	
Factor of Safety	50%		Kept from Go-by.
Required	2 5	f+	
Operational Depth	2.5	ιι	
Required	2 562 461	cf	
Operational Volume	3,302,401		

Section View: Surface area required at lowest water level





Passive Solar Evaporation Pond Sizing - 94% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 94% Recovery, Phase 1	Updated by & Date:	L.Haug; 08/12/2022
		Reviewer & Review Date:	TBD

Assume 94% RO recovery with continuous production of brine.

		Climate Inputs ¹ Volume Needs per Month						Sizin	g			
		Hist.		A	Treatment						6	-
Time	0-1	Pan	Adj. Evap. Rate	Avg.	Waste	-	Duralia	Tetel Inflore	F	Net Volume	Carryover	Required
Step	Cal.	Evap.	in /m o	Precip.	volume	freatment	Precip.	Total Inflow	Evaporation	Needs	volume	Depth
Ivionth 1	lan	11/mo. 2 0	in/mo.	in/mo.	gai 8 249 000	CT 1 102 807	CT 200.002	CT 1 202 901	cr 261.076	CT 042 724	042 724	π 0.4
2	Foh	4 65	2.03	0.76	8,249,000	1,102,807	135 181	1 227 989	578 967	542,724 659 022	1 601 7/6	0.4
2	Mar	6.45	4 515	0.70	8,249,000	1,102,807	110 279	1,237,989	803.083	410 004	2 011 750	0.8
4	Anr	9.97	6 979	0.02	8 249 000	1 102,807	71 148	1 173 955	1 241 355	-67 399	1 944 351	0.5
5	May	13.6	9 513	0.4	8 249 000	1 102,807	8 894	1 111 701	1 692 077	-580 376	1 363 975	0.5
6	Jun	15.3	10.731	0.03	8,249,000	1,102,807	5.336	1.108.144	1.908.723	-800.579	563.395	0.3
7	Jul	17.2	12.047	0.07	8.249.000	1.102.807	12.451	1.115.258	2.142.800	-1.027.542	0	0.0
8	Aug	16	11.2	0.11	8,249,000	1,102,807	19,566	1,122,373	1,992,144	-869,771	0	0.0
9	Sep	11.8	8.281	0.17	8,249,000	1,102,807	30,238	1,133,045	1,472,941	-339,896	0	0.0
10	Oct	8.28	5.796	0.2	8,249,000	1,102,807	35,574	1,138,381	1,030,935	107,447	107,447	0.1
11	Nov	4.76	3.332	0.84	8,249,000	1,102,807	149,411	1,252,218	592,663	659,555	767,002	0.4
12	Dec	3.52	2.464	0.67	8,249,000	1,102,807	119,173	1,221,980	438,272	783,709	1,550,711	0.7
13	Jan	2.9	2.03	1.13	8,249,000	1,102,807	200,993	1,303,801	361,076	942,724	2,493,436	1.2
14	Feb	4.65	3.255	0.76	8,249,000	1,102,807	135,181	1,237,989	578,967	659,022	3,152,457	1.5
15	Mar	6.45	4.515	0.62	8,249,000	1,102,807	110,279	1,213,087	803,083	410,004	3,562,461	1.7
16	Apr	9.97	6.979	0.4	8,249,000	1,102,807	71,148	1,173,955	1,241,355	-67,399	3,495,062	1.6
17	May	13.6	9.513	0.05	8,249,000	1,102,807	8,894	1,111,701	1,692,077	-580,376	2,914,686	1.4
18	Jun	15.3	10.731	0.03	8,249,000	1,102,807	5,336	1,108,144	1,908,723	-800,579	2,114,106	1.0
19	Jul	17.2	12.047	0.07	8,249,000	1,102,807	12,451	1,115,258	2,142,800	-1,027,542	1,086,565	0.5
20	Aug	16	11.2	0.11	8,249,000	1,102,807	19,566	1,122,373	1,992,144	-869,771	216,794	0.1
21	Sep	11.8	8.281	0.17	8,249,000	1,102,807	30,238	1,133,045	1,472,941	-339,896	0	0.0
22	Oct	8.28	5.796	0.2	8,249,000	1,102,807	35,574	1,138,381	1,030,935	107,447	107,447	0.1
23	Nov	4.76	3.332	0.84	8,249,000	1,102,807	149,411	1,252,218	592,663	659,555	767,002	0.4
24	Dec	3.52	2.464	0.67	8,249,000	1,102,807	119,173	1,221,980	438,272	783,709	1,550,711	0.7
25	Jan	2.9	2.03	1.13	8,249,000	1,102,807	200,993	1,303,801	361,076	942,724	2,493,436	1.2
26	Feb	4.65	3.255	0.76	8,249,000	1,102,807	135,181	1,237,989	578,967	659,022	3,152,457	1.5
27	Mar	6.45	4.515	0.62	8,249,000	1,102,807	110,279	1,213,087	803,083	410,004	3,562,461	1.7
28	Apr	9.97	6.979	0.4	8,249,000	1,102,807	71,148	1,173,955	1,241,355	-67,399	3,495,062	1.6
29	May	13.6	9.513	0.05	8,249,000	1,102,807	8,894	1,111,701	1,692,077	-580,376	2,914,686	1.4
30	Jun	15.3	10.731	0.03	8,249,000	1,102,807	5,336	1,108,144	1,908,723	-800,579	2,114,106	1.0
31	JUI	17.2	12.047	0.07	8,249,000	1,102,807	12,451	1,115,258	2,142,800	-1,027,542	1,086,565	0.5
32	Aug	11.0	11.2 9.291	0.11	8,249,000	1,102,807	19,566	1,122,373	1,992,144	-869,771	216,794	0.1
24	Sep	0.10	5.281	0.17	8,249,000	1,102,807	30,238	1,133,045	1,472,941	-339,890	107.447	0.0
25	Nov	0.20	2.790	0.2	8,249,000	1,102,807	1/0/11	1,150,501	1,030,933	107,447	767.002	0.1
35	Dec	4.70	2.552	0.64	8,249,000	1,102,807	149,411	1,252,210	392,003 128,272	783 700	1 550 711	0.4
30	lan	2.52 2.0	2.404	1 13	8,249,000	1,102,807	200 003	1 303 801	361 076	912 721	2 /03 /36	0.7
37	Feh	4 65	3 255	0.76	8,249,000	1,102,807	135 181	1 237 989	578 967	659 022	2,453,450	1.2
30	Mar	6.45	4 515	0.70	8 249 000	1 102 807	110 279	1 213 087	803.083	410 004	3 562 461	1.5
40	Anr	9.45	6 979	0.02	8 249 000	1 102 807	71 148	1 173 955	1 241 355	-67 399	3 495 062	1.7
41	Mav	13.6	9.513	0.05	8,249,000	1,102,807	8.894	1.111.701	1.692.077	-580.376	2.914.686	1.4
42	Jun	15.3	10.731	0.03	8.249.000	1.102.807	5.336	1.108.144	1.908.723	-800.579	2.114.106	1.0
43	Jul	17.2	12.047	0.07	8.249.000	1.102.807	12.451	1.115.258	2,142,800	-1.027.542	1.086.565	0.5
44	Aug	16	11.2	0.11	8,249,000	1,102,807	19,566	1,122,373	1,992,144	-869,771	216,794	0.1
45	Sep	11.8	8.281	0.17	8,249,000	1,102,807	30,238	1,133,045	1,472,941	-339,896	, 0	0.0
46	Oct	8.28	5.796	0.2	8,249,000	1,102,807	35,574	1,138,381	1,030,935	107,447	107,447	0.1
47	Nov	4.76	3.332	0.84	8,249,000	1,102,807	149,411	1,252,218	592,663	659,555	767,002	0.4
48	Dec	3.52	2.464	0.67	8,249,000	1,102,807	119,173	1,221,980	438,272	783,709	1,550,711	0.7
49	Jan	2.9	2.03	1.13	8,249,000	1,102,807	200,993	1,303,801	361,076	942,724	2,493,436	1.2
50	Feb	4.65	3.255	0.76	8,249,000	1,102,807	135,181	1,237,989	578,967	659,022	3,152,457	1.5
51	Mar	6.45	4.515	0.62	8,249,000	1,102,807	110,279	1,213,087	803,083	410,004	3,562,461	1.7
52	Apr	9.97	6.979	0.4	8,249,000	1,102,807	71,148	1,173,955	1,241,355	-67 <u>,</u> 399	3,495,062	1.6
53	May	13.6	9.513	0.05	8,249,000	1,102,807	8,894	1,111,701	1,692,077	-580,376	2,914,686	1.4
54	Jun	15.3	10.731	0.03	8,249,000	1,102,807	5,336	1,108,144	1,908,723	-800,579	2,114,106	1.0
55	Jul	17.2	12.047	0.07	8,249,000	1,102,807	12,451	1,115,258	2,142,800	-1,027,542	1,086,565	0.5
56	Aug	16	11.2	0.11	8,249,000	1,102,807	19,566	1,122,373	1,992,144	-869,771	216,794	0.1
57	Sep	11.8	8.281	0.17	8,249,000	1,102,807	30,238	1,133,045	1,472,941	-339,896	0	0.0
58	Oct	8.28	5.796	0.2	8,249,000	1,102,807	35,574	1,138,381	1,030,935	107,447	107,447	0.1
59	Nov	4.76	3.332	0.84	8,249,000	1,102,807	149,411	1,252,218	592,663	659,555	767,002	0.4
60	Dec	3.52	2.464	0.67	8,249,000	1,102,807	119,173	1,221,980	438,272	783,709	1,550,711	0.7
										Maximum	3 562 461	17

Notes: 1. Evaporation data was collected from ADEQ Engineering Bulletin No. 11. Precipitation data was collected from Buckeye, AZ.

See ADEQ Data tab

https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca6627

2. Pan evaporation data **has not** been adjusted by an evaporation adjustment factor, and by a brine/TDS factor.

3. This is annual average data, not worst case storm event.

4. Carryover volume is calcuated by the difference between evaporation and inflow by month, and previous volume balance.

Passive Solar Evaporation Pond Sizing - 96% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 96% Recovery, Phase 1	Updated by & Date:	L.Haug; 08/12/2022
		Reviewer & Review Date:	TBD

Assume 96% RO recovery with continuous production of brine.									
		Instant.		Monthly					
Treatment Waste	Instant. Flow	Flow		Quantity					
Stream	mgd	gpm	Run Factor	gal	Notes				
RO Brine	0.1808	125.6	100.0%	5,499,333	Year-round value.				

Evaporation Rate Conversions	Value	Notes
Pan Coefficient	1	Not used at this time.
Brine Derating Factor	0.7	Accounts for lower evaporation rate of brine compared to fresh water (USBR, 2006)
Evaporation Adjustment Factor	1	No adjustment provided, at this time.
Combined Derating Factor	0.7	Translates from Pan to local brine

Evaporation Pond					
Sizing Factors	Value	Units	Notes		
Depth of water	6.56	t+	From below: Total inflow divided by area		
added per year	0.50	ιι	From below. Total innow divided by area		
Solids Precipitation	0.0045	ft	LISPR 2006 Figure 10.1, soo Solids Procini Tab		
Rate	0.0045 solids,		JSBR 2000, Figure 10.1, see Solius Precip. Tab.		
Solids Precipitation	0.020	ft			
Rate	0.030	solids/yr			
Solids Storage	0.5	f+	No specific guidance found. Kent at 0.5 from go by		
Depth Reservation	vation 0.5 ft		vo specific guidance round. Kept at 0.5 from go-by.		
Required Solids	16.0				
Removal Interval	10.9	yr			
Freeboard	2	ft	Minimum per Los Angeles Region WDR requirements.		

Sizing	Value	Units	Notes
Required Minimum	22	26	*Iterate for stable annual
Surface Area	22	ac	operation
Minimum	1.6	f+	
Operational Depth	1.0	ιι	
Factor of Safety	50%		Kept from Go-by.
Required	25	£+	
Operational Depth	2.5	ιι	
Required	2 254 106	cf	
Operational Volume	2,354,190	CI	

Section View: Surface area required at lowest water level





Passive Solar Evaporation Pond Sizing - 96% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 96% Recovery, Phase 1	Updated by & Date:	L.Haug; 08/12/2022
		Reviewer & Review Date:	TBD

Assume 96% RO recovery with continuous production of brine.

Int. Optimization Apr. Parather Preatment Preatm		Climate Inputs ¹ Volume Needs per Month						Sizin	g				
India Area Yound Total Info Legar Mark Area A	T 1		Hist.	Adi Evan Pata	Δνα	Treatment					No. Malance	Carryovor	Densitie
Book Long Long <thlong< th=""> Long Long <thl< th=""><th>Stop</th><th>Cal</th><th>Pan Evan</th><th>Auj. Evap. Kate 2</th><th>Avg. Procin³</th><th>Waste</th><th>Trootmont</th><th>Procin</th><th>Total Inflow</th><th>Evaporation</th><th>Net Volume</th><th>Volumo⁴</th><th>Required</th></thl<></thlong<>	Stop	Cal	Pan Evan	Auj. Evap. Kate 2	Avg. Procin ³	Waste	Trootmont	Procin	Total Inflow	Evaporation	Net Volume	Volumo ⁴	Required
1 1 5 2 2 4 1 5 3 5 5 8 7 5 6 7 5 6 7 5 6 7 5 6 7 5 7 5 7 5 7	Month	Month	in/mo	in/mo	in/mo	gal	of	cf	rotar millow	cf	cf	cf	ft
2 6 4.85 3.255 0.06 5.498 389.416 389.416 389.416 389.416 389.416 48.02 1.06.722 66.02 A A P 9.47 6.979 0.44 5.409 73.121 836.014 -5.282 338.384 88.10 6.0 Mar 6.36 9.97 0.05 5.499.333 753.205 5.390 73.110 4.39.824 338.385 88.10 6.0 0.0 0.0 5.835 73.430 4.49.333 753.205 3.399 73.506 93.411.01 6.00.520 0 0.0 0.0 5.835 73.505 93.91.13 4.49.333 753.205 20.364 753.660 93.414 6.0 0.0 0.0 0.0 4.83.8 5.766 0.92.133 753.205 10.34.84 93.33 4.64.51 0.0 1.01.860 4.41.11 1.01.83 4.03.33 753.205 90.64 4.31.44 6.23.93 1.04.81.04 1.03.84.93 1.04.81.93 1.04.81.93 1.04	1	Jan	2.9	2.03	1.13	5.499.333	735,205	135.363	870.568	243.174	627.394	627.394	0.4
Simar 6.46 4.515 0.02 5.40.932 292.06.97 90.475 </td <td>2</td> <td>Feb</td> <td>4.65</td> <td>3.255</td> <td>0.76</td> <td>5,499,333</td> <td>735,205</td> <td>91,040</td> <td>826,245</td> <td>389,916</td> <td>436,329</td> <td>1,063,723</td> <td>0.7</td>	2	Feb	4.65	3.255	0.76	5,499,333	735,205	91,040	826,245	389,916	436,329	1,063,723	0.7
4 Apr 9.97 6.479 0.46 5.909 73.121 93.014 55.925 97.119 1.33 1.279.421 0.00 0 Im 15.3 10.711 0.03 5.499 738.799 738.799 1.287.466 346.471 0	3	Mar	6.45	4.515	0.62	5,499,333	735,205	74,270	809,475	540,852	268,623	1,332,346	0.9
S May 136 9-513 0.003 5-499.33 752,005 3.599 741,194 1.135,507 739.388 881.084 10 Plut 172 112.047 0.003 5499.333 752,056 3.885 743.890 1.443.110 6905.200 1.448.131 0 <td>4</td> <td>Apr</td> <td>9.97</td> <td>6.979</td> <td>0.4</td> <td>5,499,333</td> <td>735,205</td> <td>47,916</td> <td>783,121</td> <td>836,014</td> <td>-52,893</td> <td>1,279,452</td> <td>0.9</td>	4	Apr	9.97	6.979	0.4	5,499,333	735,205	47,916	783,121	836,014	-52,893	1,279,452	0.9
6 0 153 10.71 0.03 5.499.333 755,05 35.89 73.89 1.285,466 54.666 54.847 70.01 4.792.333 755,05 93.930 1.433,101 499.520 0.0 0.0 8/ag 16 11.12 0.11 54.993.33 755,05 93.947 755.99 93.941 232.6421 0.0 0.0 10 Oct 8.76 0.22 54.99 33.33 755,05 10.92.433 55.88 75.95 99.93.01 435.688 56.480 33.43 10.962 35.22 2.464 0.67 54.99.333 755,05 19.90.68 23.741 62.7341	5	May	13.6	9.513	0.05	5,499,333	735,205	5,990	741,194	1,139,562	-398,368	881,085	0.6
2 1 1.72 1.2.047 0.00 5.499,333 775,200 8.389 745,390 1.43,100 -993,206 0 0 9 0.01 1.18 6.783 1.13 755,200 1.20,364 775,556 991,381 6.784,402 0	6	Jun	15.3	10.731	0.03	5,499,333	735,205	3,594	738,799	1,285,466	-546,668	334,417	0.2
B Aug 16 11.2 0.11 5.499.333 775.205 13.177 748.382 13.41.426 93.2461 0 <	7	Jul	17.2	12.047	0.07	5,499,333	735,205	8,385	743,590	1,443,110	-699,520	0	0.0
9 9 118 8.281 0.17 5.493,333 725,205 20,364 755,569 991,681 -636,412 0 0 0 11 Nov 4.76 3.332 0.84 5.493,333 755,205 10.0624 835,829 399,404 456,688 5.01,284 0.01,2180 0.77 13 an 2.9 2.03 1.13 5.499,333 755,205 151,364 870,568 243,174 0.02,8573 1.15 14 reb 4.64 4.515 0.62 5.499,333 735,205 74,270 800,475 540,52 268,623 2,354,106 1.66 16 Ar 9.91 0.05 5.499,333 735,205 5,390 1,213 80,043 1.56,05 2,464,233 1,344,648 536,22 2,646 6,64,70 0.57,47 0.05 19 11.12 0.11 5,493,333 735,205 10,342 1,341,468 536,239 2,054,321 0.05,499,333 735,205 10,341,448 <td>8</td> <td>Aug</td> <td>16</td> <td>11.2</td> <td>0.11</td> <td>5,499,333</td> <td>735,205</td> <td>13,177</td> <td>748,382</td> <td>1,341,648</td> <td>-593,266</td> <td>0</td> <td>0.0</td>	8	Aug	16	11.2	0.11	5,499,333	735,205	13,177	748,382	1,341,648	-593,266	0	0.0
10 10 10 17 10 17 10<	9	Sep	11.8	8.281	0.17	5,499,333	735,205	20,364	755,569	991,981	-236,412	0	0.0
11 Nov 4.76 3.32 0.84 5.499,331 735,205 100,524 835,829 399,140 456,688 501,548 0.03 13 Dan 2.9 2.03 1.13 5.499,333 735,205 91,304 827,548 427,394 1.649,244 1.1 14 Feb 4.55 0.76 5.499,333 735,205 749,104 836,044 -22,882,22 2.241,196 1.6 16 Arr 0.45 99,333 735,205 749,104 738,204 1.335,044 -22,882,84 1.902,945 1.3 18 Inn 1.5 1.0 0.03 5.499,333 735,205 3.944 738,204 1.345,466 546,668 1.355,67 0.9 20 1.01 1.72 1.2404 0.07 5,999,333 735,205 1.3177 748,862 -448,110 699,120 666,477 0.5 21 1.0 1.2 0.01 5,999,333 735,205 1.02,40 735,569 <	10	Oct	8.28	5.796	0.2	5,499,333	735,205	23,958	759,163	694,303	64,860	64,860	0.0
12 Dec 3.52 2.464 0.67 5.499,333 735,205 35.364 70.568 279,374 329,374 735,205 35.368 270,568 274,3174 627,394 1.492,244 1.1 14 feb 4.65 3.255 0.76 5.499,333 735,205 31,346 270,309,475 404,327 243,174 627,394 1.492,244 1.1 15 for 6.6 4.515 0.62 5.499,333 735,205 74,710 309,475 404,327 248,62 248,625 2,395,196 1.6 16 pr 99 7 6 97 9 0.4 5.499,333 735,205 5.990 741,194 1.139,552 389,894 39,200,395 1.3 16 Jun 15.3 10.731 0.03 5.499,333 735,205 3.594 734,504 1.433,504 -546,668 1.566,77 0.5 20 Aug 16 11.2 0.11 5.499,333 735,205 3.594 734,508 1.443,110 4.99,220 656,747 0.5 20 Aug 16 11.2 0.11 5.499,333 735,205 3.20,364 755,566 991,981 2.364,62 6.34,81 0.0 22 loct 8.25 7.96 0.2 5.499,333 735,205 3.20,364 755,566 991,981 2.364,10 0.0 23 Nov 4.76 3.332 0.84 5.499,333 735,205 3.20,364 755,566 991,981 2.364,12 0.0 0.0 23 Nov 4.76 3.332 0.84 5.499,333 735,205 13,304 755,566 991,981 2.364,12 0.00,0 23 Nov 4.76 3.332 0.84 5.499,333 735,205 13,363 870,568 2.43,174 4.568 501,548 0.3 2 loct 8.5 7.464 0.67 5.499,333 735,205 133,363 870,568 2.43,174 4.568 501,548 0.3 2 loct 6.3 .255 0.78 5.499,333 735,205 133,363 870,568 2.43,174 4.56,88 501,548 0.3 2 Nov 4.76 3.332 0.84 5,499,333 735,205 133,363 870,568 2.43,174 4.56,88 501,548 0.3 2 Nov 4.76 3.332 0.02 5,499,333 735,205 133,363 870,568 2.43,174 4.57,394 1.469,244 1.1 25 reb 4.65 3.255 0.78 5.5,499,333 735,205 14,270 800,475 540,852 2.384,519 6 1.6 28 Apr 9.97 6.07 5,499,333 735,205 174,270 800,475 540,852 2.384,519 6 1.6 28 Apr 9.13 0.05 5,499,333 735,205 133,363 870,568 2.43,174 6,27,394 1.469,240 3 1.4 3 3 0.01 1.5.3 10.731 0.02 5,499,333 735,205 133,463 778,102 439,916 436,527 2.985,573 1.5 27 Mar 6.45 4.515 0.62 5,499,333 735,205 13,470 800,475 540,852 2.384,519 6 1.6 28 May 13.6 9.513 0.05 5,499,333 735,205 3.549 738,749 1.284,646 5.366,66 4.356,227 0.9 3 Jul 1.7.2 12.047 0.07 5,499,333 735,205 3.549 738,749 1.284,646 4.560 6.50,6207 0.9 3 Jul 1.72 1.2047 0.07 5,499,333 735,205 13,477 443,82 1,414,48 4.532,66 63,441 0.0 0.45 0cc 8.28 5.796 0.2 5,499,333 735,205 13,477 88,38	11	Nov	4.76	3.332	0.84	5,499,333	735,205	100,624	835,829	399,140	436,688	501,548	0.3
13 1a 2.9 2.03 1.13 5.499.333 735.205 15.363 870.568 243.174 645.22 2.085.573 1.5 15 Mar 6.45 4.555 0.76 5.999.333 735.205 74.270 809.9475 540.82 2.286.22 2.296.196 1.6 16 Ay 9.513 0.05 5.499.333 735.205 5.990 741.194 1.132.562 5.993.88 1.900.2955 1.36 1.77 70.93 5.993.985 1.36.074 5.993.265 5.990 741.194 1.128.566 5.666 5.6747 0.9 70.9 70.9 748.382 1.44.548 593.66 63.461 0.0 0.2 0.646 5.956.1 1.956.46 5.956.47 0.5 0.0 64.860 64.60 64.60 64.60 64.60 0.0 0.2 0.441.74 63.324 0.445.10 0.456.46 63.481 0.3 0.30.46 5.999.33 735.205 10.056.43 83.824 93.104 45.648 50.156.46 0.55.747 0.5 0.5 1.435.499.33 735.205 1.35.36 73.55.05	12	Dec	3.52	2.464	0.67	5,499,333	735,205	80,259	815,464	295,163	520,302	1,021,850	0.7
14 Feb 4.65 3.255 0.76 5,499.333 735,205 74,270 809.475 540.852 286.623 2.355,196 1.6 15 Mar 6.45 4.515 0.62 5,499.333 735,205 742.07 809.475 343.01 1.325,502 398.94 1.319,552 398.94 1.309.552 398.94 1.309.552 398.94 1.319.522 398.94 1.319.522 398.94 1.319.520 389.94 1.419.10 699.52 665.747 0.55 20 Aug 1.6 1.1.2 0.11 5,499.333 7735.205 1.3177 748.382 1.441.10 699.266 63.461 0.00 21 Oct 8.28 5.976 0.2 5.499.333 735.205 100.624 83.829 999.10 64.68 50.05.64 0.03 1.025.84 0.03 1.025.84 0.03 0.02 5.499.333 735.205 135.363 70.505.84 23.991.44 2.048.91.79 0.84.84 50.01.65.84 0.33 0.01 72.33 1.35 2.036.33 73.5205 13.504 12.35.61.01.01 2.0	13	Jan	2.9	2.03	1.13	5,499,333	735,205	135,363	870,568	243,174	627,394	1,649,244	1.1
15 Apr 99 6.97 0.4 5.499.33 735.205 74.270 809.475 56.06.23 2.25.41.96 11.6 17 May 3.6 9.51.3 0.005 5.499.333 735.205 74.194 1.12.82.6 -345.66 3.456.66 3.55.27 70.99 18 Ju 17.2 12.047 0.07 5.499.333 735.205 8.385 734.390 1.443.110 459.526 656.747 0.5 20 Aug 16 1.12 0.01 5.499.333 735.205 20.364 755.465 991.581 -236.412 0.0 0.0 21 Sep 1.48 8.281 0.17 5.499.333 735.205 20.364 759.163 664.860 64.860 0.0 3.32 20.86 5.75 2.464 0.67 5.499.333 735.205 10.46 855.27 399.140 43.69.232 2.541.13 3.33 735.205 10.46 855.27 399.140 43.69.23 2.254.11 1.13 4.99.233 735.205 1.41.40 1.39.245 3.39.324 1.33.646 2.25.8	14	Feb	4.65	3.255	0.76	5,499,333	735,205	91,040	826,245	389,916	436,329	2,085,573	1.5
16 Apr 9.97 6.979 0.41 5,499,333 735,205 5.900 741,149 1,135,562 -398,368 1,902,308 1,503 18 Jun 15.3 10.731 0.03 5,499,333 735,205 5.900 741,149 1,135,562 -398,368 1,902,308 1,902,308 1,902,308 1,902,308 1,902,308 1,902,401 1,952,90 1,441,144 593,266 63,481 0.00 20 Lag 5,706 0.2 5,499,333 735,205 1,304,808 1,241,448 593,266 63,481 0.00 20 Act 5,706 0.2 5,499,333 735,205 10,528 15,464 480,024 46,00 0.00 7,55,66 991,944 436,688 501,548 0.00 1,52,013 0.01 7,52,05 10,564 429,124 430,688 501,548 0.00 7,499,333 735,205 10,402,483 389,916 433,529 208,513 1,33 1,492,441 1,492,441 1,492,441 1,492,441 1,492,441 1,492,441 1,492,441 1,492,441 1,492,431 1,52 <t< td=""><td>15</td><td>Mar</td><td>6.45</td><td>4.515</td><td>0.62</td><td>5,499,333</td><td>735,205</td><td>74,270</td><td>809,475</td><td>540,852</td><td>268,623</td><td>2,354,196</td><td>1.6</td></t<>	15	Mar	6.45	4.515	0.62	5,499,333	735,205	74,270	809,475	540,852	268,623	2,354,196	1.6
17 May 13.6 9.513 0.05 5.499.33 735.205 5.590 741,194 1.129.24 -994,948 1.902.945 1.3 18 Jun 17.2 12.047 0.07 5.499.333 735.205 8.385 743.590 1.443.10 699.520 656,747 0.0 21 leep 11.8 8.281 0.017 5.499.333 775.205 22.395 759,163 6694.305 664.860 0.0 22 locu 8.28 5.796 0.2 5.499.333 735.205 100.624 835,422 239.40 436,688 501.448 0.3 23 locu A.52 2.464 0.67 5.499.333 735.205 153.68 205.302 1.021.850 0.11 1.549.333 735.205 153.68 205.312 436.40 1.3 1.35 0.024 835,424 289.14 1.1 1.35.205 1.33 8.62.2 2.344 1.41 1.43.68 1.43.68 1.51.201.13 1.53 1.07.31 0.35 5.499.333 735.205 1.31.41.448 1.493.491 1.43.58.21	16	Apr	9.97	6.979	0.4	5,499,333	735,205	47,916	783,121	836,014	-52,893	2,301,303	1.6
18 jul 15.3 10.731 0.003 5.499,333 735,205 8.385 735,305 1.443,101 >>99,502 65,747 0.5 20 Aug 16 1.12 0.01 5.499,333 735,205 8.385 735,555 599,191,81 >>266,647 0.5 21 bep 11.8 8.281 0.17 5.499,333 735,205 0.23,497 >>556,99 991,981 >>266,416 0.64,480 0.64,860 0.64,860 0.64,860 0.0 22 Oct 8.28 5.796 0.2 5.499,333 735,205 0.529 815,444 251,643 250,203 1.01,550 0.77 1.55 25 Feb 455 0.76 5.499,333 735,205 174,270 809,475 540,352 228,823 2,354,196 1.6 28 Apr 9.97 6.97 0.04 5.499,333 735,205 3.594 74,114 1,139,462 -398,368 1,002,35,173 1.55 29 May 13.6 9.513 0.005 5.499,333 735,205 3.594	17	May	13.6	9.513	0.05	5,499,333	735,205	5,990	741,194	1,139,562	-398,368	1,902,935	1.3
19 μul 17.2 12.047 0.007 5,499,333 735,205 13.177 748,332 1.341,648 599,266 63.481 0.00 21 Sep 11.8 8.281 0.17 5,499,333 735,205 12.341,648 564,800 64.860 60.00 22 Oct 8.28 5,796 0.2 5,499,333 735,205 12.958 75,163 643,03 64.860 60.00 22 Nov 4.76 3.332 0.84 5,499,333 735,205 15.3583 870,568 243,174 64.7394 1.649,244 1.1 25 Pech 4.55 0.67 5,499,333 735,205 174,270 809,475 500,852 22.86,22 2.88,129 2.98,573 1.5 27 Mar 645 4.515 0.67 5,499,333 735,205 74,270 809,475 500,852 22.86,22 2.88,129 1.38 1.33 1.34,141 50,135 1.03 5,499,333 735,205 5,990 74,194 1.138,562 398,368 1.00,238 1.33 1.33 1.34 </td <td>18</td> <td>Jun</td> <td>15.3</td> <td>10.731</td> <td>0.03</td> <td>5,499,333</td> <td>735,205</td> <td>3,594</td> <td>738,799</td> <td>1,285,466</td> <td>-546,668</td> <td>1,356,267</td> <td>0.9</td>	18	Jun	15.3	10.731	0.03	5,499,333	735,205	3,594	738,799	1,285,466	-546,668	1,356,267	0.9
20 Aug 16 11.2 0.11 5,449,433 (73),205 13,1// (743,432 1,24,448 2-95,608 5-95,60 5-95,60 5-95,60 5-95,60 5-95,60 5-95,60 5-95,60 5-95,60 6-0,00 0 0.00 0.	19	Jul	17.2	12.04/	0.07	5,499,333	735,205	8,385	743,590	1,443,110	-699,520	656,/4/	0.5
21 Dept 11.8 8.281 5.796 0.2 5,499,333 735,205 23,958 755,163 694,303 64,860 0.0 23 Nov 4.76 3.322 0.84 5,499,333 735,205 80,259 815,464 295,163 520,392 102,180 0.7 24 Dec 3.52 2.03 1.13 5,499,333 735,205 815,464 295,163 520,392 126,482,29 2,085,573 1.5 27 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 2,284,196 1.6 29 May 1.6 9.549 0.45 5,499,333 735,205 5.990 741,194 1.139,612 2,983,36 1,902,335 1.3 30 Jun 1.5.3 10.0731 0.02 5,499,333 735,205 3,594 738,799 1,285,466 546,668 1,356,267 0.9 31 Jul 1.72 1.0.47 5,499,333 735,205 3,354 743,500 1,443,110 699,920 656,747 0.5	20	Aug	16	11.2	0.11	5,499,333	735,205	13,177	748,382	1,341,648	-593,266	63,481	0.0
12 12 12 12 13 5,496 13 13 14,205 13 15,216 15,229 139,110 143 15,865 10,21,850 10,71 25 1an 2,9 2.03 1.13 5,499,333 735,205 80,259 815,464 125,163 520,302 1,021,850 0.7. 25 1an 2,9 2.03 1.13 5,499,333 735,205 91,040 826,245 389,916 435,822 2,085,573 1.5 28 Apr 9,97 6.47 5,499,333 735,205 74,270 809,475 540,852 2,364,032 2,354,196 1.6 29 May 13.6 9.513 0.00 5,499,333 735,205 5,990 741,194 1,139,562 398,366 1,902,393 1.3 30 Jun 15.3 10.07 5,499,333 735,205 8,385 743,500 1,441,110 695,206 656,747 0.5 24 Dug 1.01 5,499,333 735,205 13,177 748,382 1,341,648 593,266 <td< td=""><td>21</td><td>Sep</td><td>11.8</td><td>8.281</td><td>0.17</td><td>5,499,333</td><td>/35,205</td><td>20,364</td><td>750,509</td><td>991,981</td><td>-236,412</td><td>0</td><td>0.0</td></td<>	21	Sep	11.8	8.281	0.17	5,499,333	/35,205	20,364	750,509	991,981	-236,412	0	0.0
24 Doct 3.5.2 2.4.64 0.67 5,499,33 735,205 802,59 815,464 295,163 520,302 1,021,850 0.77 25 Jan 2.9 2.03 1,13 5,499,333 735,205 815,464 295,163 520,302 1,649,245 389,916 436,329 2,085,573 1,5 26 Feb 4.65 3.255 0.76 5,499,333 735,205 74,270 80,9475 540,652 288,622 2,354,196 1.6 28 Apr 9.97 6.979 0.4 5,499,333 735,205 5,990 741,194 1,139,612 548,668 1,902,935 1.33 30 Jun 15.3 10.731 0.03 5,499,333 735,205 8,385 743,500 1,443,110 699,20 656,747 0.5 32 Aug I6 1.12 0.01 5,499,333 735,205 8,358 743,500 1,414,941 643,600 60,00 0.0 0.0 0.0 0.0 0.0 2,499,333 735,205 802,59 815,464 295,168 <t< td=""><td>22</td><td>Uct</td><td>8.28</td><td>5./90</td><td>0.2</td><td>5,499,333</td><td>/35,205</td><td>23,950</td><td>/59,103</td><td>694,303</td><td>64,800</td><td>64,800</td><td>0.0</td></t<>	22	Uct	8.28	5./90	0.2	5,499,333	/35,205	23,950	/59,103	694,303	64,800	64,800	0.0
24 Dec 5.32 2.4494 0.07 5.4993,53 735,205 035,363 870,568 243,114 627,394 1,649,244 1.1 25 Jan 6.45 3.255 0.76 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5. 27 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 266,663 2,354,196 1.66 28 Apr 9.37 0.677 0.04 5,499,333 735,205 3,594 743,799 1,284,66 546,666 1,355,627 0.99 31 Jul 17.2 12.047 0.07 5,499,333 735,205 13,317 748,329 1,443,110 -699,520 656,747 0.5 32 Aug 16 1.1.2 0.11 5,499,333 735,205 13,147 748,329 1,443,410 -699,520 656,747 0.5 33 Sep 1.88 8.45 4,393,37 735,205 135,425 694,303 64,860 0.0 <t< td=""><td>23</td><td>NOV</td><td>4.70</td><td>3.332</td><td>0.84</td><td>5,499,333</td><td>/35,205</td><td>200,024</td><td>835,823</td><td>399,140</td><td>430,000</td><td>501,540 1 021 850</td><td>0.3</td></t<>	23	NOV	4.70	3.332	0.84	5,499,333	/35,205	200,024	835,823	399,140	430,000	501,540 1 021 850	0.3
22) BM 2.93 2.103 2.113 2.973,203 273,203 273,203 274,174 027,224 2.983,274 217,174 027,224 2.983,274 2.085,273 1.5 27 Mar 6.45 4.515 0.62 5.499,333 735,205 74,270 809,475 540,852 2.686,623 2.354,196 1.6 28 Apr 9.97 6.979 0.4 5.499,333 735,205 5.990 744,194 1.139,562 -398,868 1.902,935 1.33 30 Jun 15.3 10.731 0.03 5.499,333 735,205 3.594 738,799 1.285,666 9.450,668 1.356,67 0.9 31 Jul 17.2 12.047 0.07 5.499,333 735,205 3.13,177 748,382 1.341,648 593,266 63,481 0.0 33 Bep 1.8 8.281 0.17 5.499,333 735,205 23,958 759,163 540,303 64,860 0.0 353,203 3.64,640 64,860 0.0 3.520 39,140 436,628 501,548 0.33	24	Dec	3.52	2.404	1.12	5,499,555	735,205	125 262	010,404	295,105	520,502	1,021,050	0.7
20 Peo 4.00 3.233 0.00 9.34,043 9.40,042 300,244 300,244 300,245 540,052 26,052,155 4.00 27 Mar 6.45 4.515 0.62 5,499,333 775,205 74,270 809,475 540,652 25,863 2,352,196 1.6 28 May 13.6 9.513 0.05 5,499,333 735,205 3,594 738,799 1,285,66 5.4668 1,355,67 0.9 31 Jul 17.2 12.047 0.00 5,499,333 735,205 13,177 748,382 1,341,648 593,266 63,481 0.00 33 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.00 34 Oct 8.28 5.796 0.2 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.33 35 Nov 4.76 3.32 0.84 5,499,333 735,205 13,546 29,5168 52,0302 1,01,218	25	Jan	4.65	2.03	0.76	5,499,555	735,205	135,505 01 0/0	076 2/15	243,174	126 329	1,049,244	1.1
22 Wal 6.4-3 4-3.53 0.52 2.927,253 733,253 735,205 74,710 000,710 3.760,025 2.928,212,1256 2.926,221 2.927,1256 2.928,368 1,902,935 1.33 30 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.93 31 Jul 17.2 1.2047 0.07 5,499,333 735,205 3,848 743,590 1,443,110 6-69,520 656,747 0.55 32 Aug 16 1.1.2 0.01 5,499,333 735,205 20,364 755,569 91,9181 -236,412 0 0.00 34 bep 1.18 8.281 0.01 5,499,333 735,205 100,624 352,223 399,140 436,688 501,548 0.33 35 bep 1.3.3 5,499,333 735,205 135,363 870,568 243,174 627,394 1,649,244 1.11 38 Feb 4.65 3.255 0.76 5,499,333 735,205 <t< td=""><td>20</td><td>Mar</td><td>6.45</td><td>3.233 4.515</td><td>0.70</td><td>5,455,000</td><td>735,205</td><td>91,040 7/ 270</td><td>۵۷۵,۲۰۶ ۵۵۵ <u>۵</u>75</td><td>540 852</td><td>450,525 268 623</td><td>2,003,373</td><td>1.5</td></t<>	20	Mar	6.45	3.233 4.515	0.70	5,455,000	735,205	91,040 7/ 270	۵۷۵,۲۰۶ ۵۵۵ <u>۵</u> 75	540 852	450,525 268 623	2,003,373	1.5
28 Php 33.6 0.513 0.64 5,495,33 735,205 5,909 741,124 1,139,562 -398,368 1,302,935 1,33 30 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.99 31 Jul 17.2 12.047 0.07 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 656,747 0.07 32 Aug 16 11.2 0.11 5,499,333 735,205 130,777 748,382 1,341,648 -593,266 666,401 0.00 33 Oct 8.28 5.796 0.2 5,499,333 735,205 10,06,24 835,829 399,140 436,688 501,548 0.33 36 Dec 3.52 2.464 0.67 5,499,333 735,205 10,040 826,242 338,916 436,522 2,085,573 1.53 37 Jan 2.9	27	Anr	9.97	6 979	0.02	5,499,000	735,205	/+,∠,0 47 916	783 121	836 014	-52 893	2,334,130	1.0
1 1	29	May	13.6	9.513	0.05	5 499.333	735,205	5,990	741,194	1 139,562	-398,368	1 902,935	1.3
11 17.2 12.047 0.00 5,499,33 735,205 8,385 743,590 1,443,110 6-699,520 656,474 0.5 32 Aug 16 11.2 0.11 5,499,333 735,205 13,177 748,382 1,341,648 5-593,266 63,481 0.0 33 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.00 34 0.04 5.796 0.2 5,499,333 735,205 100,624 885,829 399,140 456,688 501,548 0.3 36 Dec 3.52 2.464 0.67 5,499,333 735,205 185,363 870,556 243,174 627,394 1,649,244 1.1 38 Feb 4.65 3.255 0.76 5,499,333 735,205 74,270 809,475 540,852 2,68,623 2,354,196 1.6 41 May 1.36 9,513 0.05 5,499,333 735,205 74,270 809,475 540,852 2,354,196 1.6	30	lun	15.3	10.731	0.03	5 499.333	735,205	3.594	738.799	1 285.466	-546.668	1 356.267	0.9
1 1	31	Jul	17.2	12.047	0.07	5.499,333	735,205	8,385	743,590	1.443,110	-699,520	656,747	0.5
as by by<	32	Aug	16	11.2	0.11	5.499,333	735,205	13,177	748,382	1,341,648	-593,266	63,481	0.0
A Ort 8.28 5.796 0.2 5,499,333 735,205 23,958 759,163 694,303 64,860 64,860 0.0 35 Nov 4.76 3.332 0.84 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7 7 Jan 2.9 2.03 1.13 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5 39 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 40 Apr 9.97 6.979 0.4 5,499,333 735,205 74,270 809,475 540,852 288,368 1,902,935 1.3 42 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 743,590 1,443,110 -699,520 656,747 0.5 44 Aug 16 1.1.2	33	Sep	11.8	8.281	0.17	5,499,333	735,205	20,364	755,569	991,981	-236,412	0	0.0
35 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 36 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7 37 Jan 2.9 2.03 1.13 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5 39 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 40 Apr 9.97 6.979 0.4 5,499,333 735,205 3,594 738,799 1,285,466 546,688 1,002,335 1.3 42 Jun 15.3 10.731 0.03 5,499,333 735,205 3,387 743,590 1,443,110 -699,520 656,747 0.5 44 Aug 16 11.2 <td>34</td> <td>Oct</td> <td>8.28</td> <td>5.796</td> <td>0.2</td> <td>5,499,333</td> <td>735,205</td> <td>23,958</td> <td>759,163</td> <td>694,303</td> <td>64,860</td> <td>64,860</td> <td>0.0</td>	34	Oct	8.28	5.796	0.2	5,499,333	735,205	23,958	759,163	694,303	64,860	64,860	0.0
36 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7 37 Jan 2.9 2.03 1.13 5,499,333 735,205 135,363 870,568 243,174 627,394 1,649,244 1.1 38 Feb 4.65 3.255 0.76 5,499,333 735,205 74,270 809,475 540,852 286,623 2,354,196 1.6 40 Apr 9.97 6.979 0.4 5,499,333 735,205 47,916 783,121 836,014 -52,893 2,301,303 1.6 41 May 13.6 9.513 0.05 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 43 Jun 17.2 2.047 0.07 5,499,333 735,205 13,177 748,382 1,431,10 -699,520 656,747 0.5 44 Aug 16 11.2 </td <td>35</td> <td>Nov</td> <td>4.76</td> <td>3.332</td> <td>0.84</td> <td>5,499,333</td> <td>735,205</td> <td>100,624</td> <td>835,829</td> <td>399,140</td> <td>436,688</td> <td>501,548</td> <td>0.3</td>	35	Nov	4.76	3.332	0.84	5,499,333	735,205	100,624	835,829	399,140	436,688	501,548	0.3
37 Jan 2.9 2.03 1.13 5,499,333 735,205 135,363 870,568 243,174 627,394 1,649,244 1.1 38 Feb 4.65 3.255 0.76 5,499,333 735,205 91,040 826,245 389,916 446,329 2,085,573 1.5. 39 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 40 Apr 9.97 6.979 0.4 5,499,333 735,205 5,990 741,194 1,139,562 -398,368 1,902,935 1.3 42 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 31 Jul 17.2 1.047 0.07 5,499,333 735,205 13,177 748,382 1,443,110 -699,206 656,747 0.5 44 Aug 16 1.12 0.11 5,499,333 735,205 20,364 755,569 991,981 <td< td=""><td>36</td><td>Dec</td><td>3.52</td><td>2.464</td><td>0.67</td><td>5,499,333</td><td>735,205</td><td>80,259</td><td>815,464</td><td>295,163</td><td>520,302</td><td>1,021,850</td><td>0.7</td></td<>	36	Dec	3.52	2.464	0.67	5,499,333	735,205	80,259	815,464	295,163	520,302	1,021,850	0.7
38 Feb 4.65 3.255 0.76 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5 39 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 40 Apr 9.97 6.979 0.4 5,499,333 735,205 47,916 783,121 836,014 -52,893 2,301,303 1.6 41 May 13.6 9.513 0.005 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,355,267 0.9 43 Jul 17.2 12.047 0.07 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 63,481 0.0 45 Sep 11.8 8.281 0.17 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 47 Nov 4.76 3.	37	Jan	2.9	2.03	1.13	5 <u>,</u> 499,333	735,205	135,363	870,568	243,174	627,394	1,649,244	1.1
39 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 40 Apr 9.97 6.979 0.4 5,499,333 735,205 47,916 783,121 836,014 -52,893 2,301,303 1.6 41 May 13.6 9.513 0.05 5,499,333 735,205 3,594 741,194 1,139,562 -398,368 1,902,935 1.3 42 Jun 17.2 12.047 0.07 5,499,333 735,205 8,385 743,590 1,443,110 -699,520 656,747 0.5 44 Aug 16 11.2 0.11 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.0 45 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.0 46 Oct 8.282 2.464	38	Feb	4.65	3.255	0.76	5,499,333	735,205	91,040	826,245	389,916	436,329	2,085,573	1.5
40 Apr 9.97 6.979 0.4 5,499,333 735,205 47,916 783,121 836,014 -52,893 2,301,303 1.6 41 May 13.6 9.513 0.05 5,499,333 735,205 5,990 741,194 1,139,562 -398,368 1,902,935 1.3 42 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 43 Jul 17.2 12.047 0.07 5,499,333 735,205 13,177 748,382 1,443,110 -699,520 656,747 0.0 44 Aug 16 11.2 0.11 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.0 45 Sep 1.8 8.281 0.17 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 46 Oct 3.52 0.66 5,499,333 735,205 91,040 826,245 389,164 45,329 2,035,	39	Mar	6.45	4.515	0.62	5,499,333	735,205	74,270	809,475	540,852	268,623	2,354,196	1.6
41 May 13.6 9.513 0.05 5,499,333 735,205 5,990 741,194 1,139,562 -398,368 1,902,935 1.3 42 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 43 Jul 17.2 12.047 0.00 5,499,333 735,205 8,385 743,590 1,443,110 -699,520 656,747 0.5 44 Aug 16 11.2 0.11 5,499,333 735,205 120,364 755,569 991,981 -236,412 0 0.00 45 Sep 11.8 8.281 0.17 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 47 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 48 Dec 3.52 2.464 0.67 5,499,333 735,205 11040 826,245 389,916 436,32	40	Apr	9.97	6.979	0.4	5,499,333	735,205	47,916	783,121	836,014	-52,893	2,301,303	1.6
42 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 43 Jul 17.2 12.047 0.07 5,499,333 735,205 8,385 743,590 1,443,110 -699,520 656,747 0.5 44 Aug 16 11.2 0.11 5,499,333 735,205 20,364 755,69 991,981 -236,412 0.0 0.0 46 Oct 8.28 5.796 0.2 5,499,333 735,205 20,364 259,393 -694,303 644,800 64,860 0.0 47 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 64,960 0.0 48 Dec 3.52 2.464 0.67 5,499,333 735,205 100,624 835,829 399,140 436,688 501,023 1,021,850 0.7 49 Jan 2.9 2.03 1.13 5,499,333 735,205 815,645 243,174 627,344 <td>41</td> <td>May</td> <td>13.6</td> <td>9.513</td> <td>0.05</td> <td>5,499,333</td> <td>735,205</td> <td>5,990</td> <td>741,194</td> <td>1,139,562</td> <td>-398,368</td> <td>1,902,935</td> <td>1.3</td>	41	May	13.6	9.513	0.05	5,499,333	735,205	5,990	741,194	1,139,562	-398,368	1,902,935	1.3
43 Jul 17.2 12.047 0.07 5,499,333 735,205 8,385 743,590 1,443,110 -699,520 656,747 0.5 44 Aug 16 11.2 0.11 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 63,481 0.0 45 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.0 46 Oct 8.28 5.796 0.2 5,499,333 735,205 23,958 759,163 694,303 64,860 64,860 0.0 47 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 48 Dec 3.52 2.464 0.67 5,499,333 735,205 135,363 870,568 243,174 627,394 1,649,244 1.1 50 Feb 4.65 3.255 0.76 5,499,333 735,205 74,270 809,475 540,852 2,686,23	42	Jun	15.3	10.731	0.03	5,499,333	735,205	3,594	738,799	1,285,466	-546,668	1,356,267	0.9
44 Aug 16 11.2 0.11 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 63,481 0.0 45 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.0 46 Oct 8.28 5.796 0.2 5,499,333 735,205 23,958 759,163 694,303 64,860 64,860 0.0 47 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 48 Dec 3.52 2.464 0.67 5,499,333 735,205 80,559 815,464 295,163 520,302 1,021,850 0.7 49 Jan 2.9 2.03 1.13 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5 51 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,825 268,623	43	Jul	17.2	12.047	0.07	5,499,333	735,205	8,385	743,590	1,443,110	-699,520	656,747	0.5
45Sep11.88.2810.175,499,333735,20520,364755,569991,981-236,41200.046Oct8.285.7960.025,499,333735,20523,958759,163694,30364,86064,8600.047Nov4.763.3320.845,499,333735,205100,624835,829399,140436,688501,5480.348Dec3.522.4640.675,499,333735,20580,259815,464295,163520,3021,021,8500.749Jan2.92.031.135,499,333735,205135,363870,568243,174627,3941,649,2441.150Feb4.653.2550.765,499,333735,20591,040826,245389,916436,3292,085,5731.551Mar6.454.5150.625,499,333735,20574,270809,475540,852268,6232,354,1961.652Apr9.976.9790.45,499,333735,20574,270809,475540,852268,6232,354,1961.653May13.69.5130.055,499,333735,2055,990741,1941,139,562-398,3681,902,9351.354Jun15.310.7310.035,499,333735,2053,594738,7991,285,466-546,6681,356,2670.955Jul17.212.047 <t< td=""><td>44</td><td>Aug</td><td>16</td><td>11.2</td><td>0.11</td><td>5,499,333</td><td>735,205</td><td>13,177</td><td>748,382</td><td>1,341,648</td><td>-593,266</td><td>63,481</td><td>0.0</td></t<>	44	Aug	16	11.2	0.11	5,499,333	735,205	13,177	748,382	1,341,648	-593,266	63,481	0.0
46 0ct 8.28 5.796 0.2 5,499,333 735,205 23,958 759,163 694,303 64,860 64,860 0.0 47 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 48 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7 49 Jan 2.9 2.03 1.13 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5 51 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 52 Apr 9.97 6.979 0.4 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 53 Mar 13.6 9.513 0.05 5,499,333 735,205 5,990 741,194 1,139,562 398,368 </td <td>45</td> <td>Sep</td> <td>11.8</td> <td>8.281</td> <td>0.17</td> <td>5,499,333</td> <td>735,205</td> <td>20,364</td> <td>755,569</td> <td>991,981</td> <td>-236,412</td> <td>0</td> <td>0.0</td>	45	Sep	11.8	8.281	0.17	5,499,333	735,205	20,364	755,569	991,981	-236,412	0	0.0
47 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 48 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7 49 Jan 2.9 2.03 1.13 5,499,333 735,205 135,363 870,568 243,174 627,394 1,649,244 1.1 50 Feb 4.65 3.255 0.76 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5 51 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 52 Apr 9.97 6.979 0.4 5,499,333 735,205 5,990 741,194 1,139,562 -398,368 1,902,935 1.3 53 May 13.6 9.513 0.05 5,499,333 735,205 3,594 738,799 1,285,466 -	46	Oct	8.28	5.796	0.2	5,499,333	735,205	23,958	759,163	694,303	64,860	64,860	0.0
48 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7 49 Jan 2.9 2.03 1.13 5,499,333 735,205 135,363 870,568 243,174 627,394 1,649,244 1.1 50 Feb 4.65 3.255 0.76 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5 51 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 52 Apr 9.97 6.979 0.4 5,499,333 735,205 74,270 809,475 540,852 268,623 2,301,303 1.6 53 May 13.6 9.513 0.05 5,499,333 735,205 5,990 741,194 1,139,562 -398,368 1,902,935 1.3 54 Jun 15.3 10.71 0.007 5,499,333 735,205 8,385 743,590 1,443,100 <td< td=""><td>47</td><td>Nov</td><td>4.76</td><td>3.332</td><td>0.84</td><td>5,499,333</td><td>735,205</td><td>100,624</td><td>835,829</td><td>399,140</td><td>436,688</td><td>501,548</td><td>0.3</td></td<>	47	Nov	4.76	3.332	0.84	5,499,333	735,205	100,624	835,829	399,140	436,688	501,548	0.3
49 Jan 2.9 2.03 1.13 5,499,333 735,205 135,363 870,568 243,174 627,394 1,649,244 1.1 50 Feb 4.65 3.255 0.76 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5 51 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 52 Apr 9.97 6.979 0.4 5,499,333 735,205 47,916 783,121 836,014 -52,893 2,301,303 1.6 53 May 13.6 9.513 0.05 5,499,333 735,205 5,990 741,194 1,139,562 -398,368 1,902,935 1.3 54 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 55 Jul 17.2 12.047 0.07 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 63,481 0.0 0.0 <	48	Dec	3.52	2.464	0.67	5,499,333	735,205	80,259	815,464	295,163	520,302	1,021,850	0.7
50 Feb 4.65 3.255 0.76 5,499,333 735,205 91,040 826,245 389,916 436,329 2,085,573 1.5 51 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 52 Apr 9.97 6.979 0.4 5,499,333 735,205 47,916 783,121 836,014 -52,893 2,301,303 1.6 53 May 13.6 9.513 0.05 5,499,333 735,205 5,990 741,194 1,139,562 -398,368 1,902,935 1.3 54 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 55 Jul 17.2 12.047 0.07 5,499,333 735,205 13,177 748,382 1,443,110 -699,520 656,747 0.5 56 Aug 16 11.2 0.11 5,499,333 735,205 20,364 755,569 991,981 <t< td=""><td>49</td><td>Jan</td><td>2.9</td><td>2.03</td><td>1.13</td><td>5,499,333</td><td>735,205</td><td>135,363</td><td>870,568</td><td>243,174</td><td>627,394</td><td>1,649,244</td><td>1.1</td></t<>	49	Jan	2.9	2.03	1.13	5,499,333	735,205	135,363	870,568	243,174	627,394	1,649,244	1.1
51 Mar 6.45 4.515 0.62 5,499,333 735,205 74,270 809,475 540,852 268,623 2,354,196 1.6 52 Apr 9.97 6.979 0.4 5,499,333 735,205 47,916 783,121 836,014 -52,893 2,301,303 1.6 53 May 13.6 9.513 0.05 5,499,333 735,205 5,990 741,194 1,139,562 -398,368 1,902,935 1.3 54 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 55 Jul 17.2 12.047 0.07 5,499,333 735,205 8,385 743,590 1,443,110 -699,520 656,747 0.5 56 Aug 16 11.2 0.11 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 63,481 0.0 57 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 <td< td=""><td>50</td><td>Feb</td><td>4.65</td><td>3.255</td><td>0.76</td><td>5,499,333</td><td>735,205</td><td>91,040</td><td>826,245</td><td>389,916</td><td>436,329</td><td>2,085,573</td><td>1.5</td></td<>	50	Feb	4.65	3.255	0.76	5,499,333	735,205	91,040	826,245	389,916	436,329	2,085,573	1.5
52 Apr 9.97 6.979 0.4 5,499,333 735,205 4/,916 /83,121 836,014 -52,893 2,301,303 1.6 53 May 13.6 9.513 0.05 5,499,333 735,205 5,990 741,194 1,139,562 -398,368 1,902,935 1.3 54 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 55 Jul 17.2 12.047 0.07 5,499,333 735,205 8,385 743,590 1,443,110 -699,520 656,747 0.5 56 Aug 16 11.2 0.11 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 63,481 0.0 57 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.0 58 Oct 8.28 5.796 0.2 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 60 Dec 3.52<	51	Mar	6.45	4.515	0.62	5,499,333	735,205	74,270	809,475	540,852	268,623	2,354,196	1.6
53 May 13.6 9.513 0.05 5,499,333 /35,205 5,990 /41,194 1,139,562 -398,368 1,902,935 1.3 54 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,466 -546,668 1,356,267 0.9 55 Jul 17.2 12.047 0.07 5,499,333 735,205 8,385 743,590 1,443,110 -699,520 656,747 0.5 56 Aug 16 11.2 0.11 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 63,481 0.0 57 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.0 58 Oct 8.28 5.796 0.2 5,499,333 735,205 23,958 759,163 694,303 64,860 64,860 0.0 59 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 60 Dec 3.52 <td>52</td> <td>Apr</td> <td>9.97</td> <td>6.979</td> <td>0.4</td> <td>5,499,333</td> <td>735,205</td> <td>47,916</td> <td>783,121</td> <td>836,014</td> <td>-52,893</td> <td>2,301,303</td> <td>1.6</td>	52	Apr	9.97	6.979	0.4	5,499,333	735,205	47,916	783,121	836,014	-52,893	2,301,303	1.6
54 Jun 15.3 10.731 0.03 5,499,333 735,205 3,594 738,799 1,285,400 -540,008 1,350,207 0.9 55 Jul 17.2 12.047 0.07 5,499,333 735,205 8,385 743,590 1,443,110 -699,520 656,747 0.5 56 Aug 16 11.2 0.11 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 63,481 0.0 57 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.0 58 Oct 8.28 5.796 0.2 5,499,333 735,205 23,958 759,163 694,303 64,860 64,860 0.0 59 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 60 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7	53	May	13.0	9.513	0.05	5,499,333	/35,205	5,990	741,194	1,139,562	-398,308	1,902,935	1.3
55 Jul 17.2 12.047 0.07 5,499,333 735,205 8,385 743,590 1,443,110 -699,520 656,747 0.5 56 Aug 16 11.2 0.11 5,499,333 735,205 13,177 748,382 1,341,648 -593,266 63,481 0.0 57 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 -236,412 0 0.0 58 Oct 8.28 5.796 0.2 5,499,333 735,205 23,958 759,163 694,303 64,860 64,860 0.0 59 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 60 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7 60 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302	54	Jun	15.3	10./31	0.03	5,499,333	/35,205	3,594	/38,/99	1,285,400	-546,668	1,356,267	0.9
S6 Aug I6 I1.2 0.11 5,499,333 735,205 13,177 748,382 1,341,048 593,200 05,461 0.0 57 Sep 11.8 8.281 0.17 5,499,333 735,205 20,364 755,569 991,981 236,412 0 0.0 58 Oct 8.28 5.796 0.2 5,499,333 735,205 23,958 759,163 694,303 64,860 64,860 0.0 59 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 60 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7	55	Jui	17.2	12.04/	0.07	5,499,333	/35,205	8,385	743,590	1,443,110	-699,520	656,747	0.5
57 Sep 11.8 8.281 0.17 5,499,333 735,205 20,304 755,309 991,901 -250,412 0 0.0 58 Oct 8.28 5.796 0.2 5,499,333 735,205 23,958 759,163 694,303 64,860 64,860 0.0 59 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 60 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7	57	Aug	11.0	11.2 0 201	0.11	5,499,555	/35,205	13,177	755 560	1,341,040	-593,200	b3,481 0	0.0
58 Oct 8.28 5.796 0.2 5,499,333 735,205 23,936 739,105 094,505 04,600 04,600 04,600 0.0 59 Nov 4.76 3.332 0.84 5,499,333 735,205 100,624 835,829 399,140 436,688 501,548 0.3 60 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7	57	Sep	9.29	ŏ.∠ŏ⊥ 5 706	0.17	5,499,555	/35,205	20,304	250,262	COV 205 221'201	-230,412	64.860	0.0
59 Nov 4.76 3.332 0.84 5,499,333 735,205 100,024 635,629 599,140 450,060 501,340 0.5 60 Dec 3.52 2.464 0.67 5,499,333 735,205 80,259 815,464 295,163 520,302 1,021,850 0.7 Maximum 2,254,196 1.6	50	UCI	8.20	5./90	0.2	5,499,555	/35,205	23,930	/59,105	694,505 200 140	64,800	501 549	0.0
00 Dec 3.52 2.404 0.07 5,499,333 735,205 80,259 815,404 235,205 520,502 1,021,050 0.7	50	NOV	4.70	3.332	0.64	5,455,555	/35,205	20 250	015 AGA	399,140 205 162	430,000	501,540 1 021 850	0.5
	00	Dec	3.52	2.404	0.07	5,499,000	/30,203	80,233	813,404	295,103	520,502	1,021,050 2 254 106	0.7

Notes: 1. Evaporation data was collected from ADEQ Engineering Bulletin No. 11. Precipitation data was collected from Buckeye, AZ.

See ADEQ Data tab

https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca6627

2. Pan evaporation data **has not** been adjusted by an evaporation adjustment factor, and by a brine/TDS factor.

3. This is annual average data, not worst case storm event.

4. Carryover volume is calcuated by the difference between evaporation and inflow by month, and previous volume balance.

Passive Solar Evaporation Pond Sizing - 90% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 90% Recovery, Phase 1	Updated by & Date:	F. Hayes; 10/10/2022
	10MGD - Approximate Maximum Sizing	Reviewer & Review Date:	TBD

Assume 90% RO recovery with continuous production of brine.								
		Instant.		Monthly				
Treatment Waste	Instant. Flow	Flow		Quantity				
Stream	mgd	gpm	Run Factor	gal	Notes			
RO Brine	1	694.4	100.0%	30,416,667	Year-round value.			

Evaporation Rate Conversions	Value	Notes					
Pan Coefficient	1	Not used at this time.					
Brine Derating	0.7	Accounts for lower evanoration rate of brine compared to fresh water (LISPR 2006)					
Factor	0.7						
Evaporation	1	No adjustment provided at this time					
Adjustment Factor	T	No adjustment provided, at this time.					
Combined Derating	0.7	Translates from Dan to local bring					
Factor	0.7	i ranslates from Pan to local drine					

Evaporation Pond						
Sizing Factors	Value	Units	Notes			
Depth of water	6.64	с.	From below Total inflow divided by area			
added per year	6.64	π	fom below: Total Inflow divided by area			
Solids Precipitation	0.003 ft solids/ft		LICER 2006 Figure 10.1 con Solida Drasin Tab			
Rate			SBR 2006, Figure 10.1, see Solids Precip. Tab.			
Solids Precipitation	0.020	ft				
Rate	0.020	solids/yr				
Solids Storage	0.5	£+	No constituciones found. Kent at 0.5 from as hu			
Depth Reservation	0.5	ii.	No specific guidance found. Kept at 0.5 from go-by.			
Required Solids	2F 1					
Removal Interval	25.1	yr				
Freeboard	2	ft	Minimum per Los Angeles Region WDR requirements.			

Sizing	Value	Units	Notes
Required Minimum	190	20	*Iterate for stable annual
Surface Area	100	ac	operation
Minimum	1 7	£+	
Operational Depth	1.7	ιι	
Factor of Safety	50%		Kept from Go-by.
,			, ,
Required	2 5	£+	
Operational Depth	2.5	ii.	
Required	12 170 211	of.	
Operational	13,178,211	СГ	

Section View: Surface area required at lowest water level





Passive Solar Evaporation Pond Sizing - 90% Recovery

Client:	Palmdale Water District	Rev. Date:	6/16/2022
Project:	Palmdale Regional Water Augmentation Program	Prepared By & Date:	B. Radke
Document:	Passive Solar Evaporation Pond Sizing - 90% Recovery, Phase 1	Updated by & Date:	F. Hayes; 10/10/2022
	10MGD - Approximate Maximum Sizing	Reviewer & Review Date:	TBD

Assume 90% RO recovery with continuous production of brine.

		Clima	ate Inputs ¹		Volume Needs per Month					Sizin	g	
_		Hist.	Adi Evan Pata	Aug	Treatment						Corruguer	
Time	Cal	Pan	Auj. Evap. Kate	Avg.	Waste	Treatment	Dracin	Total Inflow	Evaporation	Net Volume	Volumo 4	Required
Month	Cal.	Evap.	in/mo	in/mo	volume	reatment	ef	rotal innow	Evaporation	riveeds	volume	Deptn ft
1	lan	2 9	2.03	1 13	30 416 667	4 066 399	738 342	4 804 741	1 326 402	3 478 339	3 478 339	0.4
2	Feb	4 65	3 255	0.76	30 416 667	4 066 399	496 584	4 562 983	2 126 817	2 436 166	5 914 506	0.4
3	Mar	6 45	4 515	0.62	30 416 667	4 066 399	405 108	4 471 507	2 950 101	1 521 406	7 435 912	0.0
4	Anr	9.97	6 979	0.02	30 416 667	4 066 399	261 360	4 327 759	4 560 079	-232 319	7 203 593	0.9
5	May	13.6	9 513	0.05	30 416 667	4 066 399	32 670	4 099 069	6 215 794	-2 116 725	5 086 868	0.6
6	lun	15.3	10 731	0.03	30 416 667	4 066 399	19 602	4 086 001	7 011 635	-2 925 634	2 161 234	0.0
7	Jul	17.2	12 047	0.03	30 416 667	4 066 399	45 738	4 112 137	7 871 510	-3 759 373	2,101,201	0.0
. 8	Aug	16	11.2	0.07	30 416 667	4 066 399	71 874	4 138 273	7 318 080	-3 179 807	0	0.0
9	Sep	11.8	8.281	0.17	30,416,667	4.066.399	111.078	4.177.477	5.410.805	-1.233.328	0	0.0
10	Oct	8 28	5 796	0.2	30 416 667	4 066 399	130 680	4 197 079	3 787 106	409 973	409 973	0.1
11	Nov	4.76	3.332	0.84	30,416,667	4.066.399	548,856	4.615.255	2.177.129	2.438.126	2.848.099	0.4
12	Dec	3 52	2 464	0.67	30 416 667	4 066 399	437 778	4 504 177	1 609 978	2 894 200	5 742 299	0.7
13	Jan	2.9	2.03	1.13	30,416,667	4.066.399	738.342	4.804.741	1.326.402	3.478.339	9,220,638	1.2
14	Feb	4.65	3.255	0.76	30,416,667	4.066.399	496.584	4,562,983	2,126,817	2,436,166	11.656.805	1.5
15	Mar	6.45	4 515	0.62	30 416 667	4 066 399	405 108	4 471 507	2 950 101	1 521 406	13 178 211	1 7
16	Anr	9.97	6 979	0.02	30 416 667	4 066 399	261 360	4 327 759	4 560 079	-232 319	12 945 892	1.7
17	May	13.6	9 513	0.05	30 416 667	4 066 399	32 670	4 099 069	6 215 794	-2 116 725	10 829 167	1.7
18	lun	15.3	10 731	0.03	30 416 667	4 066 399	19 602	4 086 001	7 011 635	-2 925 634	7 903 533	1.4
19	lul	17.2	12 047	0.03	30 416 667	4 066 399	45 738	4 112 137	7 871 510	-3 759 373	4 144 160	0.5
20	Διισ	16	11.2	0.07	30,416,667	4,066,399	71 874	4 138 273	7 318 080	-3 179 807	964 353	0.5
20	Sen	11.8	8 281	0.11	30,416,667	4,066,399	111 078	4 177 477	5 410 805	-1 233 328	0	0.1
21	Oct	8 78	5 796	0.17	30,416,667	4,066,399	130 680	4 197 079	3 787 106	409 973	409 973	0.0
23	Nov	4 76	3 332	0.84	30 416 667	4 066 399	548 856	4 615 255	2 177 129	2 438 126	2 848 099	0.1
23	Dec	3 52	2 464	0.67	30,416,667	4,066,399	437 778	4 504 177	1 609 978	2,430,120	5 742 299	0.4
25	lan	2.9	2.404	1 13	30,416,667	4,066,399	738 342	4 804 741	1 326 402	3 478 339	9 220 638	1.2
26	Feh	4 65	3 255	0.76	30,416,667	4,066,399	496 584	4 562 983	2 126 817	2 436 166	11 656 805	1.2
20	Mar	6.45	4 515	0.70	30,416,667	4,000,335	405 108	4,302,303	2,120,017	1 521 406	13 178 211	1.5
27	Apr	0.43	6 979	0.02	30,416,667	4,000,399	261 360	4 327 759	4 560 079	-232 310	12 0/15 802	1.7
20	May	13.6	9 513	0.4	30,416,667	4,000,335	32 670	4,099,069	6 215 794	-2 116 725	10 829 167	1.7
30	lun	15.0	10 731	0.03	30,416,667	4,000,333	10 602	4,055,005	7 011 635	-2,110,725	7 903 533	1.4
30	Jul	17.2	12.047	0.03	30,416,667	4,000,333	15,002	4,080,001	7,011,033	-2,525,054	4 144 160	1.0
32	Διισ	16	11.047	0.07	30,416,667	4,000,335	71 874	4,112,137	7 318 080	-3,755,575	964 353	0.5
32	Son	11.8	8 281	0.11	30,416,667	4,000,335	111 078	4,130,273	5 410 805	-1 223 228	04,333	0.1
3/	Oct	8 28	5 796	0.17	30,416,667	4,000,333	130 680	4,177,477	3 787 106	1,233,328	109 973	0.0
34	Nov	1 76	3 2 2 2 2	0.2	30,416,667	4,000,333	5/8 856	4,157,075	2 177 129	2 /38 126	2 8/8 000	0.1
35	Dec	3 52	2.464	0.84	30,410,007	4,000,399	/37 778	4,013,233	1 609 978	2,438,120	5 742 200	0.4
27	lan	2.02	2.404	1 12	20,416,667	4,000,333	720 242	4,304,177	1,005,578	2,034,200	0,742,235	1.2
37	Foh	4 65	2.03	0.76	30,410,007	4,000,399	/ 36,342	4,004,741	2 126 817	2 /36 166	3,220,038	1.2
30	Mar	6.45	4 515	0.70	30,410,007	4,000,399	490,384	4,302,983	2,120,817	2,430,100	12 178 211	1.3
40	Apr	0.45	4.515	0.02	20,416,667	4,000,333	261 260	4,471,307	4 560 070	222 210	12 045 202	1.7
40	Мау	13.6	0.573	0.4	30,410,007	4,000,399	32 670	4,327,739	6 215 794	-2 116 725	10,829,167	1.7
41	lup	15.0	10 721	0.03	20,416,667	4,000,333	10 602	4,095,005	7 011 625	2,110,725	7 002 522	1.4
42	Jul	17.3	10.731	0.03	30,416,667	4,000,399	19,0UZ	4,000,001	7 871 510	-2,323,034	4 144 160	1.0
45	λuσ	17.2	11 3	0.07	30,410,007	4,000,339	71 074	4,120,137	7 210 000	-3 170 007	964 363	0.3
44	Son	11 0	11.2 g 201	0.11	30,410,007	4,000,399	111 070	4,130,2/3	5 410 905	-3,1/9,00/	504,333	0.1
45	Oct	8 20	0.201 E 706	0.17	30,410,007	4,000,399	120 690	4,107.070	3,410,805	400 072	400.072	0.0
40	Nov	0.20	2 2 2 2 2	0.2	30,416,667	4,000,399	5/12 254	4,157,079	2 177 120	2 403,373	2 8/12 000	0.1
47	Dec	3 5 2	3.332 7 AFA	0.64	30,416,667	4,000,339	J+0,030 A27 770	4 504 177	1 6/10 070	2,430,120	5 7/12 200	0.4
40	lan	2.52	2.404	1 12	30 /16 667	4,000,339	738 3/7	4,304,177	1 326 /02	2,034,200	9 220 629	1.2
50	Feh	4 65	2.03	0.76	30 416 667	4 066 200	496 584	4 562 983	2 126 817	2 436 166	11 656 805	1.2
50	Mar	6.45	3.233 A E1F	0.70	30,410,007	4,000,339	400,004	4,302,303	2,120,017	1 521 400	12 170 211	1.3
51	Apr	0.45	4.515	0.62	30,410,007	4,000,399	261 260	4,471,507	2,330,101	-222 210	12 0/5 802	1.7
52	May	12 6	0.579	0.4	30,410,007	4,000,339	201,300	4,327,739	6 215 704	-232,319	10 820 167	1./
53	lur	15.0	9.513	0.05	30,410,007	4,000,399	10 602	4,039,009	7 011 635	-2,110,/25	7 002 527	1.4
54	Juil	17.3	12 047	0.03	20,410,007	4,000,399	19,002	4,000,001	7,011,035	2,723,034	1,505,555	1.0
55	Jui Aur	1/.2	11 2	0.07	30,410,007	4,000,399	43,/38	4,112,137	7 210 000	-3,139,3/3	4,144,100	0.5
50	Aug	11.0	11.2	0.11	20,410,00/	4,066,399	111 079	4,138,2/3	7,518,080	-3,1/9,80/	904,353	0.1
5/	Sep	11.8	8.281	0.17	30,410,00/	4,066,399	120,000	4,1/7,4/7	3,410,805	-1,233,328	400.070	0.0
58	UCT	8.28	5.796	0.2	30,416,667	4,066,399	130,680	4,197,079	3,787,106	409,973	409,973	0.1
59	NOV	4.76	3.332	0.84	30,410,007	4,066,399	548,856	4,015,255	2,1/7,129	2,438,126	2,848,099	0.4
60	Dec	3.52	2.464	0.67	30,416,667	4,066,399	437,778	4,504,1//	1,609,978	2,894,200	5,742,299	0.7
Nat-	1 F···	orest.	. doto	at a d f		ring Dullatia **	11 D! '	ation data		IVIAXIMUM	13,1/8,211	1.7
notes	. τ. εναβ See ΔΓ	DFO Dat	a tah	cieu noifi i	ADEQ ENgINEE	ing pulletin NC	. 11. гтесiрit	ation udtd Wi	as conected ffo	m buckeye, /	٦٤.	

https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca6627

Pan evaporation data has not been adjusted by an evaporation adjustment factor, and by a brine/TDS factor.
 This is annual average data, not worst case storm event.

4. Carryover volume is calcuated by the difference between evaporation and inflow by month, and previous volume balance.

Appendix B2 – Pond layouts and sizing options

Passive Solar Evaporation Pond Sizing

Client:	Palmdale Water Di	istrict			Rev. Date:					6/16/.	2022
Project:	Palmdale Regional	I Water Augmentati	ion Program	Pre	pared By & Date:					B. Ra	adke
Document: Pond Sizing Layout					bdated by & Date:					L. Haug; 0	6/08/2022
				Review	er & Review Date:						iD
			90% Recovery			92% Re	covery	94% Red	covery	96% Re	covery
	Option 1a: Repurpose Existing Ponds	Option 1b: Existing Ponds w/ Berm Addition	Option 2: Rectangular, Max Ratio	Option 3: Smaller Ponds in Grid Format	Option 3: 3:1 side slope	Option 2: Rectangular, Max Ratio	Option 3: Smaller Ponds in Grid Format	Option 2: Rectangular, Max Ratio	Option 3: Smaller Ponds in Grid Format	Option 2: Rectangular, Max Ratio	Option 3: Smaller Ponds in Grid Format
Design Criteria											
% Recovery	90%	90%	90%	90%	90%	92%	92%	94%	94%	96%	96%
Minimum Area Needed (acres)	81	81	81	81	81	65	65	49	49	33	33
Area (sq ft)	3,528,360	3,528,360	3,528,360	3,528,360	3,528,360	2,831,400	2,831,400	2,134,440	2,134,440	1,437,480	1,437,480
Geometric Parameters											
Pond Quantity											
Minimum No. of Ponds	3	5	3	5	5	3	5	3	5	3	5
No. of Ponds w/ Redundancy (N+1)	4	8	4	6	6	4	6	4	6	4	6
No. of Ponds (vertical)	2	4	1	3	3	1	3	1	3	1	3
No. of Ponds (horizontal)	2	2	4	2	2	4	2	4	2	4	2
Individual Pond Dimensions											
Minimum Area per Pond (sq ft)	1,176,120	705,672	1,176,120	705,672	705,672	943,800	566,280	711,480	426,888	479,160	287,496
Pond Length (ft)	1,221	598	1,842	558	564	1,647	496	1,425	426	1,163	343
Pond Width (ft)	1,141	1,141	590	1,152	1,158	525	1,028	451	888	364	722
Aspect Ratio (1)	1.1	1.9	3.0	2.0	2.0	0.3	2.0	0.3	2.0	0.3	2.0
Provided Area per Pond (sq ft)	1,392,689	682,655	1,087,253	642,816	653,112	864,328	510,108	642,649	378,288	422,906	247,845
Pond Depth											
Operational Depth (ft)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Required Depth (ft)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Design Depth, D (ft)	9.8	9.8	6	6	5	6	6	6	6	6	6
Pond Side Slope											
Pond Side Slope Ratio (Y:1)	2	2	3	3	3	3	3	3	3	3	3
Added Side Slope Width, S (ft)	20	20	18	18	15	18	18	18	18	18	18
Pond Length w/ side slope (ft)	1,260	638	1,878	594	594	1,683	532	1,461	462	1,199	379
Pond Width w/ side slope (ft)	1,180	1,180	626	1,188	1,188	561	1,064	487	924	400	758
Access Road Requirements											
Road Width, R (ft)	12	12	15	15	12	15	15	15	15	15	15
No. Roads (vertical)	4	6	2	4	4	2	4	2	4	2	4
No. Roads (horizontal)	3	3	5	3	3	5	3	5	3	5	3
Overall Dimensions Summary											
Total Length, TL (ft)	2,568	2,622	1,908	1,842	1,830	1,713	1,656	1,491	1,446	1,229	1,197
Total Width, TW (ft)	2,396	2,396	2,580	2,421	2,412	2,319	2,173	2,023	1,893	1,674	1,562
Total Area (sq ft)	6,152,928	6,283,270	4,922,745	4,459,482	4,413,960	3,970,958	3,599,921	3,016,182	2,737,278	2,056,769	1,869,854
Total Area (acres)	141.25	144.24	113.01	102.38	101.33	91.16	82.64	69.24	62.84	47.22	42.93
Total Volume (MG)	7 5 5	7 5 2	2 6 2	2.25	2 7 2	2 00	3 50	2 1 7	1 04	1 45	1 20

Notes:

(1) Aspect ratio cannot be greater than 3.
 (2) 2:1 slope can be used based on findings from geotech.

Appendix B3 – Enhancement Technology evaluation table

Disposal Type	Picture	Treatment Process	Advantages	Disadvantage
Evaporation Pond		Passive evaporation of brine in shallow lined ponds Sized with sufficient area for total evaporation and depth to buffer against seasonal variations in evaporation and accommodate solids buildup	Relatively low maintenance Relatively low labor Relatively low electrical power requirements Most plausible baseline disposal option	Large land area required Very high capital cost particularly for high brine flows and low RO recoveries Excavation and disposal of solids is required Sizing needs to accommodate flood control freeboard in addition to brine volume
Enhanced Evaporation Pond		Solar powered mixing to improve circulation in ponds and increase air-water contact	Works with solar energy Relatively low labor Reduces the likelihood of seasonable enhancement to prevent overflow of ponds Improvement in pond performance may be worth cost of mixers	Arizona Dept. of Corrections Evaporation Pond case study (2004 to 2010) – pond receiving 0.18 mgd brine; only approx. 20% increase in evaporation Large land area and removal of salt precipitates is still required Limited installed track record
Misters		Water is sprayed over the pond surface by pumps to increase air-water contact Low salinity water is generally required	Increases water circulation and evaporation efficiency	Concerns with downwind transport of salts Clogging due to brine accumulation Higher energy cost Higher maintenance Likely not suitable for Pure Water AV
Wind Aided Intensified Evaporation		Water is pumped through screen modules that increase contact between brine and air	Requires less footprint than evaporation pond Not power intensive Increases efficiency by 20%	This alternative is suitable if the number of WAIV units are in the range of 5-45. This system may require more than 180 WAIV units. Required additional brine residual and salt management practices Holding ponds are required in any case as a buffer to deal with different flow and evaporation rates Higher equipment cost Operation and maintenance is expensive Frequency of maintenance is process dependent Limited installed track record

Vendor & Costs Involved

Land acquisition

Excavation and lining Construction (including flood control features monitoring wells) Removal of precipitated solids, approximately every 20 years

Vendor: IXOM Watercare Mixing equipment cost Capital costs associated with passive evaporation ponds but with sizing reduced ~20%.

Power cost for pumping Maintenance costs

Vendor: Clear Creek Environmental Solutions WAIV equipment and installation Ancillary equipment (storage tank, pumps) Land acquisition (for both WAIV installation and holding pond) Construction, excavation, lining (including leak detection system) Labor cost Regular maintenance

Disposal Type	Picture	Treatment Process	Advantages	Disadvantage
Brine Solutions		Halophilic micro-organisms are added to improve the efficiency of evaporation. Sufficient nutrients must be available for microbial growth	No energy requirements Low capital cost by using existing facilities Low operating cost Improvement in pond performance may be worth cost of microbes and monitoring	Influent TDS must be very high for this to be possible. Microbes cannot be applied from the outset due to TDS concentration requirements System-specific testing is required. Limited installed track record
Evaporative Matrix		Grids of helical disks are suspended over the pond to increase air-water contact	Allows for smaller pond footprint Rapid installation Power-Independent Improvement in pond performance may be worth cost of grids	Limitations in brine up to 25000 ppm Limited installed track record
Thermal Brine Concentrator and/or Crystallizer		Rely on:Heating of brine and/orcrystal formationConcentrators:Also knownas evaporators that produceconcentrated, low volumebrine but not solidsCrystallizers:precipitatesaturated minerals, producesolids. Can be used for zeroliquid discharge applications.	<u>Concentrator:</u> Evaporates about 95% of water <u>Concentrator & Crystallizer</u> <u>(Zero Liquid Discharge):</u> Evaporates virtually all of the water, no brine handling required	Installation cost of about 80% of equipment cost, plus additional cost for site preparation Requires skilled labor Land for concentrate or solids disposal Requires passing paint filter test, pH and leachable metals analysis for landfill disposal Requires centrifuges/filter-press/dryers/sacks to further process solids produced by crystallizers to pass the paint filter test High power consumption Mainly applicable at commercial and not municipal scale
Sewer Disposal		Direct disposal to sewer	Easy disposal practice Low capital cost by using existing facilities Low operating cost	Constituents of concern are concentrated in the brine and may exceed discharge limits Salts are returned to (and not removed from) the urban water cycle Generally only appropriate for very small quantities of brine Not viable for salinity management reasons
Power Generating Station		Use brine as makeup water for cooling towers at a local generating station Brine pretreatment (e.g. softening) is required to prevent scaling in the cooling towers	Land acquisition potentially reduced Potentially lower cost of disposal	Some level of brine treatment may be required to water quality requirements and control scaling potential Increases footprint required for plant construction (to install additional brine treatment process) and other ancillary costs Thermal plant is not accessible from site Not viable for Pure Water AV

Vendor & Costs Involved

Vendor: Clear Creek Environmental Seeding costs Maintenance costs

Vendor: ecoVAP Cost for grids and installation Theoretically low maintenance costs

<u>Vendor:</u> Suez

Major equipment cost Ancillary equipment (pumps, tanks, piping; mechanical vapor compressor, deaerator, heater, centrifuge/filter press) Land acquisition (for concentrate or solids disposal)

Construction and excavation

Significant power cost

Labor cost

Piping and conveyance costs

May require brine treatment – Treatment process equipment, installation, O&M, and other ancillary costs

Power cost for pumping

Labor cost

Disposal Type	Picture	Treatment Process	Advantages	Disadvantage
Deep-Well Injection		Direct disposal to a confined deep aquifer Multiple layers of casing are provided to prevent contamination of fresh aquifers	Smaller footprint Low cost for site work and excavation Potentially large capacity for brine injection Depends on local hydrogeologic conditions	 Well siting and depth selection requires significant effort and study Wells would be costly to install, especially given that they must be multi-layered Given the challenges of siting and well construction, deep-well injection cannot be assumed to be possible at this time Not viable for Pure Water AV
Capture6		Brine is used as an input to produce sodium hydroxide and mineralize carbon dioxide in CaCO ₃ form.	Brine utilization – an ancillary benefit is realized from brine disposal. Additional fresh water is recovered from the brine stream Potentially viable for demonstration-scale testing	Significant treatment of the brine is required Technology is still under development

Color Code:

Red = Not Feasible

Yellow = Potential Option

Green = Feasible Option

Vendor & Costs Involved

- Costs for hydrogeologic and siting studies
- Well drilling and equipment cost Installation of multi-layer well casing and monitoring systems
- Piping and conveyance from ARWC to well site
- Power cost for pumping

Vendor: Capture6

Equipment, chemical, and power costs for additional brine treatment

APPENDIX C

Brine Pond OPCC Calculations



ENGINEERS OPINION OF CONSTRUCTION COST - AACE CLASS 4 Regional Water Augmentation Project Brine Alternative 1A OPCC

Project:	Palmdale Regional Water Augmentation Program			Date:	10/21/2022	by: C. Warrick
Location :	Palmdale Water Reclamation Plant					
ITEM NO.	DESCRIPTION	UNIT	APPROX. QUANTITY	UNIT PRICE	AMOUNT	NOTES
1	MOBILIZATION	LS	1	\$375,000	\$375,000	1.5% total cost
2	DEMOLITION	LS	1	\$100,000	\$100,000	Assumed allocation for dispersion pipes within basin. Does not include pipe abandonment.
3	CLEARING AND GRUBBING	AC	130	\$2,100	\$272,000	Recent Bids
4	EARTHWORK	CY	35500	\$4.25	\$151,000	Recent Bids
5	ACCESS RAMPS	EA	8	\$30,000.00	\$240,000	Roughly 35 CY of reinforced sitework concrete Unit price based on recent bids
6	6" PVC CONVEYANCE PIPE	LF	21,500	\$41	\$892,000	Fergusson pipe pricing, 2021 RS Means 33 14 13.25 4530 Labor price and 31 23 16.13 0090 Labor and Equipment price escalated to present markets
7	HDPE LINER (Primary and Secondary)	SF	10,943,732	\$0.65	\$7,114,000	60 Mill HDPE liner quote with 10% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
8	GEOTEXTILE BASELAYER	SF	5,471,866	\$0.31	\$1,697,000	Quote with 10% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
9	BALLAST	LF	79,600	\$7.70	\$613,000	Assumes 8 extra feet of liner and 1/3 cubic yard excavation per LF ballast
10	FLOOD CONTROL IMPROVEMENTS	LF	3333	\$1,500	\$5,000,000	None Required

CONSTUCTION COSTS SUBTOTAL:

\$16,454,000

Contractor Overhead and Profit:	22%	\$3,619,880
Contingency	30%	\$4,936,200
Bonds and Insurance:	3%	\$493,620

OPINION OF PROBABLE CONSTRUCTION COSTS: \$25,504,000

APPROX. QUANTITY ITEM UNIT UNIT PRICE AMOUNT NO. DESCRIPTION NOTES Based on AWT real estate LAND ACQUISITION \$6,768,000 11 AC 144 \$47,000 evaluation.

CAPITAL COST SUBTOTAL: \$6,768,000

OPINION OF TOTAL PROJECT COSTS: \$32,272,000

	NOTES
1	All costs reported above are present value. No adjustments have been made to account for the future value at the time of bidding.
2	Escaltion for RS Means 2020 values determined by the California Construction Index escalation from January 2020 to June 2022, which is 25%.
3	The expected accuracy range for this opinion of probable constrcution cost is -30% to +50% in accordance with AACE Class 4 standards.



ENGINEERS OPINION OF CONSTRUCTION COST - AACE CLASS 4 Regional Water Augmentation Project Brine Alternative 1B OPCC

Location :						.,
	Palmdale Water Reclamation Plant					
ITEM NO.	DESCRIPTION	UNIT	APPROX. QUANTITY	UNIT PRICE	AMOUNT	NOTES
1	MOBILIZATION	LS	1	\$400,000	\$400,000	1.5% total cost
2	DEMOLITION	LS	1	\$100,000	\$100,000	Assumed allocation for dispersion pipes within basin. Does not include pipe abandonment.
3	CLEARING AND GRUBBING	AC	130	\$2,100	\$272,000	Recent Bids
4	EARTHWORK	CY	65,500	\$4.25	\$279,000	Recent Bids
5	ACCESS RAMPS	EA	12	\$30,000.00	\$360,000	Roughly 35 CY of reinforced sitework concrete Unit price based on recent bids
6	6" CONVEYANCE PIPE	LF	22,000	\$41	\$912,000	Fergusson pipe pricing, 2021 RS Means 33 14 13.25 4530 Labor price and 31 23 16.13 0090 Labor and Equipment price escalated to present markets
7	HDPE LINER (Primary and Secondary)	SF	10,943,732	\$0.65	\$7,114,000	60 Mill HDPE liner quote with 10% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
8	GEOTEXTILE BASELAYER	SF	5,471,866	\$0.31	\$1,697,000	Quote with 10% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
9	BALLAST	LF	85,200	\$7.70	\$657,000	Assumes 8 extra feet of liner and 1/3 cubic yard excavation per LF ballast
10	FLOOD CONTROL IMPROVEMENTS	LF	3333	\$1,500	\$5,000,000	None Required

CONSTRUCTION COSTS SUBTOTAL: \$16,791,000

Contractor Overhead and Profit:	22%	\$3,694,020
Contingency	30%	\$5,037,300
Bonds and Insurance:	3%	\$503,730

OPINION OF PROBABLE CONSTRUCTION COSTS: \$26,027,000

ITEM NO.	DESCRIPTION	UNIT	APPROX. QUANTITY	UNIT PRICE	AMOUNT	NOTES
11	LAND ACQUISITION	AC	144	\$47,000	\$6,768,000	Based on AWT real estate evaluation.
	CAPITAL COST SUBTOTAL: \$6,768,000					
OPINION OF TOTAL PROJECT COSTS: \$32,795,000						
1	All costs reported above are present value. No adjustments have been made to account for the future value at the time of bidding.					
2	2 Escaltion for RS Means 2020 values determined by the California Construction Index escalation from January 2020 to June 2022, which is 25%.					
3	The expected accuracy range for this opinion of prob	bable cons	trcution cost is	-30% to +50% in	accordance with	AACE Class 4 standards.



ENGINEERS OPINION OF CONSTRUCTION COST - AACE CLASS 4 Regional Water Augmentation Project 90% RO Recovery Brine Alternative 2 OPCC

Project: Location :	Palmdale Regional Water Augmentation Program Palmdale Water Reclamation Plant	_		Date:	9/3/2022	by: C. Warrick
ITEM NO.	DESCRIPTION	UNIT	APPROX. QUANTITY	UNIT PRICE	AMOUNT	NOTES
1	MOBILIZATION	LS	1	\$425,000	\$425,000	1.5% total cost
2	DEMOLITION	LS	1	\$50,000	\$50,000	Assumed allocation to demo fences and other miscelanous abandoned features.
3	CLEAING AND GRUBBING	AC	115	\$2,100	\$242,000	Recent Bids
4	EARTHWORK	CY	71,000	\$4.25	\$302,000	Recent Bids
5	ACCESS RAMPS	EA	8	\$30,000.00	\$240,000	Roughly 35 CY of reinforced sitework concrete Unit price based on recent bids
6	6" CONVEYANCE PIPE	LF	8,400	\$41	\$349,000	Fergusson pipe pricing, 2021 RS Means 33 14 13.25 4530 Labor price and 31 23 16.13 0090 Labor and Equipment price escalated to present markets
7	HDPE LINER (Primary and Secondary)	SF	10,176,208	\$0.68	\$6,920,000	60 Mill HDPE liner quote with 15% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
8	GEOTEXTILE BASELAYER	SF	5,088,104	\$0.31	\$1,578,000	Quote with 10% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
9	BALLAST	LF	77,600	\$7.70	\$598,000	Assumes 8 extra feet of liner and 1/3 cubic yard excavation per LF ballast
10	FLOOD CONTROL IMPROVEMENTS	LF	5000	\$1,500	\$7,500,000	Concrete lined channel, dimensions assumed roughly equal to one at exisitng Reclamation Plant
		CONST	TRUCTION CO	ST SUBTOTAL:	\$18,204,000	
	Contra	ctor Overhe	ad and Profit:	22%	\$4,004,880 \$5,461,200	
			Conungency	30%	φ0,401,200	

Bonds and Insurance:

3% \$546,120

OPINION OF PROBABLE CONSTRUCTION COSTS: \$28,217,000

ITEM NO.	DESCRIPTION	UNIT	APPROX. QUANTITY	UNIT PRICE	AMOUNT	NOTES
11	LAND ACQUISITION	AC	115	\$47,000	\$5,405,000	Based on AWT real estate evaluation.

CAPITAL COST SUBTOTAL: \$5,405,000

OPINION OF TOTAL PROJECT COSTS: \$33,622,000

	NOTES
1	All costs reported above are present value. No adjustments have been made to account for the future value at the time of bidding.
2	Escaltion for RS Means 2020 values determined by the California Construction Index escalation from January 2020 to June 2022, which is 25%.
3	The expected accuracy range for this opinion of probable constrcution cost is -30% to +50% in accordance with AACE Class 4 standards.


ENGINEERS OPINION OF CONSTRUCTION COST - AACE CLASS 4 Regional Water Augmentation Project 90% RO Recovery Brine Alternative 3 OPCC

Project:	Palmdale Regional Water Augmentation Program	-		Date:	9/3/2022	by: C. Warrick
			ADDDOV			
NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT	NOTES
1	MOBILIZATION	LS	1	\$425,000	\$425,000	1.5% total cost
2	DEMOLITION	LS	1	\$50,000	\$50,000	Assumed allocation to demo fences and other miscelanous abandoned features.
3	CLEARING AND GRUBBING	AC	105	\$2,100	\$221,000	Recent Bids
4	EARTHWORK	CY	68,000	\$4.25	\$289,000	Recent Bids
5	ACCESS RAMPS	EA	12	\$30,000.00	\$360,000	Roughly 35 CY of reinforced sitework concrete Unit price based on recent bids
6	6" CONVEYANCE PIPE	LF	9,600	\$41	\$398,000	Fergusson pipe pricing, 2021 RS Means 33 14 13.25 4530 Labor price and 31 23 16.13 0090 Labor and Equipment price escalated to present markets
7	HDPE LINER (Primary and Secondary)	SF	9,330,202	\$0.68	\$6,345,000	60 Mill HDPE liner quote with 15% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
8	GEOTEXTILE BASELAYER	SF	4,665,101	\$0.31	\$1,447,000	Quote with 10% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
9	BALLAST	LF	74,100	\$7.70	\$571,000	Assumes 8 extra feet of liner and 1/3 cubic yard excavation per LF ballast
10	FLOOD CONTROL IMPROVEMENTS	LF	5400	\$1,500	\$8,100,000	Concrete lined channel, dimensions assumed roughly equal to the channel at exisitng Reclamation Plant
CONSTRUCTION COST SUBTOTAL:						· · · · · · · · · · · · · · · · · · ·
	Contrac	\$4 005 320				
					¢ .,000,020	

Contingency	30%	\$5,461,800
Bonds and Insurance:	3%	\$546,180

OPINION OF PROBABLE CONSTRUCTION COSTS: \$28,220,000

ITEM NO.	DESCRIPTION	UNIT	APPROX. QUANTITY	UNIT PRICE	AMOUNT	NOTES
11	LAND ACQUISITION	AC	105	\$47,000	\$4,935,000	Based on AWT real estate evaluation.
	CAPITAL COST SUBTOTAL:				\$4,935,000	

CAPITAL COST SUBTOTAL:

OPINION OF TOTAL PROJECT COSTS: \$33,155,000

NOTES All costs reported above are present value. No adjustments have been made to account for the future value at the time of bidding. 1 Escaltion for RS Means 2020 values determined by the California Construction Index escalation from January 2020 to June 2022, which is 25%. 2 3 The expected accuracy range for this opinion of probable constrcution cost is -30% to +50% in accordance with AACE Class 4 standards.



ENGINEERS OPINION OF CONSTRUCTION COST - AACE CLASS 4 Regional Water Augmentation Project Two Repurposed Sanitation District Ponds (72 Acres)

Project: Palmdale Regional Water Augmentation Program

Date: 10/21/2022

by: C. Warrick

Location : Palmdale Water Reclamation Plant

ITEM			APPROX.			
NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT	NOTES
1	MOBILIZATION	LS	1	\$150,000	\$150,000	1.5% total cost
2	DEMOLITION	LS	1	\$100,000	\$100,000	Assumed allocation for dispersion pipes within basin. Does not include pipe abandonment.
3	CLEARING AND GRUBBING	AC	72	\$2,100	\$152,000	Recent Bids
4	EARTHWORK	CY	0	\$4.25	\$0	Recent Bids
5	ACCESS RAMPS	EA	8	\$30,000.00	\$240,000	Roughly 35 CY of reinforced sitework concrete Unit price based on recent bids
6	6" PVC CONVEYANCE PIPE	LF	20,500	\$41	\$850,000	Fergusson pipe pricing, 2021 RS Means 33 14 13.25 4530 Labor price and 31 23 16.13 0090 Labor and Equipment price escalated to present markets
7	HDPE LINER (Primary and Secondary)	SF	5,855,628	\$0.65	\$3,807,000	60 Mill HDPE liner quote with 10% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
8	GEOTEXTILE BASELAYER	SF	2,927,814	\$0.31	\$908,000	Quote with 10% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
9	BALLAST	LF	40,800	\$7.70	\$315,000	Assumes 8 extra feet of liner and 1/3 cubic yard excavation per LF ballast
10	FLOOD CONTROL IMPROVEMENTS	LF	0	\$1,500	\$0	None Required

CONSTUCTION COSTS SUBTOTAL:

\$6,522,000

Contractor Overhead and Profit:	22%	\$1,434,840
Contingency	30%	\$1,956,600
Bonds and Insurance:	3%	\$195,660

OPINION OF PROBABLE CONSTRUCTION COSTS: \$10,110,000

ITEM NO.	DESCRIPTION	UNIT	APPROX. QUANTITY	UNIT PRICE	AMOUNT	NOTES
11	LAND ACQUISITION	AC	72	\$47,000	\$3,384,000	Based on AWT real estate evaluation.
	CAPITAL COST SUBTOTAL:				\$3,384,000	

CAPITAL COST SUBTOTAL:

OPINION OF TOTAL PROJECT COSTS: \$13,494,000

NOTES						
1	All costs reported above are present value. No adjustments have been made to account for the future value at the time of bidding.					
2	Escaltion for RS Means 2020 values determined by the California Construction Index escalation from January 2020 to June 2022, which is 25%.					
3	The expected accuracy range for this opinion of probable constrcution cost is -30% to +50% in accordance with AACE Class 4 standards.					



ENGINEERS OPINION OF CONSTRUCTION COST - AACE CLASS 4 Regional Water Augmentation Project 72 Acres of Greenfield Construction

Project:	Palmdale Regional Water Augmentation Program	I		Date:	10/21/2022	by: C. Warrick
Location :	Palmdale Water Reclamation Plant					
ITEM NO.	DESCRIPTION	UNIT	APPROX. QUANTITY	UNIT PRICE	AMOUNT	NOTES
1	MOBILIZATION	LS	1	\$275,000	\$275,000	1.5% total cost
2	DEMOLITION	LS	1	\$50,000	\$50,000	Assumed allocation to demo fences and other miscelanous abandoned features.
3	CLEAING AND GRUBBING	AC	72	\$2,100	\$152,000	Recent Bids
4	EARTHWORK	CY	44,446	\$4.25	\$189,000	Recent Bids
5	ACCESS RAMPS	EA	8	\$30,000.00	\$240,000	Roughly 35 CY of reinforced sitework concrete Unit price based on recent bids
6	6" CONVEYANCE PIPE	LF	8,000	\$41	\$332,000	Fergusson pipe pricing, 2021 RS Means 33 14 13.25 4530 Labor price and 31 23 16.13 0090 Labor and Equipment price escalated to present markets
7	HDPE LINER (Primary and Secondary)	SF	6,370,306	\$0.68	\$4,332,000	60 Mill HDPE liner quote with 15% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
8	GEOTEXTILE BASELAYER	SF	3,185,153	\$0.31	\$988,000	Quote with 10% excess Assumed production rate of 18,000 sq. ft. per day with a crew of 8 and 4 pieces of light/medium duty equipment
9	BALLAST	LF	48,578	\$7.70	\$375,000	Assumes 8 extra feet of liner and 1/3 cubic yard excavation per LF ballast
10	FLOOD CONTROL IMPROVEMENTS	LF	3333	\$1,500	\$5,000,000	Concrete lined channel, dimensions assumed roughly equal to one at exisitng Reclamation Plant
CONSTRUCTION COST SUBTOTAL:						
	Contra	ctor Overhe	ad and Profit:	22%	\$2.625.260	
	Conna		Contingency	30%	\$3.579.900	
		Bonds a	nd Insurance:	3%	\$357,990	

Bonds and Insurance:

OPINION OF PROBABLE CONSTRUCTION COSTS:

\$18,497,000

ITEM NO.	DESCRIPTION	UNIT	APPROX. QUANTITY	UNIT PRICE	AMOUNT	NOTES
11	LAND ACQUISITION	AC	72	\$47,000	\$3,384,000	Based on AWT real estate evaluation.

CAPITAL COST SUBTOTAL: \$3,384,000

OPINION OF TOTAL PROJECT COSTS: \$21,881,000

NOTES All costs reported above are present value. No adjustments have been made to account for the future value at the time of bidding. 1 Escaltion for RS Means 2020 values determined by the California Construction Index escalation from January 2020 to June 2022, which is 25%. 2 The expected accuracy range for this opinion of probable constrcution cost is -30% to +50% in accordance with AACE Class 4 standards. 3

APPENDIX D

Economic Model

Brine Management Economic Model and Cost Curves - Solubility Limit at 94%

General Inputs



mga	(MF filtrate / RO feed flow from Feasibility Study)

Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
RO Product (mgd) =	3.39	3.62	3.84	4.07	4.16	4.25	4.34	4.43
RO Product (acre-ft/yr) =	3,800	4,054	4,307	4,560	4,662	4,763	4,864	4,966

Evaporation Pond Inputs

Brine Pond Cost = \$ 22,000 per acre (annualized capital)

Pond Footprint =	0.35 0.28 3.0	acre/gpm acre/gpm acre	(passive) (enhanced) (additional f	
Disposal Vol =	4,400	cy/yr	(annual aver	
Disposal Cost =	\$ 200) per cy	(excavation	

acre (additional footprint)	
cy/yr (annual average)	
200 per cy (excavation and dispo	sal)

Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
Brine (mgd) =	1.13	0.90	0.68	0.45	0.36	0.27	0.18	0.09
Brine (gpm) =	785	628	471	314	251	188	126	63
Pond Area (ac) =	278	223	168	113	91	69	47	25
Enhanced Pond (ac) =	223	179	135	91	73	56	38	21

RO Inputs

Secondary RO System = PFRO for 92-96% recovery

Recovery =	75%	80%	85%	90%	92%	94%	96%	98%		
RO System =	Two-Stage	Primary RO	Three-Stage	Primary RO	Two-Stage Primary	RO + Recovery RO	HE	ERO		
Annual Capex (\$/mgd) =	\$ 44,000	\$ 44,000	\$ 52,000	\$ 52,000	\$ 69,000	\$ 69,000	\$ 181,000	\$ 181,000		
Energy (kWh/kgal) =	1.6	1.5	1.4	1.3	1.6	1.7	1.3	1.3		
Acid (mg/L) =					6	16				
Antiscalant (mg/L) =	2.7	2.7	2.6	2.3	2.1	2.1	2.7	2.7		
HERO(SM/vr) =							\$ 1.92	\$ 1.92		

Cost Curve - Passive Ponds

								RO Re	cove	ery						
		75%		80%		85%		90%		92%		94%		96%		98%
Pond Capital (\$M/yr)	\$	6.11	\$	4.90	\$	3.69	\$	2.48	\$	2.00	\$	1.52	\$	1.03	\$	0.55
Pond O&M (\$M/yr)	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88
Pond Cost (\$M/yr)	\$	6.99	\$	5.78	\$	4.57	\$	3.36	\$	2.88	\$	2.40	\$	1.91	\$	1.43
Pond Cost (\$/AF)	\$	1,839	\$	1,426	\$	1,061	\$	737	\$	618	\$	503	\$	393	\$	288
RO Capital (\$M/yr)	\$	0.15	\$	0.16	\$	0.20	\$	0.21	\$	0.29	\$	0.29	\$	0.79	\$	0.80
RO Energy (\$M/yr)	\$	0.36	\$	0.36	\$	0.35	\$	0.35	\$	0.44	\$	0.47	\$	0.37	\$	0.38
RO Chems (\$M/yr)	\$	0.13	\$	0.13	\$	0.13	\$	0.11	\$	0.11	\$	0.13	\$	0.13	\$	0.13
RO Cost (\$M/yr)	\$	0.64	\$	0.65	\$	0.68	\$	0.67	\$	0.84	\$	0.90	\$	3.20	\$	3.23
RO Cost (\$/AF)	\$	167	\$	159	\$	158	\$	147	\$	180	\$	189	\$	658	\$	650
RO + Pond (\$/AF)	Ś	2.006	Ś	1.585	Ś	1.219	Ś	884	Ś	797	Ś	692	Ś	1.052	Ś	938

Cost Curve - Enhanced Ponds

	RO Recovery														
	75%		80%		85%		90%		92%		94%		96%		98%
Pond Capital (\$M/yr)	\$ 4.90	\$	3.93	\$	2.97	\$	2.00	\$	1.61	\$	1.23	\$	0.84	\$	0.45
Pond O&M (\$M/yr)	\$ 0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88
Pond Cost (\$M/yr)	\$ 5.78	\$	4.81	\$	3.85	\$	2.88	\$	2.49	\$	2.11	\$	1.72	\$	1.33
Pond Cost (\$/AF)	\$ 1,521	\$	1,187	\$	893	\$	631	\$	535	\$	442	\$	353	\$	268
RO Capital (\$M/yr)	\$ 0.15	\$	0.16	\$	0.20	\$	0.21	\$	0.29	\$	0.29	\$	0.79	\$	0.80
RO Energy (\$M/yr)	\$ 0.36	\$	0.36	\$	0.35	\$	0.35	\$	0.44	\$	0.47	\$	0.37	\$	0.38
RO Chems (\$M/yr)	\$ 0.13	\$	0.13	\$	0.13	\$	0.11	\$	0.11	\$	0.13	\$	0.13	\$	0.13
RO Cost (\$M/yr)	\$ 0.64	\$	0.65	\$	0.68	\$	0.67	\$	0.84	\$	0.90	\$	3.20	\$	3.23
RO Cost (\$/AF)	\$ 167	\$	159	\$	158	\$	147	\$	180	\$	189	\$	658	\$	650
								_							
RO + Pond (\$/AF)	\$ 1,688	\$	1,347	\$	1,051	\$	778	\$	714	\$	632	\$	1,012	\$	918



Brine Management Economic Model and Cost Curves - Solubility Limit at 96%

General Inputs



(MF filtrate / RO feed flow from Feasibility Study)

Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
RO Product (mgd) =	3.39	3.62	3.84	4.07	4.16	4.25	4.34	4.43
RO Product (acre-ft/yr) =	3,800	4,054	4,307	4,560	4,662	4,763	4,864	4,966

Evaporation Pond Inputs

Brine Pond Cost =	Ś	22,000	per acre	(annualized capital)
	Ŧ			(

Pond Footprint =	0.35	acre/gpm	(passive)
	0.28	acre/gpm	(enhanced)
	3.0	acre	(additional footprint)
Disposal Vol =	4,400	cy/yr	(annual average)
Disposal Cost =	\$ 20	10 per cy	(excavation and disposal)

Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
Brine (mgd) =	1.13	0.90	0.68	0.45	0.36	0.27	0.18	0.09
Brine (gpm) =	785	628	471	314	251	188	126	63
Pond Area (ac) =	278	223	168	113	91	69	47	25
Enhanced Pond (ac) =	223	179	135	91	73	56	38	21

RO Inputs

Secondary RO System = PFRO for 92-96% recovery

Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
RO System =	Two-Stage	Primary RO	Three-Stage	Primary RO	Two-Sta	ge Primary RO + Reco	overy RO	HERO
Annual Capex (\$/mgd) =	\$ 44,000	\$ 44,000	\$ 52,000	\$ 52,000	\$ 69,000	\$ 69,000	\$ 69,000	\$ 181,000
Energy (kWh/kgal) =	1.6	1.5	1.4	1.3	1.6	1.7	1.8	1.3
Acid (mg/L) =					6	16	71	
Antiscalant (mg/L) =	2.7	2.7	2.6	2.3	2.1	2.1	2.7	2.7
HERO(SM/vr) =							1	\$ 1.92

Cost Curve - Passive Ponds

	RO Recovery												
	75%		80%		85%		90%		92%		94%	96%	98%
Pond Capital (\$M/yr)	\$ 6.11	\$	4.90	\$	3.69	\$	2.48	\$	2.00	\$	1.52	\$ 1.03	\$ 0.55
Pond O&M (\$M/yr)	\$ 0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$ 0.88	\$ 0.88
Pond Cost (\$M/yr)	\$ 6.99	\$	5.78	\$	4.57	\$	3.36	\$	2.88	\$	2.40	\$ 1.91	\$ 1.43
Pond Cost (\$/AF)	\$ 1,839	\$	1,426	\$	1,061	\$	737	\$	618	\$	503	\$ 393	\$ 288
RO Capital (\$M/yr)	\$ 0.15	\$	0.16	\$	0.20	\$	0.21	\$	0.29	\$	0.29	\$ 0.30	\$ 0.80
RO Energy (\$M/yr)	\$ 0.36	\$	0.36	\$	0.35	\$	0.35	\$	0.44	\$	0.47	\$ 0.51	\$ 0.38
RO Chems (\$M/yr)	\$ 0.13	\$	0.13	\$	0.13	\$	0.11	\$	0.11	\$	0.13	\$ 0.28	\$ 0.13
RO Cost (\$M/yr)	\$ 0.64	\$	0.65	\$	0.68	\$	0.67	\$	0.84	\$	0.90	\$ 1.09	\$ 3.23
RO Cost (\$/AF)	\$ 167	\$	159	\$	158	\$	147	\$	180	\$	189	\$ 224	\$ 650
				1		1							
RO + Pond (\$/AF)	\$ 2,006	\$	1,585	\$	1,219	\$	884	\$	797	\$	692	\$ 617	\$ 938

Cost Curve - Enhanced Ponds

	RO Recovery														
	75%		80%		85%		90%		92%		94%		96%		98%
Pond Capital (\$M/yr)	\$ 4.90	\$	3.93	\$	2.97	\$	2.00	\$	1.61	\$	1.23	\$	0.84	\$	0.45
Pond O&M (\$M/yr)	\$ 0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88	\$	0.88
Pond Cost (\$M/yr)	\$ 5.78	\$	4.81	\$	3.85	\$	2.88	\$	2.49	\$	2.11	\$	1.72	\$	1.33
Pond Cost (\$/AF)	\$ 1,521	\$	1,187	\$	893	\$	631	\$	535	\$	442	\$	353	\$	268
RO Capital (\$M/yr)	\$ 0.15	\$	0.16	\$	0.20	\$	0.21	\$	0.29	\$	0.29	\$	0.30	\$	0.80
RO Energy (\$M/yr)	\$ 0.36	\$	0.36	\$	0.35	\$	0.35	\$	0.44	\$	0.47	\$	0.51	\$	0.38
RO Chems (\$M/yr)	\$ 0.13	\$	0.13	\$	0.13	\$	0.11	\$	0.11	\$	0.13	\$	0.28	\$	0.13
RO Cost (\$M/yr)	\$ 0.64	\$	0.65	\$	0.68	\$	0.67	\$	0.84	\$	0.90	\$	1.09	\$	3.23
RO Cost (\$/AF)	\$ 167	\$	159	\$	158	\$	147	\$	180	\$	189	\$	224	\$	650
RO + Pond (\$/AF)	\$ 1,688	\$	1,347	\$	1,051	\$	778	\$	714	\$	632	\$	577	\$	918



Brine Management Economic Model and Cost Curves - Solubility Limit at 94%

General Inputs



Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
RO Product (mgd) =	7.50	8.00	8.50	9.00	9.20	9.40	9.60	9.80
RO Product (acre-ft/yr) =	8,408	8,968	9,529	10,089	10,313	10,537	10,762	10,986

Evaporation Pond Inputs

Brine Pond Cost = \$ 22,000 per acre (annualized capital)

Pond Footprint =	0.35 0.28 3.0		acre/gpm acre/gpm acre	(passive) (enhanced) (additional footprint)
Disposal Vol =	9,735	200	cy/yr	(annual average)
Disposal Cost =	\$		per cy	(excavation and disposal)

Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
Brine (mgd) =	2.50	2.00	1.50	1.00	0.80	0.60	0.40	0.20
Brine (gpm) =	1736	1389	1042	694	556	417	278	139
Pond Area (ac) =	611	489	368	246	197	149	100	52
Enhanced Pond (ac) =	489	392	295	197	159	120	81	42

RO Inputs

Secondary RO System = PFRO for 92-96% recovery

Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
RO System =	Two-Stage	Primary RO	Three-Stage	Primary RO	Two-Stage Primary	RO + Recovery RO	HE	RO
Annual Capex (\$/mgd) =	\$ 44,000	\$ 44,000	\$ 52,000	\$ 52,000	\$ 69,000	\$ 69,000	\$ 181,000	\$ 181,000
Energy (kWh/kgal) =	1.6	1.5	1.4	1.3	1.6	1.7	1.3	1.3
Acid (mg/L) =					6	16		
Antiscalant (mg/L) =	2.7	2.7	2.6	2.3	2.1	2.1	2.7	2.7
HERO(SM/vr) =							\$ 4.24	\$ 4.24

Cost Curve - Passive Ponds

				RO Re	cove	ery			
	75%	80%	85%	90%		92%	94%	96%	98%
Pond Capital (\$M/yr)	\$ 13.43	\$ 10.76	\$ 8.09	\$ 5.41	\$	4.34	\$ 3.27	\$ 2.20	\$ 1.14
Pond O&M (\$M/yr)	\$ 1.95	\$ 1.95	\$ 1.95	\$ 1.95	\$	1.95	\$ 1.95	\$ 1.95	\$ 1.95
Pond Cost (\$M/yr)	\$ 15.38	\$ 12.71	\$ 10.03	\$ 7.36	\$	6.29	\$ 5.22	\$ 4.15	\$ 3.08
Pond Cost (\$/AF)	\$ 1,829	\$ 1,417	\$ 1,053	\$ 730	\$	610	\$ 495	\$ 386	\$ 281
RO Capital (\$M/yr)	\$ 0.33	\$ 0.35	\$ 0.44	\$ 0.47	\$	0.63	\$ 0.65	\$ 1.74	\$ 1.77
RO Energy (\$M/yr)	\$ 0.79	\$ 0.79	\$ 0.78	\$ 0.77	\$	0.97	\$ 1.05	\$ 0.82	\$ 0.84
RO Chems (\$M/yr)	\$ 0.29	\$ 0.29	\$ 0.28	\$ 0.25	\$	0.25	\$ 0.30	\$ 0.29	\$ 0.29
RO Cost (\$M/yr)	\$ 1.41	\$ 1.43	\$ 1.50	\$ 1.48	\$	1.85	\$ 2.00	\$ 7.08	\$ 7.14
RO Cost (\$/AF)	\$ 167	\$ 159	\$ 158	\$ 147	\$	180	\$ 189	\$ 658	\$ 650
RO + Pond (\$/AF)	\$ 1,997	\$ 1,576	\$ 1,211	\$ 876	\$	790	\$ 685	\$ 1,044	\$ 930

Cost Curve - Enhanced Ponds

				RO Re	cove	ery			
	75%	80%	85%	90%		92%	94%	96%	98%
Pond Capital (\$M/yr)	\$ 10.76	\$ 8.62	\$ 6.48	\$ 4.34	\$	3.49	\$ 2.63	\$ 1.78	\$ 0.92
Pond O&M (\$M/yr)	\$ 1.95	\$ 1.95	\$ 1.95	\$ 1.95	\$	1.95	\$ 1.95	\$ 1.95	\$ 1.95
Pond Cost (\$M/yr)	\$ 12.71	\$ 10.57	\$ 8.43	\$ 6.29	\$	5.44	\$ 4.58	\$ 3.72	\$ 2.87
Pond Cost (\$/AF)	\$ 1,511	\$ 1,178	\$ 885	\$ 624	\$	527	\$ 435	\$ 346	\$ 261
RO Capital (\$M/yr)	\$ 0.33	\$ 0.35	\$ 0.44	\$ 0.47	\$	0.63	\$ 0.65	\$ 1.74	\$ 1.77
RO Energy (\$M/yr)	\$ 0.79	\$ 0.79	\$ 0.78	\$ 0.77	\$	0.97	\$ 1.05	\$ 0.82	\$ 0.84
RO Chems (\$M/yr)	\$ 0.29	\$ 0.29	\$ 0.28	\$ 0.25	\$	0.25	\$ 0.30	\$ 0.29	\$ 0.29
RO Cost (\$M/yr)	\$ 1.41	\$ 1.43	\$ 1.50	\$ 1.48	\$	1.85	\$ 2.00	\$ 7.08	\$ 7.14
RO Cost (\$/AF)	\$ 167	\$ 159	\$ 158	\$ 147	\$	180	\$ 189	\$ 658	\$ 650
					_				
RO + Pond (\$/AF)	\$ 1,679	\$ 1,338	\$ 1,042	\$ 770	\$	707	\$ 624	\$ 1,004	\$ 911



Brine Management Economic Model and Cost Curves - Sensitivity Analysis

General Inputs



90% 92% 94% 96% 98% RO Product (mgd) = 3.39 3.62 3.84 4.07 4.16 4.25 4.34 4.43 RO Product (acre-ft/yr) = 3,800 4,054 4,307 4,560 4,662 4,763 4,864 4,966

Evaporation Pond Inputs

Brine Pond Cost =	\$ 33,000	per acre	(annualized capital)					
Pond Footprint =	0.35 0.28 3.0	acre/gpm acre/gpm acre	(passive) (enhanced) (additional footprint)					
Disposal Vol = Disposal Cost =	1,100 \$ 200	cy/yr per cy	(annual average) (excavation and dispo	osal)				
Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
Brine (mgd) =	1.13	0.90	0.68	0.45	0.36	0.27	0.18	0.09

						• • • •		
Brine (mgd) =	1.13	0.90	0.68	0.45	0.36	0.27	0.18	0.09
Brine (gpm) =	785	628	471	314	251	188	126	63
Pond Area (ac) =	278	223	168	113	91	69	47	25
Enhanced Pond (ac) =	223	179	135	91	73	56	38	21

RO Inputs

Secondary RO System = PFRO for 92-96% recovery

	Recovery =	75%	80%	85%	90%	92%	94%	96%	98%
F	O System =	Two-Stage	Primary RO	Three-Stage	Primary RO	Two-Stage Primary	RO + Recovery RO	HE	RO
Annual Cape	x (\$/mgd) =	\$ 44,000	\$ 44,000	\$ 52,000	\$ 52,000	\$ 69,000	\$ 69,000	\$ 181,000	\$ 181,000
Energy (Wh/kgal) =	1.6	1.5	1.4	1.3	1.6	1.7	1.3	1.3
A	cid (mg/L) =					6	16		
Antiscala	int (mg/L) =	2.7	2.7	2.6	2.3	2.1	2.1	2.7	2.7
HER	O(SM/vr) =							\$ 1.92	\$ 1.92

Cost Curve - Higher Pond Capital Cost

				RO Re	cove	ery			
	75%	80%	85%	90%		92%	94%	96%	98%
Pond Capital (\$M/yr)	\$ 9.16	\$ 7.35	\$ 5.54	\$ 3.72	\$	3.00	\$ 2.27	\$ 1.55	\$ 0.82
Pond O&M (\$M/yr)	\$ 0.88	\$ 0.88	\$ 0.88	\$ 0.88	\$	0.88	\$ 0.88	\$ 0.88	\$ 0.88
Pond Cost (\$M/yr)	\$ 10.04	\$ 8.23	\$ 6.42	\$ 4.60	\$	3.88	\$ 3.15	\$ 2.43	\$ 1.70
Pond Cost (\$/AF)	\$ 2,643	\$ 2,030	\$ 1,490	\$ 1,010	\$	832	\$ 662	\$ 499	\$ 343
RO Capital (\$M/yr)	\$ 0.15	\$ 0.16	\$ 0.20	\$ 0.21	\$	0.29	\$ 0.29	\$ 0.79	\$ 0.80
RO Energy (\$M/yr)	\$ 0.36	\$ 0.36	\$ 0.35	\$ 0.35	\$	0.44	\$ 0.47	\$ 0.37	\$ 0.38
RO Chems (\$M/yr)	\$ 0.13	\$ 0.13	\$ 0.13	\$ 0.11	\$	0.11	\$ 0.13	\$ 0.13	\$ 0.13
RO Cost (\$M/yr)	\$ 0.64	\$ 0.65	\$ 0.68	\$ 0.67	\$	0.84	\$ 0.90	\$ 3.20	\$ 3.23
RO Cost (\$/AF)	\$ 167	\$ 159	\$ 158	\$ 147	\$	180	\$ 189	\$ 658	\$ 650
RO + Pond (\$/AF)	\$ 2,810	\$ 2,190	\$ 1,647	\$ 1,157	\$	1,012	\$ 852	\$ 1,158	\$ 993

Cost Curve - Lower Annual Disposal Volume

				RO Re	cove	ery			
	75%	80%	85%	90%		92%	94%	96%	98%
Pond Capital (\$M/yr)	\$ 6.11	\$ 4.90	\$ 3.69	\$ 2.48	\$	2.00	\$ 1.52	\$ 1.03	\$ 0.55
Pond O&M (\$M/yr)	\$ 0.22	\$ 0.22	\$ 0.22	\$ 0.22	\$	0.22	\$ 0.22	\$ 0.22	\$ 0.22
Pond Cost (\$M/yr)	\$ 6.33	\$ 5.12	\$ 3.91	\$ 2.70	\$	2.22	\$ 1.74	\$ 1.25	\$ 0.77
Pond Cost (\$/AF)	\$ 1,665	\$ 1,263	\$ 908	\$ 593	\$	476	\$ 365	\$ 258	\$ 155
RO Capital (\$M/yr)	\$ 0.15	\$ 0.16	\$ 0.20	\$ 0.21	\$	0.29	\$ 0.29	\$ 0.79	\$ 0.80
RO Energy (\$M/yr)	\$ 0.36	\$ 0.36	\$ 0.35	\$ 0.35	\$	0.44	\$ 0.47	\$ 0.37	\$ 0.38
RO Chems (\$M/yr)	\$ 0.13	\$ 0.13	\$ 0.13	\$ 0.11	\$	0.11	\$ 0.13	\$ 0.13	\$ 0.13
RO Cost (\$M/yr)	\$ 0.64	\$ 0.65	\$ 0.68	\$ 0.67	\$	0.84	\$ 0.90	\$ 3.20	\$ 3.23
RO Cost (\$/AF)	\$ 167	\$ 159	\$ 158	\$ 147	\$	180	\$ 189	\$ 658	\$ 650
RO + Pond (\$/AF)	\$ 1,833	\$ 1,422	\$ 1,066	\$ 740	\$	656	\$ 554	\$ 916	\$ 805



Brine Pond Unit Costs for Economic Model

Capital Costs				Notes			
Brine Flow =		314	gpm	(For 90% conventional RO baseline case)	Discount Rate =	4%	APR
Brine Pond Size =		113	acres	(From pond sizing model)	Period =	20	yrs
Passive Loading =		0.35	acre/gpm	(Slope from pond sizing model)			
		3.0	acre	(Intercept from pond sizing model)			
Enhanced Efficicency =		20	%	(Reported for SolarBee mixers)			
Enhanced Loading =		0.28	gpm/acre				
Construction Cost -	\$	33,700,000	total	(OPCC for Alternative 2 ponds)			
Construction Cost =	\$	298,230	per acre of pond				
Annualized Cost =	\$	21,944	per acre of pond				
<u>O&M Costs</u>							
RO Feed Flow =		4.52	mgd				
RO Feed TDS =		530	mg/L	(Average water quality case)			
Annual Salt Load =		3700	ton/yr	(Raw mass of salt in dry form)			
Pond Cells =		4		(For 90% conventional RO baseline case)			
Dredge Volume per Cell =	:	22000	су	(Based on pond sizing and design solids depth)			
Cycle Length =		20	yr	(Based on BOR and Australia experience)			
Annual Volume =		4400	cy/yr				
Cleanout and Disposal Cost =	\$ \$	4,349,900 198	per cell per cy	(Quote from EWMI with hazardous tipping fee)			

RO Unit Costs for Economic Model

Capital Costs - Two-Stage Conve	entional RO		Notes				
RO OEM Equipment Cost = Annualized Cost =	\$ 600,00 \$ 44,14) per mgd permeate 9 per mgd permeate	(Typical conventional RO cost)	Discount Rate = Period =	4% 20	APR yrs	
Capital Costs - Three-Stage Conventional RO							
RO Permeate Flow = RO OEM Equipment Cost = Annualized Cost =	4.07 \$ 2,900,00 \$ 712,53 \$ 52,42	mgd) total L per mgd permeate 9 per mgd permeate	(90% Recovery case) (Quotes from H2OI and Wigen)				
Capital Costs - Two-Stage Conve	entional + CCRO Sta	<u>ge 3</u>					
Total Feed Flow = Total Permeate Flow =	4.52 4.25	mgd mgd	(94% Recovery case)				
Stages 1-2 Permeate Flow = RO OEM Equipment Cost =	3.57 \$ 2,544,30	mgd 5 total Stages 1-2	(Scaled from H2OI / Wigen quotes)				
Stage 3 Permeate Flow = RO OEM Equipment Cost =	0.68 \$ 1,000,00	mgd) total Stage 3	(Estimated for Desalitech from past quotes)				
RO OEM Equipment Cost =	\$ 3,544,30 \$ 834,19	5 total D per mgd permeate					
Annualized Cost = <u>Capital Costs - Two-Stage Conve</u>	Annualized Cost = \$ 61,381 per mgd permeate <u>Capital Costs - Two-Stage Conventional + PFRO Stage 3</u>						

Annualize	ed Cost =	\$ 68,915	per mgd permeate	
KO OEM Equipme	nt cost =	\$ 936,571	per mgd permeate	
	at Cost -	\$ 3,979,305	total	
RO OEM Equipme	nt Cost =	\$ 1,435,000	total Stage 3	(Quote from IDE)
Stage 3 Permeat	e Flow =	0.68	mgd	
RO OEM Equipme	nt Cost =	\$ 2,544,305	total Stages 1-2	(Scaled from H2OI / Wigen quotes)
Stages 1-2 Permeat	e Flow =	3.57	mgd	
Total Permeat	e Flow =	4.25	mgd	(94% Recovery case)
Total Fee	d Flow =	4.52	mgd	

Capital Costs - HERO

Total Permeate Flow =	4.07	mgd	(98% Recovery case)
HERO Equipment Cost =	\$ 10,000,000	total	(Quote from Aquatech)
	\$ 2,457,002	per mgd permeate	
Annualized Cost =	\$ 180,791	per mgd permeate	

Chemical Costs - Conventional and Advanced RO

Antiscalant Cost =	\$ \$	3.50 10,660	per lb per mgd per mg/L per year	(Recent bulk chemical quote)
Acid Cost =	\$ \$	0.15 457	per lb per mgd per mg/L per year	(Recent bulk chemical quote)

Operating Cost - HERO

Operating Cost Quote =	\$	6.00 1000	gal basis	(Budgetary quote from Aquatech)
Total Cost =	\$ \$	1,915,546 4,237,934	per year for Phase 1 per year for Phase 2	

RO Unit Costs for Brine Study

Process or Equipment	UNIT	QTY	COST	UNIT COST	Reference
Conventional RO - Brackish	MGD	0.85	\$ 510,000	\$ 600,000	Prior Schedule of Values
Conventional RO - Reuse	MGD	6	\$ 3,990,000	\$ 665,000	Prior Vendor Quote
Conventional RO - Reuse	MGD	25.5	\$ 15,225,000	\$ 597,059	Prior Vendor Quote
Conventional RO - General	MGD	4	\$ 2,434,025	\$ 608,506	Rickenbach and Kocher - Low Value
Conventional RO - General	MGD	4	\$ 3,411,868	\$ 852,967	Rickenbach and Kocher - High Value
Conventional RO - Project-Specific	MGD	4.07	\$ 2,900,000	\$ 712,531	Quote from H2OI - 7/5/22
Conventional RO - Project-Specific	MGD	4.07	\$ 2,850,000	\$ 700,246	Quote from Wigen - 7/21/22
Desalitech CCRO	MGD	2	\$ 1,150,000	\$ 575,000	Prior Vendor Quote
Desalitech CCRO	MGD	42	\$ 20,200,000	\$ 480,952	Prior Vendor Quote
IDE Pulse Flow	MGD	42	\$ 30,000,000	\$ 714,286	Prior Vendor Quote
CCRO - Project-Specific	MGD	0.68	\$ 1,000,000	\$ 1,470,588	Estimated value
PFRO - Project-Specific	MGD	0.68	\$ 1,435,000	\$ 2,110,294	Quote from IDE - 8/29/22

Chemical Unit Costs for Brine Study

	Strength	Specific	Cost		
Chemical	(%)	Gravity	(\$/gal)	(\$	/lb chem)
Antiscalant	100%	1.15	\$ 33.57	\$	3.50
Sulfuric Acid	93%	1.84	\$ 2.08	\$	0.15
Sodium Hydroxide	25%	1.28	\$ 1.49	\$	0.56

Density of Water = 8.345 lb/gal

APPENDIX E

RWQCB Call Notes



Call Notes

Brine Study Discussion with Lahontan Regional Quality Control Board

Project/File:	Palmdale Regional Water Augmentation – Brine Management Study
Date/Time:	April 24, 2023 / 1:45 pm
Call With:	Christina Guerra, RWQCB, Lahontan Region
Distribution:	Project Team

Project Background:

- Stantec provided information about the proposed Pure Water Antelope Valley reuse program, the recent techno-economic analysis of brine management, and the current Demo Plant effort. A key goal of the Demo Plant is to explore strategies for brine minimization. However, the District is planning for the likelihood of needing to build at least some evaporation pond capacity.
- Christina asked about the approximate volume of brine and whether other disposal methods (e.g. trucking) were considered. Stantec noted that the proposed initial AWT capacity will be around 5 mgd with potential future expansion. Brine volume will vary with RO recovery, but 0.45 mgd is a planning baseline value for conventional RO at 90% recovery.

Regulatory Framework:

- RO brine is considered a "designated waste" in the range of TDS anticipated for this project.
- Disposing of brine via passive solar evaporation triggers "lined surface impoundment" requirements per Title 27 of the California Code of Regulations. The Lahontan RWQCB is the relevant agency.

Lined Surface Impoundment Design Requirements:

- Title 27 is proscriptive with respect to liner requirements. The regulations specify the maximum hydraulic conductivity that must be achieved by a clay liner, and note that "engineered alternatives" (e.g. geosynthetic liners) may be used.
- Stormwater is also an important design consideration. The pond must have 2 ft minimum freeboard, and the designer must provide a volume calculation for the 100 year storm. The project sponsor needs either an Industrial Stormwater permit or a NONA for full capture of site stormwater.
- Whether or not the impoundment will include a jurisdictional dam subject to DSOD oversight depends on depth. A wide/shallow design philosophy helps avoid this, and staying <<30 ft depth is recommended. Christina is aware of some ponds deeper than 30 ft that are subject to DSOD and others up to 15 ft that are not.

Monitoring Requirements:

- Monitoring wells will be required to sample both the vadose zone and groundwater.
- The District will also need to periodically sample and report water quality for the influent brine.
- Sampling frequency will be discussed with the RWQCB. Quarterly or semi-annual sampling are typical.

Financial Assurance Requirements:

- One requirement for permitting a lined surface impoundment is financial assurance for closure costs. The RWQCB wants to be sure that a pond operator won't abandon the pond without providing for closure.
- A Memorandum of Understanding or other agreement may be needed with the District.

Go-By Projects:

- All permitted lined surface impoundment projects in California can be found in Geotracker.
- There are two nearby mining operations in the Antelope Valley area that use lined evaporation ponds. The Geotracker system can be used to review example plan submissions.

Future Coordination:

- The District can keep the RWQCB updated about the status of the project and the anticipated timeline for final siting, final design, and construction of the evaporation ponds.
- Christina Guerra will be our contact at the Lahontan RWQCB. She can be reached at <u>christina.guerra@waterboards.ca.gov</u> or 760-241-7333.
- The formal regulatory process requires submission of a Notice of Intent (Form 200) along with stamped design drawings and qualifications for the liner installer. A meeting with RWQCB and the District will be scheduled around this time.

The meeting adjourned at 2:25 pm.

The foregoing is considered to be a true and accurate record of all items discussed. If any discrepancies or inconsistencies are noted, please contact the writer immediately.

April 24, 2023 Call with Lahontan Regional Water Quality Control Board Page 3 of 3

Respectfully,

STANTEC CONSULTING SERVICES INC.

Michael Adelman P.E. Environmental Engineer Phone: (626) 568-6233 Mobile: (626) 806-9263 michael.adelman@stantec.com

APPENDIX A.5 Funding Assessment TM

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Funding Assessment – Pure Water Antelope Valley

Final Technical Memorandum

May 2023

Prepared for: Palmdale Water District

Prepared by: Stantec Team

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APPENDIX A

Preliminary Sources and Uses of Funds - For WIFIA Letter of Interest

Abbreviations May 2023

Abbreviations

AFY	acre-foot per year
AV RWMG	Antelope Valley Regional Water Management Group
BABA	Build America, Buy America
CEQA	California Environmental Quality Act
CWSRF	Clean Water State Revolving Fund
DAC	disadvantaged community
DWSRF	Drinking Water State Revolving Fund
EPA	Environmental Protection Agency
FY	Fiscal Year
IIJA	Infrastructure Investment and Jobs Act
IPR	indirect potable reuse
IRWM	Integrated Regional Water Management Plan
IUP	Intended Use Plan
JPA	Joint Powers Authority
LOI	Letter of Intent
MHI	median household income
NEPA	National Environmental Protection Act
OMB	Office of Management and Budget
PPP	Public-Private Partnership
PRWA	Palmdale Recycled Water Authority
Pure Water AV	Pure Water Antelope Valley
PWD	Palmdale Water District
SRF	State Revolving Fund
Stantec	Stantec Consulting Services Inc.
SWRCB	State Water Resources Control Board
ТМ	Technical Memorandum
U.S.	United States

Abbreviations May 2023

USBR	U.S. Bureau of Reclamation
WIFIA	Water Infrastructure Finance and Innovation Act
WRFP	Water Recycling Funding Program

Introduction May 2023

1.0 Introduction

Stantec Consulting Services Inc. (Stantec) was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional recycled water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). As part of that effort, several planning studies are underway for successful implementation of Pure Water AV. This technical memorandum (TM) provides an overview of funding available and funding approaches for Pure Water AV.

1.1 Program Background and Drivers

PWD has been providing water service to its customers since 1918, when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the groundwater basin has been in overdraft since the 1930s, resulting in land subsidence. In 1973, Palmdale Irrigation District changed its name to Palmdale Water District.

PWD has conducted a number of studies that date back to as early as the 1990s to evaluate the water resources necessary to meet future water supply demands. Concepts evaluated to date include using recycled water for landscape irrigation, discharging into Palmdale Lake, and discharging into existing sand and gravel pits to replenish the groundwater basin. In 2012, the Palmdale Recycled Water Authority (PRWA), comprising members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area. PRWA manages the distribution of recycled water and the design and construction of support facilities, and finances the efforts.

PWD has been exploring different concepts of groundwater banking, storage, and extraction. As part of that effort, PWD has conducted a series of pilot studies to determine the infiltration rates. Less than favorable results from the pilot studies led PWD to evaluate the feasibility of surface water augmentation and/or groundwater recharge via direct injection – two different forms of indirect potable reuse (IPR). Stantec was retained by PWD to conduct a feasibility study on IPR. Based on the results from the IPR feasibility study, PWD decided to pursue the concept further. Using tertiary effluent from the Los Angeles County Sanitation Districts' Palmdale Water Reclamation Plant, PWD plans to produce potable quality water for groundwater recharge via direct injection.

1.2 Study Background and Objectives

Securing external funding will be critical to Pure Water AV. To continue to meet capital and operational needs, PWD has raised water rates by 5.5% annually from 2014 to 2019 and by 8.1% annually from 2020 through 2024. Affordability is a top concern for PWD's low-income customer base. This TM reviews viable funding opportunities and strategizes how multiple opportunities could be phased together to fund the planning, design, and construction of Pure Water AV.

Introduction May 2023

1.3 Technical Memorandum Structure and Content

This TM is divided into the following sections:

- Section 1 Introduction Provides the program background and organizational structure of this TM.
- Section 2 Landscape of Water Reuse Funding Summarizes the background of water reuse funding, including demands for funding and current trends.
- Section 3 Potential Funding Sources Summarizes funding sources on the federal and state levels; compliance requirements and considerations; and alternative funding mechanisms.
- Section 4 Phased Approach to Funding Opportunities Discusses funding in the context of a phased approach, and includes a preliminary funding strategy and schedule.

Landscape of Water Reuse Funding May 2023

2.0 Landscape of Water Reuse Funding

2.1 Demand for Water Reuse Funding

More than 30 water agencies¹ around California are implementing water reuse systems to increase reliability of their water portfolio amidst worsening drought and climate change impacts. Reused water is typically desirable because it is drought proof and gives the local agency more control and typically costs less per acre-foot than imported water or desalinated water.² However, reusing water requires the construction of new facilities and treatment processes and, as such, more upfront capital investment is required. A survey of six systems with publicly available capital cost data showed that, over a 20-year design life, annual costs per acre-foot ranged from \$134 per acre-foot per year (AFY) (City of Oxnard) to \$3,090 per AFY (Pure Water Soquel). Several reuse programs are projected to cost more than \$1 billion.

The ability to secure funding has varied widely across reuse programs and has proven to be a challenge for some agencies. Across all six systems, capital costs averaged about \$1.1 billion, while only \$390 million of funding was secured on average. Successful programs like Pure Water San Diego and Pure Water Soquel have been able to cover 100% of construction costs with grants and low-interest loans – largely by spending years persistently applying for multiple sources of funds from federal and state agencies. Less successful programs have only secured startup or planning dollars, like the Metropolitan Water District's \$3.4 billion reuse program that has received less than \$5 million in grants. Funding gaps are not required to be filled by federal or state funding, as demonstrated by many reuse programs for which a majority of costs are borne by ratepayers. Orange County Water District's Groundwater Replenishment System, for example, self-funded 80% of its \$480 million Phase 1 in 2008. However, many recycled water projects in California likely will not be financially viable without the help of state or federal funding.

Funding is not necessarily a zero-sum game. Indeed, on a year-to-year basis, agencies with similar projects will compete for the same finite pool of funding. Over the long term, however, these agencies are all collectively navigating the challenging water reuse funding landscape. By joining forces with these agencies and advocating together, PWD can help move the needle on reuse funding allocations. For example, during a February 2022 stakeholder meeting held by the California State Water Resources Control Board (SWRCB), agencies like the Metropolitan Water District spoke up about the lack of reuse funding and the need for the SWRCB to finance larger projects, particularly those that benefit disadvantaged populations. This, in part, influenced the SWRCB's decision to allocate 50% of the "water recycling and cleanup" line item in the 2022 Fiscal Year (FY) State Budget appropriations to the Water Recycling Funding Program (WRFP). Beyond attending stakeholder meetings, PWD can also submit comments through the Association of California Water Agencies on proposed funding allocations and guidance documents.

² https://watereuse.org/wp-content/uploads/2021/10/Policy-Brief-Affordability.pdf



¹ https://watereuse.org/sections/watereuse-california/potable-reuse-map-of-california/

Landscape of Water Reuse Funding May 2023

PWD can also learn from past successes and challenges of other water agencies seeking reuse funding. The predominant funding sources leveraged by surveyed agencies include the California Clean Water State Revolving Fund (SRF), the United States (U.S.) Bureau of Reclamation (USBR) Title XVI WIIN Water Reclamation and Reuse Projects, Water Infrastructure Finance and Innovation Act (WIFIA), California Proposition 1 funding, and California Proposition 68 funding.

2.2 Funding Trends and Pure Water Antelope Valley Differentiators

In the most recent rounds of funding, state and federal agencies have prioritized drought and disaster resilience; equity and environmental justice; emerging contaminants and water quality; innovation in technology and project delivery methods; nature-based solutions; and collaboration and partnership across diverse stakeholders. Some trends vary by agency. For example, USBR has prioritized shovel-readiness of projects while the Environmental Protection Agency (EPA) has sought to fund more planning, design, and technical assistance. This is in part due to USBR's response to a long backlog of projects and large influxes of funds through the Infrastructure Investment and Jobs Act (IIJA), while the EPA is targeting projects that can jumpstart critical projects in disadvantaged communities (DAC) without the resources to front the costs for planning, design, or grant writing.

Most water reuse projects will build reliability and resilience to drought, but not all will have benefits to disadvantaged populations or improvements to water quality, or will be collaboratively developed with stakeholders. Reuse programs with multiple benefits that align with funder priorities will be most competitive for funding. Telling the right story about Pure Water AV can help PWD stand out among competing applicants – in particular, its unique differentiators related to equity, water quality impacts, drought conditions, and partnerships with stakeholders.

2.2.1 EQUITY

In July 2022, PWD's service area was classified as a "Large DAC" by the SWRCB, a classification that will last for three years. This new designation category allows larger utilities to access funding that prioritizes DACs, which was previously unavailable to communities larger than 10,000 people. The SWRCB defines DACs as communities with less than 80% of the statewide median household income (MHI) of \$78,672. "Large DACs" have a population greater than 100,000 people. Box 1 provides an explanation of how the SWRCB determines DAC status. Through an assessment conducted by the SWRCB, PWD's service area was found to have an MHI of \$55,129 (70% of statewide MHI) and a Lower Bound MHI of \$48,135 (61% of statewide MHI).

Landscape of Water Reuse Funding May 2023

Box 1. How does the SWRCB determine DAC status?

To make the DAC determination, the SWRCB overlays the corresponding service area with the U.S. Census Bureau's American Community Survey Five-Year Estimates data across the lowest appropriate census designation, typically either block groups or census tracts. Recognizing the limitations of using a median that only reflects the midpoint of the population, the SWRCB subtracts one standard error from the MHI for each census area. All areas are then aggregated using a weighted average to calculate a total MHI for the service area.

This process is partially described in Appendix A of the SAFER Fund Expenditure Plan³ and has been further clarified through direct discussions between Stantec and the SWRCB Division of Financial Assistance.

Beyond income metrics, PWD can also focus on other environmental justice indicators that show how parts of its community have been systemically overlooked in receiving equitable treatment and opportunities to participate in aspects of economic, social, and civic life – including lack of health insurance, speaking languages other than English at home, poverty levels, and others. These metrics can help funders understand the challenges that PWD's service population faces.

One example of how PWD advances equity and mitigates burdens experienced by these vulnerable communities is through its Rate Assistance Program. Launched in 2021, the program offers rate assistance to low-income households by covering up to 50% of monthly service charges. PWD can expand this program, and potentially partner with the California Department of Community Services and Development's newly launched Low Income Household Water Assistance Program to continue to ensure PWD is mitigating disproportionate burdens, such as increasing water utility bills, that may arise from Pure Water AV.

Pure Water AV will have many positive benefits to the disadvantaged and underserved populations within PWD's service area. The most immediate benefits are water security and reliability, which will continue to be of increasing importance as the City of Palmdale grows. From 2000 to 2010, the city's population grew by 23.6%, largely attracting working families in search of affordable housing.⁴ The city will see an increase in affordable housing units in the area, especially as it strives to meet its Regional Housing Needs Assessment allocation goals. Additionally, the city is committed to addressing the housing, community development, and economic development needs of its residents – particularly those residing in the low- and moderate-income areas.⁵ This prioritization is demonstrated through the city's 100% allocation of U.S. Department of Housing and Urban Development's Community Development Block Grant and HOME Investment Partnerships Program towards projects that will be used to provide rental assistance, increase the supply of affordable housing, ensure equal access to housing opportunities, provide for public facilities and infrastructure improvements, promote economic opportunity for low-income residents and small business owners, and provide public services to low- and moderate-income

³ <u>https://www.waterboards.ca.gov/water_issues/programs/grants_loans/sustainable_water_solutions/safer.html</u>

⁴ https://www.cityofpalmdale.org/DocumentCenter/View/10368/Draft-Housing-Element-2021---2029

⁵ <u>https://www.cityofpalmdale.org/DocumentCenter/View/11375/2022-2023-Annual-Action-Plan-PDF?bidld=</u>

Landscape of Water Reuse Funding May 2023

residents to prevent and eliminate homelessness. This growth will increase water demand in the area, disproportionately burdening disadvantaged and underserved populations. Pure Water AV provides long-term benefits, such as providing the City of Palmdale with the necessary water infrastructure, capacity, and reliability to enable and support the city's economic growth for years to come.

2.2.2 WATER RIGHTS, WATER QUALITY, AND DROUGHT

Reduction in PWD's water demand will also reduce the demand for the 1,370 AFY of unused federal government native groundwater rights through the Antelope Valley Groundwater Basin adjudication from December 2015. Since the Antelope Valley Groundwater Basin is a closed groundwater basin, reuse projects may have water quality benefits if they reduce land spreading, leading to reduction in nitrates and other emerging contaminants. Since the basin provides native water rights, pointing out water quality benefits to that basin is valuable.

While the entire U.S. West is experiencing drought conditions and an increasingly arid climate, the city is located in an area with more severe drought than other places. The federally maintained website <u>drought.gov</u>, operated by the National Oceanic and Atmospheric Administration, provides a scale to measure and compare drought conditions across the West. Palmdale's drought designation is "D3 – Extreme" compared to places like Orange County (D2 - Severe) or San Diego (D1 - Moderate) (Figure 1).



Figure 1. Map of Drought Severity Across Coastal Southern California (June 2022)

Additionally, as Pure Water AV will recharge the groundwater aquifer, the project can be considered a "nature-based solution", which has been prioritized by federal and state agencies in recent years.

Landscape of Water Reuse Funding May 2023

2.2.3 PARTNERSHIP AND STAKEHOLDER ENGAGEMENT

Topics like water reuse can be controversial and complicated. Relatively simple challenges, such as public perceptions around wastewater reused for drinking water, or the "ick factor," can cause delays; but bigger challenges, like diverting historical wastewater discharges to downstream agencies, can have complicated implications for water rights. This controversy means that program implementation or operation can get stalled by litigation, exacerbate existing tensions or conflict, or cause issues in the future.

Funders want to feel confident that the public and other stakeholders are not just generally supportive of controversial projects, but that they have been substantively involved in early stages of project development and that their considerations have been factored into the design. A project is more competitive if it has a history of community involvement and is supported by regional stakeholder groups or planning efforts, like the Antelope Valley Integrated Water Resources Management Group.

2.2.3.1 Other Considerations: Total Costs, History with Funders, and a History Of Planning

- Cost estimates for Pure Water AV suggest PWD's will be a much smaller financial request than many competitors, thereby resulting in a greater number of opportunities to receive funding.
- PWD's history with public funding and with specific funders can be included in applications. Funding agencies can have complicated compliance and reporting requirements and want to feel confident that the applicant will be able to fulfill their requirements.
- Funders like to see that a project is well-planned and is likely to be constructed and produce its
 expected benefits according to the timeline estimated. The more than 10 years of planning that
 has gone into Pure Water AV provides assurances to funders that the program will follow through
 from the 2010 Strategic Water Resources Study, to the establishment of the Palmdale Recycled
 Water Authority in 2013, to the Recycled Water Master Plan in 2015.

Potential Funding Sources May 2023

3.0 Potential Funding Sources

This section first reviews public funding opportunities from both federal and state sources, then discusses alternative financing mechanisms that could be considered by Pure Water AV.

3.1 Federal Funding Opportunities

Six federal funding opportunities align with Pure Water AV's timeline and goals. Federal funding programs tend to be allocated higher dollar amounts, but are also nationally competitive.

- WIFIA \$5.5 billion (FY 2023)
- USBR Title XVI \$1 billion (through 2027)
- USBR WaterSMART Drought Resiliency Projects Grants up to \$100 million (through 2027)
- Federal Emergency Management Agency Building Resilient Infrastructure and Communities \$5 billion (through 2027)
- EPA Midsize and Large Drinking Water System Resilience and Sustainability Program \$375 million (through 2027). This program is newly authorized through the IIJA and is still in the process of being set up.
- Congressionally Directed Spending PWD could consider advocating to Congressman Mike Garcia to submit a request for a congressionally directed spending or "earmark" from the federal budget. Typically, as earmarks are limited to 1% of federal discretionary spending, requests tend to be relatively small (<\$10 million) to increase the likelihood of being selected.

Two of these programs stood out as the best match for Pure Water AV: WIFIA and Title XVI. These programs are described in further detail below.

3.1.1 WIFIA

Background: WIFIA is an EPA credit program established to fund regionally significant water and wastewater infrastructure projects. The program prioritizes projects that protect citizens from storm events and drought impacts, increase system reliability, modernize existing infrastructure, or address emerging contaminants. WIFIA can fund up to 49% of all project costs. Federal contributions to WIFIA-funded projects are capped at 80% of total project costs.⁶ Projects must be greater than \$20 million in estimated project costs. As long as the project is large enough, all projects that are eligible for the Safe Drinking Water and Clean Water State Revolving Loan programs are eligible for WIFIA. Eligible activities include planning, engineering design, environmental review, revenue forecasting, construction, reconstruction,

⁶ SRF funding is counted as non-federal funding as long as there is no principal forgiveness. If there is principal forgiveness, the amount forgiven cannot be counted as part of the non-federal share.



Potential Funding Sources May 2023

rehabilitation, replacement, acquisition of property, and capitalized interest necessary to meet market requirements.

If a borrower is using WIFIA funding, all project costs must comply with WIFIA federal rules and regulations, including the National Environmental Protection Act (NEPA), Davis-Bacon, Build America, Buy America Act, and all other federal cross-cutters. Procurement processes and other project activities must incorporate WIFIA compliance. Previously incurred costs may be eligible for reimbursement if the borrower can demonstrate compliance. Generally, professional services (engineering, environmental, program management) contracts do not conflict with these federal requirements.

Since 2017, WIFIA has offered \$26.5 billion in financing. By far, California has had more projects selected than any other state. Sixty California projects requesting \$10.1 billion in WIFIA financing were invited to apply. As of March 2022, 25 borrowers had closed almost \$5 billion in WIFIA loans. Ten of those loans support water recycling and advanced water purification projects.

The WIFIA loan program is attractive because it offers borrowers flexible financing terms and low, but not subsidized, interest rates. The interest rate is locked at closing, but borrowers can draw down on WIFIA loans for several years, only accruing interest on the amounts drawn. The maximum final maturity date from substantial completion is 35 years. The current interest rate set by WIFIA is no lower to the U.S. Treasury rate at closing. All repayment to EPA (principal and interest) can be delayed up to five years and, during the term of the loan, repayment can be sculpted to accommodate borrowers' other debt obligations or capital expenditures. These loan characteristics allow borrowers with multi-year construction phases, significant capital costs, and long asset lives to mitigate the debt service impact on rate payers.

WIFIA's enacting legislation provided considerable latitude in the administration of the WIFIA program, and the terms offered. Recently, WIFIA has introduced the Master Credit Agreement structure. Under a Master Credit Agreement, a borrower can execute multiple WIFIA loans over many years. This allows borrowers with large, phased projects or many projects secured by a common security pledge to access flexible financing for projects at varying stages of readiness. This additional flexibility created through the Master Credit Agreement appeals to borrowers that would like to lock in WIFIA support, but are not in a position to meet all WIFIA requirements for all their capital needs.

Padre Dam's East County Advanced Water Purification Project secured \$388 million in low-interest loans from the WIFIA program.⁷ Padre Dam's Director of Finance found the WIFIA process straightforward and seamless, but cautioned that its experience may be dependent on the EPA staff managing the agreement.

Application requirements: WIFIA has a two-step application process. First, prospective borrowers must submit a Letter of Intent (LOI) explaining who the borrower is, what the project is, and how the project aligns with WIFIA priorities, as defined in the Notice of Funding Availability. In 2022, the EPA modified the LOI process from an annual deadline to a rolling submission. After September 6, 2022, prospective borrowers may submit LOIs at any time. EPA will review LOIs and reach out to prospective borrowers

⁷ https://www.epa.gov/sites/default/files/2021-06/documents/east_county_wifiaprojectfactsheet_loanclose2.pdf



Potential Funding Sources May 2023

approximately eight weeks after submission to discuss next steps. If invited to apply, the prospective borrower has one year to submit a complete application. Once the application has been deemed complete by EPA, a due diligence and credit negotiation process is initiated. Depending on the status of the project, the application process can take as little as eight months or as long as two years to complete.

As with all federal funding programs, borrowers must demonstrate NEPA compliance to access WIFIA financing for construction activities. Projects seeking WIFIA support for planning, design, permitting, and other non-construction activities can execute a WIFIA loan agreement without NEPA. For this reason, projects seeking WIFIA funding for construction are expected to be far along in the environmental review process and have at least a 30% design that EPA technical staff can review. Borrowers with non-construction activities that exceed \$20 million in costs can utilize the Master Credit Agreement structure to execute a series of loans, initially covering non-construction activities, but ultimately providing WIFIA capital for construction.

3.1.2 TITLE XVI WATER RECLAMATION AND REUSE PROGRAM

Background: Implemented through the USBR WaterSMART program, the Title XVI Water Reclamation and Reuse Program provides cost-shared financial assistance to support planning, design, and construction of water recycling and reuse projects. From program formation until 2016, a project could only receive funding through an authorization by Congress. In 2016, Section 4009(c) of the WINN act amended the program to allow funds to be awarded through a competitive submission process. Today, the competitive submission process offers three times the awards as Congressionally Authorized Projects (maximum of 30 awards compared to a maximum of 10 awards, in FY2022).

Program funding levels have increased dramatically under the IIJA. From 1992 to 2021, funding levels remained relatively steady, with the program awarding \$780 million in grants to 68 construction projects and an average award size of \$11.5 million. The IIJA authorized the Title XVI program to receive \$1 billion from FY2022 to FY2026, of which \$300 million was appropriated for FY2022 (a 30-fold increase from the FY2021 budget of \$9.5 million). Another \$400 million from IIJA is set aside for a new large-scale Title XVI program that is only available to projects with costs greater than \$500 million. Title XVI grants can cover up to 25% of project costs (planning, design, and construction), up to a maximum of \$20M for the Congressionally Authorized funding program and \$30M for the WIIN Act funding program.

Most awards have gone to non-potable reuse projects, including those for landscape irrigation, agricultural irrigation, commercial and industrial use, and habitat restoration; however, IPR projects have received increased funding in recent years.⁸

Application requirements: Projects must complete a Feasibility Study that demonstrates compliance with federal laws and regulations, technical and financial feasibility, and the extent to which the project provides a federal benefit in accordance with USBR laws. The USBR reviews submissions and submits a report with its recommendations to Congress, which then determines which projects are eligible and invites them to apply. This multi-step process has created challenges for fund disbursement in the past,

⁸ <u>https://www.gao.gov/assets/gao-19-110.pdf</u>

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where time delays and scope adaptations cause project sponsors to not apply for their allotted funds, even when the projects are deemed feasible by USBR and Congress.⁹

Like the WIFIA program, recipients of Title XVI grants must comply with federal cross-cutters, including but not limited to, Davis-Bacon, NEPA, and the Civil Rights Act.

3.2 State Funding Opportunities

State-level funding programs in California often operate with funding amounts similar to those of federal programs, but applicants must only compete with other projects in California. Connecting with State agencies is a key step toward securing funding through State administered programs. Administrators can provide information regarding application cycles and priorities that are not always included in program guidelines or posted on agency websites.

Five state-level funding opportunities align with Pure Water AV:

- 1. Drinking Water and Clean Water SRFs \$609 million (in California FY 2022)
- 2. WRFP Up to \$500 million over three years (including 2023 proposed May revision)
- Proposition 1 Integrated Water Resource Management Implementation Grant Program (\$193 million) must be on the Antelope Valley Integrated Regional Water Management Plan (IRWM), but only \$1 million is available to the Palmdale area.
- 4. Governor's Office of Planning and Research Regional Resilience Grant Program (\$250 million)
- 5. State-appropriated funding

Three of these programs stood out as the best match for PWD: the SRF, the WRFP, and the Proposition 1 IWRM program.

3.2.1 CLEAN WATER AND DRINKING WATER STATE REVOLVING FUNDS

Background: Clean Water SRF (CWSRF) and Drinking Water SRF (DRSRF) can both fund potable water reuse projects, while only the CWSRF can fund non-potable water reuse. Financing is offered through low-interest loans, and DACs have the ability to apply for principal forgiveness. The CWSRF and DWSRF act as infrastructure banks, receiving annual capitalization grants from the EPA and state funds through annual budgets, state ballot measures, and a variety of other avenues. The federal CWSRF has offered over \$150 billion in financing since 1988, and the DWSRF has offered \$48 billion since 1997. The federal SRF funds are administered through state-level SRF funds, including California's DWSRF and CWSRF, which are authorized under California Water Code Sections 13475-13485. The California DWSRF and CWSRF receives annual funds from principal and interest on past loans, federal allocations, periodic allocations to the SWRCB from the California annual budget, and other funds approved by California voters, such as Proposition 1 and Proposition 68. In FY2022, the California Budget Act of

⁹ <u>https://www.gao.gov/assets/gao-19-110.pdf</u>

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FY2021-22 allocated \$1.2 billion for the DWSRF and CWSRF, and the EPA allocated \$158.4M and \$128.4M to the California DWSRF and CWSRF, respectively, for FY2022. Applications are accepted on a rolling basis and prioritize DACs. Specific funding percentages and caps change by the year, but are developed annually through a stakeholder-driven process and released in that year's Intended Use Plan (IUP). The DWSRF can offer loans to DACs with a term of 40 years.

A minimum of 40 percent of the California CWSRF water reuse funds will be disbursed to projects within Los Angeles County, Orange County, Riverside County, San Bernardino County, San Diego County, or Ventura County.

Funding for Water Reuse Projects in Large DACs: To better understand water reuse funding from the California SRFs, the past three years of CWSRF funding awards were analyzed. CWSRF trends show funding for water reuse projects is available and has even increased 4.5 fold from FY2021-22 (Figure 2). Between FY2021 and FY2022, 12 water reuse projects have received funding from the CWSRF. Only two of the 12 projects are potable water reuse projects (Morro Bay Water Reclamation Facility Project and the East County Advanced Water Purification Project), neither of which is classified as serving DACs. The only CWSRF-funded water reuse project with a Large DAC status was for non-potable reuse (Coachella Valley Water District's Non-Potable Water Connections Project).

With a history of funding for water reuse projects, in addition to a continued prioritization of projects that serve DACs, the CWSRF is a strategic funding opportunity for Pure Water AV. PWD's Large DAC classification by the SWRCB gives this water reuse project a competitive edge. The project is also located in Los Angeles County and is a potable water reuse project – additional unique characteristics that set Pure Water AV apart from past awardees.

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CWSRF Water Reuse Funding

Figure 2. Clean Water State Revolving Fund Funding for Water Reuse in Past Two Years

Application requirements: Applications are submitted through the Financial Assistance Application Submittal Tool (FAAST) portal. Eligible applicants are encouraged to contact the SWRCB as soon as their project is identified. The SWRCB can then support the submission of a General Information Package and help the project get on the IUP. State IUPs are submitted to the EPA annually to justify receipt of federal capitalization grants. Based on total funding received, a cutoff score is determined and any project with a score higher than the cutoff will make the Fundable List.

3.2.2 WATER RECYCLING FUNDING PROGRAM

Background: The WRFP promotes beneficial use of treated municipal wastewater to offset or augment fresh water supplies in California. WRFP funds come from one-time allocations from Proposition 1 (\$625M, FY2014) and Proposition 68 (\$72M, FY2018) as well as annual funds from the CWSRF. The last of Proposition 1 and 68 funds were committed in FY2021. The California Annual Budget (Senate Bill 170) allocated \$300M for FYs 2021/2022 for "Groundwater Recycling and Cleanup," half of which the SWRCB determined will go to the WRFP. Both planning and construction grants are available and can fund up to 50% of planning costs (100% for DACs) and 35% of construction costs. Of high relevance to Pure Water AV: a minimum of 40% of construction funds will be dispersed to six Southern California counties, including Los Angeles County. The WRFP prioritizes DACs and potable reuse projects.

As the WRFP is operated through the CWSRF, the SWRCB can allocate WRFP funds to applicants that apply through the CWSRF as well as to applicants that apply to the WRFP directly. There is one advantage to applying to the WRFP directly, which is that a project with a score below the CWSRF cutoff

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score could still receive funding if there are WRFP funds left over. Stantec anticipates that Pure Water AV will score well on the CWSRF scoring, in part due to its Large DAC status. Thus, Stantec recommends PWD apply to the WRFP through the CWSRF, rather than applying separately and creating extra submission requirements. The Padre Dam East County Advanced Water Purification System secured both a grant and a loan from the WRFP through the CWSRF.¹⁰

Ultimately, when applying to the WRFP through the CWSRF, the SWRCB will determine from where Pure Water AV funds would be sourced, which has implications for funding terms and compliance requirements. The CWSRF only offers loans and principal forgiveness, while the WRFP offers loans and grants. Most CWSRF funding comes from federal sources, meaning that projects receiving money from those sources must comply with federal requirements (AIS/ Build America Buy America [BABA], Disadvantaged Business Enterprise [DBE], Davis Bacon, California Environmental Quality Act [CEQA]+). The WRFP only receives state money, so projects receiving funding from it must only comply with CEQA.

Application process: Stantec recommends that PWD apply for the WRFP through the SRF; thus, the application process will follow the same process outlined for the SRF funding.

3.2.3 PROPOSITION 1 INTEGRATED WATER RESOURCE MANAGEMENT IMPLEMENTATION GRANT PROGRAM

Background: The IRWM Grant Program was designed to advance the purpose of the Regional Water Security, Climate, and Drought Preparedness (Water Code Section 79707[c] and Section79740) by encouraging and funding integrated water management planning and implementation, including water reuse projects. Proposition 1 allocated \$403M to this program over two rounds, of which Round 2 will provide \$192 million and will close in Spring 2023. An average local cost share of not less than 50% of the total project costs included in a proposal is required, which can include federal funds. Cost share requirements can be waived or reduced for projects that serve DACs.

Applicants must coordinate their application through their established IRWM Regional Water Management Group (for PWD, the Antelope Valley IRWM Group), and ensure that the project is included on the IWRM plan. The Regional Group then, in turn, coordinates with other groups within the Proposition 1 IRWM Funding Area.

PWD is actively involved in the Antelope Valley Regional Water Management Group (AV RWMG) and sits on the board as a project partner. The AV RWMG has prepared three IRWM Plans since 2013 using a collaborative process to involve stakeholders in the process of improving water supply reliability and sufficiency in the Antelope Valley Region. The most recent plan from 2019 included three projects associated with PWD: the Palmdale Recycled Water Authority Phase 2 Distribution System, the PWD Littlerock Dam Sedimentation Removal, and the PWD Regional Groundwater Recharge Project. Based on conversations with PWD, the AV RWMG will only receive \$1 million from the Proposition 1 IRWM Grant, and there may only be \$500,000 available for PWD, which PWD intends to use for the PRWA

¹⁰ https://www.wateronline.com/doc/padre-dam-receives-conceptual-approvals-and-m-for-east-county-0001


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Phase 2 Distribution System. Many of the benefits of Pure Water AV can be discussed in the IRWM application for the PRWA Phase 2 Distribution System.

Application process: Since PWD is already in contact with the AV RWMG, PWD should first submit a project information form and coordinate for the February 1, 2023, deadline. Applications are submitted through DWR's GRanTS (Grants Review and Tracking System) portal.

3.3 Compliance Requirements and Considerations

Projects receiving funding and financing assistance from government sources must comply with relevant laws and regulations, including environmental and other compliance requirements and labor regulations. Federal requirements differ from state requirements and may occasionally conflict. Complying has cost implications for the funding recipient; and in certain instances, funding made available through a program does not justify the compliance systems and activities.

There are three areas of funding compliance for PWD to consider:

- 1. Funding eligibility
- 2. Representations and warranties previously included in grant or loan agreements
- 3. Project implementation compliance and reporting

Funding eligibility: Regarding funding eligibility, it is critical to confirm that both the project and the applicant are eligible for funding prior to developing an application. Certain activities can preclude borrowers from eligibility. For example, starting construction prior to a NEPA determination is likely to result in ineligibility. If a prospective applicant is intending to apply for funding, incorporating compliance language into bid advertisements and contracts is important. However, when funding is not confirmed, prospective applicants run the risk of contractors adding compliance costs to bids, even if the prospective applicant never receives the grant or loan money. Utilizing alternative delivery approaches may also complicate the question of eligibility, though a design-build approach would not automatically make PWD ineligible for the funding programs included in this TM. However, if PWD opts to utilize a design build or progressive design build approach, it should proactively engage funding program administrators prior to developing an application or soliciting a design-build firm.

In the near term, PWD should develop drafts of pre-bid notifications, certifications, specifications, and contracts that incorporate compliance language. This exercise will highlight areas where prospective funding compliance requirements challenge existing practices.

Representations and warranties: When executing grant and loan agreements, parties to the agreement are typically required to comply with specific rules and regulations. These representations and warranties articulate what is required of the grant or loan recipient prior to signing the agreement and vary depending on the funding program. Much can transpire between submitting an application and executing a funding agreement. PWD should understand what will be required between the submission of an application and the signing of an agreement to ensure compliance and, if possible, to expedite the negotiation process.

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Before developing funding applications, PWD should request copies of loan and grant agreements. Agreements will list representations and warranties as well as conditions precedent to loan execution and fund disbursements.

Project implementation compliance and reporting: The grant or loan agreement will include language regarding ongoing compliance. One aspect is understanding the rules and regulations PWD is subject to as a recipient of funding. For example, the federal BABA requirement may complicate the sourcing of treatment equipment. Alternatively, an equipment waiver may exist.¹¹ The specific impacts of ongoing compliance must be anticipated and accounted for in project planning.

Another aspect of this ongoing compliance is how PWD, through reporting and other communications, will demonstrate compliance to the funder. Reporting requirements vary significantly by program. In negotiating grant and loan agreements, onerous reporting requirements that include superfluous information or demand expensive monitoring should be questioned. Reporting and monitoring are often driven by a funding program's administrators and not a statutory requirement of the appropriating legislation. Reporting and monitoring requirements with minimal apparent benefits and excessive paperwork are ultimately bad for both administrators and fund recipients. Additional considerations for federalizing the project are reviewed in Box 2.

PWD should evaluate current reporting and monitoring practices to determine areas where systems and practices would need to be modified to meet compliance requirements. Draft compliance plans should be developed after notification of award.

Compliance costs should never outweigh the benefits of securing an alternative funding source. Very preliminary estimates on compliance costs have been completed for the programs included in this TM. The benefits of the programs described above are greater than the costs of compliance.

Box 2. Federalizing the Project

The IIJA directed over \$60 billion in funding to water infrastructure. This is an unprecedented level of funding available to advance water projects, but the funding comes with strings attached. Projects that use IIJA dollars are required to comply with dozens of rules and regulations previously attached to federal funding and new mandates. Borrowers and grant recipients must be prepared to proactively consult with federal representatives on NEPA. Projects must comply with the National Historic Preservation Act, Davis-Bacon, Equal Employment Opportunity, and many others. While California's numerous rules and regulations have trained California entities to be sensitive to compliance, state and federal rules differ and funding recipients must understand the nuances of where and when federal law supersedes state law.

BABA is a new mandate, included in the IIJA, that went into effect May 14, 2022. For federally financed infrastructure projects, all iron and steel, manufactured products, and construction materials must be produced in the U.S. BABA only applies to articles, materials, and supplies that are consumed in,

¹¹ WIFIA and the SRF program have programmatic <u>BABA waivers</u> for projects that were in planning and design as of May 14, 2022.



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incorporated into, or affixed to an infrastructure project. Guidance has been provided by the Office of Management and Budget (OMB), and EPA created a website to post additional guidance and approved waivers. Waivers can be granted if:

- Applying BABA would be inconsistent with the public interest (public interest waiver);
- Types of iron, steel, manufactured products, or construction materials are not produced in the U.S. in sufficient and reasonably available quantities or satisfactory quality (non-availability waiver); or
- BABA compliance will increase the cost of the overall project by more than 25% (unreasonable cost waiver).

Concerns regarding access to U.S.-produced water recycling treatment equipment have been raised by project sponsors seeking federal funding. Funding agencies recommend working with the OMB's <u>Made in America Office</u> and the <u>EPA's Office of Water's BABA</u> lead to apply for waivers as necessary and avoid project delays and excessive costs. Currently, heightened awareness of the negative project impacts of inflation and constrained supply chains is putting pressure on federal agencies to approve project specific and program-wide waivers. PWD should work with advocacy groups to raise awareness of Pure Water AV-specific BABA challenges and initiate discussions today on effectively sourcing equipment for the project.

3.4 Alternative Financing Mechanisms

There are five primary approaches to funding large water projects, and they are not mutually exclusive. Multiple, if not all of these approaches, could be applied to a single project. In addition to cash funding and the use of government programs described above, three other approaches are prevalent:

- Municipal bonds
- Public-Public Partnerships
- Public-Private Partnerships (PPP)

3.4.1 BONDS

PWD can originate tax-exempt bonds to fund essential services infrastructure projects and has broad discretion to issue these bonds. Interest rates on these bonds are primarily a function of PWD's credit rating. The credit rating takes into consideration bond-related revenues; existing and anticipated debt and other liabilities (i.e., pensions and post-employment benefits); and management. Even with today's uncertainty around interest rates, municipal bonds remain a strong source of funding for infrastructure capital.

Municipal revenue and general obligation bonds (often referred to as municipal bonds) are frequently issued to support large infrastructure investments. Revenue bonds are bonds for which the revenue generated through the operation of the project being financed, or from other non-property tax sources,

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pays the debt service. Historically, revenue bonds have had slightly higher interest rates compared to general obligation bonds, but currently, revenue and general obligation bonds have very similar interest rates. Water supply projects, providing essential services, are recognized as low risk and typically receive lower bond interest rates than municipal bonds for projects supporting non-essential services.

Revenue bonds are often the preferred source of financing for water utilities as rate revenues can support repayment of revenue bonds. Also tax-exempt, certificates of participation are an alternative to municipal bonds used by municipalities or other government entities to acquire real property. Commercial paper or bond anticipation notes may be leveraged to supplement other financing sources, support cash flow needs during project construction, and capitalize on lower interest rates often typically realized through short-term financings. Utilities and municipalities work with municipal financial advisors to evaluate the issuances of these debt securities.

3.4.2 PUBLIC-PUBLIC PARTNERSHIPS

Pure Water AV is intended to be a regional water supply solution and there are multiple ways communities other than Palmdale might participate. PWD is already coordinating with other public entities to advance water recycling projects. For example, PRWA was established by the City of Palmdale and PWD in 2012 in order to manage recycled water that is generated and used within the Palmdale area. The PWRA advances recycled water projects, including managing contracts to obtain recycled water and develop necessary facilities. The PRWA will end in two years; however, a similar effort could be used to manage Pure Water AV over a longer time period.

Expanded regional participation could help distribute the costs of projects across a larger customer base. In addition, regional solutions are often prioritized by funding programs. Being part of a regional solution that benefits multiple communities can make Pure Water AV more attractive to prospective funding partners.

Different organizational, ownership, operating, and financing structures can be designed to fit the specific requirements of partners. Key considerations related to regional participation include control, cost recovery, and timing of capital contributions. In many places, a regional authority is established or assigned to build and manage regional assets. The strength of the authority is largely a function of the perceived equity of the participants. Experience has shown, if control and financial responsibility is not equitable, participants will spend time, energy, and money in conflict. Governance challenges can complicate establishing a regional authority for a water project. An open-book discussion facilitated by a third party and supported by a trusted financial model can mitigate some of the innate tensions related to creating an effective regional water authority. PWD knows from experience not to underestimate the time and effort necessary to build a productive public-public partnership.

One clear advantage to establishing a public-public partnership or partnerships to support the development of Pure Water AV is securing capital contributions for project construction. If an equitable and sustainable governance structure is possible, regional partners can help fund the design and construction of Pure Water AV and share the ongoing financial responsibility of operating and maintaining the infrastructure.

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Timing is key in regional participation. Once a regional customer or partner commits, they reduce PWD's financial responsibility and might positively impact PWD's ability to secure government funding. Some approaches to incentivizing early regional participation while maintaining control include offering reserve capacity to communities that anticipate purchasing water or services in the future. A phased contribution approach can be crafted to suit partners that anticipate but are uncertain of growth in water demand. Regional customers might receive a discount for committing or contributing capital to the project in earlier phases.

For those regional communities that are not interested or not able to contribute capital upfront, rates can be structured to include a fee to recover capital and fixed O&M costs associated with that customer's projected capacity or off-take. The reserve capacity fee can be collected even when the customer is not receiving water and helps the city cover project-related debt service and fixed costs. Once a customer begins purchasing water, rates would include usage and variable O&M. Intergovernmental agreements can be used to establish these contractual relationships.

Joint powers authorities (JPA) have been a useful governance structure for regional water recycling projects. Padre Dam Municipal Water District formed a JPA with the City of El Cajon and San Diego County to fund, operate, and maintain the East County Advanced Water Purification project. By forming the JPA, partners avoided increasing financial liabilities on their balance sheets, and committed to the project through water purchase agreements and wastewater services agreements. The East County Advanced Water Purification JPA provided assurances to lenders by demonstrating water supply and wastewater cost savings realized through the project. The JPA administers all development and O&M contracts related to the project, reducing the potential for duplicative administrative expenditures. In addition, the JPA has structured annual rebates to partners to minimize the cost and long-term financial impact of increased borrowing and debt service coverage requirements. Essentially, if debt service coverage requirements are 1.20, the JPA collects 1.20 in revenue and then rebates partners the 0.20 at the end of the year as a sort of "equity" distribution. PWD may want to consider how alternative governance mechanisms such as a JPA may influence financing.

3.4.3 PUBLIC-PRIVATE PARTNERSHIPS

In some cases, private financing of infrastructure assets can be a viable option for local and regional projects that might otherwise face challenges or delays using traditional public financing approaches. In a typical PPP model, a private entity assembles the delivery team and takes responsibility for project design, construction, operations, and financing. The private party forms a special purpose entity or project company to deliver a public-benefit project. Infrastructure PPPs often apply capital from institutional investors with long-term investment horizons and lower return expectations than private equity investors. PPPs also tend to be heavily leveraged, meaning the equity ownership makes up a smaller percentage of the total capital provided for project development. While private investors still expect much higher returns that the municipal bond market or government loan programs, a blended capital stack in a PPP can bring down the financing costs for the project. Commercial debt, private activity bonds, and/or WIFIA funding could all be sources of debt for a PPP.

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A PPP project delivery approach is sometimes referred to as Design-Build-Operate-Finance. Private participation can create the opportunity to transfer more project risk and project responsibility from the project sponsor (PWD) to private partners. Proponents for PPPs believe private management of the design, construction, and operations can result in cost efficiencies that outweigh the higher costs related to including private financing. These savings are realized over the life cycle of the project and include the value to the public sponsor associated with risk transfer. To increase the competitiveness of a PPP with other financing options, private investors may also offer more flexibility than revenue bonds and some government financing programs in terms of repayment and maturities.

PPPs require the public project sponsor to relinquish significant control. In the water sector, it has been difficult to garner public support for PPPs and to execute PPP agreements that satisfy all parties. At present, PWD appears well positioned to develop, construct, operate, and maintain Pure Water AV. In addition to the possibility of partnerships with neighboring communities, multiple low-cost financing and funding options exist. At this point, utilizing a PPP to access capital is not advised.

Phased Approach to Funding Opportunities May 2023

4.0 Phased Approach to Funding Opportunities

Some public funding opportunities are better suited for funding different phases of the project. Combining multiple complementary funding programs can be optimized to match the Pure Water AV schedule. The Padre Dam East County Advanced Water Purification System was able to successfully weave together funding from five separate grants and three separate low-interest loans across federal, state, and local levels. Integrating these multiple funds took a minimum of four years for their \$850 million program; they started the process in 2018 and did not have all of the funding secured until a few months prior to groundbreaking in 2022. One recommendation from the Padre Dam Director of Finance is to apply for the reuse project in its entirety, rather than splitting up applications by project phases, to avoid complications in reporting and compliance.

4.1 Preliminary Funding Strategy

A preliminary strategy for phasing Pure Water AV funding is provided in Table 4-1. Application preparation, submission, and compliance varies by funding program. A detailed compliance schedule will be prepared upon receipt of each award. State and federal funding is vital to the progress of this project. For any of these programs, PWD will work with funders to coordinate funds so that no funds overlap or duplicate in terms of activities, costs, or commitment of key personnel.

Appendix A provides a detailed breakdown of preliminary cost estimates for Pure Water AV, including potential costs for eventual expansion to 10 million gallons per day. Costs are distributed across every year of the program and escalated to the year costs will be incurred. These costs are considered preliminary at the time of the creation of this TM.

Phased Approach to Funding Opportunities May 2023

Table 1.	Funding	Strategy	by	Project Phase
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	P	HASE			
PROGRAM	PLANNING	DESIGN	CONSTRUCTION	STATUS	MAXIMUM COST COVERAGE
CA Prop 1 IRWM Round 2 DAC			•	Awarded \$450 K awarded for demonstration facility conservation garden	50% of costs, up to 100% for DACs. No award maximum.
USBR Title XVI Desalination and Recycling- Planning	•	٠		Submitted \$715 K requested for planning and design funds, submitted 2/2023.	50% of planning and design costs as federal cost share, up to \$1 M.
CA DWR Urban Community Drought Relief Grant		•	•	Submitted \$13.1 M requested for demonstration facility, submitted 12/2022.	75% for non-DACs, 100% for DACs. Requested 76% cost coverage. No award maximum.
CA DWR Urban Community Drought Relief Grant		•	•	Submitted \$11.4 M requested for Extraction Well 36/37, submitted 12/2022.	75% for non-DACs, 100% for DACs. Requested 87% cost coverage. No award maximum.
CA Prop 1 IRWM Round 2 Implementation			•	Submitted \$587 K requested by IRWM region in 2/2023 for demonstration facility influent pipeline	50% of costs, up to 100% for DACs. No award maximum.
USBR WaterSMART Drought Resiliency Projects			•	Submitted, Not Awarded \$5.0 M requested for Extraction Well 36/37, submitted 6/2022.	50% of costs as federal cost share, up to \$5 M.
US EPA WIFIA loan	•	•	•	In progress Letter of interest accepted 12/2022, invited to apply. PWD will submit a request for a loan for 49% of project costs in 2023.	49% of planning, design, and construction costs as low-interest loan, allows up to 80% federal cost share. No maximum loan amount.
CA SWB Water Recycling Funding Program - Planning	•			Forecasted PWD intends to request \$500 K for planning and demonstration facility in 2023.	100% of planning and design costs, up to \$500 K.
CA SWB Water Recycling Funding Program Construction [Demonstration]			•	Forecasted PWD intends to request \$4.7 M for construction of demonstration facility in 2023 if DWR UCDRG not awarded.	35% of construction costs, up to \$15 M.
CA SWB Water Recycling Funding Program Construction [Full Scale]			•	Forecasted PWD intends to request \$15.0 M for construction of full-scale facility in FY24-25.	35% of construction costs, up to \$15 M.
USBR Title XVI Reuse & Recycling Construction			•	Forecasted PWD intends to request \$30.0 M for construction of full-scale facility in FY24.	25% of construction costs as federal share, up to \$30 M.
CA Clean Water State Revolving Fund Ioan	•	•	•	Forecasted PWD intends to fill remaining funding gaps with SRF loans.	Up to 100% as low-interest loan. Principal forgiveness option for DACs. No maximum loan amount.
Revenue Bonds	as	neede	ed	Forecasted PWD intends to issue revenue bonds to finance as needed.	N/A

Key: EPA = Environmental Protection Agency WIFIA = Water Infrastructure Finance and Innovation Act USBR = US. Bureau of Reclamation

Phased Approach to Funding Opportunities May 2023

CA = California DWR = Department of Water Resources SWB = State Water Board IRWM = Integrated Regional Water Management

APPENDIX A

Preliminary Sources and Uses of Funds – For WIFIA Letter of Interest

APPENDIX A.6 Delivery Methods Assessment TM

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Program Components Delivery Methods Assessment – Pure Water Antelope Valley

Technical Memorandum

May 2023

Prepared for: Palmdale Water District

Prepared by: Stantec Team

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APPENDIX B

Palmdale Water District Rules and Regulations – Appendix M, Procurement and Purchasing Policy



Abbreviations May 2023

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Abbreviations

APD	Alternative Project Delivery		
AWPF	Full-Scale Advanced Water Purification Facility		
CMAR	Construction Management at Risk		
DB	Design-Build		
DBB	Design-Bid-Build		
DPR	direct potable reuse		
GMP	guaranteed maximum price		
IPR	indirect potable reuse		
LACSD	Los Angeles County Sanitation District		
MF	membrane filtration		
MGD	million gallons per day		
PDB	Progressive Design-Build		
PRWA	Palmdale Recycled Water Authority		
Pure Water AV	Pure Water Antelope Valley		
PWD	Palmdale Water District		
PWRP	Palmdale Water Reclamation Plant		
RO	reverse osmosis		
Stantec	Stantec Consulting Services Inc.		
ТМ	technical memorandum		
UV/AOP	ultraviolet/advanced oxidation process		

Introduction May 2023

1.0 Introduction

Stantec Consulting Services Inc. (Stantec) was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional recycled water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). As part of that effort, several planning studies are underway for successful implementation of Pure Water AV. This technical memorandum (TM) provides an overview of delivery approaches available for the implementation of Pure Water AV and summarizes the process and outcome of the Project Delivery Workshop, during which the preferred delivery methods for the program components were selected.

1.1 Program Background and Drivers

PWD has been providing water service to its customers since 1918, when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the groundwater basin has been in overdraft since the 1930s resulting in land subsidence. In 1973, Palmdale Irrigation District changed its name to Palmdale Water District.

PWD has conducted a number of studies that date back to as early as the 1990s to evaluate the water resources necessary to meet future water supply demands. Concepts evaluated to date include using recycled water for landscape irrigation, discharging into Palmdale Lake, and discharging into existing sand and gravel pits to replenish the groundwater basin. In 2012, the Palmdale Recycled Water Authority (PRWA), comprising members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area. PRWA manages the distribution of recycled water and the design and construction of support facilities, and finances the efforts.

PWD has been exploring different concepts of groundwater banking, storage, and extraction. As part of that effort, PWD has conducted a series of pilot studies to determine the infiltration rates. Less than favorable results from the pilot studies led PWD to evaluate the feasibility of surface water augmentation and/or groundwater recharge via direct injection – two different forms of indirect potable reuse (IPR). Stantec was retained by PWD to conduct a feasibility study on IPR. Based on the results of the IPR feasibility study, PWD decided to pursue the concept further. Using tertiary effluent from the Los Angeles County Sanitation Districts' (LACSD) Palmdale Water Reclamation Plant (PWRP), PWD plans to produce potable quality water for groundwater recharge via direct injection.

1.2 Study Background and Objectives

The objective of Pure Water AV is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection (project). A key consideration for Pure Water AV is the program component delivery method assessment, which considers the complexity, time constraints, and risk of each program component, and identifies a suitable approach for program implementation. The project delivery methods available and utilized in the water/wastewater marketplace range from traditional Design-Bid-Build (DBB) to Alternative Project Delivery (APD) methods such as Design-Build (DB), Progressive Design-Build

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(PDB), and Construction Management at Risk (CMAR). The project delivery method selected for a particular project depends on a number of factors, such as legality of the delivery method for the entity in question, the goals of the project, the project schedule, and cost.

The objective of this TM is to discuss the attributes, advantages, and disadvantages of different project delivery methods, and summarize the preferred delivery method selected for each component of Pure Water AV based on the feedback received from PWD during the Project Delivery Workshop.

1.3 Technical Memorandum Structure and Content

This TM is divided into the following sections:

- Section 1 Introduction Provides the program background and drivers and study background and objectives.
- Section 2 Program Components Describes the major program components.
- Section 3 Delivery Methods Assessment Describes key drivers and selection criteria important to PWD, potential constraints related to PWD's contract mechanisms, and alternative delivery methods evaluated for this program.
- Section 4 Recommendations and Construction Schedule Provides a final recommendation and potential construction schedule for the chosen delivery method(s).

Program Components May 2023

2.0 Program Components

The major program components for Pure Water AV are still being defined and, therefore, this section provides a high-level description of these components (**Figure 1**).



Figure 1. Overview of Pure Water Antelope Valley's Major Components

Program Components May 2023

2.1 Demonstration Facility

The 100-150 gallons per minute (feedwater flow) advanced water treatment demonstration facility will be located adjacent to PWD's headquarters and will be fed tertiary effluent from the PWRP. It will consist of major unit treatment processes, including low-pressure membrane filtration (MF), reverse osmosis (RO) and ultraviolet/advanced oxidation process (UV/AOP). The demonstration facility will be used to:

- Determine the optimum process parameters for the full-scale facility
- Evaluate the operational and water quality performance of unit processes
- Support public outreach and acceptance of the project
- Collect necessary data to obtain regulatory approval of the full-scale facility

Once the necessary data is collected, PWD plans to continue operating the facility and use it as a learning center for public outreach and training center for water and conservation education.

2.2 Full-Scale Advanced Water Purification Facility

The Full-Scale Advanced Water Purification Facility (AWPF) will be designed to treat approximately 4.75 million gallons per day (MGD) of tertiary effluent from the PWRP for groundwater augmentation via direct injection. The facility could expand up to 10 MGD in a future phase. In addition to direct injection, PWD is also considering direct potable reuse (DPR) in future. The IPR treatment train at the AWPF will include MF, RO, and UV/AOP, while the DPR treatment train will include an additional ozone-biological activated carbon system upstream of the MF system. The components of the full-scale AWPF will also include operation and maintenance buildings, effluent pump stations, and chemical storage and dosing systems. The facility will include parking and other necessary amenities for the operation staff.

2.3 Injection Wells

Groundwater augmentation of the final treated effluent will utilize injection wells, sited within or nearby the AWPF. The injection well sites will be selected based on the outcome of the groundwater modeling analysis, which considers regulatory requirements, such as minimum travel time to existing extraction wells. The construction of the injection wells will include drilling wells, and installing well screens, injection pumps, and equipment. The injection system will also include a groundwater monitoring system and integrated control strategy per operations at the AWPF.

2.4 Conveyance

Three primary conveyance pipelines will be needed:

• Tertiary Effluent / Source Water to the AWPF: Tertiary effluent from the PWRP will serve as source water and will be conveyed to the AWPF. There is an opportunity to reduce the required length of the

Program Components May 2023

new pipeline by utilizing an existing 24-inch recycled water pipeline built to transport treated water for irrigation.

- **AWPF Product Water to the Injection Wells:** Treated water will be conveyed to multiple injection well sites via this pipeline. The diameter of the pipe will be based on future flows.
- **RO Brine to the Brine Evaporation Ponds:** This pipeline will be a much smaller diameter pipeline compared to the tertiary water pipeline, conveying only 10-15% of the influent flow. The location of the evaporation ponds is still being discussed, but for planning purposes, are assumed to be located at the old oxidation ponds owned by LACSD.

Overall, the design and implementation of the conveyance system is expected to be simple, involving mainly civil work to install the network of pipes and pump stations to transport the water.

2.5 Brine Ponds

The brine from the RO system will be conveyed to evaporation ponds at a separate nearby facility to facilitate brine disposal. Abandoned oxidation ponds owned by LACSD, which are located at 40th Street E and E Avenue P, may be used for this application. Construction will involve repurposing these ponds for brine evaporation and disposal. Due to the presence of nitrate-impacted groundwater in the area, it is crucial to utilize a liner that minimizes infiltration of brine (and subsequently nitrate and salts) into the soil. Based on the outcome of an ongoing brine management study, additional features to enhance evaporation rates, such as mechanical mixers and spray systems, may be considered for the construction of the evaporation ponds.

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Delivery Methods Assessment May 2023

3.0 Delivery Methods Assessment

This section describes the key priorities and drivers for PWD in the selection of delivery methods for different program components. PWD's contractual requirements and constraints will also dictate which delivery methods cannot be utilized. Therefore, a brief description of those requirements is also included in this section. Additionally, this section provides an overview of different delivery methods.

3.1 Key Selection Criteria

A Delivery Methods Assessment workshop was held on June 14, 2022, with PWD staff to discuss the key project drivers and selection criteria and the merits of different delivery methods, and to assist PWD in selecting methods for each program component. The workshop presentation is provided in **Appendix A** for reference. PWD staff indicated that, among many criteria presented, the following were important:

- Cost certainty
- Minimizing change orders
- Balanced risk
- Schedule certainty
- Qualifications-based selection of team members

Within these criteria, cost certainty was one of the most important for PWD to minimize rate changes to customers and maintain a level of integrity for its stakeholders. Utilization of outside funding sources (i.e., grants, loans, etc.) as effectively as possible to minimize the rate increase was also very important to PWD.

3.2 Palmdale Water District Contract Requirements and Constraints

There are statutory legal requirements that any delivery method considered must comply with to be judged viable. There are also constraints relative to PWD; and for this project in particular, that must be factored into delivery and procurement assessments. PWD is an independent special district formed under the California Water Code Division 11 and, as such, has the authority to establish its own rules and regulations. Procurement and Purchasing Policy (**Appendix B**) of PWD's Rules and Regulations establishes the bidding and contract procurement methods. Section 1 of the policy states that:

It is the policy of the District to ensure the maximum use of fair and open competition to obtain goods and services for operation at the lowest possible overall cost. However, notwithstanding this statement, all contracts for work and for acquisition of materials and equipment, may be made or entered into upon such terms and conditions and in such a manner as the Board may determine is in the best interest of the District.

Delivery Methods Assessment May 2023

While PWD has not used any alternative delivery method to date, per the rules and regulations, its Board may authorize to establish new contract mechanisms for different procurement and delivery methods.

3.3 Overview of Delivery Methods

As noted in Section 1, the delivery methods evaluated for Pure Water AV were:

- 1. Conventional DBB
- 2. CMAR
- 3. Fixed-price DB
- 4. PDB

Other APD methods, such as Design Build Operate, Design Build Operate Finance, and Design Build Operate Own Finance, were not considered for the program, due to PWD's preference to own and operate the facility.

The use of delivery methods other than DBB (i.e., APD methods) has become increasingly more commonplace due to owners' preferences to use qualifications-based selection of contractors; involve the contractor in the design phase of the project; reduce project schedule; allocate risk to the contractor; and lower litigation potential. The drivers for selecting a particular method can include legality and other project considerations, such as schedule and cost. **Table 1** summarizes different delivery methods considered for Pure Water AV.

In the conventional DBB delivery method, the owner selects the contractor based on lowest responsive, responsible, and qualified bid submitted per the construction documents, allowing a competitive bidding environment. The pricing structure for this method is typically fixed bid price and is suitable for projects that have a well-defined, relatively simple project scope. This method may be preferred when initial cost is the most important criteria, but results in greater potential for disputes and change orders.

In the CMAR method, separate contracts are utilized for engineering to perform the design and a construction manager is selected based on qualifications or best value. The construction manager is selected while the design is being developed to provide pre-construction services, including constructability reviews, cost savings ideas, construction scheduling, and development of a guaranteed maximum price (GMP). Cost proposals are developed as the design progresses, until a GMP can be agreed upon. The CMAR method is well suited for projects for which there is project scope uncertainty and flexibility in aligning cost, and where project scope is beneficial. This method facilitates a collaborative and innovative approach with the potential to shorten schedule and allows the owner to retain control over the design. Some drawbacks include managing multiple contracts, difficulty in negotiating GMP, public perception due to lack of fixed-price at the time of award, and the owner retaining design risk.

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The remaining two alternative methods, DB and PDB, involve a designer/builder team submitting proposals based on the owner's specification; thus, the methods allow a single point of contract responsibility for both the design and construction of the project. The fixed-price DB method is both performance-driven and cost-competitive by establishing price at time of award, which may result in a best value-based, innovative, and shortened schedule delivery method. Some of the drawbacks are limited owner input into design, complicated procurement, and price determination prior to complete design. PDB differs from DB in that the construction cost is "progressively" developed in open-book format until GMP can be agreed upon between the design-builder team and the owner. Similar to DB, the PDB method is performance driven and has potential to shorten schedule. The PDB also allows significant owner input into design and is the preferred method when controlling scope relative to the project is a driver. The drawbacks of PDB include complicated procurement, potential difficulty in negotiating GMP, and public perception due to lack of fixed-price at time of award.

Delivery Methods Assessment May 2023

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Method Description	Structure	Advantages	Disadvantages	Applications	Reasons to Consider			
	CONVENTIONAL DELIVERY METHOD							
Design Bid Build (DBB) A project delivery method in which the owner selects an engineer to design and develop construction documents, from which the owner solicits lump sum bids. Selection is based on the lowest responsible bid and the contractor serves as a single point of responsibility for construction.	Owner Designer Subconsultants Subcontractors	 Owner and contractor familiarity High level of owner control over design elements Project scope fully defined at commencement of construction Competitive bidding environment Procurement typically handled by owner's staff (no Owner's Advisor) 	 Sequential schedule Construction cost only determined at bid time (engineer's estimate during design) Selection based on low bid from contractor (qualified?) No construction contractor input during design. Cost impacts of design decisions not visible Greater potential for disputes and change orders Owner warrants design to contractor 	 Well-defined, relatively straight- forward project Schedule is not a driver Pipeline projects Treatment facility replication upgrades without significant unknowns or coordination with other parties anticipated 	 Delivery method that the owner is used to Confidence in pool of potential contractors Initial low cost is the most important criteria for selection Perception of cost competitiveness Complete owner control over the design is important Alternative delivery is not allowed or difficult to incorporate into existing practices 			

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Table 1. Summary of Delivery Methods Considered for Pure Water Antelope Valley (contd.)

Method Description	Structure	Advantages	Disadvantages	Applications	Reasons to Consider				
	ALTERNATIVE DELIVERY METHODS								
Construction Management at Risk (CMAR) A project delivery method in which the construction manager (CM) serves as the general contractor providing pre-construction and construction services, while the engineer completes design under a separate contract. Cost proposals are developed during design until a Guaranteed Maximum Price (GMP) is agreed upon.	Owner Designer Subconsultants Subconsultants	 Qualifications-based selection of designer and CM Collaborative relationships and teamwork Contractor input into design Open-book cost development Cost model established earlier in project Shortened schedule potential Ability to design and deliver project to fixed budget 	 Involvement of CMAR during design does not relieve owner of design risk Negotiating GMP sometimes difficult Managing multiple contracts by owner Performance guarantees not available Potential public concerns or perceptions with cost development process No fixed-price at time of contractor selection 	 Projects that require contractor input during design Treatment facility upgrades requiring innovative ideas from contractor Flexibility needed Projects in which there are uncertain conditions or requirements that would benefit from progressive development of design and costs as project is defined 	 Contractor design input important Controlling scope relative to budget is important Contractor innovation Contractor quality (qualifications-based selection) Owner wants to retain control of design 				

Delivery Methods Assessment May 2023

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Table 1. Summary of Delivery Methods Considered for Pure Water Antelope Valley (contd.)

Method Description	Structure	Advantages	Disadvantages	Applications	Reasons to Consider			
	ALTERNATIVE DELIVERY METHODS							
Fixed-Price Design Build (DB) A project delivery method that requires prospective design-builders to submit lump sum proposals based on the owner's specifications and project concept (usually a preliminary design). The selected design-builder works under a single contract and is required to deliver a project that meets the owner's specifications at the proposed lump sum price.	Owner Designer/ Builder Subconsultants/ Subcontractors	 Best value-based selection (qualifications and price) Shortened schedule potential Transfer of design- related performance risk to DB team Single point of responsibility for both design and construction Performance guarantees available Innovation from DB team allows potential cost savings Price competition (lump sum bid) and price established at time of award 	 Owner does not hold design contract DB contract price established prior to complete design typically leading to higher risk contingency included in bid Process to procure design-builder more complicated and costly than DBB or PDB Existing conditions and permitting uncertainty prior to contract award Owner's involvement in design is limited after contract award Design-builder is not involved in preliminary engineering 	 Projects that require contractor input during final design (after lump sum proposal) Projects in which there is sufficient preliminary design or performance definition to allow design-builder to scope project and provide lump sum bid Treatment facility upgrades requiring innovative ideas and design/ construction flexibility 	 Schedule is a driver Risk allocation important Contractor innovation Contractor quality (best value-based selection) Single point of responsibility 			

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Table 1. Summary of Delivery Methods Considered for Pure Water Antelope Valley (contd.)

Method Description	Structure	Advantages	Disadvantages	Applications	Reasons to Consider	
		ALTERNATIVE DEL	VERY METHODS			
Progressive Design Build (PDB) A project delivery method in which design-builder is selected based primarily upon qualifications (design costs or fee sometimes considered). Once selected, design commences and a construction cost estimate is "progressively" developed in an open-book format until a Guaranteed Maximum Price (GMP) can be agreed upon between the design-builder and owner.	Owner Designer/ Builder Subconsultants/ Subcontractors	 Qualifications-based selection; efficient procurement process Shortened schedule potential Transfer of design- related performance risk to DB team Single point of responsibility for both design and construction Open-book cost development Owner significantly involved in design process Innovation from DB team allows potential cost savings Early cost development by contractor 	 Owner does not hold design contract Procurement/selection of DB more complicated than DBB No fixed-price at time of design-builder selection Potential public concerns or perceptions with cost development process Negotiating GMP can sometimes be challenging 	 Projects that require contractor and owner input during design Treatment facility upgrades requiring innovative ideas and design/constructi on flexibility Projects in which there are uncertain conditions or requirements that would benefit from progressive development of design and costs as project is defined 	 Schedule is a driver Controlling scope relative to budget is important Contractor innovation Contractor quality (qualifications-based selection) Single point of responsibility Risk allocation important 	

Delivery Methods Assessment May 2023

3.4 Delivery Method Comparison

The following sections provides a high-level comparison of the project delivery methods considered for Pure Water AV.

3.4.1 PROJECT RISK ALLOCATION

Project risk can be managed and/or mitigated through the use of different delivery methods. In both DBB and CMAR delivery methods, the owner retains design risk and holds much of the overall schedule risk, because they are responsible for coordinating both the design and construction, which are performed by two different entities. Whereas in DB and PDB, since a single entity is responsible for both design and construction, design risk and construction risk can be placed on the design-builder. The optimal approach to control risk is by allocating each risk to the party best able to manage it in order to reduce risk premiums and costs.

3.4.2 OWNER INVOLVEMENT

The owner will have a high level of involvement and input throughout the design phase for DBB, CMAR, and PDB; whereas the owner's involvement in a DB design is limited after the contract is awarded. For this reason, DB was no longer considered for Pure Water AV.

3.4.3 MAJOR EQUIPMENT PROCUREMENT

Available mechanisms for major equipment procurement include conventional (open source), prequalify, preselect/assign, and prepurchase. All are acceptable means of system and equipment procurement within PWD; however, due to the proprietary nature of some of the treatment systems, prequalification and/or preselection may be desirable. Stantec will work with PWD to identify the best procurement approach for each treatment system when preparing the bridging documents. In a PDB or CMAR model, specialty and/or long-lead equipment could be procured as an early package prior to completion of the full design, thus reducing the overall project schedule.

3.4.4 SUMMARY

Overall, projects that are less complex and well-defined can benefit from the traditional DBB method, while alternative methods should be considered for projects that may require innovation and qualificationbased selection. For projects that seek the performance benefits of alternative methods, and also have sufficient design or performance definition to allow price determination at time of award, DB may be a well-suited approach. Conversely, for projects that are less developed and for which the owner wants to continue to provide input as the design develops, either CMAR or PDB would be more suitable alternatives. PDB would be a preferred approach if the owner would like to maintain a single point of responsibility and transfer cost and schedule risk to the awardee, while CMAR is the more preferred approach if the owner would like to maintain a direct contractual relationship with the designer and incorporate contractor input during design development.

Recommendations and Construction Schedule May 2023

4.0 Recommendations and Construction Schedule

Based upon the nature of the new facilities planned, and in consultation with PWD staff, Stantec recommends delivering this program in four separate packages:

- Demonstration Facility: The demonstration facility will consist of packaged vendor systems that can easily be pre-purchased, and the remainder of the demonstration facility will be DBB. Prepurchasing this equipment will expedite both the design and construction periods for this project package.
- 2. Conveyance Pipelines (Tertiary Effluent, AWPF Product Water, and RO Brine Ponds): These program components have straightforward designs. Change orders can be minimized by careful design and competitive bidding would allow for cost control. Due to the relatively simple nature of construction for these components, they do not drive the schedule and, therefore, design and construction can be staged. Based on these factors, DBB was selected as an appropriate delivery method by PWD for these program components.
- 3. **Injection Wells**: Similar to conveyance pipelines, injection well designs are also straightforward. A well-thought-out design would allow PWD to minimize change orders. Staging of design and construction is not expected to impact the schedule. Based on these factors, DBB was selected as an appropriate delivery method by PWD for these program components.
- 4. AWPF and Brine Ponds: The AWPF will be a complex facility with a lot of room for innovation in reducing the cost and achieving schedule compression. Starting some construction activities earlier for the AWPF will also be crucial to maintain overall program schedule. Although brine ponds are simpler to design and construct, bundling them in the same package as AWPF would allow early construction. It is also important for PWD to obtain a cost estimate at different design levels and adjust the design, if necessary, to control the construction cost. For these reasons, PDB was selected by PWD as delivery method for these program components.

A simplified construction schedule meant for planning purposes only, shown in **Figure 2**, depicts periods for engineering, procurement and bidding, construction, and commissioning activities. More detailed schedules will be provided in future project stages as these packages are developed further.

Recommendations and Construction Schedule May 2023

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	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
Package 1 - Demostration Facility (DBB)							
Equipment Procurement							
Engineering and Design							
Contractor Bidding							
Construction							
Commissioning							
Package 2 - Conveyance Pipelines (DBB)							
Designer Selection							
Engineering and Design							
Bidding							
Construction							
Commissioning							
Package 3 - Injection Wells (DBB)							
Designer Selection							
Engineering and Design							
Bidding							
Construction							
Commissioning							
Package 4 - AWPF and Brine Ponds (PDB)							
Design Builder Selection							
Engineering and Design							
Procurement and Bidding							
Construction							
Commissioning							

Figure 2. Simplified Pure Water Antelope Valley Project Package Implementation Schedule

APPENDIX A

Presentation Slides for Workshop 4 – Project Delivery Methods Assessment

June 14



Project Delivery Methods Review

Palmdale Regional

Water Augmentation Program







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Project Overview and Objectives

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Selecting a Delivery Method NEXT STEPS

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Project Overview

- 5 mgd from PWRP
- Demo Facility
- Conveyance
- AWPF
- Injection Wells
- Brine Ponds



Project Costs

Total Capital Cost (\$M)	\$74.0
Low Range: -50% (\$M)	\$37.0
High Range: +50% (\$M)	\$111.0
\$/gpd (effluent flow)	\$19.3
\$/acre-ft (effluent flow)	\$861
Workshop Objectives

- To discuss the attributes, advantages and disadvantages of different project delivery methods; and
- To discuss the approach for selecting a delivery method for a specific project



Tailor Delivery Method Selection to fit the Owner & Project







Consider your KPI's for successful procurement

Schedule Risk Allocation Owner input / control Early commitment to costs Complex construction / interface to ongoing operations

Assess your current delivery approach

What works What doesn't work

What are your reasons for change

Gaps in current process Change in drivers / outcomes

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Common Drivers for Utilizing APD

Common Drivers	Applicability/Need
Qualification-Based Selection of Team Members	??
Value added through Collaborative Design Development	??
Project with High Complexity and/or Unknowns	??
Interface with ongoing operations (brownfield construction)	??
Minimization of Change Orders	??
Reduced / Accelerated Project Schedule	??
Risk Allocation Control	??
Improved Efficiency /Quality	??
Cost Certainty	??
Schedule Certainty	??
Short of Resources (O&M)	??
Alternative Financing Options	??

Specific Drivers Influencing Collaborative Project Delivery according to Utility Owners



Note: Height of each colored blocks shows the number of respondents

Reasons Owners Choose Collaborative Delivery

Source - 2018 Water Design Build Council (WDBC) research study

Risk Allocation





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Project Delivery Methods

Delivery Method	Allowable?	Applicable?
Design-Bid-Build (DBB)	??	Yes
Construction Manager at Risk (CMAR)	??	Yes
"Fixed-Price" Design/Build (D/B)	??	Yes
"Progressive" Design/Build (PD/B)	??	Yes
Design-Build-Operate (DBO)	<u>??</u>	??
Design-Build-Operate-Finance (DBOF)	??	??
Design-Build-Operate-Own-Finance (DBOOF)	??	??

Overview of Delivery Methods

- Contractual Relationship
- Cost and Design Development Timeline
- Advantages/Disadvantages
- "Typical" Applications of and Reasons for using Delivery Method

Project Delivery Methods

Design-Bid-Build (DBB) Construction Manager at Risk (CMAR) Fixed Price Design Build (FPDB) Progressive Design Build (PDB)

Design-Bid Build (DBB)

Alternate Terminology

- Public
- Conventional
- Competitive Bidding

Pricing Structure

- RFPs and/or Tender, and
- Typically Fixed Bid Price (LS)



Cost Model Timeline - DBB



Advantages	Disadvantages	
• Owner and contractor familiarity	Sequential schedule	
 High level of owner control over design elements 	 Construction cost only determined at bid time (engineer's estimate along the way) 	
 Project scope fully defined at commencement of construction 	• Typically selection based on low bid (however some public agencies have started to include	
 Simple and Competitive bidding environment 	 qualifications based selection) No/limited construction contractor input during design 	
 Procurement typically handled by owner's staff (not consultant) Farly cost certainty (at time of tender) 	 Greater potential for disputes and change orders 	
	 Owner warrants design to contractor 	
Advantages/Disadvantages - DBB		

Typical Applications/Reasons for Using DBB

"Typical" Applications

- Well-defined, relatively straight-forward project
- Schedule is not a driver
- Simple conveyance projects
- Treatment facility replication upgrades without significant of unknowns anticipated or limited interface with existing operations

"Typical" Reasons

- Delivery method that the owner is used to
- Confidence in pool of potential contractors
- Initial low cost is the most important criteria for selection
- Perception of cost competitiveness
- Complete owner control over the design is important
- Alternative delivery is not allowed or difficult to incorporate into procurement policies/procedures

Construction Manager at Risk (CMAR)

Alternate Terminology

 Construction Manager/General Contractor (CM/GC)

Pricing Structure

Negotiated GMP



Cost Model Timeline - CMAR



Advantages

- Qualifications-based selection (QBS) of Contractor
- Separate QBS of Designer
- Collaborative relationships and teamwork
- Contractor input into design including estimate development, scheduling, sequencing and early works procurement
- Cost model established earlier in project
- Offers potential for accelerated schedule and/or phased construction (work packages)
- Ability to design and deliver project to set maximum budget
- Risk and Contingency owned by Owner

Involvement of CMAR during design does not relieve owner of risk

Disadvantages

- Negotiating GMP sometimes difficult
- Owner required to manage multiple contracts
- Performance guarantees not typically available
- Increased overhead associated with monitoring CM in open book delivery model

Advantages/Disadvantages - CMAR

Typical Applications/Reasons for Using CMAR

"Typical" Applications

- Projects that have potential for added value with contractor input during design (complexity and/or need for contractor innovation)
- Treatment facility or conveyance upgrades requiring innovative construction approach, complex interface with ongoing operations and design/construction flexibility

"Typical" Reasons

- Contractor design input important
- Controlling scope relative to budget is important
- Value realized by Contractor innovation
- Contractor quality (qualifications-based selection)
- Owner wants to retain control of design
- Flexibility to accelerate, stage or modify schedule

Fixed Price Design Build (FPDB or DB)



DB Variations

Fixed-Price Lump Sum DB Traditional DB

Pricing Structure Fixed Bid Price (LS)

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Cost Model Timeline - Fixed Price DB



Advantages	Disadvantages
Qualifications and price-based selection	Owner does not hold design contract, and
 Shortened schedule potential 	has limited input into the design
 Transfer of design-related performance risk to D/B team 	 D/B contract price established prior to complete design
 Single contract to manage by Owner 	Procurement/selection of D/B can be complicated to develop contracts & povigate
Performance guarantees available	legal/supply if not familiar
 Innovation from D/B team allows potential cost savings 	 Existing conditions and permitting uncertainty prior to D/B contract*
 Early cost determination 	
	*may apply

Advantages/Disadvantages - DB

Typical Applications/Reasons for Using D/B

"Typical" Applications

- Performance criteria driven
- Not critical to have heavy involvement by Owner in design details
- Projects that may benefit from innovation

"Typical" Reasons

- Schedule is a driver
- Cost Certainty is a priority
- Contractor innovation can lead to lower Capex (however typical at a trade off)
- Contractor quality (qualifications-based selection) if multi-step selection process
- Single point of responsibility



DB Variations

• Progressive

Pricing Structure

- Guaranteed Maximum Price (GMP)
- Open Book
- Negotiated LS



Owner's

Consultants

Owner

Engineering

Subconsultants

Design-Build

Contractor

Subcontractors

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Suppliers

Cost Model Timeline – Progressive D/B



Advantages Disadvantages Negotiating GMP can be challenging Similar advantage to DB plus: Off-ramp process may be necessary and • Owner has more control and input into asset disruptive through design up until GMP Assigning responsibility for design to new Project can start with less technical and party may be problematic procurement planning than a traditional competitive DB leading to potential Cost certainty not determined until later in design process after proponent selection administration and schedule savings Perception of less cost competitiveness

Advantages/Disadvantages - PDB

Typical Applications/Reasons for Using PDB

"Typical" Applications

- Projects in all sectors that allow for qualifications based selection
- Added value of a collaborative design and construction team with owner input
- Complex projects
- Desire for single point of accountability

"Typical" Reasons

- Owner wants heavy involvement in design development
- Owner requires single source responsibility for total project delivery on a fast-track schedule
- Benefits of DB but mitigating its disadvantages with simplified procurement and reduced uncertainty in DB process through Owner involvement in design development

Comparison of D/B Approaches

Fixed-Price D/B

- Price competition (lump sum bid)
- Price established at time of contract award
- Owner's involvement in design is limited after contract award
- Design/Builder is not involved in preliminary engineering
- Competitive procurement requires time/cost investment

Progressive D/B

- Owner substantially involved in design phase
- Procurement of Design-Builder efficient and streamlined
- Price established after contract award
- Flexibility to design to budget
- Negotiating price can sometimes be challenging

"Price" Options for D/B Procurement





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Selecting a Delivery Method NEXT STEPS

Delivery Model Comparison

Factors	Design-Bid-Build	Construction Management at Risk	Design-Build	Progressive Design-Build
Project Complexity	All levels of complexity	All levels of complexity	Low levels of complexity	All levels of complexity
Owner Experience	All levels of experience	Medium levels of experience	Medium levels of experience	Medium
Time constrained (schedule driven)	Not Appropriate	Fast-track delivery	Fast-track delivery	Fastest-track delivery due to less upfront planning
Process Costs	Low – industry accepted processes with standardized contracts	Low to Medium – industry accepted processes with standardized contracts but higher oversight with open book reporting	Low – industry accepted processes with standardized contracts	Low – industry accepted processes with standardized contracts
Cost Certainty At Construction Start	High – Stipulated Sum / Lump Sum Contract Amount	Medium – depending on extent of major trade awards	High – Design Build Contract Amount	High – GMP sets upper limit
Owner Risk Tolerance	Owner retains cost & schedule risk	Owner retains cost & schedule risk	Owner transfers cost & schedule risk to DB upon award of contract	Owner transfers cost & schedule risk to PDB upon award of contract
Quality Standards	Consultant reviews against contract documents	Joint responsibility between CM and Consultant	Depended on the DB specifications and compliance reviews	High – Owner establishes these with the design-builder
Cash Flow Considerations	Progress payments during construction	Progress payments during construction	Progress payments at agreed stages	Progress payments at agreed stages
Flexibility for Owner Changes	Moderately Flexible	Highly Flexible	Limited	High



Overview of Selection Process

Step 1.

Identification of Project Package Drivers and Goals

Typical Questions to Ask to Understand Drivers/Goals

- ✓ Does schedule need to be accelerated?
- ✓ Allocation of design risk to contractor?
- ✓ When is cost certainty required?
- ✓ Qualifications-based selection of contractor?
- ✓ Contractor involvement during design a benefit?
- ✓ Project complexity and level of unknowns?
- ✓ Low-bid required/desired?
- ✓ Operations contract?
- Financial return on investment potential (investor interest)?
- ✓ Early equipment procurement required?
- ✓ Would project benefit from contractor flexibility/innovation?

Step 2.

Determine Suitable Delivery Methods





Step 3.

Define Evaluation Criteria and Obtain Stakeholder Input to Determine Relative Importance

Evaluation Criteria	Sample %
Level of Control/Innovation	24
Schedule	26
Cost	30
Risk Allocation	20
TOTAL	100



Determine Weighting through stakeholder engagement focus groups (similar to project prioritization)

Sub Criteria	Description
O&M Preferences	Will the City be able to implement their O&M preferences?
Sustainability	Does the delivery method affect the ability to be incorporate project sustainability requirements?
Contractor Quality	To what extent will the City be able to control selection of contractor?
Project Quality	How does the delivery method impact the quality of the project including opportunities for innovation in design, construction, and project delivery?
City Resources (Staffing)	How does the procurement method impact the City's staffing needs?



Sub Criteria	Description
Implementation Duration	How does delivery method impact project implementation schedule/project duration?
Construction & Operational Flexibility	Does the delivery method readily allow for changes to the project if operational, cash flow or construction improvements are identified; or unknowns require adjustments

Schedule
Sub Criteria	Description
Cost Competitiveness	Will the delivery method produce a project cost that is within the range of costs for other methods of delivery?
Cash Flow	Are the cash flow requirements of the delivery method consistent with the City's financial plans and funding level?
Cost Certainty	Will the delivery method provide cost certainty that can be determined early in the development of the project and how soon?
Market and Industry Viability	Are the market and industry conditions such that the delivery method would result in a process that is competitive?

Cost

Sub Criteria	Description
Project Size & Complexity	Does the project's size and complexity provide an opportunity to realize the advantages associated with a delivery method?
Impact on Public	Will the delivery method result in a project that will reduce or minimize impact to the public?
Legislative & Legal	Does the City have the necessary legislative authorizations to utilize the delivery method?
Contractual	How does the delivery method allocate risk and is it in a manner acceptable to the City?
Regulatory Compliance	Does the delivery method impact the City's ability to comply with regulatory and permitting requirements that will be imposed on the project?
Right-of-Way & Environmental Permitting Control	Will timing for acquisition of right-of-way / land use or environmental permits be impacted by the delivery method?

Risk Allocation

Step 4.

Utilization of Evaluation Matrix to Select Preferred Delivery Method

	Weighting		DBB	CM/GC		D/B		PD/B	
	Factor	Rank	Score	Rank	Score	Rank	Score	Rank	Score
LEVEL OF CONTROL	24	4	96	4	96	3	72	4	96
SCHEDULE	26	2	52	4	104	5	130	4	104
соѕт	30	3	90	4	120	4	120	4	120
RISK ALLOCATION	20	2	40	3	60	4	80	5	100
Total Points	100	278		380		402		420	

1 = Least Favorable; 2 = Less Favorable; 3 = Neutral; 4 = Favorable; 5 = Most Favorable

OR

	Weighting	D	BB	CM	/GC	D	/В	PD	/В
	Factor	Rank	Score	Rank	Score	Rank	Score	Rank	Score
LEVEL OF CONTROL	24								
O&M Considerations	4.8	5	25	4	20	2	10	4	20
Sustainability	4.8	4	20	3	15	2	10	3	15
Level of City Control	4.8	5	25	4	20	2	10	3	15
Project Quality	4.8	2	10	4	20	3	15	5	25
City Resources	4.8	2	10	3	15	4	20	3	15
SCHEDULE	26								
COST	28								
RISK ALLOCATION	22								
Total Points	100	2	.78	38	30	40)2	42	20

1 = Least Favorable; 2 = Less Favorable; 3 = Neutral; 4 = Favorable; 5 = Most Favorable

Open Discussion and Next Steps

ALL DIN D

APPENDIX B

Palmdale Water District Rules and Regulations – Appendix M, Procurement and Purchasing Policy

APPENDIX M

PROCUREMENT AND PURCHASING POLICY

RESOLUTION NO. 20-15 A RESOLUTION OF THE BOARD OF DIRECTORS OF THE PALMDALE WATER DISTRICT ADOPTING AN AMENDMENT TO APPENDIX M, BID PROCUREMENT AND CHANGE ORDER POLICY, OF THE PALMDALE WATER DISTRICT'S RULES AND REGULATIONS

WHEREAS, Appendix M, Bid Procurement and Change Order Policy, of the Palmdale Water District's Rules and Regulations establishes the manner of calling for bids and letting contracts for the performance of work for the District or the acquisition of materials or equipment; and

WHEREAS, pursuant to Appendix M, the General Manager shall have the authority to authorize all contracts for any work or unit of work and all acquisitions of materials or equipment estimated to cost or to have a value when completed of less than \$10,000.00; and

WHEREAS, in accordance with said December 2019 CCI as reported by the ENR and as stated in said Appendix M, the appropriate Board Committee shall have the authority to authorize all contracts for any work or unit of work and all acquisitions of materials or equipment having been submitted by either informal or formal bids estimated to cost or to have a value when completed of more than \$10,000.00, but no more than \$50,000.00; and

WHEREAS, the Palmdale Water District ("District") desires to update Appendix M, the Bid Procurement and Change Order Policy, of the District's Rules and Regulations to update approval limit comparable to other water agencies and current Construction Cost Index (CCI) as reported by the Engineering News Record (ENR) by the percentage increase of the indexes from December 1990 and December 2019; and

WHEREAS, the District also desires to clarify the delegation of authority regarding requisitions and invoice approval for work and acquisition of materials or equipment budgeted in the annual budget process and change the policy's name to Procurement and Purchasing Policy to reflect this addition.

NOW THEREFORE, BE IT RESOLVED THAT THE BOARD OF DIRECTORS OF THE PALMDALE WATER DISTRICT DOES HEREBY RESOLVE AS FOLLOWS:

SECTION 1. Notwithstanding any contrary provision in Article 17 of the Palmdale Water District's Rules and Regulations, approval authorities are updated and added to Appendix M, as set forth in Exhibit "A" to this Resolution.

SECTION 2. The District shall rename said Appendix M to Procurement and Purchasing Policy.

SECTION 3. Upon the effective date of this Resolution, adopted herein, the Resolution shall supersede any and all prior resolutions adopted that are in conflict with this Resolution.

SECTION 4. If any provision in this Resolution, or the application thereof to any person or circumstances, is for any reason held invalid, the validity of the remainder of this Resolution, or the application of such provisions to other persons or circumstances shall not be affected thereby. The Board of Directors hereby declares that it would have passed this Resolution, and each provision thereof, irrespective of the fact that one or more sections, subsections, sentences, clauses or phrases or the application thereof to any person or circumstance be held invalid.

SECTION 5. This Resolution shall become effective upon the date of adoption as set forth herein.

PASSED, APPROVED AND ADOPTED on this 12th day of October 2020 by the Board of Directors of the Palmdale Water District.

Vincent Dino, President Board of Directors Palmdale Water District

Don Wilson, Secretary Board of Directors Palmdale Water District

APPROVED AS TO EORM:

Aleshire & Wynder. LLP Eric Dunn, District General Counsel

EXHIBIT "A"

APPENDIX M

PROCUREMENT AND PURCHASING POLICY

01184.0001/664844.1

PROCUREMENT AND PURCHASING POLICY

I. Statement of Policy

This statement of policy establishes the guideline for purchasing approval and letting contracts for the performance of work for the District or the acquisition of materials or equipment. It is the policy of the District to ensure the maximum use of fair and open competition to obtain goods and services for operation at the lowest possible overall cost. However, notwithstanding this statement, all contracts for work and for acquisition of materials and equipment, may be made or entered into upon such terms and conditions and in such manner as the Board may determine is in the best interest of the District.

II. Principles

A. The following apply to all purchases made by the District, unless otherwise exempted as set forth herein:

1. No purchase will be approved or undertaken unless it has been budgeted for, either through the adopted annual budget or Board approval of additional appropriations. It is the responsibility of the Department Manager to maintain control of their departmental budgets.

2. Emergency: The determination of the existence of an emergency condition shall be at the direction of the General Manager or his designated representative. In the event of an emergency, the General Manager or his designated representative may negotiate and award contracts for construction of work to prevent damage or repair damaged works without advertising for bids and expend any sum reasonably required in the emergency as outlined in Section 4.03.3(b) of the District's Rules and Regulations. The General Manager shall report to the Board of Directors, at its next meeting, the reasons justifying why the emergency will not permit a delay resulting from a competitive solicitation for bids and why the action is necessary to respond to the emergency.

All purchases shall be of the quality deemed necessary to meet District standards.

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4. Competitive offer requirements are set out in subsequent sections of this policy and are

established based on type of purchase and/or established dollar limits.

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 A purchase, including capital projects, shall not be split to avoid required procedures or established dollar limits.

6. No purchase shall be made without authorized requisition, Purchase Order (PO), contract or agreement unless exempted in these guidelines. The following purchases are exempt from these procedures:

i. Utilities

ii. Insurance premiums

iii. Membership renewals and subscriptions

iv. Postage and mailing services

v. Certain employee expense reimbursements

vi. Tuition reimbursements

vii. Conferences, seminars, and training expenses

viii. Travel expenses

ix. In emergency situations where time is of the essence

Authorized requisition process and approval rules are detailed in the District's

Requisition/PO procedures. Any changes or modifications to the procedures must be approved by the General Manager.

8. No District employee or Board member shall have a direct or indirect financial interest in any contract or purchase of goods or services entered into by the District, or shall derive any personal benefit that violates California law as a result of the District's purchase of goods and services.

 Any District employee or Board member failing to follow the procurement policy and procedures may incur personal liability or financial obligation to the vendor.

B. Exceptions to Competitive Offer Requirements

As applicable in Section III through V, the informal offers and the formal bidding process may be bypassed with General Manager approval in the following instances:

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 In emergency situations where time is of the essence, pursuant to the principles in Section II(A)(2).

Where a single source of sole source purchase is justified.

3. When there exist other governmental contracts that were competitively bid within the last year that the District is eligible to use and would result in a lower price to the District.

 When an item has been previously bid and the price has not changed by more than three percent (3%).

5. When it is not possible, practical, or cost effective to continue soliciting offers to meet minimum of three (3) bids provided that staff will use its best efforts to obtain competitive offers.

III. General Supplies, Materials and Equipment

General supplies, materials and equipment shall consist of any and all tangible items necessary for day-to-day operations, excluding goods purchased as part of a Construction Contract or Professional Agreement (Section IV). These purchases are included in the annual budget. All purchases must be approved through the District's Requisition/PO process unless otherwise specified.

- A. General Purchase ≤ \$10,000 Purchases of \$10,000 or less do not require competitive offers. Use of a Request for Quote (RFQ) or Request for Proposal (RFP) is encouraged when appropriate but not required.
- B. General Purchase > \$10,000 to \$50,000 Purchases between \$10,000 and \$50,000 must be approved by the Finance Manager or Assistant General Manager. The Department Manager should make a reasonable attempt to obtain at least two written quotes. The use of RFQ or RFP is strongly encouraged but not required.
- C. General Purchase between \$50,001 and \$100,000 Purchases between \$50,001 and \$100,000 must be approved by the General Manager. Where practical, formal bidding should be used to assure that the District is getting the best value. The Department Manager shall evaluate the quotes/proposals (formal or informal) received and determine the best value.

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D. General Purchase over \$100,001 – Purchases above \$100,001 shall be formally bid when practical. The formal process generally takes more time and expense than informal quotes. In some instances, it may not be the most cost-effective approach. Exceptions to the formal bid process are considered on a case by case basis.

IV. Construction Contract and Professional Agreement

A. Work Cost More Than \$50,000

- 1. Except as otherwise provided in this statement of policy, all contracts for any improvement, job, construction project or unit of work (herein referred to as work), and all acquisitions of material or equipment, estimated to cost or to have a value when completed in excess of Fifty Thousand Dollars (\$50,000) shall be competitively bid and awarded to the lowest responsible bidder in the manner hereinafter provided.
- 2. The Contract documents shall be prepared utilizing the District's standard forms with such modification as may be appropriate for the particular work or unit of work, or the acquisition of materials or equipment. The documents to be prepared shall ordinarily include the Notice Inviting Bids, Instructions to Bidders, the Proposal for submission by the bidder, the Information Required of Bidder, setting forth the equipment and material source and other required information, Contractor's Licensing Statement, List of Subcontractors, Bid Security Form, Agreement, Faithful Performance Bond, Payment Bond, Non-Collusion Affidavit, Notice to Proceed, General Provisions, Special Provisions, and Plans and Specifications.
- 3. Unless otherwise required by the provisions of the Public Contract Code, the District may advertise either electronically via a web base bidding service or in printed publications, for inviting proposals for furnishing labor for or materials or supplies for use or incorporation in, the proposed work or unit of work, or for providing materials or equipment. To the extent applicable to a specific work or acquisition, the notice calling for bids shall contain the information specified in Section 20564 of the Public Contract

Code. In the event that the construction of works is to be paid for with the proceeds of the sale of bonds or a limited assessment, the District shall give said notice by publication once a week for three (3) successive weeks in a newspaper of general circulation published in the District as specified in Section 20563 of the Public Contracts Code.

4. All bids shall be presented on forms furnished by the District either electronically or sealed bid, and it shall be accompanied by one of the following forms of bidder's security: (1) cash, (2) a cashier's check made payable to the District, (3) a certified check made payable to the District, or (4) a bidder's bond executed by an admitted surety insurer made payable to the District.

- At the time, place appointed, and set forth in the Notice Inviting Bids, the bids shall be available either on the bidding service website or opened in public.
- The District shall assign a five (5) percent contract bid reduction to a bidder which is a "Local Contractor or Vendor" as defined in (13)(i).
- 7. The Board may reject any and all proposals or bids should it deem it to be for the public good, or may award the contract for the work or unit of work, or materials or equipment, to the lowest responsible bidder at the prices named or specified in the bid or proposal subject however to Paragraph 8.
 - 8. Once all bids have been opened or received electronically through a web based bidding service, the bids of those bidders which are "Local Contractors or Vendor" shall be reduced by five percent (5%) for purposes of determining the lowest responsible bidder. If the bid of a Local Contractor or Vendor, after applying the contract bid reduction provided for in Paragraph 6, is then the lowest responsible bid, that Local Contractor or Vendor shall be awarded the contract at the amount of its bid without regard to any contract bid reduction, subject to the remaining provisions of this policy.
 - 9. The District or its agents may refuse to award a contract under Paragraph 8 to a Local Contractor or Vendor if it makes a determination that the products purchased or work

provided by a bidder cannot be provided within a timely manner for the performance of the contract or a determination the Local Contractor or Vendor cannot meet specified quality performance standards or experience requirements.

- 10. If any federal or state statute or regulation precludes the granting of federal or state assistance or reduces the amount of that assistance for a particular public works project because of a preference awarded according to the terms of this policy, this policy shall not apply insofar as its application would preclude or reduce federal or state assistance for that work.
- 11. In the case of work to be performed for the District, the District shall require the successful bidder or bidders to file with the Board good and sufficient bonds, to be approved by the Board, conditioned upon the faithful performance of the contract and upon payment of all claims for labor and materials in connection therewith.
 - 12. In the case of work to be performed from the District, the District shall require the successful bidder or bidders to carry public liability and property damage insurance, workers' compensation insurance, and other insurance, in the amounts and under the terms stipulated in the Contract documents.
- 13. The following terms shall have the following meanings:

 i) "Local Contractor or Vendor" means a contractor or vendor whose principal place of business as reflected in official records is located in the area shown on the Local Contractor and Vendor Boundary Map attached hereto. Those claiming to be Local Contractors and Vendors shall submit proof of their principal place of business with their bid.

ii) "Lowest Responsible Bidder" shall mean a person who submits the lowest monetary bid, taking into account the contract bid reduction provided for in paragraph g, and which responds to the terms upon which bids were requested, and who has the capacity, integrity, and ability to perform the particular requirements of the contract. Factors which may be considered in determining the "lowest responsible bidder" include, but are not limited to, all of the following:

- a) The contractor's prior record of performance on other public works projects, if any. including timely completion of performance, quality of work, and completion of projects within project budget or bid amount submitted.
- b) The contractor's involvement in any ongoing litigation or contract disputes with the awarding authority which could impair satisfactory performance on the contract to be awarded.
- c) The contractor's history of noncompliance with occupational safety and health requirements, labor statutes and regulations, and other local, state, and federal laws.

B. Work or Acquisitions Costing More Than \$10,000, But Not More than \$50,000

All contracts for any work or unit of work, and all acquisitions of materials or equipment, having been submitted either by informal or formal bids in accordance with this statement of policy and having a value in excess of Ten Thousand Dollars (\$10,000), but not more than Fifty Thousand Dollars (\$50,000), shall be reviewed and recommended by a Committee of the Board, and the Board shall concur by majority vote. In the event no formal competitive bids are solicited, the Board may also give local contractors and vendors a preference.

C. Work or Acquisitions Costing Less Than \$10,000

All contracts for any work or unit of work, and all acquisitions of materials or equipment, estimated to cost or to have a value when completed that is less than Ten Thousand Dollars (\$10,000), may be authorized by the District's General Manager without compliance with any formal competitive bidding procedure or prior Board approval, and in any such case he may authorize the work or unit of work or acquire the materials or equipment, by informal bidding or quotations or by purchase on the open market without advertising. The District's General Manager may give local contractors and vendors a preference.

D. Change Order Policy

All change orders occurring during the performance of a contract shall be reported to the Board. Change order amounts which are less than ten percent (10%) of the original contract amount up to a maximum amount of Fifty Thousand Dollars (\$50,000) may be authorized by the District's General Manager; however, change order amounts greater than Fifty Thousand Dollars (\$50,000) or greater than ten percent (10%) of the original contract amount shall be approved by the appropriate committee or full Board of Directors.

V. Electronic Bidding

- A. Notwithstanding any contrary provision in Appendix M, the use of electronic media is authorized for any formal and informal bidding process pursuant to Appendix M, including without limitation submission, identification, opening and reporting of bids electronically ("electronic bidding"; "E-Bid"), provided that it be in accordance with state law. Electronic bidding shall include measures as the District deems appropriate for security of the bidding, approval and award processes and accurate retrieval or conversion of electronic information into a medium which permits inspection and copying. All electronic bids shall be submitted in a manner set forth in the Notice Inviting Bids and/or the bid instructions.
- B. The District may, in its sole discretion, require electronic bidding for any informal and formal bids authorized under Appendix M. If the District elects to use electronic bidding, then all bids must be submitted electronically consistent with the Notice Inviting Bids and/or bid instructions. If electronic bidding is not selected, then no bids may be submitted electronically and will be submitted sealed bid at a date, time and place.

VI. Exceptions to Statement of Policy

The policy specified in this statement shall not apply in the following cases or circumstances:

- (1) A contract for the acquisition or disposal of any real property.
- (2) A contract for the leasing of any personal property or the acquisition of personal property other than materials and equipment for use in construction activities.

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- (3) A contract for the purchase of water or water rights.
- (4) A contract for the repair of District equipment.
- (5) A contract for legal, engineering and other professional services.
- (6) The repair, alteration, addition, or the making of improvements, by force account.

(7) Work related to and in furtherance of the purposes of the District, or materials or equipment acquired for such purposes, where such work is to be performed or such materials or equipment are to be acquired, for the account of other persons or entities. , An example of such work is construction of a water pipeline for a developer and done at the developer's expense.

(8) A contract for the performance of work or acquisition of materials in instances where work and materials are regularly and periodically required and work and materials for the repair or replacement of prior works or materials relating to the following:

a)	Asphalt and concrete	i)	Online analyzers
	patching;	j)	Treatment chemicals
b)	Janitorial supplies;	k)	Laboratory supplies and testing
c)	Office supplies;	1	equipment
d)	Aggregate (sand, base and	1)	Landscape services
	similar materials);	m)	Janitorial services
e)	Cold mix asphalt;	n)	Printing services
f)	Data mailers;	0)	Answering services
g)	Water meters;	p)	Pest control services
h)	Pumps and Motors		
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BID PROCUREMENT POLICY APPROVED AND ADOPTED AT A REGULAR BOARD MEETING OF THE PALMDALE WATER DISTRICT BOARD OF DIRECTORS HELD APRIL 19, 1990

Revised 1-14-92 Revised 9-15-92 Revised 4-25-94 Revised 11-10-97 Revised 2-24-2020 Revised 10-12-2020



APPENDIX A.7 Economic Impact Assessment TM

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Economic Impact Report – Pure Water Antelope Valley

Technical Memorandum

May 2023

Prepared for: Palmdale Water District

Prepared by: Stantec Team

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Abbreviations May 2023

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Abbreviations

AWPF	Advanced Water Purification Facility
FTE	full-time equivalent
GDP	Gross Domestic Product
I-O	input-output
IPR	indirect potable reuse
LA County	Los Angeles County
O&M	operations and maintenance
PRWA	Palmdale Recycled Water Authority
PWAV	Pure Water Antelope Valley
PWD	Palmdale Water District
ТМ	technical memorandum

Introduction May 2023

1.0 Introduction

Stantec Consulting Services Inc. (Stantec) was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional water augmentation program, referred to as Pure Water Antelope Valley (PWAV). As part of that effort, several planning studies are underway for successful implementation of PWAV. This technical memorandum (TM) provides an overview of the economic impacts to Los Angeles County (LA County) from constructing and operating a new Advanced Water Purification Facility (AWPF) and implementing PWAV.

1.1 Program Background and Drivers

PWD has been providing water service to its customers since 1918, when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the groundwater basin has been in overdraft since the 1930s, resulting in land subsidence. In 1973, Palmdale Irrigation District changed its name to Palmdale Water District (PWD).

PWD has conducted a number of studies that date back to as early as the 1990s to evaluate the water resources necessary to meet future water supply demands. Concepts evaluated to date include using recycled water for landscape irrigation, discharging into Palmdale Lake, and discharging into existing sand and gravel pits to replenish the groundwater basin. In 2012, the Palmdale Recycled Water Authority (PRWA), comprising members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area. PRWA manages the distribution of recycled water, and the design and construction of support facilities, and finances the efforts.

PWD has been exploring different concepts of groundwater banking, storage, and extraction. As part of that effort, PWD has conducted a series of pilot studies to determine the infiltration rates. Less than favorable results from the pilot studies led PWD to evaluate the feasibility of surface water augmentation and/or groundwater recharge via direct injection – two different forms of indirect potable reuse (IPR). Stantec was retained by PWD to conduct a feasibility study on IPR. Based on the results from the IPR feasibility study, PWD decided to pursue the concept further. Using tertiary effluent from the Los Angeles County Sanitation Districts' Palmdale Water Reclamation Plant, PWD plans to produce potable quality water for groundwater recharge via direct injection.

1.2 Study Background and Objectives

The objective of PWAV is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection (project). The purpose of this Economic Impact Analysis is to identify the potential economic impacts of the proposed PWAV to the PWD and its surrounding communities in LA County. The analysis is based on assumptions and cost estimates that were preliminarily developed in 2021 as part of a project assessment study and have since been updated and refined as of October 2022.



Introduction May 2023

The analysis is limited to an assessment of the economic benefits to LA County associated with investments and employment during the construction period, as well as those resulting from ongoing operations and maintenance. The existing preferred sites for construction of the facility are currently in the process of being acquired by PWD. The parcels are vacant and undeveloped. Hence, there are no existing economic activities being displaced by the proposed construction of the AWPF under the current assumption of the 4.75 MGD project.¹

1.3 Technical Memorandum Structure and Content

This TM is divided into the following sections:

- Section 1 Introduction Provides the program background and drivers and study background and objectives.
- Section 2 Input-Output Analysis Provides an overview description of the input-output (I-O) analysis and information about the approach using the IMPLAN I-O model application.
- Section 3 Economic Impact Describes the estimated economic impact, including projected jobs created during the construction and ongoing operations phases. Also identifies the direct, indirect, and induced economic effects of PWAV.

¹ Should the AWPF project be expanded to a 10 MGD capacity, this analysis may need to be revisited due to the potential economic effects diverting tertiary water supply from existing agricultural use for feeder crops.



Input-Output Analysis May 2023

2.0 Input-Output Analysis

When capturing the economic impacts of a project, it is important to recognize the interdependencies between different economic sectors and industries. These interdependencies result in economic multiplier effects when a project injects money into a regional economy. The additional output resulting from the project requires an increase in the demand for support services and creates more employment, which subsequently results in more spending at local businesses, which in turn increases the purchases and staffing needs of those businesses – and these impacts continue to ripple through the local economy. To capture the multiplier effects resulting from the direct impact of the project, an I-O analysis can be developed to capture these linkages and estimate the indirect impacts and induced impacts of the project. The direct impacts reflect the economic activity that arises from the construction of the project, the operation of the site, and the production from the activities that will eventually occupy the site. The indirect effects refer to the reliance on goods and services from supporting economic sectors for the construction period and during operations. The induced effects are created as a result of expenditures made by the direct and indirect activities and are seen as stimulating economic activity in areas not directly related to the project site, with typical consumer expenditures the most common examples.

2.1 Model Approach

The IMPLAN application was used to develop this economic analysis. IMPLAN is an industry accepted standard I-O model application that allows inputs such as project costs or estimated changes in investment by economic sector to generate projections of economic impacts for an identified economic region. For this analysis, the identified economic region is LA County. The inputs for the model are the direct economic effects. The IMPLAN application provides several output tables that estimate the projected impact to the economy. The model is based on the underlying assumption of I-O models that expenditures in an industry usually result in demands for goods and services in other industries.

The direct expenditures include construction purchases, such as aggregate, fencing, pipe, and injection equipment. The construction process also creates indirect impacts to the entire supply chain, such as employment created in supplemental industries and in those producing and transporting the pipes or injection equipment from the manufacturers. Induced impacts result from the increase in construction workers' income and indirect employees' income, which, in turn, results in greater household spending in the region, which then leads to induced impacts in other industries. A common example of this induced impact is at local restaurants that need to hire additional staff to accommodate construction laborers spending a portion of their wages on meals.

Using cost estimates from the TM, the economic impact model was run in two parts: one for the threeyear construction phase, and another for the continuing operations and maintenance (O&M) of the plant. The cost estimates were entered into the model using annual estimates, and the output is also in terms of annual impacts. This means that the construction phase annual impacts presented in the results below will carry on for three years, while the O&M annual impacts will carry on for the lifespan of the project. All impacts are presented in 2022 United States dollars.



Input-Output Analysis May 2023

It is estimated that the capital costs for the PWAV facility will total approximately \$196.4 million, (with \$134.4 million spent locally in LA County) and employ about 100 workers annually during the three-year construction effort. The annual local capital cost for the PWAV facility is \$44.8 million. Once constructed, the primary annual O&M costs for the project are estimated to be approximately \$6.1 million (\$5.5 million spent locally in LA County). The PWD estimates that four full-time jobs will be required for ongoing O&M of the project. This economic impact analysis is constrained by regional data and multipliers, such that only the estimated dollar amounts of spending projected to occur in LA County are used as inputs for the model. Therefore, \$134.4 million is the baseline three-year impact cost estimate for the construction phase, and \$5.5 million is the annual baseline impact cost estimate for O&M, after the construction phase.

2.2 Key Inputs

The preliminary analysis presented herein primarily relies upon cost estimates and other data included in the TM. Other requested data was provided by PWD. Specific data used in the analysis includes:

- 1. General overview of the proposed project
- 2. Estimate of the cost of proposed facilities construction
- Estimate of the ongoing operations employment after the construction period, including the number full-time equivalent (FTE) employees and approximate salary levels and ranges (as provided by PWD)

The development of an I-O model begins with including the pertinent inputs as a starting point for analyzing the economic multiplier effect throughout the economy. PWAV's LA County- based financial and job information serving as the model starting point inputs are detailed below:

- Capital Expenditures in LA County: \$134.4M over 3 years
- Annual Construction FTE: 100
- Annual O&M Cost in LA County: \$5.5M
- Annual O&M jobs: 4
- Life of project: 50+ years²

² While the overall project life is projected at over 50 years, equipment will likely need replacement over a shorter timeframe, currently projected at approximately 20 years. Given substantial uncertainties regarding equipment specification, life-cycle patterns, and costs, this additional capital spending was not modeled as a part of the I-O analysis.



Input-Output Analysis May 2023

2.3 Other Considerations

I-O models, including IMPLAN, are widely adopted approaches to regional economic impact analyses. While I-O models are commonly used for assessing the economic impacts of new activity on a regional economy, there are certain limitations to these models and the multipliers used. As such, the reader of this report should be mindful of the following dynamics driving the limitations of this analysis:

- Additional labor demand may not drive increases to the quantity of labor supplied, if suitable labor is not locally available;
- The model inputs are preliminary estimates of future project investment and are subject to refinement and change; and
- The multipliers used are based on existing industry trends and may fluctuate throughout the life of the project and its impacts.

Economic Impact May 2023

3.0 Economic Impact

The potential for economic activity arises from the construction of the AWPF and the groundwater injection processes that are part of the operation of the facility once it has been developed. As such, the project can be generally categorized in two distinct periods: the construction period and the post-construction operating period. The construction period will be considered as a non-recurring impact that materializes only during the construction timeline, whereas the operating impacts will be incorporated in the stabilized economy and more reflective of structural economic impacts of the project life of the AWPF, estimated to be approximately 50 years.

An economic impacts analysis generally reflects the effects of a new activity, industry, or event on a regional economy. In this context, Stantec's analysis focuses on the effects of the PWAV facility on LA County's economy, with a particular emphasis on the following economic indicators:

- Output
- Value Added / Gross Domestic Product (GDP)
- Labor Income
- Jobs

The effects on production generally refer to the value of the goods and services produced, where "value" is the market value of the items produced. Total output refers to the total value of all goods and services produced within an economy, whereas GDP is the total value of the final goods and services produced within an economy. The fundamental difference between the two metrics is that total output captures the value of intermediate and final goods and services, and GDP only captures the value of final goods and services. Final goods and services are those produced for the final user, while intermediate goods are produced to be a component of a final good or service. It is important to note that output captures intermediate goods, which are not necessarily included in value added or labor income, so output is not the sum of labor income and value added.

The labor market impacts generally reflect the changes in demand for labor and the overall effects they have on earnings and jobs. Jobs are expressed in terms of FTE. Earnings refer to the total wage/salary, benefits, and proprietor income that is earned. The purpose of this economic impact analysis is to measure the estimated total economic impact the change in land use will have on the level of economic activity throughout the economy, and this analysis specifically focuses on the impacts to LA County.

3.1 Job Creation and Economic Output

Using the IMPLAN application, a series of job creation and economic output impacts pertaining to PWAV were captured. The Project's estimated 100 annual construction jobs and related services and construction costs are \$196.4 million, with \$134.4 million spent locally over three years (\$44.8 million per



Economic Impact May 2023

year). Using these inputs, the IMPLAN application estimates that construction of the project will result in annual labor income impacts of approximately \$26.0 million, with \$12.2 million of the labor income not being directly related to PWAV construction. The purchase of materials and equipment, as well as employment of construction workers, will create demand for local business through the duration of construction, generating revenue within the regional economy. Equipment and materials manufacturing and supply chain jobs plus induced jobs are predicted to create an additional 169 FTE jobs (in addition to the 100 on-site jobs) within LA County related to construction of the project.

Based on the IMPLAN application, the annual economic output from the construction phase, including onsite labor and related services, supply chain impacts, and induced impacts, could total approximately \$79.8 million annually. When removing the intermediate goods from the total output, we can evaluate the estimated value-added, or GDP impacts. The estimated value added from the construction phase, including on-site labor and related services, supply chain impacts, and induced impacts could total about \$34.8 million annually. Total indirect and induced labor income from the construction phase is estimated to be around \$12.2 million per year for the three-year period. A breakdown of the jobs, earnings, and economic output is provided in Table 1.

Job Type		Jobs (FTE)	Labor Income	Value Added (GDP)	Output
Direct E	ffects	100	\$13,800,000	\$13,800,000	\$44,800,000
Regional Economic	Indirect Effects	90	\$7,200,000	\$12,000,000	\$20,800,000
Impact via Multiplier Effects	Induced Effects	79	\$5,000,000	\$9,000,000	\$14,200,000
Total Indirect	and Induced	169	\$12,200,000	\$21,000,000	\$35,000,000
Total Regio	nal Effects	269	\$26,000,000	\$34,800,000	\$79,800,000

Table 1. Pure Water Antelope Valley – Construction Phase Annual Economic Impacts

Key: FTE = Full-Time Equivalent

GDP = Gross Domestic Product

The annual indirect and induced impacts are the result of regional multiplier effects from the annual direct impacts (direct impacts are the sum of annual labor and equipment costs of the construction project specifically). The model predicts that the \$44.8 million of annual local direct impact from the three-year construction phase creates annual indirect and induced local output of \$35.0 million, which is a multiplier of 0.78. This means that for every \$1 spent annually during the construction phase, an additional \$0.78 of spending is estimated to be generated in LA County via indirect and induced effects.

During operation of the project, PWD has estimated that four FTE jobs will be created to handle needed O&M activities. The resulting direct, indirect, and induced effects on labor income, value added, and output are provided below in Table 2. The model inputs (direct impacts) come directly from the estimated \$5.5 million in annual O&M costs.



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Job Type		Jobs (FTE)	Labor Income	Value Added (GDP)	Output
Direct Ef	fects	4	\$1,500,000	\$3,300,000	\$5,500,000
Regional Economic	Indirect Effects	10	\$850,000	\$1,300,000	\$2,300,000
Impact via Multiplier Effects	Induced Effects	9	\$500,000	\$1,000,000	\$1,500,000
Total Indirect a	nd Induced	19	\$1,350,000	\$2,300,000	\$3,800,000
Total Region	al Effects	23	\$2,850,000	\$5,600,000	\$9,300,000

Table 2. Pure Water Antelope Valley – Annual Operation and Maintenance Economic Impacts

Key:

FTE = Full-Time Equivalent

GDP = Gross Domestic Product

The IMPLAN application estimates that total annual economic output, including direct, indirect, and induced impacts from PWAV, could total \$9.3 million. Removing intermediate goods from the impact calculations gives the estimated value-added (GDP) from the Project. The IMPLAN application estimates an annual value-added contribution of \$5.6 million from the project, with more than \$2 million of value added coming from indirect and induced impacts via regional multiplier effects. While \$1.5 million of labor income will result from the four O&M jobs added, another \$1.3 million in labor income could be generated as indirect and induced impacts from the project in LA County.

The model predicts that the \$5.5 million of annual local direct impact from the O&M phase creates annual indirect and induced local output of \$3.8 million, which is a multiplier of 0.69. For every \$1 spent annually during the O&M phase, an additional \$0.69 of spending is estimated to be generated in LA County via indirect and induced effects.

3.2 Conclusions

The overall economic impacts of the project could total about \$79.8 million annually during the three-year construction period, and \$9.3 million annually once the plant is operating. The regional economic multiplier from the construction phase of the project is 0.78, and 0.69 for the O&M phase. This means that for every \$1 spent during construction of the project, an additional \$0.78 could be generated in the LA County economy. For every \$1 spent during operational life of PWAV, \$0.69 could be generated in the LA County economy. During the construction phase, about 269 construction, related support, and induced jobs are expected to be created, bringing economic benefits to the community through labor income and economic output from on-site construction as well as supply chain services and induced jobs. The operational phase of the project will require four full time jobs annually over the estimated 50-year life of PWAV. In addition to these direct jobs, indirect and induced jobs related to O&M services could create 19 additional jobs, earning approximately \$1.3 million more in labor income within LA County per year (in 2022 dollars).



APPENDIX A.8

3

Summary of Numerical Groundwater Model Results TM



Summary of Numerical Groundwater Model Results - Pure Water Antelope Valley

Technical Memorandum

May 2023

Prepared for: Palmdale Water District

Prepared by: Stantec Team Montgomery & Associates Table of Contents May 2023

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SUMMARY OF NUMERICAL GROUNDWATER MODEL RESULTS - PURE WATER ANTELOPE VALLEY

Executive Summary May 2023

Executive Summary

Stantec Consulting Services Inc. was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). The objective of Pure Water AV is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection (project). As part of that effort, several planning studies are underway for successful implementation of Pure Water AV. Through an indirect potable reuse (IPR) approach, Pure Water AV will treat between 5 and 10 million gallons per day (MGD) of tertiary treated wastewater in accordance with California Title 22 regulations. Montgomery & Associates (M&A) will develop a numerical groundwater flow and particle tracking model to support project design and permitting.

The following information is presented in this technical memorandum (TM):

- An overview of the hydrogeologic conceptual model (HCM) developed in a previous M&A study (M&A, 2022)
- A summary of the numerical groundwater model construction and calibration
- A summary of model results
- Recommendations for further actions to improve confidence in the underground retention time estimates

Local-Scale Hydrogeologic Conceptual Model

M&A compiled and analyzed hydrogeologic data, reviewed other Antelope Valley numerical groundwater flow models, and developed a local-scale HCM. Results of the data analysis and conceptual modeling study are summarized in the TM, *Data Compilation and Analysis for Numerical Groundwater Model* (M&A, 2022). The HCM is the basis of the numerical groundwater flow model. Data for the HCM were obtained from PWD, the Antelope Valley Watermaster Engineer (Todd Groundwater), the United States Geological Survey (USGS), and the California Department of Water Resources. Data compilation and analysis focused primarily on groundwater elevation data, groundwater well construction and performance data, and lithologic data, and identified data gaps. The HCM was informed by information reported by the United States Geological Survey (USGS) for its basin-wide groundwater model (Siade et al., 2014) and for an injection study conducted in the Lancaster area (Phillips et al., 2003). The HCM includes information about aquifer properties, groundwater conditions, and recharge and discharge processes. The HCM informed a preliminary assessment of injection feasibility and preliminary underground retention time estimates. Based on the HCM, injection appears feasible in the project area and preliminary underground retention times were favorable compared to Title 22 IPR regulatory requirements.
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Numerical Model Construction and Calibration

The numerical model was developed primarily to estimate underground retention times of purified water in the saturated zone between the injection and extraction wells. The model was also used to confirm injection feasibility and evaluate conceptual injection well and monitor well locations. The model was developed using MODFLOW-USG. This model code provides flexible model grid design features favorable for the Pure Water AV model.

The numerical model was developed specifically for Pure Water AV. The model grid was designed to simulate the steep hydraulic gradients expected during Pure Water AV operation. Groundwater flow was simulated in three dimensions in two model layers. Pumping from PWD's wells and other wells were simulated in the model. The model hydraulic conductivities and boundary conditions were informed by data compiled and analyzed for the HCM and from the USGS basin-wide model. The model was calibrated in steady state to groundwater elevation data. The primary calibration goal was to reproduce the prevailing converging groundwater flow system in the project area, which is caused in part by PWD pumping.

A particle tracking model was developed to estimate underground retention time. The particle tracking model uses the numerical model flow field to track particles from the injection wells to the pumping wells. This approach mimics purified water flow in the aquifer and enables estimation of underground retention time.

Model Results

The model was used to simulate 5 and 10 MGD Pure Water AV projects. PWD plans to construct full-scale and demonstration treatment facilities on two newly purchased parcels in the project area. A conservative analysis was conducted to develop reasonable estimates of the shortest underground retention times. Key assumption include: (1) injection wells would be located on the new treatment facility properties and (2) future pumping rates in the six closest PWD pumping wells would be increased to remove all purified water. Two injection wells on the full-scale treatment facility property were simulated for the 5 MGD scenario. For the 10 MGD scenario, two injection wells were simulated on the full-scale property and one was simulated on the demonstration facility property.

The following table summarizes simulated underground retention times.

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Full-Scale Facility Production Scenario (MGD)	Number of Injection Wells ¹	Simulated Injection Rate (gpm)	Shortest Simulated Underground Retention Time (in years)	Shortest Credited Underground Retention Time (in years)
5	2	1,750	2.1	1
10	3	2,300	1.5	0.7

Table ES-1. Simulated Underground Retention Times

Note:

¹ One additional injection well would be needed for operational redundancy.

Key:

gpm = gallons per minute

MGD = million gallons per day

Results of the conservative modeling analysis indicate favorable simulated and credited underground retention times compared to Title 22 IPR regulations. Credited underground retention time reflects the 50% reduction applied to results from a numerical groundwater flow model. Title 22 regulations for IPR require a minimum of two months underground retention time. Credited underground retention times for the 5 and 10 MGD scenarios exceed the two-month requirement. Regulations also allows for up to six months of log virus reduction credit. Credited underground retention times for the 5 and 10 MGD scenarios exceed the two-month requirement. Regulations also allows for up to six months of log virus reduction credit. Credited underground retention times for the 5 and 10 MGD scenarios exceed the six months to qualify for the maximum credit.

Model results also indicate that operating injection wells on the treatment facility properties would result in manageable groundwater level rise, indicating that these locations are conceptually feasible. Title 22 IPR regulations also require monitoring of purified water flow in at least two monitor wells to demonstrate effective underground treatment and ensure a safe water supply. Model results indicate that one of these monitor wells could be located on the full-scale treatment facility property and one would be located between the injection and pumping wells. Two additional monitor wells, for a total of four, may be required for the 10 MGD scenario.

Conclusion and Recommendations

Results of the modeling analysis are generally favorable compared to Title 22 IRP regulations. However, important data gaps exist that reduce model confidence. Important data gaps include: (1) uncertainty regarding the presence of preferential rapid flow paths between the injection and pumping wells, (2) injection capacity and capability of wells located on the full-scale and demonstration facility properties, and (3) uncertainty on effective porosity. To improve model confidence, supplemental hydrogeologic characterization in the project area is recommended. Characterization activities include:

- Enhancing the pumping test program at newly constructed PWD well 36 to acquire additional aquifer property data
- Conducting spinner logs in one or more of PWD's wells to provide groundwater flow into the well to identify preferential flow pathways

V

Executive Summary May 2023

- Conducting drilling, logging, well construction, and testing on the treatment facility properties to assess injection feasibility and estimate injection capacity
- Conducting a tracer test between newly constructed wells on the full-scale treatment facility property to estimate effective porosity; this tracer test is for model data acquisition purposes and not to address the Title 22 IRP regulation requirements for an operational-scale tracer test

A characterization work plan should be prepared to guide field activities.

Abbreviations May 2023

Abbreviations

feet below ground surface		
feet per day		
gallons per minute		
hydrogeologic conceptual model		
indirect potable reuse		
Montgomery & Associates		
million gallons per day		
Augmentation of groundwater supplies with advanced treated wastewater via direct subsurface injection		
Palmdale Recycled Water Authority		
Pure Water Antelope Valley		
Palmdale Water District		
Stantec Consulting Services Inc.		
technical memorandum		
United States Geological Survey		

Introduction May 2023

1.0 Introduction

Stantec Consulting Services Inc. (Stantec) was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional recycled water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). As part of that effort, several planning studies are underway for successful implementation of Pure Water AV. This technical memorandum (TM) summarizes the results of numerical groundwater modeling conducted for Pure Water AV permitting and conceptual design.

1.1 Program Background and Drivers

PWD has been providing water service to its customers since 1918, when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the groundwater basin has been in overdraft since the 1930s, resulting in land subsidence. In 1973, Palmdale Irrigation District changed its name to Palmdale Water District.

PWD has conducted studies that date back to as early as the 1990s to evaluate the water resources necessary to meet future water supply demands. Concepts evaluated include using recycled water for landscape irrigation, augmentation of Palmdale Lake, and recharge at existing sand and gravel pits to replenish the groundwater basin. In 2012, the Palmdale Recycled Water Authority (PRWA), comprising members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area. PRWA manages the distribution of recycled water and the design and construction of support facilities, and finances the efforts.

PWD has been exploring different concepts of groundwater banking, storage, and extraction, including a series of pilot studies to determine the infiltration rates of sand and gravel pits. Less than favorable results from the pilot studies led PWD to evaluate the feasibility of surface water augmentation and/or groundwater recharge via direct injection – two different forms of indirect potable reuse (IPR). PWD retained Stantec to conduct a feasibility study on IPR. Based on the results from the IPR feasibility study, PWD decided to pursue the concept further. Using tertiary effluent from the Los Angeles County Sanitation Districts' Palmdale Water Reclamation Plant, PWD plans to produce potable quality water for groundwater recharge via direct injection.

1.2 Study Background and Objectives

This TM summarizes the results of numerical groundwater flow modeling for Pure Water AV development. The Pure Water AV objective is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection (project). Through an IPR approach, Pure Water AV will treat between 5 and 10 million gallons per day (MGD) of tertiary treated wastewater in accordance with California Title 22 regulations. Montgomery & Associates (M&A) developed and applied a numerical groundwater flow and particle tracking model to support Pure Water AV conceptual design and permitting. The model was used to confirm injection feasibility, estimate potential injection well capacities, and to estimate underground retention time in accordance with Title 22 regulations, which are summarized below in Section 1.2.1.

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This TM presents the following information:

- An overview of the hydrogeologic conceptual model (HCM) developed in a supporting study
- The methods and assumptions used to develop and calibrate the numerical model
- Model results for 5 and 10 MGD Pure Water AV projects

Figure 1 shows the active PWD groundwater pumping wells in the project area.

1.2.1 OVERVIEW OF REGULATIONS FOR UNDERGROUND RETENTION TIME

To ensure safe water supply, California Title 22 regulations require groundwater replenishment reuse projects like Pure Water AV to retain purified injected water underground for a specified time prior to extraction from any drinking water well. The length of the underground retention period between injection and extraction is referred to as the underground retention time. Underground retention time varies based on distance from the injection well, groundwater flow velocity, direction, and dispersion.

Title 22 regulations for underground retention time specify the following:

- Underground retention is a treatment process to remove any residual pathogenic microorganisms in recharged purified water. A maximum of six pathogen log-reduction values can be credited for an underground retention treatment process, as described in Section 60320.208 of the Title 22 regulations. One month of underground retention time is equal to one log-reduction value for virus removal.
- Response retention time is the necessary response time to identify potential treatment failures
 and implement appropriate actions to protect public health, as described in Section 60320.224 of
 the Title 22 regulations. The underground retention time cannot be shorter than the response
 retention time. The response retention time can be no less than two months, but may be longer.
 The project-specific response retention time is calculated based on the shortest travel times for
 purified water to arrive at a monitor well from any of the injection wells, as well as the time
 required to identify groundwater quality issues and implement protective actions.

For Pure Water AV planning and conceptual design and until the project meets Title 22 requirements, underground retention times were estimated using analytical equation and a numerical groundwater flow model. Estimates of underground retention time from analytical equations receive a 25% virus log-reduction credit and estimates from a numerical groundwater flow model receive a 50% virus log-reduction credit.

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Figure 1. Project Area

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To meet requirements in Sections 60320.208 and 60320.224 of the Title 22 regulations, a tracer study will be required in the future to demonstrate that Pure Water AV meets the project-specific, log-reduction value credit and ensure response retention time is met. Per Title 22 requirements, the tracer study will be implemented "under hydraulic conditions representative of normal project operations," initiated within the first three months of operation and conducted for each aquifer that receives purified water. Title 22 requirements specify use of an added tracer but provide for using an intrinsic tracer with prior approval from the regulators.

1.3 Technical Memorandum Structure and Content

This TM is divided into the following sections:

- Section 1 Introduction Provides the program background and drivers, study background and objectives, and an overview of Title 22 IPR regulations.
- Section 2 Overview of Hydrogeologic Conceptual Model Summarizes the HCM that is the basis for the numerical model.
- Section 3 Numerical Model Development Summarizes the model development and calibration process and results.
- Section 4 Predictive Simulations Summarizes the model simulation results for 5 and 10 MGD Pure Water AV projects.
- Section 5 Conclusions and Recommendations Provides conclusions and recommendations based on the modeling results.
- Section 6 References Provides a list of references used in the TM.

Overview of Hydrogeologic Conceptual Site Model May 2023

2.0 Overview of Hydrogeologic Conceptual Site Model

Prior to developing the numerical groundwater flow model, M&A compiled and analyzed hydrogeologic data, reviewed other Antelope Valley numerical groundwater flow models, and developed a local-scale HCM. Results of the data analysis and conceptual modeling study are summarized in the TM, *Data Compilation and Analysis for Numerical Groundwater Model* (M&A, 2022).

The HCM is the basis of the numerical groundwater flow model. Data for the HCM were obtained from PWD, the Antelope Valley Watermaster Engineer (Todd Groundwater), the United States Geological Survey (USGS), and the California Department of Water Resources. Data compilation and analysis focused primarily on the following:

- Groundwater elevation data
- Groundwater well construction, performance, and pumping data
- Lithologic and geophysical logs from wells

The following groundwater models were reviewed:

- USGS Basin-wide Model (Siade et al., 2014)
- USGS Amargosa Creek Recharge Project Model (Christensen et al., 2015)
- USGS Injection Study Model (Phillips et al., 2003)
- Palmdale Water District Littlerock Creek Groundwater Recharge and Recovery Project Model (Kennedy/Jenks, 2015)

A brief overview of the HCM is provided below.

2.1 Aquifer Properties

Three primary aquifers – the upper, middle, and lower – occur in the Antelope Valley groundwater basin. The upper aquifer and middle aquifers are the primary water-bearing aquifers in the Pure Water AV area and are the focus of the local-scale HCM. Most wells in the model area are completed in the upper and middle aquifers. The bottom of the middle aquifer in the project area corresponds to the contact between basin-fill sediments and either a regional clay unit or bedrock. The regional clay unit is often referred to as the "blue clay."

Basin-fill deposits of the upper and middle aquifers extend to approximately 900 to 1,000 feet below ground surface (ft bgs) and are predominantly a mixture of sand and gravel, with interbedded silt and clay-rich zones in some areas. Based on drillers' logs, coarse-grained sediments comprise approximately

Overview of Hydrogeologic Conceptual Site Model May 2023

30% to 90% of the sediments encountered during well drilling, with an average percentage of approximately 70%.

The thickness of the upper aquifer is generally believed to be larger than the thickness of the middle aquifer in the project area (Siade et al., 2014; Phillips et al., 2003). The contact between the upper and middle aquifers in the model area is reported to be related to depositional age, with an erosional surface occurring between the younger sediments of the upper aquifer and the older sediments of the middle aquifer (Phillips et al., 2003). The contact between the upper area is not well defined.

Hydraulic conductivity was estimated from pumping well-specific capacity data for the PWD wells in the project area. Estimated combined upper and middle aquifer hydraulic conductivity in the project area ranges from 2 to 35 feet per day (ft/d), with an average of approximately 20 ft/d. According to USGS (Phillips et al., 2003), hydraulic conductivity of the upper aquifer is interpreted to be greater than that of the middle aquifer.

Faults are inferred to affect groundwater flow in the model area based on geophysical surveys and groundwater elevations (Siade et al., 2014). The USGS model includes a fault in its active domain. This inferred fault is also simulated in the Pure Water AV model.

2.2 Groundwater Conditions

Regional groundwater in the project area occurs primarily under unconfined conditions. Groundwater elevations in the project area indicate a consistent pumping depression, which causes groundwater to flow to the PWD wells in the project area. Groundwater generally flows laterally into the model area and leaves by pumping.

Average depth to groundwater in the project area is approximately 550 ft bgs. Saturated thickness ranges from approximately 350 to 450 feet in the project area and generally increases from south-southeast to the northwest in the model area. The change in saturated thickness across the model area may be related to the inferred fault between the two areas.

Groundwater elevations in the project area exhibit some short-term fluctuations, but the groundwater flow field in the project area has been relatively stable for more than a decade. The average pumping rate from PWD's wells in the project area between 2012 and 2021 was approximately 6 MGD.

2.3 Recharge and Discharge

Recharge in the model area includes infiltration of stormwater, excess agricultural and urban irrigation, water system conveyance losses, and domestic/rural residential septic systems. Groundwater discharge in the model area is most likely from groundwater pumping for municipal, industrial, agricultural, environmental remediation, and domestic use.

Overview of Hydrogeologic Conceptual Site Model May 2023

As described in the data memo, data were used to conceptually assess the feasibility of groundwater augmentation via injection wells and to develop preliminary estimates of underground retention time using analytical equations. Results of these efforts are summarized below.

- Injection Feasibility Groundwater augmentation via injection wells generally appears feasible in the Pure Water AV project area. A range in attainable injection well capacity of 1,000 to 1,500 gallons per minute (gpm) was estimated based on historical PWD pumping well performance data and an assumed groundwater level rise of 100 feet in the injection wells. This range is likely conservative, because the vadose zone in the project area is about 500 feet thick and more than 100 feet of groundwater level rise in the injection wells would be possible, which would likely result in higher injection capacities.
- Analytical Retention Time Estimates A preliminary estimate of underground retention time of 24 months was developed for a 5 MGD project using an analytical equation derived by Luo & Kitanidis (2004). For comparison with regulatory requirements, a 25% credit is applied to estimates based analytical equations. Therefore, the preliminary estimates result in six months of underground retention time that could be used for comparison with regulatory requirements. This estimate exceeds the minimum two-month retention time required for IPR via subsurface injection and just achieves the maximum six months of retention time that can be used for log reductions of viruses in groundwater.

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3.0 Numerical Model Development

A numerical groundwater flow and particle tracking model was developed for Pure Water AV to support project implementation, as described below.

3.1 Model Objectives

The numerical model was developed to achieve the following objectives:

- Estimate underground retention time of purified water in the saturated zone between the injection and extraction wells. Underground retention time estimates from a numerical model receive a 50% credit to meet regulatory requirements instead of the 25% credit assigned to estimates from analytical equations.
- Confirm the feasibility of groundwater augmentation via injection wells by reviewing projected groundwater mounding near the injection wells.
- Conceptually locate injection wells and monitor wells.

3.2 Model Design

The Pure Water AV model was designed to achieve the modeling objectives and was based on the local-scale HCM.

3.2.1 MODEL CODE

The unstructured grid version of MODFLOW was used (Panday et al., 2017). This model is commonly referred to as MODFLOW-USG. This model code was selected primarily because of its flexibility for refining the model's finite difference grid in specific areas of the model.

3.2.2 MODEL AREA AND GRID

Figure 2 illustrates the model grid.

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Figure 2. Model Grid

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The model grid was designed to simulate the hydraulic effects of existing pumping wells and future injection wells with minimal boundary effects. Grid cell sizes are smaller in the project area to better simulate the steep hydraulic gradients that will occur during Pure Water AV pumping and injection and facilitate more accurate particle tracking to estimate travel times in the project area. Details about the model grid are below:

- Model area: 46.5 square miles
- Number of rows and columns along model lateral boundaries: 45
- Grid cell sizes: largest (800 by 800 feet); smallest (200 by 200 feet)
- Total number of active grid cells: 8,090

The converging groundwater flow pattern in the model area enabled orientation of the grid in the northsouth direction.

3.2.3 MODEL LAYERS

The model includes two layers to simulate groundwater flow within the saturated portion of the upper and middle aquifers. Layer one conceptually corresponds to the upper aquifer and layer two conceptually corresponds to the middle aquifer. The bottom of layer two is the model bottom. The model bottom elevations were developed by contouring the well depth data for the model area. This approach was considered appropriate, because the bottom of the model conceptually corresponds to the contact between basin fill, and either the regional clay unit or bedrock and most wells in the model area appear to be drilled to bedrock/clay or close to these units. Figure 3 shows model bottom elevation contours. The contours indicate that model layer elevation generally becomes deeper from east-southeast to west-northwest.

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Figure 3. Elevation Contours of Model Bottom

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Figure 4 depicts the model layer thickness along the transect lines shown on Figure 3.



Figure 4. Model Thickness Along Transect Lines

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The thickness of the upper aquifer is generally believed to be larger than the thickness of the middle aquifer in the project area (Siade et al., 2014; Phillips et al., 2003). The contact between the upper and middle aquifers in the model area is not well defined. For the Pure Water AV model, the top 80% of the total model thickness of basin-fill sediments above bedrock or clay was assumed to represent the upper aquifer and the bottom 20% of the total thickness was assumed to represent the middle aquifer.

3.2.4 INITIAL HYDRAULIC CONDUCTIVITIES AND FAULTS

Initial hydraulic conductivities for the numerical model were developed based on the HCM. Based on model reports from the USGS, the hydraulic conductivity of the upper aquifer is generally considered to be higher than the hydraulic conductivity of the middle aquifer in the project area (Siade et al., 2014; Phillips et al., 2003). The initial layer one hydraulic conductivity was assumed to be a uniform 20 ft/d based on an analysis of specific capacity data from the PWD wells. The initial layer two hydraulic conductivity was assumed to be 2 ft/d based on the interpretations of relative hydraulic conductivity by the USGS (Phillips et al., 2003). The final model hydraulic conductivities used in the predictive simulations were determined during model calibration.

Figure 5 shows the location of an inferred fault simulated in the Pure Water AV model. This inferred fault was also simulated by USGS in its basin-wide model. The fault was simulated using the MODFLOW horizontal flow barrier package. Conceptually, the fault was assumed to impede groundwater flow. To simulate this impedance, the hydraulic conductivity of the fault zone was specified to be 0.001 ft/d, the same value used by the USGS.

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Figure 5. Simulated Fault

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3.2.5 BOUNDARY CONDITIONS

The model simulates saturated groundwater flow in the upper and middle aquifers in the project area. Basin-fill sediments extend from ground surface to the top of a regional clay layer or bedrock. The top model boundary is the water table. The bottom model boundary corresponds to the contact between basin-fill sediments and the clay or bedrock. As described in the data report, the model area lies within an area of regional converging groundwater flow caused by groundwater pumping. Inferred flow into the model area varies due to variations in the direction and magnitude of hydraulic gradients. Initially, constant head were assigned along the lateral model boundaries in layers one and two. The final model boundary conditions were developed during model calibration.

3.2.6 PUMPING WELLS

Figure 6 shows the location of known pumping wells in the model.

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Figure 6. Model Pumping Wells

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The model simulates pumping at PWD wells and wells owned by others. Pumping in the model area may occur for municipal, industrial, agricultural, environmental remediation, and domestic purposes. A total of 35 pumping wells are simulated in the model. Groundwater pumping data were obtained from PWD and the Watermaster Engineer. Detailed pumping records exist for the PWD wells from 1995 to 2021. Pumping data available for other wells are incomplete and generally start in 2019.

Where available, well construction data indicate that most wells are constructed and screened into the deep portion of basin-fill deposits most likely into the middle aquifer; therefore, the model wells pump from layers one and two.

3.3 Model Calibration

The model was calibrated in steady state to a combined dataset of 2021 and 2022 groundwater elevations. Groundwater elevation data were combined to improve data density. Because groundwater occurs under unconfined conditions in the project area, groundwater elevation data represent the water table. Based on Kyle (2020), static depths to groundwater in the project area have generally been greater than 500 ft bgs for more than a decade in PWD's wells in the project area, indicating that a regional cone of depression has existed for at least that time. The primary calibration goal was to simulate the observed relatively stable converging groundwater flow field in the project area. The model simulates 2021 pumping rates at wells in the model area to be consistent with the groundwater elevation data.

Figure 7 shows a contour map of observed 2021-2022 water table elevation (map on left) and a contour map of the simulated steady-state water table elevation (map on right). The observed water table map has been clipped to the model boundary from a regional water table map developed from a larger dataset. For the area inside the model grid, the groundwater elevation data and south of the fault were contoured independently using a method like the Watermaster Engineer in their annual reports. Using this approach results in a water table discontinuity along the fault suggesting the fault affects groundwater flow. The model steady-state map on the right is the from the calibrated model simulation, which simulates the fault using the same parameters as reported for the USGS model. The simulated steady-state water table does not show a water table discontinuity, suggesting that the fault does not have much effect on groundwater flow.

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Figure 7. Comparison Between Observed and Simulated Water Table Elevations

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The match between observed and simulated groundwater flow directions and gradients in the project area was considered acceptable for use in the predictive simulations. In particular, the observed and simulated flow directions and gradients in the southeastern portion of the project area and in the area between the project area and fault are similar. The acceptable match was achieved by adjusting hydraulic conductivity of layers one and two and the lateral boundary conditions during numerous model simulations.

The final calibrated layer one and layer two hydraulic conductivities are shown on Figure 8. The calibrated layer one and layer two hydraulic conductivities in the project area are 5 ft/d and 2 ft/d, respectively.

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Figure 8. Calibrated Hydraulic Conductivities

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The layer one value is within, but on the low end, of the hydraulic conductivity range estimated from the PWD well-specific capacity data. Data to estimate layer two hydraulic conductivity are not readily available. The lower calibrated hydraulic conductivities in layer two were assigned based on interpretations reported by the USGS on relative differences in hydraulic conductivity between the upper and middle aquifers. Overall, the relatively low hydraulic conductivities were needed to reproduce the observed hydraulic gradients in the project area (Figure 8). The area of low hydraulic conductivity south of the project area deviates from the USGS-calibrated hydraulic conductivities and was added to the Pure Water AV model to improve the match between observed and simulated gradients. Overall, the tendency for a better calibration with lower hydraulic conductivity values might suggest that the middle aquifer, which is believed to have lower conductivity, may make up a larger percentage of the saturated zone than assumed.

The final calibrated ratio of horizontal to vertical hydraulic conductivity is 100 to 1. Model calibration was not sensitive to variations in vertical hydraulic conductivity.

Figure 9 shows the final calibrated lateral boundary conditions. The calibrated lateral boundary conditions include constant head and no-flow boundaries. The boundary conditions in layers one and two are the same. The boundary conditions were initially assigned based on groundwater elevation contours in the model area and were modified during calibration. In general, the model area lies within a region of converging groundwater flow caused primarily by groundwater pumping. The southwest corner of the model is inactive and represents an area where little to no groundwater flow enters the model area. Boundary reaches simulated by constant heads correspond to the primary areas of groundwater inflow to the model area. No-flow reaches along the east and west boundaries generally correspond to flow lines where minimal groundwater enters the model area. The no-flow boundary along the north boundary generally corresponds to an area where hydraulic gradients are relatively flat and the groundwater flow into the model area is small. Groundwater elevation data for some years suggest that a groundwater divide exists in the area just north of the model area and is caused by two pumping areas: one in the Lancaster area to the north of the model area and one in the Palmdale area within the model area. The groundwater divide limits groundwater inflow to the model from the north.

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Figure 9. Calibrated Lateral Boundary Conditions

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3.4 Particle Tracking Model

A particle tracking model was developed to estimate underground retention time of the purified water between the injection and pumping wells. The mod-PATH 3DU code was used (Muffels et al., 2022). This code is specifically designed to work with MODFLOW-USG. The particle tracking model applies the groundwater flow field from the numerical groundwater flow model to calculate the movement of particles. To simulate the flow of purified water, particles were started at the injection wells and the resulting particle path lines represent the zone of purified water flow. Underground retention time was calculated as the time it takes for particles to flow from the injection wells to the pumping wells.

The particle tracking model only simulates advective flow; dispersion and dilution are not simulated. This approach assumes that the front of purified water in the groundwater system is flowing at the average groundwater flow rate. To simulate advective flow, the particle tracking model requires an effective porosity value. Effective porosity is the portion of total porosity that represents connected pore space where groundwater flow primarily occurs. Site-specific effective porosity data do not exist. As described in the data memo, an effective porosity of 0.15 is assumed to be representative of site conditions.

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4.0 Predictive Simulations

The calibrated model was used to simulate 5 and 10 MGD Pure Water AV projects. PWD will purchase a new property for the Pure Water AV full-scale treatment facility. The demonstration facility will be located on property owned by PWD. These properties are located south and southeast and upgradient of the nearest PWD pumping wells. The location of these properties is shown on Figure 10.

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Figure 10. Project Area Map

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The following assumptions were made for the predictive simulations:

- Injection wells will be located on the treatment facility properties. This approach minimizes the cost of conveying treated water to the injection wells.
- PWD will increase pumping rates in the six closest pumping wells (wells 2A, 3A, 23A, 4A, 7A, and 8A) to the injection wells to recover all injected purified water. This highly conservative assumption was made to recognize the conceptual benefit of higher groundwater pumping with Pure Water AV groundwater augmentation and to simulate a groundwater flow condition that would approximate the shortest underground retention times expected during operation.
- Other PWD pumping wells in the model will operate at average pumping rates estimated from pumping data from 2012 to 2021.
- New PWD wells 36 and 37 will be operating before Pure Water AV starts at the locations shown on Figure 10. Based on reports from the field during ongoing construction of well 36, the estimated short-term maximum pumping rate is approximately 1,000 gpm. To estimate a future pumping rate for wells 36 and 37, the reported short-term maximum instantaneous pumping rates and long-term average pumping rates for PWD wells in the project area were compared. This comparison indicates that PWD wells typically operate over the long-term at approximately 40% of their short-term maximum pumping rate. Applying this percentage to the estimated rate suggests that wells 36 and 37 might operate at average rates of approximately 400 gpm.

Table 1 summarizes the pumping rates used for the 5 and 10 MGD predictive simulations (sorted by largest to smallest average pumping rate). The assumed pumping well rates are conceptual and are not intended to suggest a recommended future operating condition. The model can be used in the future to assist PWD with wellfield operational improvements.

Well Identifier	Estimated 10-Year Average Pumping Rates (gpm)	5 MGD Scenario Constant Pumping Rates (gpm)	10 MGD Scenario Constant Pumping Rates (gpm)
8A	750	1,760	2,780
15	660	660	660
2A	640	1,510	2,380
11A	480	480	480
3A	470	1,110	1,750
36	400	400	400
37	400	400	400
7A	380	890	1,400
14A	310	310	310
23	270	640	1,010
6	80	80	80
4A	60	130	210
10A	60	60	60

Table 1. Palmdale Water District Well Pumping Rates for Predictive Simulations

Key: gpm = gallons per minute

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Table 1 includes the 10-year average pumping rates estimated from PWD pumping data, including assumed rates for future wells 36 and 37. Average pumping rates range from approximately 60 to 750 gpm. The total average pumping rate for project area wells (including wells 36 and 37) is approximately 5,000 gpm, or approximately 7 MGD.

4.1 5 MGD Scenario

The calibrated model was used to simulate the 5 MGD Pure Water AV project. For the simulation, two injection wells were assumed to operate continuously on the full-scale treatment facility property to achieve the 5 MGD discharge rate. A third injection well would be needed to ensure continuous operation if one of the simulated wells were inoperative. The two injection wells were assumed to operate at 1,750 gpm each to achieve the 5 MGD discharge capacity.

Table 1 shows the assumed 5 MGD scenario pumping rates. Pumping rates at the six closest PWD pumping wells to the injection wells were conservatively assumed to be proportionally larger to recover the 5 MGD of injected purified water. For the conceptual 5 MGD scenario, the total pumping rate of PWD wells in the project area would be approximately 8,400 gpm, or approximately 12 MGD for the 5 MGD Pure Water AV project.

Figure 11 shows simulated steady-state groundwater elevations for the 5 MGD scenario and includes two maps:

- The map on the left shows simulated steady-state groundwater elevations for a conceptual wellfield operation at 10-year average rates with wells 36 and 37 in service. This map was included as a reference to compare to simulated groundwater elevations for the future Pure Water AV project. The map indicates that pumping at average rates would maintain the pumping depression that has prevailed in the project area for more than a decade.
- The map on the right shows simulated steady-state groundwater elevations with the 5 MGD Pure Water AV project in operation, including the increase in pumping to 12 MGD.

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Figure 11. Simulated Steady-State Groundwater Elevations – 5 MGD Pure Water Antelope Valley Project

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Figure 11 indicates the following future groundwater conditions for Pure Water AV operating at 5 MGD:

- A groundwater mound would exist around the injection wells. Ground surface elevation at the full-scale treatment facility property is approximately 2,600 feet above mean sea level. The simulated groundwater mound at the facility during 5 MGD Pure Water AV operation would rise to approximately 2,275 above mean sea level, or more than 300 ft bgs. The simulated groundwater elevation rise is the simulated groundwater elevation in the model grid cell containing the injection well. This result suggests that operating two injection wells on the facility at 1,750 gpm each would not likely cause excessive groundwater mounding in the aquifer system. However, the current model does not account for well losses which would cause the water level in the injection well to be higher than the groundwater elevation in the aquifer outside the well.
- Steep hydraulic gradients would exist between the injection wells and nearest PWD pumping wells.
- A localized cone of depression would exist near well 2A, because this is one of the six wells assumed to operate at a larger rate to recover purified water. The other wells with larger pumping rates lie between well 2A and the injection wells where gradients reflect both increased pumping and injection.

Figure 12 shows the simulated particle path lines and estimated underground retention times for the 5 MGD Pure Water AV project. The reported path lines are for layer one, where the shortest underground retention times are simulated.

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Figure 12. Simulated Particle Path Lines and Estimated Underground Retention Times for 5 MGD Pure Water Antelope Valley Project (Layer One)

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Figure 12 indicates that PWD wells 2A, 3A, 4A, 7A, and 23A are simulated to pump purified water in less than five years after Pure Water AV starts. Simulated underground retention times for the four closest PWD wells are shown in Table 2.

Palmdale Water District Well Number	Simulated Underground Retention Time in Years	Credited Underground Retention Time in Years ¹
4A	2.1	1
23A	2.3	1.1
7A	3.5	1.7
3A	4.5	2.2

Table 2. Simulated Underground Retention Times for 5 MGD Scenario

Note:

¹ Credited underground travel time rounded down to be conservative.

Credited underground retention time reflects the 50% reduction applied to results from a numerical groundwater flow model. Title 22 regulations for IPR requires a minimum of two months underground retention time. Credited underground retention time for the 5 MGD scenario exceed the two-month requirement. Regulations also allow for up to six months of log virus reduction credit. Credited underground retention time for the 5 MGD scenario exceeds the six months to qualify for the maximum credit.

4.2 10 MGD Scenario

The calibrated model was used to simulate the 10 MGD Pure Water AV project. For the simulation, it was assumed that two injection wells would continuously operate on the full-scale treatment facility and one would continuously operate on the demonstration facility property to achieve the 10 MGD discharge rate. A fourth injection well would be needed to ensure continuous operation if one well is inoperative. The three injection wells were assumed to operate at 2,300 gpm each to achieve 10 MGD capacity. The model results suggest this rate is feasible with manageable groundwater elevation rise; however, confidence in this model projection is lower than that of the 5 MGD project.

Table 1 shows the simulated pumping rates for the 10 MGD scenario for wells in the project area. As previously described, the pumping rates in the six closest PWD pumping wells to the injection wells were conservatively assumed to operate at proportionally larger rates to recover all injected purified water. The total pumping rate of PWD wells in the project area would be approximately 11,900 gpm, or approximately 17 MGD for the 10 MGD Pure Water AV project.

Like Figure 11, Figure 13 shows the simulated future steady-state groundwater elevations for average pumping rates and for the 10 MGD Pure Water AV project.

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Figure 13. Simulated Steady-State Groundwater Elevations – 10 MGD Pure Water Antelope Valley Project
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Figure 13 indicates the following groundwater conditions might prevail in the future with Pure Water AV operating at 10 MGD:

- A groundwater mound would exist around the injection wells. Ground surface elevation at the full-scale treatment facility property is approximately 2,600 feet above mean sea level. The simulated groundwater mound at the facility during 10 MGD Pure Water AV operation would rise to approximately 2,325 feet msl, or over 200 ft bgs, approximately 50 feet higher than for the 5 MGD scenario. The simulated groundwater elevation rise is the simulated groundwater elevation in the model grid cell containing the injection well. This result suggests that operating two injection wells on the facility at 2,300 gpm each would not likely cause excessive groundwater mounding in the aquifer system. The result also suggests that operating three injection wells on the full-scale property operating at 2,300 gpm each may also be feasible. However, the current model does not account for well losses, which would cause the water level in the injection well to be higher than the groundwater elevation in the aquifer outside the well. As a result, it was assumed that the third injection well would be constructed on the demonstration facility property.
- Steep hydraulic gradients would exist between the injection wells and nearest PWD pumping wells.
- A localized cone of depression would exist near wells 2A and 8A, because they are two of the six wells that have larger pumping rates to recover purified water. The other wells with larger pumping rates lie between wells 2A and 8A, and the injection wells where gradients reflect both increased pumping and injection.

Figure 14 shows the simulated particle path lines and estimated underground retention times for the 10 MGD Pure Water AV project. The reported path lines are for layer one, where the shortest underground retention times are simulated.

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Figure 14. Simulated Particle Path Lines and Estimated Underground Retention Times for 10 MGD Pure Water Antelope Valley Project

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Figure 14 indicates that PWD wells 2A, 3A, 4A, 7A, 8A and 23A are simulated to pump purified water within five years after Pure Water AV starts. PWD well 3A is projected to pump purified water from the injection well located on the demonstration facility. Simulated underground retention times for the four closest PWD wells are shown in Table 3.

Palmdale Water District Well Number	Simulated Underground Retention Time in Years	Credited Underground Retention Time in Years ¹
4A	1.5	.7
23A	1.9	.9
7A	2.4	1.2
3A	1.8	.9

Table 3. Simulated Underground F	Retention Times for	10 MGD Scenario
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Note:

¹ Credited underground travel time rounded down to be conservative.

The simulated underground retention times for the 10 MGD scenario are shorter than those of the 5 MGD scenario. The shorter times are caused by steeper hydraulic gradients between the injection wells and the closest pumping wells. Credited underground retention time reflects the 50% reduction applied to results from a numerical groundwater flow model. Title 22 regulations for IPR require a minimum of two months underground retention time. Credited underground retention time for the 10 MGD scenario exceeds the two-month requirement. Regulations also allow for up to six months of log virus reduction credit. Credited underground retention exceeds the six months to qualify for the maximum credit.

4.3 Monitor Wells

Pure Water AV operation will require monitoring of purified water flow in the saturated zone between the injection wells and pumping wells. Title 22 regulations require at least two monitor wells to be located downgradient of the injection wells and upgradient of the pumping wells. At least one monitor well shall be located as follows:

- No less than two weeks, but no more than six months, of purified water travel time in the aquifer system
- At least one month of purified water travel time upgradient of the nearest drinking water well

Figure 15 shows the conceptual location of these monitor wells superimposed on the particle tracking maps for the 5 and 10 MGD Pure Water AV projects.

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Figure 15. Conceptual Monitor Well Locations

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Applying the permit requirements to the 5 and 10 MGD Pure Water AV projects and considering the simulated credited underground retention times suggest that one monitor well could be located on the full-scale treatment facility property and one monitor well could be located in the vicinity of 25th Street East and East Avenue Q, where property access might be easier to secure than locating the well on private property. For the 10 MGD project, two additional monitor wells could be required between the injection well on the demonstration facility and PWD well 3A, because purified water from the injection well is captured by well 3A, as shown on Figure 15.

4.4 Assessment of Model Predictions

The Pure Water AV numerical groundwater flow and particle tracking model is based on readily available hydrogeologic data, a local-scale HCM, and concepts simulated in USGS models. Like all numerical models, it is a simplification of the actual complex hydrogeologic system. The regional groundwater flow field surrounding the Pure Water AV area is conceptually understood and relatively stable. Regional groundwater flow conditions were reasonably reproduced by the Pure Water AV model. However, the Pure Water AV project will be implemented in a relatively small 1 square mile area (Figure 10). Estimating the rate of purified water flow and underground retention time in this small area requires accurate simulation of groundwater flow velocities, which are controlled by hydraulic gradient, hydraulic conductivity data are limited, effective porosity data are not available, and hydraulic gradients in the small project area are not fully understood. Data limitations increase model uncertainty and reduce confidence in model results. To minimize the impact of data limitations and improve confidence in the model predictions, a conservative analysis was conducted. However, field studies should be considered to acquire site-specific data to refine the model and improve confidence in the model predictions. Concepts and specific goals of the field studies are as follows:

- Preferential Pathway Thin and connected zones of high hydraulic conductivity within the saturated zone between the injection and pumping wells could provide preferential pathways for rapid purified water flow. To assess this potential, geophysical logs received during the modeling work were evaluated. While the evaluation did not identify obvious preferential pathways, it did indicate that the subsurface is stratified with interbedded zones of fine- and coarse-grained sediments a condition that could indicate possible preferential pathways. Because of this possibility, and considering the sparseness of available logs, additional evaluation of preferential pathways is recommended. One way to do this would be to conduct spinner logs in the wells.
- Injection Feasibility Available production and performance data for the PWD wells indicates
 that injection in the project area is feasible. However, the available information is insufficient to
 assess the feasibility and estimate the performance of injection wells on the treatment facility
 properties. Subsurface characterization would be needed to assess injection feasibility on the
 treatment facility properties. Conceptually, this would entail drilling, logging, well construction, and
 testing on the properties.

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• Effective Porosity – If wells are constructed during future site characterization, a tracer test could be conducted to estimate effective porosity. For example, if a full-scale injection well and a monitor well were installed on the full-scale treatment facility property, a relatively short-term tracer test could be conducted to estimate effective porosity. Underground retention time is directly related to effective porosity, meaning smaller effective porosities lead to shorter underground retention time. For example, an effective porosity value of 0.15 was assumed for the numerical model based on estimates from the scientific literature for similar hydrogeologic conditions. This effective porosity value resulted in a shortest credited underground retention time for the 5 MGD scenario of approximately one year. Holding all other parameters constant and reducing effective porosity to 0.10 would lead to an underground retention time of approximately 0.7 years. This conceptual analysis indicates that uncertainty in effective porosity could be important for achieving Title 22 regulations.

More specific recommendations for field studies are provided in Section 5.

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5.0 Conclusions and Recommendations

The following is concluded from the numerical modeling results:

5-MGD Scenario:

- Projected groundwater elevations indicate that operating two injection wells on the full-scale treatment facility property is feasible with manageable groundwater elevation rise.
- The shortest simulated underground retention time for the conservative 5 MGD Pure Water AV scenario is approximately 2.1 years. After factoring in the 50% credit for the numerical model, the credited underground retention time is one year, which exceeds the minimum two-month permit requirement and the six-month period required to achieve maximum log virus reduction credit.
- Applying the permit monitoring requirement and considering the simulated underground retention times, one monitor well could be located on the full-scale treatment facility property and one could be located between the property and the closest PWD well 4A. Conceptually, this well could be located along East Avenue Q, where property access might be easier to secure than locating the well on private property.

10-MGD Scenario:

- Projected groundwater elevations indicate that operating two injection wells on the full-scale treatment facility property and one on the demonstration facility is feasible with manageable groundwater elevation rise.
- The shortest simulated underground retention time for the conservative 10 MGD Pure Water AV scenario is approximately 1.5 years. After factoring in the 50% credit for the numerical model, the credited underground retention time is between 0.7 years, which exceeds the minimum two-month permit requirement and the six-month period required to achieve maximum log virus reduction credit.
- Applying the permit monitoring requirement and considering the simulated underground retention times, the same monitor well locations identified for the 5 MGD scenario appear to be suitable for the 10 MGD scenario. However, for the 10 MGD scenario, additional monitor wells between the injection well on the demonstration facility and well 3A may be required and would need to achieve permit requirements.

The following actions are recommended based on the results of the numerical modeling.

• Schedule a meeting with the regulators that will review the modeling work for the operating permit. Early engagement with the regulatory staff will streamline permitting.

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- Obtain site-specific hydrogeologic data to refine the model and improve confidence in the results. The following field studies should be considered.
 - Enhance the planned pumping tests at well 36. M&A has coordinated with PWD and Kyle Groundwater to expand monitoring during the test to nearby wells.
 - Conduct a spinner log in well 23A. For the spinner log, the permanent pumping equipment is typically removed from the well and temporarily replaced by a test pump. An economical way to do the pump work is to run the spinner log during the next rehabilitation effort at the well, which required removal of the permanent pump. The spinner log would profile groundwater flow into the well during pumping, which would provide a better indicator of the potential for preferential pathways than the review of available geophysical logs. Depending on the results of the well 23 spinner log, spinner logging in additional PWD wells could be beneficial to further characterize the potential for preferential flow pathways. If more than one spinner log is conducted, the next priority wells would be wells 3A, 4A, and 7A.
- Develop a characterization plan for the treatment facility properties. This plan would be informed by the results of the well 36 pumping test and spinner logging results and designed to maximize benefits to the Pure Water AV project. Investigative activities that could be considered include pilot hole drilling and lithologic/geophysical logging, zonal testing and sampling, injection well construction, monitor well construction, well testing activities, and a tracer test. Results of subsurface investigation on the treatment facility properties would substantially improve confidence in injection feasibility.

Results of additional site characterization would be used to refine the groundwater model. The refined model would be used to reassess injection feasibility, underground retention times, and monitor well locations.

References May 2023

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APPENDIX A.9

3

Conceptual Design Report for Pure Water AV – Advanced Water Treatment Demonstration Facility





Conceptual Design Report for Pure Water AV – Advanced Water Treatment Demonstration Facility

Draft Report

Pure Water Antelope Valley

September 16, 2022

Prepared for:

Palmdale Water District

Prepared by:

Stantec Team

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1.0 INTRODUCTION

The Stantec team including Trussell Technologies was retained by Palmdale Water District (PWD) to provide Program Management services for its regional water augmentation program referred to as Pure Water Antelope Valley (PWAV). As part of that effort, several planning studies are underway for successful implementation of PWAV.

This report provides an overview of the conceptual design for the Advanced Water Treatment Demonstration Facility (Demonstration Facility).

1.1 PROGRAM BACKGROUND AND DRIVERS

PWD has been providing water service to its customers since 1918 when the Palmdale Irrigation District was formed. Due to extensive agricultural use, the groundwater basin has been in overdraft since the 1930's resulting in land subsidence. In 1973, Palmdale Irrigation District changed its name to Palmdale Water District (PWD).

PWD has conducted a number of studies that date back to as early as the 1990's to evaluate the water resources necessary to meet future water supply demands. Concepts evaluated to date include using recycled water for landscape irrigation, discharging into Palmdale Lake, and discharging into existing sand and gravel pits to replenish the groundwater basin. In 2012, the Palmdale Recycled Water Authority (PRWA), comprised of members from the City of Palmdale and PWD, was established to manage recycled water that is generated and used within the Palmdale area. PRWA manages the distribution of recycled water, designing and constructing support facilities and financing the efforts.

PWD has been exploring different concepts of groundwater banking, storage and extraction. As part of that effort, PWD has conducted a series of pilot studies to determine the infiltration rates. Less than favorable results from the pilot studies led PWD to evaluate the feasibility of surface water augmentation and/or groundwater recharge via direct injection – two different forms of indirect potable reuse (IPR). Stantec was retained by PWD to conduct a feasibility study on IPR. Based on the results from the IPR feasibility study, PWD decided to pursue the concept further. Using tertiary effluent from the Los Angeles County Sanitation Districts' (LACSD) Palmdale Water Reclamation Plant (PWRP), PWD plans to produce potable quality water for groundwater recharge via direct injection. The Stantec Team (including Stantec, Trussell, MWA, Katz, and Montgomery & Associates) was retained by PWD to provide Program Management services for its regional recycled water augmentation program, the PWAV.

1.2 REPORT BACKGROUND AND OBJECTIVES

One of the major program components of the overall program plan is the design and implementation of the advanced water treatment facility (AWT Facility), which will utilize tertiary treated water from Los Angeles County Sanitation Districts' (LACSD) Palmdale Water Reclamation Plant (PWRP). The AWT is projected to include a treatment train consisting of membrane filtration (MF), reverse osmosis (RO) and ultraviolet-advanced oxidation process (UV/AOP). Additionally, as one of the first steps of program implementation, the Pure Water Antelope Valley Advanced



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CONCEPTUAL DESIGN REPORT FOR PURE WATER AV – ADVANCED WATER TREATMENT DEMONSTRATION FACILITY

Water Treatment Demonstration Facility (Demonstration Facility) has been conceived by PWD to promote public outreach, enable operator training, optimize the treatment process for full-scale design, and garner regulatory acceptance.

This report provides an overview of the design for the Demonstration Facility. It is to be used to inform project participants of the basic features for the planned system. Input from the project participants may be obtained and incorporated into the Demonstration Facility detailed and final design along with informing the Testing and Monitoring Plan.

1.3 REPORT STRUCTURE AND CONTENT

- Section 1 Introduction Provides the Program background and drivers as well as study background and objectives.
- Section 2 Facilities Description Describes the proposed Demonstration Facility site and the existing facilities at the PWRP.
- Section 3 Project Delivery Method Describes project delivery model and equipment preselection.
- Section 4 Groundwater Recharge Regulations Summarizes regulatory provisions related to groundwater replenishment via subsurface injection.
- Section 5 Water Quality Summarizes PWRP's tertiary water quality, highlighting parameters influencing the basis of design for sizing, performance, and regulatory compliance.
- Section 6 Process Description Describes preliminary design criteria and sizing of major process equipment and treatment systems.
- Section 7 Control Strategies Provides high-level preliminary control strategies for the Demonstration Facility.
- Section 8 Discipline Design Guidelines Describes conceptual-level general design requirements and basis of design for each discipline.
- Section 9 Operations Plan Defines preliminary operations plan for the Demonstration Facility.
- Section 10 Schedule Presents a schedule of the Demonstration Facility design, construction, and testing phases.
- Section 11 Cost Estimate Provides a Class 5 Opinion of Probable Construction Cost estimate for the Demonstration Facility.
- Section 12 Public Outreach Describes public engagement related to the Demonstration Facility.



2.0 FACILITIES DESCRIPTION

2.1 PROPOSED AWT DEMONSTRATION FACILITY SITE LOCATION

The Demonstration Facility will be located in Palmdale, California on East Avenue Q, east of PWD Headquarters and west of the Antelope Valley Chamber of Commerce and Palmdale Women's Club. The influent to the facility will be fed from a tertiary recycled water pipeline that is currently in design by PWD for this project along Avenue Q. Facility drains will discharge into a sanitary sewer line that will be connected to a main in Avenue Q. The Demonstration Facility preliminary site layout is presented below as Figure 1. Further information regarding the site and building conceptual design basis is included in Section 8.



Figure 1. Preliminary Site Layout



2.2 EXISTING PALMDALE WATER RECLAMATION PLANT

LACSD's PWRP currently provides primary, secondary, and tertiary wastewater treatment and has a maximum daily design capacity of 12 mgd. The plant is located at 39300 30th Street East, Palmdale, California, 93550. The plant's service area includes portions of the City of Palmdale and nearby unincorporated areas of Los Angeles County located in the Antelope Valley, which is part of the Lahontan Region.

The primary treatment at PWRP is comprised of bar screens and grit removal, followed by primary clarification. Secondary treatment includes activated sludge with anoxic and aerated zones that provide nitrification and partial denitrification, followed by polymer addition and secondary clarification. A secondary flow equalization basin is located downstream of the secondary clarifiers to provide a more stable flow to the tertiary treatment process. Tertiary treatment is achieved by cloth-media filtration and chloramination.

Secondary sludge undergoes dissolved air flotation, and the thickened waste sludge is combined with primary sludge before entering anaerobic digesters. The digested biosolids are dewatered via centrifugation and ultimately hauled offsite. Figure 2 portrays the PWRP treatment train schematic.



Figure 2. PWRP Treatment Train Schematic



3.0 PROJECT DELIVERY METHOD

3.1 DESIGN AND CONSTRUCTION

The Demonstration Facility will be delivered under a traditional design-bid-build model. The design submittals from the Stantec Team to PWD include this conceptual design report (CDR), 30% design plans and specifications, 100% design plans and specifications, and a final design package that will be used as the basis for construction bids.

3.2 EQUIPMENT PRESELECTION

Suppliers of major unit process equipment including, but not limited to, the MF System, the conventional RO System, the Secondary RO Systems (i.e., high-recovery technologies) and the UV/AOP System will be preselected during the 30% design. Preselection will enable the design to be focused on single Suppliers for each major unit process as to make the design process more efficient while minimizing uncertainty during construction that could result in change orders and schedule delays. It is anticipated that the preselected Suppliers will deliver equipment-specific design packages for incorporation into the 100% design plans and specifications. All preselected equipment will be assigned to the selected contractor to purchase during construction.

3.3 CONSTRUCTION

A contractor will be selected based on a traditional design-bid-build procurement approach.

4.0 GROUNDWATER RECHARGE REGULATIONS

The purpose of this section is to summarize the applicable regulations that drive the design and permitting of the PWVAP. While the Demonstration Facility will not be permitted for groundwater injection, it will be designed and tested to demonstrate compliance with the groundwater recharge regulations. The regulatory drivers for the conceptual design of the Demonstration Facility are based on purified water from the future full-scale AWT Facility being injected into the Antelope Valley Groundwater Basin as a form of indirect potable reuse called groundwater replenishment (GWR) via subsurface injection. One of the purposes of the Demonstration Facility is to develop the data necessary to obtain regulatory approval for the full-scale project. The performance of the Demonstration Facility will be utilized to fulfill the permit requirements for the full-scale project. The full-scale project will require an approved Water Recycling Permit from the Regional Water Quality Control Board, Water Recycling Requirements (WRRs) to ensure compliance with applicable water recycling criteria, and Waste Discharge Requirements for GWR are summarized in Table 1 below.



Туре	Public Health Criteria	Environmental Discharge Criteria	
Regulations	Recycled Water Policy	Basin Plan	
	California Code of Regulations (CCR)	Salt and Nutrient Management Plan	
	Title 22, Division 4, Chapter 3	CA Antidegradation Policy	
Requirements	s Approved Title 22 Engineering Report (State Water Board)		
	Approved Operation Optimization Plan (State Water Board)		
	Approved Test Protocol and Subsequent Results (State Water Board)		
	Water Recycling Requirements (WRRs) (Regional Water Board)		
	Waste Discharge Requirements (WDRs) (F	Regional Water Board)	

Table 1. Regulations and Requirements for GWR

4.1 WATER RECYLING CRITERIA

Table 2 provides a summary of the CCR requirements for GWR potable reuse projects.

Table 2. Summa	y of CCR Requir	ements for	GWR Projects
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Wastewater Source Control	Required
Pathogen Log Removal (V/G/C)	12/10/10 ⁽¹⁾
Full Advanced Treatment	Required ⁽²⁾
Nitrogenous Compounds	≤ 10 mg/L
Regulated/Emerging Contaminants and Physical Characteristics Control	≤ maximum contaminant levels (MCLs), California Notification Levels (NLs), or action levels (Als)
Total Organic Carbon	≤ 0.5 mg/L
Notes: (1) Credited up to 1-log removal of virus per mo	onth of subsurface travel time

(2) CCR defines FAT as RO with <0.25 mg/L TOC at startup and advanced oxidation to achieve 0.5-log removal of 1,4-Dioxane

4.1.1 TREATMENT REQUIREMENTS

GWR via subsurface injection requires the use of Full Advanced Treatment (FAT), or the treatment of the entire flow of water with RO and an advanced oxidation process (AOP) (Title 22, Chapter 3, Article 5.2, Section 60320.201). All FAT AWT Facilities in California currently include MF as pretreatment prior to RO and UV/AOP.



Performance requirements for RO include demonstrating minimum levels of salt rejection and ensuring permeate total organic (TOC) remains within specified limits¹. Initially, RO was considered an absolute barrier to pathogens and chemicals; however, with advancing analytical techniques, trace organic compounds have been detected in RO permeate. This recognition gave rise to the requirements for an AOP following RO. To demonstrate AOP performance, regulations allow one of two methods to be used. However, the only pursued method to date is to demonstrate the ability of an AOP to provide 0.5-log reduction of 1,4-Dioxane (Title 22, Chapter 3, Article 5.2, 60320.201.d). 1,4-Dioxane was selected because it serves as an indicator of the low molecular weight, uncharged constituents that have been shown to pass through RO membranes and are susceptible to oxidation by hydroxyl radicals generated through AOP. Studies have shown that processes that reduce 1,4-Dioxane levels are also effective at removing a wide variety of contaminants of emerging concern (CECs).

4.1.2 PATHOGEN CONTROL

The public health aspects of the GWR regulations focus first and foremost on minimizing the acute risk of pathogenic microorganisms. Requirements for pathogen control include 12-log reduction of enteric virus, 10-log reduction of *Giardia* cysts, and 10-log reduction *Cryptosporidium* oocysts. These "12/10/10" requirements must be met using a multi-barrier approach; for each type of pathogen, a minimum of three treatment processes must be used, with each providing at least 1-log reduction, but no more than 6-log reduction of an individual pathogen.

For subsurface injection, credit for *Giardia* cysts and *Cryptosporidium* oocysts cannot be granted through aquifer retention. Consequently, the full log removal requirements for *Giardia* cysts and *Cryptosporidium* oocysts must be accomplished prior to injection. Virus removal can be accomplished through combination of treatment at the AWT Facility and subsurface attenuation, where up to a 1-log reduction of virus credit is awarded for each month water is retained in the aquifer (up to 6 months or 6-logs).

Pathogen reduction credits can be achieved either through treatment processes or retention time in the aquifer; in both cases, demonstration of performance or retention time must be provided. For treatment processes that are used to meet the pathogen requirements, projects must validate unit process performance and demonstrate their effectiveness via on-going monitoring of a surrogate parameter.

4.1.3 CHEMICAL CONTROL

Chronic and acute risks to public health associated with chemical contaminants are also addressed in the GWR regulations, including nitrogen compounds (60320.110 and 60320.210), regulated contaminants (60320.112 and 60320.212), and additional chemical and contaminant monitoring, including various unregulated contaminants (60320.120 and 60320.220) as listed in

¹ The RO membranes must achieve minimum and average sodium chloride rejections of 99.0% and 99.2%, respectively. Initial RO permeate TOC must be less than 0.25 mg/L and not exceed 0.5 mg/L over the long term, based on a 20-week running average of all TOC results and the average of the last four TOC results.



Table 4. Total nitrogen must be sampled twice per week with any exceedances above 10 mg/L as N requiring additional action.

Regulated contaminants with MCLs or ALs – including inorganics, radionuclides, organic chemicals, disinfection byproducts (DBPs), as well as lead and copper – must be monitored quarterly. Constituents with secondary MCLs must be measured at least once annually. Actions to take in the event of exceedances are also described.

Additional chemical and contaminant monitoring requirements include (a) the priority toxic pollutants, (b) a list of site-specific, unregulated chemicals that must be determined in conjunction with the State Water Board, and (c) constituents with California Notification Levels (NLs).

4.2 ENVIRONMENTAL CRITERIA

Recycled water discharges to groundwater in Los Angeles County where Palmdale is are regulated by the Lahontan Regional Water Board. Under the Porter-Cologne Water Quality Control Act, all proposed discharges that could affect the quality of water of the state must file a Report of Waste Discharge to the Regional Water Quality Control Board. Permit limits for GWR projects are set to ensure that groundwater does not contain concentrations of chemicals that adversely affect beneficial uses or degrade water quality. Criteria governing discharge water quality to the environment are contained in the Basin Plan and Salt and Nutrient Management Plan (SNMP).

4.2.1 BASIN PLAN

The Basin Plan typically identifies both narrative and numeric objectives for the affected groundwater; these objectives are supplemented with basin-specific and/or site-specific objectives as needed. The primary objective of the groundwater quality standards is to maintain the existing high quality of groundwater in the region. The Lahontan Region Basin Plan covers the project area for the PWAVP. While no specific Basin Plan Objectives are defined for the Antelope Valley Groundwater Basin, the Lahontan Regional Water Quality Control Board has approved a SNMP with relevant water quality goals. These are defined in the following subsection.

4.2.2 SALT AND NUTRIENT MANAGEMENT PLAN

The SNMP sets basin-specific water quality objectives meant to serve as a tool for planning and managing the groundwater basin while protecting its designated beneficial uses. The water quality objectives for arsenic, boron, chloride, fluoride, nitrate, and total dissolved solids (TDS) are summarized in Table 3.



Table 3. SNMP Water Quality Objectives for Antelope Valley Groundwater Basin.

Constituent	Units	SNMP Water Quality Management Goals
Arsenic	µg/L	10 ⁽¹⁾
Boron	mg/L	0.7 ⁽²⁾ -1 ⁽³⁾
Chloride	mg/L	238/250/500 (4)
Fluoride	mg/L	1 ⁽²⁾ -2 ⁽¹⁾
Nitrate as Nitrogen	mg/L	10(1)
Total Dissolved Solids (TDS)	mg/L	450/500/1000 ⁽⁵⁾

¹Municipal and Domestic Supply (MUN) Water Quality Objective, which is based on the Title 22 CCR drinking water primary MCL

² Based on the agricultural supply beneficial use threshold

³ Based on California's Notification Level

⁴ Recommended value (based on agricultural supply beneficial use threshold)/upper value (based on MCL)/short-term value

⁵ Recommended value (based on agricultural supply beneficial use threshold)/upper value/short-term value

4.3 CECS

The Recycled Water Policy (amended April 8th, 2019) provides monitoring requirements and criteria for CECs for GWR. The State Water Board utilized a risk-based framework to prioritize and select CECs for potable reuse applications. The framework was used to screen known CECs and develop a list of health-based CECs (i.e., toxicologically relevant CECs) and performance indicators (i.e., CECs with properties that demonstrate a capacity for reduction by a particular treatment process). To monitor treatment efficacy, the State Water Board also lists surrogates that should be monitored as indicative of removal of CECs through individual unit processes or combinations of unit processes. Other surrogates not listed may be considered. Surrogates should be able to be measured using on-line or hand-held instruments. The State Water Board also requires the use of bioanalytical tools (e.g., bioassays) for screening of unmonitored CECs for potable reuse applications. These bioassays complement the other CEC monitoring requirements by assessing whether product water can elicit specific effects in living cells.

The CEC Monitoring Parameters in Attachment A of the Recycled Water Policy are summarized in Table 4 Table 4 below.



Indicator Type	Constituent
Health-Based CECs	 1,4-Dioxane NDMA NMOR PFOS PFOA
Performance Indicators	 Gemifibrozil lohexol Sucralose Sulfamethoxazole
Surrogates	 Ammonia Dissolved organic carbon Nitrate Total Fluorescence UV Absorbance Electrical Conductivity
Bioanalytical Screening Tools	Estrogen receptor-alphaAryl hydrocarbon receptor

Table 4. Summary of CEC Monitoring Parameters for GWR Projects

5.0 WATER QUALITY

The purpose of this section is to summarize water quality for both the feed water to and the anticipated treated water from the Demonstration Facility. PWRP's tertiary effluent water quality, which will be the source water for the Demonstration Facility, is used as the basis of design for the sizing and performance of the treatment processes described in Section 6.0. Additionally, key parameters in the tertiary effluent are identified that may pose a challenge for regulatory compliance and operational efficiency at the Demonstration Facility. The anticipated removal of these key water quality constituents is also defined, as it relates to establishing appropriate design criteria for the treatment processes that target them. This operational and water quality data at PWRP are summarized for the period of 2017 through 2021. The technical memorandum (TM) **Tertiary Water Requirements** describes this water quality analysis in more detail.

5.1 TERTIARY EFFLUENT WATER QUALITY

PWRP's tertiary effluent will be the source water to the Demonstration Facility and to the future fullscale AWT Facility. Water quality parameters that are relevant for the implementation of a potable reuse project were analyzed in the PWRP tertiary effluent. Some of these parameters are relevant for compliance while others are important for operations and design of the unit processes at the Demonstration Facility. Key findings regarding the source water quality include:



- TDS concentrations averaged 471 mg/L with a maximum of 539 mg/L, both of which exceed the SNMP goal of 450 mg/L for Antelope Valley Groundwater Basin (Table 3). The TDS compliance goal can be met with the use of RO at the Demonstration Facility.
- NDMA concentrations averaged 532 ng/L with a maximum of 1,200 ng/L, both of which are higher than the California NL for this constituent at 10 ng/L. These high NDMA concentrations are likely due to the use of cationic polymer along with chloramination at PWRP. The NDMA compliance goal can be met with the use of RO and properly designed UV/AOP at the Demonstration Facility, but source control measures may be a more economical and reliable solution for the future full-scale AWT Facility.
- Perfluorooctanoic acid (PFOA) concentrations averaged 6.9 ng/L with a maximum of 8.2 ng/L, both of which are higher than the NL for this constituent of 5.1 ng/L. The PFOA compliance goals can be met with the use of RO.
- Chloramine residuals are not insignificant and relatively variable. Historical chloramine residuals in PWRP's tertiary effluent ranged from 1.5 to 4.0 mg/L as Cl₂. Since chloramines are needed upstream of the MF and RO systems to mitigate biofouling of these processes, monitoring and control of chloramine addition at the Demonstration Facility needs to be robust and reliable to ensure accurate and consistent chloramine levels are delivered to the treatment systems under these variable conditions. If chloramine residuals are excessive (i.e., >4 mg/L) in the PWRP tertiary effluent, this could adversely impact the efficiency of the UV/AOP system by decreasing the ultraviolet transmittance (UVT) to below permit limits, increasing the power requirements for the UV reactor and increasing the hydroxyl scavenging demand of the UV/AOP process. In addition, chloramines react with the free chlorine used as the oxidant for AOP, thus increased free chlorine doses may be required to overcome breakpoint chlorination.
- Other important water quality parameters for potable reuse projects, such as total organic carbon (TOC), total nitrogen, constituents with federal and state regulated MCLs, among many others, were present at typical levels for tertiary effluent from a nitrified water reclamation plant. Therefore, these parameters are expected to comply with their limits following treatment at the AWT Facility.
- Table 5 summarizes the results for the water quality parameters that are most relevant to the sizing of MF, RO, and UV/AOP systems:

Constituent	Units	2017-2021 PWRP Tertiary Effluent Water				
		Minimum	Maximum	Average	90th Percentile	Count
Aluminum	µg/L		N	D		1
Total Ammonia	mg/L as N	0.65	5.27	1.93	3.21	62
Barium	µg/L		22.	.5		1
Boron	µg/L		29	0		1
Calcium	mg/L	24.5	39.5	33.5	39.1	20
Chloride	mg/L	107	180	145.1	172.9	20
Iron	µg/L		40	C		1
Magnesium	mg/L	5.8	12.9	9.3	12.1	21
Manganese	µg/L		20	.7		1
Nitrate	mg/L as N	0.91	8.9	2.62	5.44	62
Nitrite	mg/L as N	0.03	0.4	0.1	0.3	60
рН	-	6.3	7.8	7.1	7.4	261
Potassium	mg/L		15.	.9		1
Sodium	mg/L	95.3	139	118.2	133.7	20
Sulfate	mg/L	49.4	78.7	67.3	78.4	20
TDS	mg/L	406	536	471	522	21
Temperature	°C	14.5	30.1	23.0	27.5	261
Total Organic Carbon	mg/L	5.26	7.78	6.08	6.87	25
Total Alkalinity	mg/L	65	127	97.2	126.5	10

Table 5 Expected Feedwater Quality for the Demonstration Facility

The AWT Facility's product water must meet regulatory requirements and monitor compounds at frequencies listed in Title 22 of the California Code of Regulations (CCR). Title 22 CCR specifies that potable reuse projects must comply with Federal and State drinking water regulations. The product water must also meet the SNMP goals which manage salts, nutrients, and other constituents in the Antelope Valley Groundwater Basin.



Table 6 presents the water quality goals for the Demonstration Facility product water to meet the SNMP goals, MCLs for inorganic and organic chemicals, radionuclides, and DBPs, ALs for copper and lead under the Lead and Copper Rule (LCR), and the California NLs.



Parameter	Unit	Value		
SNMP Constituents				
Arsenic	µg/L	10		
Boron	mg/L	0.7–1		
Chloride	mg/L	238/250/500		
Chromium, total	µg/L	50		
Fluoride	mg/L	1 - 2		
Nitrate	mg/L as N	10		
Total dissolved solids (TDS)	mg/L	450/500/1000		
Primary MC	Ls for Organics			
Aluminum	mg/L	1		
Antimony	µg/L	6		
Arsenic	µg/L	50		
Asbestos	MFL	7		
Barium	µg/L	1,000		
Beryllium	µg/L	4		
Cadmium	µg/L	5		
Chromium, Total	µg/L	50		
Cyanide	µg/L	150		
Fluoride	mg/L	2		
Mercury	µg/L	2		
Nickel	µg/L	100		
Nitrate (as N)	mg-N/L	10		
Nitrite (as N)	mg-N/L	1		
Nitrate + Nitrite ⁽¹⁾	mg-N/L	10		
Perchlorate	µg/L	6		
Selenium	µg/L	50		
Thallium	µg/L	2		
Fluoride	mg/L	2		
Primary MCLs for Vol	atile Organic Chemicals			
Benzene	mg/L	0.001		
Carbon Tetrachloride CTC	mg/L	0.0005		
1,2-Dichlorobenzene	mg/L	0.6		
1,4-Dichlorobenzene	mg/L	0.005		
1,1 -Dichloroethane	mg/L	0.005		
1,2-Dichloroethane	mg/L	0.0005		

Table 6. Water Quality Goals for the Demonstration Facility.



1,1-Dichloroethene	mg/L	0.006
Cis-1,2-Dichloroethylene	mg/L	0.006
Trans-I ,2-Dichloroethylene	mg/L	0.01
Dichloromethane	mg/L	0.005
1,2-Dichloropropane	mg/L	0.005
1,3-Dichloropropene	mg/L	0.0005
Ethylbenzene	mg/L	0.3
Methyl-tert-butyl-ether (MTBE)	mg/L	0.013
Monochlorobenzene	mg/L	0.07
Styrene	mg/L	0.1
1,1,2,2-Tetrachloroethane	mg/L	0.001
Tetrachloroethylene PCE	mg/L	0.005
Toluene	mg/L	0.15
1 ,2,4-Trichlorobenzene	mg/L	0.005
1,1,1 -Trichloroethane	mg/L	0.2
1,1 ,2-Trichloroethane	mg/L	0.005
Trichloroethylene TCE	mg/L	0.005
Trichlorofluoromethane	mg/L	0.15
1,1,2-Trichloro-1,2,2-Trifluoroethane	mg/L	1.2
Vinyl Chloride	mg/L	0.0005
Xylenes m,p	mg/L	1.75
Primary MCLs for Non-Volatile	Synthetic Organic C	hemicals
Alachlor	mg/L	0.002
Atrazine	mg/L	0.001
Bentazon	mg/L	0.018
Benzo(a)pyrene	mg/L	0.0002
Carbofuran	mg/L	0.018
Chlordane	mg/L	0.0001
2,4-D	mg/L	0.07
Dalapon	mg/L	0.2
1,2-Dibromo-3-chloropropane (DBCP)	mg/L	0.0002
Di(2-ethylhexyl)adipate	mg/L	0.4
Di(2-ethylhexyl)phthalate	mg/L	0.004
Dinoseb	mg/L	0.007
Diquat	mg/L	0.02
Endothall	mg/L	0.1
Endrin	mg/L	0.002



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Ethylene Dibromide (EDB)	mg/L	0.00005			
Glyphosate	mg/L	0.7			
Heptachlor	mg/L	0.00001			
Heptachlor Epoxide	mg/L	0.00001			
Hexachlorobenzene	mg/L	0.05			
Hexachlorocyclopentadiene	mg/L	0.05			
Lindane	mg/L	0.0002			
Methoxychlor	mg/L	0.03			
Molinate	mg/L	0.02			
Oxamyl	mg/L	0.05			
Pentachlorophenol	mg/L	0.001			
Picloram	mg/L	0.5			
Polyhlorinated Biphenyls	mg/L	0.0005			
Simazine	mg/L	0.004			
Thiobencarb	mg/L	0.07			
Toxaphene	mg/L	0.003			
2,3,7,8-TCDD (Dioxin)	mg/L	3x10 ⁻⁸			
2,4,5-TP (Silvex)	mg/L	0.05			
Lead and Copper Rule	(LCR) Action Levels (A	Ls)			
Copper	µg/L	1,300			
Lead	µg/L	15			
Primary MCLs for DBPs					
Total Trihalomethanes (TTHMs)	µg/L	80			
Bromodichloromethane	µg/L				
Bromoform	µg/L				
Chloroform	µg/L				
Dibromochloromethane	µg/L				
Haloacetic Acids (five) (HAA5)	µg/L	60			
Monochloroacetic Acid	µg/L				
Dichloroacetic Adic	µg/L				
Trichloroacetic Acid	µg/L				
Monobromoacetic Acid	µg/L				
Dibromoacetic Acid	µg/L				
Bromate	mg/L	0.01			
Chlorite	mg/L	1			
Secondary Drinking Water Standards (sMCLs)					
Aluminum	mg/L	0.2			



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Chloride	ma/l	250
Color	upite	15
	units	15
Copper	mg/L	1.0
Fluoride	mg/L	2.0
Foaming Agents (MBAS)	mg/L	0.5
Iron	mg/L	0.3
Manganese	mg/L	0.05
Methyl-ted-butyl ether	mg/L	0.005
Odor—Threshold	Units	3
рН	Standard	6.5-8.5
Silver	mg/L	0.1
Sulfate	mg/L	250
Total Dissolved Solids (TDS)	mg/L	500
Thiobencarb	mg/L	0.001
Turbidity	Units	5
Zinc	mg/L	5.0
California Noti	fication Levels (NLs)	
Naphthalene	µg/L	17
N-Nitrosodimethylamine (NDMA)	ng/L	10
N-Nitrosodi-n-propylamine (NDPA)	ng/L	10
Perfluorobutane Sulfonic Acid (PFBS)	ng/L	500
Perfluorooctane Sulfonate (PFOS)	ng/L	6.5
Perfluorooctanoic Acid (PFOA)	ng/L	5.1
Vanadium	mg/L	0.05
Naphthalene	µg/L	17

5.2 DEMONSTRATION FACILITY PRODUCT WATER QUALITY

At a minimum, the AWT Facility will employ a treatment train consisting of MF, RO, and UV/AOP. MF serves as pretreatment ahead of RO by removing particulate matter and providing additional pathogen log reduction credits. The RO process can reject more than 99.5% of ion concentrations in the water, while also addressing many trace organic compounds and providing further pathogen log reduction. UV/AOP can eliminate and oxidize harmful chemicals such as nitrosamines and 1,4-dioxane, as well as pathogens. The summary of the pathogen LRVs granted by each of the treatment processes are shown in Table 7. Note that for the virus LRV requirement to be met (i.e., 12), the groundwater must provide at least 4.5 LRVs, i.e., the time the water spends underground between the injection point and the groundwater well must be at least 5 months.



Process	Viruses	Giardia	Cryptosporidium
MF	0	4	4
RO	1.5	1.5	1.5
UV/AOP	6	6	6
Groundwater	6	0	0
Total	13.5	11.5	11.5
Required	12.0	10.0	10.0

Table 7. Anticipated LRVs for the Three Pathogens by Each of the Treatment Processes.

5.2.1 MEMBRANE FILTRATION AND REVERSE OSMOSIS SYSTEMS

The MF process will remove large particles that would otherwise harm the RO membranes. MF can provide significant turbidity reduction, and continuous turbidity monitoring is used as a surrogate for membrane integrity. The effluent turbidity of an individual MF unit must be less than 0.2 NTU 95% of the time and less than 0.5 NTU at all times to maintain pathogen LRVs for *Giardia* and *Cryptosporidium*. Up to 4.0 LRVs of each of these protozoa are credited via daily pressure decay tests on each MF train.

RO is highly effective in rejecting salts and ions, at rates above 99%. Different RO systems will be employed at the Demonstration Facility for comparison. At the worst-case scenario, the recovery rate will be 90%, when employing 3-stage conventional RO. Other technologies tested will increase the recovery.

Using this expected 90% recovery and the feed water quality previously presented, a preliminary RO permeate water quality can be estimated. These concentrations are summarized below.

Parameter	Units	Predicted RO Permeate Values for 90% Recovery
Hardness	mg/L as CaCO₃	0.95
Calcium	mg/L	0.27
Magnesium	mg/L	0.07
Sodium	mg/L	4.41
Potassium	mg/L	0.73
Ammonia	mg/L	0.11
Barium	mg/L	0.00
Strontium	mg/L	0.00
Carbonate	mg/L	0.00
Bicarbonate	mg/L	5.35
Sulfate	mg/L	0.44

Table 8. Preliminary Stage 3 Conventional RO Permeate Water Quality, Using 90% Recovery



Chloride	mg/L	3.72	
Fluoride	mg/L	0.00	
Nitrate	mg/L	2.03	
Phosphate	mg/L	0.03	
Silica	mg/L	0.19	
Boron	mg/L	0.00	
Carbon Dioxide	mg/L	14.1	
TDS	mg/L	17.4	
рН	mg/L	5.79	

From Table 8, it is possible to see that even more stringent requirements can be met after the RO process, including the recommended SNMP TDS goal of 450 mg/L.

Not depicted in Table 8 is the chloramine residual after RO. RO can reject roughly 50% of chloramines, which will impact the downstream UV/AOP process. Other compounds that are only moderately rejected by RO that are relevant to potable reuse are NDMA and 1,4-dioxane. They will be addressed in the following section.

5.2.2 UV/AOP SYSTEM

Chloramines are directly related to the UVT of the water, such that higher chloramine residuals lead to lower UVT. Lower UVT requires higher power to deliver the same UV dose, which increases the energy costs of the system. Chloramines also compete with free chlorine as the oxidant agent for the AOP system. In order for free chlorine to be effective as the AOP oxidant, a higher dose is required to overcome the breakpoint chlorination reaction with chloramines in the feed water. The increased free chlorine dose also impacts the chemical costs. While chloramines are needed to control biofouling through the MF and RO systems, the dosing should be optimized during the pilot to counterbalance these adverse impacts on the UV/AOP system.

NDMA is highly susceptible to photolysis, and therefore, the UV process can be sized to reduce NDMA concentrations below the NL. Often, the UV dose is controlled by the influent and the target effluent NDMA concentrations. The NL in California for NDMA in drinking water is 10 ng/L, and applying a safety factor, a target final NDMA value of 5 ng/L is appropriate when designing the UV system. Since NDMA is only moderately rejected by RO (~50%), the UV doses would still be significant to reduce NDMA to below the NL.

The effectiveness of the UV/AOP process is a combination of the UV dose and the concentration of the oxidant in the water (e.g., free chlorine). This combination forms hydroxyl radicals that are highly effective in oxidizing a series of compounds in the water. One of these compounds is 1,4-dioxane, that serves as a surrogate compound for a greater pool of contaminants. The UV/AOP system will target at least a 0.5-log removal of 1,4-dioxane, while bringing its concentrations to below 1.0 μ g/L.



6.0 PROCESS DESCRIPTION

This section describes the preliminary design criteria and sizing of the major process equipment and systems for the Demonstration Facility.

6.1 OVERVIEW

A process flow diagram for the Demonstration Facility is presented as Figure 3. Major process Streams are labeled numerically, and their respective design flow rates—assuming an overall RO recovery of 96%—are listed in a summary table in the upper lefthand corner. The Demonstration Facility layout is provided as Figure 4 and described below, moving from the north end of the site to the south. Detailed descriptions of each process are provided in the subsequent sections.

Chemical storage and dosing equipment will be located outside in the Chemical Utility Area under a canopy. Metering pumps will be connected to process equipment or pipelines (e.g., sulfuric acid addition for pH control upstream of RO systems), and transfer pumps will be connected to the CIP skids. The CIP skids for cleaning the MF and RO membranes will also be located outside to minimize piping runs between chemical transfer pumps and the chemical solution tanks. The chemical storage units will be lined up along the northern edge of the Chemical Utility Area for easy access by delivery trucks from the road that loops around the exterior of the Demonstration Facility. The process equipment skids for MF, RO, and UV/AOP are located adjacent to the walkway for high visibility during tours and O&M accessibility purposes. A minimum of three-foot clearance—indicated by the green lines—was maintained for the process equipment. An exception is the clearance required for removal and installation of the lamps for the UV/AOP skid, which is around 5.5 feet based on a vendor proposal. Dimensions for the process skids are based on information provided by vendors; these values are preliminary and subject to change. However, conservatism was emphasized when developing the layout, so it is expected that all process equipment will fit within the Process Area.

As tour participants reach the end of the walkway near the UV/AOP skid, they will encounter a Tasting Station with a bar designed to resemble a household sink in a space large enough to accommodate up to 30 people to gather while sampling the final product water. A granular activated carbon system, which is not shown in the layout, will be used to remove any residual chlorine from the water before tasting. It is expected that the system will be small enough to be comfortably located in the Tasting Station (e.g., under the bar).
Figure 3. Process Flow Diagram for Demonstration Facility







Figure 4. Layout of Process Area



6.2 FLOWS

A total of 189-240 gallons per minute (gpm) of tertiary treated effluent from PWRP via the pressurized non-potable reuse line will be conveyed to the MF feed tank at the Demonstration Facility from a connection to the non-potable reuse pipeline located along Avenue Q. The MF system will produce an average of 180 gpm filtrate to meet the anticipated flow requirements for the Primary RO system (i.e., conventional RO stage 1 feed) but has the capability to produce more than 180 gpm if needed by the Primary RO system or by the MF system (i.e., higher flux rate testing) during testing and operations. The Primary RO system will feed stage 2 concentrate to the Secondary RO system (i.e., conventional third stage RO system) and to the Secondary RO Feed Equalization Tank that feeds the CCRO and PFRO systems. RO permeate from the Primary RO, Secondary RO, CCRO, and PFRO will be directed to the RO flush tank. A portion of the RO permeate (i.e., 5-15 gpm) will be fed to the UV/AOP system and any excess RO permeate in the RO flush tank will overflow to drain. The UV/AOP effluent will flow through a calcite contactor prior to entering a Purified Water Tank which will serve as the source drinking water supply for the tasting bar. Any excess/unused water in the Purified Water Tank will overflow to drain. A summary of the process flows is shown in Table 9. Values for conventional RO are based on overall three-stage recovery of 90%.

Process	Flow Rate (gpm)
Source Water to MF Feed Tank	189–240
MF Feed	189
MF Filtrate (assuming minimum 95% recovery)	180
Primary RO Feed (Conventional RO Stage 1 Feed)	180
Primary RO Permeate (Conventional RO Stage 1 and 2 Permeate)	137
Primary RO Concentrate (Conventional RO Stage 2 Concentrate)	43
Secondary RO Feed (Conventional RO Stage 3 Feed)	7.2
Secondary RO Permeate (Conventional RO Stage 3 Permeate)	4.1
Secondary RO Concentrate (Conventional RO Stage 3 Concentrate)	3.0
CCRO Net Feed (recoveries of 92%/94%/96%)	10.5/9.9/9.4
CCRO Net Permeate (recoveries of 92%/94%/96%)	7.0/7.4/7.8
CCRO Net Concentrate (recoveries of 92%/94%/96%)	3.5/2.5/1.6
PFRO Feed (recoveries of 92%/94%/96%)	6.3/5.6/5.0
PFRO Permeate (recoveries of 92%/94%/96%)	4.2/4.2/4.2
PFRO Concentrate (recoveries of 92%/94%/96%)	3.5/2.5/1.6
UV/AOP Feed	5 -15
Calcite Contactor Feed	5 -15

Table 9. Demonstration Facility Process Flow Summary



The water will be pumped throughout the processes at the Demonstration Facility to ensure there is sufficient head to overcome major and minor pressure losses through piping, fittings, and process equipment. Break tanks between the processes (e.g., RO Flush Tank) will all be constructed above grade. Waste flows such as tank overflows and RO concentrates will all flow by gravity to the sanitary sewer. All tanks will be at atmospheric pressure. Head will be broken at the Secondary RO Feed Equalization Tank, and the flow will be re-pressurized via pumping upstream of the secondary CCRO and PFRO systems.

6.3 ADVANCED WATER PURIFICATION SYSTEMS

The treatment processes employed at the Demonstration Facility are further explained below along with schematics and design criteria.

6.3.1 MF SYSTEM

A description of the MF process at the Demonstration Facility is included in this Section along with design criteria and instrumentation.

6.3.1.1 PROCESS DESCRIPTION

MF will be the first treatment process at the Demonstration Facility. The purpose of MF is to provide LRVs for *Cryptosporidium* and *Giardia* and to polish the feed water (tertiary effluent from PWRP) for the RO process. The current plan is to utilize a universal platform design to test MF modules manufactured by Toray, DuPont, and Scinor, but other modules may be considered. There will be a universal microfiltration/ultrafiltration skid consisting of two trains, so two different modules can be tested simultaneously. It is planned to include remote monitoring and control of the skid. A comparison of these membrane modules is provided in Table 10.

Parameter	Units	Toray	DuPont (Dow)	Scinor
Product Model	-	HFUG-2020AN	SFD-2880XP	SMT600-P72
Membrane Area per Module	ft ²	969	829	775
Membrane Material	-	Polyvinylidene Fluoride	Polyvinylidene Fluoride	Polyvinylidene Fluoride
Flow Configuration	-	Outside-In	Outside-In	Outside-In
Nominal Pore Size	μm	0.01	0.03	0.1

Table 10. Comparison Of Membrane Filtration Modules

The feed water to the MF system will be collected in a MF feed tank with a hydraulic retention time (HRT) of 15 minutes to provide constant flow to the skid. Sodium hypochlorite and liquid ammonium sulfate will be dosed, as needed, prior to the skid to form chloramines to control biofouling on the MF and RO membranes, at a range from 1 to 5 mg/L as Cl₂, that will be optimized during operations. MF feed pumps will draw the water from the MF feed tank and pass it through automatic backwashing strainers prior to sending it to the skid. The strainers will remove larger particles that could be in the water to prevent any damage to the membranes.



Four LRVs for *Cryptosporidium* and four LRVs for *Giardia* can be granted to MF systems with intact membranes; no credits are granted for viruses by MF treatment. The integrity of the membranes is evaluated to establish log reduction value credits based on daily pressure decay tests (PDTs) and continuous turbidity monitoring from individual MF units. PDTs have the sensitivity to detect a 3 µm defect in the membranes. Successful PDTs show little to no variation in MF filtrate turbidity values compared to baseline filtrate turbidity values. Therefore, turbidity is a key parameter for MF.

Backwashing of the membranes will take place approximately every hour and last for 30 seconds. These frequencies might change for the different products from different vendors, and it could be optimized during the testing and monitoring plan. A tank will collect MF filtrate and will serve as both the RO feed tank as well as the MF backwashing supply tank. Membrane cleaning will be accomplished with CIPs, using RO permeate as make-up water fed from the RO Flush Tank, described as daily or every-other-day maintenance cleans (MCs) and monthly recovery cleans (RCs). MCs and RCs will utilize a cleaning solution of either chlorine/caustic or citric acid. RCs will run at higher doses than MCs. Sodium hydroxide will also be used for the system's RCs, and the waste will be neutralized with citric acid. The cleaning waste as well as backwashing water and other waste or overflow streams will be directed to the drains, that will discharge into the sanitary sewer.

The membrane filtration skid will be designed to replicate the full-scale system by including fully automated backwashing, daily integrity testing (PDTs), and chemically enhanced backwashing. It will be pre-programmed with Allen Bradley CompactLogix PLC and human-machine interface (HMI) for efficient operation with all tested modules.

6.3.1.2 DESIGN CRITERIA

The preliminary design criteria and sizing of the MF system for the Demonstration Facility are listed in Table 11. These criteria were based on Toray's membranes, but they are different for the other manufacturers and will be confirmed by the MF supplier.

Parameter	Unit	Value/Range		
MF Fee	ed Tank			
Hydraulic Retention Time ¹	min	15		
Tank Volume	gallons	4,030		
Tank Height	ft	14		
Tank Diameter	ft	7.0		
MF Feed Pump				
Number of Pumps (duty + standby)		2 + 0		
Feed Pump Capacity, per pump	gpm	100		
Pump Differential Pressure	psi	28		
Pump Horsepower, per pump	hp	3		
VFD	-	yes		

Table 11. Design Criteria for MF Systems at the Demonstration Facility



MF Strainer			
Feed Flow, per strainer	gpm	100	
Strainer Mesh Size	μm	300	
Strainer Type		Self-Backwashing	
Number of Strainers		2	
MF Sy	stem		
Feed Flow	gpm	189	
Number of Trains		2	
Number of Modules per Train		7	
Total Number of Modules		14	
Recovery	%	95	
Design Flux	gfd	30	
Maximum Flux	gfd	40	
Total Membrane Surface Area (All Trains)	SF	13,566 (Toray HFUG-2020AN)	
		11,606 (DuPont SFD-2880XP) 10,650 (Scinor SMT600-P72)	
Skid Length	ft	11	
Skid Width	ft	7	
Skid Height	ft	8.8	
MF Backwashing System			
Backwashing Flux	gfd	110	
Backwashing Duration	sec	30	
Backwashing Frequency	min	60	
Backwashing Volume	gal	259	
Air Flow Source	-	Air Compressors	
Air Flow for Scrubbing	SCFM/module	3.5	
Air Scrubbing Duration	sec	30	
Air Pressure	psi	5	
Air Storage	gallons	370	
MF CIP Tank			
CIP Volume Needed	gallons	300	
CIP Tank Height	ft	7	
CIP Tank Diameter	ft	3.0	
CIP Tank Base Area	ft2	5.5	

¹ Typical design value

² Based on design information provided by vendor



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6.3.1.3 INSTRUMENTATION

The critical online instruments to monitor the performance of the MF systems are flow meters (feed and filtrate), turbidimeters (individual filtrate), pressure gauges (feed, filtrate, and backwash), pH meters (feed, CIP, and neutralization), total chlorine analyzer (feed), and a temperature analyzer (feed).

6.3.2 RO SYSTEM

A description of the Primary and Secondary RO systems at the Demonstration Facility is included in this Section along with design criteria and instrumentation.

6.3.2.1 GENERAL PROCESS DESCRIPTION AND PURPOSE

The RO process removes contaminants as the feed water is pumped at high pressure across a semipermeable membrane. This separation process yields two different water streams, (a) the purified RO permeate and (b) a reject stream, or concentrate, containing high concentrations of the dissolved solutes. The water quality of the RO permeate is largely a function of the feed water quality, that was further detailed in Section 5, and the design of the RO system.

The RO system is a requirement in potable reuse applications such as GWR via direct injection. It provides removal of dissolved constituents – including inorganic salts, TOC, and trace organic contaminants – while also serving as a barrier for pathogens. Standard RO credits are 1.5 LRV credits for virus, *Giardia*, and *Cryptosporidium* when using online conductivity and/or TOC as a surrogate parameter.

The RO system at the Demonstration Facility will be placed after the MF system. MF filtrate will be collected in a RO feed tank – which is the same tank used for the MF backwashing– with an HRT of 15 minutes to allow constant flow to the Primary RO system (i.e., conventional 2-stage RO system). The volume within that HRT is sufficient to feed the RO system while either conducting a backwash or MC on one of the two trains of the MF system. A low-pressure transfer pump will draw the flow from the RO feed tank to the RO membranes. A cartridge filter will be placed ahead of the RO membranes to protect them from larger particles that pass through the MF system or accumulate in the feed tanks and pipelines (e.g., pipe shavings).

Sulfuric acid and antiscalant will be injected in the RO feed line to decrease the pH and protect the membranes from scaling. Chloramine residual will be present at the RO feed since its removal by MF is minimal, to control biofouling on the membranes. ORP will also be monitored to ensure that free chlorine residual is not present to protect the RO elements.

The Primary RO at the Demonstration Facility, a conventional 2-stage RO, will be the first step in the RO process and is designed to achieve an overall recovery of 76%. Overall water recovery of the RO system can be improved by passing the concentrate through subsequent RO stages and combining the permeate from each stage. The target recovery range for the overall RO system (I.e., Primary and Secondary RO) at the Demonstration Facility is 90-96%. The 90% value will serve as a baseline for comparison per the technical memorandum **Brine Management Strategy**. The



overall recovery may be increased to approximately 92% during testing at the Demonstration Facility to determine effects on performance. The permeate from the Primary RO system will be split between the RO Flush Tank and the UV/AOP system. The RO Flush Tank will continuously fill and have enough volume to flush all RO systems (i.e., Primary and Secondary RO) twice in case of shutdown for long periods of time.

The Primary RO concentrate (i.e., second stage concentrate) will then have two destinations: a Secondary RO (i.e., conventional 3rd stage RO system) or collection into a Secondary RO Feed Equalization Tank, which will normally overflow because it is projected that there will be more concentrate from Stage 2 than is needed to feed the conventional 3rd stage, CCRO, and PFRO combined. From the Secondary RO Feed Equalization Tank, a feed pump will split the flow into two streams: one will feed a closed-circuit RO (CCRO) skid while the second one will feed a pulse flow RO (PFRO). The purpose of having three different RO strategies as the third stage is to test and compare the cleaning frequencies and recoveries as well as determine points of fundamental chemical solubility limits for each one. The **Brine Management Strategy** TM describes the drivers for comparing these various high recovery approaches. Figure 5 illustrates the approach on the RO, and further details are presented in the following sections. Note that Figure 5 does not include all equipment for the RO system (e.g., RO Transfer Pump). See the full process flow diagram (Figure 3) for greater detail.



Figure 5. Schematic of all RO Systems



6.3.2.2 CONVENTIONAL RO SYSTEM

DEMONSTRATION FACILITY

A description of the conventional RO system at the Demonstration Facility is included in this Section along with design criteria and instrumentation.

Process Description

In the conventional RO system, the feed water is pressurized by a high-pressure RO feed pump and fed to the RO vessels, which contain the membranes. The feed flow undergoes the first stage, where the concentrate flow is separated from the permeate. The concentrate from stage 1 is used as the feed flow to stage 2. The permeates are typically combined, whereas the resulting concentrate flow will be produced only from the last stage. The brine exits from the middle of the membranes whereas the permeate is produced on the outside of the elements. Higher recoveries can be achieved by adding additional stages (e.g., stage 3). Because the feed water to each subsequent phase is the concentrate from the prior stage, later stages have increased salinity levels in the feedwater any may require more frequent membrane replacement due to a higher scaling potential.

A 3D example of an RO skid is provided in Figure 6.



Figure 6. 3D example of an RO skid (courtesy of H2O Innovation)



Design Criteria

The design criteria for the Primary RO System (i.e., 2-stage conventional RO) are summarized in Table 12.

Parameter	Unit	Value	
RO Feed Tank			
Hydraulic Retention Time	min	15.4	
Target Operating Volume	gallons	2700	
Tank Nominal Volume	gallons	3455	
Tank Height	ft	12	
Tank Diameter	ft	7.0	
RO Cartridge Filter			
Feed Flow	gpm	180	
Number of Cartridge Filters		1	
Filter Retention Rating	μm	5	
Filter Material		Polypropylene	
Maximum Differential Pressure	psi	35	
Primary RO 2-Stage Conventional System			
Stage 1 Feed Flow	gpm	180	
Stage 1 Recovery	%	55	
Stage 1 Permeate Flow	gpm	99	
Number of Elements in Stage 1		28	
Surface Area per Element	ft²	400	
Stage 1 Surface Area	ft²	11,200	
Stage 1 Concentrate Flow (Stage 2 Feed Flow)	gpm	81	
Stage 2 Recovery	%	47	

Table 12. Design Criteria for Primary RO System at the Demonstration Facility



Parameter	Unit	Value
Stage 2 Permeate Flow	gpm	38.1
Number of Elements in Stage 2		14
Stage 2 Surface Area	ft²	5,600
Stage 2 Concentrate Flow (Overall Conventional 2-Stage Concentrate Flow)	gpm	42.9
Overall Conventional 2-stage Recovery	%	76.2
Overall Conventional 2-stage Permeate Flow	gpm	137.1
Total number of elements		42
Total Surface Area	ft²	16,800
Pre-Treatment Chemicals		
Antiscalant Concentration	%	100
Antiscalant Average Dose	mg/L	2
Antiscalant Maximum Dose	mg/L	4
Antiscalant Average Usage	gpd	1.9
Antiscalant Maximum Usage	gpd	3.2
Sulfuric Acid Concentration	%	93
Sulfuric Acid Average Dose	mg/L	50
Sulfuric Acid Maximum Dose	mg/L	100
Sulfuric Acid Average Usage	gpd	7.6
Sulfuric Acid Maximum Usage	gpd	15.2
RO Flush Tank		
Number of Flushes		2
Tank Nominal Volume	gallons	2115
Tank Height	ft	10
Tank Diameter	ft	6.0



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Parameter	Unit	Value
Feed Pumps		
Number of Transfer Pumps		1 + 0
Transfer Pump Capacity	gpm	180
Transfer Pump Horsepower	hp	3
Number of High-Pressure Stage 1 Feed Pump		1 + 0
High-Pressure Stage 1 Feed Pump Capacity	gpm	180
High-Pressure Stage 1 Feed Pump Discharge	psi	130
High-Pressure Pump Horsepower	hp	15

The Secondary RO System (i.e., conventional RO third stage) is summarized in Table 13. The system will be mounted on the same skid as the Primary RO system.

Table 13. Design Criteria for Secondary RO System Using Conventional RO

Parameter	Unit	Value ¹
3 rd Stage Feed Flow	gpm	7.2
3 rd Stage Recovery	%	58 (67)
3 rd Stage Permeate Flow	gpm	4.1 (4.8)
3 rd Stage Concentrate Flow	gpm	3.0
Number of Elements in 3 rd Stage		7
Element Size	inches	4
Surface Area per Element	ft²	80
Total Surface Area in 3rd Stage	ft²	560
System Equivalent Recovery (based on Primary RO and Secondary RO)	%	90 (92)
System Equivalent Permeate Flow (based on Primary RO and Secondary RO)	gpm	162 (166)
Feed Pumps		
Number of Booster Pumps		1 + 0
Booster Pump Discharge	psi	75
Booster Pump Horsepower	hp	15

¹ Values for 92% recovery are included within parentheses if different from those for 90% recovery



Instrumentation

Essential instrumentation for the conventional 2-stage RO are: TOC analyzer (feed, combined permeate), electric conductivity analyzer (feed, stage 1 permeate, stage 1 concentrate, stage 2 permeate, stage 2 concentrate, combined permeate), flow meters (feed, stage 1 permeate, stage 2 concentrate), pH meter (feed), temperature analyzer (feed), oxidation-reduction potential (ORP) analyzer (feed), pressure gauges (before cartridge filter, feed after cartridge filter, permeate lines, concentrate lines). Nitrite and nitrate analyzers are optional. Strontium analyzer could be used if preliminary strontium values in the AWT Facility feed water are sufficiently high to prove more than 1.5 log removals by RO.

Additional instrumentation for the conventional 3rd stage RO include: flow meters (feed and permeate), pressure gauges (feed and concentrate), electric conductivity, (permeate and concentrate). A TOC analyzer could also be placed at the permeate line to calculate combined rejection.

The final RO concentrate from all of the secondary RO systems will be sent to drain.

6.3.2.3 CLOSED-CIRCUIT RO

A description of the CCRO system at the Demonstration Facility is included in this Section along with design criteria and instrumentation.

Process Description

The CCRO process relies on the use of a recirculation loop that decouples cross-flow velocity from the flow rate through the system. In a recirculation loop, feedwater enters the system in the first cycle, producing permeate and recirculating concentrate. As more product water is produced and brine is recirculated, the brine concentration increases. When the system achieves its recovery set point, the brine is purged from the system and the cycle begins again. Due to its operating modes, the concentration of both the feed-brine and permeate produced inherently increase as each closed-circuit cycle progresses. Removal is kept constant during the closed-circuit cycle. This creates variability in the permeate quality that comes from the CCRO system. The placement of a separate CCRO permeate tank will diminish variability in the permeate water quality by averaging the water quality over the various cycles. An additional pump will be included after the CCRO permeate tank to supply the permeate to the downstream equipment.





Figure 7. Schematic for Closed-Circuit RO

From the Secondary RO Feed Equalization Tank collecting RO concentrate from the primary RO system, feed pumps will split the flow to the two other secondary RO systems: CCRO and PFRO. A pressure reducing valve will be added upstream of the equalization tank to control the RO concentrate pressure prior to the transfer pump. Overflow of the tank will be directed to the drain. For the CCRO system, a high-pressure feed pump will be placed in the feed to the system while a loop pump will be placed in the concentrate/feed line (Figure 7).

Design Criteria

The design criteria for the CCRO as a third stage system are summarized in Table 14. Ranges are provided to account for the 90% overall recovery baseline as well as the target range of 92–96%.

Parameter	Unit	Value
RO Concentrate Equalization Tank		
Hydraulic Retention Time	min	15.6
Nominal Tank Volume	gallons	423
Tank Height	ft	8
Tank Diameter	ft	3.0
CCRO System		
CCD Mode Feed Flow	gpm	8.5
Loop Flow	gpm	20
Mode Period	min	4.7–11.6
PFD Mode	min	1
Net Feed Flow	gpm	9.4–10.5

Table 14. Design Criteria for Secondary RO System Using CCRO



Net Permeate Flow	gpm	7.0-7.8
Net Recovery	%	66.5-83.1
Net Concentrate Flow	gpm	1.6
Number of Elements in CCRO		4
Element Size	inches	8
Surface Area per Element	ft²	400
Total Surface Area in CCRO	ft²	1,600
System Equivalent Recovery (based on Primary RO and Secondary RO)	%	92–96
System Equivalent Permeate Flow (based on Primary RO and Secondary RO)	gpm	165.6–172.7
Feed and Circulation Pumps		
Number of CCRO Transfer Pumps		1
CCRO Transfer Pump Horsepower	hp	3
Number of High-Pressure Feed Pumps		1 + 0
High-Pressure Feed Pump Horsepower	hp	3
Number of Circulation Pumps		1 + 0
Circulation Pump Horsepower	hp	3

Instrumentation

Instrumentation for the secondary RO using CCRO can include: flow meters (feed and permeate), pressure gauges (before and after booster pump and concentrate), electric conductivity (permeate and concentrate). A TOC analyzer could also be placed at the permeate line to calculate further rejection.

6.3.2.4 PULSE FLOW RO

A description of the PFRO system at the Demonstration Facility is included in this Section along with design criteria and instrumentation.

Process Description

Pulse flow RO (PFRO) is a single stage batch process developed by IDE Technologies that features a concentrate valve downstream of the membranes that operates between two cycles: a production cycle and a flush cycle. During the production cycle, the concentrate valve remains closed, and salinity builds up in the feedwater. During the flush cycle, the valve is quickly opened and closed, releasing concentrate in a short, forceful burst. The duration of each cycle is in the order of seconds. The quick closing of the valve creates a water hammer that strikes and mechanically shakes the membrane. This energy is returned when the valve opens again seconds later, providing a high shear velocity. This operational strategy is claimed to limit scaling formation and biological fouling. A schematic for PFRO is provided in Figure 8, along with a diagram of the permeate and concentrate flow regime in PFRO.





Another technology known as high efficiency RO (HERO) was also considered. HERO is a highrecovery process that operates at high pH to prevent membrane scaling, particularly from silica, and biological fouling. The process typically includes an ion exchange or lime softening step to remove hardness and a decarbonation step prior to RO treatment. The high operating pH creates a continuous cleaning environment as it enhances silica solubility, mitigates biological activity, and reduces zeta potential between surface particles, thereby minimizing silica scaling, biofouling, and particulate fouling. This also reduces the frequency of offline cleaning required and minimizes the amount of redundant equipment needed to account for cleaning downtime. HERO can achieve recoveries greater than 90% and can be used as a brine concentrator. This technology requires greater footprint than other high recovery technologies to accommodate the ion exchange and decarbonation steps. A schematic of a HERO system is presented in Figure 9.

Figure 9. Schematic for High-Efficiency RO from Aquatech



A cost analysis completed in the **Brine Management Strategy** TM (2022) found HERO had a higher overall cost than other options for the expected overall target recovery range of 92–96% due to the additional treatment steps (e.g., lime-soda softening, ion exchange, and decarbonation). Therefore, it was decided to include PFRO instead of HERO at the Demonstration Facility.



Design Criteria

The design criteria for the secondary RO using PFRO are provided in Table 15.

Table 15. Design Criteria for Secondary RO System Using PFRO.

Parameter	Unit	Value
Feed Flow	gpm	5.0-6.3
Recovery	%	66.5–83. 1
Concentrate Flow	gpm	0.8–2.1
Number of Elements		7
Element Size	inches	8
Surface Area per Element	ft²	80
Total Surface Area at PFRO	ft²	560
System Equivalent Recovery (based on Primary RO and Secondary RO)	%	92–96
System Equivalent Permeate Flow (based on Primary RO and Secondary RO)	gpm	165.6–172.7
Feed Pumps		
Number of PFRO Transfer Pumps		1
PFRO Transfer Pump Horsepower	hp	3
Number of High-Pressure Pumps		1 + 0
High-Pressure Pump Horsepower	hp	3

Instrumentation

Instrumentation for the secondary RO using PFRO can include: flow meters (feed and permeate), pressure gauges (before and after booster pump and concentrate), electric conductivity (permeate and concentrate), and pH (feed, permeate and concentrate). A TOC analyzer could also be placed at the permeate line to calculate further rejection.

6.3.3 UV/AOP SYSTEM

A description of the UV/AOP process at the Demonstration Facility is included in this Section along with design criteria and instrumentation.

6.3.3.1 PROCESS DESCRIPTION

The UV/AOP system will be located downstream of the conventional RO process and fed with a dedicated flow of combined permeate from all three stages. An oxidant is injected into the water, and as a high dose of UV is irradiated, hydroxyl radicals are created. Common oxidants are sodium hypochlorite and hydrogen peroxide, but only sodium hypochlorite will be used at the Demonstration Facility.

UV/AOP is commonly employed in potable reuse applications due to its high efficiency in inactivating pathogens, including *Cryptosporidium* and *Giardia*, that are resistant to other disinfection methods. While the UV photolysis is also highly effective in photolyzing harmful



contaminants such as NDMA, AOP can oxidize other types of harmful contaminants present in the water due to the hydroxyl radicals created. Photos of UV/AOP systems from other projects are show in **Error! Reference source not found**.



Figure 10. Examples of UV/AOP Pilot Skids (courtesy of Xylem)

The NL for NDMA in drinking water is 10 ng/L, but UV systems are usually designed to reduce NDMA concentrations to around 5 ng/L to ensure compliance. For designing the UV system, some vendors prefer working with log removal values based on the typical feed NDMA concentrations to the reactor and the end target. The AOP system is required to provide minimum log removals for a series of classes of constituents found in water reuse, or alternatively, provide at least 0.5 log removal of 1,4-dioxane as a surrogate for these types of compounds, since 1,4-dioxane is relatively resistant to oxidation. Additionally, 1,4-dioxane's NL is 1.0 µg/L.

Important parameters for the efficiency of the UV/AOP process are the UV transmittance (UVT), that is directly related to the chloramine concentration, nitrite, and free ammonia concentrations. In addition to decreasing the UVT, which results in increased UV dose, chloramines compete with free chlorine, increasing the sodium hypochlorite dose needed to reach breakpoint chlorination. No significant nitrite or free ammonia are expected to be in the UV/AOP feed water, and chloramine dosing at the MF will be optimize throughout piloting.



6.3.3.2 DESIGN CRITERIA

At the Demonstration Facility, the feed water will be combined RO permeate from the Primary conventional 2-stage RO system and conventional third stage. The preliminary design criteria for the UV/AOP system are presented in Table 16.

Parameter	Unit	Value		
UV System				
UV/AOP Design Feed Flow	gpm	5-15		
Type of UV System	-	Low Pressure High Output (LPHO)		
Number of Trains	-	1 + 0		
Minimum Ballast Power	%	60		
Minimum UV Transmittance	%	96		
Design NDMA log removal	-	2.0		
NDMA Concentration in the Effluent	ng/L	5		
	AOP System			
Oxidant	-	Sodium Hypochlorite (NaOCl)		
Oxidant Concentration	%	12.5		
Oxidant Target Dose	mg/L	2.0		
Oxidant Usage for Average Dose	gpd	0.3		
Oxidant Maximum Dose	mg/L	4.0		
Oxidant Usage for Maximum Dose	gpd	0.7		
Design 1,4-Dioxane log removal	-	≥0.5		
1,4-Dioxane Concentration in the Effluent	µg/L	<1.0		

Table 16. Design Criteria for UV/AOP System at the Demonstration Facility.

6.3.3.3 INSTRUMENTATION

Critical instrumentation for the UV/AOP system are: flow meter (influent), UVT analyzers (influent), pH meter (influent), total chlorine analyzers (before and after oxidant injection), and free chlorine analyzers (after oxidant injection).

6.3.4 PRODUCT WATER STABILIZATION

A description of the product water stabilization process at the Demonstration Facility is included in this Section along with design criteria and instrumentation.

6.3.4.1 PROCESS DESCRIPTION

The product water stabilization process will take place downstream of the UV/AOP system. The low alkalinity, low concentrations of calcium, and relatively low pH leave RO permeate with an imbalance for ions and bicarbonate buffering capacity. This chemical disequilibrium makes RO



permeate corrosive, which is a problem for the downstream piping and the overall water quality at the end of the pipeline. The deionized characteristic of the RO permeate is also aggressive for human health when consumed as drinking water. Therefore, RO permeate must be stabilized, or remineralized, before it can go into the distribution system. The downstream UV/AOP process does not have a significant impact on RO permeate water quality in respect to salts, ions, alkalinity, etc.

Several strategies can be used to remineralize the water, with lime slurry and calcite contactors the most common ones. At the Demonstration Facility, calcite contactors will be used as the stabilization process, and the stabilized water will be stored in the Purified Water Tank.

Calcite contactors provide both alkalinity and calcium hardness for the water, as the water passes through them. The empty bed contact time (EBCT), i.e., the time the water takes to pass through the whole calcite bed, will be optimize as the testing begins to provide the best water quality and aesthetics. Carbon dioxide (CO₂) might be needed to be added upfront of the contactors to aid the dissolution of the calcite into the water. Alternatively, other acids can be used.

6.3.4.2 DESIGN CRITERIA

The preliminary design criteria for the post treatment are presented in Table 17.

Parameter	Unit	Value
Calcite Contactors	Crint	Value
Calcite Contactor Feed Flow	gpm	5-15
Number of Contactors	-	1 + 0
Bed Height	ft	2
Bed Diameter	ft	1
Contactor Empty Bed Contact Time	min	10

Table 17. Design Criteria for Product Water Stabilization at the Demonstration Facility

6.3.4.3 INSTRUMENTATION

One key instrument for monitoring of the product water as well as the performance of the contactors is a pH meter at the effluent. Other online meters such as flow meter and temperature analyzers could be used. Additionally, it is recommended that alkalinity samples be collected if the placement of an online analyzer is not possible.

6.4 CHEMICAL SYSTEMS

The chemicals required for the Demonstration Facility are described in this Section. They will be stored on site in the Chemical Utility Area. There will be a canopy to provide shade for the equipment. The Chemical Utility Area will be accessible for chemical deliveries via a secured road that loops around the Demonstration Facility. The chemical system design is based on storing the required chemicals for at least 14-day consumption at average doses. N + 1 redundancy was assumed for all chemical storage units to ensure that Demonstration Facility operation will not be



interrupted during chemical deliveries. N + 1 redundancy was also assumed for all metering and transfer pumps. They will be in the Chemical Utility Area along with the CIP skids for the RO and MF skids. Chemical usage calculations indicated that either drums or totes would be sufficient for all chemicals given the Demonstration Facility's relatively low flow capacity. See Figure 11 for a preliminary layout of the Chemical Utility Area. Dimensions in Figure 11 are in feet unless noted otherwise. Acids and bases will not be placed side-to-side to comply with hazardous materials storage specifications. Also, reductants and oxidants will not be placed side-by-side to each other. A hose bib, drains, and eyewash station are not shown in Figure 11 but are recommended for inclusion in the Chemical Utility Area.



Figure 11. Layout of Chemical Utility Area

Average and maximum cleaning frequencies for maintenance and recovery cleans for MF and RO are listed in Table 18 because they impact chemical usage. For recovery cleans, neither the chemical dose nor the cleaning frequency were varied between the average and maximum conditions. For maintenance cleans, the chemical dose was not varied between the average and maximum conditions, but the cleaning frequency was assumed to be higher under maximum conditions (Table 18).

Parameter	Average Frequency	Maximum Frequency	Units
RO Recovery Clean	1	1	month ⁻¹
MF Recovery Clean	1	1	month ⁻¹
MF Acid Maintenance Clean	0.5	1	day-1
MF Hypochlorite and Caustic Maintenance Clean	0.5	1	day-1

6.4.1 SODIUM HYPOCHLORITE

Sodium hypochlorite will be used for several purposes, including the following: (1) Chloramination of the MF feed, (2) Maintenance cleans for MF system, (3) Recovery cleans for MF system, and (4) Oxidation of UV influent. Design criteria for the sodium hypochlorite system are summarized in Table 19 below.



Descriptor	Units	Average Condition	Maximum Condition	
Solution Strength		12.5	5%	
Specific Gravity		1.2	21	
	Chlorami	ines		
Dose	mg/L as Cl ₂	3	5	
Daily Use	gal solution/d	5.7	9.5	
	Maintenance Cleans	s for MF System		
Dose	mg/L as Cl ₂	500	500	
Daily Use	gal solution/d	0.8	1.7	
	Recovery Cleans f	or MF System		
Dose	mg/L as Cl ₂	3,500	3,500	
Daily Use	gal solution/d	0.4	0.4	
	Oxidation of U	V Influent		
Dose	mg/L as Cl ₂	2	5	
Daily Use	gal solution/d	0.3	0.7	
Total				
Total Daily Use	gal solution/d	7.3	12.4	

Table 19. Design Criteria for Sodium Hypochlorite System

6.4.2 LIQUID AMMONIUM SULFATE

Liquid ammonium sulfate (LAS) will be used for chloramination of the MF feed. Design criteria for the LAS system are summarized in Table 20 below.

Table 20. Design Criteria for Liquid Ammonium Sulfate

Descriptor	Units	Average Condition	Maximum Condition
Dosing Location and Purpose		Chloramination	n of MF Feed
Solution Strength		40%	6
Specific Gravity		1.2	5
Dose	mg/L as N	0.75	1.25
Daily Use	gal solution/d	1.9	3.2

6.4.3 SULFURIC ACID

Sulfuric acid will be used to adjust the pH of the RO feed to control scaling of the membrane. Design criteria for the sulfuric acid system are summarized in Table 21 below.



Table 21. Design Criteria for Sulfuric Acid System

Descriptor	Units	Average Condition	Maximum Condition
Dosing Location and Purpose		pH Control of	of RO Feed
Solution Strength		93%	
Specific Gravity		1.84	
Dose	mg/L	50	100
Daily Use	gal solution/d	7.6	15.2

6.4.4 ANTISCALANT

Antiscalant will be dosed to the RO feed to prevent/reduce scaling of the RO membranes. Design criteria for the antiscalant system are summarized in Table 22 below.

Table 22. Design Criteria for the Antiscalant System

Descriptor	Units	Average Condition	Maximum Condition
Dosing Location and Purpose		RO Feed for Membrane Sc	caling Control
Solution Strength		100%	
Specific Gravity		1.10	
Dose	mg/L	2	4
Daily Use	gal solution/d	0.5	0.9

6.4.5 SODIUM BISULFITE

Sodium bisulfite will be used to neutralize the sodium hypochlorite solution after oxidative maintenance and recovery cleans of the MF system. Design criteria for the sodium bisulfite system are summarized in Table 23 below. Note that heat tracing will likely be required for pipes conveying the sodium bisulfite solution based on expected ambient temperatures at the Demonstration Facility.



Descriptor	Units	Average Condition	Maximum Condition
Solution Strength		389	6
Specific Gravity		1.2	4
ı	Neutralization for NaO	CI Maintenance Cleans	
Concentration ^a	mg/L	1,200	1,200
Solution Volume per Clean	gal	0.08	0.08
Daily Solution Volume	gal/d	0.04	0.08
	Neutralization for Na	OCI Recovery Cleans	
Concentration ^a	mg/L	175	175
Solution Volume per Clean	gal	0.01	0.01
Daily Solution Volume	gal/d	0.005	0.01
Total			
Total Daily Use	gal solution/d	0.04	0.09

Table 23. Design Criteria for Sodium Bisulfite System

^a Assumed that 25% of sodium hypochlorite dose remains at the end of the maintenance clean or recovery clean.

6.4.6 CITRIC ACID

Citric acid will be used for the following: (1) MF maintenance clean, (2) MF recovery clean, (3) RO recovery clean, (4) Neutralization for sodium hydroxide recovery clean for RO system, and (5) Neutralization for sodium hydroxide maintenance clean for MF system. Design criteria for the citric acid system are summarized in Table 24.



Descriptor	Units	Average Condition	Maximum Condition	
Solution Strength		509	%	
Specific Gravity		1.2	4	
	MF Maintena	nce Clean		
Dose	mg/L	1,000	1,000	
Daily Use	gal solution/d	0.02	0.05	
	MF Recove	ry Clean		
Dose	mg/L	20,000	20,000	
Daily Use	gal solution/d	0.5	0.5	
	RO Recove	ry Clean		
Dose	mg/L	20,000	20,000	
Daily Use	gal solution/d	0.5	0.5	
	Neutralization for NaOH	RO Recovery Clean		
Concentrationa	mg/L	16,000	16,000	
Solution Volume per Clean	gal	25.3	25.3	
Daily Solution Volume	gal/d	0.8	0.8	
	Neutralization for NaOH	RO Recovery Clean		
Concentration ^a	mg/L	1,600	1,600	
Solution Volume per Clean	gal	2.5	12.5	
Daily Solution Volume	gal/d	0.08	0.08	
Total				
Total Daily Use	gal solution/d	2.0	2.0	

Table 24. Design Criteria for the Citric Acid System

^a Calculated based on a neutralization ratio of 0.6 g NaOH/0.6 g citric acid using molar masses and stoichiometric ratios from the chemical reaction

6.4.7 SODIUM HYDROXIDE

Sodium hydroxide is used for the following: (1) MF maintenance clean, (2) RO recovery clean, and (3) Neutralization of CIP citric acid waste flows. Design criteria for the sodium hydroxide system are summarized in Table 25.



Descriptor	Units	Average Condition	Maximum Condition	
Solution Strength		25	%	
Specific Gravity		1.2	28	
	MF Maintena	nce Clean		
Dose	mg/L	1,000	1,000	
Daily Use	gal solution/d	0.05	0.09	
	RO Recove	ry Clean		
Dose	mg/L	10,000	10,000	
Daily Use	gal solution/d	0.5	0.5	
Neu	utralization for Citric Ac	cid RO Recovery Clean		
Concentrationa	mg/L	12,500	12,500	
Solution Volume per Clean	gal	19.7	19.7	
Daily Solution Volume	gal/d	0.6	0.6	
Neutr	alization for Citric Acio	MF Maintenance Clean		
Concentration ^a	mg/L	12,500	12,500	
Solution Volume per Clean	gal	19.7	19.7	
Daily Solution Volume	gal/d	0.6	0.6	
Neutralization for Citric Acid MF Recovery Clean				
Concentration ^a	mg/L	625	625	
Solution Volume per Clean	gal	1.0	1.0	
Daily Solution Volume	gal/d	0.03	0.03	
Total				
Total Daily Use	gal solution/d	3.0	3.0	

Table 25. Design Criteria for the Sodium Hydroxide System

^a Calculated based on a neutralization ratio of 0.6 g NaOH/0.6 g citric acid using molar masses and stoichiometric ratios from the chemical reaction

6.4.8 CHEMICAL STORAGE TANKS

Each chemical drum or tote will be installed on spill-containment pallets directly on a leveled concrete pad. The drums and totes will be changed with the aid of an electric forklift by trained operators onsite. Table 26 summarizes the chemical tank volumes and corresponding days of storage.



Chemical Sto	Storage Unit	Volume per	No. Storage	Days of Storage	
		Unit (gal)	Units	Average Dose	Max Dose
Ammonium Sulfate	Drum	55	2	57	34
Sodium Hypochlorite	Drum	55	2	15	9
Antiscalant	Drum	55	2	233	117
Sulfuric Acid	Tote	275	2	72	36
Sodium Hydroxide	Drum	55	2	37	36
Citric Acid	Drum	55	2	55	54
Sodium Bisulfite	Drum	55	2	2,472	1,236

Table 26. Summary of Chemical Storage

7.0 CONTROL STRATEGIES

This section describes the high-level preliminary control strategies for the Demonstration Facility.

7.1 MF SYSTEM

7.1.1 FILTRATION

The MF feed tank is filled from a lateral that will be connected to the existing pressurized conveyance pipe of non-potable reuse water from the PWRP. The lateral to the MF feed tank includes an automatic isolation valve, flow totalizer, and automatic flow control valve. The automatic flow control valve modulates to maintain an operator-specified level setpoint in the MF feed tank. If the Demonstration Facility needs to be shut down or isolated from the existing pressurized conveyance line, the automatic isolation valve can be closed automatically to prevent excessive overflowing of the MF feed tank to drain. The MF feed tank contains a low-level switch to protect the MF feed pumps.

Each of the two trains of the MF system is fed via a dedicated MF feed pump directly from the MF feed tank. The MF system operates to the Primary RO feed flow setpoint calculated by dividing the Primary RO total permeate flow setpoint by the Primary RO recovery setpoint and multiplying by a MF multiplier setpoint. The MF flow setpoint is automatically trimmed based on the level in the RO feed tank so that the RO feed tank level is maintained. , but this can optional if the MF system needs to operate at higher flow rates than needed by the RO for MF flux optimization by allowing the RO Feed Tank to overflow. The MF flow setpoint for each MF train is determined by accounting for the number of trains available for service (not backwashing, cleaning, or integrity testing) within minimum and maximum production flow rates for each train set by the operator. The MF feed pumps modulate speed to maintain a pressure setpoint in the MF feed header. A flow control valve is modulated to achieve the MF flow setpoint.



The discharge from the MF feed pump is pretreated with an automatic backwashing strainer along with sodium hypochlorite and liquid ammonium sulfate to form chloramines, as needed, beyond the amount already present in the source water from PWRP. There are two metering pumps for each chemical that operate in a duty/standby configuration to deliver the chemicals to the injection point at the static mixers prior to the automatic backwashing strain. The metering pumps are flow-paced based on the MF feed flow rate, while the sodium hypochlorite metering pump is trimmed to meet the MF feed total chlorine setpoint. The liquid ammonium sulfate metering pump doses at an operator-specified chlorine to ammonia ratio. The chloramines are measured via a total chlorine analyzer at the inlet to the MF system after the automatic backwashing strainer.

The status of the MF system depends on the status of permissive conditions. Each MF train has several monitors that are used to regulate and evaluate system performance. In addition to feed flow meters discussed previously, each MF train has pressure transmitters on the feed and filtrate side that are used to determine the TMP. TMP, when normalized for temperature and flow, indicates the degree of MF membrane fouling and helps inform decisions about cleaning frequency. Filtrate turbidity monitors on each train are used in addition to direct integrity testing as an indication of membrane integrity.

The MF trains continue to operate in filtration mode until conditions (i.e., time interval, totalized volume, etc.) trigger a backwash, CIP, or integrity test. A backwash, CIP, or integrity test may also be initialed manually by the operator.

7.1.2 BACKWASH

The MF backwash process uses backwash water and compressed air. Backwash water is drawn from the RO feed tank by the backwash pump and controlled to a backwash flow rate setpoint to totalized volume. Air is drawn from an air tank to an air scour flow rate setpoint and totalize volume. Backwash waste flows to a drain connected to the sewer line. Only one train may backwash at a given time.

7.1.3 CIP

The MF system has two CIP strategies – maintenance cleans (MC) and recovery cleans (RC). The MCs are short duration (i.e., less than 1 hour) and use a cleaning solution (either chlorine/caustic or acid). These cleans are typically conducted every 1 to 3 days. The MCs can be initiated manually based on TMP by the operator or automatically based on an operator-designated time interval. The RCs are longer duration (i.e., up to several hours) and are initiated manually by the operator based on overall unit performance decline. Once a MC or RC is initiated, the CIP procedures are executed automatically. Only one train may undergo a CIP at a given time, and a CIP may not occur during a backwash for either train.

7.1.4 MEMBRANE INTEGRITY TESTING

Membrane integrity is tested using a pressure decay test (PDT). PDTs are performed on unit at a time. To conduct the test, a unit is isolated by closing the filtrate valve, pressurizing the MF modules



with air by opening the appropriate integrity test valve, and measures the pressure decay rate over a period. This method directly quantifies any breaches in the membrane hollow fibers down to 3 µm in size.

PDTs will be initiated daily to determine the LRV for each train and can be initiated either manually by the operator or automatically based on an operator-designated time interval. The operator selects either a filtrate side (for LRV calculation) or a feed side test for diagnostic testing. Filtrate side testing is typically used for LRV calculations because it provides more consistent results and because the volume of the air on the filtrate side test is lower. Feed size testing is used diagnostically to identify air leaks in the filtrate header to assist with pinning fibers in modules with defects and fixing leaking valves on the filtrate header. The MF train is pressurized to a start pressure and then the end pressure is logged after a specified time. The pressure decay rate is then calculated based on the difference in start pressure and end pressure divided by the time. The calculated pressure decay rate is used to calculate the LRV per the methodology of the Membrane Filtration Guidance Manual (USEPA 2005). Following the PDT, air is vented either from the side the test was performed, the PDT interval test timer is reset, and the MF train returns to filtration mode.

7.2 CONVENTIONAL RO SYSTEM

The Conventional RO system consists of a Primary RO (i.e., first and second stage) and a Secondary RO (i.e., third stage).

7.2.1 PRIMARY AND SECONDARY RO

The Primary RO is fed via a high-pressure RO feed pump directly from the RO feed tank. The Primary RO operates to the Primary RO total permeate flow setpoint (i.e., permeate from the first and second stage) and the Primary RO recovery setpoint. The Primary RO total permeate flow rate via a flow meter serves as the process variable for the high-pressure RO feed pump speed control. The Primary RO total permeate flow and recovery setpoints are used to calculate the target Primary RO concentrate flow. The Primary RO concentrate flow rate via a flow meter serves as the process variable for the via the target Primary RO concentrate flow. The Primary RO concentrate flow rate via a flow meter serves as the process variable for modulating the concentrate control valve.

The discharge from the high-pressure RO feed pump is pretreated with cartridge filtration along with sulfuric acid and antiscalant addition. There are two metering pumps for each chemical that operate in a duty/standby configuration to deliver the chemicals to the injection point at the static mixer prior to the cartridge filter. The metering pumps are flow-paced based on the RO feed flow rate, while the sulfuric acid metering pump is trimmed to the RO feed pH setpoint. The pH is measured via a pH meter at the inlet to the Primary RO after the cartridge filter.

The Secondary RO will be fed via an interstage booster pump from a portion of the pressurized concentrate of the second stage of the Primary RO. As described in Section 7.3, the balance of the pressurized concentrate from the secondary stage of the Primary RO that is not used by the Secondary RO will be delivered to a Secondary RO Feed Equalization Tank, which will be constantly full and overflow when the Primary RO is operating, to feed the CCRO and PFRO systems. The Secondary RO operates to the Secondary RO permeate flow setpoint and the



Secondary RO recovery setpoint. The Secondary RO permeate flow rate via a flow meter serves as the process variable for the interstage booster pump speed control. The Secondary RO permeate flow and recovery setpoints are used to calculate the target Secondary RO concentrate flow. The Secondary RO concentrate flow rate via a flow meter serves as the process variable for modulating the concentrate control valve.

The permeate from the Primary and Secondary RO system, along with permeate from the CCRO and PRFO systems, will be conveyed to the RO Flush Tank. As discussed in Section 7.4, a portion of the combined permeate from the conventional RO system will bypass the RO Flush Tank and be conveyed directly to the UV/AOP system. The RO Flush Tank will continuously fill to remain full with excess continuously overflowing to drain. This will ensure adequate volume of RO permeate is always available in the event the Primary RO, Secondary RO, CCRO, or PFRO need to be flushed.

The status of the Primary and Secondary RO systems depends on the status of permissive conditions. A RO feed water instrument panel monitors the characteristics of the RO feed water and activates advisory warnings and critical alarms for parameters exceeding established limits. Monitored parameters include TOC, pH, turbidity, conductivity, temperature, and total chlorine. If the pH or turbidity are outside of the range the established limits, the system will shut down to protect the membranes. Some of these analyzers are also used as critical control point (CCP) monitors, or correlate to CCPs, such as calculated log reduction (LRV) via conductivity and TOC removal and RO permeate TOC.

7.2.2 CIP

The CIP system is used to remove scaling and fouling from the membranes. It is triggered by a drop in specific flux, an increase in normalized differential pressure, and/or an increase in normalized permeate conductivity. Prior to starting a CIP, the operator shuts down, flushes, and isolates the RO train. The operator fills the CIP tank, heats the solution, and batches and mixes the CIP chemicals. The CIP solution is prepared using RO permeate and cleaning chemicals, such as sodium hydroxide, citric acid, detergents, and/or proprietary cleaning solutions. The CIP pump draws from the CIP tank and can be used to either circulate the solution to the RO train (for cleaning) or back to the CIP tank (for mixing). The pump stops if tank low- or high-levels alarms are triggered. The CIP tank is equipped with a heater to achieve the required temperature of the cleaning solution. The heaters are controlled to maintain a temperature setpoint entered at the temperature controller.

7.2.3 FLUSH

When the Primary RO or Secondary RO is shut down due to an alarm or operator intervention, it receives a flush with RO permeate from the RO flush tank. The flush occurs automatically when the operator takes the RO offline but must be initiated manually if the train shuts down due to an alarm. The flush serves to remove water from the feed and concentrate side of the membranes and keeps the membranes stored in a clean state. The system is not designed to flush the Primary RO and Secondary RO at the same time.



7.3 CCRO AND PFRO SYSTEMS

A Secondary RO Feed Equalization Tank will be fed a via a split stream from the Primary RO (i.e., second stage) concentrate flow of the conventional RO system. As described in Section 7.2, the third stage of the conventional RO system will be designed to only utilize a portion of the Primary RO concentrate flow. The balance of the Primary RO concentrate flow will feed the Secondary RO Feed Equalization Tank. The RO Feed Equalization Tank will include a low-level switch to protect the feed pump to each the CCRO and the PRFO in the event the Primary RO system is offline or not delivering enough concentrate to the Third Stage Break Tank. Excess concentrate delivered to the Third Stage Break Tank will overflow to drain. An air gap will be used on the Third Stage Break Tank to prevent any cross-connection issues.

As described in 7.2 CONVENTIONAL RO SYSTEM, the permeate from the CCRO and PFRO systems will be conveyed directly to the RO Flush Tank. Concentrate from the CCRO and PRFO systems will be conveyed directly to drain.

Similar to the Primary RO and Secondary RO systems, the CCRO and PFRO will undergo periodic CIPs and flushes as required.

The status of the CCRO and PFRO systems depends on the status of permissive conditions. Each system has a water instrument panel that monitors the characteristics of the RO feed and permeate water and activates advisory warnings and critical alarms for parameters exceeding established limits. Monitored parameters include TOC, pH, turbidity, conductivity, temperature, and total chlorine. If the pH or turbidity are outside of the range the established limits, the system will shut down to protect the membranes. Some of these analyzers are also used as critical control point (CCP) monitors, or correlate to CCPs, such as calculated log reduction (LRV) via conductivity and TOC removal and RO permeate TOC.

7.4 UV/AOP SYSTEM

The UV/AOP system will be fed via a split stream from the combined permeate line of the conventional RO system. The UV/AOP system will not be fed from the RO flush tank as exposing the RO permeate to the atmosphere may increase the pH above 6.0 and adversely impact the performance of the UV/AOP system. The UV/AOP system will not be fed from the CCRO or PRFO systems as to remain independent of these proprietary high recovery RO technologies that may only be operated temporarily at the Demonstration Facility, but provisions may be put into place to allow for future feed of CCRO or PFRO permeate to the UV/AOP system. The pressure of the combined permeate will be adequate to overcome head losses due to the static mixer and UV reactor to reach the Purified Water Tank. As the combined RO permeate will have a significantly higher flow rate than the capacity of the UV/AOP system and the demand of the tasting station, only a split stream of the combined RO permeate will be fed to the UV/AOP system. The UV/AOP system operates to the UV/AOP flow setpoint. The UV/AOP flow rate via a flow meter serves as the process variable for modulating the UV/AOP flow control valve. The balance of the Primary RO combined RO permeate that does not feed the UV/AOP system will be sent to the RO flush tank. The UV/AOP system will be interlocked with the conventional RO system - if the conventional RO



system is offline, shuts down, or the UV/AOP flow rate drops below a low-low flow alarm, then the UV/AOP system will either shut down or not be able to start up.

The UV/AOP system also operates to a UV dose setpoint and free chlorine residual setpoint. UV dose will be calculated as a function of UV/AOP flow rate, influent UVT, and UV intensity (measuring the lamp output inside the reactor) through the UV/AOP Supplier's proprietary UV dose algorithm. The calculated UV dose is compared to the UV dose setpoint and the power to the lamps is turned up or down to meet the performance target. If necessary, the UV/AOP flow rate setpoint will be adjusted to accommodate a target UV dose range based on operating conditions. There are two metering pumps that operate in a duty/standby configuration to deliver sodium hypochlorite to the injection point at the static mixer prior to the UV reactor. The metering pumps are flow-paced based on the UV/AOP influent flow rate and trimmed to the free chlorine residual setpoint. The free chlorine residual is measured via a free chlorine analyzer at the inlet to the UV reactor after the static mixer.

The status of the UV/AOP system depends on the status of permissive conditions. Critical alarms will be in place to protect the UV reactor and public health including, at a minimum, high UV reactor temperature and ballast/lamp failure. A UV/AOP feed water instrument panel monitors the characteristics of the UV/AOP feed water and activates advisory warnings and critical alarms for parameters exceeding established limits. Monitored parameters include flow, pH, UVT, and free chlorine residual. If a critical alarm is activated, the UV/AOP effluent will divert to drain instead of the Purified Water Tank to prevent off-spec water from reaching the tasting bar. The operator will have the option to shut down the UV/AOP if the condition causing the critical alarm cannot be resolved while still operating under an off-spec status.

7.5 POST TREATMENT AND TASTING BAR

The UV/AOP effluent will be conveyed through a calcite contactor and stored in the Purified Water Tank where it will be pumped to a pressurized bladder tank that feeds a GAC filter (to remove chlorine) and chiller prior to reaching a touchless faucet in the sink at the tasting bar. The Purified Water Tank will include a low-level switch to protect the tasting bar pump in the event the UV/AOP system is offline or not delivering enough flow to the Purified Water Tank. Excess water delivered to the Purified Water Tank will overflow to drain. While there will not be any online monitoring at the tasting bar, bacteriological samples should be taken routinely to ensure no contamination has occurred after the UV/AOP system.

8.0 DISCIPLINE DESIGN GUIDELINES

The following sections describes the general design requirements and design basis for each discipline for the conceptual design of the facility.

8.1 CIVIL

The civil guidelines provided here pertain to the yard piping, conduits, site surface improvements and improvements within the public rights of way as required.



8.1.1 DESIGN REQUIREMENTS AND REFERENCES

The civil design will be in accordance with applicable codes, specifications, and standards. Procedures and standards described in the latest edition of the following design publications are planned to be used in the design:

- City of Palmdale Engineering Design Standards Street Improvement Plans (<u>https://www.cityofpalmdale.org/259/Forms-Resources</u>)
- American Water Works Association Standards and Manuals of Water Supply Practices
- Project Geotechnical Reports
- HydroCalc modeling software provided by Los Angeles County Public Works via web site for determining hydrographs.
- Los Angeles County Hydrology Manual
- Construction Contract Standards for Construction of Local Streets and Roads, California
 Department of Transportation, 2018
- Standard Specifications for Public Works Construction, ("Green Book"), Public Works Standard, Inc., 2018 with 2019 Errata
- National Association of Corrosion Engineers (NACE) guidelines

8.1.2 DESIGN BASIS

8.1.2.1 SURVEY

The design team will rely on survey data provided by PWD.

8.1.2.2 SITE LAYOUT

The site will incorporate the following:

- Containment areas around all chemical storage and feed facilities to provide for containment of materials provided by the largest volume of tankage or 50% of the volume provided by materials stored by portable containers. Drainage with the chemical storage areas shall be physically independent of areas exposed to rainfall. Drainage shall be directed to onsite sanitary sewer controlled by manual operating valving prior to entering into the sanitary sewer.
- Bollards around equipment or above-grade utilities that are exposed to potential collision (other than described for guardrails above). All bollards shall be removable for specific access to equipment
- Sidewalks, Ramps, Stairways:



- Select portions of the project will be accessible to meet ADA standards for public access of the facility for education and tour functions. However, the building overall is exempt from ADA accessibility standards
- Sidewalks will be used in high foot traffic areas accessible to the general public as noted on preliminary layouts provided.
- Stairs will be provided where pedestrian access is required and grade exceeds 10 percent.

8.1.2.3 SECURITY ACCESS REQUIREMENTS

In areas where chemical storage is required, primary access for vehicle entry shall be fenced and provide motorized (traction drive) gates or as directed by PWD. Secondary access immediately into chemical storage areas, shall at a minimum provide a chain-link fence enclosure with lockable gates.

8.1.2.4 ROADWAYS

New roadways will be designed to accommodate school buses for the public entry and exit and parking area, and the largest chemical delivery truck anticipated for the access roadway to and from the chemical area with a minimum loading criteria of HS-20 axle loading.

8.1.2.5 GRADING

Grading design will conform to the California Building Code and the recommendations in the geotechnical reports. The minimum drainage slopes on paved and unpaved areas are 1%. Concrete gutters have a minimum drainage slope of 0.4%. Sheet flow will not be permitted to drain across cut or fill slopes from adjacent areas. Finished or first floor elevations of buildings will be set a minimum 3.0 inches above adjacent outdoor grade. All areas where exposed soils including shall provide for a minimum slope of 2% away from buildings or other structures onsite.

The design of cut and fill slopes, including requirements for benches, keyed foundations, and allowable inclinations (horizontal and vertical) will conform to the recommendations in the geotechnical report completed as part of final design.

8.1.2.6 DRAINAGE

Site drainage will be designed in accordance with applicable codes and requirements. Site drainage will either be routed to pervious percolation areas if suitable, or routed to a City of Palmdale storm drain.

8.1.2.7 STRIPING AND MARKING

Striping, signage, and markings conform to Caltrans Traffic Manual or City of Palmdale requirements.



8.1.2.8 PAVEMENT DESIGN

Areas receiving pavement will consist of the following:

- Roadways will be asphalt concrete.
- Chemical unloading areas will be concrete and sealed in accordance with Los Angeles County Fire Department requirements
- Walkways will be concrete

8.1.2.9 SECONDARY CONTAINMENT OF HAZARDOUS LIQUID

Secondary containment of hazardous liquids, if any, will be designed in accordance with the appropriate NFPA standards, Uniform Fire Code, and the requirements of the local Los Angeles County Fire Department. Linings and coatings to be provided in accordance with the properties of the specific liquid being contained.

8.1.2.10 LANDSCAPING AND IRRIGATION

Landscaping design work will mimic existing landscaping at the PWD office building and parking lot. Water for irrigation will be provided by the treatment process, if feasible.

8.1.2.11 YARD PIPING

Yard piping design will incorporate the following criteria:

- Minimum cover for pressure pipes will be 4.0 feet.
- Buried valves will be installed in vaults or as deemed appropriate by PWD.
- Piping materials will be as summarized in Table 27.



Service	Pipe Material	Pipe Lining & Coating
Plant Feed Water (Tertiary Treated Recycled Water from Palmdale Water Reclamation Plant)	Steel, Ductile Iron, HDPE, or PVC	Cement-mortar lining / Fusion Bonded Epoxy coating for ductile iron only, otherwise none
Treated Process Water Drain and Waste Flows	HDPE or PVC	None
Potable water	Steel or Copper	Cement-mortar lining / Fusion Bonded Epoxy coating or copper
Onsite sanitary sewer drains (from restrooms, sinks)	HDPE or PVC	None
Stormwater Drains, if applicable	HDPE or RCP with gasketed joints	None
Fire Service	Steel, Ductile Iron, HDPE or PVC	Cement-mortar lining / Fusion Bonded Epoxy coating for ductile iron only, otherwise none

Table 27. Pipe Service and Materials

8.1.2.12 POTABLE WATER SERVICE

Potable water will be supplier either from existing water service at PWD offices or from a new connection. Potable water lines will be sized to accommodate demand. Proper separation will be maintained between potable water lines and sanitary sewers in accordance with the requirements of the Los Angeles County Department of Public Health and California State Water Resources Control Board Division of Drinking Water.

8.1.2.13 STORM DRAIN SYSTEM

Runoff from new facilities will be captured if feasible. Where not feasible, will be directed to existing storm drain systems.


8.2 ARCHITECTURAL

Project objectives are listed in bullet form below:

- Optimize the comfort and safety of the working environment
- Provide a safe, secure, and welcoming building for visitors that promotes a positive public interface
- Use practical architectural forms and features
- Utilize building materials that promote durability, longevity, and ease of maintenance
- Design for energy efficiency

8.2.1 ARCHITECTURAL DESCRIPTION

Figure 12. 3D View of the Demonstration Facility



The Demonstration Facility is a single-story structure totaling 5,647 square feet of enclosed area with an attached covered utility area of 1303 square feet. The building will be comprised of a preengineered metal building frame with exterior insulated metal panel skin on a slab-on-grade concrete foundation. The design blends a minimalist, industrial character into the surrounding suburban neighborhood with simple, conventional building forms and materials.

The large single-span structure is articulated with human-scaled openings and exterior finish materials to create an inviting appearance from the street. Recessed in the center is a welcoming glass entrance framed on one side by a large solid wall serving as a billboard for the District's branding and on the other by a covered courtyard area. Perimeter windows will provide daylight to occupied spaces and views out to drought-tolerant landscaping. Skylights and a clerestory window provide generous daylighting to the building interior and accentuate the building roofline.



Inside, the building is organized in around a central lobby space to receive visitors and serve as a starting point for public tours. The central lobby promotes efficient circulation and convenient adjacencies. The community room is prominently located at the front of the building and adjacent to the lobby. Behind the community room, a staff support area includes 2 gender-neutral restrooms, janitor closet, and staff office with water sample testing laboratory. A clear and defined path throughout the process equipment space leads to a tasting area and out to a shaded courtyard. A plan view of the Demonstration Facility is provided as Figure 13





Figure 13. Revit Plan View of the Demonstration Facility



8.2.2 ARCHITECTURAL DESIGN CRITERIA

This section describes the architectural design criteria that will be used for design of the Palmdale Water District (PWD) Demonstration Facility, including applicable codes and standards, health and safety, and materials of construction.

8.2.2.1 CODES AND STANDARDS

The project shall be designed to comply with applicable portions of the codes and standards listed in Table 28 below. The edition of codes shall be the latest state and local edition adopted at the time of the permitting by the local Fire Marshall. The edition of the referenced standards shall be the latest published edition at the time of the project final design:

Table 28. Codes and Standards for Building Construction

Relevant Codes and Standards			
2022 California Building Code (CBC) Volumes			
Chapters 2-35, of Vol I and II and Appendix II			
City of Palmdale Municipal Code Amendments to Chapters 7, 16, 17, 18, 19, 23, and 31			
2022 California Energy Code (Energy Efficiency Standards)			
2022 California Green Building Standards Code (CALGreen)			
2022 California Plumbing Code			
2022 California Fire Code			
CalOSHA			
NFPA 70, NFPA 101, NFPA 820			

8.2.2.2 CODE SUMMARY

The following preliminary code review is based on codes and standards listed on Table 29. This review does not list all possible code options or compliance issues associated with the facilities and should be verified with local code officials (AHJs) during design.

Table 29. Preliminary Code Summary

Title	Description
Occupancy Type CBC Chapter 3	F-2: Low-hazard factory industrial, B: Business, A-3: Assembly
Building Construction Type CBC Chapter 6	Type IIB, Unprotected non-combustible construction materials.
Automatic Fire Protection Sprinklers, CBC 903	Not required



Maximum Allowed Building Height	3 Stories (B) 3 Stories (F-2)	
*Most stringent limits apply	2 Stories (A-3)	
CBC 503, 504, 506	55 feet	
Maximum Allowed Building	Business (B): 23,000 SF	
Area	Low-Hazard Factory Industrial (F-2): 23,000 SF	
CBC 506.2	Assembly (A-3): 9,500 SF	
	Mixed use: $X/23,000$ (B) + $X/23,000$ (E-2) + $X/9,500 < 1$	
	Note: Non-sprinklered building	
Fire Extinguishers	One per room	
CFC 906.3		
Occupancy Load Factor	Assembly without fixed seats: 7 net SF	
CBC Table 1004.5	Storage Areas: 300 Gross SF	
	Business Areas: 150 Gross SF	
	Mechanical Equipment Room: 300 Gross SF	
Minimum Egress Width CBC 1010.1	32" Clear Width	
Minimum Number of Exits	1 exit for F-2 and B occupancy with maximum occupant load of 49	
CBC 1006, 1021	2 exits for A-3 occupancy	
Maximum Path of Travel	B or A-3 - Maximum egress travel distance of 200ft	
CBC 1017.2	F-2 - Maximum egress travel distance of 300ft	
	Note: Non-sprinklered building	
Exit Signs CBC 1013	Not required if only one exit is provided; if more than one exit is provided, illuminated exit signage required for all exits	
Roof Access	Not required	
Fall Protection	Personal fall arrest protection system and tie-offs	
CalOSHA 3212		
Plumbing Fixture Count (CPC 422.1)	Occupancy Mixed: (Factory or Industrial Occupancy)	
	Water Closets & Lavatories:	
	Male: 1: 1-50 occupants	
	Water Closets & Lavatories:	
	Female 1 - 1-50 occupants	
	Showers:	
	1 shower for each 15 persons exposed to excessive heat or to skin contamination with poisonous, infectious or irritating material.	
	Drinking Fountains:	
	1 for 1-250 persons	



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	Other: 1 Eye wash station in lab, 1 emergency shower/eyewash in process area, and 1 for each chemical containment area
Climate Zone	14
Zoning Code (PMC)	M-1 – Light Industrial
FEMA Flood Zone	X (0.2%) – Moderate to Low Risk

The square footage of the indoor and outdoor areas of the Demonstration Facility are provided in Table 30.

LOCATION	SPACE NAME	TOTAL SF	Notes
Process Areas	Process Area & Tour Route	2500	
	Tasting Area	344	
	Chemical/Utility Area	1336	Covered outdoor
	NET AREA	4180	
Non-Process Areas	Lobby	419	Tour reception, sitting area
	Community Room	834	30 people + kitchenette. Moveable furniture
	Storage	62	PPE equipment and
	Lab/Office	287	3 workstations (incl. Facility Control)
	Restroom	102	2 individual gender neutral toilet facilities
	Janitor	42	includes a mop sink and shelving
	Electrical Room	275	Must be sprinklered or fully CMU enclosure
	IT/COMM	103	conditioned space for IT and communication equipment
	Mechanical Room	167	double door to the exterior of this room
	NET AREA	2291	
	TOTAL NET BUILDING AREA	6471	
	GROSSING FACTOR (11.5%)	649	
	TOTAL GROSS BUILDING AREA	7120	
Outdoor Areas	Courtyard	973	
	Porch	84	
	TOTAL COVERED AREA	1057	
	TOTAL AREA	8177	

Table 30. Footprint of Spaces in the Demonstration Facility

8.2.3 ARCHITECTURAL BUILDING COMPONENTS

The following section presents design criteria for major architectural building components, with an emphasis on exterior and interior materials and finishes.

8.2.3.1 EXTERIOR WALLS

Exterior walls shall be constructed of insulated metal panels (IMPs) over pre-engineered metal building (PEMB) structural framing. Insulated metal panel system will provide both interior and exterior finished wall surfaces and serve as the primary air and moisture barrier for the building. Panels shall be factory finished in a custom color Kynar coating.



Public facing portions of the building will be covered with a decorative rainscreen cladding system over the IMP wall surface. This system may be composed of wood, metal, or fiber cement panels.

Exterior wall assemblies shall be designed to meet or exceed minimum requirements of the California Energy Efficiency Standards.

8.2.3.2 ROOFS

The design arrangements of roofs, canopies, fascia, overhangs, or other roof elements shall be in harmony with the massing and materials of the structures, and to control runoff and direct drainage away from equipment, doorways, sidewalks, ramps, or other occupied areas. The following design directions shall be followed.

Sloped roofs shall be constructed of insulated metal roof panel over PEMB structural framing. Insulated metal panel system will provide both interior and exterior finished wall surfaces and serve as the primary air and moisture barrier for the building. Panels shall be factory finished in a custom color Kynar coating.

Roof assemblies shall be designed to meet or exceed minimum requirements of the California Energy Efficiency Standards.

Eaves of enclosed building structure shall not have roof overhangs. Concealed gutters and downspouts shall be incorporated into the rainscreen wall system. Exposed gutters and downspouts shall be provided at other locations as required. Roof flashing and break metal shall be prefinished to match adjacent roof and wall panels.

A sloped canopy shall be provided for entire extents of chemical storage area. Canopy shall be composed of standing seam metal roof over metal deck. Roof panels shall be factory finished to match primary roof panels. Fascia, gutters, and downspouts shall be prefinished to match the roof panels.

- Assume all roofs will be accessed for ongoing maintenance and inspection activities and provide a tie off for personal fall arrest protection system. Access to roofs shall be provided by portable ladders or lift equipment.
- All roofs shall be Title 24 SRI (Solar Reflective Index) compliant. Roofs on unoccupied and unconditioned structures shall have a minimum SRI of 64 for flat roofs and 16 for steep roofs.
- Skylights shall be mounted on roof curbs.
- Sloped roofs must have a minimum 1 inch per foot slope.
- Roof slope shall be achieved through the structural roofing members, not with tapered insulation board.
- Provide crickets to sufficiently divert water around curbs and other roof mounted equipment.
- Color selection of roof panels and accessories shall consider sustainable principles to reduce "heat island effect."



8.2.3.3 DOORS, WINDOWS, AND LOUVERS

Exterior doors and frames shall be insulated and be composed of pre-primed galvanized metal, ready for field painting. Exterior storefront entrance and window frames and louvers shall be designed of extruded aluminum sections with Kynar coating or anodized finish. Sills, thresholds, flashing, and trim shall be provided to prevent water penetration to the interior of the building.

Louver assemblies shall be designed complete with bird screens, filters, dampers, blank-off panels, or acoustical treatment as required. Louver assemblies shall be designed to prevent infiltration of rain and provide positive drainage to the exterior.

All doors, windows, and louvers shall be provided with corrosion resistant hardware, accessories, fasteners, and operating mechanisms.

Skylights and Clerestory Windows:

- Skylights and roof clerestory windows shall be incorporated to provide consistent daylight distribution to large interior spaces.
- Skylights and clerestory windows should be glazed with low-e, frosted or similarly opaque type of glass to diffuse light transmission. Translucent fiberglass material may be used where glass would create a safety hazard. Skylights shall meet fall protection requirements per code.

Fixed Storefront Windows:

- Windows should be incorporated into facilities to provide daylight into occupied spaces, views out, and views in as appropriate.
- Glass used for exterior windows shall be low-e, insulated glass.
- See CBC for locations requiring tempered, fire-rated, or safety glass.
- Operable roller shades shall be provided for all windows in occupied spaces.

Doors:

- Canopies and overhangs shall be incorporated to protect all main entrances from sun and inclement weather.
- Standard interior and exterior doors shall be hollow metal construction with in-door, transom, or side lites as appropriate for views between spaces.
- Use galvanized steel in moderately corrosive environments and 316 stainless steel or FRP in harsh environments.
- Standard personnel door size shall be 3 feet wide by 7 feet tall.
- All hollow metal doors except for restrooms will provide a view light.
- Storefront entrances shall be provided at non-fire rated building entrances.
- Glass used for exterior doors, sidelights, and transoms shall be low-e, insulated glass.
- Coiling service doors shall be galvanized steel, insulated, factory primed and field painted, and motor operated.
- Provide 12-inch clearance on each side and 24 inches of clearance above the coiling door head assembly.
- Overhead sectional door shall be constructed with an aluminum frame and have glass infill panels. Aluminum frame shall have Kynar coating or anodized finish.
- Access doors shall be sized and located at valves or controls within walls or hard ceilings.



8.2.3.4 EXTERIOR SIGNAGE

Street facing building identification signage shall be provided. Signage shall be illuminated. Signage design to be coordinated with client.

8.2.3.5 INTERIOR WALLS

Interior wall finish materials shall be selected with an emphasis on durability and low maintenance.

Process Spaces:

- Interior walls shall be constructed of painted gypsum board over metal stud framing.
- Sound attenuation blankets shall be provided between process and occupied nonprocess spaces with a minimum Sound Transmission Class (STC) rating of 45.

Non-Process Spaces:

- Interior walls within administrative/personnel areas shall be constructed of painted gypsum board over metal stud framing.
- Sound attenuation blankets shall be provided between occupied non-process spaces with a minimum Sound Transmission Class (STC) rating of 45.
- Translucent hollow-cell polycarbonate panels mounted to metal stud framing shall be provided at lobby walls adjacent to process space.
- Restrooms shall have ceramic tile at walls behind and adjacent to plumbing fixtures.
- Custodial closets shall have protective FRP panels behind and adjacent to plumbing fixtures.

Where required for fire separation, walls shall be designed in accordance with recognized tested UL assemblies.

8.2.3.6 FLOORS

Flooring and base materials shall be selected based on minimum maintenance requirements and high durability. Wall base materials shall be selected to be compatible with adjacent floor and wall finishes.

Process and Utility Spaces:

- Process demonstration space: clear floor sealer/hardener or chemically resistant epoxy coating over concrete
- Electrical and mechanical room: exposed concrete

Non-Process Spaces:

- Office/lab: resilient sheet flooring
- Lobby and hallway: polished concrete
- Community space, janitor closets, IT closet, and storage closet: resilient tile flooring
- Restrooms: ceramic tile



8.2.3.7 CEILINGS

Ceiling materials shall be selected based on minimum maintenance requirements, access to space above ceiling, acoustical control, and durability.

Process and utility areas shall have exposed ceilings with structural elements painted in an appropriate coating system.

Non-Process Spaces:

- Community room, office/lab, IT room, and hallway: suspended acoustical tile
- Janitor closet and restrooms: painted gypsum board
- Ceiling materials and finishes shall be appropriately applied for acoustic and light reflective properties.

8.2.3.8 FURNISHINGS FOR NON-PROCESS SPACES

General casework shall be of wood construction with plastic laminate finish. Chemical resistance laminate casework with epoxy countertops will be provided for the lab area. Sinks in epoxy countertops shall be integrated epoxy basins. An industrial style bar height counter with dishwasher and storage for glassware shall be provided in tasting area.

Office space shall have two modular style desks and desk chairs. Configurations of desks and additional storage shall be coordinated with staff during design.

Interior Signage: Room name signs shall be provided for all major spaces and pictorial symbol signs provided at restrooms. Informational signs (hazardous materials, warning, danger, caution) shall be provided as required by code and where appropriate for each space. Educational signage and displays shall be provided along tour route and community room. Design of these informational signs will be developed during design.

Stackable chairs shall be provided for the community room. Make and model of furniture shall be selected by city representative. Wall or ceiling mounted visual displays will be incorporated into the community room. Procurement of loose furniture shall have a lump sum allowance.

Outdoor space adjacent to tasting room shall have movable picnic tables and benches. A fabric sail canopy will provide shade to courtyard. A wood fence structure will be provided at perimeter of outdoor space. The fence shall be constructed of cedar or redwood with a transparent stain.

Preliminary lab equipment listed below shall be confirmed with lab staff during design:

- Sink with emergency eyewash
- Full height Refrigerator / Freezer
- Drying rack
- Glassware
- Testing equipment
- Dishwasher
- Fume Hood



8.2.3.9 HARDWARE

All doors shall be provided with corrosion-resistant hardware, accessories, fasteners, and operating mechanisms. Use brushed 316 stainless steel as default hardware finish.

Locksets and keying arrangements shall match District standards and preferences. Locksets on interior doors shall be equipped with passage locksets with storeroom function unless security issues take precedence.

Doors must have the ability to open a minimum of 90 degrees. All doors shall be provided with a means of stopping before hardware or door leaf contacts the adjacent wall or similar feature. Doorstop control shall be accomplished with floor mounted stops. Where door frame is not flush with the swing side wall surface, and floor mounted doorstop would otherwise present a tripping hazard, provide door stop control through closer or other means to prevent contact with corner of rough opening. Doorstops shall be installed at 90-degree open position or 180-degree open position depending on location of adjacent wall or other obstruction. Wall-mounted doorstops shall have backing in metal stud constructed walls.

Exit doors shall be equipped with rim type panic hardware. Provide rim devices in lieu of vertical rod type exit devices. See CBC for panic hardware requirements.

8.2.3.10 PAINTING AND PROTECTIVE COATINGS

Where practical, the design shall include factory finished items. Field-applied finishes and protective coatings shall be provided to all other building elements that are not supplied with factory-applied protective coatings. Factory- or field-applied coatings that provide corrosion resistance and long-term service use with minimum maintenance shall be used.

8.2.3.11 ACOUSTICAL PANELS

Prefabricated panels designed for sound absorption shall be provided as required in the process demonstration space. Panels shall have factory-painted perforated metal skin with acoustical insulation held behind the panel face. Panels shall also be designed for wall or ceiling mounting.

8.2.3.12 VAPOR RETARDER

Apply vapor retarder below concrete slab on grade at all locations where a finish floor product or coating is to be applied.

8.2.3.13 SEALANTS

Design building and flashings so as not to rely on sealants in the shedding of water and moisture. Make sure to use capillary breaks.

Sealants:

- Sealant and waterproofing materials shall be warranted for at least 30 years.
- Check the width of the gap to be sealed with the manufacturer's recommended span.
- Check substrate and compare with manufacturer's recommendation.



- Check elasticity is appropriate for joint movement.
- Check performance of UV exposure if in direct sunlight.
- Use backer rods of appropriate size and compatible materials as per sealant manufacturer's requirements.
- Sealant or caulking materials shall be compatible with the construction materials and location

8.3 STRUCTURAL

The structural design requirements apply to the design of concrete foundation for the building and concrete pads for equipment. The structures anticipated for this project include a single-story pre-engineered/pre-manufactured steel building (design by others) and equipment in the process area.

8.3.1 DESIGN REQUIREMENTS AND REFERENCES

The anticipated structure for the project is a single-story pre-engineered/pre-manufactured steel building that houses a large community room, lab/office, process demonstration room, other supporting rooms, and chemical storage located outdoors under a canopy. This building will have a reinforced concrete slab-on-grade and spread footings under building columns and perimeter walls. It is essential to coordinate the gravity and seismic loads imposed by the pre-engineered steel building (designed by others) to design the concrete supporting structure. In addition, there would be miscellaneous non-structural items (e.g., equipment pads and pipe support) and architectural items (e.g., partition and canopy) that requires structural attention.

Structural designs will be prepared in accordance with recognized engineering principles and accepted practices established by building codes and the codes published by various professional institutions.

8.3.1.1 REINFORCED CONCRETE DESIGN

- Foundation for a single-story pre-engineered/pre-manufactured steel building: 2022 CBC and ACI 318-19
- Non-hydraulic/Water Bearing Structures: Strength design method in accordance with CBC Chapter 19 and ACI 318-19.
- Hydraulic: Design will be based on ACI 350-20 and ACI 350.3-20.
- Testing Reinforced Concrete Hydraulic/Water Bearing Structures will be based on ACI 350.1-10.
- Underground reinforced concrete structures subjected to traffic loading will be per Caltrans Bridge Design Specifications (BDS) Section 3.



8.3.1.2 STRUCTURAL STEEL DESIGN

- All structural steel will be designed per the American Institute of Steel Construction "Manual of Steel Construction", 15th Edition and per the American Institute of Steel Construction (AISC) "Seismic Design Manual" 3rd Edition.
- All steel framing for hatches, or steel exposed to earth or weather will be hot dipped galvanized in accordance with ASTM A123.
- Cold-formed steel structural designs will be in accordance with the provisions of the American Iron and Steel Institute Specifications.
- AISC, Structural Design Guide 01 by AISC Steel Design Guide will be utilized for Base Plate and Anchor Rod Design, 2nd Edition.
- AISC, Structural Design Guide 24 by AISC Steel Design Guide will be utilized for Hollow Structural Section Connections.

8.3.1.3 GRATING DESIGN

FRP grating is planned to be used in the chemical area above piping trenches to avoid overhead chemical piping. Other locations may also have grating and will be determined during design progression.

- Weight of grating or plate segment will be limited to 80 pounds maximum.
- Steel bar grating will be welded, type W-19, designed for a uniform distributed live load of 100 psf or the actual applied loads, whichever are greater, and a deflection of 1/240 of the span or ¼ inch maximum. All grating will be galvanized in accordance with ASTM A123.
- FRP grating will be VEFR pultruded fiberglass grating wherever possible and one piecemolded construction at all other locations and will have a slip resistant surface. Resin for FRP grating will be vinyl ester to provide maximum corrosion resistance. FRP grating will be used for all platforms or walkways.

8.3.1.4 STEEL PLATE DESIGN

Steel floor plates will conform to ASTM A36 steel and will be designed for a uniform live load of 100 psf or the actual applied loads, whichever are greater, and a deflection of 1/240 of the span or 1/4 inch maximum. Steel floor plate will have a raised pattern in accordance with ASTM A786 Pattern No. 4 or No. 5. Floor plates will be galvanized in accordance with ASTM A123. Plates immersed in water, intermittently or continuously, or in a moist environment will be stainless steel type 316.



8.3.2 DESIGN BASIS

8.3.2.1 FOUNDATION DESIGN

The structural design of all foundations will be based upon geotechnical investigations that are currently under development.

8.3.2.2 DEAD LOADS

Dead loads will be comprised of the weight of all permanent construction, including walls, floors, roofs, ceilings, stairways, and fixed mechanical equipment, heating, ventilation and air conditioning (HVAC) ducting and piping, mechanical distribution systems and electrical distribution systems. In estimating dead loads for purposes of design, the actual weights of materials and construction will be used.

- Weight of pre-engineered building structure (column loads)
- Weight of structure, including tank operating weights
- Weight of pipe and valves, including the weight of contents
- Weight of mechanical and electrical equipment
- Weights of mechanical and electrical distribution systems

8.3.2.3 LIVE LOADS

Live loads are those loads produced by the use and occupancy of the building or other structure and do not include environmental loads such as wind load, snow load, rain load, earthquake load, or dead load. Live loads on a roof are those produced (1) during maintenance by workers, equipment, and materials, and (2) during the life of the structure by people and by movable objects such as planters.

The live loads assumed in the design of the building and other structures will be the maximum loads likely to be produced by the intended use of occupancy but will in no case be less than the minimum uniform or concentrated loads required by the 2022 CBC Table 1607.1.

Unless otherwise indicated, the following minimum live loads will be used:

- Mechanical and operating forces and reactions
- Reactions due to hydraulic thrusts
- Demonstration Facility Building Process Area, Chemical Area: 300 pound per square foot (psf)
- All other floors: 100 psf uniform load



- Walkways, platforms, and stairs: 100 psf uniform load
- Concentrated live load of 2,000 pounds minimum on any floor span supporting a tributary area greater than 200 square feet

8.3.2.4 WIND LOADS

Basic wind speed will be 110 mile per hour (mph) for a 3-second gust and assume Exposure "C" and Risk Category "IV" per 2022 CBC.

8.3.2.5 FLOOD LOADS

The flood loads will be applied per Section 1603.1.7 of 2022 CBC as needed by the final geotechnical investigation report.

8.3.2.6 SEISMIC LOADS

Seismic forces will be verified with site-specific geotechnical reports commissioned by the Designer as part of detailed design. Assume Risk Category "IV" when determining importance factors in accordance with the CBC or ACI 350.3 as applicable which will equate to $l_e = 1.5$ for structural lateral elements and $l_p = 1.5$ for all the nonstructural components including architectural panels and MEP components.

8.3.2.7 VEHICLE LOADS

All new underground structures (e.g. vaults, if applicable) subject to traffic loading will be designed to withstand standard H 20 vehicle loading as defined in Caltrans Bridge Design Specifications (BDS) Section 3.

Construction vehicle loading that exceeds the standard Caltrans H 20 loading will be considered individually for each case.

8.3.2.8 SOIL DESIGN PARAMETERS

Geotechnical design criteria, including allowable vertical and lateral passive bearing pressures, lateral pressures, and minimum footing depth and width requirements, will be specified in the project geotechnical report.

8.3.2.9 EQUIPMENT ANCHORAGE

Anchorage of equipment will be based on 2022 CBC criteria, which, in general references the requirements in ASCE 7-16 Chapter 13, and the seismic important factor shall be $I_p = 1.5$. Cast-in-place anchors will be used whenever possible. Adhesive anchors, only if approved by PWD will be in accordance with the requirements listed under Structural Bolts. No cinch anchors or expansion anchors are acceptable. No cinch anchor, expansion anchor, or chemical anchor will be used on equipment.



For all equipment weighing 400 pounds (181 kilograms) or more, the minimum anchor bolt (including chemical anchor bolt) diameter will be 1/2-inch with minimum 5-inch embedment. The minimum anchor bolt diameter for all other equipment will be 3/8-inch with minimum 3-inch embedment.

8.3.2.10 PRE-ENGINEERED METAL BUILDINGS

Pre-engineered metal buildings (PEMB) shall be designed, detailed and fabricated in accordance with governing design codes and standards by a metal building manufacturer qualified for the applicable scope of work. PEMB buildings will consist of all steel structures, occupied or not, located throughout the project site. All metal buildings will be classified as frame-and-purlin buildings and will be in accordance with the project documents. All frame reaction loads will be provided by the metal building manufacturer for design of foundations in accordance with the parameters of the project geotechnical report. Detailed shop drawings and calculations sealed by a registered professional engineer, licensed in the state of California will be required.

8.4 PROCESS MECHANICAL

8.4.1 DESIGN REQUIREMENTS AND REFERENCES

The process mechanical design will be in accordance with applicable industry codes and standards.

The following references and applicable provisions of industry standards and publications are used in the design. Unless specifically stated otherwise, the latest edition of all codes will apply.

- ASME Piping and ASME Boiler and Pressure Vessel Code
- ASHREA- American Society of Heating, Refrigerating and Air-Conditioning Engineers.
- ANSI American National Standards Institute
- AWWA American Water Works Association Standards and Manuals of Water Supply
 Practices
- ASTM American Society for Testing and Materials Standards
- HIS Hydraulic Institute Standard.
- NFPA National Fire Protection Association Standard
- SMACNA standards
- ACMA Certified Ratings Seal for Air Performance & Water Penetration
- Los Angeles County Fire Department
- NSF National Sanitation Foundation, NSF 60 & 61



8.4.2 DESIGN BASIS

8.4.2.1 PIPE SUPPORT / ROUTING CONCEPT

The process piping is planned to be routed overhead, supported by the building roof structure to save space in the process area around equipment. This will be investigated further during the next phase of design to confirm that the PEMB manufacturer could accommodate these loads economically. The alternative is to support the piping from the floor and/or in trenches in the slab which may require a slightly larger process area in order to accommodate access clearances around equipment. This will be evaluated to see if it is more economical with a larger building size, but the preference is to support the piping overhead.

8.4.2.2 PIPING MATERIALS

The pipe and fitting materials will be selected based on the type of material or fluid being handled and selected for longevity, durability and economy. Special consideration will be made for the selection of materials serving chemical with a potential for corrosiveness. The pipe material for different fluid services at the Demonstration Facility is summarized in Table 31. For services not listed but necessary in the design, the appropriate pipe materials will be considered and selected during design.

Service	Pipe Material	Pipe Manufacturing Standard
Plant Feed and Drain	(Refer to C	ivil Design Criteria)
Storm Water (Storm Sewers)	(Refer to C	ivil Design Criteria)
MF Feed, Filtrate	Schedule 80 PVC	ASTM D1785
MF Air Scour / Air Piping	Schedule 80 PVC	ASTM D1785
RO Feed – low pressure	Schedule 80 PVC	ASTM D1785
RO Feed – high pressure	316L stainless steel	ASTM A778
RO Concentrate – high pressure	316L stainless steel	ASTM A778
RO Concentrate – low pressure	316L stainless steel	ASTM A778
RO Flush/CIP	Schedule 80 CPVC	ASTM F441

Table 31. Piping Systems Summary



RO Product Water/Permeate	Schedule 80 CPVC	ASTM F441
Feed Piping (Off-skid)	Schedule 80 CPVC	ASTM F441
Concentrate Manifolds (Off-skid)	Schedule 80 CPVC	ASTM F441
Permeate Manifolds (Off-skid)	Schedule 80 CPVC	ASTM F441
UV Feed / Treated Water	Schedule 80 CPVC	ASTM F441

8.4.2.3 VALVES

- Isolation valves installed in utility water lines will be eccentric plug valves, resilient seat gate valves, ball valves or butterfly valves.
- Valves installed in chemical solution lines will be Type 316 stainless steel ball valves, PVC ball valves, or PVC diaphragm valves suitable for the intended service.

8.4.2.4 FLOW METERS

Meters will be sized and design relative to the required range of measurement, degree of accuracy and compatibility with service. A summary of the meter type and application is provided in Table 32.

Table 32. Description of Flow Meters for the Demonstration Facility

Meter Application	Туре	
Main Process	Magnetic meter, thermal/mass meter (gas flow)	
Chemical solution	Magnetic meter	
Utility water and potable water	Magnetic meter	

8.4.2.5 PRESSURE VESSELS.

All pressure vessels are designed, fabricated and inspected in accordance with the applicable sections of the ASME Boiler and Pressure Vessel Code, Sections I, V, and VIII.



8.4.2.6 PUMPS

In general, pumps will be selected such that their best efficiency point (BEP) occurs at or near the most frequently occurring operating points. Each pump will be selected with minimum efficiencies reflective of industry standards for the respective pump type. All operating points will fall within the selected pump's allowable operating range (AOR), and the pump's net positive suction head requirements will have sufficient margins consistent with Hydraulic Institute Standards for the specific application. Each pump motor will be sized such that it is non-overloading at any point along the pump's AOR.

Pump stations will be provided with at least one standby pump sized equivalent to the largest installed pump, unless more stringent criteria are established. The acceptable pump types depending on the application is provided in Table 33.

Application	Pump Types	VFD?
MF Feed, Backwash Pumps	Horizontal End Suction, or	Yes
	Per Vendor Recommendations	
MF and RO CIP Pumps	Vertical Inline Centrifugal or	No
	Per Vendor Recommendations	
RO Transfer Pumps	Horizontal Split Case or	Yes
	Horizontal End Suction	
RO High Pressure Pumps	Vertical Turbine or	Yes
	Per Vendor Recommendations	
RO Flush Pumps	Horizontal Split Case or	Maybe, Per Vendor
	Horizontal End Suction	Recommendations
Final Effluent	Horizontal End Suction	No
	(small pump to pressurize tasting station)	
Chemical Feed	Peristaltic (where possible), Diaphragm	Yes

Table 33. Pump Type Summary



8.4.2.7 AIR COMPRESSOR DESIGN

Compressed air will be provided for the MF system by the vendor for air scour and pneumatic actuators. Compressor types will be one of the following:

- Rotary Scroll Air Compressor
- Base Mounted Air Compressor
- Tank Mounted Air Compressor

8.5 BUILDING MECHANICAL (HVAC, PLUMBING, FIRE PROTECTION)

8.5.1 DESIGN REQUIREMENTS AND REFERENCES

HVAC, plumbing and fire protection systems are design to meet the following objectives:

- Provide an operable, maintainable, and economical HVAC system design, which meets all applicable code requirements.
- Provide plumbing system designs that conform to the requirements of all applicable codes, standards, and any supplementary requirements of the authorities having jurisdiction.
- Filter particles from incoming outside air as required by ASHRAE Standard 62.1.
- Protect equipment and piping from overheating or freezing.
- Provide redundant or partially redundant cooling system design to ensure uninterruptable operation of electrical and IT/Comm room.
- Maintain appropriate space pressurization between process, laboratory, office, and public spaces.

The building mechanical design will be in accordance with applicable industry codes and standards. The following references and applicable provisions of industry standards and publications are used in the design. Unless specifically stated otherwise, the latest edition of all codes will apply.

- 2022 California Building Code with state and local ordinances and amendments
- 2022 California Fire Code with state and local ordinances and amendments
- 2022California Mechanical Code with state and local ordinances and amendments
- 2022 California Plumbing Code with state and local ordinances and amendments
- 2017 ASHRAE Fundamentals Handbook



- 2005 SMACNA Duct Construction Standards, Metal and Flexible
- 2005 SMACNA Duct Construction Standards, Fibrous Glass Duct
- 2017 NFPA 70, National Electrical Code with City Amendments
- 2019 NFPA 13 Fire Sprinkler Systems, Installation
- 2017 NFPA 90A Air Conditioning and Ventilating Systems
- 2020 NFPA 820 Fire Protection in Wastewater Treatment and Collection Facilities
- CalOSHA—California Organization Safety and Health Administration

8.5.2 DESIGN BASIS - HVAC

The Project's HVAC systems will have industrial quality and will be selected to provide high reliability and efficiency.

HVAC equipment, ductwork, and air distribution components serving corrosive areas will be provided with protective coatings and/or constructed of corrosion-resistant materials such as fiberglass reinforced plastic, stainless steel, or aluminum.

8.5.2.1 ENERGY EFFICIENCY

All HVAC equipment will be designed to perform at, or above, code required minimum efficiency levels, and according to the latest rules and regulations of International Energy Conservation Code and U.S Department of Energy

8.5.2.2 CALCULATIONS

Calculations will follow the methodology outlined in the applicable energy codes, ASHRAE Handbook of Fundamentals, and referenced ASHRAE handbooks and publications. If requested by the Owner, calculations will be provided.

8.5.2.3 OUTDOOR DESIGN CONDITIONS

Climatic design information for the Demonstration Facility location is provided in Table 34.



Location	Temperature (Degrees F) ²			Elevation (Feet
	Summer DB (Dry Bulb)	Summer WB (Wet Bulb)	Winter	above sea level)
Barstow, Callifornia, USA ¹	107	68.0	28	872

Table 34. Outdoor Design Conditions

Notes:

- 1. The above climatic design information has been collected from ASHRAE fundamentals handbook 2021. This is the closest geographic location with a similar climate collected by ASHRAE.
- 2. This climatic design information represents approximately 99.6% heating, 0.4% cooling design conditions and 0.4% Evaporation Conditions in a ten-year period; it does not take into consideration extreme climatic conditions.

8.5.2.4 INDOOR DESIGN CRITERIA

Design information for the various indoor areas of the Demonstration Facility is provided in Table 35.

Area Designation(s)	Temperature (Degrees F)		Noise Criteria, Maximum
	Summer	Winter	(decibels, dB)
Electrical Room	78	60	NA
Mechanical Room	104	60	NA
Process Area	80	60	NA
Lab Room	75	70	45
Office, Hallway, lobby, kitchenette I/T Community	75	70	45
Room			
Restrooms	75	70	55
Janitor	80	60	NA
Storage	80	60	NA

Table 35. Indoor Design Criteria



8.5.2.5 NOISE CONTROL

For recommended noise criteria in various spaces, see Table 2: Indoor Design Criteria. Additional design considerations include:

- While some equipment noise is inevitable in process spaces and mechanical rooms, noise levels will nevertheless be considered an important criterion in the design of the HVAC systems.
- HVAC systems serving occupied areas are designed to meet the average noise criteria levels recommended by ASHRAE.
- Where efficient HVAC equipment selection does not result in acceptable noise levels, sound attenuation devices such as duct silencers will be utilized to reduce noise levels.
- Duct velocities will be maintained in accordance with the recommendations in the ASHRAE Applications Handbook.
- Noise produced outside of the buildings is evaluated to comply with local codes and ordinances. The evaluations will also consider the sound emission criteria for all other sources.

8.5.2.6 AREA VENTILATION REQUIREMENTS

Ventilation requirements for various areas of the Demonstration Facility are provided in Table 36.

Area Designation	Outside Air Volume	Room Pressurization	NEC Classification
Electrical Room Mechanical Room	As Indicated by Heat Load Calculations	Positive	Unclassified
Public Spaces, Office Space	As Indicated by Heat Load Calculations	Positive	Unclassified
Laboratory	To be Calculated	Negative	Unclassified
Process Area (See Notes 1,2)	As Indicated by Heat Load Calculations	Negative	NA

Table 36. Area Classification and Ventilation Requirements

Notes:

- 1. The exhaust ventilation system shall be designed to consider the density of the potential fumes or vapors released. For fumes or vapors that are heavier than air, exhaust shall be taken from a point within 12 inches of the floor.
- 2. Laboratory ventilation will be updated based on hazards to be analyzed.



8.5.2.7 BUILDING PRESSURIZATION

HVAC systems will be designed to move air from spaces with high air quality to those with lower air quality.

For air-conditioned spaces, adequate ventilation air quantities will be provided to ensure the building is maintained at a slight positive air pressure. This will minimize infiltration of dust and maintain the conditioned spaces dust free.

The HVAC systems will be balanced after construction to the required pressure differential.

Door Forces: ANSI limits door opening force to 8.5 pounds for exterior doors and 5 pounds for interior doors. HVAC systems will be designed to limit the required door opening force to these recommended values.

8.5.2.8 AESTHETICS

Certain exterior locations in the plant require more attention to visual aesthetics than others. HVAC equipment will be located away from those areas where practical, or equipment will be hidden behind screens. Wall openings required for air passage will be provided with louvers.

8.5.3 HVAC SYSTEMS AND COMPONENTS

8.5.3.1 AIR CONDITIONING SYSTEMS

The Electrical Room will be provided with two single-zoned heat pumps.

Hence, two heat pumps will be provided for the electrical rooms, each sized to offset 60% to 75% of the total heat load generated by electrical equipment. This method will provide partial redundancy, less maintenance issues and better temperature and humidity control. The heat pumps will be programmed to operate in lead/lag mode to allow the first heat pump to operate for longer periods of time. The second heat pump will energize only when the first heat pump is unable to maintain the room temperature set point.

The occupied spaces will be conditioned to comfortable temperatures. These systems will typically use a split system air conditioning unit sized for 100% of the load without a redundant unit. Various equipment types will be evaluated during design due to the architectural and space constraints.

8.5.3.2 HUMIDITY CONTROL SYSTEM

Air Conditioning equipment can provide dehumidification during cooling mode and are sized to achieve 55 percent maximum relative humidity at peak design conditions. Minimum relative humidity is not controlled since humidification is not provided.



8.5.3.3 HEATING SYSTEMS

Heat will be provided in all indoor spaces in the building. Heating will be provided by electric resistance coils depending on the of the utilities to the site. Unit heaters will be used for heating in the process area and unoccupied areas. Air handling units will use internal heating coils or duct mounted heating coils as required. Electric baseboard heaters may be used in isolated spaces as the design requires.

8.5.3.4 VENTILATION SYSTEMS

In classified areas where continuous ventilation is required, outside air will be provided via supply fans, and air will be exhausted from the area via exhaust fans.

In unoccupied, non-classified areas where summer ventilation is required, outside air will be provided via air intake louvers, and air will be exhausted from the area via exhaust fans. Supply fans will be used where required.

In occupied spaces, the minimum code required outside air will be provided the air handling unit or a dedicated outside air unit.

8.5.3.5 DUCTWORK SYSTEMS

Aluminum ductwork is used for common office type layouts and non-corrosive areas. Ductwork design and installation will follow the latest SMACMA standards.

In highly corrosive areas, like the chemical room, FRP ductwork will be used.

8.5.3.6 INSULATION

Ductwork conveying mechanically conditioned air will be insulated in accordance with applicable International Energy Conservation Code (IECC) requirements.

All outside air intake and supply air ductwork will be insulated to prevent surface condensation where ducts carry cold air through warm, moist spaces. Supply air ductwork located in conditioned spaces will not be insulated.

Internal duct liner will be used on supply, return, and exhaust ductwork, where required, for sound attenuation and thermal insulation.

Internal duct liner will not be used on outside air intakes serving normally occupied spaces due to potential for growth of microorganisms in accumulated dust on the liner media.

Internal duct liner will not be used on cooled air ductwork when cooling mode will be turned off at night to prevent mold growth in ducts.

Pipes transferring fluids at temperatures below ambient temperature will be insulated with closedcell thermal insulation.



8.5.3.7 LOUVERS

Heavy gauge aluminum louvers with drainable blades and bird screens will be used for all buildings.

8.5.3.8 EQUIPMENT LOCATIONS

In general, the mechanical and HVAC equipment will be concealed in the inside the building. The condensing units serving the air-conditioned spaces will be located outside the building. Small air handling units and evaporator units will be either wall mounted, or ceiling suspended inside the building. Exhaust fans and ventilation equipment will be mounted on the building roof or exterior walls; however, fans may be located inside the building when space permits. The mechanical room is a dedicated space for mechanical equipment and will typically house the potable water valves, pumps, heaters and other equipment. HVAC equipment will be located in the mechanical room as space permits.

8.5.3.9 CONTROL SYSTEMS

Control systems will be Direct Digital Control (DDC) type. Control panels in outside areas, wet areas, or corrosive areas will be corrosion resistant, NEMA 4X, 316 Stainless Steel.

- All HVAC systems, except for unitary equipment controlled by a thermostat, are provided with automatic temperature control (ATC) panel, complete with the required control capability, operator manual, and system indicator lights to clearly indicate system status and alarms.
- 2. Alarm signals from each ATC panel will be sent to the SCADA when any alarm condition exists. Typically, alarms will be generated upon equipment failure, high or low room temperature, or dirty air filters.
- 3. HVAC systems serving hazardous areas, such as chemical storage rooms and classified areas, will be provided with local ATC panels showing the system status and capability for manual override.

Each HVAC system will be provided with a sequence of operation for optimum performance, energy efficiency, and according to the code requirements and application.

Examples of temperature controls sequence of operation are:

- Summer-winter operation
- Occupied and unoccupied conditions
- High and low Ventilation control via VFD's or two speed motors
- Temperature set-points



- Damper and louver operation
- Fan operation
- Manual or automatic control
- Control interlocks
- Smoke or fire detector equipment sequence shutdown
- Tie-ins with central control panel and all other or low voltage, incidental to the temperature control system (interconnecting starters, thermostats, PE switches, relays, and like devices)

8.5.4 DESIGN BASIS - PLUMBING

8.5.4.1 DESIGN FEATURES

The plumbing system design will provide the followings:

- Sewer and potable water service for non-process sanitary fixtures.
- Potable tempered water services for emergency shower and eyewash fixtures where required.
- Backflow prevention devices to protect potable water from cross contamination.
- Medium duty hose bibbs and hydrants for interior and exterior wash-down.
- Floor drains, floor sinks, and hub drains.
- Building sanitary sewage system.
- Perimeter drains pumped up and discharged to grade if required.

8.5.4.2 CALCULATIONS

Calculations for potable water piping design, drainage system design, and equipment design will follow the methodology outlined in the applicable codes.

Water heaters will be sized in accordance with the guidelines recommended by the American Society of Plumbing Engineers (ASPE).

8.5.5 PLUMBING SYSTEMS AND COMPONENTS

8.5.5.1 DOMESTIC WATER

The building will be served by a 2" (estimated) domestic water line that will enter the building in the mechanical room. The source of the domestic water line will be coordinated with the Owner and Civil Engineer as required.



Domestic hot water will be supplied by instantaneous electric water heaters. A new electric tank type hot water heater will supply hot water to the mixing valve serving each safety shower/eyewash. The hot water heater will be sized to supply the safety shower/eyewash with a minimum of 20 gallons per minute of 85F water for 15 minutes at 30 psig.

The following fixtures are planned to be included in the design:

Safety shower/eyewash:

- Multiple located near the Chemical area.
- One located in the Laboratory area.

Interior hose bibbs locations (minimum):

- One in Mechanical Room.
- Two in Process Area.
- Coordinate additional locations with Owner.

Exterior hose bibbs:

• Coordinate locations with Owner.

Pipes shall be chlorinated poly vinyl chloride (CPVC) with solvent cement joints, with pipe insulation as required by code.

8.5.5.2 SANITARY DRAIN SEWER

A 6" line from the building will be connected to the local sanitary sewer system. A fiberglass sump pit with duplex sump pump will be provided if required. Sanitary sewer connection will be coordinated with Civil and AHJ and local plumbing code.

Provide the drainage fixtures listed below. Drainage fixtures shall be connected to a drainage sump pump as described above.

Process area:

- Trench / floor drains as needed and desired by owner.
- Oil/water separator if required by plumbing code.

Restrooms:

- Floor drain.
- Sanitary drains from Plumbing fixtures.



Mechanical Room:

• Provide floor drains as needed and desired by owner.

Janitor:

• Sanitary drains from Plumbing fixtures

Kitchenette:

• Sanitary drains from Plumbing fixtures.

Lab Area Room:

- Sanitary drains from Plumbing fixtures.
- Floor drain for emergency shower if required.

Electrical Room:

• No trench or floor drains

Pipes shall be schedule 40 PVC with solvent cement joints.

8.5.6 DESIGN BASIS - FIRE PROTECTION

There is no code required fire protection system for this building. The building design will be coordinated with the local Authority Having Jurisdiction (AHJ) and will be provided if required.

8.6 ELECTRICAL

8.6.1 DESIGN REQUIREMENTS AND REFERENCES

The design for this project will be in accordance with all applicable federal, state, and local laws and regulations, codes, ordinances, and general industry standards.

8.6.2 **DESIGN BASIS**

The conceptual design includes the electrical distribution systems necessary to support the equipment for the Demonstration Facility. The new equipment will be powered by an electrical distribution system designed to support the installed load with additional capacity to support future loads, if anticipated. A preliminary calculation for the necessary electrical power to supply the connected load has been included. This calculation shall be updated and refined during the detailed design stage.

The design of the primary power supply for the new distribution system has not yet been determined at this stage in the design though the options that will be considered are discussed below.



The distribution of power, instrumentation, and control wiring is planned to be primarily via cabletrays and overhead or wall-mounted conduit within the building. The cabletrays are planned to be routed overhead, supported by the building roof structure to save space in the process area around equipment and avoid cost of embedding conduit in the slab. This will be investigated further during the next phase of design to confirm that the PEMB manufacturer could accommodate the loads from the cabletrays on from the roof structure economically.

8.6.2.1 ELECTRICAL SUPPLY

Two different options have been considered to supply the new facility with the necessary electrical power: The required power for the new facility can be taken from the existing PWD headquarters power distribution system if available or can be obtained from the existing utility lines adjacent to the plant via a new overhead or underground utility service connection. The final power source and tie points will be defined during the detailed design stage, though it is anticipated that a new power supply will be required.

8.6.2.2 480V PAD-MOUNTED TRANSFORMER AND MCC

The new 480 VAC distribution system will be designed for high-impedance-grounded wye with a ground fault current limited to 5 Amp, and it will also include ground fault monitoring, alarming, and relay protection. The electrical distribution equipment will be sized to safely and reliably meet the peak demand load requirements of the loads serviced. Sizing shall include allowance for a minimum of 20% future load growth.

A new 300 kVA pad-mounted main transformer is anticipated to supply a local Motor Control Centre (MCC), pumps, lighting, and control equipment. A dedicated electrical room will be used to house the necessary electrical equipment including MCC, VFDs and control equipment. Considerations for installation of an outdoor receptacle to connect a portable generator to supply the system in case of a utility outage.

The MCC will be suitable for operation on 480 VAC, 3-phase, 3-wire, 60 Hz, high-impedance grounded system that complies with NEC Standard, UL 845, and applicable NEMA, ANSI and IEEE standards. Provision for future loads has been considered in the design of the MCC.

8.6.2.3 ELECTRICAL CONNECTED AND OPERATING LOADS LIST

A preliminary estimate of the connected and operating loads is 252 kW (280 kVA). The list of connected and operating loads is included in Appendix A. The preliminary one-line power diagram is included in Appendix B.

8.6.2.4 EQUIPMENT LOCATION

The project will consist of one Electrical Room located in the Demonstration Facility Building. Much of the electrical distribution equipment will be contained in the electrical room. A preliminary layout of the electrical room and MCC area has been provided in Appendices C and D, respectively. Additional equipment that is provided on vendor provided skids includes vendor



PLCs, control cabinets, and power distribution panels. VFDs are planned to be included in the MCC, provided by the vendors for Contractor installation.

8.6.2.5 LIGHTING AND RECEPTACLES

The lighting design will be based on the following:

- Lighting systems will comply with the California Energy Code and UL certification requirements
- All outdoor lighting will be LED type. The lighting design will minimize light trespass without compromising requirements for adequate lighting for security and road safety.
- Emergency lighting will be powered from an AC power supply and will be provided with an integral 90-minute battery backup.
- Roadway and area floodlighting will be controlled by photocell or time clock in conjunction with a contactor or by individual photocell within the fixture. Roadway lighting will only be provided for asphalt paved roadways. Roadway fixtures will be mounted on galvanized steel poles with helix anchor or concrete foundations.

8.7 INSTRUMENTATION AND CONTROL

This section describes the instrumentation and control system design criteria.

8.7.1 DESIGN REQUIREMENTS

The instrumentation and control system will be designed in accordance with the industry codes and standards, while complying with Palmdale Water District standards where applicable and available. The facility will be designed with a high level of automation through remote monitoring and control.

Each piece of equipment, such as a pump, motorized valve, etc., will be normally controlled from a central Human Machine Interface (HMI). However, each piece of equipment shall also be provided with local manual control options independent of the PLC. Local manual control will be via hardwired selector switches and pushbuttons at a local control station (LCS) adjacent to the equipment or via remote manual control at an operator interface terminal (OIT) for vendorcontrolled skid equipment. All automatic functions will be provided through the Vendor's PLCs and/or the main facility balance of plant PLC.

Four levels of control will be provided (where appropriate):

- Local Manual Control
- Local Automatic Control
- Remote Manual Control



Remote Automatic Control

Additionally, the following safety features will be included:

Emergency Shutdown: An emergency shutdown button will be located at each Vendor Control Panel (VCP) which will shut down all their respective equipment. The equipment will only become available once the reset has been operated.

Local Safety Interlocks/Emergency Stop Protection: This level of control is not selectable and is always active. It specifically refers to protection logic integral to the equipment or equipment package that is directly interlocked with the equipment controls and which automatically executes regardless of the current method of operation.

Controller Programmed Safety Interlocks: This level of control is not selectable and is always active unless parameter bypass selection is required to be HMI accessible and then invoked by a Supervisor. It specifically refers to protection logic programmed at the PLC with an output that is directly hardwire interlocked with the equipment controls and which automatically executes regardless of the current method of operation. Note: The output will be wired fail-safe such that in the event of controller failure, the equipment will be forced to stop.

8.7.2 SUMMARY OF DESIGN BASIS

8.7.2.1 PROCESS AND INSTRUMENTATION DIAGRAMS AND TAGGING

Stantec standards for Input/Output (I/O) and equipment tagging will be used as we understand that Palmdale does not have a standard to follow. PWD tagging conventions could be employed if available. Process and Instrumentation Diagrams (P&ID's) will be developed in accordance with ISA Standard S5.1 diagram format.

8.7.2.2 PLC HARDWARE REQUIREMENTS

The Industrial Control System (ICS) PLC hardware shall be selected from two manufacturers.

The Balance of Plant equipment and instrumentation that does not fall within the scope of the vendor packages shall utilize Schneider Electric SCADAPack 575 Series, this is the standard PLC for the Palmdale Water District.

For vendor package systems, Rockwell ControlLogix or Compactlogix line of processors with appropriately sized processing and memory capacity shall be utilized. The PLC's will operate under 120 VAC supply power. Discrete I/O modules will be suitable for 24VDC devices and analog modules will be defined as 4-20mA DC. Communications cards will be utilized as required to support fieldbus devices.

8.7.2.3 SCADA SYSTEM & HMI (WORKSTATIONS) REQUIREMENTS

The new control system will be configured to tie into the existing Schneider Electric Geo SCADA.



Two windows based HMI workstations will be provided at the central control room for operators to monitor and control equipment at the facility. Graphic displays will be developed to show each process status, provide control of the equipment and display alarms.

All plant I/O will be displayed on the station HMI control screens. All analog data (as well as alarms and status points) will be historically collected, recorded and trended. All newly developed control screens will be consistent in presentation, quality, color usage, symbol usage, font usage and navigation options with Palmdale's existing system.

8.7.2.4 SECURITY/REMOTE ACCESS REQUIREMENTS

A secure network connection with PWD's SCADA system will be provided with a designated firewall. Remote access will be established using an encrypted VPN connection granted only to certain individuals from the consultant operations support team. Remote access will also be provided to certain vendors to facilitate remote access support and troubleshooting, but only to their respective PLCs and not to systems outside of their limited scope.

8.7.2.5 INSTRUMENT SELECTION

Instrument requirements:

- Field instruments where available will be 24VDC UPS powered from their respective PLC panel.
- Local power disconnects will be located next to each instrument only if the Instrument is supplied by 120 VAC power.
- Remote displays will be installed for inaccessible instruments at a minimum height of 60" above the finished floor level.
- Corrosion resistant wetted material (316 stainless steel or Hastelloy-C) will be utilized in corrosive or chemical environments in accordance with the process compatibly chart.
- Outdoor instruments will be designed with appropriate environmental considerations.

Instrument types to be used:

- Analyzers will be reagent-less type (where practical) and equipped with smart sensors.
- Radar measurement will be the preferred level measurement technology for chemical storage tanks.
- Point level floats will be employed as a backup to radar continuous level measurement.
- Magnetic flow meters will be the preferred flow measurement instrument for chemical lines.



- Analog instruments installed outdoors will include lighting and surge suppressors.
- Magnetic flow meters will be the preferred flow measurement instrument for process water.

8.7.2.6 BACKUP POWER SUPPLIES (UNINTERRUPTABLE POWER SUPPLY)

Each PLC control panel will incorporate a UPS system with external battery module where necessary that will maintain power for a minimum of 30 minutes. A load calculation will be used to size the UPS. Floor mounted UPS units will follow NEC code clearance requirements. An external, manual by-pass switch will be included for maintenance activities. The UPS will be configured to support Ethernet communication as well as hardwired dry contacts monitoring the following statuses:

- UPS On Battery
- UPS Low Battery
- UPS Fault
- UPS Bypass (Maintenance or Fault mode)

8.7.2.7 OPERATOR INTERFACE TERMINAL (OIT)

Generally, each vendor skid with have local monitoring and control of vendor skid equipment provided via a panel mounted electronic OIT. Allen Bradley OIT's will communicate with the local PLC and be configured to display process screens, trends and allow local manipulation of setpoints for the respective process units. OITs will be limited to the vendor control panels (VCP).

The operator display will allow control of local equipment via interface with the process unit PLC. The OIT configuration will include requirements that all command outputs to local equipment and set point adjustments require verification. OITs will be installed 60" from the finished floor.

8.7.2.8 PLC ENCLOSURES

All PLC enclosures will preferentially be in climate controlled, non-hazardous environments with thermostatically controlled fans/heaters (as required) and remote temperature monitoring. Outdoor panels or panels that will be located in corrosive areas indoors will be rated NEMA 4X and will be made of 316 Stainless Steel (SS), whereas as indoor panels that will be located in non-corrosive areas will be rated NEMA 12, and will be made of painted mild steel. Cabinets will be sized to allow for future expansion and facilitate easy maintenance and operation. Free standing enclosures will be installed on a dedicated housekeeping pad. All enclosures will be designed to meet enclosed equipment manufacturer's recommended operating environment. Instrument enclosures will not be used as a pull box or junction box.



8.7.2.9 FIRE ALARM CONTROL PANEL

The plant fire control panel (if applicable) will be integrated with the plant control system only to the extent that area/building alarms will be annunciated and recorded at the plant HMI. Individual smoke and heat detectors will be monitored by the fire alarm system independently.

8.7.2.10 HVAC CONTROL PANEL

The HVAC system will be independently controlled and not integrated into the plant control system.

8.7.2.11 EYEWASHES

Hazardous chemical areas will have eyewash stations with a flow switch for remote alarming at the plant HMI.

9.0 OPERATIONS PLAN

This section describes the preliminary operations plan. The plan will be updated as the design progresses.

9.1 STARTUP AND COMMISSIONING

Once the contractor has achieved substantial completion of the Demonstration Facility, commissioning will take place to ensure that all components of the Demonstration Facility are designed, installed, tested, and operated in conformance with the design and operational requirements of the plans, specifications, and approved submittals. The contractor will prepare a startup and commissioning plan which will outline the sequence of startup and commissioning activities and performance testing.

Consultant staff will assist PWD during the commissioning process to witness loop checks, inspection and calibration of instruments and analyzers, certification of proper mechanical installation, control system testing, and performance testing.

9.2 TRAINING

Consultant staff will develop and deliver a training program to PWD operators and staff. This training will supplement the standard equipment training included by the major equipment suppliers. This consultant-led training program will include both formal classroom and hands-on training specific to the Demonstration Facility. The formal classroom training will occur prior to startup and include a presentation and interactive discussion regarding key process, regulatory, optimization, maintenance, and safety aspects for potable reuse of the MF, RO, UV/AOP, and chemical systems. The hands-on training will occur during startup and initial operations. PWD may record a video of the training sessions to assist with training future staff and providing refresher training for existing staff.



9.3 STAFFING

The Demonstration Facility will be intermittently staffed during business hours (8 hours per day) Monday through Friday by at least one PWD operator, especially during chemical deliveries, MF and RO CIPs, startups, shutdowns, sampling events, and significant adjustments to operating conditions or setpoints. Additional PWD personnel should be available, as needed, to assist with routine and preventative maintenance including instrument calibration along with testing and sampling activities. PWD operators and support personnel will be provided with an office, inclusive of an Operator Workstation to access the Demonstration Facility SCADA system, along with a laboratory for conducting basic water quality analyses and storing samples.

The Demonstration Facility SCADA system will be accessible from a remote workstation, as well, to allow for off-site support by PWD staff during business hours, off-hours, and weekends.

Consultant staff will provide operational and test plan execution support during the first year of operation. Both remote (emails, calls, SCADA access and data logging retrieval) and on-site (hands on) support will be provided by consultant staff for troubleshooting, sampling, data analysis, and optimization.

9.4 TEST PLAN

A testing and monitoring plan (test plan) will be developed during the design phase and finalized prior to startup and commissioning. After completion of startup and commissioning and handover from the contractor to PWD, consultant staff will execute the test plan over a 12-month period with assistance from PWD staff. The purpose of the test plan is to optimize the treatment process for full-scale design and generate necessary data to ensure regulatory compliance and approval with potable reuse regulations to eventually obtain a permit to operate the future full-scale AWT Facility. Consultant staff will collect key data and optimize the Demonstration Facility by assessing source water quality impacts on system performance, operating the Demonstration Facility at multiple operating conditions (MF flux rates, RO recoveries, UV/AOP dose setpoints) to find the best points of efficiency, and comparing multiple high recovery RO technologies side-by-side with respect to operability, reliability, and cost. The test plan will detail the test conditions, sampling locations, sampling frequency, and analytical methods.

10.0 SCHEDULE

Vendors for the treatment system equipment will be chosen in a pre-selection process which occurs before the bidding and construction phase. This allows the vendor drawings to be used in conjunction with the creation of the detail design drawings, leading to a reduction the project schedule of up to three months. This time savings results from the vendor drawings being created during the detail design phase, reducing the additional time that would otherwise be needed after bidding and during construction phase for vendor shop drawing production. Additionally, pre-selection reduces the risk of potential change orders as a result of differing vendor products that after selection would require changes to the facility design if pre-selection had not been used.


Pre-selection will be comprised of a preparation phase to develop specification documents for procurement and help determine which vendors are potential candidates for pre-selection, followed by the selection, award, and negotiation with the selected vendors. This will take place over the course of up to 6 months and has been underway already. Upon completion both vendor drawing production and detailed design will begin. Detailed design will have two submittal milestones at 30% and 100%, each with a two-week client review period and will take up to 9 months. This will then be followed by the bidding and construction phase. After commissioning and initial startup, the testing and operation phase will begin. Testing will take up to 12 months and will be used to support permitting and inform full scale design criteria and equipment selection. Procurement of the design-build contractor for the full-scale advanced treatment facility will likely occur concurrently with the Demonstration Facility completion and testing.

An overall schedule of the Demonstration Facility design, construction, and testing phases is shown below in Figure 14. This schedule is based on information known at this time and estimation of fabrication and lead times of equipment and the PEMB from information by vendors and other recent projects. The lead times for certain equipment and components in the construction market could be much longer than typical due to supply chain shortages. Efforts will be made during the detailed design phase to solicit input from a construction contractor on long lead time items to avoid, and the schedule and design will be updated during design progression to avoid schedule delays if possible, or account for them if necessary.

		2022			20	23			20	24			20	25	
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Early Key Decisions															
Conceptual Design Report															
Pre-selection prep															
Pre-selection bid, award, negotiation															
Vendor drawing production															
Detailed Design - 30%															
Detailed Design - 100%															
Bidding & Construction															
Bidding															
Vendor lead time															
Commissioning and Initial Startup															
Testing & Operation															
	potential extended lead time for some equipment														

Figure 14. Demonstration Facility Schedule

The pre-selection process allows for the total lead time during construction for the unit process equipment to be reduced so that they are not the critical path items. Currently, it is estimated that the Pre-Engineered Metal Building (PEMB) rather than the individual unit processes will be the critical path on the overall schedule. The estimated timetables on the PEMB and unit processes are shown below in Table 37.



Procurement Schedule	Unit	PEMB	Pre-Selected Process Equipment						
			MF	Primary RO	Secondary RO	UVAOP			
Estimated lead time during construction phase	weeks	42-52	22-34	22-34	26-30	26-32			
(shop drawings through delivery)									

Table 37. PEMB and Process Equipment Estimated Lead Times

11.0 COST ESTIMATE

The cost estimate summary for this project is shown below in Table 38 and with greater detail in Appendix E. This is a Class 5 Opinion of Probable Construction Cost estimate per the definition from the Association for the Advancement of Cost Engineering International (AACEI), using planning level parametric estimates based on similar facilities. Vendor quotes were used for major process equipment where available, and prices from similar projects were used in the case that quotes had not yet been received. Additional notes on each of the line items can also be found in Appendix E.

Area/Title	Cost
Equipment	
Process Equipment Subtotal	\$1,894,000
Installation	\$663,000
Electrical and I&C	\$1,500,000
Civil Sitework and Yard Piping	\$550,000
Sales Tax (9.5% on equipment)	\$195,000
Contractor Markups (30%)	\$1,441,000
Equipment and Material Subtotal	\$6,250,000
Building	
Pre-Engineered Metal Building	\$3,750,200
Landscaping and Paving	\$534,000
Building Subtotal	\$4,290,000
Construction Cost Subtotal	\$10,600,000
Construction Cost with Contingency (20%)	\$12,800,000
Engineering & ESDC (13% of Construction Cost + Contingency)	\$1,537,000
CM (6% of Construction Cost + Contingency)	\$768,000
Project Cost ¹	\$15,000,000

Table 38 Class 5 OPCC Estimate for Demonstration Facility

Notes:

1. Does not include escalation or owner costs

12.0 PUBLIC OUTREACH

Recognizing the importance of public acceptance, the design of this Demonstration Facility has been undertaken with public engagement top of mind. The design focuses on the public's experience visiting the demonstration plant, including tours, educational opportunities and creating an inviting space available to the public for district sponsored events.



The design team considered multiple uses for the facility, both during the potable reuse demonstration phase, but also to maximize public engagement for all PWD's outreach activities for years to come. During the design process, multiple layouts were considered, each evaluated for its strength in providing an effective design for future public engagement at the demonstration facility. This section describes the visitor experience at the Demonstration Facility, highlighting the features of the Community Center and treatment areas that will be used to engage the public on PWD's efforts from the PWAV and beyond.

12.1 COMMUNITY CENTER

The Demonstration Facility will be housed in a community center that offers an inviting space for the public. A ground-level 3D view of the Demonstration Facility is provided as Figure 15.



Figure 15. Ground-level 3D View of the Demonstration Facility

The visitor experience begins upon approach to the facility from the vehicle and pedestrian entrance to the site. Clear wayfinding ensures that drivers and pedestrians are aware of turns, crossings, security boundaries, parking area, and the public entrance to the facility. There should also be adequate space for bus drop-off and parking. Once vehicles or buses are parked, the public entrance and path to it should be clear.

A welcoming plaza outside the building entrance should be provided for staging and receiving visiting groups. The space also offers opportunities to initiate the educational program with interpretive signage and demonstration landscaping or water conservation features. The green area may also serve as a meeting point for off-site plant tours. Amenities such as outdoor furniture, bicycle parking, and shading elements can also be provided for visitor and District staff use.



12.1.1 LOBBY

The secure building entrance provides controlled access to an inviting reception lobby (Figure 16). The space should be mostly an open floor area to comfortably accommodate small groups. A full high storefront facing South will provide natural light to the space.

Durable yet attractive finish materials will provide a clean, low-maintenance aesthetic. Two of the walls enclosing the space will be translucent, enhancing the visual quality the space, diffusing daylight from rooftop skylights, and providing an initial view of the demonstration process area. Solid wall surface will allow for the installation of AV monitors, interpretive graphics, and awards plaques. Modular, informal seating can also be provided.



Figure 16. 3D Rendering of the Lobby

12.1.2 COMMUNITY ROOM

Tour participants are first introduced to PWD, PWAV, and the demonstration project in the large community room adjacent to the lobby (Figure 17). The space could also double as a conference/training room for PWD staff use. The room will be sized to accommodate 30 seated people. It will be equipped with movable chairs and AV equipment (TV monitor or projector with computer connection and speakers) for presentations.





Figure 17. 3D Rendering of the Community Room

Tour participants will begin their complimentary tour of the demonstration facility in the community room where they receive a multi-media presentation from PWD on the history of water in the Antelope Valley, historical and present challenges associated with water supplies, and the proposed solution of potable reuse as a reliable, drought-proof water supply. The presentation will be designed with Pure Water AV branded look, incorporate graphics to assist in telling the PWD story and will afford visitors with an opportunity to learn about the stages of advanced water treatment and ask questions before embarking on the guided tour. The presentation should incorporate imagery and video and/or animation to help tell the story of the water purification process.

PWD logo inspired graphics will be created and installed in several locations around the facility to aid in public education. From the outside of the facility, where signage will be developed to identify the facility and be visible from East Avenue Q, to welcome signage, historical photos, timelines and graphics in the lobby as visitors enter and begin to learn about PWD and its history. Additional graphics can be installed in the community room to support the messaging of the multi-media presentation.

Once inside the process area, branded signage will be incorporated at each stage of the purification process to help tour participants identify the stage of the process they are visiting. To complement the tour, a monitor that is showing a live look at the status of each treatment phase should be installed along the tour path and will be another stop in the guided tour where visitors can graphically see the equipment working in real time.



12.1.3 PROCESS SPACE

Three-dimensional renderings of the Process Area are presented as Figure 18 and Figure 19.



Figure 18. 3D Rendering of the Process Area (View 1)

Guided tours will be escorted through the Demonstration equipment space for a true-to-function experience with epoxy-finished flooring and industrial interior finishes. A view into the adjacent office and sample testing lab, will serve as an additional educational opportunity. Clearly delineated directional markings will provide a safe, accessible path for participants of all ages. Along the tour route, interpretive stations with graphics and signage will identify each step of the advanced treatment process.



Figure 19. 3D Rendering of the Process Area (View 2)

12.1.4 TASTING AREA

The demonstration process tour route will conclude at the tasting area (Figure 20), which will include a bar or central island, where the visitor will be able to gather, sample the purified water from the plant, and take photos.





12.1.5 COURTYARD AREA

An outdoor courtyard adjacent to the tasting area will allow tour participants to gather informally to gather prior to departure (Figure 21). The District may also use this space for other gatherings or activities. The courtyard will provide informal seating and will be partially covered by a large shade canopy. It will be enclosed by decorative wood fencing and drought-tolerant landscaping.



Figure 21. 3D Rendering of the Courtyard Area



12.2 TASTING BAR

"Tasting is believing." There is no better way to for the public to appreciate the high-quality of the purified water than for them to taste the water at the conclusion of the process tour. After participants have learned about each step of the treatment process, the culmination of their tour will be an opportunity to sample the water directly from the purification process they just toured.

The tasting bar will be designed to resemble a household sink in a space large enough to accommodate up to 30 tour participants to gather while sampling the water. Here the tour guide will provide participants with a small recyclable cup for them to fill and try the new water. Because the water purification process is so successful and the water tends to heat up during the treatment process, a chiller and a conditioning system should be considered for water being delivered at the tasting station. It is imperative, should those be included, that the tour guide be forthright and share that information with the tour participants.

By utilizing a sink like one they might have in their own homes, an emotional connection can be created to the everyday use of the advanced purified water as a part of their drinking water supply. With today's technology, installing a touchless kitchen faucet should be considered to promote cleanliness.

Adjacent to the purified water tasting station, a large group gathering space has been created near the access point to the patio area. This will provide a location for additional Pure Water AV branded signage and background graphic to serve as a backdrop for tour participant photos. The graphics will include the social media handles for PWD to encourage participants to share their photo and tour experience on their personal social media channels, while tagging PWD.



		MCCA -	480 VAC	Load L	ist							1.1						
	2		Unit	1.0					1.000			N = 2		OPERATIONAL LOAD			D	i
Equipment Tag	Device Description	Connected Load	A,hp kVA,kW	Device Volts	System Volts	Ρh. Φ	PF %	Eff %	Connected FLA	Connected kVA	Connected kW	Connected kVAR	Operate Y/N	Load Factor %	Operate Amps	Operate kVA	Operate kW	Operate kVAR
TBD	MF - FEED PUMP NO.1	10.00	HP	480	480	3	90	90		9	8	4	Y	100%	11.08	9	8	4
TBD	MF - FEED PUMP NO.2	10.00	HP	480	480	3	90	90	11	9	8	4	Y	100%	11.08	9	8	4
TBD	MF - BACK WASH PUMP NO.1	20.00	HP	480	480	3	90	90	22	18	17	8	Y	100%	22.16	18	17	8
TBD	MF - BACK WASH PUMP NO.2	20.00	HP	480	480	3	90	90	22	18	17	8	Y	100%	22.16	18	17	8
TBD	RO - FEED PUMP NO.1	10.00	HP	480	480	3	90	90	- 11	9	8	4	Y	100%	11.08	9	8	4
TBD	RO - BOOSTER PUMP NO.1	40.00	HP	480	480	3	90	90	44	37	33	16	Y	95%	42.10	35	31	15
TBD	SOR - CIRCULATION PUMP NO.1	5.00	HP	480	480	3	90	90	6	5	4	2	Y	95%	5.26	4	4	2
TBD	SOR - CIRCULATION PUMP NO.2	5.00	HP	480	480	3	90	90	6	5	4	2	Y	95%	5.26	4	4	2
TBD	SRO - BOOSTER PUMP NO.1	15.00	HP	480	480	3	90	90	17	14	12	6	Y	95%	15.79	13	12	6
TBD	SRO - BOOSTER PUMP NO.2	15.00	HP	480	480	3	90	90	17	14	12	6	Y	95%	15.79	13	12	6
TBD	SRO - CIP FLUSH PUMP NO.1	2.00	HP	480	480	3	90	90	2	2	2	1	Y	95%	2.10	2	2	1
TBD	SRO - CIP FLUSH PUMP NO.2	2.00	HP	480	480	3	90	90	2	2	2	1	Y	95%	2.10	2	2	1
TBD	SRO - FEED PUMP NO.1	2.00	HP	480	480	3	90	90	2	2	2	1	Y	95%	2.10	2	2	1
TBD	SRO - FEED PUMP NO.2	2.00	HP	480	480	3	90	90	2	2	2	1	Y	95%	2.10	2	2	1
TBD	RO - THIRD STAGE BOOSTER PUMP NO.1	1.00	HP	480	480	3	90	90	1	1	1	0	Y	95%	1.05	1 -	- ï	0
TBD	MF - CIP PUMP NO.1	5.00	HP	480	480	3	90	90	6	5	4	2	Y	95%	5.26	4	4	2
TBD	MF - AIR COMPRESSOR NO.1	1.00	HP	480	480	3	90	90	1	1	1	0	Y	100%	1.11	1	1	0
TBD	MF - AIR COMPRESSOR NO.2	1.00	HP	480	480	3	90	90	1	1	1	0	Ý	100%	1.11	1	1	0
TBD	MF - TANK MIXER NO.1	1.00	HP	480	480	3	90	90	Ĩ.	1	1	0	Y	100%	1.11	1	1	0
TBD	RO - CIP HEATER BKR	80.00	A	480	480	3	90	90	80	67	60	29	Y	80%	64.00	53	48	23
TBD	DISTRIBUTION TRANSFORMER	45.00	KVA	480	480	3	90	90	54	45	41	20	Y	80%	43.30	36	32	16
					400.144													
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														PEcorrec	ted		0.90	
														XEMP Fut	ure Facto	r	20	7
													1.	A MARTON	one rue iu		20	- 10

APPENDIX A—ELECTRICAL LOAD CALCULATIONS



APPENDIX B—ONE LINE POWER DIAGRAM





APPENDIX C-LAYOUT OF ELECTRICAL ROOM





APPENDIX D—ELEVATION VIEW OF THE MCC

_	1	2	3	4	5	6	7	8	9	10				
MF - F	EED PUMP	MF - FEED PUMP	RO - FEED PUMP	RO - CIP FLUSH PUMP	SOR - CIRCULATION PUMP NO.1 5HP-VED	CIP HEATER NO.1 2HP-VFD	SRO - FEED PUMP NO.2 2HP-VFD	MF - AIR COPMPRESSOR NO. 1 HIP-FVNR MF - AIR COMMRESSOR NO. 2 HIP-FVNR MF - CIP TANK MIXER NO. 1 HIP-FVNR	SPACE	SPAC				
10	HP-VFD	10HP-VFD	10HP-VFD	NO.1 10HP-VFD				MF - CIP TANK HEATER BREAKER 50A						
	10 M (1				SOR - CIRCULATION	MF - CIP HEATER	RO - CIP HEATER 100A BREAKER	DISTRIBUTION XFMR 100A BREAKER	SPACE	SPAC				
									PUMP NO.2 5HP-VFD	2HP-VFD	RO - THIRD STAGE BOOSTER PUMP	SPACE	SPACE	SPAC
MF - B PU	- BACK WASH PUMP NO.1	MF - BACK WASH PUMP NO.2	RO - FEED	SRO -FEED BOOSTER PUMP NO.1 15HP-VFD	SRO - FEED BOOSTER PUMP NO.2 15HP-VFD	SRO - FEED PUMP	NO.1 2HP-VFD	SPACE	SPACE	SPACE				
20	HP-VFD	20HP-VFD	BOOSTER PUMP NO.1 40HP-VFD			NO.1 2HP-VFD								
						-	- NO.1 5HP-VED			SPACE				
	0.00			SRO - CIP FLUSH PUMP NO. 1		SPACE		SPACE	SPACE					
5	SPACE	SPACE		2HP-FVNK SRO - CIP FLUSH PUMP NO. 2 2HP-FVNR			SPACE							
-														
- :	20.0 -	- 20.0 -	- 20.0 -	- 20.0 -	- 20.0 -	- 20.0 -	- 20.0 -	- 20.0 -	- 20.0 -	- 20				



APPENDIX E—DEMO FACILITY CONSTRUCTION COST ESTIMATE

Parameter	Cost	Notes
Equipment		
MF System	\$ 550,000	estimated, based on other projects/similar quotes, & recent information fro
Primary RO System	\$ 450,000	estimated, based on other projects/similar quotes
Secondary RO Systems*	\$ 328,000	estimate, based on quotes for purchase
UV System	\$ 226,000	average of 2 quotes from Trojan & Xylem
Break Tanks, Transfer Pumps	\$ 105,000	20k per 4,000 gal break tank, 25k for transfer pumps
Chemical Feed Systems	\$ 210,000	30k per chemical feed system (drum/totes, 2 metering pumps each system
Calicite Contactor and Tasting Station	\$ 25,000	
Equipment Subtotal	\$ 1,894,000	
Yard Piping	\$ 200,000	based on utilities, plant influent, drain
Sitework	\$ 350,000	site removals and preparation
Installation (35% of Equipment Subtotal)	\$ 663,000	percentage of equipment as shown
Electrical and I&C, allowance	\$ 1,500,000	~15% of total construction, lower than typical due to large building cost an
Equipment and Material Subtotal	\$ 4,607,000	
Sales Tax (10.25% of Equipment Subtotal)	\$ 195,000	
Contractor Markup & Overheads (30% of Material and Equipment Subtotal + Sales Tax)	\$ 1,441,000	
Equipment and Material Total	\$ 6,250,000	
Building		
Landscaping	\$ 59,000	\$5/sf
Parking/Driveways	\$ 475,000	\$10/sf
Pre-engineered Metal Building (5,490 sf indoor, 1,309 sf canopy)	\$ 3,371,000	based on \$500/sf for indoor area, \$200/sf for canopy areas
Furnishings (Community Room, Office, Lab, Tour Displays)	\$ 50,000	
HVAC - Air Conditioning	\$ 289,200	5784 sf at \$50/sf for A/C
Exterior lighting and signage	\$ 40,000	
Building Total	\$ 4,290,000	
Construction SubTotal Cost*	\$ 10,600,000	
*Class 5 Opinion of Probably Construction Cost (-20%, +35%), low range	\$ 8,500,000	
*Class 5 Opinion of Probably Construction Cost (-20%, +35%), high range	\$ 14,400,000	
Construction Cost Contingency (20% of Construction Cost)	\$ 2,120,000	
Construction Cost	\$ 12,800,000	
Engineering & ESDC (13% of Construction Cost + Contingency)	\$ 1,537,000	Stantec Team Fees
CM (6% of Construction Cost + Contingency)	\$ 768,000	full CM including oversight, inspection
Engineering, ESDC, CM Subtotal	\$ 2,305,000	
Capital Cost	\$ 15,000,000	
Escalation	\$ -	
Owner Implementation Cost	\$ -	
Total Project Cost*	\$ 15,000,000	





APPENDIX A.10 Public Outreach Plan TM

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Public Outreach – Pure Water Antelope Valley Technical Memorandum

May 2023

Prepared for: Palmdale Water District

Prepared by: Stantec Team

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Introduction and Background May 2023

1.0 Introduction and Background

Stantec Consulting Services Inc. was retained by the Palmdale Water District (PWD) to provide Program Management services for its regional water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV). The objective of Pure Water AV is to augment groundwater supplies with advanced treated wastewater via direct subsurface injection.

Pure Water AV proposes to use recycled water to either supplement surface water supplies or groundwater supplies. PWD is evaluating the preferred approach for potable reuse through technical studies, engineering reviews, water treatment processes, and modeling. Phase 1 of Pure Water AV would use 5,325 acre-feet per year—with options for expansion in future phases—of recycled water from the Palmdale Water Reclamation Plant. The recycled water would undergo further advanced purification processes to meet regulatory requirements before being added to Lake Palmdale or injected into the local aquifer.

For surface water augmentation, recycled water would be processed through an advanced purification system and piped to Palmdale Lake to blend with the existing local water supply that currently provides drinking water to customers. Water from Palmdale Lake undergoes drinking water treatment at the Leslie O. Carter Water Treatment Plant.

Pure Water AV is also evaluating replenishing the local groundwater basin with advanced purified water. To do so, advanced purified water would be piped to injection wells, where the purified water would be injected into the groundwater aquifer, travel through the aquifer, and then pumped out of the aquifer by PWD's wells.

As part of Pure Water AV, PWD is designing and plans to construct an advanced purified water demonstration facility. The 200 gallons per minute Pure Water AV Demonstration Facility will generate the information needed for the future construction of a full-scale water purification facility. The demonstration facility also provides an opportunity to raise awareness among PWD's customers and stakeholders about the safety and reliability of this potential new local water supply for Antelope Valley. PWD will work to inform community leaders, customers, stakeholders, and others about Pure Water AV. Pure Water AV's community outreach will be diverse, equitable, and inclusive. In addition to identifying outreach strategies for various audiences that will guide the outreach program, this plan also includes measurable objectives to document the public outreach activities conducted.

This is an audience-driven plan, meaning that the outreach activities outlined are tailored to the various audiences that need to be informed about the Pure Water AV. The Public Outreach Plan is also a "living" document that should be reviewed and revised on an annual basis. The Public Outreach Plan and its associated information tools should be revised once PWD completes further research (i.e., additional one-on-one meetings with key stakeholders, quantitative surveys, and focus groups) and as Pure Water AV progresses through phases (e.g., the environmental review process).

Public Outreach Challenges May 2023

2.0 Public Outreach Challenges

Developing and acknowledging situational and communication challenges early will help the Pure Water AV team identify and develop strategies to successfully address these challenges. For example, water recycling agencies across the nation often face negative public opinion about potable reuse projects. The fact that the product water was once municipal wastewater continues to generate a "yuck" factor among certain audiences. Below are several key challenges to informing the public and raising awareness about potable reuse at the Pure Water AV Demonstration Facility.

2.1 Water Quality Concerns

In recent years, the issue of pharmaceuticals present in wastewater has been a drinking water quality concern raised in the media and other forums. Previous recycled water educational campaigns have addressed how the advanced treatment process effectively eliminates these contaminants in advanced treated recycled water. However, emotional fears about the effects pharmaceuticals in drinking water could have on human health cannot always be effectively addressed with technical facts.

2.2 Lack of Trust in Public Water Systems

Concerns about the quality of the public drinking water supply can be highly prevalent in some communities, particularly for areas that have experienced systemic challenges with water service or where reports of poor water quality have gone unaddressed. Literature suggests that mistrust can stem from household characteristics like income, racial and ethnic minority status, foreign-born nativity, and influence from high-profile cases like Flint, Michigan. People with an existing lack of trust in the government and its ability to provide safe drinking water may strongly reject any changes that they perceive compromises water quality. Others may believe this as an "experimental" project directed at a specific group and raise concerns from that perspective. Concerns about water supply safety may be further exacerbated by instances of taste, odor, and color issues in local water supplies.

University of California, Los Angeles' work on trust and drinking water quality and Pierce and Gonzalez's paper on mistrust at the tap may be helpful references.

2.3 Technical Information

The potable reuse process involves many treatment steps described in technical terms. In some cases, lay terms cannot be used as replacements for technical terms. Audiences may have to learn a new vocabulary and quickly assimilate new information from simple to complex in a short amount of time during presentations or meetings.

Public Outreach Challenges May 2023

2.4 Diverse Population Groups

The customers of PWD are part of different and diverse ethnic and linguistic groups. The larger groups have their own communication networks, publications, and community leaders. In addition, key publications and avenues of communication may not use English as their primary language to communicate with their audiences.

2.5 Information Available on New Media

While new media and social media outlets offer a way to reach a different demographic and expand project visibility, online sites such as Twitter and Facebook can be vehicles for misinformation about Pure Water AV. Networks of followers and fans can increase negative publicity or opinions about Pure Water AV with astounding speed and volume. Social media is often opinionated. As such, there are no checks and balances or accountability to provide accurate data, facts or claims in social media. This disconnect can put agencies at a significant disadvantage. Time is needed to monitor these sites and having a rapid response plan to address misinformation is critical.

2.6 Lack of Clarity about Project Opposition

Currently, it is not clear whether there are project opponents in the communities that will receive the water or be impacted by project construction. Who will attend board meetings and speak out against Pure Water AV? Are opponents against specific pipeline alignments or the idea of potable reuse? What communities will organize opposition once they learn more about Pure Water AV? How can outreach activities facilitate a response to community opposition, provide information to help parties understand Pure Water AV, and incorporate feedback? These are a few of the unknowns that need to be determined.

As the outreach program progresses and knowledge about stakeholders and community sentiment regarding Pure Water AV becomes better understood, message development and tactics will be developed to help assuage public concerns.

2.7 Water Affordability

Upward pressure on water rates is challenging for many ratepayers. There are many factors that might be the cause for increasing water rates. Understanding these factors and incorporating information about the value of the Pure Water AV project as a strategic investment in water supply reliability to support the region's economy and quality of life can help to address these concerns.

Public Outreach Opportunities May 2023

3.0 Public Outreach Opportunities

In addition to situational and communication challenges that need to be addressed, there are currently opportunities to aid in building understanding of Pure Water AV, momentum, visibility, and support. Public outreach activities can capitalize on these. Below are several key opportunities that can contribute to the success of Pure Water AV.

3.1 General Opportunities

3.1.1 INCREASED ENVIRONMENTAL AWARENESS AND SUPPORT

The environmental protection or "green" movement is strong in California. Popular slogans such as "Reduce – Reuse – Recycle" are also appropriate to increase regional uses of recycled water. Communication about the Pure Water AV Demonstration Facility can emphasize certain environmental benefits such as the ability to use recycled water daily and not just seasonally and the reuse of a scarce natural resource.

3.1.2 SUCCESSFUL CALIFORNIA PROJECTS

There are numerous potable reuse projects in various stages throughout California. Leading examples of successful projects include the Groundwater Replenishment System, operated by the Orange County Water District and West Basin's Edward C. Little Water Recycling Facility, which produces five different qualities of custom-made recycled water that meet the unique needs of West Basin's municipal, commercial, and industrial customers, including indirect potable reuse via groundwater recharge. Both facilities use an advanced water treatment process to purify recycled water similar to the one recommended for the Pure Water AV Demonstration Facility. These projects, and others like them in California, afford examples of much of the proven technology proposed for Pure Water AV at publicly owned and operated advanced water treatment facilities. These facilities have proven track records of demonstrating treatment process safety and water quality success. An outreach team can refer to public and regulatory acceptance for the Orange County and West Basin projects as examples of successful potable reuse projects. As other projects move forward, it will be important to share their successes as well.

3.1.3 HEIGHTENED AWARENESS OF LIMITED WATER SUPPLIES

Recent droughts have received a great deal of media attention. Even if rainfall levels go back to "normal" in a given year, climate change impacts and regulatory restrictions and allocations limiting imported water supplies will create ongoing challenges to meet water demands. Outreach activities can capitalize on the public's knowledge of the drought and a lack of sustainable water supplies by showing how Pure Water AV will help meet this need with locally produced, locally controlled water that is available year-round.

Public Outreach Opportunities May 2023

3.1.4 GRASSROOTS OUTREACH

With PWD possessing real, on-the-ground understanding of the communities and the people who will be impacted by Pure Water AV, the team can approach outreach on a more local level and work directly within those communities to implement outreach strategies, tactics, and tools in a tailored, innovative way that connects with a specific community.

3.1.5 VIRTUAL ENGAGEMENT

Preparing for and implementing virtual tours and presentations for stakeholders is an important tool to broaden the reach of the message. There is also an opportunity to expand the outreach program engagement through development of additional videos, teacher toolkits, youth materials, and interactive website tools that can serve virtual audiences. However, virtual formats will not reach all audiences. Older community members, people with varying abilities, or people without access to technology should continue to be reached in other ways.

3.1.6 USING COMMUNITY LEADER RELATIONSHIPS FOR COMMUNITY COLLABORATION

PWD is poised to use already established relationships with key project stakeholders. The next step is continuing to collaborate with these stakeholders to connect to communities. This could include enlisting their help in holding community workshops, meetings, virtual forums, etc.

3.2 Pure Water Antelope Valley Advanced Purification Demonstration Facility—Specific Opportunities

There are numerous ways that PWD, through the Pure Water AV Demonstration Facility, can provide opportunities for education, information dissemination, and raising awareness about advanced water purification.

3.2.1 GENERAL PUBLIC EDUCATION

One of the goals of the demonstration facility is to provide an opportunity for the residents of PWD's service area and the surrounding areas to visit and see firsthand the technology developed to produce advanced purified water. The facility will allow groups to learn about PWD, the challenges associated with water supply, and new technologies and processes that will enhance the region's ability to produce local water.

Reports and papers discussing project results may be made available on Pure Water AV's website for viewing and downloading. In addition, PWD may share availability of these reports through tools such as e-blasts and social media posts.

Public Outreach Opportunities May 2023

3.2.2 THE WATER AMBASSADOR PROGRAM COMMUNITY ROOM

PWD has already established the Water Ambassador Academy and the Junior Water Ambassadors Academy that provides participants an opportunity to learn more about the services, activities, and planning conducted by PWD. The demonstration facility will include a community room that can serve as the future home of the academies, thereby highlighting the advanced water purification process and value to the region's sustainable and resilient water supplies while providing comprehensive curriculum about PWD.

3.2.3 HOSTING WATER USE, BUSINESS, AND ENVIRONMENTAL GROUPS AND OTHER INDUSTRY MEETINGS AT THE FACILITY

Working directly with regional organizations such as chambers of commerce, environmental groups, or other industry groups in the region, PWD can host one of the organization's meetings at the Pure Water AV Demonstration Facility. Providing a brief presentation and facility tour to these groups will be a useful way to expand the reach of information about the potential for potable reuse.

3.2.4 HOSTING EDUCATIONAL TRAINING/CLASSES AT THE FACILITY

PWD can host the organization's educational trainings at the Pure Water AV Demonstration Facility for regional organizations such as the California–Nevada American Water Works Association, California Water Environment Association, and Antelope Valley Community College. Providing classroom training and hands-on training to these groups will help supplement the education of future water employees.

3.2.5 ONE-ON-ONE MEETINGS

It is recommended that one-on-one meetings be conducted with representative stakeholders and key community leaders. These meetings with regional and community leaders will provide information about how to communicate about potable reuse and help build support among leaders for potable reuse projects, including the Pure Water AV Demonstration Facility.

Key Messages May 2023

4.0 Key Messages

Although the public outreach program will provide detailed information on topics of interest to audiences and stakeholders, informational materials should emphasize a few messages with underlying themes. The key messages below help to focus communication efforts and frame the conversation around Pure Water AV. They may be refined in the future based on feedback and information gathered through community engagement and tour surveys.

4.1 Key Message #1 and Supporting Themes

- 1. The Palmdale Water District has embarked on Pure Water Antelope Valley which will use advanced technology to purify wastewater that has already been cleaned extensively to help meet the District's water needs.
 - Wastewater that is currently cleaned at the Palmdale Water Reclamation plant would be purified to produce a safe, new local water supply to either replenish Antelope Valley's groundwater basin or conveyed to Lake Palmdale. Either process will result in a new water supply.
 - Pure Water AV would help meet the needs of the region's growing economy and population at a
 cost comparable to other local water resources. A thorough evaluation will be completed prior to
 any full-scale implementation to show that the true costs of Pure Water AV compare favorably to
 other regional water sources.
 - At full-scale, the water purification plant could produce up to 3.84 million gallons of purified water daily, enough to serve more than 12,500 homes.

4.2 Key Message #2 and Supporting Themes

- 2. The purified water would be a local, reliable, drought proof, and long-term source that would help provide water reliability for the region.
 - For more than 100 years, PWD has provided safe, high-quality water to its customers.
 - PWD is committed to working to develop a new local source of water to add to existing water supplies and create a new long-term, drought proof, and reliable supply.
 - Water is too precious to use just once. Pure Water AV could cost-effectively recycle treated wastewater and create a new drought-resilient water supply.

4.3 Key Message #3 and Supporting Themes

3. Once operational, Palmdale Water District will be conducting testing at its 200 gallon per minute Pure Water Antelope Valley Demonstration Facility in 2024, which will provide data for regulatory approval of a full-scale water purification plant and program.

Key Messages May 2023

- PWD is committed to conducting necessary research and regulatory testing to evaluate purification processes and associated design parameters, operational criteria, and costs.
- The technologies used at the Pure Water AV Demonstration Facility, including microfiltration, reverse osmosis, ultraviolet, and advanced oxidation for disinfection, have been used in California and across the globe for decades to purify water that is then safely used to replenish groundwater basins or augment local water reservoirs.
- Scientists and engineers will continuously monitor and test the water produced at the Pure Water AV Demonstration Facility to see that it meets the highest water quality standards.

Getting Ready: Informational Materials May 2023

5.0 Getting Ready: Informational Materials

Before launching the Pure Water AV outreach program, PWD should develop a variety of general and tailored informational materials that will be distributed to visitors and used for presentations at regional organization meetings or with groups of stakeholders or elected officials. These materials should clearly communicate the need, history, safety, value, and other relevant information points regarding recycled water and potable reuse. Materials and presentations should be translated as needed. An important part of the development process is providing materials (except those specifically developed for technical audiences) that are easily understandable to the layperson, frequently asked questions documents (FAQs) that are comprehensive, and graphics or infographics that accurately and simply convey technical information. It is also important to post all materials on the Pure Water AV website with links from other PWD website pages.

Construction of the Pure Water AV Demonstration Facility is expected to be completed in 2024. Tour guide manuals, tour presentations suitable for the range of groups that will visit the facility (i.e., from elementary students to engineering classes to groups of dignitaries) can be developed after launching the general outreach program. These materials should be completed in advance of the opening of the demonstration facility. During construction, the outreach team should identify tour guides and speakers bureau presenters and provide an opportunity for these individuals to practice guiding a tour, making a presentation, and responding to questions about Pure Water AV. Following are the key materials that should be developed to support the outreach program.

5.1 Website

The Pure Water AV website should be geared to a general audience, use layperson's language, be accessible to all users, and include simple graphics depicting the treatment processes. It should be interactive so users can learn about the water cycle and how Pure Water AV will be part of the long-term solution to water supply. All public-facing documents should be hosted on the website along with a timeline of events.

5.2 General Fact Sheet

This document should be geared to a general audience, use layperson's language, and include simple graphics depicting the treatment processes. The fact sheet should be distributed at community events, speaking engagements, and posted on the website. Once the Pure Water AV Demonstration Facility is constructed, information about how to register for a tour and directions to the facility should be included.

5.3 Pure Water Antelope Valley Demonstration Facility Brochure

Develop a tour brochure that includes an overview of Pure Water AV, a schematic of the facility, icons and photographs of the equipment, and an explanation of each of the treatment barriers involved in the purification process. The brochure should be geared to a general audience and use layperson's language.

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5.4 Outreach at the Demonstration Facility

Provide space at the Pure Water AV Demonstration Facility to conduct outreach through tours, presentations, exhibits, and informational materials. Include project materials and exhibits describing the treatment process and how this new water supply fits into the PWD's water resources. Include key messages, outreach activities, and media coverage.

5.5 Virtual Tour and Online Video Footage

Create a virtual tour that provides an online look at the Pure Water AV Demonstration Facility and host it on the Pure Water AV website. Include footage of the equipment and explanations of each treatment barrier in the process. Also post video footage of interviews with Pure Water AV stakeholders. Excerpts could be used as background footage for television coverage as needed. For additional exposure, the virtual tour could be posted on YouTube and promoted through PWD-owned social media channels. A short version of the tour should also be created to share on social media.

5.6 Tour and Speakers Bureau Presentation

Create, and update as needed, a Microsoft PowerPoint presentation about the Pure Water AV and the demonstration facility. Monitor the content and update the presentation with new information as it becomes available. The presentation can be used at speakers bureau activities and other outreach events. Incorporate key messages throughout. Develop long and short versions of presentations to accommodate varying timeframes available for presenters. Include animations and/or interactive elements.

5.7 Tour Guide Script and Talking Points

Develop a script for the tour guides. Conduct training so guides are familiar with the content, know what key messages to make at each location along the tour route, and are prepared for questions asked by participants. Provide additional talking points relevant to the problems that the Pure Water AV Demonstration Facility is addressing and the solutions that it provides.

5.8 Frequently Asked Questions Document

Develop FAQs for use in two documents: an internal and detailed FAQ for use by speakers and other Pure Water AV staff so they are well-versed in responding to questions consistently and a public-friendly document that can be posted on the Pure Water AV website and distributed at speaking engagements and events.

5.9 Quick Facts Card

Create a pocket-size card that provides quick facts about Pure Water AV. This is an opportunity to highlight key messages and benefits in a succinct format. It should also contain contact information and

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the website URL. The card will be for use by Pure Water AV team members and member agency staff and will be particularly useful to them during construction activities.

Audiences (Listed in Alphabetical Order) May 2023

6.0 Audiences (Listed in Alphabetical Order)

This targeted audience approach is aimed at active, involved leaders and groups in the region and various communities. It is based on the theory that these people share information with those around them and within their spheres of influence. It also assumes that those who are not active in the community ask those who are active for information before taking a position on an issue.

- 6.1 Ratepayers
- 6.2 Department of Defense Air Force (Plant 42)
- 6.3 Defense Contractors (Lockheed Martin, Boeing, Northrup-Grumman)
- 6.4 Local Public Agencies (City of Palmdale, City of Lancaster, LACSD, Los Angeles County, Littlerock Creek Irrigation District, Antelope Valley East Kern Water Authority)
- 6.5 Elected Officials at Federal Government
- 6.6 Regulatory Agencies and Officials

6.7 Academic/Education

Leaders in the local academic arena can hold a position of influence are often sought after for advice and counsel. Additionally, parent groups and parent teacher associations should be considered important stakeholder groups at the local level offering an excellent opportunity for collaboration with PWD.

6.7.1 STRATEGIES

- Develop informational materials to clearly communicate the need, history, safety, value, and other relevant information regarding recycled water and potable reuse projects.
- Provide links to potable reuse research materials.
- Work with board members and other PWD staff to engage collegiate and other educational program staff and find appropriate ways to deliver Pure Water AV information that is informative and student friendly.
- Create and encourage an environment of open dialogue.
- Provide tour opportunities.

Audiences (Listed in Alphabetical Order) May 2023

• Seek support letters.

6.7.2 SUGGESTED COMMUNICATION METHODS

- Meetings with local community college instructors or high school instructors to foster partnerships.
- Fact sheets, white papers, and other informational materials including relevant research reports.
- Periodic email updates.
- Facility tours, particularly for nursing schools and other healthcare, engineering, or environmental classes.
- Classroom partnership programs with communications, health care, and engineering instructors.

6.8 Business Organizations/Labor Groups

Many communities have organizations that advocate for economic stimulation and business growth. They are often concerned with issues such as job growth, retention of businesses or industries, and real estate values. These organizations include chambers of commerce, economic development corporations, development and planning organizations, and labor unions. Leaders within organizations should include board officers, chief executive officers, presidents, and other high-level managers. In addition, these groups may have committees and subcommittees (e.g., water, energy, infrastructure, planning, public policy) that would be interested in learning more about potable reuse or touring the Pure Water AV Demonstration Facility or who may take positions of support on projects that improve water sustainability or resilience.

6.8.1 STRATEGIES

- Keep businesses and labor groups well-informed about the purpose and need for and benefits to the community of potable reuse projects.
- Participate in sponsored events and create partner events to highlight PWD's strategies and projects to provide water sustainability and local water resource enhancement.

6.8.2 SUGGESTED COMMUNICATION TACTICS

- Speakers bureau presentations.
- Small group and roundtable discussions.
- Event participation and exhibits.
- Template articles about water supply reliability and the role played by recycled water and potable reuse placed in the communication channels of these organizations.

Audiences (Listed in Alphabetical Order) May 2023

- Periodic email updates.
- Facility tours.
- Support letters or resolutions.

6.9 California Environmental Quality Act

According to the requirements of California Environmental Quality Act (CEQA), PWD must reach out to the following stakeholders during the environmental planning process:

- Responsible Agencies, including all cities and counties that are along the pipeline alignments and/or in whose jurisdictions the facilities, such as the full-scale plant, are located.
- Trustee agencies.
- Any city or county that borders on a city or county within which Pure Water AV is located.
- Any public agency that has jurisdiction by law with respect to Pure Water AV.
- Any organization or individual who has indicated interest in participating in Pure Water AV.

6.9.1 STRATEGIES

- Engage stakeholders in the scoping process through meetings to understand their environmental concerns and help address those concerns in the environmental planning process.
- Obtain written and verbal documentation of support.
- Keep the stakeholders well-informed of progress in the environmental planning process and identify opportunities for them to get involved.

6.9.2 SUGGESTED COMMUNICATION TACTICS

- Mailings.
- Periodic email updates.
- Large meetings or workshops, such as open houses.
- Speakers bureau presentations.
- Ads, announcements, and articles in the stakeholders' communication tools such as their newsletters, social media, and websites.
- Pure Water AV website.
- Facility tours.

Audiences (Listed in Alphabetical Order) May 2023

6.10 Civic Groups

Community leaders are often highly involved with organizations that are concerned with the growth, planning, and leadership of their communities. These organizations include, but are not limited to, Kiwanis or Lions clubs, Rotary and other similar groups, neighborhood planning associations, homeowner associations, etc.

6.10.1 STRATEGIES

- Facilitate two-way communication to raise awareness about potable reuse, groundwater replenishment, and reservoir augmentation among civic groups and their membership.
- Provide opportunities for community leaders and other group members to see the technology behind potable reuse, including providing transportation to and from the Pure Water AV Demonstration Facility for those groups that request assistance for their members.
- Participate in local events and create partner events to provide information about the benefits of Pure Water AV.

6.10.2 SUGGESTED COMMUNICATION TACTICS

- Speakers bureau presentations.
- Small group and round table discussions.
- Event participation and exhibits.
- Periodic email updates.
- Template articles.
- Facility tours.
- Support letters.

6.11 Environmental Organizations

Organizations that concentrate on regional environmental issues and impacts should be considered highlevel stakeholders in a potable reuse implementation program. Support from environmental advocates is important to the success of a potable reuse project and strong opposition from this group could make a significant negative impact on public perception.

6.11.1 STRATEGIES

• Increase awareness among environmental organizations about PWD's plans for meeting future water supply challenges by increasing the amount of local water available in Antelope Valley.

Audiences (Listed in Alphabetical Order) May 2023

- Create a two-way dialogue to share information and updates about Pure Water AV and learn about potential concerns.
- Provide opportunities to see the technology behind potable reuse such as providing tours to the Pure Water AV Demonstration Facility or inviting environmental organizations to hold their meetings in the community room.

6.11.2 SUGGESTED COMMUNICATION TACTICS

- Speakers bureau presentations.
- Letters of support.
- Template potable reuse articles.
- Frequent email updates.
- Template articles.
- Facility tours.
- Participation in environmental groups' events.

6.12 Industry Experts

Industry experts can be important groups of community leaders whose support is vital to the success of a potable reuse project. This group consists of water industry experts (e.g., American Water Works Association, WateReuse California, and other regional water agencies). If a significant number of water industry experts express their support for the concept of potable reuse, or Pure Water AV specifically, it will positively impact perception among the public.

6.12.1 STRATEGIES

- Increase industry awareness of Pure Water AV through individual communications and participation at regional and statewide events.
- Present at conferences and other industry meetings.

6.12.2 SUGGESTED COMMUNICATION TACTICS

- Letters of support.
- Template articles about local and regional water supply reliability and the role played by recycled water and potable reuse.
- Frequent email updates.
- Conference participation.

Audiences (Listed in Alphabetical Order) May 2023

6.13 Internal Stakeholders

All communication efforts need to begin internally with staff and board members of PWD. In addition to seeing that staff understand the purpose and need for Pure Water AV, providing opportunities to ask questions, addressing any concerns they may have, and disseminating project information, it is important to have mechanisms to work with PWD Board members who will have contact with stakeholders in key audiences and can help arrange meetings or tours.

6.13.1 STRATEGIES

- Provide all staff with access to the most up-to-date Pure Water AV information and give them opportunities to ask questions and relay the questions they receive from others.
- Coordinate with PWD Board members to equip them with tools they can use to facilitate stakeholder interactions and to track efforts in an outreach database.

6.13.2 SUGGESTED COMMUNICATION TACTICS

- Employee briefing updates through existing communication methods such as employee enewsletters, new employee orientation, etc.
- Staff and field office briefings.
- Tours of the Pure Water AV Demonstration Facility for PWD staff.
- Conduct speakers training for any employees who communicate with stakeholders and the public.
- Internal poster displayed in common areas.
- Regular reporting to the PWD Board about outreach progress, new informational materials, and opportunities for engagement at the board level.
- Materials binders for PWD Board members.

6.14 Media

Reporters, editors, and publishers of print, online, radio, and television media should be considered a toptier level stakeholder as they have an effective platform for influencing public opinion. When they are wellinformed about the potable reuse process and the Pure Water AV approach and water supply reliability goal, they are more likely to write and publish accurate articles or editorials about Pure Water AV and its potential to enhance local water supply reliability. These communication leaders should be updated frequently with both top-level and detailed reports to provide accuracy of the information disseminated. It is important to be mindful of multi-language and ethnic media outlets and to communicate accordingly and equally to all platforms.

Audiences (Listed in Alphabetical Order) May 2023

6.14.1 STRATEGIES

- Cultivate working relationships with regional media representatives, bloggers, and specialty reporters to facilitate accurate media coverage.
- Provide stimulating and newsworthy content about Pure Water AV and the demonstration facility.
- Have a rapid response protocol (see Section 7) in place to directly address and respond to misinformation about Pure Water AV that has been expressed publicly via social media, public displays, high-profile activities, or through communication to stakeholders.
- Establish a social media presence for Pure Water AV and contribute engaging content.

6.14.2 SUGGESTED COMMUNICATION TACTICS

- One-on-one briefings for reporters who cover water issues for the Los Angeles Times, Daily News of Los Angeles, Antelope Valley Press, Palmdale Journal and The Antelope Valley Times.
- Media kits that include a variety of informational materials, articles about Pure Water AV, and articles about other potable reuse projects.
- Editorial briefings.
- Facility tours.
- Press releases and media advisories.
- Frequent email updates.
- Updates via social media (many media representatives prefer using Twitter for news tips and stories), including a newsroom on social media pages.

6.15 State, County, and Local Elected Officials and Staff

It is vital to brief elected and appointed officials so that they are aware of progress and have up-to-date information about Pure Water AV. They are typically the first to receive questions from community members and are significantly influential on opinions and attitudes of other leaders and the public. Establishing a working relationship with state and local government elected officials will help provide an open and honest exchange of project-level information. Develop an elected official briefing binder that includes materials, maps, and key information to provide concise information to answer constituent questions about Pure Water AV.

Be responsive to Palmdale and Lancaster City Councils and Los Angeles County Board of Supervisors' requests for information or presentations, especially at major project milestones. Community leaders in this category will likely include state and federal legislators, county board of supervisors and their chiefs of staff, and council members and their staff.
Audiences (Listed in Alphabetical Order) May 2023

6.15.1 STRATEGIES

- Keep elected officials and their staff updated with written and oral communication.
- Gain support of local and state elected officials.
- Leverage distribution of informational materials through elected officials' offices.

6.15.2 SUGGESTED COMMUNICATION TACTICS

- PWD Board member involvement.
- Briefing binder.
- One-on-one briefings.
- Frequent email updates.
- Facility tours.
- Letters of support.
- Template articles for adaptation for legislators' newsletters or other communication with constituents.

6.16 Underserved and Environmental Justice Communities

A truly inclusive outreach program sees that stakeholders, no matter their social or economic status, are fully informed about the programs that impact their communities and that they are reflected as voices that matter. Often these communities require a "go to them" approach to share information and see that they are effectively included when it comes to stakeholder input. Working in these communities could involve working with a third-party advocate or community leader who is trusted in their community and who can relay Pure Water AV information and provide guidance on the best ways to reach people in that community.

When working with these groups, there are additional considerations that need to be made that may not be thought of with other stakeholder groups. For example, events need to be held in locations that are accessible by public transportation, activities should take place at a time that best accommodates working schedules, attendees might not use English as their primary language, and childcare options during the event or activity should be included if possible.

6.16.1 STRATEGIES

- Develop relationships with community leaders and trusted community members.
- Be transparent and inclusive when it comes to information distribution.

Audiences (Listed in Alphabetical Order) May 2023

• Leverage relationships to reach broadly into these communities.

6.16.2 SUGGESTED COMMUNICATION TACTICS

- Community event participation.
- Virtual or in-person community forums.
- Workshops led by trusted community leaders/organizations.
- Articles in local publications.
- Translate materials into Spanish.

Rapid Response Plan May 2023

7.0 Rapid Response Plan

Events related to Pure Water AV that require an urgent response will likely vary in nature, e.g., misinformation, project opposition, an injury to a member of the public during a visit to the demonstration facility, or an emergency. During such occurrences, it is the public outreach team's responsibility to provide a response to the event and to communicate promptly, effectively, and efficiently with affected internal and external stakeholder groups. If the public outreach team is prepared and responds appropriately, consistent, and vital information will be provided in a timely manner, resulting in positive, lasting effects on PWD's reputation and credibility. The basic steps outlined here will help to appropriately address events requiring urgent responses.

In our experience, potable reuse projects are much more prone to be the subject of misinformation or project opposition circulating in mainstream or social media, in conversations at organization meetings, etc. These instances could be damaging to Pure Water AV and need to be countered as soon as possible. This process will be the most effective when PWD's team and contractor staff work together to provide a consistent and prompt communication response to misinformation or a similar situation. With multiple staff members and consultant teams, an agreed-upon protocol with agreed-upon assignments must be in place long before they are needed. The following steps are included in that protocol:

- Determine whether a response is needed.
 - The PWD's Public Affairs Director is the lead in assessing the situation and determining that a response is warranted.
- Develop response and determine the format the response will take.
 - If a response is warranted/needed, PWD's Public Affairs Director will oversee messaging to respond, address the concern(s) expressed, and provide correct information about Pure Water AV.
- Finalize and distribute the response.
 - Check that all pertinent information about the comment, incident, or event is gathered and Pure Water AV information (e.g., a fact sheet, a news release, or other materials) is prepared and available in the format required. Refine the response and messaging, if required, and distribute it to the individual or group that raised the issue, expressed a concern, or is promulgating misinformation so that correct information about Pure Water AV is provided. It is also important to determine whether additional staff members (e.g., operations staff, engineering and any appropriate consultants, or stakeholders, including board members, legislators, or others) should be informed concurrently with the response or if they need to be informed after the response. These individuals should be notified and briefed at the appropriate time. This is a major potable reuse project, and it is very important that any

Rapid Response Plan May 2023

- incorrect information about it is corrected within 24 hours, and that internal distribution of the response is completed appropriately.
- See that spokespeople are briefed and prepared to speak to the media if necessary.
- Use existing internal communications procedures to move forward with any additional information dissemination and/or briefings for the public or the media.
- Update social media platforms and the Pure Water AV website to include a response or correct any misinformation.

Other incidences that might require a rapid response:

- An event (e.g., major delay, accident) occurs on-site or in a nearby location.
- The media arrives on-site in response to a reported event.
- District liaison is alerted to a potential crisis at the Pure Water AV Demonstration Facility.
- Regulators provide negative feedback or do not give approval to Pure Water AV.
- Tour participants publicly share negative reactions about the Pure Water AV Demonstration Facility.

Outreach Measurements May 2023

8.0 Outreach Measurements

A variety of tools can be used to measure the effectiveness of communication efforts. These measurements document outreach effectiveness to a variety of audiences and provide a concrete way to track public understanding and support for Pure Water AV.

Audience opinions can also be measured and documented in several ways, including any of the following:

- Audience comments received following speakers bureau activities.
- Comments gathered during public outreach community events (include options for community members to submit comments or feedback on the website).
- Presentation evaluation forms submitted following speakers bureau activities.
- General comments registered by the public through the website.
- Number of information and interest cards collected from one-on-one meetings process.
- Number of information and interest cards or letters of support received from stakeholder groups.
- Responses collected during pre- and post-tour surveys.

APPENDIX A

Public Outreach Program – Strategies, Tactics and Tools

Public Outreach Program – Strategies, Tactics and Tools May 2023

Appendix A Public Outreach Program – Strategies, Tactics and Tools

A.1 Goal/Mission Statement

Develop a robust, creative, and comprehensive outreach and education program that engages, among others, staff and board members of Palmdale Water District (PWD), the community and general public, government representatives, elected officials, corporations, community leaders and organizations, including environmental, academic, community, labor and business, and fosters support for its regional water augmentation program, referred to as Pure Water Antelope Valley (Pure Water AV).

As part of the outreach program, conduct extensive outreach to communities that may receive the new purified recycled water and/or be impacted by construction of the Pure Water AV Demonstration Facility, inform them of Pure Water AV, respectfully seek their input, and build trust and positive relationships along the way. The efforts will be broad and inclusive, encompassing diverse audiences and helping ensure that all communities have access to program information and involvement opportunities.

A.2 Strategies

The following strategies may be used to meet the goals of the outreach program:

- Develop and disseminate key messages and provide detailed information to staff and board members so that they are knowledgeable about the program and its goals.
- Conduct stakeholder research to determine what information resonates with their constituencies and how best to communicate the messages and goals of the program to target audiences.
- Communicate with government representatives and local, regional, state, and federal elected officials to help them understand Pure Water AV.
- Update and continue to develop, as needed, a variety of general and tailored communication materials to clearly communicate need, history, safety, value, and other relevant information regarding potable reuse.
- Engage schools and youth programs and find appropriate ways to deliver program information that is informative and student friendly.
- Provide opportunities for community members to see the technology behind potable reuse, including tours of the Pure Water AV Demonstration Facility.
- Cultivate working relationships with local media representatives, bloggers, and specialty reporters to facilitate accurate, positive, and proactive media coverage about potable reuse projects.
- Provide media with stimulating and newsworthy content about Pure Water AV.

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- Reach broadly into the communities that will benefit from the program so that all voices are represented, and audiences will receive information in a way that is tailored to them.
- Have a rapid response protocol in place to directly address and respond to misinformation about Pure Water AV that is expressed publicly. The protocol will use social media, public displays, high-profile activities, or direct communication to address an individual or group that raises an issue, expresses a concern, or is promulgating misinformation.
- Establish social media presence for the program and contribute engaging and inviting content.
- Demonstrate transparency by discussing pertinent aspects of the program with customers, such as water quality, cost, regulatory oversight, safety, and environmental issues.
- Create and encourage an environment of open dialogue with key stakeholders and the public in the region.

A.3 Identify Community Leaders

Some of the following guidelines for identifying community leaders originally appeared in the WateReuse DPR Communication Plan.

When provided with accurate and up-to-date information, community leaders can serve as a program's most effective advocates. Each agency and municipality will have its own unique set of influencers and the list will likely change and grow as a program progresses. Keeping an accurate database of community leaders, contact information, preferred communication methods, and other pertinent notes is imperative to a successful outreach program.

Community leaders should be aware of the need to increase water supply sources and be knowledgeable about potable reuse as an option. Although time-consuming, it is important to identify the appropriate leaders and their staff, if applicable. A community leader can be identified by a few characteristics: their appointed or elected position, values and traits, competence or expertise, and social position (i.e., who knows them and how accessible they are). Multicultural and minority-focused associations should be considered during this process along with faith-based organizations and leaders. Community leaders can include, but are not limited to, the following interests (the list below is in alphabetical order):

- Academic and education leaders.
- Business organizations, labor groups, and corporations.
- Large employers.
- Department of Defense Air Force Plant 42 Command.
- Civic groups.
- Environmental groups.

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- Health and medical community.
- Industry experts.
- Media.
- Multicultural communities.
- State and regional elected officials and their staff appointees to commissions and boards, such as the California Water Commission, State Water Resources Control Board, and Regional Water Quality Control Boards.

A.3.1 ACADEMIC/EDUCATION LEADERS

Leaders in the local academic arena can hold a position of influence; and as educators, they are often sought after for advice and counsel. Additionally, relationships with parent groups and parent teacher associations should be considered important stakeholder groups at the local level, offering an excellent opportunity for collaboration with PWD.

A.3.2 BUSINESS ORGANIZATIONS/LABOR GROUPS/CORPORATIONS

Every community has organizations that advocate for economic stimulation and business growth. They are more often concerned with job growth and real estate value. These organizations include chambers of commerce, economic development corporations, development and planning organizations, and labor unions. Leaders of businesses that have significant water requirements should be included on this list. Corporations with a strong presence in the community should also be included in any outreach. Community leaders within organizations should include the following:

- Board officers.
- Chief executive officers.
- Presidents.
- Committees and subcommittees (e.g., water, energy, power, infrastructure, planning).
- Public policy directors, public information officers, or other individuals responsible for organization communication.
- Schedulers and assistants.
- Sustainability officers and managers.

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A.3.3 CIVIC GROUPS

Community leaders are often highly involved with organizations that are concerned with the growth, planning, and leadership of their communities. These organizations include, but are not limited to, the following:

- Kiwanis clubs, Rotary, Lions clubs, etc.
- Neighborhood planning associations.
- Homeowner associations.

A.3.4 ENVIRONMENTAL GROUPS

Organizations that concentrate on environmental issues and impacts should be a high-level stakeholder in a potable reuse implementation program. These groups should be included from the onset of the planning process. Support from environmental advocates is vital to the success of a potable reuse project and strong opposition from this group could make for a significant negative impact on public perception.

A.3.5 INDUSTRY EXPERTS

An important group of community leaders whose support is vital to the success of a potable reuse project is industry experts. This group consists of water industry experts (e.g., American Water Works Association), private industry (e.g., brewing), agricultural groups, and neighboring agencies (e.g., water districts). If a significant number of water industry experts pledge support to the project, it will increase public support and positively impact perception.

A.3.6 MEDIA

Reporters, editors, and publishers of print, online, radio, and television media should be considered a toptier level stakeholder as they have the most effective platform for influencing public opinion. If they are included in the planning stages and are well-informed about the potable reuse process and PWD's project approach, they are more likely to become and remain supportive of Pure Water AV. These community leaders should be updated frequently with both top-level and detailed reports to help disseminate accurate information. It is important to be mindful of multi-language media outlets and to communicate accordingly and equally to all platforms.

A.3.7 MULTICULTURAL COMMUNITIES

Antelope Valley has a rich and diverse population, some of which are more comfortable hearing or reading about projects in a language other than English. It is important to identify the community leaders and meet with them early to explain the project as research has identified specific concerns about water quality that may be held in some of these communities based on cultural norms and water supplies in countries of origin. Find more about multicultural outreach in the *Community Outreach* section of this Appendix.

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A.3.8 STATE AND REGIONAL ELECTED OFFICIALS AND STAFF

It is vital to brief elected and appointed officials early in the process. They are typically the first to receive questions from community members and are significantly influential on opinions and attitudes of other leaders and the general public. Briefings scheduled early and often also work to keep city and county resolutions of opposition at a minimum because they establish a working relationship between the state and local government bodies, whereby an open and honest exchange of project-level information can take place. For each briefing, an elected official briefing binder with project materials, maps, and key information should be provided with concise information to answer constituent concerns.

PWD should also be responsive to Palmdale City Council's requests for presentations, with presentations scheduled as requested prior to each major project milestone. Community leaders in this category will likely include the following:

- State Legislators, U.S. Representative, and their chiefs of staff.
- County Board of Supervisors and their chiefs of staff.
- Mayors, City Council, and staff.

A.3.9 UNDERSERVED AND ENVIRONMENTAL JUSTICE COMMUNITIES

A truly inclusive outreach program sees that program stakeholders, no matter their social or economic status, are fully informed about the programs that impact their communities and that those communities are reflected as voices that matter. Often these communities require a "go to them" approach to share information and to see that they are effectively included when it comes to stakeholder input. Working in these communities could involve working with a third-party advocate or community leader who is trusted in their community and who can relay program information and provide guidance on the best ways to reach people.

A.4 Tactics

A.4.1 INTERNAL COMMUNICATIONS

Pure Water AV will require understanding and buy-in from PWD staff. Below are some ways that staff can stay informed about the program, so that they are knowledgeable when asked questions by family members, friends, customers, member agency staff, or community members.

Message Plan

Although the program will provide detailed information on a variety of topics of interest to audiences and stakeholders, the materials should emphasize overarching themes and messages. Distribute the message plan with its key messages and supporting information points to internal team and board members.

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Key Message Card

Create a pocket-size card that highlights the key messages and the benefits of Pure Water AV. It should also contain contact information and the website URL. The card will be for use by program team members, PWD Board members, and other staff identified as having regular public interactions.

Employee Tours

Provide tours of the Pure Water AV Demonstration Facility for PWD employees to develop knowledge and understanding. This also provides an opportunity to respond to questions or concerns and improves their ability to be effective ambassadors in their communities.

Speaker Workshops

Conduct training for all speakers and media representatives and see that they always have the most upto-date information and are well-versed in delivering presentations and speaking publicly about Pure Water AV.

Staff Program-Specific Training Sessions

Provide opportunities for employees in key roles, such as the management team, tour guides, speakers, educational specialists, customer service staff, and others who deal directly with community members, so that they gain a clear understanding about the program. They should also be provided the opportunity to practice responding to difficult questions, public and board member concerns, and statements of misinformation. Staff who interact with the public should have up-to-date program information and be well-versed in the key messages.

A.4.2 RESEARCH

Informing community leaders (e.g., key community leaders and other stakeholders) about Pure Water AV at an early stage will help raise awareness about and foster support for it. Community leaders can influence opinions in the community, establish norms, and leverage resources due to their high visibility and defined constituencies. Reaching out to community leaders first will help gather significant opinions about a program, build strong relationships, and garner third-party involvement in disseminating information to a broader network of interested public. An important first step is to identify these key community leaders and stakeholders (see *Identify Community Leaders* in this Appendix). Use appropriate methods to contact identified leaders and request that they participate in one-on-one or small group meetings as the first step in the research process.

Stakeholder Database

Develop a comprehensive list of stakeholders and member agency customers who would be interested in learning more about the program and/or those who are key community leaders who should receive updates going forward.

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One-on-One Meetings with Stakeholders and Regional or Community Leaders

Coordinate one-on-one meetings to both provide information about Pure Water AV; and gather opinions, questions and concerns, and information about the best way to communicate with the constituency of each stakeholder or community leader. Perform follow-up as needed to answer questions. Document the content and comments anonymously from the meetings in a summary report.

A.4.3 INFORMATIONAL MATERIALS

Informational materials should address specific concerns and needs, be written for a varying knowledge base, and convey key messages in a consistent manner. Materials and communication tools should be reviewed for cultural sensitivity and appropriateness for different age groups. Information should be available in multiple formats (e.g., written text, graphics, displays) to appeal to various learning styles. Additionally, materials should be distributed in a variety of ways and include both electronic and non-electronic outlets to reach multiple audiences.

Infographics/Fact Sheets

Develop infographics and fact sheets that explain program facts, statistics, and information in a visually appealing, dynamic manner. Distribute at one-on-one meetings, presentations, events, and other public venues. Post materials on PWD's website and distribute to partner agencies, regional organizations, elected officials, etc. for their use.

Frequently Asked Questions Documents

Develop a public-friendly frequently asked questions document (FAQ) that can be posted on the Pure Water AV website and distributed at speaking engagements and events. As needed, develop topic-specific FAQs. Revise the FAQs to include updated information as needed.

Quick Facts Card

Create a pocket-size card that provides quick facts about the program. This is an opportunity to highlight key messages and the benefits of the program in a succinct format. It will also contain contact information and the website URL. The card will be for use by Pure Water AV team members and PWD staff and will be particularly useful during Demonstration Facility construction activities.

Email Updates

Provide timely and as needed e-updates to program stakeholders. Content may include updates, recent media clips, and events in which PWD is participating.

Support Cards

Develop support cards for those community leaders or organizations who wish to express their support for the program. Distribute cards at presentations or events in which PWD is participating. The website can also offer a convenient way to pledge support via a digital support card.

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Support Letter Templates

Develop templates for support letters and resolutions from elected officials, partner agencies, cities, counties, etc.

Website

Develop content for the Pure Water AV website. Include visuals, graphics, interactive elements, and key information about Pure Water AV. Make the following easily accessible:

- PowerPoint presentations.
- Fact sheets and FAQs.
- News clips.
- Program milestones and key activities.
- A method to sign up to receive program materials by email.
- Information on how to reach the program team.
- How to request a speaking engagement and tours.
- Support cards.
- An opportunity to provide suggestions for outreach activities.
- Links to additional information about potable reuse projects.

Template Articles

Prepare template articles that can be provided to stakeholders to either use as written, or to customize for their own newsletters or communications channels. Customize as needed.

Evaluation Forms/Surveys

Develop surveys to gather information about public opinion and attitudes toward Pure Water AV. Distribute at events, presentations, or other gatherings in which PWD is participating. Review presentations and informational materials against feedback received and update accordingly. Check that all materials are easy-to-understand, responsive to public concerns and accessible for all community members. Develop feedback surveys specifically for the demonstration facility and have attendees complete them after their tour.

Microsoft PowerPoint Presentations

Develop a standard community presentation and specific topic presentations as needed. Monitor the content and revise the presentations when new information is available. Develop versions to



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accommodate appropriate timeframes and age levels, especially when the presentations may be used in a joint opportunity with stakeholders.

Materials Translations

Provide Spanish language translation of the base informational materials (e.g., fact sheets, FAQs) to provide accessibility for Spanish-speaking stakeholders.

Additional Informational Materials

As needed, develop graphics, brochures, white papers, or stakeholder updates that further explain program information.

A.4.4 COMMUNITY OUTREACH

Cultivating and maintaining strong relationships with members of the community increases understanding of Pure Water AV. A variety of outreach activities provide open channels of communication and opportunities for collaboration with stakeholders which helps ensure program visibility throughout the region.

Civic, Business and Community Events

Participate in civic, business, and community events, including events held by stakeholder groups. Focus on events that attract a large number of attendees as well as those that attract multicultural populations. Focus on having a presence at key events identified by community leaders during one-on-one meetings. When possible, engage the audience with interactive activities.

Engage Multicultural Audiences

Many in multicultural communities are less trusting of potable reuse, either as a result of cultural norms and experience or because potable reuse is a new concept to them. Develop materials and information in English and Spanish languages and reach out to and raise awareness among diverse audiences. Participate in key multicultural community events, reach out to Spanish language media, and conduct one-on-one meetings with key community leaders in the multicultural community.

Tours of the Demonstration Facility

Invite stakeholders, interested parties, students, and other civic, business, environmental and community groups, including those from multicultural communities, to attend Pure Water AV Demonstration Facility tours so that they can see firsthand the advanced water treatment process. All tour presenters should participate in tour guide training workshops. Solicit post-tour feedback from tour participants to help learn about their tour experience and provide insight for the public outreach team to make adjustments to the tour and/or messaging to ensure the tours are meaningful for visitors.

To expand the reach of information and expose a wide audience to the Pure Water AV Demonstration Facility and learning center, create a virtual "real-time" walkthrough video with graphic support, and brief subject matter expert videos that can meet multiple uses, including website and social media posting. The

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virtual tour should contain the same information provided in the in-person tours so that there is consistency of messaging and information being shared with the community.

Community Meetings/California Environmental Quality Act

Plan and hold community events to raise awareness among community members about the program. Provide an opportunity for attendees to engage with PWD representatives to discuss the quality of the purified water and local benefits it offers.

In addition to the meetings about the program, host California Environmental Quality Act-focused meetings to support Pure Water AV. Prepare participation logistics plan, related notifications, fact sheets, poster boards, FAQs, and agenda to prepare subject matter experts for public engagement and risk communications.

Speakers Bureau

Reach out to community groups and their leaders (e.g., business, environmental, and labor groups and their multicultural counterparts in these categories) through speaking engagements. Recruit and train speakers and publicize the availability of presentations to these categories of organizations and the public. Identify a point person within each group to follow-up with on additional engagement opportunities, support letters, and/or resolutions. Train member PWD representatives to be part of the speakers bureau as needed.

A.4.5 MEDIA OUTREACH

Media coverage can be an effective way to disseminate program information and raise awareness about Pure Water AV among a wide audience of regional and local residents. Engaging media representatives will enhance their understanding and facilitate accurate coverage of the program. Understanding current and past media trends and influences, including social media platforms, must be considered as part of an effective media strategy.

Media Contact Database

Review PWD's current list of media organizations and update as needed with specific contacts that do or could have an interest in Pure Water AV.

Media Kit

Develop a printed and electronic version of a media kit with program information for distribution to media representatives and editorial boards. Update the kit as needed for various activities. Include fact sheets, FAQs, key messages, local and national news articles about similar projects and programs, information about other potable reuse projects, and other relevant materials.

Media Screening and Distribution

Monitor local and national media to identify any report, story, or blog that is directly related to the program or has a connection to a related field. Distribute relevant articles to the program team. Record and save

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all program media gathered throughout the program implementation for reference and program outreach measurement.

News Releases

Assist PWD with creation of news releases to raise awareness about Pure Water AV and to share updates around special events or milestones.

Social Media Content

Establish and implement an annual social media and editorial calendar to align with project schedule and milestones for posting on social media sites and blogs. This will help reach new audiences and provide programmatic information to existing project stakeholders.

A.4.6 RAPID RESPONSE PLAN

Events related to Pure Water AV that require an urgent response will likely vary in nature, from misinformation to program opposition. During such occurrences, PWD should follow protocols to provide a response that corrects misinformation or provides another viewpoint to opponents. It is critical to communicate promptly, effectively, and efficiently with affected internal and external stakeholder groups. If the team is prepared and responds appropriately, consistent—and often vital—information will be provided resulting in positive, lasting effects on PWD's and Pure Water AV's reputation and credibility. Following the basic steps outlined below will help appropriately address events requiring urgent responses.

Determine Whether a Response is Needed

PWD's Public Affairs Director should determine whether a rapid response is needed for a specific incident or event.

Prepare the Appropriate Response

If a response is determined to be necessary, the response team should work together to gather all pertinent information and prepare a fact sheet, a news release, or other appropriate materials. It is also important to determine whether additional staff members or stakeholders should be informed concurrently with the response or if there are those who need to be informed after the response. These individuals should be notified and briefed at the proper time. If the spokesperson is not part of the group determining the response, remember to brief and prepare the spokesperson to speak to the media.

APPENDIX A.11 Project Construction Costs

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FEAUTRE: Alternative 1 - Groundwater Augmentation via Subsurface Injection		PROJECT: Pure Water Antelope Valley					
			ESTIMATE LEVEL: Feasibility				
		File:	https://stantec.sharepoint.com/teams/184031611/Sh				
	Summary Sheet		ared Documents	/General/Task 7 - B	ureau of		
Pay Item	Description	Quantity	Unit	Unit Price	Amount		
Equipment			I				
1	MF System	1	lump sum	\$3,350,000	\$3,350,000		
2	Primary RO System	1	lump sum	\$3,882,000	\$3,882,000		
3	Secondary RU Systems	1	lump sum	\$1,435,000	\$1,435,000		
4 5	UV Systemi Rreak Tanks Transfer Pumns	4	ea	\$1,655,000	\$80.000		
6	Transfer Pumps	4	ea	\$50.000	\$200,000		
7	Chemical Pump Skids	14	ea	\$50,000	\$700,000		
8	Chemical Tanks	7	ea	\$100,000	\$700,000		
9	Eyewash Stations	7	ea	\$3,000	\$21,000		
10	Chemical Secondary Containment	1	lump sum	\$100,000	\$100,000		
11	AWPF Effluent Pumps	1	lump sum	\$2,360,000	\$2,360,000		
				├ ────			
Conveyance	o see Noollos Allislant influent	7 720	1: £+	¢540	¢4 175 000		
12	Conveyance Pipeline - 18" plant influent	/,/3U E00	lin ît	\$340 \$480	\$4,175,000		
13	Conveyance Pipeline - 16 plant enluent	17.000	lin It	\$480	\$240,000		
14		3	ea	\$180	\$3,000,000		
16	Injection Well Pumps	3	ea	\$80,000	\$240,000		
17	Monitoring Wells	6	ea	\$500,000	\$3,000,000		
Buildings							
18	Pre-engineered Metal Building for Equipment and Storage Warehouse	32,000	ea	\$450	\$14,400,000		
19	O&M and Lab Building	5,000	ea	\$600	\$3,000,000		
20	Concrete Foundation	1,370	yd3	\$2,500	\$3,425,000		
Princ Evaporation Pond				├			
21	HDPF Liner (Primary and Secondary)	10 176.208	ft2	\$0.68	\$6.920.000		
22	Geotextile Baselaver	5,088,104	ft2	\$0.31	\$1,578,000		
23	Access Ramps	8	ea	\$30,000	\$240,000		
24	Ballast	77,600	lin ft	\$7.70	\$598,000		
25	Flood Control Improvements	5,000	lin ft	\$1,500.00	\$7,500,000		
			Ţ				
Sitework and Installation			<u> </u>	<u> </u>	<u> </u>		
26	Demolition	1	lump sum	\$100,000	\$100,000		
2/	Clearing and Grubbing	13U 91.000	acre	\$2,100	\$273,000		
20		δ1,000 1	yuə lumn sum	د2.44 م00 000 ¢2	\$343,000 \$7 900 000		
30		1	lump sum	\$7.040.000	\$7.040,000		
31	Electrical and I&C	1	lump sum	\$5.150,000	\$5,150,000		
			in the second second	<i>vvi</i> ===,===	<i>v</i> =,,		
		<u> </u>	T				
	Subtotal				\$81,050,000		
	Mobilization	+/-		5%	\$4,060,000		
	Subtotal with Mobilization				\$85,110,000		
	Contract Cost Allowances (Sum of):	+/-			+ L 2 C 2 2 2 2		
	Design Contingencies, 5% (+/-)	_		5%	\$4,260,000		
	Sales Tax - 9.5% of equipment and materials			9.5%	\$6,250,000 \$25,540,000		
	Contractor iniarkups and overneads, 50% (+)-)	-		3070	323,340,000		
	CONTRACT COST		1		\$121,160,000		
	Construction Contingencies	+/-		25%	\$30,290,000		
	FIELD COST Unit Price Level (XXX)			l	\$151,450,000		
	Escalation to Notice to Proceed (NTP), from Unit Price Level not included h	iere					
			-	│			
	Non-Contract Costs			259/	627 970 000		
	Engineering, ESDC, PM, CM	+/-		25%	\$37,870,000		
	Land Acquisition Cost for AWTP	115	acre	\$47,000	\$5,410,000 \$710,000		
	Permitting	13		\$1,000.000	\$1.000.000		
	refilitions		iump sum	91,000,000	91,000,000		
	CONSTRUCTION COST				\$196,500,000		
			<u> </u>				
			PR	ICES			
BY KM	CHECKED	ВҮ	CHECKED				
DATE PREPARED	PEER REVIEW / DATE	DATE PREPARED	PEER REVIEW / DATE				

Annual O&M Costs Alternative 1 - Groundwater Augmentation via Subsurface Injection										
Parameter	Influent	MF	Primary RO	Secondary RO	UV/AOP	Chemical Feed systems	Conveyance	Brine Ponds	Injection Wells	Total
Power, Chemicals, Maintenance and Consumables										
Power, \$/yr		\$66,600	\$311,502	\$167,220	\$83,611	\$5,680			\$118,260	\$753,000
Chemicals, \$/yr		\$146,100	\$279,000	\$16,000	\$27,000	\$142,000				\$611,000
Maintenance, \$/yr		\$100,500	\$116,460	\$43,050	\$49,050	\$27,000	\$35,838	\$50,000	\$169,200	\$592,000
Major Equipment Replacement, \$/yr		\$167,500	\$194,100	\$71,750	\$81,750	\$45,000				\$561,000
Labor, \$/yr		\$438,000	\$438,000	\$438,000	\$438,000					\$1,752,000
Disposal, \$/yr								\$1,069,200		\$1,070,000
Contingency		\$137,805	\$200,859	\$110,403	\$101,912	\$32,952	\$5,376	\$167,880	\$43,119	\$801,000
Water Purchase	\$798,713									\$799,000
Total O&M Cost, \$/yr	\$799,000	\$1,057,000	\$1,540,000	\$847,000	\$782,000	\$253,000	\$42,000	\$1,288,000	\$331,000	\$6,140,000
Influent Flow, MGD	4.75	4.75	4.51	0.97	4.24	4.24	4.75	0.27	4.24	4.75
Effluent Flow, MGD	4.75	4.51	3.56	0.72	4.24	4.24	4.75	-	4.24	4.24
\$/gpd	\$0.17	\$0.23	\$0.43	\$1.18	\$0.18	\$0.06	\$0.009	\$0.30	\$0.08	\$1.45
\$/acre-ft/yr	\$150	\$209	\$385	\$1,056	\$164	\$53	\$8	\$271	\$70	\$1,291

O&M Cost Assumptions

Power Cost, \$/kWh	
Labor Rate, \$/hr	
Maintenance Percent	
Annual Replacement cost	
Contingency	
Salt Disposal cost, \$/cy	
Annual volume salt from ponds, cy	
Assumed recovery for O&M	
Energy for Primary+Secondary RO, kwh/kgal	
Primary RO power, kWh/kgal	
Secondary RO power, kWh/kgal	
Tertiary Water Purchase, \$/AF	Γ

\$0.18 \$150 3% 5% \$243.00 4400 94% 1.7 1.33 3.558 \$150



SUBMITTING WITH



