San Francisco Public Utilities Commission,
City of San José, City of Santa Clara
South Bay Purified Water Project

FEASIBILITY STUDY

FINAL | July 2023

San Francisco Water Power Sewer

Services of the San Francisco Public Utilities Commission

CITY OF SAN JOSE

CAPITAL OF SILICON VALLEY

THE CITY OF SANTA CLARA CALIFORNIA

The Mission City

INCORPORATED 1852

San Francisco Public Utilities Commission,
City of San José, City of Santa Clara
South Bay Purified Water Project

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Abbreviations

$	dollars
$/acre-foot	dollars per acre-foot
$/kWh	dollars per kilowatt hour
$/MG	dollars per million gallons
$M	dollars in millions
AL	action level
AOP	advanced oxidation process
AWPC	Advanced Water Purification Center
AWPF	Advanced Water Purification Facility
AWTO	Advanced Water Treatment Operator
BAC	biological activated carbon
BAF	biologically active carbon filter
Basin Plan	Water Quality Control Plan for the San Francisco Bay Basin
BDPL	Bay Division Pipeline
Carollo	Carollo Engineers, Inc.
CBOD	carbonaceous biochemical oxygen demand
$CBOD_5$	5-day carbonaceous biochemical oxygen demand
CEC	contaminant of emerging concern
CEQA	California Environmental Quality Act
CIP	clean-in-place
CIWQS	California Integrated Water Quality System
CT	contact time
DBP	disinfection byproduct
DDW	Division of Drinking Water
DiPRRA	direct potable reuse responsible agency
DPR	direct potable reuse
EBCT	empty bed contact time
EPA	Environmental Protection Agency
ESCP	enhanced source control program
GAC	granular activated carbon
gfd	gallons per square foot of membrane per day
GWR	groundwater replenishment
hp	horsepower
hpd	hours per day
IAP	Independent Advisory Panel
IPR	indirect potable reuse

kg/yr	kilograms per year
kW	kilowatt
kWh	kilowatt hour
kWh/day	kilowatt hours per day
LRV	log removal value
MCL	maximum contaminant level
MF	microfiltration
MG	million gallons
mg/L	milligrams per liter
mg-min/L	milligram-minutes per liter
mgd	million gallons per day
mJ/cm^2	millijoules per centimeter squared
MOU	memorandum of understanding
NDMA	N-nitrosodimethylamine
NL	notification level
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity unit
NWRI	National Water Research Institute
NWRI Guide	DPR Implementation Guide for California Water Utilities
O&M	operations and maintenance
PCB	polychlorinated biphenyl
PG&E	Pacific Gas & Electric
PPA	Power Purchase Agreement
Project	South Bay Purified Water Project
psi	pounds per square inch
PV	photovoltaic
RO	reverse osmosis
ROC	reverse osmosis concentrate
RWF	Regional Wastewater Facility
RWS	Regional Water System
RWQCB	Regional Water Quality Control Board
SCADA	supervisory control and data acquisition
sf	square feet
sf/kW	square feet per kilowatt
SF Bay	San Francisco Bay
SFPUC	San Francisco Public Utilities Commission
sMCL	secondary maximum contaminant level
SWA	surface water augmentation

SWRCB	State Water Resources Control Board
TDS	total dissolved solids
TEQ	toxic equivalency
TOC	total organic carbon
TSS	total suspended solids
TWA	treated drinking water augmentation
UF	ultrafiltration
µg/L	micrograms per liter
UV	ultraviolet
WWTP	wastewater treatment plant

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EXECUTIVE SUMMARY

ES.1 Background

The San Francisco Public Utilities Commission (SFPUC) provides drinking water services to 2.7 million residents and businesses in San Francisco, Alameda, San Mateo, and Santa Clara counties. Like many utilities in drought-impacted California, SFPUC is proactively searching for sustainable measures to secure a safe, reliable, and long-term drinking water supply for their communities and partner agencies. The cities of San José and Santa Clara are interruptible customers of SFPUC, meaning that deliveries from the SFPUC are subject to reduction or termination if sufficient water supplies from the SFPUC are not available. San José and Santa Clara are seeking permanent status from SFPUC to support projected future demands.

This South Bay Purified Water Project (Project) evaluates the feasibility of purified water using treated effluent from the San José-Santa Clara Regional Wastewater Facility (RWF). Purified water would be provided to San José and Santa Clara in all years, and to the SFPUC for the benefit of all its customers during dry years when supply shortages are anticipated.

This evaluation is a joint effort between the SFPUC, San José, and Santa Clara, and recommends a viable approach to purifying filtered tertiary effluent that is normally discharged to the San Francisco Bay (SF Bay) to supplement drinking water supplies sustainably. Two purified water production capacity scenarios were analyzed: 10 and 20 million gallons per day (mgd). The Project is being planned to treat the RWF's effluent to very stringent drinking water standards. This study analyzed three potential connection points, one to each agency, where the purified water could then be introduced into their respective drinking water distribution systems.

ES.2 Regulatory Summary

Purified water can be produced by four major pathways that can have some differences in the way that they are regulated in California. Two of these pathways are grouped as direct potable reuse (DPR), for which regulations are not yet finalized but are well developed. The draft DPR regulations contain extensive requirements for treatment, monitoring, source control, reporting, and more. The framework remains similar to what has been promulgated for other forms of purified water production. It is anticipated that regulations will be finalized by the end of 2023 and adopted in 2024. The key requirements are summarized in Chapter 2.

ES.3 DPR Treatment Facility Analysis

To develop the required treatment facility components and sizing needed to produce purified water, this report first looked at the existing effluent quality and quantity at the RWF.

The effluent water quality is important for this feasibility evaluation for multiple reasons. First, it informs the identification of appropriate treatment technologies and the development of certain design criteria for the proposed treatment train to ensure that all regulatory standards can be met. In addition, it informs the analysis of the reverse osmosis concentrate (ROC) (byproduct generated from reverse osmosis [RO] treatment) disposal, discussed in Chapter 6.

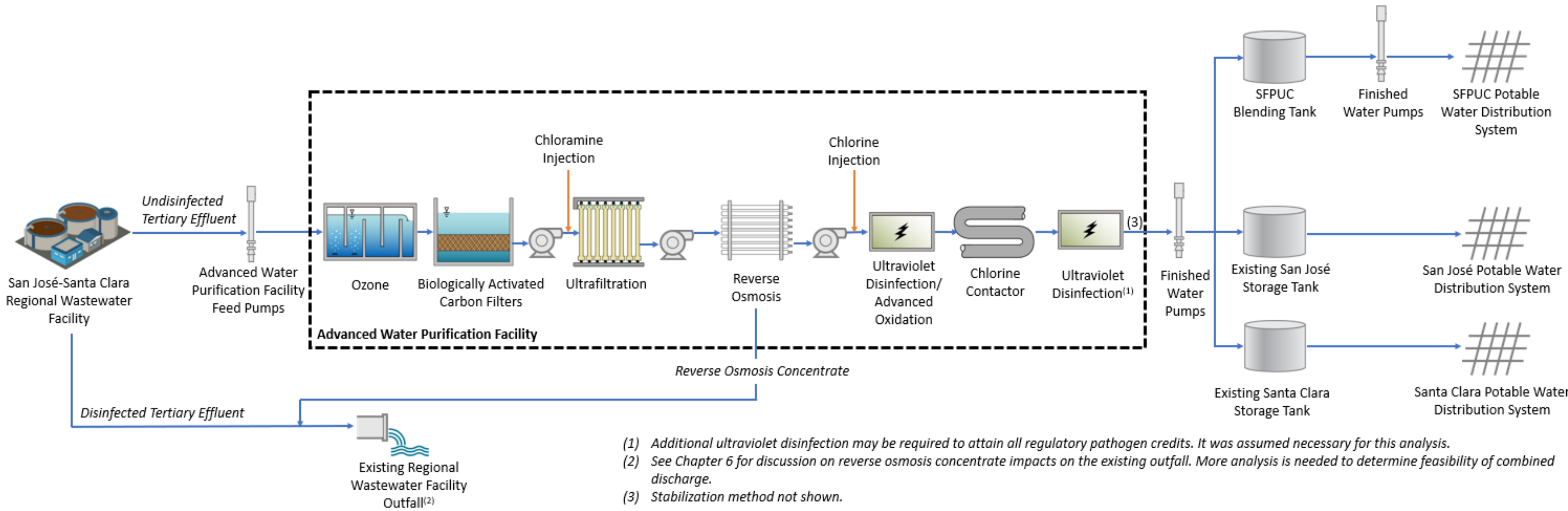
In addition to water quality, Chapter 3 also examines the water quantity available for reuse. Taking into account historical flow data and other future uses of RWF effluent, the available maximum continuous feed flow for this project is 25 mgd. This feed flow allows for a maximum Advanced Water Purification Facility (AWPF) production of 20 mgd (accounting for unit process recoveries). This larger scenario and a smaller 10 mgd scenario are the two alternatives that are evaluated in this report.

The proposed location for the Project treatment facility is to the southeast of the RWF and immediately adjacent to the Valley Water Advanced Water Purification Center (AWPC). For this effort, we examine a one-story facility for both the 10 mgd production and 20 mgd production scenarios. Since the project must be capable of meeting California's draft regulatory standards, the recommended treatment train includes the following key processes:

- Ozone
- Biological activated carbon (BAC)
- Ultrafiltration (UF)
- RO
- Ultraviolet (UV) light advanced oxidation process (AOP) using free chlorine as the oxidant
- Free chlorination
- Secondary UV disinfection
- Stabilization

The treatment train also includes adding several different chemicals to adjust for alkalinity and pH and improve process operation. Figure ES.1 shows a process flow diagram of this highly engineered treatment train.

Conceptual treatment site layouts were developed for the 10 mgd and 20 mgd production scenarios. The one-story layouts include plant feed pump stations, all treatment processes, electrical infrastructure, and ancillary equipment, such as chemical storage. Layouts also include a blending tank for water going to SFPUC to provide sufficient dilution prior to conveyance to the existing potable water distribution system. Plan views of the two facility sizes are shown in Figures ES.2 and ES.3.



(1) Additional ultraviolet disinfection may be required to attain all regulatory pathogen credits. It was assumed necessary for this analysis.
(2) See Chapter 6 for discussion on reverse osmosis concentrate impacts on the existing outfall. More analysis is needed to determine feasibility of combined discharge.
(3) Stabilization method not shown.

Figure ES.1 Proposed Treatment Train for the South Bay Purified Water Project

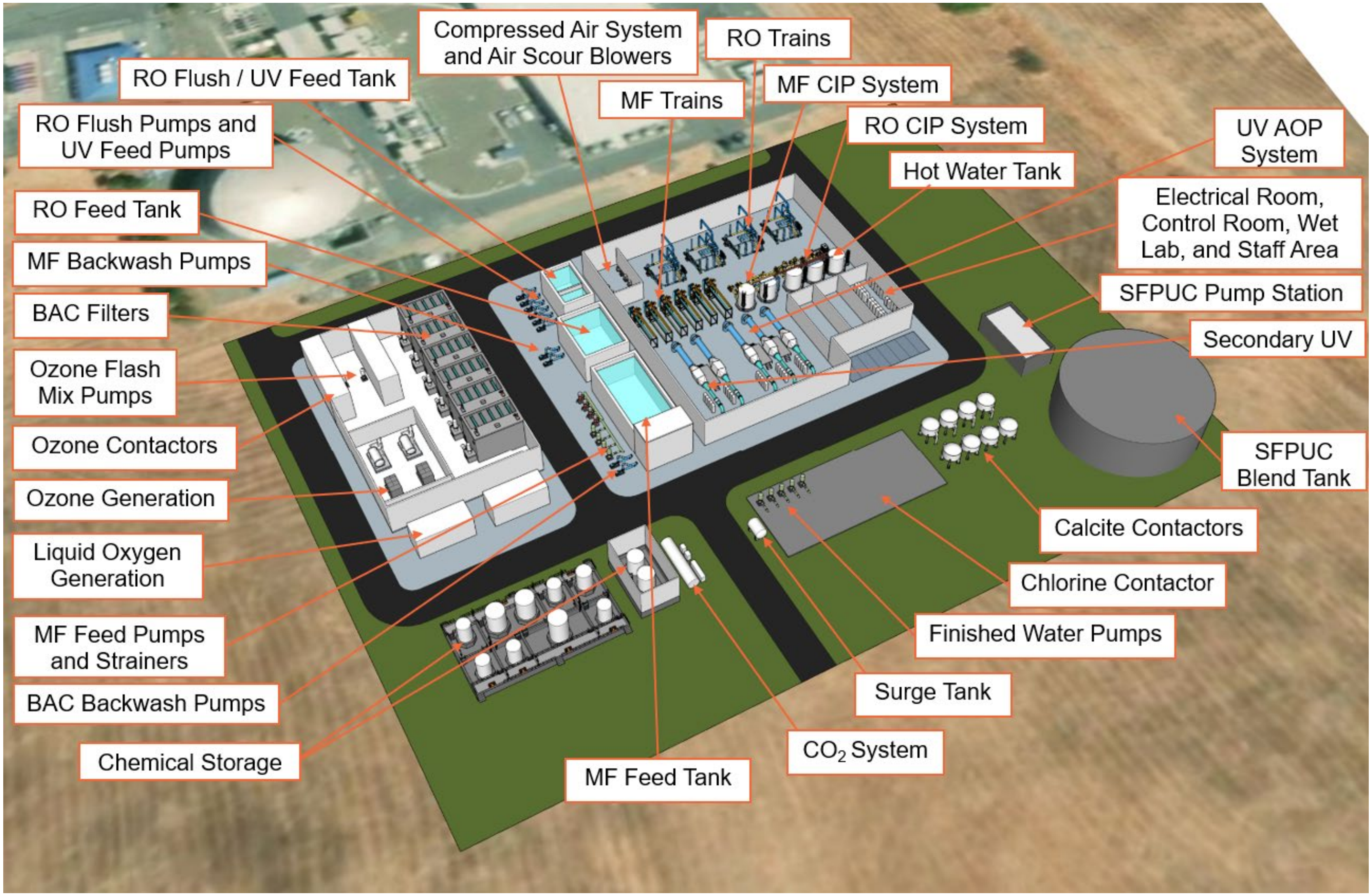


Figure ES.2 Isometric View of One-Story 10 mgd Production AWPF Located at the RWF

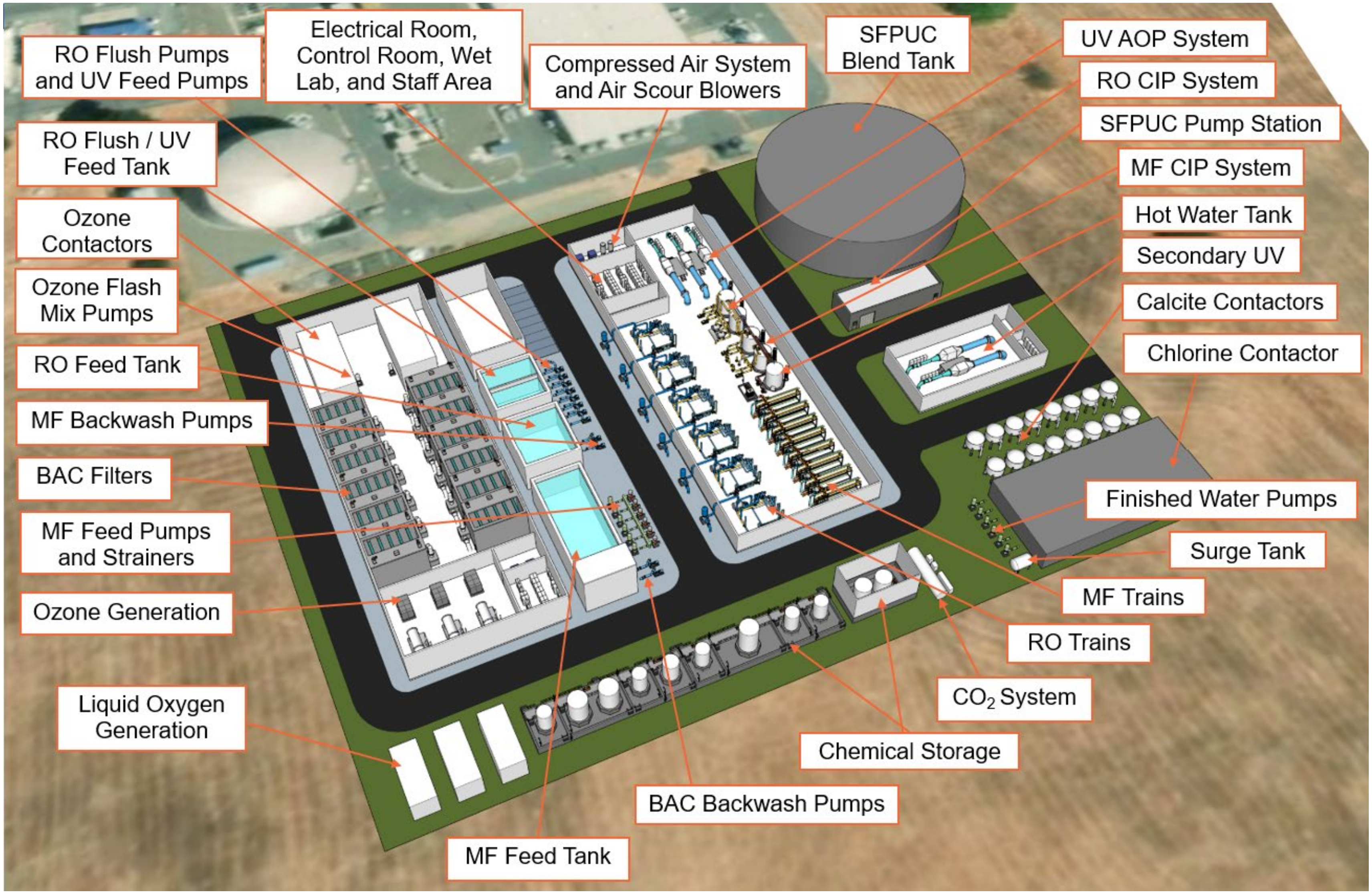


Figure ES.3 Isometric View of One-Story 20 mgd Production AWPF Located at the RWF

ES.4 Supporting Infrastructure Needs

There are a number of infrastructure components needed to integrate the purified water treatment facility into water delivery systems. The additional infrastructure components analyzed here are:

- Feed pipeline and pump station
- Finished water pump station
- Finished water pipelines to existing San José and Santa Clara drinking water storage tanks/reservoirs
- Finished water pipeline to new SFPUC blending tank
- SFPUC blending tank
- SFPUC finished water pump station
- Finished water pipeline to SFPUC distribution system
- ROC disposal pipeline
- Waste/backwash return pipeline and pump station

These components are shown in Figure ES.4 for the treatment feed system, Figure ES.5 for the finished water system, Figure ES.6 for the ROC disposal system, and Figure ES.7 for the waste/backwash return system. The design criteria and cost estimates for these components are discussed in Chapter 4.

Figure ES.4 AWPF Feedwater Pipe Alignment

Figure ES.5 AWPF Finished Water Pipe Alignment and Blending Reservoir Sites

Figure ES.6 ROC Outfall Pipeline Alignment

Figure ES.7 AWPF Waste/Backwash Return Pipeline Alignment

ES.5 Power and Solar Analysis

Anticipated power requirements for purified water treatment and projected power output from installation of a solar photovoltaic (PV) system at the proposed treatment site were analyzed for both the 10 mgd and 20 mgd production scenarios. In this analysis, available space for land, carport, and roof installed solar panels was considered at the site in addition to ground mounted solar panels on two adjacent land parcels. These adjacent areas may be available for solar based on input from San José. Figure ES.8 shows the potential areas considered for solar installation.

An alternatives analysis performed examined installation of just solar panels or solar panels with battery storage included. For all alternatives, the amount of energy generated is significantly less than what is needed to operate the Project but would be dependent on the actual amount of space available to install these panels. Table ES.1 and Table ES.2 summarize the expected cost and payback for the solar options considered for both the 10 mgd production and 20 mgd production scenarios, respectively.

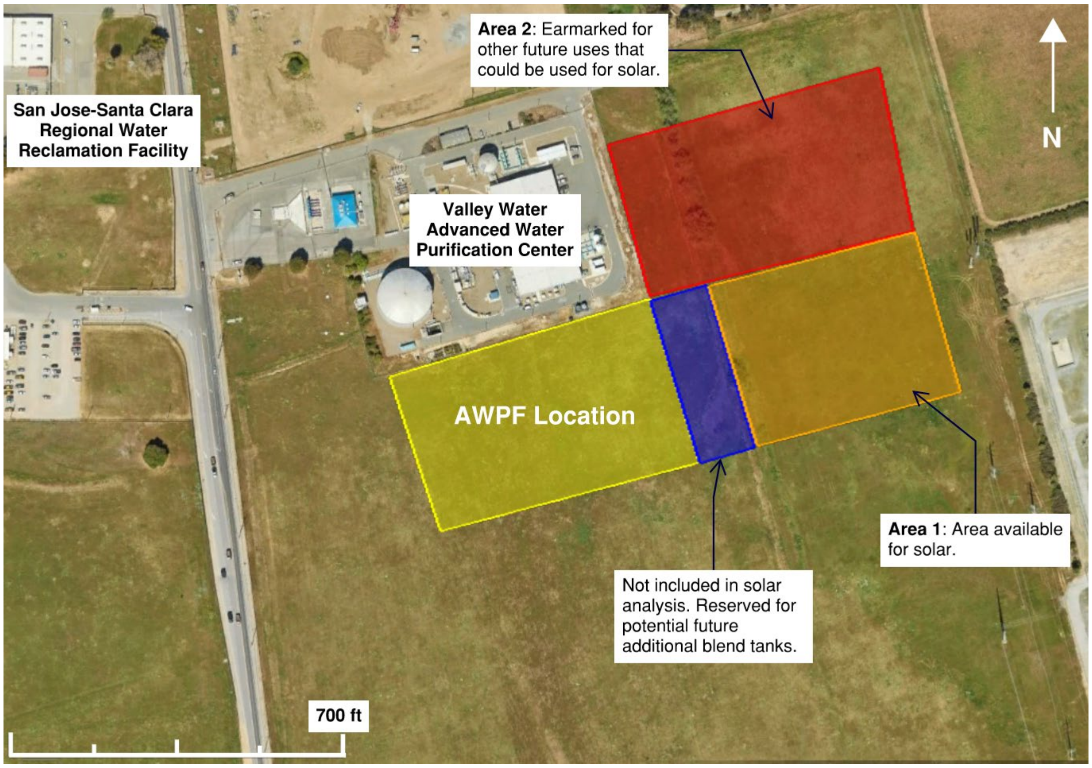


Figure ES.8 AWPF Site Layout With Adjacent Possible Solar Land Sites

Table ES.1 10 mgd Costs, Payback, and Percent Solar

	Capital Expenditure ($ in Millions)	Capital Expenditure(1) after 30% Federal Tax Credit ($ in Millions)	Levelized Cost of Energy(2,3) ($/kWh)	Payback(3,4) (years)	Renewable Fraction(5) (%)
Base Case	-	-	$0.225	-	-
Battery Only	$2.05	$1.44	$0.224	10.4	0.0
Site Only (1,000 kW)					
Solar + Battery	$5.58	$3.91	$0.223	15.2	10.0
Solar Only	$3.53	$2.47	$0.223	14.5	10.4
Site + Area 1 (1,700 kW)					
Solar + Battery	$8.05	$5.64	$0.219	13.8	17.3
Solar Only	$6.00	$4.20	$0.219	12.8	17.7
Site + Area 1 + Area 2 (2,600 kW)					
Solar + Battery	$11.23	$7.86	$0.214	13.1	26.4
Solar Only	$9.18	$6.42	$0.212	12.3	26.6

Notes:
Abbreviations: $ - dollars; $/kWh - dollars per kilowatt hour; kW - kilowatt.
(1) The total installation cost at the beginning of the project.
(2) Levelized cost of energy: average cost per kilowatt hour (kWh) of electrical energy of the system (both solar and purchased).
(3) The levelized cost of energy and payback take into consideration a 30 percent Federal Tax Credit (or similar incentive if constructed after 2032).
(4) The number of years it will take to recover the difference in investment costs including annual operations and maintenance (O&M) costs compared to the base case, i.e., the number of years for the project to pay for itself.
(5) The percentage of renewable energy (i.e., solar) versus grid purchases.

Table ES.2 20 mgd Costs, Payback, and Percent Solar

	Capital Expenditure ($ in Millions)	Capital Expenditure(1) after 30% Federal Tax Credit ($ in Millions)	Levelized Cost of Energy(2,3) ($/kWh)	Payback(3,4) (years)	Renewable Fraction(5) (%)
Base Case	-	-	$0.221	-	-
Battery Only	$2.05	$1.44	$0.222	8.9	0.0
Site Only (1,000 kW)					
Solar + Battery	$5.58	$3.91	$0.221	13.7	5.0
Solar Only	$3.53	$2.47	$0.222	13.9	5.2
Site + Area 1 (1,700 kW)					
Solar + Battery	$8.05	$5.64	$0.219	12.9	8.6
Solar Only	$6.00	$4.20	$0.220	12.6	8.8
Site + Area 1 + Area 2 (2,600 kW)					
Solar + Battery	$11.23	$7.86	$0.217	12.4	13.2
Solar Only	$9.18	$6.42	$0.218	12.0	13.4

Notes:
Abbreviations: $ - dollars; $/kWh - dollars per kilowatt hour; kW - kilowatt.
(1) The total installation cost at the beginning of the project.
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(4) The number of years it will take to recover the difference in investment costs including annual operations and maintenance (O&M) costs compared to the base case (i.e., the number of years for the project to pay for itself).
(5) The percentage of renewable energy (i.e., solar) versus grid purchases.

ES.6 Discharge Analysis

An analysis was conducted to determine if there are any potential constituents in the ROC that could cause an exceedance of the existing discharge permit if ROC is added to the existing RWF outfall. The analysis is intended as a preliminary step that will inform future additional work to evaluate the impacts of ROC discharge.

Based on defined assumptions for treatment performance, ROC concentrations were estimated based on 95th percentile tertiary effluent data. For the 10 mgd production scenario, 12.5 mgd of RWF effluent would be available for blending in the existing outfall based upon a total available flow of 25 mgd to the project (12.5 mgd used to produce 10 mgd of purified water, 12.5 mgd used to dilute ROC). It is expected that this blending is sufficient to prevent exceedances of the existing discharge limits. However, for the 20 mgd production scenario, no RWF effluent would be available for blending with the ROC. In this case, there are a number of constituents that could exceed discharge limits. This is not anticipated to be a fatal flaw for a DPR project, and the following strategies are presented in Chapter 6 to mitigate this issue:

- **Negotiation of mass-based limits to utilize the existing RWF outfall:** Mass-based limits, rather than concentration-based limits, will allow for a higher volume of ROC to be discharged to the existing outfall. Efforts to utilize the existing outfall generally would require additional modeling to refine dilution factors for constituents that show potential to violate the existing permit as well as ongoing conversations and negotiations with the permitting entity (the Regional Water Quality Control Board [RWQCB]).

- **New discharge permit via a separate outfall:** Construct a new outfall with a new permit for ROC discharge. Decoupling the ROC from the existing RWF discharge will allow for more operational independence compared to a shared discharge point.
- **Natural treatment for ROC:** The following natural treatment strategies would also require a new discharge permit:
  - **Engineered wetlands:** Utilization of vegetation to naturally uptake and remove pollutants from the ROC stream to create a wetlands habitat and decrease pollutants to the Bay.
  - **Ecotone/horizontal levees:** Creates hydraulic gradient between the ROC entry and discharge points to result in a combination of sub surface seepage and surface flow. Along the way, pollutants are removed through uptake in the plants and soil comprising the levee.

ES.7 DPR Implementation Plan and Next Steps

Recent work by the National Water Research Institute (NWRI) provided water utilities with a clear vision of the steps and approach necessary to implement DPR[1]. That work, co-authored by Carollo Engineers, Inc. (Carollo), is titled *DPR Implementation Guide for California Water Utilities* (NWRI Guide). This report builds on this work to describe the timeline for DPR implementation, including the ***phases*** of a DPR project, then describe the key ***elements*** for DPR success defined by the NWRI Guide. For each key element, example action items are provided, along with the project phase where they might occur. The timeline to implement a potable reuse project can vary greatly depending on the urgency and need, the regulatory climate, and the specific project details. The goal of the DPR implementation timeline and approach is to provide perspective on key project elements and how they might fit within an overall project delivery timeline.

The DPR timeline, presented in Figure ES.9, has been divided into four ***phases***: planning, demonstration and public outreach, implementation, and operations/operator training. Although these phases are ordered generally in sequence, there is overlap between them and some activities continue throughout the life of the project. Throughout the implementation timeline there are elements that can result in schedule delays or increased uncertainty; these challenges, such as consensus on the project, water supply need, and public perception, are discussed in further detail in Chapter 7.

[1] State Water Resources Control Board (SWRCB) (2016). Evaluation of the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse. Prepared by NWRI for the State (of California) Water Resources Control Board.

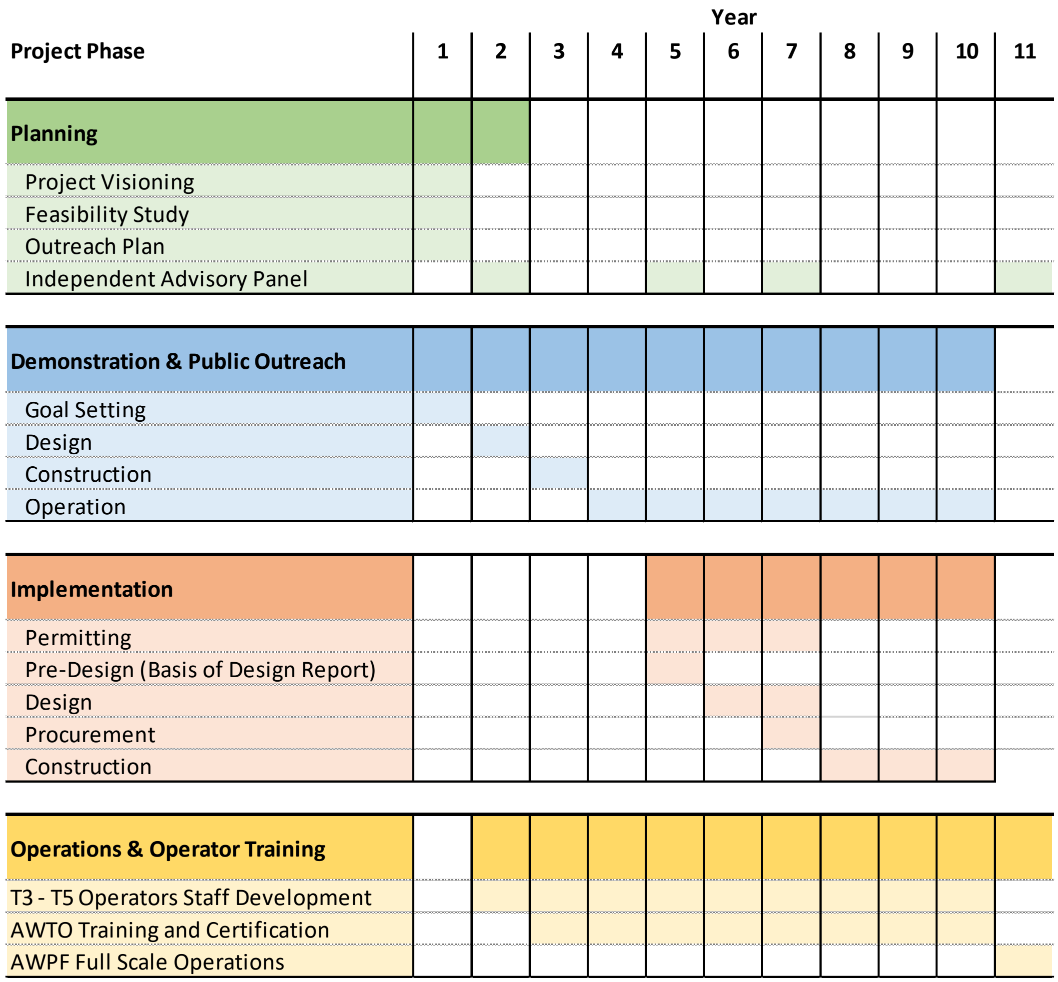

Figure ES.9 Potential DPR Implementation Timeline Based on Four Main Project Phases

The NWRI Guide incorporated perspectives from state and federal resources, published and ongoing research studies, and a number of California utilities to summarize the essential principles of DPR. The 2021 NWRI Guide includes specific elements that are key for DPR success, including technical, operational, managerial, and regulatory elements. These 13 elements are summarized in Chapter 7 and provide valuable perspective on the necessary components of DPR implementation. The chapter also links the project elements to the main phases of the DPR project timeline to illustrate how these elements fit within the overall project timeline.

This report focuses upon the treatment and infrastructure necessary to implement DPR. There are other elements of a DPR project that require further evaluation and cost analysis, which could be done as part of the next steps for this project. These include:

- **Enhanced source control program (ESCP):** The ESCP builds upon existing industrial waste pretreatment programs and is required by the California Division of Drinking Water (DDW)
- **Pilot testing of DPR treatment:** Pilot testing of the proposed advanced treatment systems can be used to (a) refine design criteria, (b) train operations staff, (c) public engagement, and (d) regulatory permitting

- **Independent Advisory Panel (IAP):** An IAP is required by DDW for a DPR project. Such an IAP would have experts in various types of engineering and public health and provide valuable independent guidance to a DPR project
- **California Environmental Quality Act (CEQA) reporting and other required environmental documentation:** Necessary with any project of this magnitude
- **Development of an operator training program:** DDW will require a robust operations staff with Advanced Water Treatment certification

Further discussion on next steps for this project can be found in Chapter 7.

ES.8 Planning Level Cost Estimates

Estimated costs for implementing either the 10 mgd production or 20 mgd production scenarios include costs associated with both infrastructure and treatment. Both of these costs are detailed in their respective report chapters (Chapter 3 for treatment costs and Chapter 4 for infrastructure costs). However, an overall cost summary is provided here for reference.

ES.8.1 Project Capital Costs

Project capital costs are divided into two key categories:

- Infrastructure costs
- Treatment costs

Infrastructure costs include the cost to transfer effluent (filtered but not disinfected) from the RWF to the new AWPF facility, transfer ROC to the existing RWF outfall (see Chapter 6 for further details), and transfer finished water to the three distribution systems (San José, Santa Clara, and SFPUC). Treatment costs include all costs associated with constructing the treatment needed to create water fit for DPR. A summary of these total project costs, as well as annualized costs, are shown in Table ES.3.

Table ES.3 Capital Cost Estimates

Cost Type	Alternative Cost ($M)	
	10 mgd Production	20 mgd Production
Infrastructure Costs	$111.21	$218.26
Treatment Costs	$209.73	$365.29
Total Project Capital Cost	**$320.94**	**$583.55**
Annualized Total Project Cost(1)	**$17.45**	**$31.73**

Notes:
Abbreviations: $M - dollars in millions; mgd - million gallons per day.
(1) Calculated assuming an interest rate of 3.5 percent and annualized over 30 years.

ES.8.2 O&M Costs

O&M costs were also developed for the two proposed AWPF facility scenarios. These O&M costs include power consumption, chemical consumption, maintenance, and staffing. These costs are divided into the following categories:

- Infrastructure costs
- Treatment costs

A summary of these O&M costs is shown in Table ES.4.

Table ES.4 O&M Cost Estimates

Cost Type	Alternative Cost ($M)	
	10 mgd Production	20 mgd Production
Annual Infrastructure O&M	$2.26	$5.39
Annual Treatment O&M	$14.90	$25.80
Total Annual O&M	**$17.16**	**$31.19**

Notes:
Abbreviations: $M - dollars in millions; mgd - million gallons per day; O&M - operations and maintenance.

ES.8.3 Unit Costs

Unit costs were developed in dollars per million gallons (MG) of finished water produced and dollars per acre-foot of finished water produced for each alternative. These unit costs are shown in Table ES.5. Note that these unit costs do not account for the addition of solar. See Chapter 5 for details on cost associated with a number of solar addition options.

Table ES.5 AWPF Unit Cost Estimates

Cost Type	Alternative	
	10 mgd Production	20 mgd Production
$/MG(1,2)	$9,700	$8,600
$/acre-foot(1,2)	$3,200	$2,800

Notes:
Abbreviations: $/acre-foot - dollars per acre-foot; $/MG - dollars per million gallons; mgd - million gallons per day.
(1) Calculated using the annualized capital cost, annual operations and maintenance (O&M) cost, and assuming the facility is running at capacity 365 days per year.
(2) These unit costs do not include any solar analysis. See Tables ES.1 and ES.2 for anticipated solar cost savings.

Chapter 1

INTRODUCTION

1.1 Background and Purpose

The San Francisco Public Utilities Commission (SFPUC) provides drinking water services to 2.7 million residents and businesses in San Francisco, Alameda, San Mateo, and Santa Clara counties. Like many utilities in drought-impacted California, SFPUC is proactively searching for sustainable measures to secure a safe, reliable, and long-term drinking water supply for their communities and partner agencies. The cities of San José and Santa Clara are interruptible customers of SFPUC, meaning that deliveries from the SFPUC are subject to reduction or termination if sufficient water supplies from the SFPUC are not available. San José and Santa Clara are seeking permanent status from SFPUC to support projected future water demands.

This South Bay Purified Water Project (Project) evaluates the feasibility of purified water using treated effluent from the San José-Santa Clara Regional Wastewater Facility (RWF). Purified water would be provided to San José and Santa Clara in all years, and to the SFPUC for the benefit of all its customers during dry years when supply shortages are anticipated.

1.2 Project Summary

The California Division of Drinking Water (DDW) anticipates finalizing direct potable reuse (DPR) regulations in the State by the end of 2023 for adoption in 2024. This project assesses the current draft DPR regulations to determine the feasibility of the construction of an Advanced Water Purification Facility (AWPF) at the RWF, producing purified water serving the Cities of San José and Santa Clara as well as customers of the SFPUC Regional Water System (RWS).

This Project evaluates the treatment, infrastructure, and power needs of two DPR production capacities (10 and 20 million gallons per day [mgd]). The two DPR project sizes analyzed involve the construction of an AWPF adjacent to the RWF, treating the tertiary effluent that, after disinfection, is normally discharged to the San Francisco Bay (SF Bay). The AWPF would treat the RWF's undisinfected tertiary effluent after it is treated by tertiary filtration (but before chlorination) to stringent drinking water standards and to meet the current draft regulations for DPR in California. This project analyzed three connection points where the purified water would be introduced into the Cities of San José and Santa Clara's local distribution system as well as SFPUC's RWS via the Bay Division Pipeline (BDPL). Purified water will be blended prior to entering each of the three distribution systems.

To confidently result in an AWPF finished water[1] that meets the DDW draft standards, the recommended treatment train includes the following processes:

- Ozone
- Biological activated carbon (BAC)
- Ultrafiltration (UF)

[1] Finished water and purified water both refer to potable water produced by the AWPF process. While these terms can be used interchangeably, "finished water" is used typically in reference to the treatment train and deliveries, whereas "purified water" is used more independently in reference to the overall project and customer needs.

- Reverse osmosis (RO)
- Ultraviolet (UV) light advanced oxidation process (AOP) using free chlorine as the oxidant
- Free chlorination
- Secondary UV disinfection
- Stabilization

The treatment train also includes adding several different chemicals to adjust for alkalinity and pH and improve process operation. Figure 1.1 shows a preliminary process flow diagram of this highly engineered treatment train.

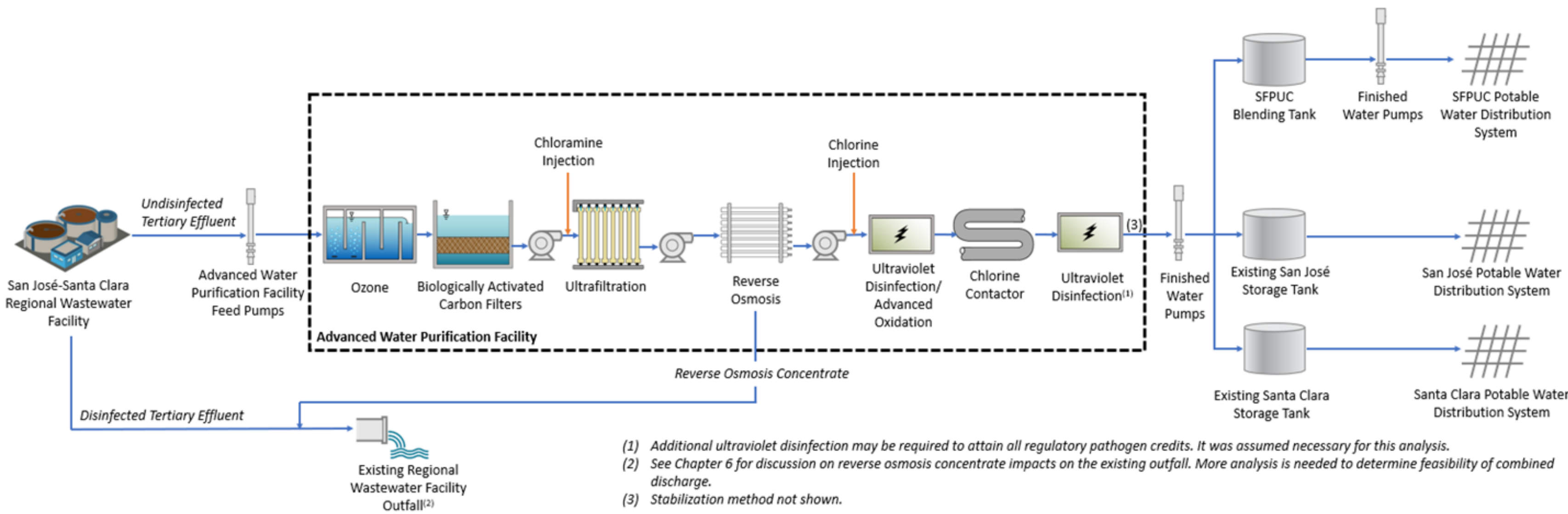

Figure 1.1 Proposed Treatment Train for the South Bay Purified Water Project

1.3 Topics Covered in This Report

This report summarizes the analysis that was done for this DPR evaluation, covering the following topics:

- Regulatory summary:
  - Current potable water reuse regulations
  - Draft DPR regulations for California
- Treatment and monitoring systems:
  - **Feedwater analysis:** Available flows and water quality for an AWPF feed
  - **Treatment train analysis:** Recommended treatment train, monitoring systems, and AWPF layouts
  - **Costs:** Summary of expected AWPF capital and operations and maintenance (O&M) costs
- Conveyance infrastructure:
  - **Reverse osmosis concentrate (ROC) infrastructure:** Infrastructure for transfer of ROC to the existing RWF outfall and discussion of other potential disposal methods for ROC
  - **Feedwater infrastructure:** Infrastructure for transfer of effluent from the RWF to the proposed AWPF
  - **Finished water infrastructure:** Delivery methods for purified water into SFPUC, City of San José, and City of Santa Clara's potable water systems
  - **Infrastructure costs:** Summary of expected infrastructure capital and O&M costs
- Power needs:
  - Summary of expected power usage for AWPF treatment and associated infrastructure
  - Analysis of land available for solar, associated solar production capacity, and costs
- National Pollutant Discharge Elimination System (NPDES) discharge analysis:
  - Anticipated water quality of the ROC
  - Analysis of the RWF's existing NPDES permit and discussion of anticipated compliance challenges associated with the discharge of ROC to the SF Bay
- DPR implementation plan:
  - DPR implementation timeline, including identification of four major project phases and potential schedule challenges
  - Outline of major aspects of a successful potable reuse program using the National Water Research Institute's (NWRI) 2021 *DPR Implementation Guide for California Water Utilities* (NWRI Guide)
  - Anticipated technical challenges for DPR implementation

1.4 Background Documentation

An early step on the Project was the review of existing documentation and materials to inform this new analysis. The reviewed materials were from similar adjacent work (such as the Valley Water Advanced Water Purification Center [AWPC]). The reviewed materials also helped the project team better understand the treatment and infrastructure needs that would be required for the proposed purified water project. Documentation reviewed includes the following:

- The 2021 Countywide Water Reuse Master Plan prepared by Brown and Caldwell for Valley Water
- Existing RWF NPDES permit documentation including considerations for future permit changes
- Five years of data of available filtered tertiary water quality and quantity from the RWF

- Summary and location of existing San José and Santa Clara drinking water reservoirs including operating volumes
- Map of the existing SFPUC RWS

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Chapter 2

REGULATORY SUMMARY

2.1 Introduction

This chapter provides an overview of the anticipated requirements for direct potable reuse (DPR) as they are laid out in the latest draft regulations (issued August 2021), expert panel comments and responses (issued June 2022), and requested changes from WateReuse California to the Division of Drinking Water (DDW) (dated February 13, 2023). This series of documentation allows for perspective and expert input on the anticipated treatment needs for DPR compared to conventional indirect potable reuse (IPR) projects. This chapter also highlights a number of key challenges that must be overcome for successful DPR implementation.

2.2 Background and Context

The DPR regulations build on the public health protection requirements from IPR and incorporate:

- New elements to account for the loss of an environmental buffer (e.g., a groundwater basin or surface water reservoir)
- New information on pathogen concentrations
- Safety factors for unknown or undetected chemical constituents

Water recycling and potable reuse in California fall under the jurisdiction of the State Water Resources Control Board (SWRCB). Within the SWRCB, two departments are responsible for protecting public health and the environment with respect to water: (1) the DDW; and (2) the Regional Water Quality Control Boards (RWQCBs). DDW regulates public drinking water systems and is responsible for developing regulations for recycled water and for reviewing recycled water projects. The RWQCBs, which are divided into regions across the state, develop and enforce water quality objectives and implementation plans to protect the beneficial uses of the state's waters, and write the permits for recycled water projects.

2.3 Pathways for Potable Reuse

The four main pathways to potable reuse in California include groundwater replenishment (GWR), surface water augmentation (SWA), raw water augmentation, and treated drinking water augmentation (TWA). GWR and SWA are both forms of IPR, while raw water augmentation and TWA are forms of DPR.

2.3.1 Overview of Groundwater Replenishment

GWR, a form of IPR, has been practiced successfully in California since the 1970s. Final regulations have been in place for GWR since 2014, although they existed in draft form prior to that for almost 40 years.[1] GWR can take two forms–surface spreading, which entails percolating tertiary effluent through spreading basins, and direct injection, which entails injecting purified water directly into an aquifer. A schematic for GWR via direct injection is shown in Figure 2.1.

[1] SWRCB (2018) Regulations Related to Recycled Water. Sacramento, CA. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/rwregulations.pdf

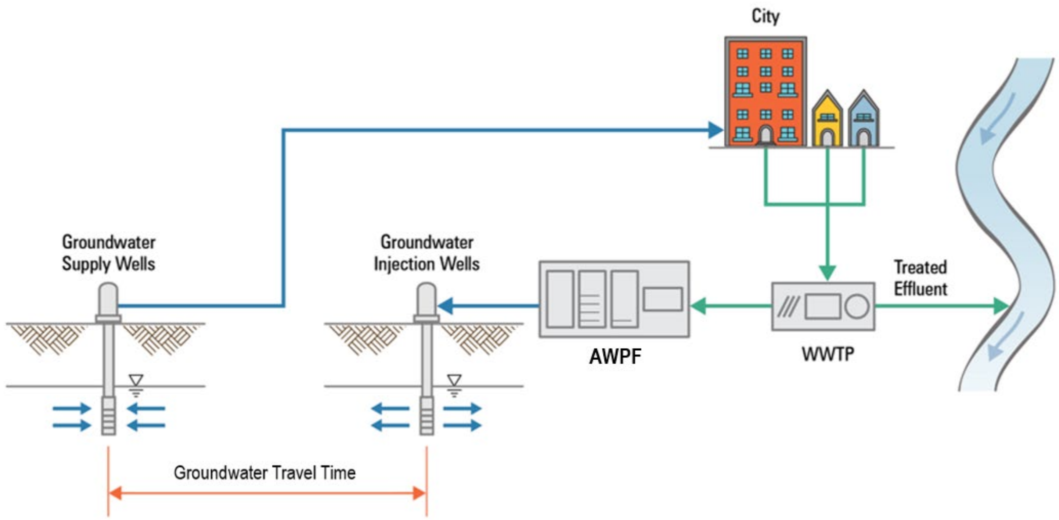

Figure 2.1 Schematic of IPR via GWR

2.3.2 Overview of Surface Water Augmentation

In 2018, DDW finalized its regulations for IPR via SWA. SWA entails augmenting an existing drinking water reservoir with purified water, and later treating that water at a water treatment plant prior to serving it to customers. Regulatory considerations for SWA consider many of the same elements as GWR, but also include new requirements to account for the lack of experience with this type of project and the complexities introduced by the use of a surface water reservoir. A schematic for SWA is shown in Figure 2.2.

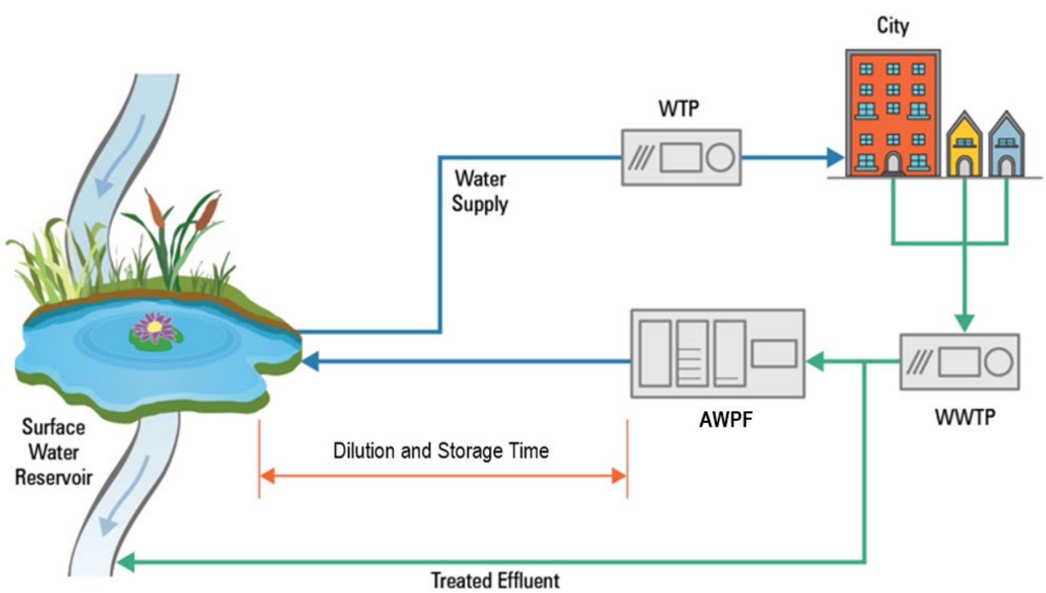

Figure 2.2 Schematic of IPR via SWA

2.3.3 Overview of Raw Water Augmentation

The DDW is developing regulations for DPR via raw water augmentation and TWA. A proposed timeline for the release of these regulations is discussed in Section 2.4. Raw water augmentation adds purified water to the feedline of an existing water treatment plant where it is blended with raw water. The blended water treated is at the water treatment plant prior to delivering it to customers. A schematic for raw water augmentation is shown in Figure 2.3.

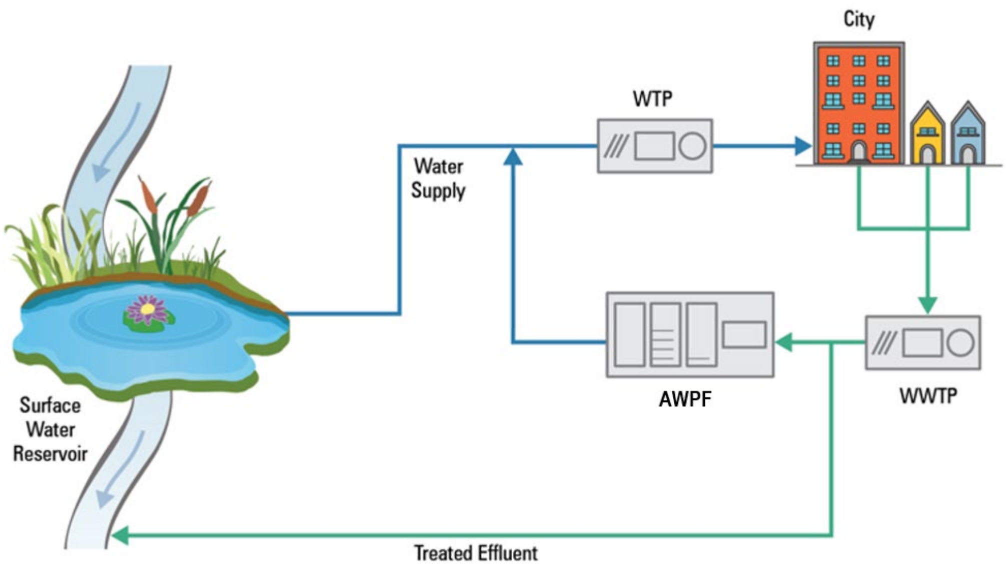

Figure 2.3 Schematic of DPR via Raw Water Augmentation

2.3.4 Overview of Treated Drinking Water Augmentation

As noted, the DDW is developing regulations for DPR via raw water augmentation and TWA. A proposed timeline for the release of these regulations is discussed in Section 2.4. TWA adds purified water directly into an existing drinking water distribution system. A schematic for TWA is shown in Figure 2.4.

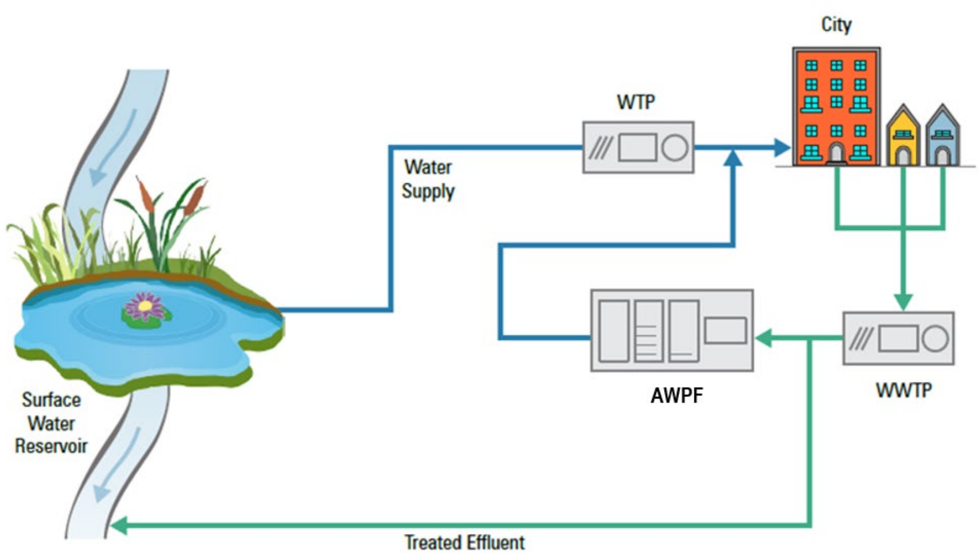

Figure 2.4 Schematic of DPR via TWA

2.4 Draft Regulations for DPR

Based on discussions with the project team, the focus of this effort is TWA. Accordingly, this regulatory summary excludes considerations specific to raw water augmentation.

There is currently one municipal scale operating DPR system in the country in Big Spring, Texas which has been in operation since 2014. The Big Spring facility sends purified water into a raw water supply ahead of a water treatment plant (i.e., raw water augmentation). There is one other DPR project in development in the United States, namely the El Paso TWA project, which has procured a contractor and will break ground in 2024. There are currently no operating DPR systems in California, although several agencies, including Metropolitan Water District and the City of Los Angeles, are in the midst of DPR project planning. Currently both agencies are pilot testing treatment technologies and developing long-term plans for combined IPR/DPR projects. At this point, given the novelty of DPR in California, any DPR project proposed will be on the leading edge and need to work closely with DDW.

Regulations for DPR in California are not yet finalized but are well developed. Assembly Bill 574 was signed into law in October 2017 and requires that DDW develop raw water augmentation regulations by December 2023. Since then, DDW has published a proposed framework and a second edition framework stating that they intend both raw water augmentation and TWA to be regulated under one uniform regulation published in 2023[2]. In August 2021, DDW published Addendum version 8-17-2021 to A Framework for Direct Potable Reuse[3], which provides the second draft of regulations as they might be housed within a new Article under the Surface Water Treatment chapter of Title 22 of the California Code of Regulations. The regulations are still under an iterative review and revision process by DDW and an expert panel. This report encompasses expert panel comments and DDW responses dated June 2022.[4] In February 2023, a meeting with DDW and the DPR working group of WateReuse California established an updated anticipated timeline of release and adoptions of DPR regulations. It is anticipated that updated draft regulations will be released in mid-2023 with a 45-day public comment period. After review and update, the DDW will adopt the regulations in late 2023. DPR regulations will be formally complete after the Office of Administrative Law reviews and publishes them, likely to occur in Spring of 2024.

The current draft regulations (June 2022) contain extensive requirements for treatment, monitoring, source control, reporting, and more. The framework remains similar to what has been promulgated for IPR, i.e., GWR and SWA, but many of the requirements have been made more stringent, and new elements have been introduced. It is important to note that they are still in draft form, and the final version of the regulations may look different. With that in mind, the key elements of the draft regulations are defined below, with a comparison summary of IPR and draft DPR regulations in Table 2.1.

It is also important to note that during the February 2023 meeting with DDW and the DPR working group of WateReuse California additional changes to the regulations were discussed, although an update to the draft regulations was not presented. These discussed changes are not included in the regulation summary below

[2] SWRCB (2019). A Proposed Framework for Regulating Direct Potable Reuse in California, Second Edition. Prepared by the State of California Water Resources Control Board Division of Drinking Water, August 2019.
[3] SWRCB (2021). A Proposed Framework for Regulating Direct Potable Reuse in California, 2nd Edition Addendum: Early Draft of Anticipated Criteria. August 17, 2021.
[4] SWRCB (2022). DDW Response to "Expert Panel Preliminary Findings, Recommendations, and Comments on the Draft DPR Criteria (dated August 17, 2021)" in the Memorandum of Findings Submitted by National Water Research Institute (NWRI) dated March 14,2022.

since no updated regulations we issued. However, a summary of the February 2023 discussion includes the following potential regulation changes:

- Including waivers for reduced monitoring for non-detect chemicals
- Allowing two additional log removal credits for small reservoirs
- Allowing groups of agencies to jointly conduct a Quantitative Risk Assessment
- Include an early warning system instead of sewershed monitoring in the collection system
- Increased flexibility to the biological activated carbon (BAC) process
- A total organic carbon (TOC) monitoring frequency of 15 minutes
- Advanced Water Treatment Operator (AWTO) requirements will be specific to chemical control processes instead of pathogen control

Table 2.1 Summary Comparison of Key Regulatory Requirements for GWR, SWA, and DPR – TWA

	GWR	SWA	DPR – TWA
Project Structure and Interagency Coordination	• Main entity is project sponsor	• Involves both a Water Recycling Agency and a Public Water System • Joint Plan required	• DiPRRA is the public water agency responsible for project • Joint Plan required
Source Control	• Requires industrial pretreatment and pollutant source control program including: – Assessment of the fate of site-specific chemicals through the wastewater and recycled water treatment systems – Monitoring and investigation of chemical sources – Outreach program to minimize discharge of chemicals into the feedwater	• Requires industrial pretreatment and pollutant source control program including: – Assessment of the fate of site-specific chemicals through the wastewater and recycled water treatment systems – Monitoring and investigation of chemical sources – Outreach program to minimize discharge of chemicals into the feedwater	• Requires ESCP • All elements of source control as needed for IPR • Quantitative evaluation of chemicals discharged to collection system • Online monitoring that may indicate a chemical peak resulting from an illicit discharge • Coordination with the pretreatment program for notification of discharges above allowable limits • Monitoring of local surveillance programs to determine when community outbreaks of disease occur • Form a source control committee and institute a continuous improvement process for the feedwater
Feedwater Monitoring	None	None	• Prior to operation, 24 months of monthly feedwater monitoring for regulated contaminants (i.e., those with an MCL), priority pollutants, NLs, a specific list of solvents, DBPs, and DBP precursors
Pathogen Control	• 12-log enteric virus • 10-log Giardia • 10-log Cryptosporidium	• 12 to 14-log enteric virus • 10 to 12-log Giardia • 10 to 12-log Cryptosporidium	• 20-log enteric virus • 14-log Giardia • 15-log Cryptosporidium

	GWR	SWA	DPR – TWA
Treatment Train	• RO + UV/AOP required	• RO + UV/AOP required	• Ozone/BAC + RO + UV/AOP required in this order
Chemical Control	• Maximum recycled water TOC contribution of 0.5 mg/L • Must meet all current drinking water standards, including MCLs, DBPs, and ALs. Quarterly monitoring	• Maximum recycled water TOC contribution of 0.5 mg/L • Must meet all current drinking water standards, including MCLs, DBPs, and ALs. Quarterly monitoring	• Maximum effluent TOC contribution of 0.5 mg/L; additional more stringent TOC thresholds with response actions • Must meet all current drinking water standards, including MCLs, DBPs, and ALs. Monthly monitoring • Control of one-hour chemical spike • Continuous monitoring of nitrate and nitrite in RO permeate
Additional Monitoring	• Quarterly sampling in recycled water and downgradient groundwater 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 sMCLs, 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 feedwater, directly after oxidation process, and finished water for: – Monthly: All MCLs, sMCLs, NLs, priority toxic pollutants, action levels, DBPs and DBP precursors, and specified solvents – Quarterly: Chemicals known to cause cancer or reproductive issues for at least three years • Weekly monitoring of nitrate, nitrite, perchlorate, and lead in the finished water only
Environmental Buffer	• Minimum aquifer retention time of 2 months	• Initial minimum reservoir hydraulic retention time of 6 months; potential to reduce down to 2 months with additional pathogen control • Initial minimum reservoir dilution of 10:1, 1 LRV of pathogen treatment added if dilution is <100:1	• No environmental buffer

	GWR	SWA	DPR – TWA
Response Time	• Minimum aquifer response retention time of 2 months	None	• The system must be designed to meet certain response time requirements to ensure that diversion and/or shutoff can occur in the event of a failure to meet the pathogen and/or chemical control requirements • If a failure is identified, the system must divert or shut off before 10 percent of the off-spec water reaches the diversion or shutoff point
Operations	None	None	• AWTO Grade 5 required on site at all times, with some exceptions for remote operations allowed • All facility operators must be AWTO certified
Plans	• Engineering Report • Operations Optimization Plan	• Joint Plan • Engineering Report • Operations Plan • Plan to address impacts to water treatment plant and distribution system	• Joint Plan • Water Safety Plan • Engineering Report • Operations Plan • Pathogen and Chemical Control Point Monitoring and Response Plan • Monitoring Plan • Corrosion Control and Stabilization Plan • Additional Reporting (climate change)
Reporting	• Annual compliance reporting	• Annual compliance reporting	• Monthly compliance reporting

Notes:
Abbreviations: AL - action level; AOP - advanced oxidation process; AWTO - Advanced Water Treatment Operator; BAC - biological activated carbon; DBP - disinfection byproduct; DiPRRA - direct potable reuse responsible agency; DPR - direct potable reuse; ESCP - enhanced source control program; GWR - groundwater replenishment; IPR - indirect potable reuse; LRV - log removal value; MCL - maximum contaminant level; mg/L - milligrams per liter; NL - notification level; RO - reverse osmosis; sMCL - secondary maximum contaminant level; SWA - surface water augmentation; TOC - total organic carbon; TWA - treated drinking water augmentation; UV - ultraviolet.

2.4.1 Project Structure and Interagency Coordination

Like IPR, DPR projects will require the participation of both water and wastewater agencies. Because DPR projects produce drinking water, the regulations define the DiPRRA as a public water agency that is responsible for using municipal wastewater for treatment and provides DPR project water, in this case directly for distribution. The DiPRRA could be a single agency or a multi-agency joint powers authority. The DiPRRA could also be a private water company. Any of the three entities (or a combination of the three) could serve as the DiPPRA. It may be most logical to have the cities of San José and Santa Clara serve jointly as the DiPPRA because the feedwater originates from the jointly operated San José-Santa Clara Regional Wastewater Facility (RWF), but this should be evaluated and discussed further should this project proceed to implementation.

The DiPRRA must prepare a Joint Plan describing all agencies involved in the DPR project, their roles and responsibilities, and procedures to implement the requirements of the DPR regulations. The plan must also describe procedures for corrective actions that may be taken in the event of a failure to meet the requirements, procedures for public notifications, and provisions for backup supply in the event that purified water is not available. If required by the SWRCB, a DiPRRA must utilize an Independent Advisory Panel (IAP) to conduct reviews of various project elements, including the ESCP, Water Safety Plans, and water quality data.

Of note, the DiPRRA need not be the entity that operates/maintains the wastewater source control program, wastewater treatment plant (WWTP), and advanced treatment facilities, though is responsible for the overall program management and control as well as final water quality.

2.4.2 Enhanced Source Control

The requirements for source control are more extensive than what is required for IPR projects and include the addition of either online monitoring or an early warning system in the sewershed (or potentially at the feed to the WWTP), as well as coordination with local health surveillance programs. An ESCP must be implemented by the wastewater management agency to limit contaminants in wastewater used in DPR projects. The source control program has several required elements, including investigation and monitoring of SWRCB-specified chemicals and contaminants and an outreach program to industrial, commercial, and residential dischargers within the service area contributing to the DPR project. In addition, contaminant concentrations in the feedwater must be evaluated and compared against public health goals or results of the United States Environmental Protection Agency (EPA) or analogous state agency conducted health risk assessments.

A sewershed surveillance program must also be implemented to provide early warning of a potential occurrence that could adversely impact the DPR treatment. It must include online monitoring that may indicate a chemical peak resulting from an illicit discharge, coordination with the pretreatment program for notification of discharges above allowable limits, and monitoring of local surveillance programs to determine when community outbreaks of disease occur.

2.4.3 Feedwater Quality Monitoring

For a DPR project, there are requirements for monitoring the feedwater. Prior to operation, the feedwater to a DPR project must be monitored monthly for a minimum of 24 months for regulated contaminants (i.e., those with a MCL, priority pollutants, NLs, a specific list of solvents, DBPs, and DBP precursors). Existing monitoring data meeting certain criteria may be substituted for 12 months of the required data. Appendix A lists the anticipated feedwater monitoring parameters.

2.4.4 Pathogen Control Requirements

DPR projects must address the same three classes of pathogens as IPR, but with higher levels of pathogen reduction required. Treatment and monitoring systems must be designed and validated to attain 20, 14, and 15-LRVs for virus, *Giardia*, and *Cryptosporidium*, respectively. The treatment train must consist of at least four separate treatment processes for each pathogen type (a single process can receive credit for multiple pathogens), and each credited process must demonstrate at least 1-log reduction of the target pathogen.[5] In addition, the treatment train shall consist of at least one physical separation process, one chemical disinfection process, and one UV disinfection process. For each treatment process that is proposed to receive pathogen reduction credit, a validation study must be conducted, and a report of the results must be submitted to the SWRCB.

2.4.5 Wastewater Treatment Requirements

The current draft DPR regulations do not specify performance criteria for the WWTP. However, there are some discussions about a potential requirement that the WWTP provides nitrification. The level of nitrification, and the related public health and operational benefits of nitrification, are not defined at this time. Accordingly, for this analysis we are assuming no modifications would be required of the existing RWF, which already provides nitrification.

2.4.6 Treatment Train Requirements

Additional prescriptions for required treatment have been included in the DPR regulations and are summarized below:

- In addition to RO and an AOP, as required for IPR, the treatment train for DPR must include ozone/BAC ahead of RO[6]. It must also subsequently include UV disinfection with a dose of at least 300 millijoules per centimeter squared (mJ/cm^2)
- The system must be designed to meet specific response time requirements to ensure that diversion and/or shutoff can occur in the event of a failure to meet the pathogen and/or chemical control requirements. If a failure is identified, the system must divert or shut off before 10 percent of the off-spec water reaches the diversion or shutoff point
- The ozone process must be designed to provide an ozone dose that results in a ratio of the applied ozone dose to the design feedwater TOC greater than 1.0 (after accounting for nitrite which exerts an ozone demand). Lower ozone to TOC ratios must be proven through pilot testing of performance
- The BAC process must be designed with an empty bed contact time (EBCT) of at least 15 minutes

2.4.7 Chemical Control Requirements

DPR product water must meet all existing standards for drinking water, and there is also a limit on RO permeate TOC. Requirements include:

- Monthly monitoring in the product water is required. Product water must meet all current drinking water standards, including MCLs, DBPs, and ALs, listed in Appendix A

[5] Per the June 2022 DDW Response to Expert Panel Comments, clarification was added to note that the ozone and BAC processes must each separately provide 1-log reduction.

[6] The latest version of the draft regulations has included a provision that allows for a treatment train without ozone/BAC, provided that the purified water comprises 10 percent or less of total water supplied on a continuous basis. Partial ozone/BAC treatment is allowable if purified water will comprise up to 50 percent of the total water supplies. For example, if the purified water were going to make up 25 percent of the water supplied, then approximately 75 percent of the purified water would need to be treated through ozone/BAC.

- The TOC shall not exceed 0.5 mg/L prior to distribution. TOC shall be monitored continuously, at an anticipated frequency of 15 minutes
- For the ozone process, at least one surrogate or operational parameter shall be monitored continuously to confirm a minimum of 1 log removal of carbamazepine and sulfamethoxazole are being met
- For the BAC process, at least one surrogate or operational parameter shall be monitored continuously to confirm a minimum of 1 log removal of formaldehyde and acetone are being met
- Continuous monitoring of the ozone feedwater for nitrate is required
- Nitrate and nitrite must be continuously monitored in the RO permeate. Continuous monitoring of lead and/or perchlorate may also be required if the required weekly grab samples indicate that it is justified. The control system must be designed to automatically divert purified water if there is an exceedance of the TOC limit, the nitrate MCL, and potentially levels for perchlorate and lead
- In order to address a potential chemical peak, the system must provide sufficient mixing at some point prior to distribution to attenuate a 1-hour elevated concentration of a contaminant by a factor of 10 (10:1 dilution). This dilution can occur at any point in the treatment and distribution process before the water is consumed. Examples include:
  - Peak attenuation within a WWTP, such as occurs with return activated sludge recycle streams
  - Peak attenuation in an equalization basin, such as primary equalization or tertiary effluent equalization
  - Peak attenuation within a distribution system, such as blending within a water storage reservoir before distribution to customers

2.4.8 Additional Monitoring Requirements

The additional monitoring requirements for IPR have been expanded for DPR to include additional locations and additional classes of chemicals. In addition, the frequency is increased to weekly or monthly for many chemicals. Extensive chemical monitoring is required on an ongoing basis in the feedwater to the DPR project, the effluent from the AOP, and the finished water prior to entering distribution.[7] In each location, monthly sampling is required for all MCLs, sMCLs, NLs, priority toxic pollutants, alert levels, DBPs and DBP precursors, and specified solvents, as listed in Appendix A. Weekly sampling is required for nitrate, nitrite, perchlorate, and lead. In addition, quarterly sampling is required for chemicals known to cause cancer or reproductive issues for at least three years.

The SWRCB last amended its Recycled Water Policy in 2018 with a revised list of contaminants of emerging concern (CECs) recommended for monitoring in potable water reuse projects.[8,9] The amendment contains a revised list of CECs recommended for monitoring in potable water reuse projects. CECs with health-based significance are assigned health-based screening levels, or monitoring trigger levels, which are designated for different types of potable reuse. The required monitoring locations for CECs and surrogates are such that health-based CEC monitoring follows treatment, prior to release to the pipeline, while performance-based

[7] DDW may allow for the finished water sampling location to be used to satisfy the requirement for the post-oxidation sampling point.

[8] SWRCB (2018) Regulations Related to Recycled Water. Sacramento, CA. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/rwregulations.pdf

[9] Updates were based on the 2018 reconvened science advisory panel published Monitoring Strategies for CECs in Recycled water, Recommendations of a Science Advisory Panel (Southern California Coastal Water Research Project, 2018).

CEC monitoring is typically at two locations: prior to RO (or AOP if RO does not substantially remove a CEC and is allowed by the RWQCB) and following all treatment prior to release to the pipeline.

2.4.9 Operations Requirements

The draft DPR regulations contain new requirements for AWTO. The AWTO certification goes from Grade 3 to Grade 5. In order to obtain AWTO certification, a Grade 3 water or wastewater treatment operator certification is needed. There must be one chief and one shift operator that are AWTO Grade 5 certified. An AWTO Grade 5 must be present on site at all times, except as described below. All operators at the advanced treatment facility must be AWTO certified (can be at any grade). The latest version of the draft regulations does allow for some degree of remote operations after 12 months of operation. The chief or shift operator must still be able to monitor operations and exert physical control over the treatment facility within a maximum of one hour.

2.4.10 Plans and Reporting

DPR projects will be required to prepare several plans that are not required for IPR projects. These plans provide extensive documentation of the public health protection elements of the system, and how any issues or failures will be addressed and mitigated. Compliance reporting to the SWRCB will be required on a monthly basis.

There are several plans that must be prepared prior to the operation of a DPR project; these plans must also be updated and maintained over time, and some require periodic review by the IAP. These include:

- **Joint Plan:** Describes all agencies involved in the DPR project, their roles and responsibilities, and procedures to implement the requirements of the DPR regulations. The Joint Plan also describes procedures for corrective actions that may be taken in the event of a failure to meet the requirements, procedures for public notifications, and provisions for backup supply in the event that purified water is not available
- **Water Safety Plan:** Requires project proponent to conduct a hazard analysis that considers all steps in the drinking water supply chain from wastewater source to consumer. The Water Safety Plan documents the result and describes risk management controls necessary beyond those outlined in these regulations (e.g., critical limits, monitoring, and corrective actions)
- **Engineering Report:** Details the design criteria of the DPR project as well as facilities, staffing, and support services required to continuously produce safe drinking water. The report must also include a third-party review of the DPR project design. The report must be reviewed and approved by the SWRCB and updated every five years to account for any design changes
- **Operations Plan:** Describes the operations, maintenance, and monitoring necessary for a DiPRRA to meet the regulatory requirements. The plan must also identify an ongoing training program covering several topics related to DPR operations. The plan must be reviewed and approved by the SWRCB
- **Pathogen and Chemical Control Point Monitoring and Response Plan:** Describes the monitoring and response for each treatment process used to comply with the LRV requirements. Describes online monitoring, control system, alarms and failure response actions, and other items. The plan must be reviewed and approved by the SWRCB
- **Monitoring Plan:** Describes monitoring conducted for ESCP, treatment process monitoring, chemical monitoring, and any other required monitoring. The Monitoring Plan also describes follow-up actions that will be taken in the event of an MCL or NL exceedance in the purified water. The plan includes schedules, laboratories used, analytical methods, quality assurance procedures,

calibration and verification plans, and other items. Reporting of the results of monitoring would be performed monthly, including all online and grab sample results

- **Corrosion Control and Stabilization Plan:** Describes how the DiPRRA and any other public water systems receiving finished water will address potential impacts resulting from the introduction of purified water into the distribution system
- **Additional Reporting:** Requires an annual, publicly available report detailing the DPR project's response to climate change. The report includes identified climate change threats and steps taken relative to the DPR project to adapt to these threats as well as mitigate greenhouse gas contributions to the atmosphere

The DiPRRA must submit monthly compliance reports to the SWRCB including a summary and results of the month's treatment plant compliance monitoring, including treatment performance records, summary of log reduction performance, any excursions outside approved operating limits, calibration records, equipment failures and corrective actions, analytical results of water quality monitoring, and other items.

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Chapter 3

TREATMENT AND MONITORING SYSTEMS

3.1 Introduction

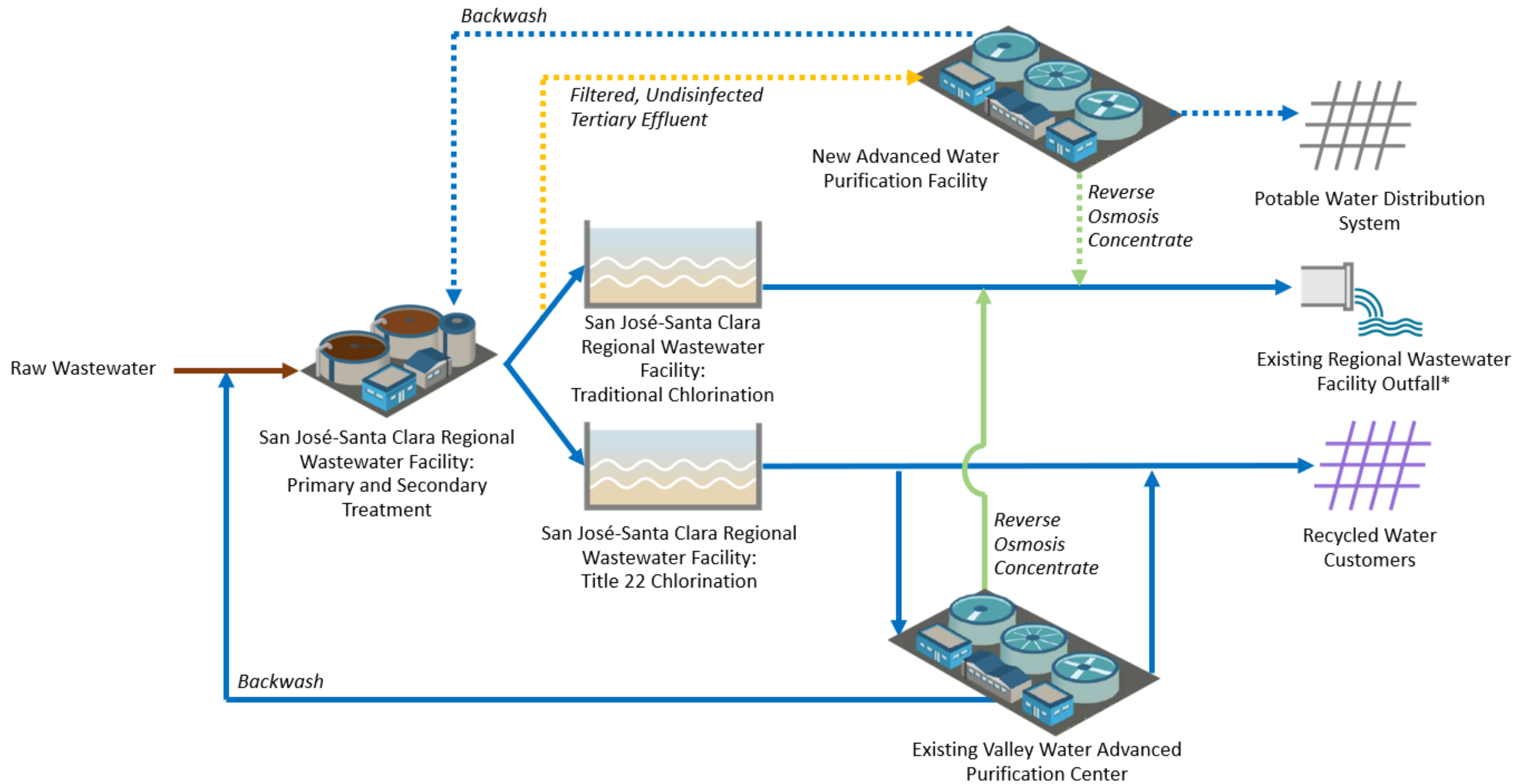
This chapter provides an overview of both the water quantity and water quality that may be available for a new Advanced Water Purification Facility (AWPF) from the San José-Santa Clara Regional Wastewater Facility (RWF). It was assumed that filtered undisinfected tertiary effluent would be used for AWPF feedwater.

Within this chapter the water quality and quantity information is used to size and cost a direct potable reuse (DPR) treatment train. Two size scenarios were considered: 1) production of 10 million gallons per day (mgd) of purified water for treated drinking water augmentation (TWA), and 2) production of 20 mgd of purified water for TWA.

3.2 DPR Feedwater Analysis

The purpose of the DPR feedwater analysis is to characterize the typical feedwater quality and quantity available for a new AWPF. The influent quality and quantity will be used to properly size the AWPF's treatment and infrastructure components.

The feedwater for the AWPF will be a nitrified, filtered, and undisinfected tertiary effluent from the RWF. A filtered, tertiary effluent that has removed/reduced the solids ahead of ozone and biofiltration results in greater efficiency of these processes. Undisinfected effluent is preferred because disinfected effluent will have chlorine residual, which impacts ozone treatment efficacy. The current configuration of the RWF does not allow for filtered undisinfected tertiary effluent to be pulled off the treatment train. There is a planned capital improvements project to replace the filter and disinfection facilities. The design of this replacement could accommodate this future reuse project and allow undisinfected tertiary effluent to be pulled off and conveyed to the AWPF. If it is not possible to pull undisinfected tertiary effluent off the RWF treatment train, disinfected tertiary effluent would need to be utilized at the AWPF. Figure 3.1 schematically illustrates the process flows for the RWF, Valley Water Advanced Water Purification Center (AWPC), and the potential new AWPF.



** See Chapter 6 for discussion on reverse osmosis concentrate impacts on the existing outfall. More analysis is needed to determine feasibility of combined discharge.*

Figure 3.1 Overall Process Flow Diagram for the RWF, Valley Water AWPC, and AWPF

3.2.1 Feedwater Quality

The RWF effluent discharge permit and past water quality data were evaluated to characterize both the allowed discharge limits and the typical range of effluent water quality.

3.2.1.1 RWF Effluent Permit

The RWF currently discharges disinfected filtered tertiary effluent to Artesian Slough, a tributary to southern San Francisco Bay (SF Bay) via Coyote Creek. Because Artesian Slough is a shallow water, dead-end slough supporting biologically sensitive habitats, no dilution credit is awarded for most pollutants, except for cyanide and chronic toxicity, each receiving a credit of 3:1 dilution. The RWF National Pollutant Discharge Elimination System (NPDES) permit (No. CA0037842) discharge limits are summarized in Table 3.1.

Table 3.1 RWF NPDES Discharge Limits by Parameter

Parameter	Units	Average Monthly	Maximum Daily	Instant Minimum	Instant Maximum	Annual Mass
$CBOD_5$	mg/L	10	20	--	--	--
TSS	mg/L	10	20	--	--	--
Oil and Grease	mg/L	5	10	--	--	--
pH	Standard Units	--	--	6.5	8.5	--
Total Residual Chlorine	mg/L	--	--	--	0.0	--
Turbidity	NTU	--	--	--	10	--
Ammonia, Total	mg/L as N	3.0	8.0	--	--	--
Copper, Total Recoverable	µg/L	11	16	--	--	--
Nickel, Total Recoverable	µg/L	25	33	--	--	--
Cyanide, Total	µg/L	5.7	11	--	--	--
Dioxin-TEQ	µg/L	1.4×10^{-8}	2.8×10^{-8}	--	--	--
Mercury	µg/L	0.025	0.027	--	--	0.8 kg/yr
PCB	µg/L	0.00039	0.00049	--	--	--

Notes:
Abbreviations: $CBOD_5$ - 5-day carbonaceous biochemical oxygen demand; kg/yr - kilograms per year; mg/L - milligrams per liter; NTU - Nephelometric Turbidity unit; PCB - polychlorinated biphenyl; TEQ - toxic equivalency; TSS - total suspended solids; µg/L - micrograms per liter.

3.2.1.2 RWF Effluent Water Quality Data

RWF tertiary effluent data to support this analysis were obtained from the California Integrated Water Quality System (CIWQS) system for the period from 2015 through 2021. Table 3.2 summarizes the effluent water quality over this period.

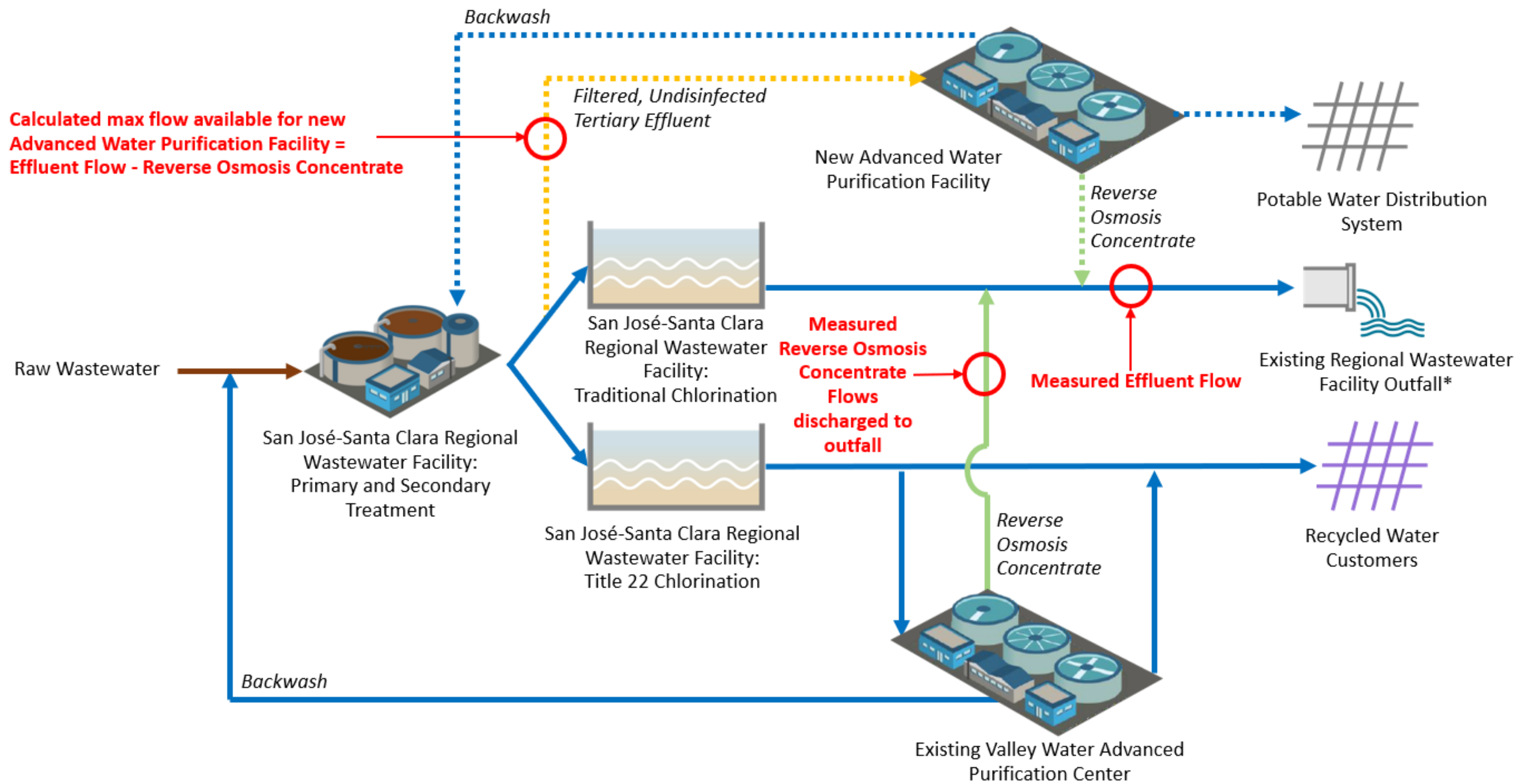
Table 3.2 Summary of the RWF Tertiary Effluent Water Quality From 2015 to 2021

Parameter	Units	Minimum	Average	95th Percentile	Maximum
$CBOD_5$, Daily Maximum	mg/L	1.2	2.85	4	8.5
$CBOD_5$, Monthly Average	mg/L	1.63	2.85	3.6	5.82
TSS, Daily Maximum	mg/L	0.5	1.26	1.9	4
TSS, Monthly Average	mg/L	0.72	1.25	1.68	2.2
Oil and Grease, Monthly Average	mg/L	0.7	1.42	1.7	2
pH	Standard Units	6.9	7.39	7.5	7.8
Total Residual Chlorine	mg/L	--	--	--	--
Turbidity	NTU	0.5	1	1.5	3.6
Ammonia, Daily Maximum	mg/L as N	0.27	0.6	1.01	3.17
Ammonia, Monthly Average	mg/L as N	0.34	0.6	0.98	1.9
Copper, Daily Maximum	µg/L	1.75	2.74	3.69	4.08
Copper Monthly Average	µg/L	1.75	2.77	3.69	4.08
Nickel	µg/L	25	33	--	--
Cyanide, Daily Maximum	µg/L	0.36	1.08	2	2
Cyanide, Monthly Average	µg/L	0.36	1.08	2	2
Mercury, Daily Maximum	µg/L	5.80×10^{-4}	1.18×10^{-3}	1.75×10^{-3}	2.34×10^{-3}
Mercury, Monthly Average	µg/L	6.00×10^{-4}	1.18×10^{-3}	1.80×10^{-3}	2.30×10^{-3}

Notes:
Abbreviations: $CBOD_5$ - 5-day carbonaceous biochemical oxygen demand; mg/L - milligrams per liter; NTU - Nephelometric Turbidity unit; TSS - total suspended solids; µg/L - micrograms per liter.

3.2.2 Feedwater Quantity

Based on review of the overall process flow diagram for the RWF, Valley Water AWPC, and the new AWPF, the flow available to the AWPF is the difference between the RWF's measured effluent flow and the measured reverse osmosis concentrate (ROC) flow from the Valley Water AWPC, as shown in Figure 3.2.



** See Chapter 6 for discussion on reverse osmosis concentrate impacts on the existing outfall. More analysis is needed to determine feasibility of combined discharge.*

Figure 3.2 Overall Process Flow Diagram, Illustrating the Calculation for Available Flow to AWPF

Supervisory control and data acquisition (SCADA)-recorded process flow data at hourly and daily resolution were made available by RWF staff. In order to conservatively assess worst-case water quantity conditions, only flow data from the months of June through September were included in the analysis.

Calendar years 2015 and 2016 were selected as dry weather years representative of expected future conditions and the typical volume of tertiary effluent that would be available to the AWPF. Figures 3.3 and 3.4 summarize available tertiary effluent flow during dry weather months in 2015 and 2016, respectively.

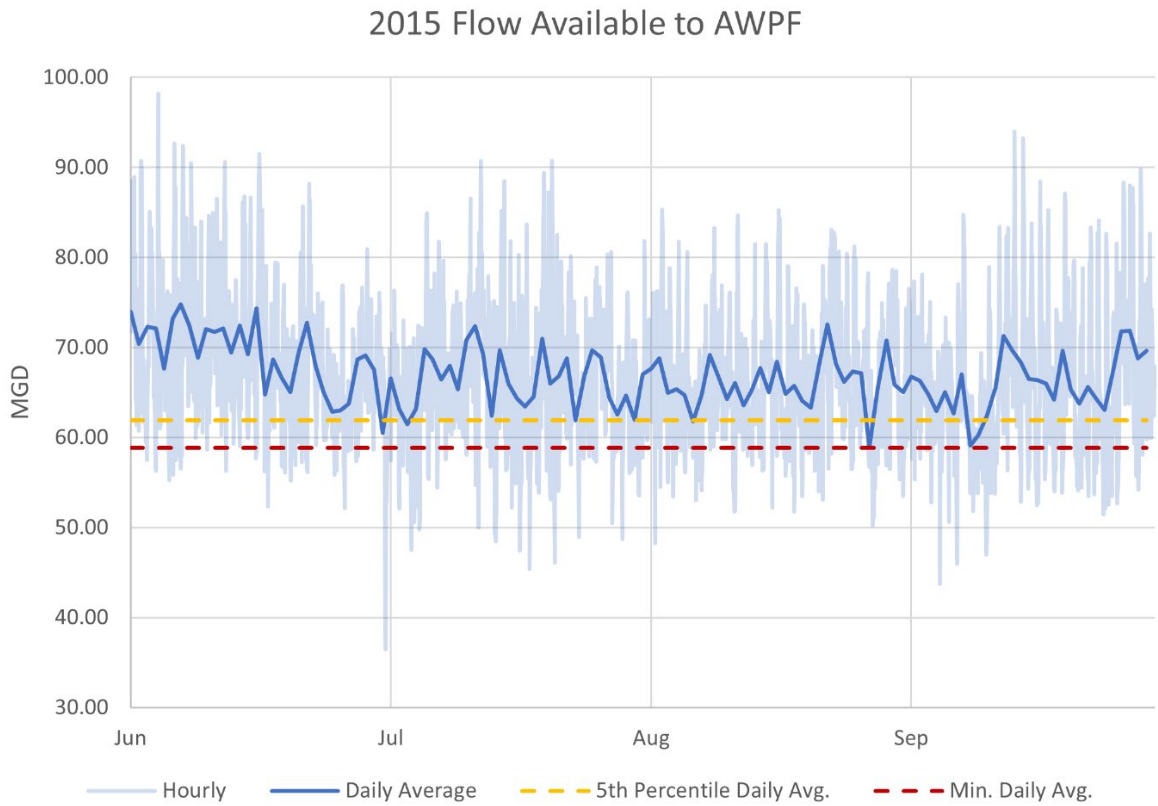


Figure 3.3 2015 RWF Tertiary Effluent Flows Available to the AWPF

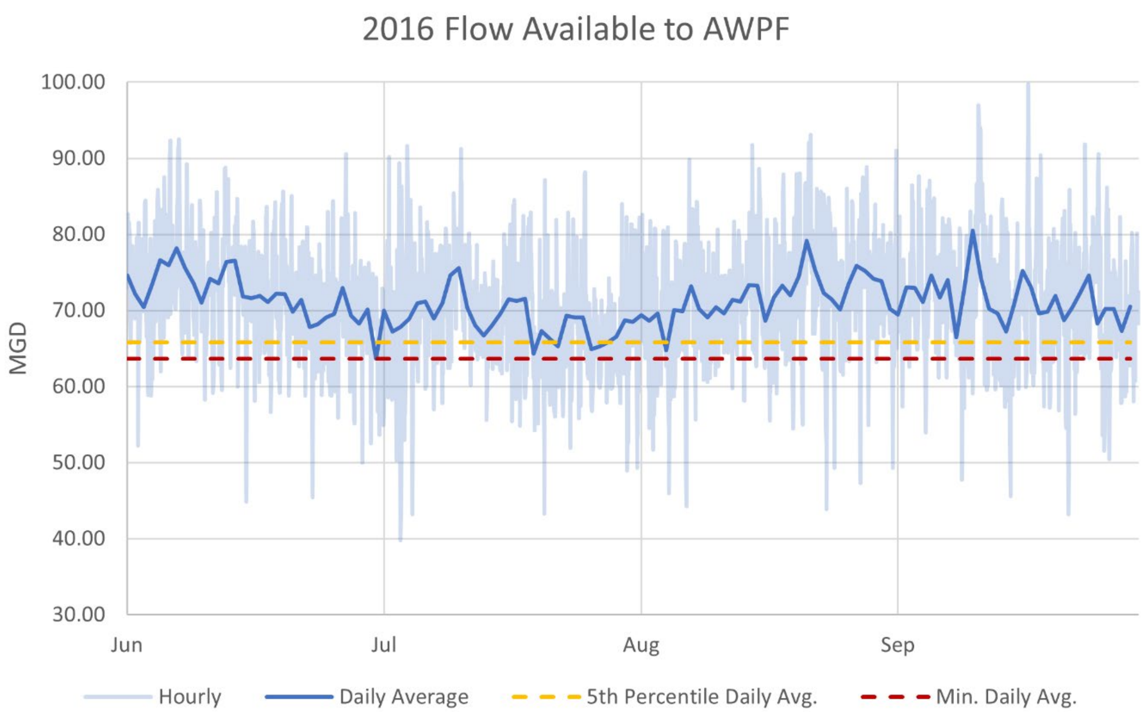


Figure 3.4 2016 RWF Tertiary Effluent Flows Available to the AWPF

Table 3.3 summarizes the range of dry weather tertiary effluent flows available to the AWPF. These tertiary effluent flows are after plant equalization. The RWF has two flow equalization basins: a raw sewage equalization basin and a primary equalization basin. The raw sewage equalization basin is designated for emergency use only while the primary effluent equalization basin is in regular use to dampen diurnal fluctuations. However, as shown in Figures 3.3 and 3.4, hourly flow is still variable.

On a daily average basis, 60 mgd was found to be a conservative estimate of the flow available for AWPF use. If all 60 mgd was used for the AWPF, additional storage upstream of the AWPF for flow equalization would be needed. However, upon discussion with stakeholder agencies, it was agreed that, for the purposes of this study, of the 60 mgd of undisinfected tertiary effluent potentially available, 25 mgd would be allocated as available feedwater to the potential future AWPF. The remaining 35 mgd is planned for recycled water expansion. This limited available flow falls below expected hourly variation and thus additional pre-AWPF storage was not included in this analysis. This analysis utilizes flow data from 2015 and 2016 and does not account for an increase in these flows due to population increase or a decrease in flows due to conservation.

Table 3.3 Summary of 2015 and 2016 Dry Weather Tertiary Effluent Flows Available to the AWPF

Year	Average Flow (mgd)	5th Percentile Flow (mgd)	Minimum Flow (mgd)
2015	66.9	61.9	58.9
2016	71.0	65.8	63.7

Notes:
Abbreviations: mgd - million gallons per day.

3.2.3 Proposed AWPF Sizing Scenarios

Based on the water quality and available quantity of RWF tertiary effluent, two AWPF sizing scenarios are proposed: 10 mgd and 20 mgd of finished water production. Table 3.4 provides flow balances for these two scenarios.

Table 3.4 Flow Balances for 10 and 20 mgd AWPF Size Scenarios

Total Tertiary Effluent Used (mgd)	Total DPR Production (mgd)	San José Share (mgd)	Santa Clara Share (mgd)	SFPUC Share (mgd)	Additional Partner Agency Share (mgd)
12.5	10	4.5	2.0	3.5	0
25	20	4.5	2.0	8.5	5

Notes:
Abbreviations: DPR - direct potable reuse; mgd - million gallons per day; SFPUC - San Francisco Public Utilities Commission.

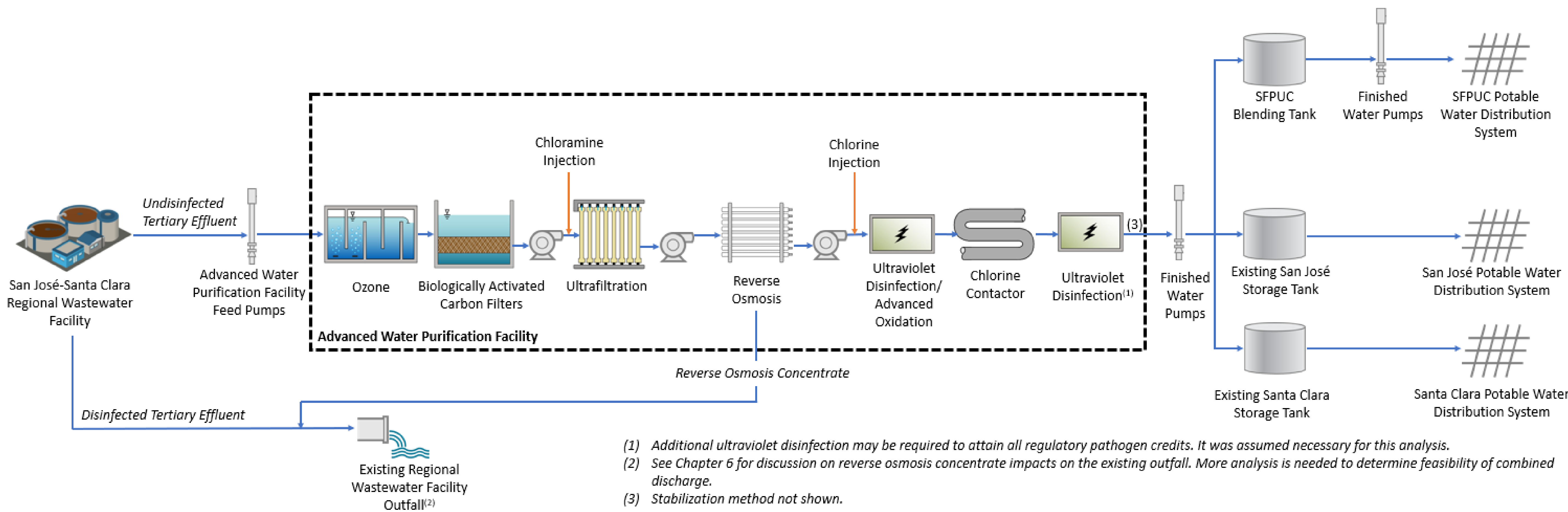
3.3 Proposed AWPF Information

The location of the potential AWPF is shown in Figure 3.5 and is approximately 4.5 acres in size. This location was identified by the cities of San José and Santa Clara and is located to the southeast of the RWF and immediately adjacent to the existing Valley Water AWPC. For this effort, we are examining a one-story treatment facility for the AWPF. Footprint could be reduced (and costs increased) through the use of a multiple story building.

Figure 3.5 Potential Location of AWPF Adjacent to Valley Water AWPC

3.3.1 Proposed Process Train

Table 3.5 summarizes the proposed treatment train to produce purified water for DPR, which is also graphically shown in Figure 3.6. Table 3.5 also contains the descriptions and purpose of each treatment process recommended in the DPR treatment train. Table 3.6 lists the pathogen removal credits assigned to each process in the DPR treatment train.



(1) Additional ultraviolet disinfection may be required to attain all regulatory pathogen credits. It was assumed necessary for this analysis.
(2) See Chapter 6 for discussion on reverse osmosis concentrate impacts on the existing outfall. More analysis is needed to determine feasibility of combined discharge.
(3) Stabilization method not shown.

Figure 3.6 Proposed Treatment Train for the South Bay Purified Water Project

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Table 3.5 Key Treatment Processes Recommended for DPR

Process	Description
Ozone	• Provides pathogen disinfection • Facilitates biological treatment by breaking down organic carbon for removal by the downstream biological filters • Reduces concentrations of some chemicals through chemical oxidation, thereby: – Improving water quality of the treated water as well as the ROC – Providing effective pretreatment of water upstream of membranes thereby reducing fouling potential and required level of chloramines
BAC Filtration	• Biological filtration process • Removes organic carbon, made more bioavailable by the upstream ozone process • Decreases level of some chemicals, including NDMA • Reduces turbidity • Can provide some nitrification (if needed)
UF	• Membrane filtration process • Reduces turbidity in BAC filtrate to less than: – 0.2 NTU more than 5 percent of the time within a 24-hour period – 0.5 NTU at any time • Removes pathogens via size exclusion through membranes • Provides necessary pretreatment upstream of RO and UV AOP similar to all existing California potable reuse plants
RO	• Reduces total organic carbon • Reduces TDS • Decreases level of all chemicals with high molecular weights, and charged chemicals with low molecular weights • Removes pathogens via size exclusion
UV Disinfection/ AOP	• Combination disinfection and chemical oxidation process • Provides pathogen disinfection • Achieves oxidation requirement by providing no less than 0.5-log (69 percent) reduction of 1,4-dioxane • Provides photolysis of some chemicals (e.g., NDMA)
Chlorination	• Provides pathogen disinfection (free chlorine only)
Stabilization (Calcite Contactors)	• Provides corrosion control • Required for water treated by RO
UV Disinfection	• Disinfection process • Provides final pathogen disinfection to meet full draft DPR pathogen removal requirements. Credits can potentially be met without this additional process based upon maximizing upstream credits
Finished Water Pumps	• Wet well provides for engineered storage, with a response retention time sufficient to divert off-spec flow
Blending	• Meets draft DPR blending requirement to reduce a one-hour chemical spike by a factor of 10

Notes:
Abbreviations: AOP - advanced oxidation process; BAC - biological activated carbon; DPR - direct potable reuse; NDMA - N-nitrosodimethylamine; NTU - Nephelometric Turbidity unit; RO - reverse osmosis; ROC - reverse osmosis concentrate; TDS - total dissolved solids; UF - ultrafiltration; UV - ultraviolet.

Table 3.6 Key Pathogen Log Removal Values per Process

Process	Pathogen Log Removals by Pathogen Category		
	Virus	Giardia	Cryptosporidium
WWTP(1)	0+	0+	0+
Ozone/BAC(2)	6	6	1
UF(3)	0	4	4
RO(4)	2	2	2
UV AOP	6	6	6
Stabilization	0	0	0
UV Disinfection(5)	4+	6	6
Chlorination(6)	2+	0	0
Total	**20**	**24**	**19**
Required	20	14	15

Notes:
Abbreviations: AOP - advanced oxidation process; BAC - biological activated carbon; RO - reverse osmosis; UF - ultrafiltration; UV - ultraviolet; WWTP - wastewater treatment plant.

(1) Pathogen removal through the WWTP would need to be evaluated and confirmed through a 3 to 12 months study including evaluation of a broad range of pathogens and surrogates. Such a study, including the tertiary filtration, is anticipated to provide some pathogen removal which could lessen the burden of other treatment processes and potentially eliminate the need for the last UV disinfection system.

(2) Credits shown are from Pure Water San Diego based on United States Environmental Protection Agency (EPA) protocols with a contact time (CT) of 6.24 milligram-minutes per liter (mg-min/L).

(3) UF systems can remove virus (2 to 4+ log removal value [LRV]) but currently are not credited due to the lack of a reliable surrogate to be used daily to verify performance (e.g., pressure decay tests) are used daily to verify protozoa removal). Ongoing research with novel monitoring systems is anticipated to allow for future virus credit, which may allow for reduction or elimination of other virus treatment steps, such as the supplemental UV system listed in this table.

(4) Can receive up to 1 log credit during permitting for electrical conductivity as a monitoring surrogate: 1.5 log credit for total organic carbon (TOC), and 2 for strontium without pilot data. An additional half log can typically be gained once the facility is operational.

(5) UV disinfection sized for a dose of 186 millijoules per centimeter squared (mJ/cm^2) following EPA protocols to result in 4 log reduction of adenovirus and 6 log reduction of protozoa (Giardia and Cryptosporidium). Higher UV doses could also be applied to result in increased virus credits.

(6) Chlorination credits based upon the Australian WaterVal analysis, which has been approved by the State of California for up to 6 log reduction of virus. The low LRV shown here is representative of a relatively high concentration times CT (Value 9 mg-min/L, based upon a t10 CT of 6 minutes, and a minimum wastewater temperature of 15 degrees Celsius, and a pH of <8.5). Sampling for pH and temperature could allow for lower CT values to meet the target credits. Higher residuals could also be applied to result in increased virus credits.

3.3.2 AWPF Design Criteria

The treatment train was developed to meet California's draft DPR regulations, described in Chapter 2. Table 3.7 summarizes design capacities for each treatment process. The processes are sized to provide the design final product flow, given the recoveries of upstream and downstream processes. Upstream processes must be sized at higher instantaneous flow rates to provide sufficient process effluent for backwashes and other losses. Water used for backwashes would be sent back to the headworks at the RWF. The backwash water is not anticipated to impact the performance of the RWF, though further analysis is recommended to confirm this. Water lost to ROC would be discharged through the existing RWF outfall (see Chapter 6 for additional discussion). Detailed treatment process design criteria for each of the alternatives can be found in Appendix B.

The sections that follow provide more information on each of the AWPF treatment processes.

Table 3.7 Summary of Capacity Criteria for Each Alternative

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Ozone + BAC			
Feed Flow(1)	mgd	14.2	28.3
Rated Capacity (Effluent)	mgd	13.0	26.0
Recovery	percent	92	92
UF			
Average Feed Flow	mgd	13.0	26.0
Net Filtrate Capacity	mgd	12.5	25.0
Recovery	percent	96	96
RO			
Average Feed Flow	mgd	12.5	25.0
Net Permeate Capacity	mgd	10.0	20.0
Recovery	percent	80	80
UV AOP			
Rated Capacity (Effluent)	mgd	10.0	20.0
Dose	mJ/cm^2	1,000	1,000
Calcite Contactor			
Capacity	mgd	5.0	10.0
Chlorination			
Capacity	mgd	10.0	20.0
Concentration Times CT	mg-min/L	8.0	8.0
UV (Disinfection)			
Capacity	mgd	10.0	20.0
Dose	mJ/cm^2	186	186

Notes:
Abbreviations: AOP - advanced oxidation process; BAC - biological activated carbon; CT - contact time; mg-min/L - milligram-minutes per liter; mgd - million gallons per day; mJ/cm^2 - millijoules per centimeter squared; RO - reverse osmosis; UF - ultrafiltration; UV - ultraviolet.
(1) Total feed flow includes backwash flows that are recirculated to the head of the San José-Santa Clara Regional Wastewater Facility (RWF). These backwash flows are not included in the total feed flows required from the RWF.

3.3.2.1 Ozone and BAC

Ozone is a chemical disinfection process that provides reduction for virus, *Cryptosporidium*, and *Giardia*. Ozonation breaks down organic molecules to increase their bioavailability, thereby allowing improved removal via biological degradation through BAC filtration. The BAC process can remove organic matter, including trace constituents and their ozonation byproducts, via the microbial communities that develop on the surface of the media. Ozone/BAC reduces TOC, NDMA, and trace organics. The use of ozone/BAC results in improvements to downstream UF performance, as the BAC filtrate is more biostable and causes less fouling on downstream membranes.

Ozone Process

The ozone process involves several components: ozone gas generation, ozone injection into an ozone contactor, and destruction of off-gassed ozone.

To achieve LRVs of 6, 6, and 1 for virus, *Giardia*, and *Cryptosporidium*, respectively, the concentration times CT method is required. At a temperature of 15 degrees Celsius (a conservative assumption based on the effluent data provided from 2015 through 2021), a concentration times CT of 6.43 mg-min/L is required for 1 LRV of *Cryptosporidium*. At that concentration times CT, virus and *Giardia* LRVs exceed 6, which is the maximum log removal that can be assigned to any one process. Both temperature sampling as well as ozone jar testing must be used to confirm the dose-response curve for ozone. Jar testing can also help determine the ozone transfer efficiency and number of ozone injection points required. Ozone design criteria are summarized in Appendix B.

BAC Process

The BAC process can be in the form of a gravity or pressurized filter. For this analysis, gravity filters were assumed for space efficiency; however, the type of filter should be refined during design.

As the filtration run time increases over a period of days, solids and biomass build up on the filter media until a backwash is needed. The backwash process includes draining the filter, agitating the media with air scour, backwashing the media with a fluidized wash, and then refilling the filter and returning it to service. The entire backwash process typically lasts from 30 to 60 minutes.

A key design criterion for BAC is the empty bed contact time (EBCT), or the amount of time that the water resides with the filter media. Higher EBCT results in better biological degradation and TOC removal but increases capital and operational costs. The optimal EBCT should be selected through piloting; however, EBCTs of between 10 and 30 minutes are typical for wastewater effluents. The filtration systems for the two alternatives are sized to maintain an EBCT of at least 15 minutes at the design flow rates with one filter in backwash.

Additionally, historical ammonia concentrations in the feedwater were reviewed and we do not anticipate impairment of the BAC operation at these historical levels. However, due to ozonation and high oxygen feed to BAC, we do expect full nitrification to occur in the BAC.

The BAC filter media typically used is granular activated carbon (GAC), selected to maximize surface area for biological growth and performance. Initially, the GAC will also provide additional treatment of chemicals by adsorbing chemical constituents; however, over time, as the adsorption site are used up, the dominant chemical removal mechanism will become biological. BAC design criteria are summarized in Appendix B.

3.3.2.2 UF

The UF system is a low-pressure membrane filtration system that removes pathogens and removes particulate matter from BAC filtrate in order to enhance downstream RO membrane performance.

The UF feed tank will store and equalize BAC filtrate and will also provide storage for BAC backwash water. UF feed pumps will pressurize flow from the UF feed tank through the UF system. Chloramine is added ahead of the UF system to minimize biofouling of the membranes. The UF modules and rack sizing was provided by WesTech based on a design flux of 50 gallons per square foot of membrane per day (gfd); however, following an ozone/BAC process, UF flux may be higher (e.g., 70 gfd), resulting in cost savings (capital and operations). The achievable flux rate should be confirmed through pilot testing.

The UF filtrate/RO feed tank must provide both sufficient backwash volume for the UF system and feed flow for the RO. The UF clean-in-place (CIP) and neutralization tanks are designed to allow adequate water for conducting CIP maintenance on membranes followed by neutralization of cleaned membranes before being put back into use. Design criteria for the UF system are summarized in Appendix B.

3.3.2.3 RO

RO is a well-established process used to remove contaminants that remain after the low-pressure membrane system. The RO process uses semi-permeable membranes and a driving force of hydraulic pressure to remove dissolved contaminants, making it a physical separation process that can reject constituents as small as 0.0001 micrometer. RO can remove dissolved salts, TDS, hardness, dissolved organic carbon, synthetic organic chemicals, and disinfection byproduct (DBP) precursors.

The basic unit of an RO system is the spiral-wound RO element, which consists of several layers of RO membranes wound around a central permeate collection tube and enclosed in a cylindrical housing. The membranes separate the feed flow into treated water (permeate) and a waste stream (concentrate). As feedwater flows along the length of the element, permeate passes through the membrane leaving behind most dissolved constituents, resulting in a progressively decreasing flow (concentrate) to carry the same mass of dissolved constituents. The ratio of the permeate production to the feed flow is known as the RO system recovery.

The permeate is composed of low salinity, high-quality water. Some salts, neutrally charged chemicals, and gasses will pass through the RO membrane into the permeate. The concentrate stream contains the remaining constituents that were trapped on the feed side. Since the ions being removed are further concentrated as the water passes through the system, there is potential for scaling and foulants to form on the membrane surface that can decrease the efficiency of the system. Scaling is prevented by the addition of sulfuric acid and chemical scale inhibitor upstream of the RO process, which keep scalants in solution.

RO trains are typically designed in stages, the number of which depends on the water supply and the design recovery. In a typical advanced wastewater treatment RO system operating at 75 to 85 percent recovery, a two-stage system with multiple RO elements per pressure vessel is typical. In a two-stage system, the concentrate from the pressure vessels in the first stage is combined and fed to a smaller number of pressure vessels in a second stage. This approach increases the RO system's recovery.

The RO transfer pump located in the RO feed tank supplies UF filtrate to the RO feed pump, which provides the pressure needed for the RO train, UV reactor, and chlorine contactor. Solids, such as fine sands or organic debris, will result in RO membrane fouling and may cause mechanical damage to the RO membrane elements. Although the UF system will provide exceptionally high-quality water that is free of suspended solids, cartridge filters are still required to protect against membrane damage from suspended material that may be introduced into the RO feed tank, leftover construction debris, or other unexpected solids. Cartridge filters are provided as the final barrier to protect the valuable RO membrane elements against fouling or damage from these particulates. RO design criteria are provided in Appendix B.

3.3.2.4 UV Disinfection/AOP

The UV disinfection system with an AOP component (typically referred to as UV AOP) uses UV light coupled with an oxidant—in this case sodium hypochlorite—to break down organics via oxidative reactions and photolysis, and to disinfect pathogens. The UV light alone provides pathogen disinfection and photolysis reactions. Photolysis can lower concentrations of certain chemicals, such as NDMA. The AOP is required to lower concentrations of other chemicals, such as 1,4-dioxane, which serves as an indicator of AOP performance.

The AOP is achieved by introducing an oxidant into the system with UV light, which reacts with the oxidant to produce hydroxyl radicals. Hydroxyl radicals react rapidly with organics and lower the concentrations of a broad range of organic compounds. Appendix B summarizes UV AOP system design criteria.

3.3.2.5 Stabilization

Water that has undergone RO treatment is exceedingly low in salts and minerals, with a low pH. Without the addition of minerals back into the water, RO permeate water can be aggressive and corrosive and should not be sent directly into a distribution system. The stabilization can be configured to match existing water supply alkalinity and can be refined during the design phase of this project. Three options commonly considered for stabilization are as follows:

- Option 1: Calcite Contactor + Sodium Hydroxide + Carbon Dioxide
- Option 2: Hydrated Lime + Carbon Dioxide dosing
- Option 3: Calcium Chloride + Sodium Hydroxide + Carbon Dioxide

For the purposes of this feasibility study, Option 1 (calcite contactors) were selected as they are an established technology used for conditioning RO permeate. Capital and operations and maintenance (O&M) costs for this selected option are included in the detailed cost estimate, available in Appendix D. The RO permeate is fed to the calcite contactor, dissolving/absorbing calcium carbonate as it passes through the bed of calcite. To provide additional stability to the finished water, sodium hydroxide (i.e., NaOH or caustic soda) is necessary to increase the alkalinity of the RO permeate to provide buffer capacity and pH stability. Sodium hydroxide is a strong base that increases the pH, therefore carbon dioxide must also be added to further lower and adjust the pH between 6.5 to 8.5 without consuming alkalinity.

Option 2 adds lime slurry and carbon dioxide to the RO permeate. The addition of lime raises the pH, adds alkalinity, meeting calcium carbonate saturation objectives. Carbon dioxide addition then lowers the pH level back down to a target range to minimize scaling of the injection well screens. One concern with implementing Option 2 is that lime can increase the turbidity of the water, which could hinder public perception of the water. Lime addition can also be challenging to operate.

Option 3 adds calcium chloride, sodium hydroxide, and carbon dioxide to the RO permeate to stabilize the finished water. The addition of calcium chloride and sodium hydroxide adds calcium, alkalinity, and TDS to achieve the finished water corrosion objectives. Carbon dioxide lowers the pH level to remain in a reasonable range.

The preferred stabilization method should be refined during detailed design. The cost differences for the three stabilization methods were not evaluated for this project. Work on prior, similar potable reuse projects in suggest that generally Option 1 may be the most expensive while Option 3 is the least expensive option. Stabilization criteria for selected Option 1 are provided in Appendix B.

3.3.2.6 UV Disinfection

A second UV system is necessary to meet virus log removal requirements. This system, which is disinfection only, also provides protozoa additional protozoa removal. UV disinfection design criteria are provided in Appendix B.

3.3.2.7 Purified Water Storage Tank/Chlorine Disinfection

A tank is required for purified water storage to allow for pump station cycling. The tank will also serve as a chlorine contact basin before the purified water is distributed to the three water distribution systems (SFPUC, Santa Clara, and San José). Based on conversations with SFPUC, Santa Clara, and San José, the proposed size of this purified water storage tank will allow for 30 minutes of plug flow storage time.[1] This storage time is also known as the response retention time of the system. As discussed in the draft DPR regulations (detailed in Chapter 2) the AWPF must be designed to ensure that, in the event of system failure, diversion or system shutoff can occur before more than 10 percent of the off-spec water reaches the diversion or shutoff point. The 30-minute response retention time provided by the storage tank will allow operations staff sufficient time to (1) allow online monitoring systems to cycle several times to confirm

[1] San José has indicated that further analysis of the necessary storage time will be conducted as part of a subsequent phase of work for this project.

performance and divert flow if needed and (2) provide the necessary CT for free chlorine disinfection to mitigate off-spec water.

As this tank is dual purpose, design considerations need to accommodate both the California Division of Drinking Water (DDW) diversion requirement while achieving adequate free chlorination credit. Free chlorination credits are based on the 2017 Australian WaterVal Validation Protocol. As indicated in the design criteria denoted in Appendix B, the tank will be designed to target a concentration times CT of 8 mg/min-L with a 6-minute CT. Therefore, adequate free chlorine credits will be achieved 6 minutes into a 30-minute contact basin. Accordingly, there will be 24 minutes from the moment the target CT is not met to shut down, if necessary.

For virus removal, this project assumes two LRV from free chlorination to meet the 20 LRV total requirement. However, there are other virus credits not currently accounted for. This includes credits for the RWF (which includes filtration), credits from UF (which will be 3 to 4 once online virus monitoring is established), and RO credits up to 2.5 or even 3 depending upon the monitoring system. Thus, our expectation is that the free chlorine credits will be supplemental by the time a project such as this is permitted. Effluent water will target a 1 mg/L monochloramine residual, per input from SFPUC. The target residual may change based upon pilot testing, future analysis, and input from San José and Santa Clara based on their respective residual targets.

Design criteria for the purified water tank are provided in Appendix B.

3.3.2.8 Blending

As part of the proposed DPR regulations, a 10:1 dilution of a one-hour chemical spike is required. This peak attenuation can occur at any point in the treatment and distribution process before the water is consumed. Thus, blending within the sewer collection system, the WWTP, a separate equalization basin, or within the distribution system could be considered. For this analysis, blending in the sewer collection system and/or the WWTP was not considered. Instead, the following approach was taken for peak attenuation for each of the three utilities:

- For both San José and Santa Clara, existing water distribution system storage tanks exist near the RWF. These existing storage tanks have sufficient storage capacity for the required 10:1 dilution and no further evaluation is necessary
- For SFPUC, dilution in the existing Bay Division Pipeline (BDPL) was initially considered. However, based on low flows possible in that pipeline, sufficient dilution was not available. Thus, a new blending tank at the AWPF is needed

Further discussion on sizing this blending tank and on confirming the sizes of the existing San José and Santa Clara blending tanks is discussed in Chapter 4. Since it was ultimately decided that a new blending tank is needed for SFPUC at the AWPF and additional land was identified by San José and Santa Clara for that blending tank, it would also be possible to increase the size of the on-site blending tank to accommodate the full AWPF flow. This would minimize the piping requirement for purified water to get to San José and Santa Clara. However, the on-site blending tank would be approximately 86 percent larger for the 10 mgd scenario (2.3 million gallons [MG] would increase to 4.3 MG) and approximately 35 percent larger for the 20 mgd scenario (4.5 MG would increase to 6.0 MG).

3.3.2.9 Chemicals

Chemicals are used throughout the treatment train as described in the previous subsections. A chemical feed station will store the required chemicals and serve as a chemical refill station for chemical deliveries.

Storage requirements for each chemical should be determined during design. Appendix B summarizes the chemicals required and the purpose for each chemical.

3.3.3 AWPF Layout

A layout was developed for the 10 and 20 mgd AWPF alternatives as shown in Figures 3.7 and 3.8. Space was available at the 5.3-acre site to fit all the required components within a one-story building. The layouts include plant feed pump stations, all treatment processes, ancillary equipment such as chemical storage, and the on-site SFPUC blending tank.

Some of the assumptions/decisions that went into these particular layouts are as follows:

- The plant feed pump station provides the feed pressure required to move water through ozone and BAC and into the UF feed tank
- The UF feed tank and RO feed tanks are constructed at grade. An air gap is required after BAC, after UF, after RO, and after UV treatment
- The chemical equipment was located away from the front of the plant, providing a more visually appealing facility for public tours
- All chemical tanks, with the exception of sodium hypochlorite, are located outside under canopies. This can be further evaluated during design. Sodium hypochlorite is located in an air-conditioned storage building to prevent excessive degradation in the heat
- The current layouts assume that the plant will take full chemical deliveries. The chemical area could be smaller depending on what chemicals are stored on site, and if there is the ability to receive partial chemical deliveries
- The ozone generation equipment shown are larger, conventional generators. There are new ozone generation technologies that may be able to save space in the process area
- All tanks are located above grade except for the Waste Equalization Tank, which collects the waste flows from each system before pumping them out at a constant rate to the sewer or head of the RWF
- A new, dedicated space for the AWPF's control room, wet lab, and staff area is provided as a conservative assumption. It is possible that these spaces can be combined elsewhere with existing control rooms, labs, and staff areas

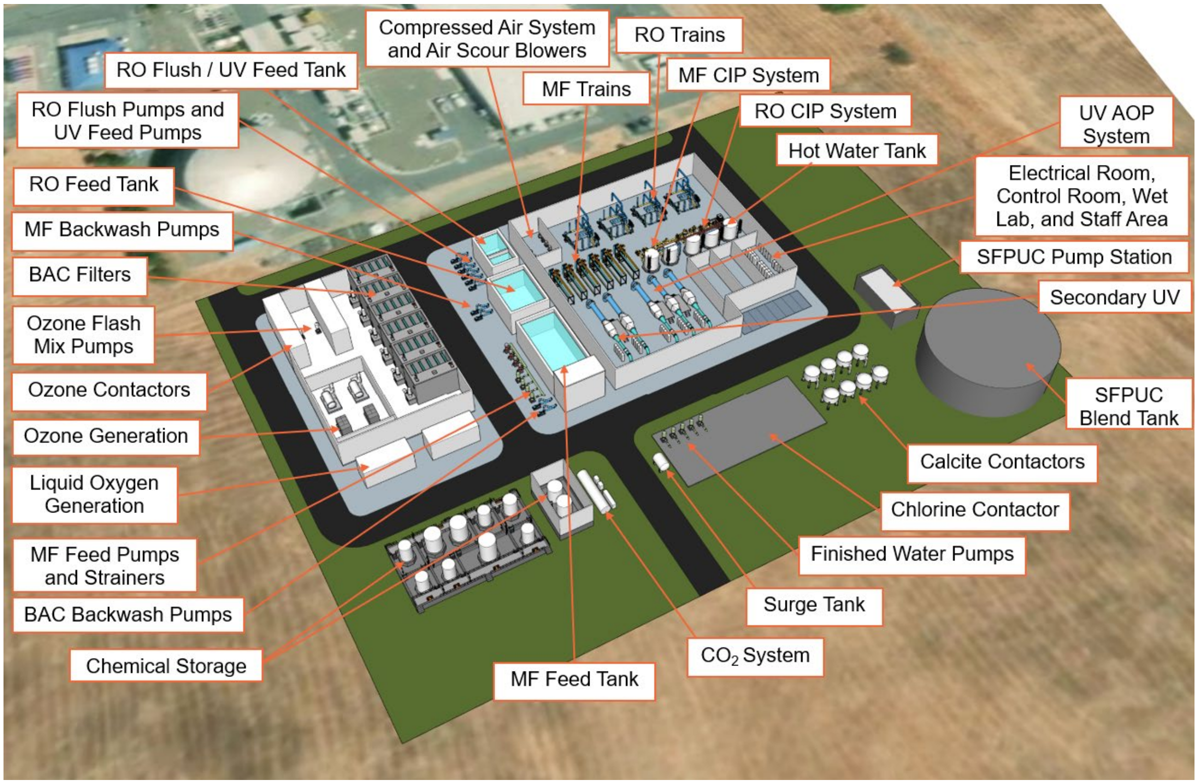

Figure 3.7 Isometric View of One-Story, 10 mgd Production AWPF Located at the RWF

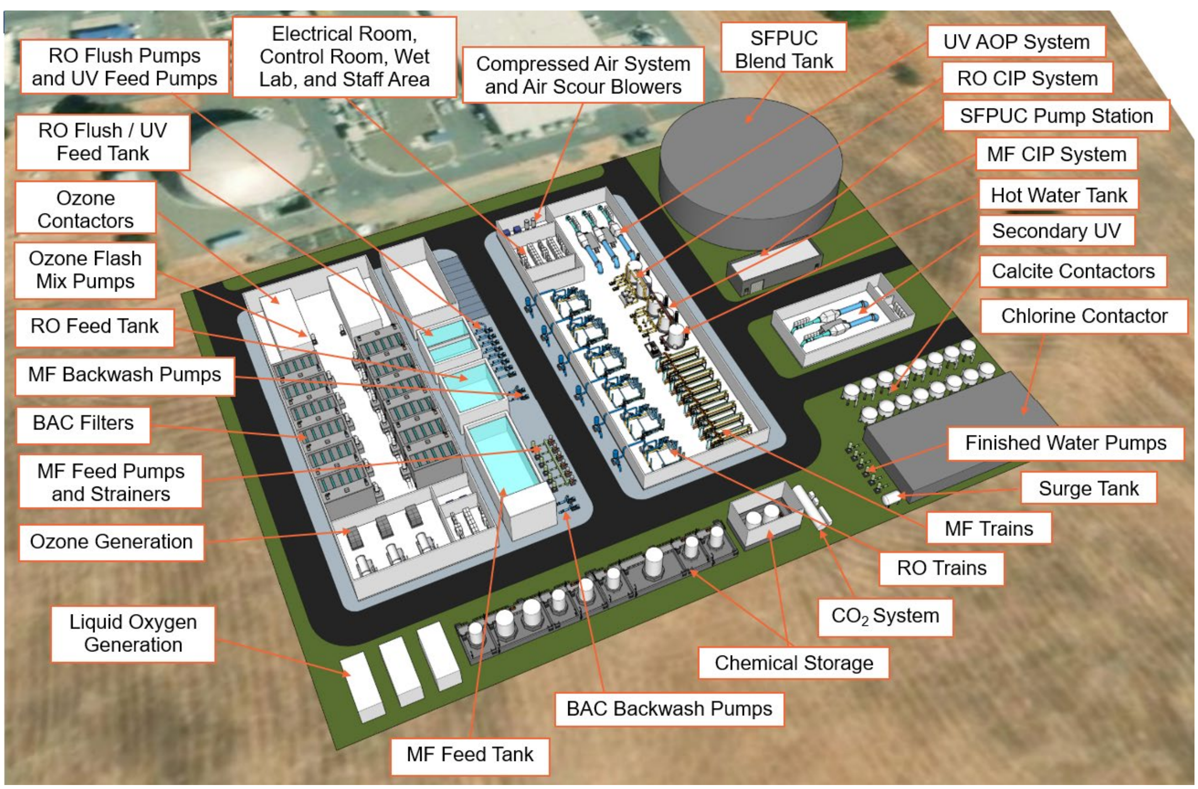

Figure 3.8 Isometric View of One-Story, 20 mgd Production AWPF Located at the RWF

3.3.4 AWPF Treatment Costs

Table 3.8 summarizes the capital costs, O&M costs, and life cycle costs for both the 10 and 20 mgd AWPF treatment alternatives. Information on the basis for the development of these planning level costs is available in Appendix C and detailed cost estimates are provided in Appendix D. The executive summary provides a summary of all costs required for this project (infrastructure, treatment, and solar).

Table 3.8 AWPF Treatment Cost Estimates

Cost Type	Alternative Cost ($M)	
	10 mgd Production	20 mgd Production
Total Project Capital Cost	$209.73	$365.29
Annualized Total Project Capital Cost(1)	$11.40	$19.86
Annual O&M Cost(2,3)	$14.90	$25.80

Notes:
Abbreviations: $M - dollars in millions; mgd - million gallons per day; O&M - operations and maintenance.
(1) Calculated assuming an interest rate of 3.5 percent and annualized over 30 years.
(2) Staffing costs included as part of the O&M costs were based on a detailed review of proposed Advanced Water Purification Facility (AWPF) size and layout. A detailed report of the required staffing numbers can be found in Appendix E.
(3) These O&M costs do not include source control or feedwater monitoring.

Chapter 4

CONVEYANCE INFRASTRUCTURE

4.1 Introduction

This chapter provides an overview of proposed pipe routing necessary to feed filtered undisinfected tertiary effluent from the San José-Santa Clara Regional Wastewater Facility (RWF) to the Advanced Water Purification Facility (AWPF); to convey finished purified water to the San Francisco Public Utilities Commission (SFPUC), San José, and Santa Clara distribution systems; and to route reverse osmosis concentrate (ROC) to the existing RWF outfall. This chapter also discusses the pump stations needed as well as the costs associated with this infrastructure.

Both scenarios considered in the South Bay Purified Water Project (Project) are evaluated in this chapter. These two scenarios are: 1) production of 10 million gallons per day (mgd) of purified water for treated drinking water augmentation (TWA), and 2) production of 20 mgd of purified water for TWA.

4.2 AWPF Feedwater Infrastructure

A single pipeline will convey RWF filtered undisinfected tertiary effluent from the RWF to the proposed AWPF. As noted in Chapter 3, the current configuration of the RWF does not allow for filtered undisinfected tertiary effluent to be pulled off the treatment train. There is a planned capital improvements project that will address this and allow filtered undisinfected tertiary effluent to be pulled off and conveyed to the AWPF. The pipe alignment is shown in Figure 4.1.

Figure 4.1 AWPF Feedwater Pipe Alignment

Table 4.1 provides pipeline details for both the 10 and 20 mgd production scenarios. Additionally, a newly constructed pump station at the RWF will convey filtered undisinfected tertiary effluent to the AWPF. Pump station power demands are also included in Table 4.1.

Table 4.1 AWPF Feedwater Pipeline Design Details

DPR Production Scenario (mgd)	Pipeline Length (miles)	Pipeline Flow (mgd)	Pipe Diameter (inches)	Pump Power Demand (hp)
10	1.1	14.1	30	85
20	1.1	27.2	42	120

Notes:
Abbreviations: DPR - direct potable reuse; hp - horsepower; mgd - million gallons per day.

4.3 AWPF Finished Water Infrastructure

After purification, finished water will be conveyed from the AWPF to delivery points within each of the three agencies' distribution systems. Table 4.3 shows the amount of finished water conveyed to each agency with the two scenarios considered.

State regulations require that prior to delivery to the end user, the water system must provide a 10:1 dilution to attenuate a one-hour peak flow. Such dilution can be achieved at any single or combination of locations along the flow scheme. For this analysis, the blending will occur with finished water after treatment in blending reservoirs. In particular, finished water will be delivered to the nearest existing tanks in San José and Santa Clara's distribution systems, while a new tank will be constructed for SFPUC adjacent to the AWPF. An initial evaluation was conducted to determine if sufficient blending would be available in the SFPUC Bay Division Pipelines (BDPLs) 3 and 4 to avoid the need for a new blending tank. However, it was determined that during extreme drought conditions, when AWPF flow would be maximized as a percent of total flow, there is not sufficient flow in the BDPLs 3 and 4 to provide the required 10:1 dilution. Thus, a new blending tank for SFPUC's portion of the water was included in this analysis. A conservative costing approach was taken in this report due to uncertainty surrounding use of the land adjacent to the proposed AWPF. Figure 4.2 shows all three agencies' finished water pipelines and respective blending reservoirs.

If this Project moves forward, it is worth considering upsizing this new blending tank to accommodate the total finished water sent to SFPUC, San José, and Santa Clara. While the cost of the blending tank would increase, distribution piping costs would likely decrease. The on-site blending tank would be approximately 186 percent larger for the 10 mgd scenario (2.3 million gallons [MG] would increase to 4.3 MG) and approximately 135 percent larger for the 20 mgd scenario (4.5 MG would increase to 6.0 MG).

Table 4.2 AWPF Finished Water Allocations for Each Scenario

	10 mgd Scenario				20 mgd Scenario				
	Total DPR Production	San José Portion	Santa Clara Portion	SFPUC Portion	Total DPR Production	San José Portion	Santa Clara Portion	SFPUC Portion	Unclaimed Portion(1)
Normal Year	6.5 mgd	4.5 mgd	2 mgd	-	Up to 20 mgd	4.5 mgd	2.0 mgd	Up to 3.5 mgd	Up to 10 mgd
Dry Year	10 mgd	4.5 mgd	2 mgd	3.5 mgd	Up to 20 mgd	4.5 mgd	2.0 mgd	Up to 8.5 mgd	Up to 5 mgd

Notes:
Abbreviations: DPR - direct potable reuse; mgd - million gallons per day; SFPUC - San Francisco Public Utilities Commission.
(1) A fourth partner agency would need to be identified for the 20 mgd scenario.

Figure 4.2 Overview of AWPF Finished Water Pipe Alignments and Blending Reservoir Sites

A single pipeline will convey finished water to the Nortech and Northside Tanks for San José and Santa Clara, respectively. Separate pipelines will convey finished water from the AWPF to SFPUC's blending reservoir and from the SFPUC blending reservoir to injection points at an existing turn-out on the SFPUC BDPLs 3 and 4. Both finished water pipelines cross Highway 237 at least once. Two crossing options were considered at these locations: jack and bore and bridge-supported pipe hangers. Pipeline alignments presented will be refined as a part of the detailed design efforts to meet separation requirements from other utilities and easements as needed.

The finished water infrastructure will also require two new pump stations:

- AWPF Pump Station: Conveys finished water to San José, Santa Clara, and the SFPUC blending reservoir. Pumps will be housed within the AWPF
- SFPUC Pump Station: Conveys finished water from SFPUC's blending reservoir to injection points on SFPUC's BDPLs 3 and 4. Pumps will be housed in a newly constructed structure adjacent to the AWPF and the SFPUC blend tank
- Power demands for these pump stations are shown in Table 4.4

Note: Through discussion of the distribution infrastructure with utility partners, questions were asked about finished water quality. Any DPR project in California will require pilot testing. As part of that pilot testing, detailed analysis of water quality, stabilization needs, and distribution system impacts can be evaluated.

Table 4.3 Finished Water Pump Stations' Power Demands for Each Scenario

	10 mgd Scenario	20 mgd Scenario
AWPF Pump Station Power Demand, hp(1)	480	960
SFPUC Pump Station Power Demand, hp(2)	430	1,600

Notes:
Abbreviations: AWPF - Advanced Water Purification Facility; hp - horsepower; mgd - million gallons per day; SFPUC - San Francisco Public Utilities Commission.
(1) Pumps flow from all partner agencies.
(2) Pumps flow from SFPUC only.

4.3.1 San José Finished Water Infrastructure

The alignment of the pipeline conveying finished water from the AWPF to San José's Nortech Reservoir Tank and beyond must avoid burrowing owl habitat protected in a conservation easement area shown in Figure 4.3. This easement has been agreed upon by the City of San José, City of Santa Clara, and the Santa Clara Valley Habitat Agency. Table 4.4 provides the design details for this portion of the combined San José/Santa Clara finished water pipeline. The chosen alignment avoids the burrowing owl habitat and utilizes an existing San José utility tunnel at the eastern crossing of Highway 237.

Figure 4.3 San José's Finished Water Pipe Alignment

Table 4.4 Design Details for the Finished Water Pipeline Between the AWPF and San José's Nortech Reservoir

DPR Production Scenario (mgd)	Pipeline Length (miles)	Pipeline Flow (mgd)	Pipe Diameter (inches)(1)
10, 20	1.8	6.5	24

Notes:
Abbreviations: DPR - direct potable reuse; mgd - million gallons per day.
(1) Pipeline sized for full buildout pipeline flow.

For the 4.5 mgd of finished water allocated to San José, a minimum tank volume of 1.9 MG is required to meet the 10:1 blending/attenuation requirement. The Nortech reservoir has a total storage capacity of 3 MG, although it is currently operated with a minimum storage level of 0.7 MG. To satisfy the blending/attenuation requirement, the minimum operating level would have to be raised from 7 to 19 feet. The current maximum water level in the tank is 23 feet. Accordingly, we anticipate that raising the minimum water level would not cause structural and seismic concerns. However, future more detailed analysis is needed to determine if the operational range of 17 to 23 feet is viable. Additional design and improvements may be needed to accommodate the flow needs of this project. This is discussed further in the Next Steps section of Chapter 7.

At the Nortech Reservoir delivery point, the 24-inch pipeline will tee and be reduced in diameter to 18 inches for the line connecting to Nortech Reservoir and 12 inches for the pipeline continuing to Santa Clara's delivery point. Details of this tee are presented in Table 4.5 and depicted in Figure 4.4.

Table 4.5 Design Details for the Tee at Nortech Reservoir

Pipe Segment	Pipeline Flow (mgd)	Pipe Diameter (inches)(1)
San José Supply	6.5	24
Nortech Supply	4.5	18
Santa Clara Supply	2	12

Notes:
Abbreviations: mgd - million gallons per day.
(1) Pipeline sized for full buildout pipeline flow.

Figure 4.4 The Pipeline Tee at Nortech Reservoir

4.3.2 Santa Clara Finished Water Infrastructure

After reaching Nortech Reservoir, the finished water pipeline will continue to deliver finished water to Santa Clara at the existing Northside Reservoir Tank site. Table 4.6 provides the design details of this portion of the pipeline, and Figure 4.5 illustrates the proposed pipe alignment.

Table 4.6 Design Details for the Santa Clara Portion of the Finished Water Pipeline

DPR Production Scenario (mgd)	Pipeline Length (miles)	Pipeline Flow (mgd)	Pipe Diameter (inches)(1)
10, 20	2.7	2	12

Notes:
Abbreviations: DPR - direct potable reuse; mgd - million gallons per day.
(1) Pipeline sized for full buildout pipeline flow.

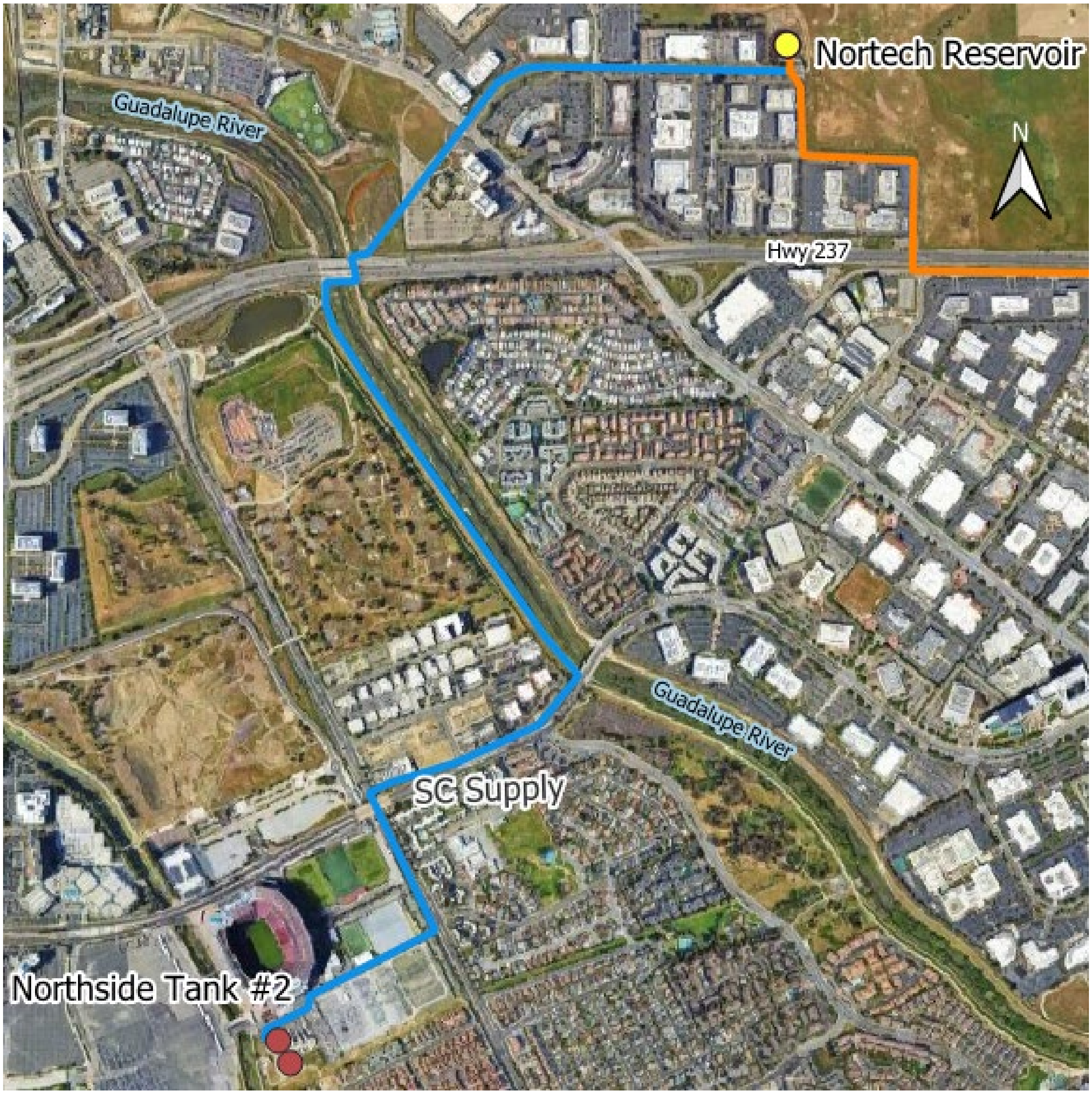

Figure 4.5 The Pipe Alignment of the Santa Clara Portion of the Finished Water Pipeline

The Santa Clara supply pipeline crosses both Highway 237 and the Guadalupe River. Figure 4.6 presents the two crossing pipe alignments considered: a bridge-supported pipe hanger crossing and a jack and bore crossing. In the bridge-supported pipe hanger approach, the pipe would cross under Highway 237 via an open cut trench along the Guadalupe River Trail and then cross over the Guadalupe River via bridge-supported pipe hangers. In the jack and bore option, the pipeline would cross under both Highway 237 and the Guadalupe River via jack and bore, following existing San José recycled water pipe alignments.

Figure 4.6 Two Alignment Options for the Santa Clara Finished Water Pipeline Crossing at Highway 237 and the Guadalupe River

Finished water will be delivered to Santa Clara's Northside Tank No. 2, as shown in Figure 4.7. The tank's minimum operating volume of 3.1 MG exceeds the 0.8 MG required for 10:1 dilution/attenuation and does not require any operational changes. The alignment, as shown in Figures 4.5 and 4.6, was selected using the City of Santa Clara staff's guidance with regards to existing utilities and alignments.

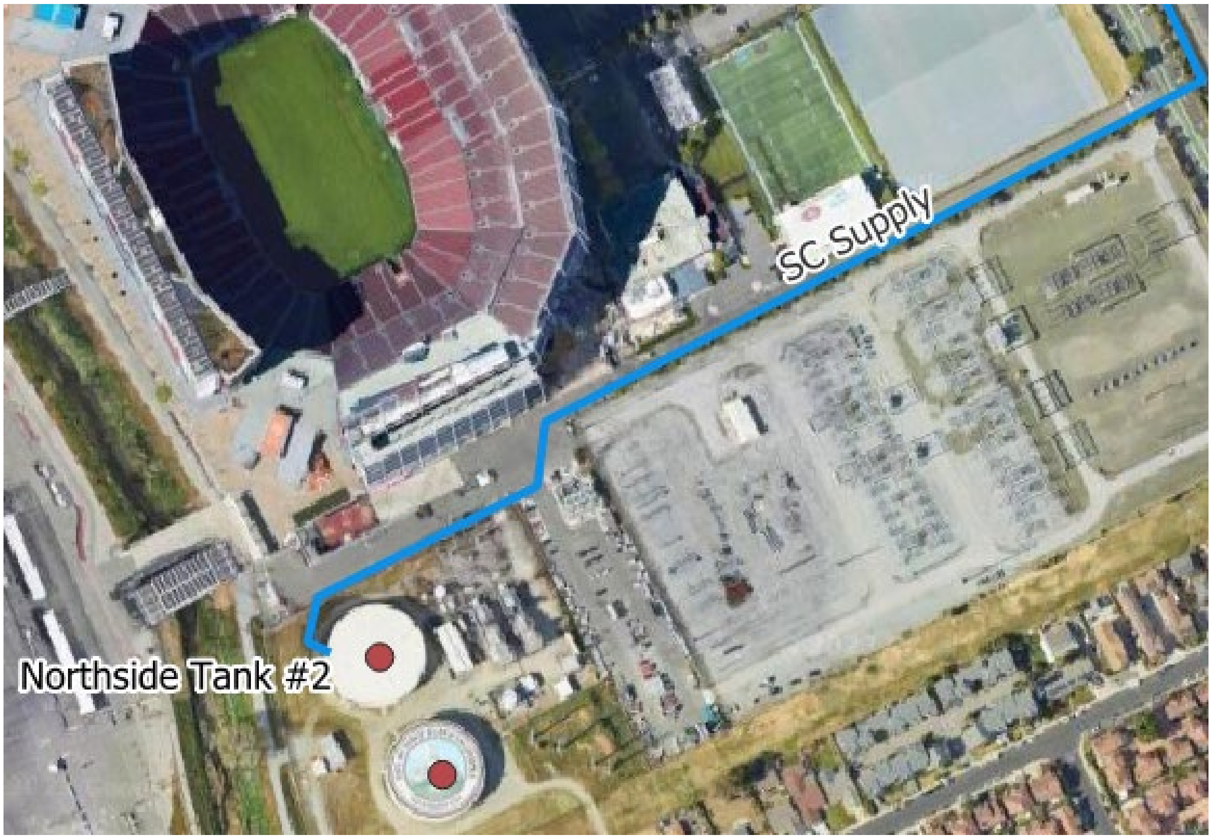

Figure 4.7 Connection Detail for Finished Water Delivery at Santa Clara's Northside Tank No. 2

4.3.3 SFPUC Finished Water Infrastructure

From the AWPF pump station, a separate line will supply finished water to SFPUC's blending tanks; locations within the AWPF footprint are shown in Figure 4.8. The new blending tank will be constructed to meet 10:1 dilution/attenuation requirements for SFPUC's allocation of finished water with a 25 percent safety factor. In the 10 mgd production scenario, SFPUC will be allocated 3.5 mgd. To dilute one hour of this expected flow ten-fold and provide a 25 percent safety factor, the SFPUC dilution tank would need to have a nominal capacity of 1.8 MG. In the 20 mgd production scenario, SFPUC will be allocated 8.5 mgd. To dilute one hour of this expected flow ten-fold and provide a 25 percent safety factor, the SFPUC dilution tank would need to have a nominal capacity of 4.4 MG.

It is important to note that in this larger scenario, blending is not accounted for the 5 mgd of water allocated to a fourth agency (see Table 4.2), per direction from SFPUC. If a fourth agency is identified, the 10:1 dilution/attenuation requirement would need to be met through an additional blending tank, through upsizing the SFPUC blending tank, or through an existing tank in the fourth agency's distribution system.

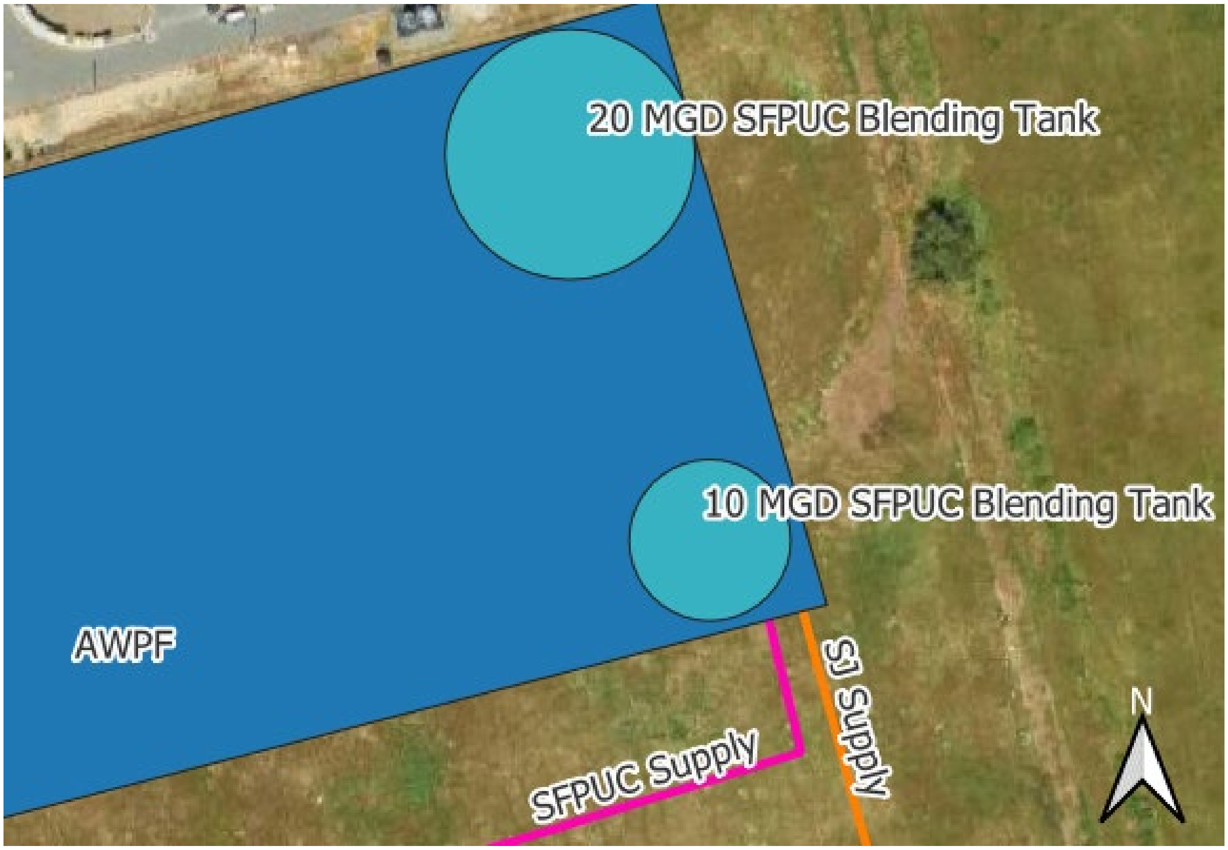

Figure 4.8 Pipe Alignment at the AWPF and New SFPUC Blending Tank Layout for 10 and 20 mgd Production Scenarios

Following the blending tank, a newly constructed pump station will convey finished water to an injection point on BDPLs 3 and 4 via the pipe alignment shown in Figure 4.9. The chosen alignment follows the most direct path to BDPLs 3 and 4. Table 4.8 summarizes the design details for the SFPUC finished water pipeline requirements under both 10 and 20 mgd production scenarios.

During drought conditions, when SFPUC would be receiving water from the AWPF, the combined flow within BDPLs 3 and 4 is expected to be in the range of 10 to 30 mgd. Under these flow conditions the minimum finished water blending achieved within BDPLs 3 and 4 would be roughly 3.85:1 for the 10 mgd production scenario and 2.2:1 for the 20 mgd production scenario. Additional infrastructure needed to allow SFPUC to throttle flow from the AWPF based on the operational goals of the SFPUC Regional Water System (RWS) is not considered in this study but can be addressed in future studies. The SFPUC customers downstream of the connection point to BDPLs 3 and 4 may have specific water quality needs for their water uses and therefore addressing the needs of the downstream customers should be considered in the next stage of the study. This is discussed further in the Next Steps section of Chapter 7.

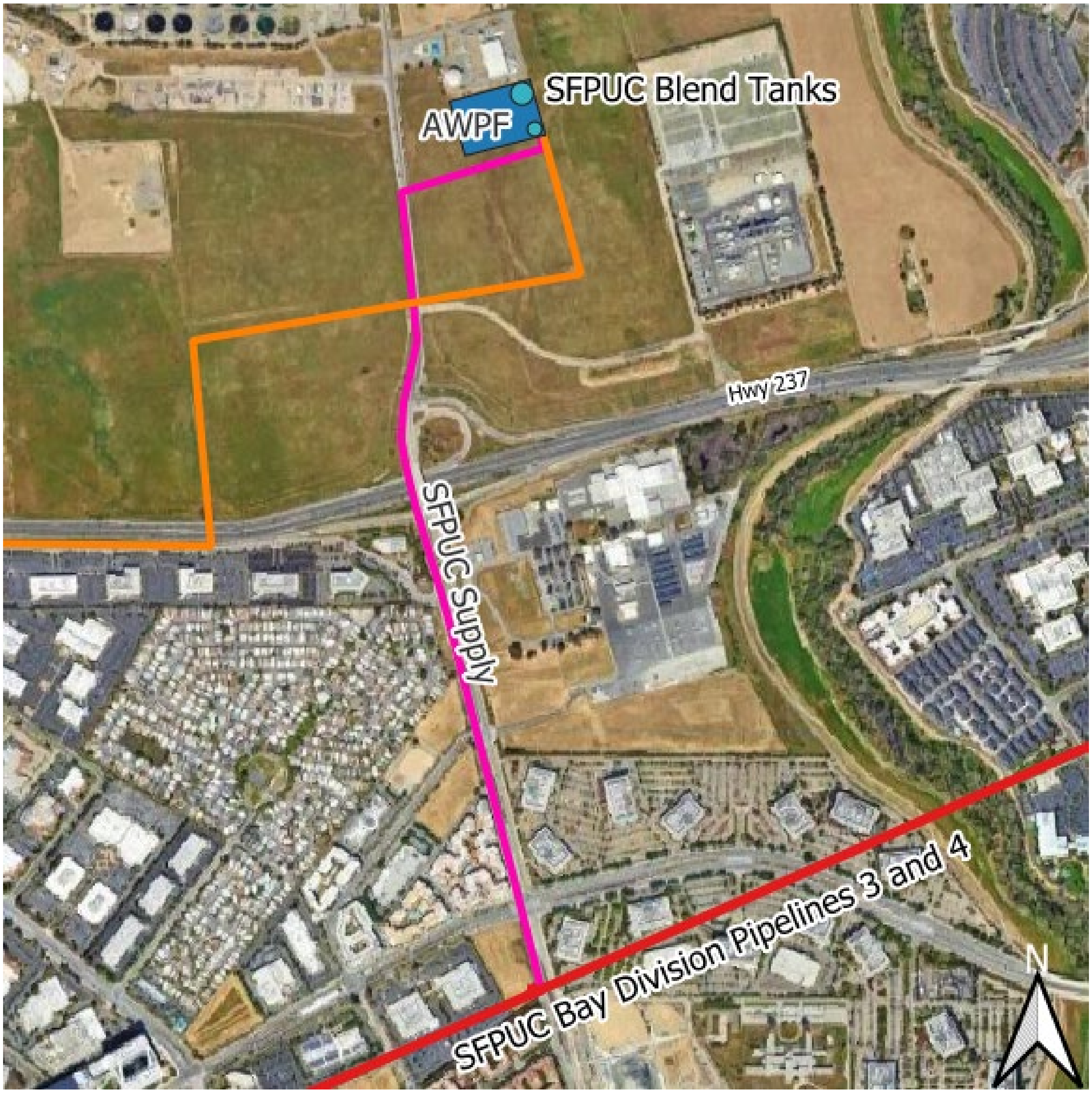

Figure 4.9 Overview of SFPUC's Finished Water Pipeline

Table 4.7 SFPUC Finished Water Pipeline Design Details

DPR Production Scenario (mgd)	Pipeline Length (miles)	Pipeline Flow (mgd)	Pipe Diameter (inches)(1)
10	1.4	3	16
20	1.4	13.5	30

Notes:
Abbreviations: DPR - direct potable reuse; mgd - million gallons per day.
(1) Pipeline sized for full buildout pipeline flow.

4.4 ROC Infrastructure

For this project analysis, ROC will be conveyed to the existing RWF effluent outfall channel as shown in Figure 4.10. Pipeline design details are provided in Table 4.8. It is estimated that around 40 feet (17 pounds per square inch [psi]) of head is required to move the ROC to the RWF effluent channel. Typically, over 100 psi is available at the process ROC discharge point. This available pressure is sufficient to convey the ROC to the outfall without the need for additional pumps. However, it is important to note that a portion of the available ROC pressure is usually recovered to decrease the energy usage at the AWPF. The use of this available pressure for ROC conveyance versus energy recovery will be refined during design and is addressed in the Next Steps section of Chapter 7. Alternatives to use of the existing outfall are briefly described in Section 6.3 of Chapter 6, but no sizing or cost estimates are available for those alternatives at this time.

Figure 4.10 ROC Pipeline Alignment to Existing RWF Outfall

Table 4.8 ROC Outfall Pipeline Design Details

DPR Production Scenario (mgd)	Pipeline Length (miles)	Pipeline Flow (mgd)	Pipe Diameter (inches)(1)
10	1.4	2.5	16
20	1.4	5	18

Notes:
Abbreviations: DPR - direct potable reuse; mgd - million gallons per day.
(1) Pipeline sized for full buildout pipeline flow.

Figure 4.11 depicts an alternative ROC outfall pipe alignment per input from San José. This pipe routing would entail construction of a new outfall for discharge to Pond A18. This alignment is approximately 1.3 miles in length and is for qualitative comparison only (no sizing or costing has been performed as a part of this project). As noted, discussion on implementation of a new outfall in lieu of use of the existing outfall is available in Chapter 6.

Figure 4.11 ROC Pipeline Alignment to New Outfall

4.5 AWPF Waste/Backwash Return Infrastructure

A single pipeline will convey backwash and other waste flows from the AWPF back to the existing 84-inch RWF sewer mains as shown in Figure 4.12. The primary sources of backwash flows are the ultrafiltration (UF) and biological activated carbon (BAC) treatment processes. Both backwash flows are routed to an equalization reservoir, allowing the combined backwash to be pumped off site at a constant rate.

In addition to backwash flows, any water identified to be off-spec during AWPF operation will need to be conveyed back to the RWF sewer lines. Off-spec flows are assumed to be redirected after either the BAC or reverse osmosis (RO) treatment steps and conveyed via treatment system pumps. Because the production flowrate of a single RO train is greater than that of a single biologically active carbon filter (BAF) train, the AWPF Waste/Backwash Return Pipeline is sized to accommodate flow from a single RO train. Pipeline design details are provided in Table 4.9.

A combined air gap structure will receive flows from both the backwash and off-spec flows. A newly constructed pump station will then pressurize the combined return flow sufficiently for delivery into RWF's pressurized sewer mains. Pump station power demands are also included in Table 4.9.

Figure 4.12 AWPF Waste/Backwash Return Pipeline Alignment

Table 4.9 AWPF Waste/Backwash Return Pipeline Design Details

DPR Production Scenario (mgd)	Pipeline Length (feet)	Pipeline Flow (mgd)	Pipe Diameter (inches)	Pump Power Demand (hp)(1)
10	275	5.1	18	140
20	275	6.8	24	180

Notes:
Abbreviations: DPR - direct potable reuse; hp - horsepower; mgd - million gallons per day.
(1) Assumes a minimum pressure of 30 pounds per square inch (psi) for injection into pressurized sewer mains.

4.6 Infrastructure Costs

Table 4.10 summarizes the infrastructure capital costs broken down by infrastructure component: AWPF feedwater, AWPF finished water, and ROC; the operations and maintenance (O&M) costs; and the lifecycle costs for both the 10 and 20 mgd production scenarios. Note that these costs are for conveyance infrastructure only and do not include treatment costs. Treatment costs are provided in Table 3.8. Information on the basis for the development of these planning level costs is provided in Appendix C and detailed cost estimates are provided in Appendix D. The executive summary provides a summary of all costs required for this project (infrastructure, treatment, and solar).

Table 4.10 Conveyance Infrastructure Cost Estimates

Cost Type	Alternative Cost ($M)	
	10 mgd Production	20 mgd Production
Total Project Capital Cost(1)	**$111.21**	**$218.26**
AWPF Feedwater Pump and Pipeline Total Project Capital Cost	$17.35	$30.13
AWPF Finished Water Pump and Pipeline Total Project Capital Cost(2)	$80.87	$172.08
ROC Pipeline Total Project Capital Cost	$5.09	$5.78
AWPF Waste/Backwash Return Pump and Pipeline Capital Cost	$7.90	$10.27
Annualized Total Project Capital Cost(3)	**$6.05**	**$11.87**
Annual O&M Cost(4)	**$2.26**	**$5.39**

Notes:
Abbreviations: $M - dollars in millions; AWPF - Advanced Water Purification Facility; mgd - million gallons per day; O&M - operations and maintenance; ROC - reverse osmosis concentrate.
(1) Costs presented do not include the cost of land acquisition.
(2) Costs presented assume jack and bore instead of bridge supports construction. If bridge supports are used instead of jack and bore construction, the 10 mgd scenario cost would decrease by $4.10 million and the 20 mgd scenario cost would decrease by $6.56 million.
(3) Calculated assuming an interest rate of 3.5 percent and annualized over 30 years.
(4) O&M costs assume a power cost of $0.23 per kilowatt hour (kWh) and an annual maintenance cost of 0.5 percent of the capital cost.

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Chapter 5

POWER NEEDS

5.1 Introduction

This chapter provides an overview of the power requirements and projected power output from solar photovoltaic (PV) systems for both scenarios considered in the South Bay Purified Water Project (Project). These two scenarios are: 1) production of 10 million gallons per day (mgd) of purified water for treated drinking water augmentation (TWA), and 2) production of 20 mgd of purified water for TWA.

The advanced water purification facility (AWPF) required for production of purified water is an energy intensive process. Evaluation of a solar PV installation at the AWPF site and adjacent land area was conducted as part of this study to reduce the AWPF's reliance on grid power. This analysis considers the energy demands of the new AWPF, the solar power generation that may be available with the land, rooftop, and carport space available, and the costs and savings of implementing a solar project based on various scenarios.

Both AWPF sizes developed as a part of this project will be configured to operate at a reduced capacity during non-drought conditions and at full capacity during drought conditions. The solar analysis was performed over a year with a period at full capacity and a period at reduced capacity, simulating the longer non-drought (years) and drought (year+) conditions. It is acknowledged that the planned operation for either sized AWPF would not be ramped up or down seasonally, rather the AWPF would operate consistently, either at reduced or full capacity, over several years depending on drought conditions. Findings of this analysis note that solar PV systems will only fulfill a fraction of power needs in all flow rate conditions assessed. Thus, the anticipated payback period for the solar PV systems will not change regardless of how the AWPF is operated.

5.2 System Power Demands

To understand how much solar power a system could use, a review of the historical electrical demands is typically conducted. As the AWPF has not been built yet, an electrical load profile was simulated based on the rated loading of each of the AWPF process components and pumping and their anticipated corresponding run times. Each treatment component is identified along with its run time to get the total daily load and the peak load.

Additionally, for both scenarios, the expected water production will vary with drought cycles. For the 10 mgd scenario, only 6.5 mgd of finished water will be produced during non-drought conditions while 10 mgd will be produced during a critical drought period. For the 20 mgd scenario, only 10 mgd will be produced during non-drought conditions while 20 mgd will be produced during a critical drought period.

The expected electrical power demands for both drought and non-drought conditions are presented in Table 5.1 and Table 5.3 for the 10 mgd scenario and 20 mgd scenario, respectively. Table 5.2 and Table 5.4 summarize these loadings into average, peak, and minimum expected demands for the 10 mgd scenario and 20 mgd scenarios, respectively.

Table 5.1 10 mgd Expected Electrical Demand

Item	Output Rating, hp	10 mgd (Drought Conditions)			6.5 mgd (Non-Drought Conditions)		
		Total Connected Load, kW	Connected Load Running 24 hpd, kW	Total Connected Load, kWh/day	Total Connected Load, kW	Connected Load Running 24 hpd, kW	Total Connected Load, kWh/day
Treatment							
Oxygen Generators	-	73	73	1,749	73	73	1,749
Ozone Generators	-	438	438	10,505	285	285	6,828
Ozone Flash Mix System	6	4	4	107	4	4	107
BAF Backwash Pumps	100	75	-	298	75	-	298
MF Feed Pumps	150	336	336	8,057	224	224	5,371
MF Strainers	0.5	1	1	27	1	1	18
MF Backwash Pumps	75	56	-	336	56	-	336
MF Air Scour Blowers	60	45	-	269	45	-	269
MF Compressors	10	7	-	45	7	-	45
MF CIP Feed Pumps	75	56	-	336	56	-	336
MF CIP Strainers	0.5	0.4	-	2	0.4	-	2
MF CIP Drain Pump	2.5	2	-	11	2	-	11
RO Flash Mix Pumps	2.5	2	2	45	2	2	45
RO Feed Pumps	300	671	671	16,114	448	448	10,742
RO Interstage Pumps	50	112	112	2,686	75	75	17,90
RO CIP Pumps	250	187	-	187	187	-	187
RO Flush Pumps	10	7	-	15	7	-	15
UV Flash Mix Pumps	2.5	1.9	1.9	45	1.9	1.9	45
UV Feed Pumps	60	134	134	3,223	90	90	2,148
UV AOP System	-	115	115	2,760	75	75	1,794
Calcite Flush Pumps	7	-	15	7	-	15	7
Secondary UV System	40	40	40	960	26	40	624

Item	Output Rating, hp	10 mgd (Drought Conditions)			6.5 mgd (Non-Drought Conditions)		
		Total Connected Load, kW	Connected Load Running 24 hpd, kW	Total Connected Load, kWh/day	Total Connected Load, kW	Connected Load Running 24 hpd, kW	Total Connected Load, kWh/day
Hot Water Transfer Pumps	1	-	9	1	-	9	1
Immersion Heaters	500	-		500	-		500
Infrastructure							
AWPF Feed Pumps	20	45	44.76	1,074	30	29.84	716
Backwash/Off-Spec Water Pumps	140	104	21[(1)]	504	104	21[(1)]	504
Finished Water Pumps for San José/Santa Clara	111	248	248	5,962	166	166	3,975
Finished Water Pumps for SFPUC	100	224	224	5,371	0	0	0
SFPUC Tank Mixer	0.5	0.37	0.37	9	0	0	0
San José Tank Mixer	0.5	0.37	0.37	9	0.37	0.37	9
Santa Clara Tank Mixer	0.5	0.37	0.37	9	0.37	0.37	9

Notes:
Abbreviations: AOP - advanced oxidation process; AWPF - Advanced Water Purification Facility; BAF - biologically active carbon filter; CIP - clean-in-place; hp - horsepower; hpd - hours per day; kW - kilowatt; kWh/day - kilowatt hours per day; MF - microfiltration; mgd - million gallons per day; RO - reverse osmosis; SFPUC - San Francisco Public Utilities Commission; UV - ultraviolet.
(1) Backwash/off-spec water pumps are sized to pump the continuous flow of backwash back to the San José-Santa Clara Regional Wastewater Facility (RWF) in addition to intermittent slugs of off-spec water. The connected running load is assumed to be approximately 20 percent of the total connected load to accommodate the continuous backwash flow and intermittent off-spec water flow and should be refined further should this project proceed to design.

Table 5.2 10 mgd Expected Electrical Demand Summary

Period	10 mgd (Drought Conditions)	6.5 mgd (Non-Drought Conditions)	Annual Average
Average Day, kW	3,014	2,066	2,350
Peak, kW	3,998	3,051	3,231
Minimum, kW	2,950	2,003	2,287
Total, kWh/day	60,737	37,997	44,819

Notes:
Abbreviations: kW - kilowatt; kWh/day - kilowatt hours per day; mgd - million gallons per day.

Table 5.3 20 mgd Expected Electrical Demand

Item	Output Rating, hp	20 mgd (Drought Conditions)			10 mgd (Non-Drought Conditions)		
		Total Connected Load, kW	Connected Load Running 24 hpd, kW	Total Connected Load, kWh/day	Total Connected Load, kW	Connected Load Running 24 hpd, kW	Total Connected Load, kWh/day
Treatment							
Oxygen Generators	-	146	146	3,504	73	73	1,749
Ozone Generators	-	875	875	21,000	438	438	10,505
Ozone Flash Mix System	6	9	9	216	4	4	107
BAF Backwash Pumps	100	75	-	300	75	-	298
MF Feed Pumps	200	746	746	17,904	448	448	10,742
MF Strainers	0.5	2	2	48	1	1	27
MF Backwash Pumps	75	56	-	336	56	-	336
MF Air Scour Blowers	60	45	-	270	45	-	269
MF Compressors	10	7	-	42	7	-	45
MF CIP Feed Pumps	75	56	-	336	56	-	336
MF CIP Strainers	0.5	0.4	-	2	0.4	-	2
MF CIP Drain Pump	2.5	2	-	12	2	-	11
RO Flash Mix Pumps	5.0	4	4	96	4	4	90
RO Feed Pumps	350	1,306	1,306	31,344	783	783	18,799
RO Interstage Pumps	75	280	280	6,720	112	112	2,686
RO CIP Pumps	250	187	-	187	187	-	187
RO Flush Pumps	50	37	-	74	37	-	75
UV Flash Mix Pumps	5	3.7	3.7	89	3.7	3.7	90
UV Feed Pumps	75	280	280	6,720	168	168	4,028
UV AOP System	-	230	230	5,520	115	115	2,760
Calcite Flush Pumps	10	7	-		7	-	
Secondary UV System	-	67	67	1,608	40	40	960

Item	Output Rating, hp	20 mgd (Drought Conditions)			10 mgd (Non-Drought Conditions)		
		Total Connected Load, kW	Connected Load Running 24 hpd, kW	Total Connected Load, kWh/day	Total Connected Load, kW	Connected Load Running 24 hpd, kW	Total Connected Load, kWh/day
Hot Water Transfer Pumps	2	1	-	6	1	-	9
Immersion Heaters	-	500	-	3,000	500	-	3,000
Infrastructure							
AWPF Feed Pumps	28	63	63	1,512	42	42	1,003
Backwash/Off-Spec Water Pumps	180	134	27[(1)]	644	134	27[(1)]	644
Finished Water Pumps for San José/Santa Clara	222	497	497	11,928	248	248	5,962
Finished Water Pumps for SFPUC	367	821	821	19,704	274	274	6,571
SFPUC Tank Mixer	0.5	0.37	0.37	9	0	0	0
San José Tank Mixer	0.5	0.37	0.37	9	0.37	0.37	9
Santa Clara Tank Mixer	0.5	0.37	0.37	9	0.37	0.37	9

Notes:
Abbreviations: AOP - advanced oxidation process; AWPF - Advanced Water Purification Facility; BAF - biologically active carbon filter; CIP - clean-in-place; hp - horsepower; hpd - hours per day; kW - kilowatt; kWh/day - kilowatt hours per day; MF - microfiltration; mgd - million gallons per day; RO - reverse osmosis; SFPUC - San Francisco Public Utilities Commission; UV - ultraviolet.
(1) Backwash/off-spec water pumps are sized to pump the continuous flow of backwash back to the San José-Santa Clara Regional Wastewater Facility (RWF) in addition to intermittent slugs of off-spec water. The connected running load is assumed to be approximately 20 percent of the total connected load to accommodate the continuous backwash flow and intermittent off-spec water flow and should be refined further should this project proceed to design.

Table 5.4 20 mgd Expected Electrical Demand Summary

Period	20 mgd (Drought Conditions)	10 mgd (Non-Drought Conditions)	Annual Average
Average Day, kW	6,165	3,588	4,361
Peak, kW	6,948	4,372	5,145
Minimum, kW	5,973	3,398	4,171
Total, kWh/day	133,149	71,307	89,859

Notes:
Abbreviations: kW - kilowatts; kWh/day - kilowatt hours per day; mgd - million gallons per day.

The expected daily loads for both scenarios were converted to an annual load profile so that the benefit of solar addition could be evaluated using daily and seasonal solar radiation.

As an example only for this study, we examined a condition where drought conditions were extreme in the summer months but relaxed through the winter months. In this example, it was assumed that there are three months in the summer (July, August, and September) when the plant is at full capacity (drought conditions). It was also assumed there are two shoulder months (June and October) where the AWPF is ramping from drought conditions to non-drought conditions and a weighted average amount of power is required. For the remaining months, it was assumed that the AWPF is consistently processing either 6.5 mgd at the 10 mgd plant or 10 mgd at the 20 mgd plant (non-drought conditions). The annual assumed profile that reflects this example condition for the 10 mgd scenario is presented in Figure 5.1. As noted previously, it is acknowledged that the planned operation for the future AWPF would operate at one flow rate over several years depending on drought conditions.

To address the peak demands that will occur over the course of a day and a month, the maximum demand load was simulated over the year. A heat map showing the fluctuations in the 10 mgd scenario is presented in Figure 5.2. Capturing the peaks is essential because the utility provider charges a demand charge which is based on the highest 15-minute rolling interval of the previous month. This charge is for the service of maintaining the capacity in the future. Minimizing peaks through solar power generation and energy storage is key in decreasing demand charges, which can constitute 30 to 70 percent of a monthly bill.

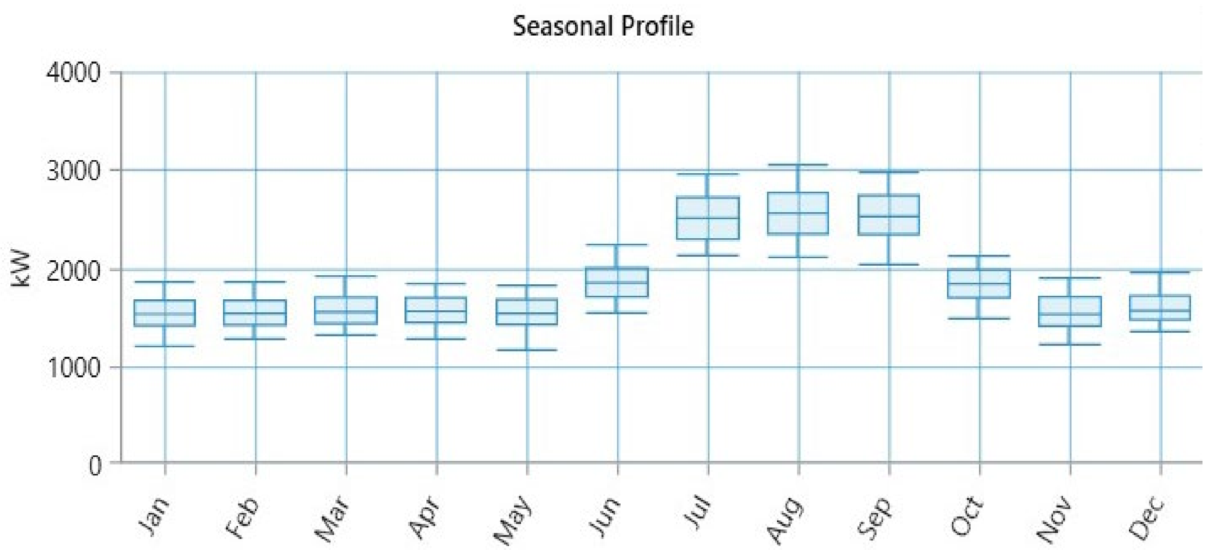

Figure 5.1 10 mgd Assumed Annual Demand Load Profile

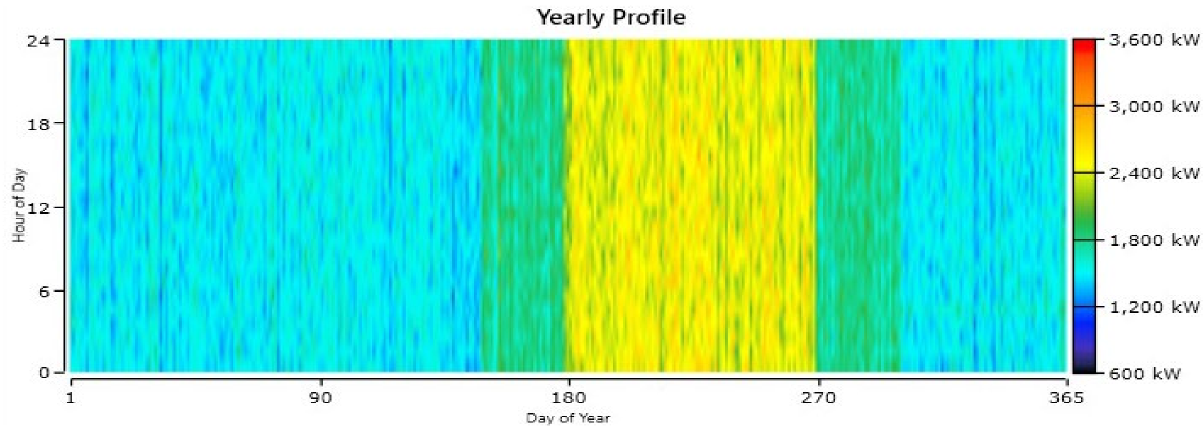

Figure 5.2 10 mgd Assumed Annual Demand Load Profile Heat Map Simulation

5.3 Available Solar Output

The local utility, Pacific Gas & Electric (PG&E) can be expected to service the AWPF power demand. For customers with maximum demands of 1,000 kW or more, i.e., the AWPF, the current tariff used by PG&E is "B-20".[1] There are different charges for this tariff based on both summer and winter energy use and demand charges. Demand charges are calculated looking at the maximum peak 15-minute period of the previous month. Minimizing peaks reduces demand charges which can be a significant portion of a utility bill. Solar and/or battery storage are alternatives to relying on traditional utilities. These alternatives are evaluated further in this section.

The amount of energy a solar project can produce is directly related to the number of solar panels that can be located at the site and the amount of sunlight reaching the panels. The area available for solar was identified for both the 10 mgd and 20 mgd scenarios and is presented in Figure 5.3 and Figure 5.4, respectively (Site Only). Additional land was identified by the City of San José that was also evaluated for its additional solar potential. The additional land is presented in Figure 5.5 as Area 1 (approximately 3.7 acres) and Area 2 (approximately 4.5 acres). A small 0.8-acre area of land (between the AWPF location and Area 1) was not included in the solar analysis. This was to provide additional flexibility and space for potential modifications at the AWPF site, including installation of additional blending tanks for San José and Santa Clara on site. The solar output calculated with this total available land represents a conservative estimate that can be refined as AWPF design progresses.

A summary of the land area available for each 10 mgd scenario (Site Only, Site Plus Area 1, and Site Plus Areas 1 and 2) is presented in Table 5.5 and in Table 5.6 for each 20 mgd scenario. The corresponding potential solar output is also presented in these tables. In all cases, the daily amount of solar power produced is much less than the energy required to run the AWPF and associated infrastructure.

The location of the site, 4190 Zanker Road, San José, California 95143 (37°25.7'N, 121°56.4'W) receives sufficient solar radiance to support solar production. The National Renewable Energy Laboratory measures the three most common measurements of solar radiation: global horizontal, direct normal, and diffuse horizontal irradiance throughout the United States and provides this in its National Solar Radiation Database. This data was used to model solar output in each scenario.

[1] PG&E B-20 tariff can be found at: https://www.pge.com/tariffs/electric.shtml.

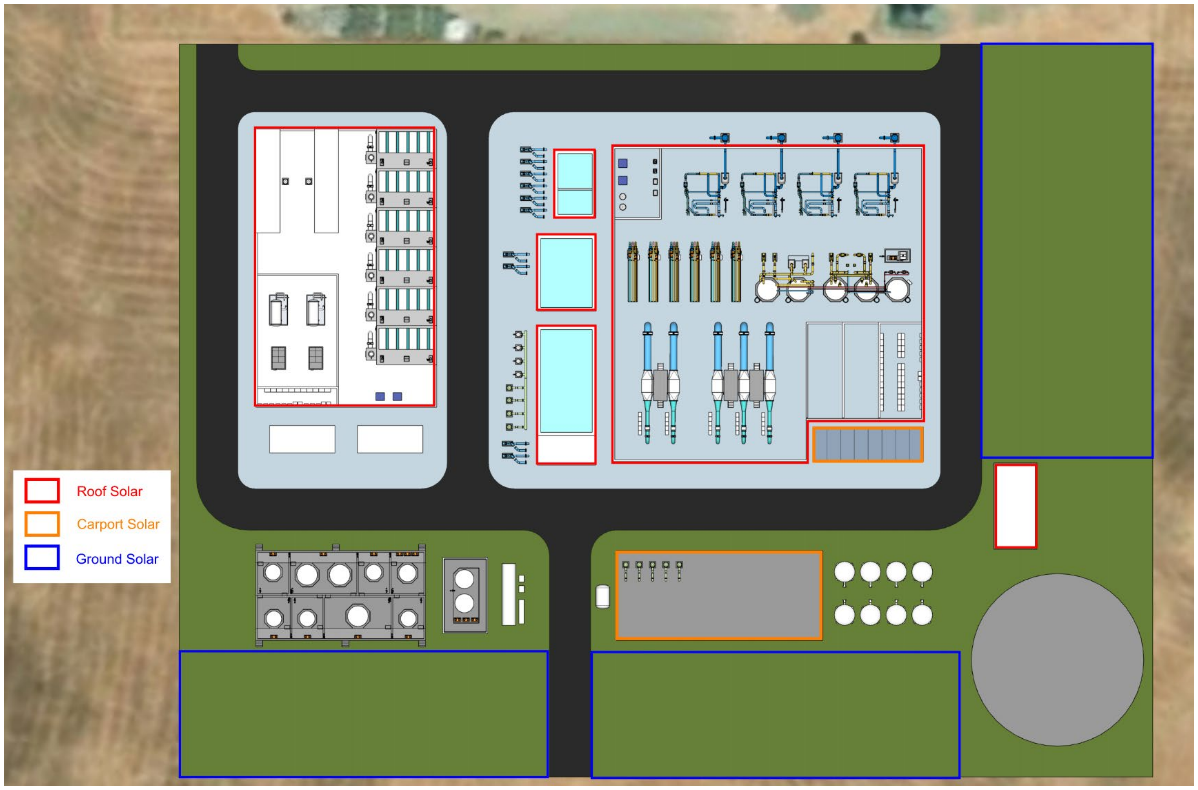

Figure 5.3 10 mgd AWPF Site Layout With Potential Solar Sites

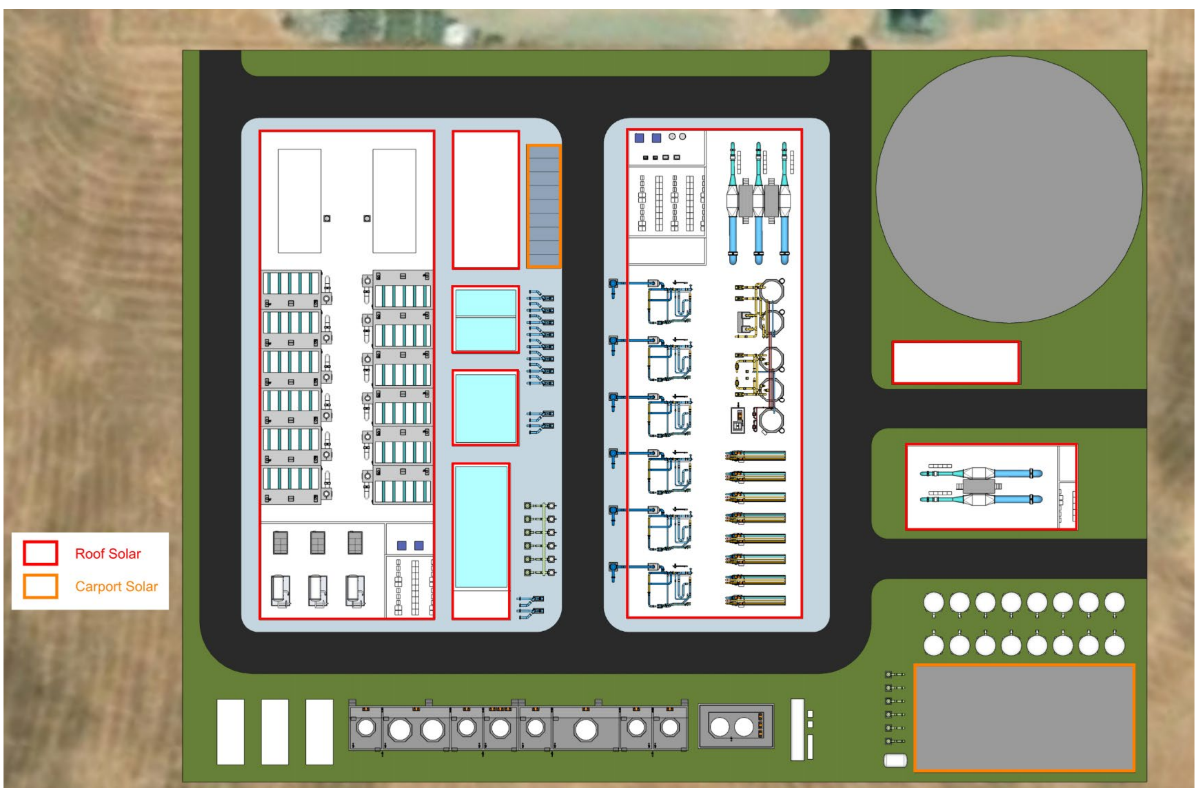

Figure 5.4 20 mgd AWPF Site Layout With Potential Solar Sites

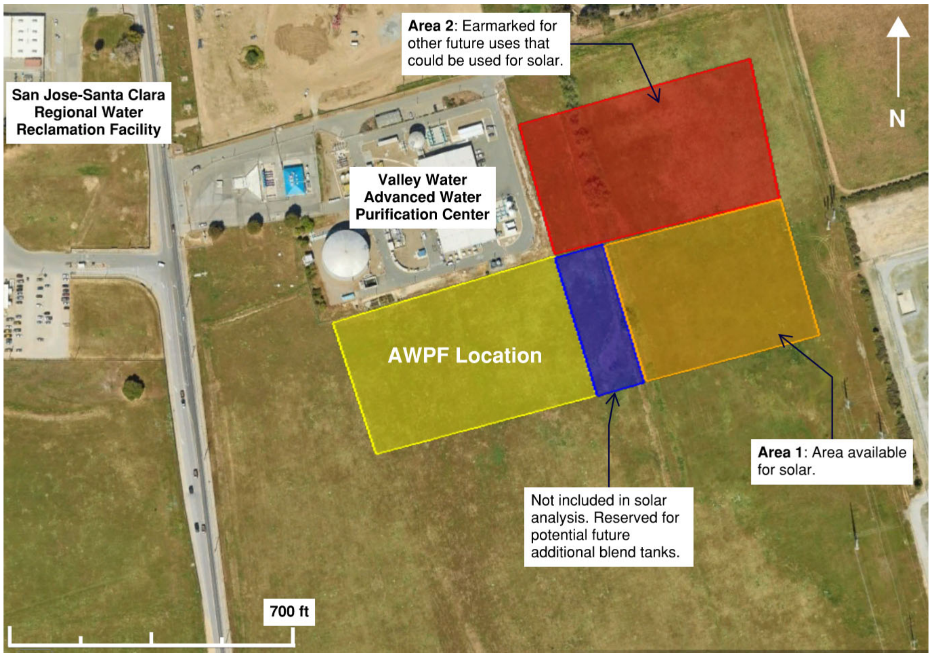

Figure 5.5 AWPF Site Layout With Adjacent Possible Solar Land Sites

Table 5.5 10 mgd Potential Solar Area and Output

Site	Unit Output, sf/kW	Solar Area			Solar Output		
		Site Only, sf	Site + Area 1, sf	Site + Area 1 + Area 2, sf	Site Only, kW	Site + Area 1, kW	Site + Area 1 + Area 2, kW
Roof	84	55,000	55,000	55,000	655	655	655
Carport	70	7,800	7,800	7,800	111	111	111
Ground Mounted	218	55,700	214,700	407,700	256	985	1,870
Total		**118,500**	**277,500**	**470,500**	**1,022**	**1,751**	**2,636**
Model Assumption					**1,000**	**1,700**	**2,600**

Notes:
Abbreviations: kW - kilowatt; sf - square feet; sf/kW - square feet per kilowatt.

Table 5.6 20 mgd Potential Solar Area and Output

Site	Unit Output, sf/kW	Solar Area			Solar Output		
		Site Only, sf	Site + Area 1, sf	Site + Area 1 + Area 2, sf	Site Only, kW	Site + Area 1, kW	Site + Area 1 + Area 2, kW
Roof	84	74,900	68,900	68,900	892	820	820
Carport	70	9,400	9,300	9,300	134	133	133
Ground Mounted	218	-	159,000	352,000	0	729	1615
Total		**84,300**	**237,200**	**430,200**	**1,026**	**1,682**	**2,568**
Model Assumption					**1,000**	**1,700**	**2,600**

Notes:
Abbreviations: kW - kilowatt; sf - square feet; sf/kW - square feet per kilowatt.

5.4 Alternatives Analysis

Several options were evaluated for solar project implementation. For both the 10 mgd scenario and 20 mgd scenario, the option of placing solar on the Site Only, the Site Plus Area 1, and the Site Plus both Area 1 and Area 2 were each evaluated based on the estimated solar output presented in Tables 5.5 and 5.6, respectively.

In addition, three potential technological conditions were evaluated. The first condition is having solar panels without battery storage. The second condition includes battery storage without solar panels. In this condition, battery usage can be optimized to purchase power during off-peak times and store the power so it can later be used during peak times when purchasing from the grid is expensive. The third condition is having both solar panels and battery storage. In addition to storing off-peak purchased power, the battery can store any excess energy that is produced by the solar panels. In both instances, the battery can shave off peak usage thereby reducing demand charges which drive up utility bills.

To evaluate the numerous options for each scenario, this analysis used Homer Grid, a software that integrates engineering and economics to optimize solar design and rank options considered on an economic basis.

The results of the Homer Grid analysis for each scenario are presented in Table 5.7 for the 10 mgd facility and Table 5.8 for the 20 mgd facility. Further details on the capital cost estimates can be found in Appendix D.

The assumptions used to develop the Homer Grid model are as follows:

- The PV system assumed is based on generic flat plate high efficiency solar panels with a panel life of 20 years
- Storage is assumed to be a 1-megawatt lithium-ion battery with a battery life of 15 years (assuming degradation)
- Project life: 20 years
- Discount rate: 5.0 percent
- Inflation rate: 3.5 percent
- The utility tariff used is PG&E's B-20 tariff, which is for service to customers with maximum demands of 1,000 kW or more

The AWPF consumes nearly all (greater than 99 percent) of the energy produced by the solar system with or without the battery. Consequently, export prices back to the grid are not a factor in this analysis.[2] Due to variances in the loading profile, there is a slight variation in the base case calculated cost of energy for the 10 mgd plant and 20 mgd plant scenarios.

Solar systems that begin construction before the end of 2032 are eligible for a 30 percent Federal Tax Credit if they meet labor requirements issued by the Treasury Department. After 2032, the Federal Tax Credit will incrementally decrease over several years. A construction start date has not been set for this project, yet if construction were to begin after 2032, it is anticipated that a similar tax credit will be in place. Therefore, a 30 percent reduction has been applied and the levelized cost of energy and payback are based on application of the reduction.

[2] The Net Energy Metering 3.0 Program, which was recently adopted in California, significantly changes the export price back to the grid.

Table 5.7 10 mgd Costs, Payback, and Percent Solar

	Capital Expenditure ($ in Millions)	Capital Expenditure(1) after 30% Federal Tax Credit ($ in Millions)	Levelized Cost of Energy(2,3) ($/kWh)	Payback(3,4) (years)	Renewable Fraction(5) (%)
Base Case	-	-	$0.225	-	-
Battery Only	$2.05	$1.44	$0.224	10.4	0.0
Site Only (1,000 kW)					
Solar + Battery	$5.58	$3.91	$0.223	15.2	10.0
Solar Only	$3.53	$2.47	$0.223	14.5	10.4
Site + Area 1 (1,700 kW)					
Solar + Battery	$8.05	$5.64	$0.219	13.8	17.3
Solar Only	$6.00	$4.20	$0.219	12.8	17.7
Site + Area 1 + Area 2 (2,600 kW)					
Solar + Battery	$11.23	$7.86	$0.214	13.1	26.4
Solar Only	$9.18	$6.42	$0.212	12.3	26.6

Notes:
Abbreviations:$ - dollars; $/kWh - dollars per kilowatt hour; kW - kilowatt.
(1) The total installation cost at the beginning of the project.
(2) Levelized cost of energy: Average cost per kilowatt hour (kWh) of electrical energy of the system (both solar and purchased).
(3) The levelized cost of energy and payback take into consideration a 30 percent Federal Tax Credit (or similar incentive if constructed after 2032).
(4) The number of years it will take to recover the difference in investment costs including annual operations and maintenance (O&M) costs compared to the base case, i.e., the number of years for the project to pay for itself.
(5) The percentage of renewable energy (i.e., solar) versus grid purchases.

Table 5.8 20 mgd Costs, Payback, and Percent Solar

	Capital Expenditure ($ in Millions)	Capital Expenditure(1) after 30% Federal Tax Credit ($ in Millions)	Levelized Cost of Energy(2,3) ($/kWh)	Payback(3,4) (years)	Renewable Fraction(5) (%)
Base Case	-	-	$0.221	-	-
Battery Only	$2.05	$1.44	$0.222	8.9	0.0
Site Only (1,000 kW)					
Solar + Battery	$5.58	$3.91	$0.221	13.7	5.0
Solar Only	$3.53	$2.47	$0.222	13.9	5.2
Site + Area 1 (1,700 kW)					
Solar + Battery	$8.05	$5.64	$0.219	12.9	8.6
Solar Only	$6.00	$4.20	$0.220	12.6	8.8

	Capital Expenditure ($ in Millions)	Capital Expenditure(1) after 30% Federal Tax Credit ($ in Millions)	Levelized Cost of Energy(2,3) ($/kWh)	Payback(3,4) (years)	Renewable Fraction(5) (%)
Site + Area 1 + Area 2 (2,600 kW)					
Solar + Battery	$11.23	$7.86	$0.217	12.4	13.2
Solar Only	$9.18	$6.42	$0.218	12.0	13.4

Notes:
Abbreviations: $ - dollars; $/kWh - dollars per kilowatt hour; kW - kilowatt.
(1) The total installation cost at the beginning of the project.
(2) Levelized cost of energy: Average cost per kilowatt hour (kWh) of electrical energy of the system (both solar and purchased).
(3) The levelized cost of energy and payback take into consideration a 30 percent Federal Tax Credit (or similar incentive if constructed after 2032).
(4) The number of years it will take to recover the difference in investment costs including annual operations and maintenance (O&M) costs compared to the base case (i.e., the number of years for the project to pay for itself).
(5) The percentage of renewable energy (i.e., solar) versus. grid purchases.

5.5 Renewable Fraction of AWPF Energy Consumption with Solar

As discussed above, the amount of solar power that could be produced with any of the alternatives considered is significantly less than the energy required to run the AWPF. The portion of this energy usage that could be produced by solar is called the Renewable Fraction. Figure 5.6 through Figure 5.9 show the Renewable Fraction graphically for the Site Only and Site Plus Area 1 and Area 2 cases for both the 10 mgd and 20 mgd Solar Only scenarios.

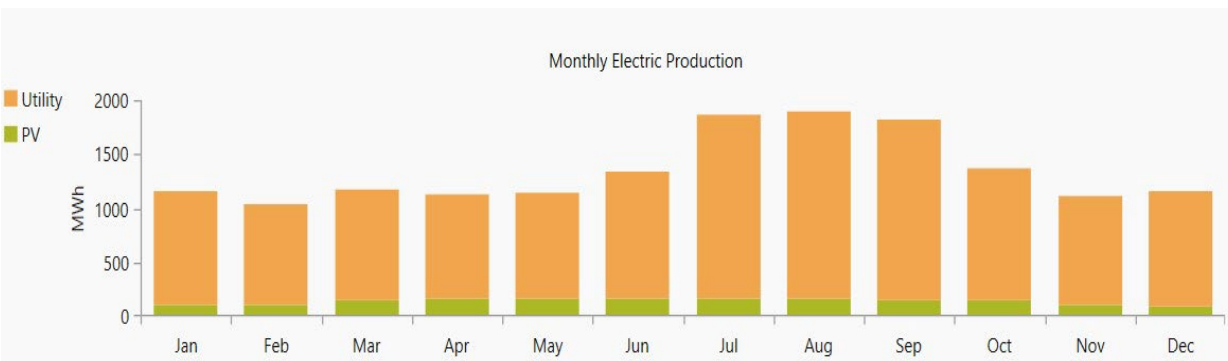

Figure 5.6 Renewable Fraction – 10 mgd Site Only Monthly Grid Purchase and Solar Production

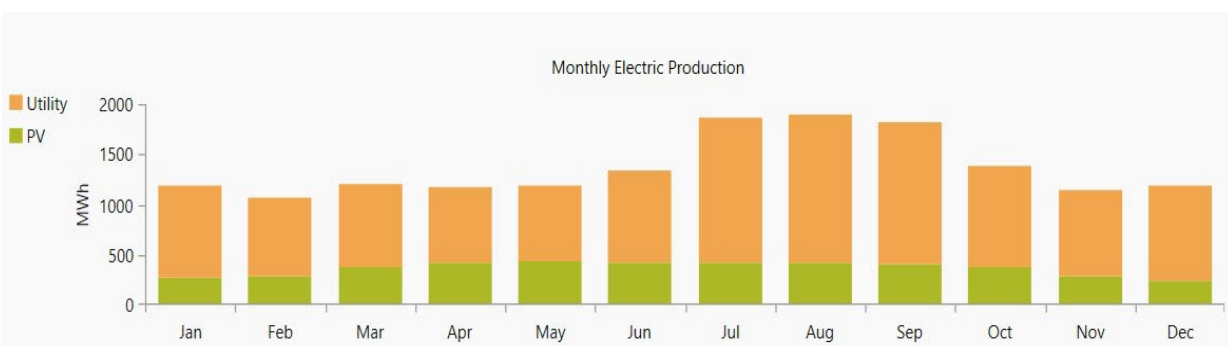

Figure 5.7 Renewable Fraction – 10 mgd Site Plus Area 1 and Area 2 Monthly Grid Purchase and Solar Production

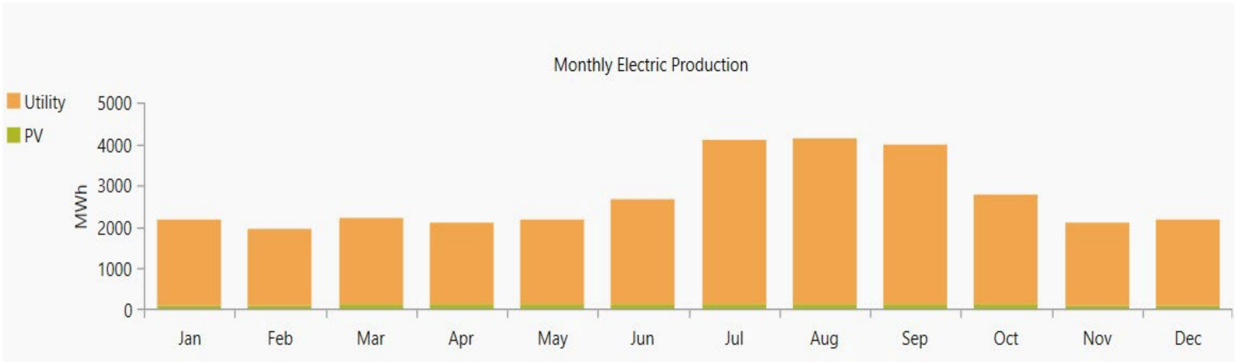

Figure 5.8 Renewable Fraction – 20 mgd Site Only Monthly Grid Purchase and Solar Production

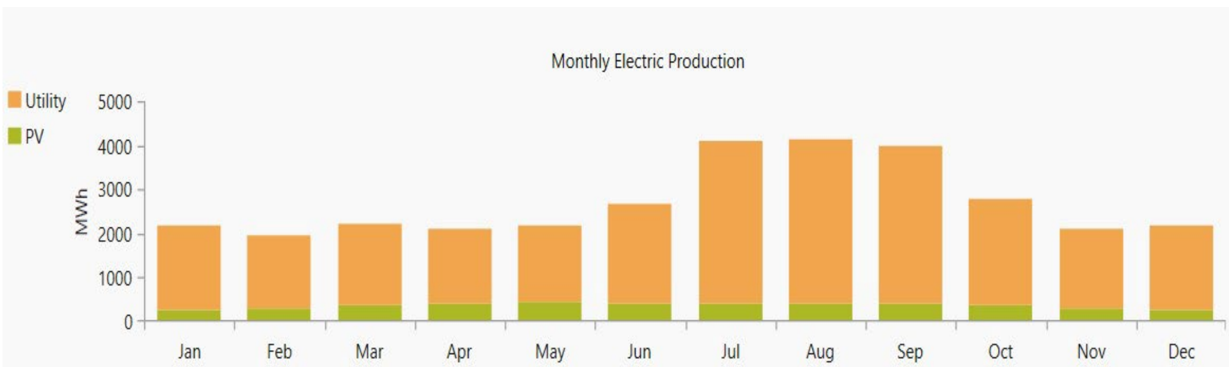

Figure 5.9 Renewable Fraction – 20 mgd Site Plus Area 1 and Area 2 Monthly Grid Purchase and Solar Production

5.6 Power Purchase Agreement

A Power Purchase Agreement (PPA) is another option that may be more economical for solar implementation. A PPA is an arrangement in which a third-party installs, owns, and operates the solar system on your property. When a PPA is entered, a purchase price to buy back the electrical output for a set number of years is agreed upon. The third-party is able to take direct advantage of renewable energy tax incentives, tax credits, tax write-offs, and/or sales of tax liability that allows them to profit from the sale of the electricity at a much lower price than a facility could otherwise achieve on their own. The benefit to the facility is that there are no upfront capital expenditures, no annual maintenance costs, and lower electrical purchase prices (typically 10 to 30 percent lower).

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Chapter 6

NPDES DISCHARGE ANALYSIS

6.1 Introduction

This chapter provides an overview of the options available for reverse osmosis concentrate (ROC) disposal for the two scenarios considered in the South Bay Purified Water Project (Project). These two scenarios are: 1) production of 10 million gallons per day (mgd) of purified water for treated drinking water augmentation (TWA); and 2) production of 20 mgd of purified water for TWA.

The evaluated approach for ROC management is disposal into the San José-Santa Clara Regional Wastewater Facility's (RWF) existing outfall. This chapter also reviews other potential ROC disposal solutions at a high level for future consideration.

6.2 ROC in the Existing RWF Outfall

This evaluation considers if sending ROC to the RWF outfall is feasible within the requirements of the RWF's existing National Pollutant Discharge Elimination System (NPDES) permit.[1] The RWF currently complies with three NPDES permits (NPDES No. CA0037842, NPDES No. CA0038849, and NPDES No. CA0038873). It is important to note that the existing permits are based on past discharge water quality and adding ROC to the existing outfall will change the discharge water quality. A new permit, if granted, may have different discharge limits. This is noted in the Next Steps section of Chapter 7.

Potential constituents in the ROC waste stream that could cause an NPDES exceedance must be identified. This analysis is a preliminary step on which to base future evaluation of the impacts of ROC discharge. Tertiary effluent data to support this analysis were obtained from the California Integrated Water Quality System (CIWQS) for the period from 2015 through 2021.

6.2.1 Determination of Relevant Constituents

Constituents of interest included in this analysis were selected as follows:

- Constituents that currently have NPDES discharge limits:
  - **Ammonia, copper, nickel, cyanide, and mercury:** These constituents were detected in CIWQS data for 2015 through 2021, and they are therefore included in the quantitative analysis.
  - **Biological constituents, carbonaceous biochemical oxygen demand (CBOD), total suspended solids (TSS), oil and grease, pH, and turbidity:** These constituents were not included in the quantitative analysis because they will be removed through treatment processes prior to the reverse osmosis (RO).[2] Given the low concentrations that might enter the RO process, the resulting ROC concentrations are not anticipated to approach discharge limits.

[1] This report did not evaluate a new separate NPDES permit at a new discharge point. Qualitative discussion on pursuing a new discharge point is provided in Section 6.3.

[2] CBOD will be removed via biodegradation through RWF biological process as well as the ozone/biologically active carbon filter (BAF) process. TSS, oil and grease, and turbidity will be removed through both ozone/biological activated carbon (BAC) and ultrafiltration (UF).

   - **Dioxin toxic equivalency (TEQ):** Data from the CIWQS indicate that the method detection limit for 2,3,7,4-TCDD, i.e., dioxin, is above the NPDES discharge limit. Because this compound was not detected from 2014 to 2018, including it in the current analysis (e.g., by assuming half the detection limit) would lead to results that were an artifact of the method detection limit. Future sampling using a method with a lower detection limit, if available, is recommended to confirm this constituent is not an issue in the ROC.
- Other constituents from the NPDES permit, Reasonable Potential Analysis:
   - Additional constituents of potential concern were identified in the RWF's NPDES permit, Table F-7, Reasonable Potential Analysis. The RO process concentrates effluent constituents not removed by microfiltration (MF)/UF by a factor of roughly five. Any constituent in this table with a maximum effluent concentration within five times the governing water quality criterion or objective was included in the quantitative analysis. Two constituents met this criterion: Selenium and zinc.
   - The Reasonable Potential Analysis governing water quality criterion was assumed to be the discharge limit. Although the actual determination of discharge limits would involve additional factors, such as site-specific conditions and background concentrations, this simplified estimate is sufficient to determine whether these constituents are likely to be of concern.
   - To estimate concentrations in the ROC, 95th percentile effluent concentrations were used. In accordance with the RWF NPDES permit, no dilution credits were applied except for cyanide (3:1 dilution credit).

6.2.2 Anticipated ROC Concentrations

Three assumptions were made about RO performance:

- RO recovery of 80 percent
- No removal of constituents by ozone/BAC and UF other than those previously noted
- Ninety-nine percent removal of constituents through RO, which means that one percent of constituents in the tertiary effluent pass through RO and are not captured and transferred to the ROC

Based on these assumptions for the RO process, the ROC concentrations based on 95th percentile tertiary effluent data were estimated and are summarized in Table 6.1. The results of the analysis show that without dilution ammonia, copper, and nickel in ROC discharge could exceed NPDES limits if there is no dilution of the ROC. Copper poses the greatest potential issue, as both the monthly average and the daily maximum limits would be exceeded in the ROC. Cyanide, mercury, selenium, and zinc are not expected to exceed existing or estimated potential NPDES discharge limits.

Table 6.1 Summary of Estimated Highest ROC Discharge Concentrations for Constituents of Interest Relative to NPDES Permit Discharge Limits

Constituent	Units	NPDES Limit	Tertiary Effluent Concentration(1)	Estimated ROC Concentration(2)	Likely to Exceed Limit?
Ammonia, Daily Maximum	mg/L	8	1.01	5.00	No
Ammonia Monthly Average	mg/L	3	0.98	4.85	Yes
Copper, Daily Maximum	µg/L	16	3.69	18.27	Yes

Constituent	Units	NPDES Limit	Tertiary Effluent Concentration(1)	Estimated ROC Concentration(2)	Likely to Exceed Limit?
Copper Monthly Average	µg/L	11	3.69	18.27	Yes
Nickel, Daily Maximum	µg/L	33	6.12	30.29	No
Nickel Monthly Average	µg/L	25	5.99	29.65	Yes
Cyanide Daily Maximum	µg/L	11(3)	2	3.30	No
Cyanide Monthly Average	µg/L	5.7(3)	2	3.30	No
Mercury Daily Maximum	µg/L	0.027	0.00175	0.01	No
Mercury Monthly Average	µg/L	0.025	0.00180	0.01	No
Selenium(4)	µg/L	5	0.9	4.46	No
Zinc(4)	µg/L	161	27.7	137.12	No

Notes:
Abbreviations: mg/L - milligrams per liter; NPDES - National Pollutant Discharge Elimination System; ROC - reverse osmosis concentrate; µg/L - micrograms per liter.
(1) Values are 95th percentile from 2015 to 2021 San José-Santa Clara Regional Wastewater Facility (RWF) effluent data from California Integrated Water Quality System (CIWQS).
(2) Assumes 80 percent reverse osmosis (RO) recovery and 99 percent constituent removal.
(3) The RWF NPDES permit grants a 3:1 dilution credit for cyanide. The dilution credit is reflected in the estimated ROC concentration. No other constituents receive a dilution credit.
(4) Selenium and zinc are reasonable potential analysis constituents, not part of the effluent discharge requirements. It was assumed that no dilution credits would be granted for these constituents.

6.2.3 Anticipated Outfall Concentrations

As discussed in Chapter 3, the maximum amount of tertiary effluent available for the Advanced Water Purification Facility (AWPF) feedwater is 25 mgd. For the 10 mgd production scenario, 12.5 mgd of tertiary effluent will be needed to produce purified water, leaving 12.5 mgd available for blending with ROC in the outfall. However, for the larger 20 mgd production scenario, all the available tertiary effluent from the RWF would be fed to the new AWPF, leaving no water available for blending in the existing RWF outfall (*this assumes all other water from the RWF is allocated to other uses*). Table 6.2 summarizes the expected concentration of blended water at the outfall for the two scenarios. Since no tertiary effluent is available for blending in the 20 mgd finished water scenario, the concentrations shown match the expected ROC concentrations. However, in the 10 mgd finished water scenario, it is expected that blending provides sufficient dilution to avoid permit exceedances. There is sufficient tertiary effluent to provide dilution of the ROC up to an AWPF production capacity of 16.2 mgd.

Table 6.2 Summary of Estimated Highest ROC Discharge Concentrations for Constituents of Interest Relative to NPDES Permit Discharge Limits

Constituent	Units	NPDES Limit	10 mgd Scenario		20 mgd Scenario	
			Estimated Outfall Concentration(1)	Likely to Exceed Limit?	Estimated Outfall Concentration(2)	Likely to Exceed Limit?
Ammonia, Daily Maximum	mg/L	8	1.68	No	5.01	No
Ammonia Monthly Average	mg/L	3	1.63	No	4.86	Yes
Copper, Daily Maximum	µg/L	16	6.13	No	18.30	Yes
Copper Monthly Average	µg/L	11	6.13	No	18.30	Yes
Nickel, Daily Maximum	µg/L	33	10.16	No	30.36	No
Nickel Monthly Average	µg/L	25	9.94	No	29.71	Yes
Cyanide Daily Maximum	µg/L	11(3)	1.11	No	3.31	No
Cyanide Monthly Average	µg/L	5.7(3)	1.11	No	3.31	No
Mercury Daily Maximum	µg/L	0.027	0.00	No	0.01	No
Mercury Monthly Average	µg/L	0.025	0.00	No	0.01	No
Selenium(4)	µg/L	5	1.49	No	4.46	No
Zinc(4)	µg/L	161	45.98	No	137.39	No

Notes:
Abbreviations: mg/L - milligrams per liter; mgd - million gallons per day; NPDES - National Pollutant Discharge Elimination System; µg/L - micrograms per liter.
(1) Assumes reverse osmosis concentrate (ROC) is blended with 12.5 mgd of San José-Santa Clara Regional Wastewater Facility (RWF) effluent.
(2) Assumes no RWF effluent is available for blending.
(3) The RWF NPDES permit grants a 3:1 dilution credit for cyanide. The dilution credit is reflected in the estimated ROC concentration. No other constituents receive a dilution credit.
(4) Selenium and zinc are reasonable potential analysis constituents, not part of the effluent discharge requirements. It was assumed that no dilution credits would be granted for these constituents.

It is important to note that this analysis is conservative because it assumes the 95th percentile concentration of constituents will be in the tertiary effluent at all times. For the 20 mgd scenario, a compliance strategy (either ROC treatment or greater dilution in the discharge or other methods) will likely be needed during these times to avoid exceedances of discharge limits.

Other utilities implementing potable reuse have successfully conducted additional modeling of dilution through their outfall to demonstrate that during periods with high concentration discharge, the flows being discharged are generally much lower than average, and therefore higher levels of dilution and mixing are achieved at the outfall. Different dilution credits can be granted for different flow ranges of tertiary effluent to account for the increase in dilution and mixing at lower discharge flows. Monterey One Water received regulatory approval for this approach, and both Morro Bay and Ventura are performing similar modeling and anticipating similar success.

6.2.4 Additional NPDES Permitting Considerations

The State Water Resources Control Board (SWRCB) develops water quality control planning documents that designate beneficial uses and water quality objectives for groundwater, surface water, and marine waters within the state. The relevant plan governing permitting considerations for the RWF is the *Water Quality Control Plan for the San Francisco Bay Basin* (Basin Plan).[3] Under the SWRCB, nine Regional Water Quality Control Boards (RWQCBs) issue permits to dischargers that enforce the requirements set forth by the relevant water quality control planning document. The permits are in the form of NPDES permits for surface water discharges. The San Francisco Bay RWQCB has jurisdiction over and issues NPDES permits for the RWF.

Water quality-based effluent limitations in the NPDES permit are based on the amount (mass, concentration, or both) of a specific pollutant that can be discharged into the receiving water body while still meeting the water quality objectives. Water quality-based effluent limitations are calculated for any given facility using the water quality objectives and applying a dilution ratio that accounts for the rapid mixing that occurs in the receiving water body as the treated effluent exits the outfall diffuser.

For an indirect potable reuse (IPR) project, the ROC contains approximately the same mass of pollutants as the wastewater effluent stream from which it was derived. For a direct potable reuse (DPR) project, which employs ozone and biofiltration, less mass of pollutants can be reasonably assumed. With that said, because the flow rate of the ROC is typically about 20 percent the flow rate of the wastewater effluent and because the ROC contains the bulk of the constituents in the feedwater, the concentrations of pollutants in the ROC is approximately five to seven times what was formerly discharged. The increased pollutant concentrations of the resulting blend of effluent and ROC, depending upon the blending, may be higher than existing NPDES permit water quality-based effluent limitations. Thus there is the potential need to limit the size of the purified water project.

The RWQCB has shown flexibility to meet water quality-based effluent limitations for potable reuse projects, while remaining protective of the environment. Other purified water projects in the state, such as in Monterey and Morro Bay, have successfully negotiated multiple dilution factors to maintain concentration-based limits , though it is noted that these two examples are ocean dischargers and are subject to the governance of the *California Ocean Plan* rather than the Basin Plan.[4]

In general, the following steps could be taken to negotiate alternative limits in the NPDES permit, such as a mass-based limit, should a purified water project be pursued:

1. Perform a preliminary Reasonable Potential Analysis to determine the concentrations of the resulting stream of ROC and wastewater effluent. Compare the resulting waste stream against relevant NPDES limitations. This exercise was performed in this chapter and should be refined should the Project move forward.
2. Perform outfall plume modeling for a range of ROC and wastewater effluent flow combinations to determine if there are anticipated NPDES permit violations and how much dilution would be needed to mitigate these exceedances. Such an analysis was not done for this project.

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[3] SWRCB (2023). Water Quality Control Plan for the San Francisco Bay Basin, March 2023. https://www.waterboards.ca.gov/sanfranciscobay/basin_planning.html
[4] SWRCB (2019). California Ocean Plan, February 2019. https://www.waterboards.ca.gov/water_issues/programs/ocean/docs/oceanplan2019.pdf

3. Develop different dilution factors for identified constituents. Different outfall diffuser configurations should also be considered in this exercise. Such an analysis was not done for this project.
4. Perform a more detailed Reasonable Potential Analysis after the dilution factors have been developed. Such an analysis was not done for this project.
5. Conduct ongoing discussions with the RWQCB to negotiate and request permit changes including mass-based limits and updated dilution factors. Such an analysis was not done for this project.

6.3 ROC Management Strategies

If use of the existing RWF outfall is not available, or if additional dilution is not allowed for the larger 20 mgd scenario, other ROC management strategies are needed. Potential options for ROC management strategies include:

- New NPDES Discharge Permit via a separate outfall
- Engineered wetlands
- Ecotone/horizontal levee

Obtaining a new NPDES discharge permit for a newly constructed ROC outfall separate from the RWF discharge point offers several benefits. Separate NPDES permits would mean that the AWPF's discharge compliance would not impact the RWF permit. This decoupling of the two systems could allow for more operational independence than a shared discharge point. In addition, hydrodynamic modeling analysis would allow strategic selection of a new discharge point to maximize the dilution credits awarded in a new NPDES permit.

Engineered wetlands rely on vegetation to naturally uptake and remove metals and nutrients in the ROC stream. Various combinations of vegetation planting and engineered flow conditions can be used to achieve specific removal goals, and for this project, a configuration would be specifically tailored to the expected ROC characteristics defined in Table 6.1. The engineered wetlands approach has the benefit of decreasing pollutants reaching the Bay while also creating critical wetlands habitat. However, this approach has the potential for high operations and maintenance (O&M) costs, as solids need to be removed from the wetlands and new plants need to be purchased and planted on a regular basis. A separate NPDES discharge permit would be required. Figure 6.2 shows a conceptual schematic of an engineered wetland.

An ecotone/horizontal levee is similar to engineered wetlands in that it relies on natural processes to remove pollutants in the ROC stream. Figure 6.1 shows a conceptual schematic of a horizontal levee cross-section. A horizontal levee is designed so that a hydraulic gradient between the ROC entry and discharge points results in a combination of sub-surface seepage and surface flow. Along the way, pollutants are removed through uptake in the plants and soil comprising the levee. In addition to reducing pollutant loading and creating critical habitat, this approach has the added benefit of potentially providing a resilient barrier to sea level rise. Application of an ecotone/horizontal levee for ROC management within the South Bay has been explored in detail in the *Reverse Osmosis Concentrate Treatment Research Results and Context for San Francisco Bay* report and was referred to in the completion of this high-level evaluation.[5] O&M costs for the horizontal levee would be similar to those of engineered wetlands, as solids and plant matter would have to be periodically removed and vegetation replanted.

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[5] San Francisco Estuary Institute (2020). Reverse Osmosis Concentrate Treatment Research Results and Context for San Francisco Bay, April 2020.

It is expected that if a new outfall is to be obtained, more information will be gathered in future studies, including the treatment efficacy of the strategies above. This is discussed further in the Next Steps section of Chapter 7.

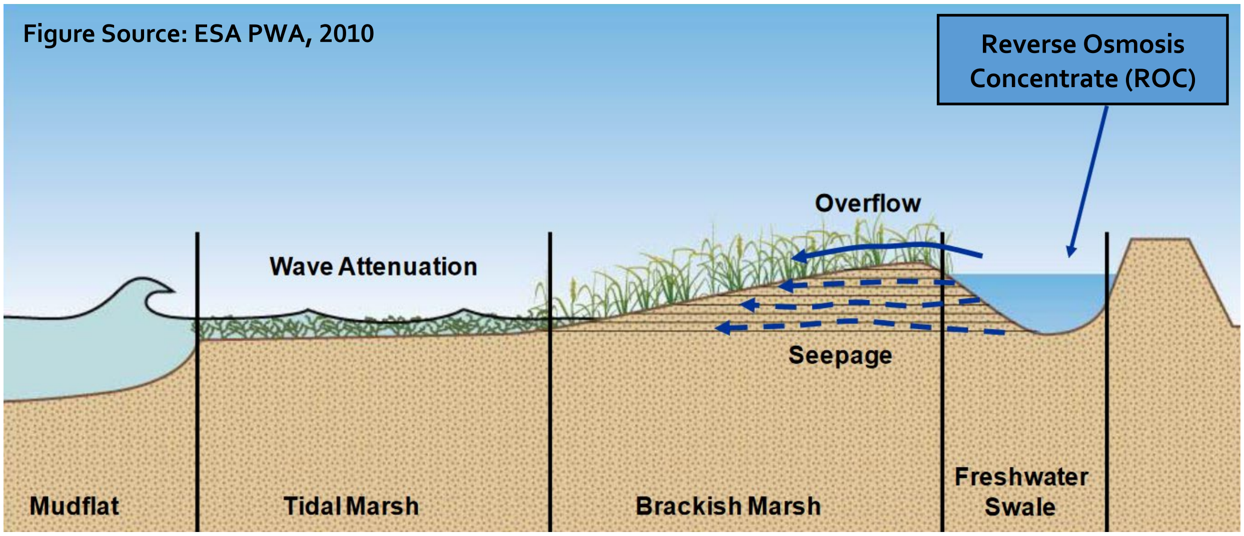

Figure 6.1 Conceptual Cross-Section of an Ecotone/Horizontal Levee

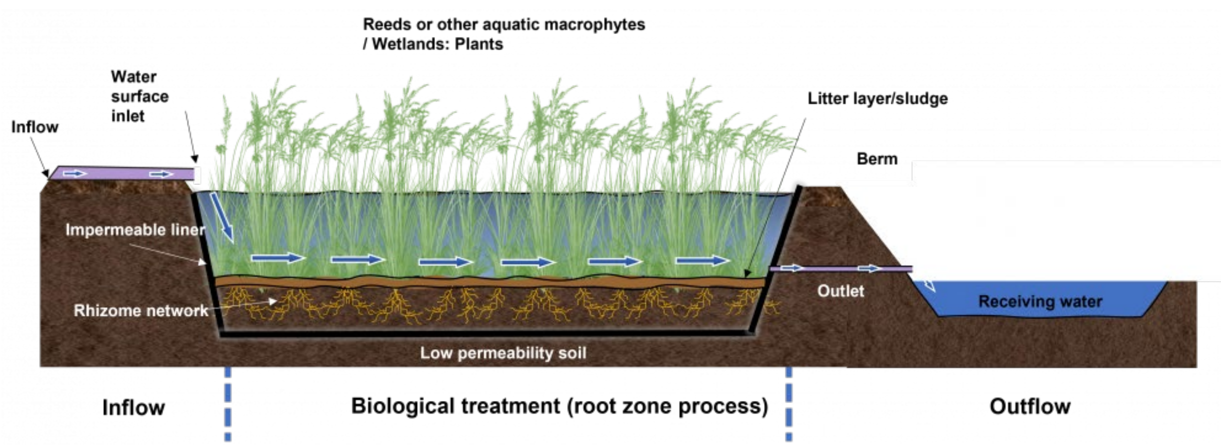

Figure 6.2 Conceptual Cross-Section of an Engineered Wetland

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Chapter 7

DPR IMPLEMENTATION PLAN

7.1 Introduction

Direct potable reuse (DPR) is complex, time-consuming, and costly when compared to more traditional water treatment processes. Recent work by the National Water Research Institute (NWRI) provided our industry with a clear vision of the steps and approach necessary to implement DPR. That work, to which both San Francisco Public Utilities Commission (SFPUC) and Carollo were principal contributors, is titled *DPR Implementation Guide for California Water Utilities* (NWRI Guide). The following sections first describe the timeline for DPR implementation, including the phases of a DPR project, then describe the key elements for DPR success defined by the NWRI Guide. For each key element, example action items are provided, along with the project phase where they might occur. The NWRI Guide is intended to be a companion to the current draft DPR regulations.

7.2 DPR Project Timeline

The timeline to implement a potable reuse project can vary greatly depending on the urgency and need, the regulatory climate, and the specific project details. The goal of this DPR implementation timeline and approach is to provide perspective on key project elements and how they might fit within an overall project delivery timeline.

Figure 7.1 shows a general sequence of events typically assumed for DPR implementation. The timeline has been divided into four phases: planning, demonstration, implementation, and operations/operator training. Although these phases are ordered generally in sequence, there is overlap between them and some activities, particularly those associated with implementation and operation and training, continue throughout the life of the project. For example, projects may be required by the Division of Drinking Water (DDW) to convene an Independent Advisory Panel (IAP) during the planning phase to provide input on project concepts, and the IAP will typically also convene at key points throughout the project. Another example is with operations. Although the actual operation of a purified water facility wouldn't start until the facility is built, advanced planning for plant staffing and operator training would need to start much earlier to ensure that there are sufficient qualified operators once the Advanced Water Purification Facility (AWPF) comes online.

Figure 7.1 Four Main Phases of DPR Implementation

Some key assumptions and considerations incorporated into the development of the DPR project timeline in Figure 7.1 are as follows.

7.2.1 Planning Phase

Project visioning is a key component of planning for a DPR project. Visioning starts with clearly laying out and defining the need for the project, i.e., defining the water supply challenge addressed by the project, and quantifying how much water is needed. It is also an opportunity to place the project within the larger planning context and begin to think about coordination with existing or planned projects and availability and sources of funding. This Feasibility Study herein represents the project visioning and feasibility components of the planning phase of the South Bay Purified Water Project (Project), to be followed by outreach and engagement, and NWRI efforts if the Project is selected to progress.

7.2.2 Demonstration and Public Outreach Phase

The first step to implementing a demonstration facility is goal setting. In this stage, the project sponsor defines the demonstration goals, which are typically: design, permitting, operations, engagement, and innovation. Some examples of demonstration facility goals are:

- Validating the project concept
- Engaging with the public and stakeholders
- Demonstrating the ability to effectively operate advanced water treatment technologies
- Researching issues of emerging concern
- Engaging with regulators

Defining the timing for a demonstration facility and committing to funding and building a demonstration facility is the first major action item for a DPR project. The demonstration facility will provide information to support the decision to move forward with a full-scale project.

7.2.3 Implementation Phase

Typically, a demonstration facility would precede a decision about moving forward with a full-scale project. However, if a project sponsor has full commitment to move forward with a project prior to a demonstration facility, the implementation phase could begin sooner, in parallel with the demonstration phase.

Permitting for a potable reuse project includes several elements. Environmental permitting is conducted via the National Environmental Protection Act and the California Environmental Quality Act (CEQA) process. Projects must also be permitted by the Regional Water Quality Control Board (RWQCB), which requires preparation of a Title 22 Engineering Report (with review and approval by DDW). Projects may also require updates of the relevant National Pollutant Discharge Elimination System (NPDES) discharge permit to accommodate discharge of reverse osmosis concentrate (ROC).

7.2.4 Operations and Operator Training

The timeline for operator training assumes that all Advanced Water Treatment Operators (AWTO) will be promoted from within the existing water utility and trained as an AWTO. Given the small number of existing AWTO certified operators, it does not currently make sense to assume these operators can be hired from outside the organization. This also leads to the need to train replacement staff for the operators who transition into the AWTO role.

7.2.5 Schedule Risks

Throughout the implementation timeline there are elements that can result in schedule delays or increased uncertainty. Some examples of challenges faced by utilities working to implement DPR are:

- Consensus on the project:
  - Internal discussion on the project definition, value, and urgency can significantly impact timeline.
- Water supply need:
  - Projects have been deferred due to reduction of drought conditions.
  - If other potential new water sources are in play, these may be preferred under certain supply demand scenarios.
- Public perception:
  - As a utility implements a potable reuse project, community confidence, understanding, acceptance, and support, as well as stakeholder involvement, become essential. However, members of the general public often are not aware of the details of their water supply or the systems in place to bring drinking water to their business and homes, and the mechanisms employed to ensure that the quality of their finished water is protective of public health.
  - Issues that commonly come up with the public include no-growth concerns, rate impacts, and general concern over the concept of potable reuse. Project sponsors should work to understand likely concerns in the service area early on so they can be addressed directly.
  - Initiating and maintaining an extensive public engagement campaign is critical.
  - Early understanding of public support or opposition becomes an important part of the decision-making process.

- Interutility or interagency agreements:
  - To implement a successful DPR project, a high degree of interagency coordination is needed. An interagency agreement, such as a memorandum of understanding (MOU), will be needed to define elements of the project, including items such as:
    - Cost sharing
    - Responsibility for risk and liability
    - Operational responsibilities
    - Response to system failure and/or interruption
    - Meeting regulatory requirements
  - Developing consensus between multiple agencies, each with their own governing bodies and stakeholders, can be time consuming. This should be a priority early in the project to avoid creating a roadblock when the project is further along.
- Regulatory uncertainty:
  - The lack of precedent for implementation of a treated drinking water augmentation (TWA) project in California may lead to a slow permitting process as DDW navigates this process.

The example timeline shown in Figure 7.2 assumes the project sponsor is committed to implementing the project and is actively and consistently working to move the project forward. However, it should be well understood that a decision on whether to move forward with design and construction of a full-scale facility would be made after a demonstration facility has been built and supporting data collected.

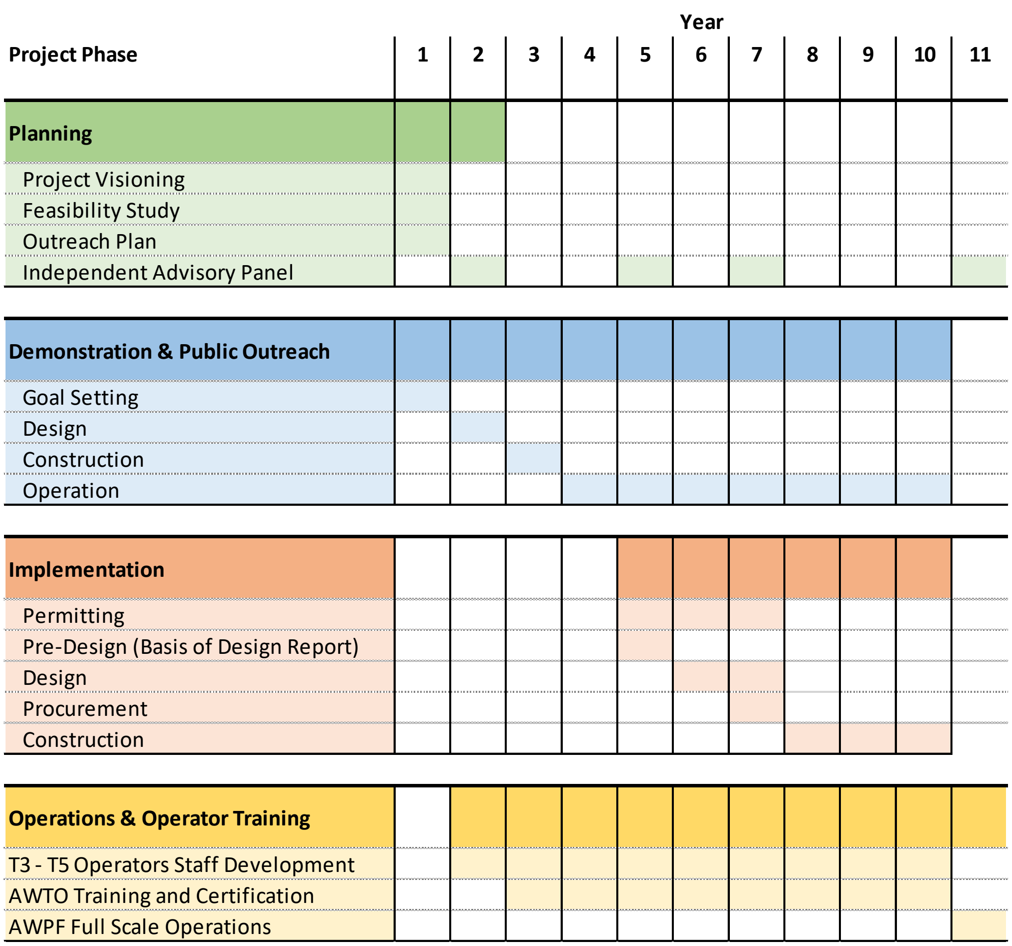

Figure 7.2 Potential DPR Implementation Timeline Based on Four Main Project Phases

7.3 Components of a Successful DPR Program

The NWRI Guide incorporated perspectives from state and federal resources, published and ongoing research studies, and a number of California utilities to summarize the essential principles of DPR. The 2021 Guide includes specific elements that are likely to be key for DPR success, including technical, operational, managerial, and regulatory elements. These 13 elements are summarized in Table 7.1 and provide valuable perspective on the necessary components of DPR implementation. The table also links the project elements to the main phases of the DPR project timeline to illustrate how these elements fit within the overall project timeline.

7.3.1 Technical Challenges

The items below highlight key technical challenges to consider for a potential South Bay Purified Water Project (Project).

7.3.1.1 Treatment Train Size and Complexity

As discussed previously, a complex treatment train is needed to meet the requirements for DPR. Each unit process must be validated and operated in such a way as to achieve the necessary pathogen log reduction credits. There will also be a large amount of data that must be collected, analyzed, and synthesized for monthly compliance reporting.

7.3.1.2 Enhanced Source Control Program

An enhanced source control program (ESCP) is an aggressive wastewater source control program, extending beyond local limits and industry-specific monitoring to include regulated and unregulated chemical testing across the AWPF, across the San José-Santa Clara Regional Wastewater Facility (RWF), and across the collection system.

Potable reuse requires a "water first" mentality. An effective source control program should strive to avoid negatively affecting industries while also aggressively engaging them to fully understand the waste streams they discharge and how those streams can be best handled while reliably producing purified recycled water. The success of a source control program depends on strong interagency cooperation and responsiveness between the RWF and AWPF. For a project whose agency that administers the source control program differs from the agency that operates the AWPF, entering into a MOU or other contractual agreement may be required, so that appropriate source control actions can be taken, as necessary, to protect water quality.

7.3.1.3 Advanced Control System

DPR systems must be quickly responsive to any detected issues or failures. Because DPR systems have no environmental buffer, the response time is a key element of public health protection. The inclusion of an engineered storage buffer can help provide additional time to respond to issues, but requires space and infrastructure. As a point of reference, the El Paso TWA DPR system will have a storage buffer with a minimum of 30 minutes of retention time, sufficient for monitoring systems to run through several cycles and for diversion to occur prior to delivering off-spec water. The current AWPF analyzed within this document includes a buffer as part of the finished water storage tank. This buffer provides 30 minutes of retention time but can be further refined as the project develops.

In the DPR paradigm, the online monitoring and data processing systems are extremely important. This includes maintaining analyzers to a higher degree of accuracy and precision as well as a more complex supervisory control and data acquisition (SCADA) system and dashboards to track safety factors for combined system performance. Current work on such controls and dashboards, which is being implemented at the pilot scale as part of a United States Bureau of Reclamation research grant by Carollo Engineers, Inc.

(Carollo) (referred to as the OPTICS project) and a project for the Department of Energy, is incorporating machine learning and artificial intelligence to predict issues before they arise and prescribe proactive measures for operations to implement.

7.3.1.4 Achieving the Required Dilution of a One-Hour Chemical Peak

DDW has provided minimal guidance on how they envision projects can meet the requirement for dilution of a one-hour chemical peak. The dilution can occur in many different ways, and could be in a primary equalization basin, secondary equalization basin, as part of recirculation of flows within the activated sludge process, or in a finished water tank, as several possible examples. There are also no currently proposed TWA projects with a defined concept to meet this requirement. As discussed in Chapters 3 and 4, it is assumed for this analysis that dilution for the SFPUC portion of the purified water will occur in a new dilution tank while dilution for the San José and Santa Clara portion of the purified water will occur in existing tanks in their respective potable water distribution system.

7.3.1.5 WWTP Reliability/Performance

The wastewater treatment plant (WWTP) providing the feedwater for a DPR project has a key role to play in providing a stable, high quality feedwater. The optimal feedwater for a DPR project has low suspended solids and turbidity, low total organic carbon (TOC), and low levels of nutrients. Facilities that employ consistent nutrient removal and have tertiary filtration, as one example, will have a more efficiently operating advanced treatment system. Advanced purification can and does happen for potable reuse on tertiary effluents without nutrient removal (biochemical oxygen demand only) and without tertiary filtration. The current draft regulations for DPR do not require a specific level of wastewater treatment (e.g., does not specify nitrification). However, there are internal conversations underway that are debating if specific levels of wastewater treatment should be required. For this project, which has a nitrified and tertiary filtered water quality, downstream negative impacts to advanced treatment are minimized.

7.3.1.6 Resources to Support Ongoing Operation

The regulations require the presence of an AWTO Grade 5 certified operator on site at all times (except with an approved operations plan that allows for some degree of remote operations). At this time, there are only a handful of AWTO Grade 5 operators in the State of California; therefore, additional investment in operator certification is needed to ensure sufficient operator capacity in the future.

Specifically, there are several project elements that will require extensive staff resources to develop and maintain, such as:

- Developing and implementing all necessary plans
- Implementing monitoring program and tracking all water quality data
- Monthly compliance reporting
- Implementing and managing the ESCP

It is anticipated that AWPF analyses will be performed by the operations manager, operations supervisor, water quality coordinator, and water quality analyst. The ESCP will be staffed by RWF staff that oversee the existing wastewater source control program, with additional support as needed. Additional staffing considerations can be found in Appendix E.

The ongoing operational costs of a DPR project will be significant. The water quality monitoring required may be in excess of $200,000 annually. DDW will want to see that there are financial resources dedicated to the project on an ongoing basis.

Table 7.1 Implementation Steps for DPR From 2021 NWRI Guide for California Utilities

No.	Project Element	Details	Key Subtasks(1)			
			Planning	Demonstration	Implementation	Operations/Operator Training
1	Project Definition	• How, what, when, why, where • Internal buy-in and agreement	• Define wastewater effluent source, identify advanced water treatment system location, and define delivery mechanism of purified water to distribution system • Conduct a feasibility study for project concept			
2	Technical, Managerial, and Financial Capability	• Resources • Internal culture • Organizational structure	• Define governance structure for project, including DiPRRA • Identify and commit funding sources			
3	Interagency Agreements	• Are there other agencies that need to be involved	• Define roles and responsibilities for all involved agencies • Identify any other agencies with a role to play • Develop Joint Plan			
4	Outreach and Education	• Comprehensive, proactive communication plan addressing a range of stakeholders (e.g., agency leadership, community organizations, elected officials, community members)	• Identify potential areas of concern for different stakeholder groups, e.g., CECs, cost impacts • Develop communication and outreach plan to educate and address concerns	• Use demonstration facility as outreach tool to conduct tours and other educational activities	• Maintain stakeholder outreach and engagement throughout implementation process	• Continue to inform public and other stakeholders about project success
5	Wastewater Source Control	• ESCP required	• Identify areas of enhancement for existing source control program, including risk assessments for chemicals of concern	• Use demonstration testing and water quality data to inform needs for ESCP	• Implement collection system online monitoring	• Implement continuous improvement procedures for ESCP
6	Wastewater Treatment	• Reliable, high-quality feedwater	• Evaluate whether any modifications are needed to ensure the wastewater produced can reliably meet water quality standards needed at AWPF	• Use demonstration testing as opportunity to support evaluation of wastewater treatment on AWPF performance	• Conduct 24 months of sampling in feedwater to AWPF	• Continue WWTP operations consistent with AWPF needs
7	Multiple Treatment Barriers	• Risk minimization • Demonstration/pilot testing • Risk analysis	• Define treatment barriers, which for DPR must include minimum of ozone/BAC + RO + UV AOP	• Use demonstration facility to verify treatment train effectiveness		
8	Pathogen Control and Monitoring	• Precise and accurate pathogen reduction • Diversion • Demonstration/pilot testing • Risk analysis	• Define multi-barrier treatment train to meet pathogen reduction requirements • Develop control system and diversion capabilities to provide protection at all times	• Use demonstration facility to verify treatment train effectiveness		

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No.	Project Element	Details	Key Subtasks[1]			
			Planning	Demonstration	Implementation	Operations/Operator Training
9	Chemical Control and Monitoring	• Precise and accurate chemical reduction • Demonstration/pilot testing • Risk analysis	• Define multi-barrier treatment needed to meet chemical requirements • Determine strategy for required chemical peak reduction • Develop and implement schedule for chemical monitoring in multiple locations	• Use demonstration facility to verify treatment train effectiveness		
10	Operations	• Operator training and staffing	• Develop staffing program to develop AWTO operators and replace water operators	• Use demonstration facility as a training opportunity for operators	• Begin training operators to become AWTO certified	• Continue planning for operations staffing to ensure continuity
11	Water Quality Management	• Finished water quality and corrosion		• Evaluate impacts of purified water on distribution system stability and corrosion • Evaluate any potential aesthetic issues from blending purified water into supply		
12 and 13	Emerging Issues and Collaboration to Spur Innovation	• Leadership in research on emerging contaminants • Partnerships with other California agencies doing or planning potable reuse		• Engage the research community to build credibility with regulators and public		• Keep up to date with latest research and industry best practices

Notes:
Abbreviations: AOP - advanced oxidation process; AWPF - Advanced Water Purification Facility; AWTO - Advanced Water Treatment Operator; BAC - biological activated carbon; CEC - contaminant of emerging concern; DiPRRA - direct potable reuse responsible agency; DPR - direct potable reuse, ESCP - enhanced source control program; RO - reverse osmosis; UV - ultraviolet; WWTP - wastewater treatment plant.
(1) Key subtasks are linked to the DPR implementation timeline through connection to the four main phases of the timeline: Planning, Demonstration, Implementation, and Operation.

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7.4 Next Steps

This Project report focused upon the treatment and infrastructure necessary to implement DPR. There are other elements of a DPR project that require further evaluation and cost analysis, which could be done as part of next steps for this Project. These include:

- **ESCP:** The ESCP builds upon existing industrial waste pretreatment programs and is required by DDW
- **Pilot testing of DPR treatment:** Pilot testing of the proposed advanced treatment systems can be used to (a) refine design criteria, (b) train operations staff, (c) public engagement, and (d) regulatory permitting. Among the typical design criteria to be refined, stakeholder feedback flagged the following specific items to be confirmed during pilot testing:
  - Feedwater quality analysis for all regulated parameters
  - Confirmation of optimal empty bed contact time (EBCT) for biologically activated carbon filtration
  - Confirmation of optimal ultrafiltration (UF) flux rate
  - Confirmation of stabilization method
  - Confirmation of target chlorine residual (currently assumed to be 1 milligram per liter (mg/L) monochloramine residual per SFPUC input)
- **IAP:** An IAP is required by DDW for a DPR project. Such an IAP would have experts in various types of engineering and public health and provide valuable independent guidance to a DPR project
- **CEQA reporting and other required environmental documentation:** Necessary with any project of this magnitude
- **Development of an operator training program:** DDW will require a robust operations staff with Advanced Water Treatment certification

In addition to the key items above, the project stakeholders raised important questions that merit further evaluation during the next steps of the project (see Table 7.2).

Table 7.2 Recommended Next Steps

Element	Recommended Actions
Follow-up Studies	• Distribution study to determine tie-in locations and flow requirements for the three agencies, including an operational analysis for the Bay Division Pipeline (BDPL) • Demand study to better understand water demand from the three agencies to refine operational plans for the AWPF (i.e., should the facility operate at a constant rate annually, or seasonally ramp up and down) • Additional analysis and modeling to determine impacts to the RWF NPDES permit • Consideration of new discharge point and new NPDES permit for ROC discharge • Additional analysis on ROC management strategies • Legal analysis to determine DiPRRA ownership and general program management • Additional staffing analysis to determine staffing needed at the San José and Santa Clara storage reservoir sites and staff needed to operate the ESCP

Element	Recommended Actions
Treatment Design Considerations	• Determine storage requirements for chemicals • Refinement of available RO pressure for energy recovery • Consideration of impacts on AWPF backwash to the RWF • Further analysis to determine the adequate retention time for engineered storage (e.g., 30 minutes)
Infrastructure Design Considerations	• Additional analysis to evaluate use of existing San José and Santa Clara storage reservoirs as a blending tank for purified water including review of potential operational changes • Future analysis should consider the evaluation of a larger blending tank either for the combined San José and Santa Clara flow or the combined flow for all three agencies • Sizing and costing of a new outfall, if needed • Analysis to determine if any existing Valley Water Advanced Water Purification Center (AWPC) pipelines (including the feedwater pipeline and ROC outfall pipe) can be utilized for this proposed project

Notes:
Abbreviations: AWPC - Advanced Water Purification Center; AWPF - advanced water purification facility; BDPL - Bay Division Pipeline; DiPRRA - direct potable reuse responsible agency; ESCP - enhanced source control program; NPDES - National Pollutant Discharge Elimination System; RO - reverse osmosis; ROC - reverse osmosis concentrate; RWF - San José-Santa Clara Regional Wastewater Facility.

Appendix A
MONITORING REQUIREMENTS

Appendix A

MONITORING REQUIREMENTS

The expected water quality monitoring parameters for direct potable reuse (DPR) feedwater and product water are defined below.

Tables A.1 through A.6 constitute the anticipated water quality performance for an indirect potable reuse (IPR) project, consistent with 22 California Code of Regulations (2019).[1] Within each table is a specific reference to the section or table within the regulation. Table A.7 indicates the monitoring requirements for contaminants of emerging concern (CECs) per the State Water Resources Control Board (SWRCB) *Water Quality Control Plan for Recycled Water*.[2] It is anticipated that these will be the majority of constituents that require monthly monitoring for a DPR project. There may be additional parameters added upon regulation finalization.

Table A.1 Inorganics With Primary Maximum Contaminant Levels or Action Levels[(1)]

Constituents	Primary MCL or AL (in mg/L)	Constituents	Primary MCL or AL (in mg/L)
Aluminum	1.0	Fluoride	2
Antimony	0.006	Lead	0.015(3)(4)
Arsenic	0.010	Mercury	0.002
Asbestos	7 (MFL)(2)	Nickel	0.1
Barium	1	Nitrate (as N)	10
Beryllium	0.004	Nitrite (as N)	1
Cadmium	0.005	Total Nitrate/Nitrite (as N)	10
Chromium	0.05	Perchlorate	0.006
Copper	1.3(3)	Selenium	0.05
Cyanide	0.15	Thallium	0.002

Notes:
Abbreviations: AL - action level; MCL - maximum contaminant level; MFL - million fibers per liter; mg/L - milligrams per liter.
(1) Based on Table 64431-A and Section 64678.
(2) MFL with fiber lengths >10 microns.
(3) Regulatory action level; if system exceeds, it must take certain actions such as additional monitoring, corrosion control studies, and treatment, and for lead, a public education program; replaces MCL.
(4) The MCL for lead was rescinded with the adoption of the regulatory action level described in note 3.

[1] SWRCB (2018). Regulations Related to Recycled Water. Effective October 1, 2018. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/RWregulations_20181001.pdf
[2] SWRCB (2019). Water Quality Control Policy for Recycled Water. Adopted December 11, 2018. Effective April 8, 2019. https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2018/121118_7_final_amendment_oal.pdf

Table A.2 Radioactivity[1]

Constituents	MCL (in pCi/L)	Constituents	MCL (in pCi/L)
Uranium	20	Beta/Photon Emitters	50[2]
Combined Radium-226 & 228	5	Strontium-90	8[2]
Gross Alpha Particle Activity	15	Tritium	20,000[2]

Notes:
Abbreviations: MCL - maximum contaminant level; pCi/L - picocuries per liter.
(1) Based on Tables 64442 and 64443.
(2) MCLs are intended to ensure that exposure above 4 millirem per year does not occur.

Table A.3 Regulated Organics[1]

Constituents	MCL (in mg/L)	Constituents	MCL (in mg/L)
Volatile Organic Compounds			
Benzene	0.001	Monochlorobenzene	0.07
Carbon Tetrachloride	0.0005	Styrene	0.1
1,2-Dichlorobenzene	0.6	1,1,2,2-Tetrachloroethane	0.001
1,4-Dichlorobenzene	0.005	Tetrachloroethylene	0.005
1,1-Dichloroethane	0.005	Toluene	0.15
1,2-Dichloroethane	0.0005	1,2,4 Trichlorobenzene	0.005
1,1-Dichloroethylene	0.006	1,1,1-Trichloroethane	0.2
cis-1,2-Dichloroethylene	0.006	1,1,2-Trichloroethane	0.005
trans-1,2-Dichloroethylene	0.01	Trichloroethylene	0.005
Dichloromethane	0.005	Trichlorofluoromethane	0.15
1,3-Dichloropropene	0.0005	1,1,2-Trichloro-1,2,2-Trifluoroethane	1.2
1,2-Dichloropropane	0.005	Vinyl Chloride	0.0005
Ethylbenzene	0.3	Xylenes	1.75
MTBE	0.013		
Synthetic Organic Compounds			
Alachlor	0.002	Heptachlor	0.00001
Atrazine	0.001	Heptachlor Epoxide	0.00001
Bentazon	0.018	Hexachlorobenzene	0.001
Benzo(a) Pyrene	0.0002	Hexachlorocyclopentadiene	0.05
Carbofuran	0.018	Lindane	0.0002
Chlordane	0.0001	Methoxychlor	0.03
Dalapon	0.2	Molinate	0.02
Dibromochloropropane	0.0002	Oxamyl	0.05
Di(2-ethylhexyl)adipate	0.4	Pentachlorophenol	0.001
Di(2-ethylhexyl)phthalate	0.004	Picloram	0.5
2,4-D	0.07	Polychlorinated Biphenyls	0.0005
Dinoseb	0.007	Simazine	0.004

Constituents	MCL (in mg/L)	Constituents	MCL (in mg/L)
Diquat	0.02	Thiobencarb	0.07/0.001(2)
Endothall	0.1	Toxaphene	0.003
Endrin	0.002	1,2,3-Trichloropropane	$5x10^{-6}$
Ethylene Dibromide	0.00005	2,3,7.8-TCDD (Dioxin)	$3x10^{-8}$
Glyphosate	0.7	2,4,5-TP (Silvex)	0.05

Notes:
Abbreviations: MCL - maximum contaminant level; mg/L - milligrams per liter; MTBE - methyl tertiary-butyl ether.
(1) Based on Table 64444-A.
(2) Second value is listed as a secondary MCL.

Table A.4 Disinfection Byproducts(1)

Constituents	MCL (in mg/L)	Constituents	MCL (in mg/L)
Total Trihalomethanes	0.080	Bromate	0.010
Total Haloacetic Acids	0.060	Chlorite	1.0

Notes:
Abbreviations: MCL - maximum contaminant level; mg/L - milligrams per liter.
(1) Based on Table 64533-A.

Table A.5 Constituents/Parameters With Secondary MCLs

Constituents(1)	MCL (in mg/L)	Constituents(2)	MCL (in mg/L)
Aluminum	0.2	TDS	500
Color	15 (units)	Specific Conductance	900 µS/cm
Copper	1	Chloride	250
Foaming Agents (MBAS)	0.5	Sulfate	250
Iron	0.3		
Manganese	0.05		
MTBE	0.005		
Odor Threshold	3 (units)		
Silver	0.1		
Thiobencarb	0.001		
Turbidity	5 (NTU)		
Zinc	5		

Notes:
Abbreviations: MBAS - methylene blue active substances; MCL - maximum contaminant level; mg/L - milligrams per liter; MTBE - methyl tertiary-butyl ether; NTU - Nephelometric Turbidity unit; TDS - total dissolved solids; µS/cm - microsiemens per centimeter.
(1) Based on Table 64449-A.
(2) Based on Table 64449-B.

Table A.6 Constituents With Notification Levels[1, 2]

Constituents	NL (in µg/L)	Constituents[3]	NL (in µg/L)
Boron[4]	1,000	MIBK	120
n-Butylbenzene	260	Naphthalene	17
sec-Butylbenzene	260	NDEA	0.01
tert-Butylbenzene	260	NDMA	0.01
Carbon disulfide	160	NDPA	0.01
Chlorate	800	PFBS	0.5
2-Chlorotoluene	140	PFOA	0.0051
4-Chlorotoluene	140	PFOS	0.0065
Diazinon	1.2	Propachlor	90
Dichlorodifluoromethane (Freon 12)	1,000	n-Propylbenzene	260
1,4-Dioxane	1	RDX[3]	0.3
Ethylene glycol	14,000	TBA	12
Formaldehyde	100	1,2,4-Trimethylbenzene	330
HMX	350	1,3,5-Trimethylbenzene	330
Isopropylbenzene	770	TNT	1
Manganese	500[2]	Vanadium	50

Notes:
Abbreviations: HMX - high melting explosive; MIBK - methyl isobutyl ketone; NDEA - N-nitrosodiethylamine; NDMA - N-nitrosodimethylamine; NDPA - N-nitrosodi-n-propylamine; NL - notification level; PFBS - perfluorobutanesulfonic acid; PFOA - perfluorooctanoic acid; PFOS - perfluorooctanesulfonic acid; RDX - research department explosive $(O_2NNCH_2)_3$; TBA - tertiary butyl alcohol; TNT - 2,4,6-trinitrotoluene; µg/L - micrograms per liter.
(1) Based on https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/notificationlevels/notification_response_level_overview_2022_02_09.pdf, published February 9, 2022.
(2) The web link above also contains the levels of the pollutants in this table that must result in a removal of the water source from service.
(3) RDX - research department explosive $(O_2NNCH_2)_3$.
(4) Central Coast Basin Plan Water Quality Objective is more stringent: Boron- 750 µg/L (500 µg/L is the "no problem" water quality guideline).

Table A.7 Monitoring Requirements for CECs per SWRCB (2019a)

Constituent	Relevance	MTL (in µg/L)	Example Removal Percentages (%)
1,4-Dioxane	Health	1	--
NDMA[1]	Health and Performance	0.010	>25-50, 80
NMOR[2]	Health	0.012	--
PFOS	Health	0.0065	--
PFOA	Health	0.0051	--
Sulfamethoxazole[2]	Performance	-	>90
Sucralose[2]	Performance	-	>90
Dissolved Organic Carbon[2]	Surrogate (example)[3]	-	>90
UV Absorbance[2]	Surrogate (example)[3]	-	>50
EC[2]	Surrogate (example)[3]	-	>90

Constituent	Relevance	MTL (in µg/L)	Example Removal Percentages (%)
Estrogen receptor-alpha bioassay(2)	Bioanalytical Screening	-	--
Aryl hydrocarbon bioassay(2)	Bioanalytical Screening	-	--

Notes:
Abbreviations: CECs - contaminants of emerging concern; EC - electrical conductivity; MTL - monitoring trigger levels; NMOR - N-nitrosomorpholine; PFOA - Perfluorooctanoic acid; PFOS - Perfluorooctanesulfonic acid; SWRCB - State Water Resources Control Board; µg/L - micrograms per liter; UV - ultraviolet.
(1) Health-based CECs and Bioanalytical Screening to be monitored following treatment.
(2) Performance indicator CECs to be monitored before reverse osmosis and after treatment.
(3) Surrogates are provided as examples. Surrogates should be used to demonstrate effectiveness of individual processes for removing CECs.

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Appendix B

DPR DESIGN CRITERIA SUMMARY

Appendix B

DPR DESIGN CRITERIA SUMMARY

The design criteria for each unit process are summarized in the tables below.

Table B.1 Ozone Design Criteria

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Feed Flow	mgd	14.15	28.31
Ozone Production			
Ozone Applied Dose	mg/L	20	20
Ozone MTE	percent	90	90
Ozone Transferred Dose	mg/L	18	18
Ozone Production	ppd	2,361	4,721
Power Consumption	kW	438	875
Ozone wt %	percent	12	12
Ozone CT	min	10	10
Ozone Concentration Times CT(1)	mg-min/L	6.43	6.43
Oxygen Required	ppd	19,673	36,346

Notes:
Abbreviations: CT - contact time; kW - kilowatt; mg/L - milligrams per liter; mg-min/L - milligram-minutes per liter; mgd - million gallons per day; min - minute(s); MTE - mass transfer efficiency; ppd - pounds per day; wt - weight.
(1) Ozone concentration times CT required to remove 1 log *Cryptosporidium* at 10 degrees Celsius, according to the equation *Cryptosporidium* log removal value = CT*0.0397*(1.09757)^Temperature (Environmental Protection Agency 2010). The ability to achieve this concentration times CT is dependent on the dose-response curve and must be confirmed through jar testing.

Table B.2 Biological Activated Carbon Design Criteria

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
No. of Filters	No.	6	12
Filter Area, each	sq ft	456	456
Filter Depth	ft	10	10
Flow per Filter			
All Filters Operating	gpm	1,638	1,638
One Filter in Backwash	gpm	1,966	1,787
Hydraulic Loading			
All Filters Operating	gpm/ft	3.6	3.6
One Filter in Backwash	gpm/ft	4.3	3.9

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
EBCT			
All Filters Operating	min	20.8	20.8
One Filter in Backwash	min	17.4	19.1

Notes:
Abbreviations: EBCT - empty bed contact time; ft - feet; gpm - gallons per minute; gpm/ft - gallons per minute per foot; mgd - million gallons per day; min - minutes; No. - number; sq ft - square feet.

Table B.3 Ultrafiltration Design Criteria

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
UF Process			
Type	-	Pressurized, Polymeric Hollow Fiber UF	
Flow Rate	gpm	9,042	18,083
Number of Trains in Service	No.	4	8
Number of Redundant Trains	No.	2	2
Number of Total Trains	No.	6	10
Installed Modules per Train	No.	76	76
Spare Module Spaces per Train	No.	24	24
Temperature Correction			
Peak Capacity Design Temperature	°C	15	15
Reference Temperature	°C	20	20
Temperature Correction Factor	-	1.14	1.14
Pilot Peak Flux Direct (at Reference Temperature)	gfd	70	70
Design Peak Flux (at Design Temperature)	gfd	61.3	61.3
Flow Criteria			
Average Feed Flowrate	gpm	9,042	18,083
Feed Water Loss	percent	2%	2%
Gross Filtrate Production	gpm	8,861	17,722
Filtrate Losses	percent	2%	2%
Overall Recovery	percent	96%	96%
System Net Filtrate	gpm	8,680	17,360
Instantaneous Factor	-	1.15	1.15
Online Factor (1/Instantaneous)	percent	87%	87%
Instantaneous Filtrate Production	gpm	10,190	20,380

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Module Criteria			
Membrane Area per Module	sq ft	775	775
Membrane Area per Train	sq ft	58,900	58,900
Membrane Area Total	sq ft	353,400	589,000
Gross Flux Rate	gfd	54.2	54.2
Instantaneous Flux Rate	gfd	62.3	62.3
Backwash Criteria			
Type		Reverse Flow Followed by Air Scour and Drain	
Backwash Interval per Train			
Minimum	min	20	20
Maximum	min	30	30
Filtration Flow	Ratio	1.1	1.1
Backwash Supply Flowrate	gpm	2,802	2,802
Backwash Duration	sec	30	30
Air Scour Flowrate	ACFM	532	532
Air Scour Duration	sec	30 – 60	30 – 60
Forward Flush Flowrate	gpm	1,368	1,368
Forward Flush Duration	sec	20	20

Notes:
Abbreviations: °C - degrees Celsius; ACFM - actual cubic feet per minute; gfd - gallons per square foot per day; gpm - gallons per minute; mgd - million gallons per day; min - minutes; No. - number; sec - seconds; sq ft - square feet; UF - ultrafiltration.

Table B.4 Reverse Osmosis Design Criteria

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Design Feed Flowrate	gpm	8,680	17,360
Recovery	percent	80%	80%
Permeate Flowrate	gpm	6,944	13,888
Concentrate Flowrate	gpm	1,736	3,472
Feed Flowrate Per Train	gpm	2,893	3,472
Permeate Flowrate per Train	gpm	2,315	2,778
Concentrate Flow per Train	gpm	579	694
Number of RO Trains			
In-Service	No.	3	5
Reliability	No.	1	1
Total	No.	4	6

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Staging of RO Trains			
First Stage			
Pressure Vessels per Train	No.	72	86
Elements per Pressure Vessels	No.	7	7
Second Stage			
Second Stage	No.	36	43
Elements per Pressure Vessels	No.	7	7
Number of Elements			
Per Train	No.	756	903
Total (In-Service)	No.	3,024	5,418
Membrane Area			
Per Element	sq ft	400	400
Per Train	sq ft	302,400	361,200
Total (In-Service)	sq ft	907,200	1,806,000
Average Flux Rate	gfd	11.0	11.1

Notes:
Abbreviations: gfd - gallons per square foot per day; gpm - gallons per minute; mgd - million gallons per day; No. - number; RO - reverse osmosis; sq ft - square feet.

Table B.5 Ultraviolet Advanced Oxidation Process Design Criteria

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Number of Vessels			
In-Service	No.	2	2
Reliability	No.	1	1
Total	No.	3	3
Feed Flowrate	mgd	10.0	20.0
Feed Flowrate per Reactor	mgd	5.0	10.0
Lamp Aging and Fouling Factor	percent	80%	80%
Design Inlet UVT	percent	96%	96%
Design Outlet UVT	percent	98%	98%
Design NDMA LRV(1)	LRV	1	1
Design 1,4-Dioxane LRV	LRV	0.5	0.5
Hypochlorite Dose	mg/L	4.0	4.0

Notes:
Abbreviations: LRV - log removal value; mg/L - milligrams per liter; mgd - million gallons per day; NDMA - N-nitrosodimethylamine; No - number; UVT - ultraviolet transmittance.
(1) Assumed NDMA reduction requirement. Bench scale testing required to confirm NDMA in reverse osmosis (RO) permeate.

Table B.6 Stabilization Design Criteria: Calcite Contactors

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Flowrate	gpm	3,472	6,944
No. of Filters	No.	8	16
Filter Diameter	ft	12	12
Area per Filter	sq ft	113	113
Media Depth	ft	3	3
Flow per Filter			
All Filters Operating	gpm	434	434
One Filter Offline	gpm	496	463
Hydraulic Loading			
All Filters Operating	gpm/ft	3.8	3.8
One Filter Offline	gpm/ft	4.4	4.1
EBCT			
All Filters Operating	min	5.8	5.8
One Filter in Backwash	min	5.1	5.5
Calcite Flush Pump Skids	No.	2	2

Notes:
Abbreviations: EBCT - empty bed contact time; ft - feet; gpm - gallons per minute; gpm/ft - gallons per minute per foot; mgd - million gallons per day; min - minute(s); No. - number; sq ft - square feet.
(1) Calcite Contactors are treating split flow then blending back.

Table B.7 Secondary Ultraviolet Design Criteria

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Number of Reactors			
In-Service	No.	1	1
Reliability	No.	1	1
Total	No.	2	2
Feed Flowrate	mgd	10.0	20.0
Feed Flowrate per Reactor	mgd	10.0	20.0
End of Lamp Life Factor	(-)	0.81	0.81
Sleeve Fouling Factor	(-)	0.95	0.95
Lamp Aging Factor	(-)	0.85	0.85
Design UVT	percent	95	95
Validated Dose	mJ/cm^2	186	186

Notes:
Abbreviations: mgd - million gallons per day; mJ/cm^2 - millijoules per square centimeter; No. - number; UVT - ultraviolet transmittance.

Table B.8 Product Water Tank/Chlorine Disinfection Design Criteria

Process and Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Flowrate	gpm	6,944	13,888
Baffling Factor	-	0.3	0.3
Virus LRV(1)	-	2	2
pH	-	≤8.5	≤8.5
Turbidity	NTU	≤0.2	≤0.2
Temperature(2)	°C	21	21
Concentration Times CT Value(1)	mg-min/L	8	8
Residual Monochloramine(3)	mg/L	1	1
Minimum Tank Volume(4)	gal	185,173	370,347

Notes:
Abbreviations: °C - degrees Celsius; CT - contact time; gal - gallons; gpm - gallons per minute; LRV - log removal value; mg/L - milligrams per liter; mg-min/L - milligrams-minutes per liter; mgd - million gallons per day; NTU - Nephelometric Turbidity unit.

(1) The Australian WaterVal Validation protocol published in 2017 was used to determine the concentration times CT value. Per Table 1 of WaterVal, assuming a pH of ≤8.5, >21°C, and ≤0.2 NTU, the concentration times CT required for 2 LRV virus is 8 mg-min/L. Note that there is a lot of flexibility in the use of the Australian WaterVal free chlorine credit document. There is no minimum concentration times CT, just minimum concentration times CT values to meet different LRV credits.

(2) Based on historical plant effluent data from 2015 through 2021.

(3) Target monochloramine residual is per San Francisco Public Utilities Commission (SFPUC) input. This residual value may change upon pilot testing and future analysis or to meet different residual goals for the San José and Santa Clara systems.

(4) Tank volume is for calculation of CT. This volume does not include operational volume, the volume required for pumping, or the volume required for response time. Actual volume included in the layouts account for these additional space requirements.

Table B.9 Chemical Storage Design Criteria

Chemical	Purpose
Aluminum Chloride Hydroxide	Pretreatment
Antiscalant	RO Influent
Citric Acid	UF MCs and CIPs
Gypsum	Post-Treatment
Hydrochloric Acid	UF MCs, CIPs, and Neutralize Clean
Sodium Bisulfite	Ozone Quench, Neutralize Clean
Sodium Hydroxide	UF MC, CIP, and Neutralize Clean
Sodium Hypochlorite	Pretreatment, UF MC, CIP, and Residual Disinfectant, UV AOP
Sulfuric Acid	RO Influent, Calcite Contactor Influent

Notes:
Abbreviations: AOP - advanced oxidation process; CIP - clean-in-place; MC - maintenance clean; RO - reverse osmosis; UF - ultrafiltration; UV - ultraviolet.

Table B.10 On-site San Francisco Public Utilities Commission Blend Tank

Criteria	Unit	Alternatives	
		10 mgd Production	20 mgd Production
Nominal Capacity	MG	2.31	4.48
Inner Diameter	ft	0.3	0.3
Sidewater Depth	ft	33	33
Freeboard	ft	3	3

Notes:
Abbreviations: ft - feet; MG - million gallons; mgd - million gallons per day.

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Appendix C
BASIS OF COST

Appendix C

BASIS OF COST

C.1 Planning Level Cost Estimate

The Association for the Advancement of Cost Engineering International (AACE International) has suggested levels of accuracy for five estimate classes. These five estimate classes are presented in the AACE International Recommended Practice No. 18R-97 (Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries). Table C.1 presents a summary of these five estimate classes and their characteristics, including expected accuracy ranges (AACE International, 2020).

Table C.1 Classes of Cost Estimates

Estimate Class	Maturity Level of Project Definition Deliverables(1)	End Usage(2)	Methodology(3)	Expected Accuracy Range(4)
Class 5	0% to 2%	Concept Screening	Capacity factored, parametric models, judgement, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or Feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or Bid/Tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check Estimate or Bid/Tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Notes:
Abbreviations: H - high; L - low.
(1) Expressed as percent of complete definition.
(2) Typical purpose of estimate.
(3) Typical estimating method.
(4) Typical variation in low and high ranges at an 80 percent confidence interval.

The quantity and quality of the information required to prepare an estimate depends on the end use for that estimate. Typically, as a project progresses from the conceptual phase to the study phase, preliminary design and final design, the quantity and quality of information increases, thereby providing data for development of a progressively more accurate cost estimate. A contingency is often used to compensate for lack of detailed engineering data, oversights, anticipated changes, and imperfection in the estimating methods used. As the quantity and quality of data becomes better, smaller contingency allowances are typically utilized. For this project, cost estimates are developed following the AACE International Recommended Practice No. 18R-97 estimate classes 5 and 4.

C.1.1 Capital Cost Basis

Capital costs reflect a March 2022 Engineering News-Record (ENR) Construction Cost Index value of 12,791 and are based on quantity takeoffs and similar facilities with allowances for civil, mechanical, structural, and electrical improvements, as well as engineering cost.

Construction costs presented typically include an estimating contingency, sales tax, general conditions, and contractor's overhead and profit. The percentages assumed for these factors are shown in Table C.2.

Total project costs presented typically include a fee for engineering, legal, and administration, as well as an owner's reserve for change orders. The percentages assumed for these factors are also shown in Table C.2. Note that capital costs do not include land acquisition, escalation to midpoint of construction, and insurance costs.

Table C.2 Basis for Estimating Capital Costs

Item	Estimated Cost	Estimated Cost of "A"
Equipment / Infrastructure Cost Total	**"A"**	**100%**
Estimating Contingency	40% of "A"	40%
Direct Cost Total	**"B"**	**140%**
Sales Tax	9.38%(1) of 1/2 "B"	7%
General Conditions	15% of "B + Sales Tax"	22%
Contractor Overhead and Profit	15% of "B+ Sales Tax + General Conditions"	25%
Construction Cost Total	**"C"**	**194%**
Engineering, Legal, and Administrative	20% of "C"	39%
Owner's Reserve for Change Orders	5% of "C"	10%
Project Cost Total	**"D"**	**242%**

Notes:
(1) City of San Jose 2022 sales tax rate.

Appendix D

DETAILED COST ESTIMATES

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	10/7/2022
BY:	Madison Rasmus
ALTERNATIVE:	10 MGD Production
COST:	AWPF Treatment Costs
DESCRIPTION:	Level 5 Cost Estimate for the 10 MGD AWPF

CAPITAL COST ESTIMATE

Classification	Quantity	Units	Unit Cost	Estimated Cost
Treatment Process Equipment Cost				
Ozone/BAF and Oxygen Generation[4]	1	LS	$ 15,043,449	$ 15,043,000
Ozone Contactor (tank)	1	LS	$ 288,860	$ 289,000
Ultrafiltration Process	1	LS	$ 3,785,485	$ 3,785,000
Reverse Osmosis Process	1	LS	$ 6,717,333	$ 6,717,000
Ultraviolet/Advanced Oxidation Process System	1	LS	$ 1,272,585	$ 1,273,000
Calcite Contactor	1	LS	$ 1,895,128	$ 1,895,000
Chemical Systems	1	LS	$ 2,481,422	$ 2,481,000
UV Disinfection	1	LS	$ 362,467	$ 362,000
Chlorine and Storage Tank	1	LS	$ 1,771,154	$ 1,771,000
Break Tanks	1	LS	$ 463,886	$ 464,000
			Subtotal	$ 34,080,000
Treatment Facility Items				
Process Equipment Installation, 25% of Unit Process Cost			25%	$ 8,520,000
Sitework			15%	$ 5,112,000
Electrical & I/C			25%	$ 8,520,000
Mechanical			15%	$ 5,112,000
Piping and valves			20%	$ 6,816,000
Treatment Building	46,000	SF	$ 400	$ 18,400,000
Total Direct Cost				*$ 86,560,000*
Estimating Contingency	40%			$ 34,624,000
Subtotal				*$ 121,184,000*
Sales Tax (applied to 50% of direct costs)	9%			$ 5,684,000
Subtotal				*$ 126,868,000*
General Conditions	15%			$ 19,030,000
Subtotal				*$ 145,898,000*
Contractor Overhead & Profit	15%			$ 21,885,000
Subtotal				*$ 167,783,000*
TOTAL CONSTRUCTION COST				*$ 167,783,000*
Engineering, Legal, and Administrative	20%			$ 33,557,000
Owners Reserve for Change Orders	5%			$ 8,389,000
TOTAL PROJECT COST				**$ 209,730,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include piles. Piles would add approximately $2.3 million in direct cost.
3. Costs presented do not include land acquisition.
4. Oxygen generation was assumed for the ozone process. This decision should be further refined if the project moves into design.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	11/20/2022
BY:	Madison Rasmus
ALTERNATIVE:	20 MGD Production
COST:	AWPF Treatment Costs
DESCRIPTION:	Level 5 Cost Estimate for the 20 MGD AWPF

CAPITAL COST ESTIMATE

Classification	Quantity	Units	Unit Cost	Estimated Cost
Treatment Process Equipment Cost				
Ozone/BAF and Oxygen Generation[4]	1	LS	$ 28,636,192	$ 28,636,000
Ozone Contactor (tank)	1	LS	$ 573,690	$ 574,000
Ultrafiltration Process	1	LS	$ 6,555,720	$ 6,556,000
Reverse Osmosis Process	1	LS	$ 12,779,908	$ 12,780,000
Ultraviolet/Advanced Oxidation Process System	1	LS	$ 2,202,176	$ 2,202,000
Calcite Contactor	1	LS	$ 3,141,357	$ 3,141,000
Chemical Systems	1	LS	$ 4,474,536	$ 4,475,000
UV Disinfection	1	LS	$ 557,665	$ 558,000
Chlorine and Storage Tank	1	LS	$ 3,540,202	$ 3,540,000
Break Tanks	1	LS	$ 920,669	$ 921,000
			Subtotal	$ 63,383,000
Treatment Facility Items				
Process Equipment Installation, 25% of Unit Process Cost			25%	$ 15,845,750
Sitework			15%	$ 9,507,450
Electrical & I/C			25%	$ 15,845,750
Mechanical			15%	$ 9,507,450
Piping and valves			20%	$ 12,676,600
Treatment Building	60,000	SF	$ 400	$ 24,000,000
Total Direct Cost				*$ 150,766,000*
Estimating Contingency	40%			$ 60,306,000
Subtotal				*$ 211,072,000*
Sales Tax (applied to 50% of direct costs)	9%			$ 9,899,000
Subtotal				*$ 220,971,000*
General Conditions	15%			$ 33,146,000
Subtotal				*$ 254,117,000*
Contractor Overhead & Profit	15%			$ 38,118,000
Subtotal				*$ 292,235,000*
TOTAL CONSTRUCTION COST				*$ 292,235,000*
Engineering, Legal, and Administrative	20%			$ 58,447,000
Owners Reserve for Change Orders	5%			$ 14,612,000
TOTAL PROJECT COST				**$ 365,290,000**

Notes

1. Costs presented in 2022 dollars. Costs may change slightly depending on specific chemical preferences
2. Costs presented do not include piles. Piles would add approximately $2.3 million in direct cost.
3. Costs presented do not include land acquisition.
4. Oxygen generation was assumed for the ozone process. This decision should be further refined if the project moves into design.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	7/3/2023
BY:	Madison Rasmus
DESCRIPTION:	Level 5 O&M Treatment Cost Estimates

O&M Item	Quantity		Unit	Unit Cost	Annual Cost(1)	
	10 mgd	20 mgd			10 mgd	20 mgd
Ozone						
Ozone Power	3,834,176	7,669,884	KW-hr/year	$0.23	$882,000	$1,765,000
Oxygen Power Generation	1,596,353	2,982,568	KW-hr/year	$0.23	$368,000	$686,000
Oxygen Generator Maintenance(2)	**See footnote (2)**		LS		$11,000	$20,000
Chloramination						
Sodium hypochlorite (12.5% solution)	31,659	63,317	gal/year	$2.50	$80,000	$159,000
Liquid Ammonium Sulfate (40% solution)	148,400	296,800	gal/year	$2.55	$379,000	$757,000
Ultrafiltration						
Power(3)	**See footnote (3)**		LS		$119,000	$238,000
Membrane Replacement(4)	1	2	module	$100,000	$100,000	$200,000
Reverse Osmosis						
Power	5,790,936	11,581,872	KW-hr/year	$0.23	$1,332,000	$2,664,000
Liquid Ammonium Sulfate (40% solution)	27,179	54,359	gal/year	$2.55	$70,000	$139,000
Membrane Replacement(5)	460	915	modules	400	$184,000	$366,000
Ultraviolet/Advanced Oxidation Processes						
Power	1,007,400	2,014,800	KW-hr/year	$0.23	$232,000	$464,000
Sodium hypochlorite (12.5% solution)	97,411	194,822	gal/year	$2.50	$244,000	$488,000
Calcite Contactor						
Power	2,555	2,555	KW-hr/year	$0.23	$1,000	$1,000
Carbon Dioxide	1,152,670	2,327,328	lb/year	$0.17	$196,000	$396,000
Calcite	2,341,964	4,693,600	lb/year	$0.31	$727,000	$1,456,000
Sodium hydroxide	2,638,220	5,284,616	lb/year	$0.29	$766,000	$1,533,000
UV Disinfection						
Power	350,400	586,920	KW-hr/year	$0.23	$81,000	$135,000
Chlorine Disinfection						
Sodium hypochlorite (12.5% solution)	35,312	70,623	gal/year	$2.50	$89,000	$177,000
Liquid Ammonium Sulfate (40% solution)	34,790	69,579	gal/year	$2.55	$89,000	$178,000
Annual Maintenance(6)	**See footnote (6)**		LS		$4,637,000	$9,216,000
Staffing Costs(7)	**See footnote (7)**		LS		$4,328,000	$4,760,000
	TOTAL ESTIMATED ANNUAL O&M COSTS				**$14,900,000**	**$25,800,000**

(1) Expressed in 2022 dollars.

(2) Oxygen generator maintenance is estimated on a per generator basis using a cost curve generated from recent vendor quotes.

(3) Power for MF/UF processes estimated using a cost curve generated from recent vendor quotes.

(4) MF/UF membrane replacement assumes full membrane replacement required every ten years. Annual cost shown represents approximately one-tenth of total replacement cost.

(5) RO membrane replacement assumes full module replacement required every five years. Modules shown are approximately one-fifth of modules required for the full system.

(6) Annual maintenance for the AWPF facility is estimated using a cost curve generated from recent vendor quotes.

(7) Further detail on staffing cost estimates available in Appendix E.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	3/1/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	10 MGD Production
COST:	Feed Water Pipe
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

	Classification	**Quantity**	**Units**	**Unit Cost**	**Estimated Cost**
Pipeline Cost					
	30" Pipeline	5,855	LF	$ 560	$ 3,280,000
				Subtotal	$ 3,280,000
Pipeline Allowances					
	Electrical			3%	$ 98,400
	Instrumentation			3%	$ 98,400
	Fittings and Appurtenances			10%	$ 328,000
				Subtotal	$ 524,800
Pump Station Cost					
	Pump Station Structure	1	LS		$ 916,500
	Feed Water Pumps	2	EA	$ 381,000	$ 762,000
				Subtotal	$ 1,678,500
Pump Station Allowances					
	Process Equipment Installation			25%	$ 419,625
	Sitework			15%	$ 251,775
	Electrical & I/C			25%	$ 419,625
	Mechanical			15%	$ 251,775
	Piping and valves			20%	$ 335,700
				Subtotal	$ 1,678,500
	Total Direct Cost				*$ 7,161,800*
	Estimating Contingency	40%			$ 2,865,000
	Subtotal				*$ 10,026,800*
	Sales Tax (applied to 50% of direct costs)	9%			$ 470,000
	Subtotal				*$ 10,496,800*
	General Conditions	15%			$ 1,575,000
	Subtotal				*$ 12,071,800*
	Contractor Overhead & Profit	15%			$ 1,811,000
	Subtotal				*$ 13,882,800*
	TOTAL CONSTRUCTION COST				*$ 13,882,800*
	Engineering, Legal, and Administrative	20%			$ 2,777,000
	Owners Reserve for Change Orders	5%			$ 694,000
	TOTAL PROJECT COST				**$ 17,350,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	3/1/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	20 MGD Production
COST:	Feed Water Pipe
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification	Quantity	Units	Unit Cost	Estimated Cost
Pipeline Cost				
42" Pipeline	5,855	LF	$ 994	$ 5,817,000
			Subtotal	$ 5,817,000
Pipeline Allowances				
Electrical			3%	$ 174,510
Instrumentation			3%	$ 174,510
Fittings and Appurtenances			10%	$ 581,700
			Subtotal	$ 930,720
Pump Station Cost				
Pump Station Structure	1	LS		$ 1,768,000
Feed Water Pumps	2	EA	$ 538,000	$ 1,076,000
			Subtotal	$ 2,844,000
Pump Station Allowances				
Process Equipment Installation			25%	$ 711,000
Sitework			15%	$ 426,600
Electrical & I/C			25%	$ 711,000
Mechanical			15%	$ 426,600
Piping and valves			20%	$ 568,800
			Subtotal	$ 2,844,000
Total Direct Cost				*$ 12,435,720*
Estimating Contingency	40%			$ 4,974,000
Subtotal				*$ 17,409,720*
Sales Tax (applied to 50% of direct costs)	9%			$ 817,000
Subtotal				*$ 18,226,720*
General Conditions	15%			$ 2,734,000
Subtotal				*$ 20,960,720*
Contractor Overhead & Profit	15%			$ 3,144,000
Subtotal				*$ 24,104,720*
TOTAL CONSTRUCTION COST				*$ 24,104,720*
Engineering, Legal, and Administrative	20%			$ 4,821,000
Owners Reserve for Change Orders	5%			$ 1,205,000
TOTAL PROJECT COST				**$ 30,130,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	3/1/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	10 MGD Production
COST:	Finished Water Pipe
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification		Quantity	Units	Unit Cost	Estimated Cost
Pipeline Cost					
	24" Pipeline to San Jose	9,710	LF	$ 427	$ 4,143,000
	12" Pipeline to Santa Clara	14,145	LF	$ 190	$ 2,692,000
	16" Pipeline to SFPUC	7,273	LF	$ 257	$ 1,870,000
	Tank Mixer at San Jose Tank (3 MG)	1	LS	$ 11,708	$ 12,000
	Tank Mixer at Santa Clara Tank (4.7 MG)	1	LS	$ 15,512	$ 16,000
	Structural/Seismic Analysis at Bridge Crossings	2	LS	$ 50,000	$ 100,000
				Subtotal	$ 8,833,000
Pipeline Allowances					
	Electrical			3%	$ 264,990
	Instrumentation			3%	$ 264,990
	Fittings and Appurtenances			10%	$ 883,300
				Subtotal	$ 1,413,280
Pump Station and Dillution Tank Cost					
	SJ / SC Pumps	2	EA	$ 2,152,000	$ 4,304,000
	SFPUC Pumps	2	EA	$ 1,928,000	$ 3,856,000
	SFPUC Pump Station	1	LS	$ 228,000	$ 228,000
	SFPUC Dilution Tank	1	LS	$ 2,400,000	$ 2,400,000
	SFPUC Dilution Tank Mixers	1	EA	$ 11,708	$ 12,000
				Subtotal	$ 10,800,000
Pump Station Allowances					
	Process Equipment Installation			25%	$ 2,700,000
	Sitework			15%	$ 1,620,000
	Electrical & I/C			25%	$ 2,700,000
	Mechanical			15%	$ 1,620,000
	Piping and valves			20%	$ 2,160,000
				Subtotal	$ 10,800,000
	Total Direct Cost				*$ 31,846,280*
	Estimating Contingency	40%			$ 12,739,000
	Subtotal				*$ 44,585,280*
	Sales Tax (applied to 50% of direct costs)	9%			$ 2,091,000
	Subtotal				*$ 46,676,280*
	General Conditions	15%			$ 7,001,000
	Subtotal				*$ 53,677,280*
	Contractor Overhead & Profit	15%			$ 8,052,000
	Subtotal				*$ 61,729,280*
	TOTAL CONSTRUCTION COST				*$ 61,729,280*
	Engineering, Legal, and Administrative	20%			$ 12,346,000
	Owners Reserve for Change Orders	5%			$ 3,086,000
	TOTAL PROJECT COST				**$ 77,160,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	3/1/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	10 MGD Production
COST:	Finished Water Pipe - Jack and Bore
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification	Quantity	Units	Unit Cost	Estimated Cost
Pipeline Cost				
24" Pipeline to San Jose	9,710	LF	$ 427	$ 4,146,000
12" Pipeline to Santa Clara	14,083	LF	$ 220	$ 3,102,000
16" Pipeline to SFPUC	7,313	LF	$ 393	$ 2,876,000
Tank Mixer at San Jose Tank	1	LS	$ 11,708	$ 12,000
Tank Mixer at Santa Clara Tank	1	LS	$ 15,512	$ 16,000
			Subtotal	$ 10,152,000
Pipeline Allowances				
Electrical			3%	$ 304,560
Instrumentation			3%	$ 304,560
Fittings and Appurtenances			10%	$ 1,015,200
			Subtotal	$ 1,624,320
Pump Station and Dillution Tank Cost				
SJ / SC Pumps	2	EA	$ 2,152,000	$ 4,304,000
SFPUC Pumps	2	EA	$ 1,928,000	$ 3,856,000
SFPUC Pump Station	1	LS	$ 227,500	$ 228,000
SFPUC Dilution Tank	1	LS	$ 2,400,000	$ 2,400,000
SFPUC Dilution Tank Mixers	1	EA	$ 11,708	$ 12,000
			Subtotal	$ 10,800,000
Pump Station Allowances				
Process Equipment Installation			25%	$ 2,700,000
Sitework			15%	$ 1,620,000
Electrical & I/C			25%	$ 2,700,000
Mechanical			15%	$ 1,620,000
Piping and valves			20%	$ 2,160,000
			Subtotal	$ 10,800,000
Total Direct Cost				*$ 33,376,320*
Estimating Contingency	40%			$ 13,351,000
Subtotal				*$ 46,727,320*
Sales Tax (applied to 50% of direct costs)	9%			$ 2,192,000
Subtotal				*$ 48,919,320*
General Conditions	15%			$ 7,338,000
Subtotal				*$ 56,257,320*
Contractor Overhead & Profit	15%			$ 8,439,000
Subtotal				*$ 64,696,320*
TOTAL CONSTRUCTION COST				*$ 64,696,320*
Engineering, Legal, and Administrative	20%			$ 12,939,000
Owners Reserve for Change Orders	5%			$ 3,235,000
TOTAL PROJECT COST				**$ 80,870,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	3/1/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	20 MGD Production
COST:	Finished Water Pipe
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification	Quantity	Units	Unit Cost	Estimated Cost
Pipeline Cost				
24" Pipeline to San Jose	9,710	LF	$ 427	$ 4,146,000
16" Pipeline to Santa Clara	14,145	LF	$ 190	$ 2,692,000
30" Pipeline to SFPUC	7,273	LF	$ 575	$ 4,182,000
Tank Mixer at San Jose Tank (3 MG)	1	LS	$ 11,708	$ 12,000
Tank Mixer at Santa Clara Tank (4.7 MG)	1	LS	$ 15,512	$ 16,000
Structural/Seismic Analysis at Bridge Crossings	2	LS	$ 50,000	$ 100,000
			Subtotal	$ 11,148,000
Pipeline Allowances				
Electrical			3%	$ 334,440
Instrumentation			3%	$ 334,440
Fittings and Appurtenances			10%	$ 1,114,800
			Subtotal	$ 1,783,680
Pump Station and Dillution Tank Cost				
SJ / SC Pumps	2	EA	$ 4,303,000	$ 8,606,000
SFPUC Pumps	2	EA	$ 7,172,000	$ 14,344,000
SFPUC Pump Station	1	LS	$ 877,500	$ 878,000
SFPUC Dilution Tank	1	LS	$ 3,925,000	$ 3,925,000
SFPUC Dilution Tank Mixers	1	EA	$ 15,512	$ 16,000
			Subtotal	$ 27,769,000
Pump Station Allowances				
Process Equipment Installation			25%	$ 6,942,250
Sitework			15%	$ 4,165,350
Electrical & I/C			25%	$ 6,942,250
Mechanical			15%	$ 4,165,350
Piping and valves			20%	$ 5,553,800
			Subtotal	$ 27,769,000
Total Direct Cost				*$ 68,469,680*
Estimating Contingency	40%			$ 27,388,000
Subtotal				*$ 95,857,680*
Sales Tax (applied to 50% of direct costs)	9%			$ 4,496,000
Subtotal				*$ 100,353,680*
General Conditions	15%			$ 15,053,000
Subtotal				*$ 115,406,680*
Contractor Overhead & Profit	15%			$ 17,311,000
Subtotal				*$ 132,717,680*
TOTAL CONSTRUCTION COST				*$ 132,717,680*
Engineering, Legal, and Administrative	20%			$ 26,544,000
Owners Reserve for Change Orders	5%			$ 6,636,000
TOTAL PROJECT COST				**$ 165,900,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	3/1/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	20 MGD Production
COST:	Finished Water Pipe - Jack and Bore
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification	Quantity	Units	Unit Cost	Estimated Cost
Pipeline Cost				
24" Pipeline to San Jose	9,710	LF	$ 427	$ 4,146,000
16" Pipeline to Santa Clara	14,083	LF	$ 220	$ 3,102,000
30" Pipeline to SFPUC	7,313	LF	$ 830	$ 6,070,000
Tank Mixer at San Jose Tank	1	LS	$ 11,708	$ 12,000
Tank Mixer at Santa Clara Tank	1	LS	$ 15,512	$ 16,000
			Subtotal	$ 13,346,000
Pipeline Allowances				
Electrical			3%	$ 400,380
Instrumentation			3%	$ 400,380
Fittings and Appurtenances			10%	$ 1,334,600
			Subtotal	$ 2,135,360
Pump Station and Dillution Tank Cost				
SJ / SC Pumps	2	EA	$ 4,303,000	$ 8,606,000
SFPUC Pumps	2	EA	$ 7,172,000	$ 14,344,000
SFPUC Pump Station	1	LS	$ 877,500	$ 878,000
SFPUC Dilution Tank	1	LS	$ 3,925,000	$ 3,925,000
SFPUC Dilution Tank Mixers	1	EA	$ 15,512	$ 16,000
			Subtotal	$ 27,769,000
Pump Station Allowances				
Process Equipment Installation			25%	$ 6,942,250
Sitework			15%	$ 4,165,350
Electrical & I/C			25%	$ 6,942,250
Mechanical			15%	$ 4,165,350
Piping and valves			20%	$ 5,553,800
			Subtotal	$ 27,769,000
Total Direct Cost				*$ 71,019,360*
Estimating Contingency	40%			$ 28,408,000
Subtotal				*$ 99,427,360*
Sales Tax (applied to 50% of direct costs)	9%			$ 4,663,000
Subtotal				*$ 104,090,360*
General Conditions	15%			$ 15,614,000
Subtotal				*$ 119,704,360*
Contractor Overhead & Profit	15%			$ 17,956,000
Subtotal				*$ 137,660,360*
TOTAL CONSTRUCTION COST				*$ 137,660,360*
Engineering, Legal, and Administrative	20%			$ 27,532,000
Owners Reserve for Change Orders	5%			$ 6,883,000
TOTAL PROJECT COST				**$ 172,080,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	3/1/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	10 MGD Production
COST:	ROC Pipe
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification		Quantity	Units	Unit Cost	Estimated Cost
Pipeline Cost					
	16" Pipeline to Existing Outfall	7,260	LF	$ 249	$ 1,810,000
				Subtotal	$ 1,810,000
Additional Items					
	Electrical			3%	$ 54,300
	Instrumentation			3%	$ 54,300
	Fittings and Appurtenances			10%	$ 181,000
				Subtotal	$ 289,600
	Total Direct Cost				*$ 2,099,600*
	Estimating Contingency	40%			$ 840,000
	Subtotal				*$ 2,939,600*
	Sales Tax (applied to 50% of direct costs)	9%			$ 138,000
	Subtotal				*$ 3,077,600*
	General Conditions	15%			$ 462,000
	Subtotal				*$ 3,539,600*
	Contractor Overhead & Profit	15%			$ 531,000
	Subtotal				*$ 4,070,600*
	TOTAL CONSTRUCTION COST				*$ 4,070,600*
	Engineering, Legal, and Administrative	20%			$ 814,000
	Owners Reserve for Change Orders	5%			$ 204,000
	TOTAL PROJECT COST				**$ 5,090,000**

Notes
1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	3/1/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	20 MGD Production
COST:	ROC Pipe
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification		Quantity	Units	Unit Cost	Estimated Cost
Pipeline Cost					
	18" Pipeline to Existing Outfall	7,260	LF	$ 283	$ 2,056,000
				Subtotal	$ 2,056,000
Additional Items					
	Electrical			3%	$ 61,680
	Instrumentation			3%	$ 61,680
	Fittings and Appurtenances			10%	$ 205,600
				Subtotal	$ 328,960
	Total Direct Cost				*$ 2,384,960*
	Estimating Contingency	40%			$ 954,000
	Subtotal				*$ 3,338,960*
	Sales Tax (applied to 50% of direct costs)	9%			$ 157,000
	Subtotal				*$ 3,495,960*
	General Conditions	15%			$ 524,000
	Subtotal				*$ 4,019,960*
	Contractor Overhead & Profit	15%			$ 603,000
	Subtotal				*$ 4,622,960*
	TOTAL CONSTRUCTION COST				*$ 4,622,960*
	Engineering, Legal, and Administrative	20%			$ 925,000
	Owners Reserve for Change Orders	5%			$ 231,000
	TOTAL PROJECT COST				**$ 5,780,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	5/2/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	10 MGD Production
COST:	AWPF Backwash and Off-Spec Return Pipe
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification		Quantity	Units	Unit Cost	Estimated Cost
Pipeline Cost					
	18" Pipeline to RWF Headworks	275	LF	$ 283	$ 78,000
				Subtotal	$ 78,000
Pipeline Allowances					
	Electrical			3%	$ 2,340
	Instrumentation			3%	$ 2,340
	Fittings and Appurtenances			10%	$ 7,800
				Subtotal	$ 12,480
Pump Station Cost					
	Pump Station Structure	1	LS		$ 330,200
	Waste Discharge Pumps	2	EA	$ 627,571	$ 1,255,000
				Subtotal	$ 1,585,200
Pump Station Allowances					
	Process Equipment Installation			25%	$ 396,300
	Sitework			15%	$ 237,780
	Electrical & I/C			25%	$ 396,300
	Mechanical			15%	$ 237,780
	Piping and valves			20%	$ 317,040
				Subtotal	$ 1,585,200
	Total Direct Cost				*$ 3,260,880*
	Estimating Contingency	40%			$ 1,304,000
	Subtotal				*$ 4,564,880*
	Sales Tax (applied to 50% of direct costs)	9%			$ 214,000
	Subtotal				*$ 4,778,880*
	General Conditions	15%			$ 717,000
	Subtotal				*$ 5,495,880*
	Contractor Overhead & Profit	15%			$ 824,000
	Subtotal				*$ 6,319,880*
	TOTAL CONSTRUCTION COST				*$ 6,319,880*
	Engineering, Legal, and Administrative	20%			$ 1,264,000
	Owners Reserve for Change Orders	5%			$ 316,000
	TOTAL PROJECT COST				**$ 7,900,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	5/2/2023
BY:	Patrick Hassett - WRE
ALTERNATIVE:	20 MGD Production
COST:	AWPF Backwash and Off-Spec Return Pipe
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification		Quantity	Units	Unit Cost	Estimated Cost
Pipeline Cost					
	24" Pipeline to RWF Headworks	275	LF	$ 399	$ 110,000
				Subtotal	$ 110,000
Pipeline Allowances					
	Electrical			3%	$ 3,300
	Instrumentation			3%	$ 3,300
	Fittings and Appurtenances			10%	$ 11,000
				Subtotal	$ 17,600
Pump Station Cost					
	Pump Station Structure	1	LS		$ 442,000
	Waste Discharge Pumps	2	EA	$ 806,877	$ 1,614,000
				Subtotal	$ 2,056,000
Pump Station Allowances					
	Process Equipment Installation			25%	$ 514,000
	Sitework			15%	$ 308,400
	Electrical & I/C			25%	$ 514,000
	Mechanical			15%	$ 308,400
	Piping and valves			20%	$ 411,200
				Subtotal	$ 2,056,000
	Total Direct Cost				*$ 4,239,600*
	Estimating Contingency	40%			$ 1,696,000
	Subtotal				*$ 5,935,600*
	Sales Tax (applied to 50% of direct costs)	9%			$ 278,000
	Subtotal				*$ 6,213,600*
	General Conditions	15%			$ 932,000
	Subtotal				*$ 7,145,600*
	Contractor Overhead & Profit	15%			$ 1,072,000
	Subtotal				*$ 8,217,600*
	TOTAL CONSTRUCTION COST				*$ 8,217,600*
	Engineering, Legal, and Administrative	20%			$ 1,644,000
	Owners Reserve for Change Orders	5%			$ 411,000
	TOTAL PROJECT COST				**$ 10,270,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	7/3/2023
BY:	Patrick Hassett
DESCRIPTION:	Level 5 O&M Infrastructure Cost Estimates

O&M Item	Quantity		Unit	Unit Cost	Annual Cost[1]	
	10 mgd	20 mgd			10 mgd	20 mgd
Power						
Feed Water Pump Station	555,472	784,195	KW-hr/year	$0.23	$128,000	$181,000
AWPF Pump Station[2]	3,136,781	6,273,562	KW-hr/year	$0.23	$722,000	$1,443,000
SFPUC Pump Station[3]	2,810,033	10,455,936	KW-hr/year	$0.23	$647,000	$2,405,000
AWPF Waste/Backwash Pump Station	914,894	1,176,293	KW-hr/year	$0.23	$211,000	$271,000
Annual Maintenance[4]	**See footnote (4)**				$556,000	$1,091,000
		TOTAL ESTIMATED ANNUAL O&M COSTS			**$2,262,000**	**$5,390,000**

(1) Expressed in 2022 dollars.

(2) Conveys finished water to San Jose, Santa Clara, and the SFPUC blending tank.

(3) Conveys finished water from SFPUC's blending tank to injection points on SFPUC's Bay Division Pipelines 3 and 4.

(4) Annual maintenance estimated as 0.5% of total capital costs.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	2/23/2023
BY:	Patricia McGovern, MME
ALTERNATIVE:	Solar Unit Cost per Watt (W)
COST:	Solar System
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

Classification		Quantity	Units	Unit Cost	Estimated Cost
				Ground Mounted	Roof Top
Solar System Cost					
	Module		$/W	$ 0.41	$ 0.41
	Inverter		$/W	$ 0.08	$ 0.14
	Electrical Balance of System		$/W	$ 0.18	$ 0.12
	Structural Balance of System		$/W	$ 0.14	$ 0.14
			Subtotal	$ 0.81	$ 0.81
Allowances					
	Installation			25%	$ 0.20
	Sitework			15%	$ 0.12
	Electrical & I/C			25%	$ 0.20
	Mechanical			15%	$ 0.12
	Total Direct Cost (per Watt)				*$ 1.46*
	Estimating Contingency	40%			$ 0.58
	Subtotal				*$ 2.04*
	Sales Tax (applied to 50% of direct costs)	9%			$ 0.10
	Subtotal				*$ 2.14*
	General Conditions	15%			$ 0.32
	Subtotal				*$ 2.46*
	Contractor Overhead & Profit	15%			$ 0.37
	Subtotal				*$ 2.83*
	TOTAL CONSTRUCTION COST (per Watt)				*$ 2.83*
	Engineering, Legal, and Administrative	20%			$ 0.57
	Owners Reserve for Change Orders	5%			$ 0.14
	TOTAL PROJECT COST (per Watt)				**$ 3.53**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

PROJECT:	South Bay Purified Water Project
JOB NO.:	200663
DATE:	2/23/2023
BY:	Patricia McGovern, MME
ALTERNATIVE:	1 MW Lithium Ion Battery
COST:	Battery for Solar System
DESCRIPTION:	Level 5 Cost Estimate

CAPITAL COST ESTIMATE

	Classification	**Quantity**	**Units**	**Unit Cost**		
	Battery 1 MW Lithium Ion Battery		1 MW		$	800,000
				Subtotal	$	800,000
					$	-
Allowances						
	Sitework			10%	$	80,000
	Electrical & I/C			10%	$	80,000
	Total Direct Cost				*$*	*960,000*
					$	-
	Estimating Contingency	40%			$	384,000
	Subtotal				*$*	*1,344,000*
	Sales Tax (applied to 50% of direct costs)	9%			$	63,000
	Subtotal				*$*	*1,407,000*
	General Conditions	15%			$	211,000
	Subtotal				*$*	*1,618,000*
	Contractor Overhead & Profit	15%			$	243,000
	Subtotal				*$*	*1,861,000*
	TOTAL CONSTRUCTION COST				*$*	*1,861,000*
					$	*-*
	Legal, and Administrative	5%			$	93,000
	Owners Reserve for Change Orders	5%			$	93,000
	TOTAL PROJECT COST				**$**	**2,047,000**

Notes

1. Costs presented in 2022 dollars.
2. Costs presented do not include land acquisition.

Appendix E
FACILITY STAFFING RECOMMENDATION

Appendix E
FACILITY STAFFING RECOMMENDATION

E.1 Overview

San Francisco Public Utilities Commission (SFPUC) faces water supply shortfalls during future droughts. In response, SFPUC continues to look for opportunities to develop alternative water supplies regionally that can provide dry year supply reliability. Simultaneously, the cities of San José and Santa Clara who are interruptible customers of SFPUC, are seeking permanent supplies to support projected future demands. SFPUC must evaluate whether it can provide permanent status and meet the needs of both existing and future permanent customers. As part of continuing services to SFPUC, Carollo is evaluating the implementation of an Advanced Water Treatment Facility (AWTF) that would produce purified water that would be integrated directly into the potable water system, termed treated drinking water augmentation (TWA). The water supply for the AWTF is from the San José-Santa Clara Regional Wastewater Facility (RWF). The purified water would be provided to San José and Santa Clara in all year types, and to the Regional Water System (RWS) for the benefit of all SFPUC customers during dry years when supply shortages are likely to occur.

This document supports the above broader effort by recommending a staffing schedule and plan in accordance with the Proposed Framework of Regulating Direct Potable Reuse in California Addendum. Specifically, adhering to §64669.35 Operator Certification. The State of California Division of Drinking Water (DDW) requires that facilities with the types of process and equipment sophistication and effluent quality requirements as will be in use for TWA be staffed 24 hours per day, 7 days per week unless approval from §64669.35 section (e) is granted. If a lower amount of staffing is granted, based upon the text excerpt from the regulations below, it would significantly reduce the number of Advanced Water Treatment Operator (AWTO) Grade 5 operators required to staff the facility, shifting the majority of certificates required to be an AWTO Grade 3. The staffing recommendation would shift from 10 AWTO Grade 5 operators to 2 and increase the number of Grade 3 operators from 2 to 10. The staffing schedule and plan presented represents staff needs for the AWTF facility only, additional staff needs for off-site conveyance infrastructure (e.g., pipelines, storage tanks, and off-site pump stations) were not considered in this analysis.

> (e) If an operations plan, submitted to the State Board for review and approval pursuant to section 64669.80, demonstrates an equivalent degree of operational oversight and reliability with either unmanned operation or operation under reduced operator oversight, the chief operator or shift operator is not required to be on-site at all times, but shall be able to monitor operations and exert physical control over the treatment facility within the period specified in the operations plan, or one hour, whichever is shorter.

Figure E.1 Text Excerpt From §64669.35 section (e)

E.2 The 12-Hour Shift

For this analysis, we assume a 12-hour shift for operations staff. Many facilities use a 12-hour shift to achieve 24/7 operational staffing requirements. Use of 12-hour shifts has increased to maintain enough staff to appropriately staff facilities in the face of shortages of available candidates to work water treatment operations jobs while addressing the impacts of shift work on their employees.

Any staffing approach has strengths and concerns, with tradeoffs between various approaches. Adequate coverage is essential to maintain operational continuity while proactively addressing unforeseen conditions that could compromise permit compliance, staff safety, and facility and/or staff security. Schedules that offer shorter work periods for plant operations, such as 5 day/8 hour and 4 day/ 10 hour, require a greater number of full-time employees to provide 24-hour coverage. Any schedule must acknowledge complications that develop from use of sick leave, use of vacation time, hours required for personnel training, and call-in expertise.

12-hour shifts offer some efficiencies but require different oversight and managing policies or procedures to accommodate the work hours. Among these are:

- Every day is covered by two crews (day and night shift), with each working crew on a different shift. The other two crews are off. This allows continuous coverage using four crews in total.
- There are two shift handoffs each day. This often improves communication during the days that the same crews are working. Information is received from and passed on to the same person each day. Protocols must be in place to ensure crucial information is communicated through each bridge period, when the working groups swap out.
- Pay and work policies must fit the schedule. Traditional policies are often based on 8-hour shifts.
- Leave usage policies or procedures that may differ from other work schedules are required. If someone on-shift is not available to cover for illness and other unscheduled absences, someone on their day off may be needed to provide coverage.

E.3 Staffing Approach

The recommended staffing for this project is summarized in Table E.1. The total full-time equivalent (FTE) count assumes the four crews in total to provide continuous, 24-hour coverage as noted previously in Section E.2.

Table E.1 Recommended FTEs for Both AWPF Sizes

Position	Number of FTE for 10 mgd Scenario	Number of FTE for 20 mgd Scenario
Water Quality Coordinator(1)	1	1
Water Quality Analyst(1)	1	1
AWTO 5: Including the Operations Manager and Supervisor	10	10
AWTO 3	2	2
AWTO 1-3	2	4
Senior Mechanical Technician(1)	1	1
Mechanical Technician(1)	1	2

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Position	Number of FTE for 10 mgd Scenario	Number of FTE for 20 mgd Scenario
Senior Instrumentation Technician(1)	1	1
Instrumentation Technician(1)	1	1
Total	**20**	**23**

Notes:
Abbreviations: AWTO - Advanced Water Treatment Operator; FTE - full-time equivalent; mgd - million gallons per day.
(1) Positions with one FTE are day-shift only positions and are not needed during the night shift. Night shift operators will cover any nighttime facility needs (such as sampling).

A hybrid schedule that melds 24-hour coverage with 8-hour coverage is recommended. This approach provides 24/7 coverage using 10 operators. Governing considerations are:

- Staff holding active Water Treatment Grade 5 and Advanced Water Treatment Grade 5 licensing must always be on site. This can be one person holding both licenses - or - two or more persons holding the required licensing. If the sitting staff members do not hold one of these licenses, a workaround such as contracted support is necessary. It is anticipated that the Operations Manager and Operations Supervisor will meet these criteria.
- Requirements for the Chief Operator to be available by phone during nights and weekends must be approved by the regulator. For this reason, the current staffing recommendation is staffed allowing a Chief Plant Operator and Grade 5 shift operator to be available for every shift, complying with section (a) and (b) of the draft addendum requirements.
- This schedule has two hours of built in overtime.

Figure E.2 shows a 12-hour schedule that provides appropriate coverage using a 7 days on/7 days off approach. The red and blue font indicate groups of operators working different parts of a two-week period. These operators are charged with operating all the processes within the fence line of the facility. Coverage during the day is supplemented by members of the 8-hour shift or the Operations Supervisor shown in Figure E.3.

		Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
DAY 1	CO1 - AWT 5	12	12	12	12	6 6	12	12	7 days off						
	SO1 - AWT 5	12	12	12	12	6 6	12	12							
	Op1 AWT 3	12	12	12	12	6 6	12	12							
DAY 2	CO2 - AWT 5	7 days off							12	12	12	12	6 6	12	12
	SO2 - AWT 5								12	12	12	12	6 6	12	12
	Op2 - AWT 3								12	12	12	12	6 6	12	12
Night 1	CO1 - AWT 5	12	12	12	12	6 6	12	12	7 days off						
	SO1 - AWT 5	12	12	12	12	6 6	12	12							
Night 2	CO2 - AWT 5	7 days off							12	12	12	12	6 6	12	12
	SO2 - AWT 5								12	12	12	12	6 6	12	12

** CO = Chief Operator; SO = Shift Operator; Op = Operator*

Figure E.2 12 Hour 7 on / 7 off Shift

The hybrid schedule in Figure E.3 below, uses 8-hour shifts to deal with day-to-day facility needs. Responsibilities include:

- Receiving chemical deliveries
- Equipment and material procurement
- Daily inspection rounds
- Support for compliance monitoring/ and reporting
- Operator-performed equipment, building, and grounds maintenance

- Mechanical and Instrumentation maintenance and calibration
- Support to maintenance, engineering, or construction projects
- Support for special studies or optimization efforts
- Overall facility management

This shift offers continuous supervisory oversight for Operators-in-Training. It is likely that this shift will be the last to be staffed as ensuring adequate and appropriate coverage for the 12-hour slots are essential.

Days - 8 Hours		Mon	Tues	Wed	Thurs	Fri
AWTO 5 WW 5	Ops Manager	x	x	x	x	x
AWTO 5 WW 5	Ops Supervisor	x	x	x	x	x
AWTO 1-3	Op1	x	x	x	x	x
AWTO 1-3	Op1	x	x	x	x	x
Lab Cert	Water Quality Coordinator	x	x	x	x	x
Lab Cert	Water Quality Analyst	x	x	x	x	x
CWEA Grade IV	Senior Mechanical Tech	x	x	x	x	x
CWEA Grade IV	Senior Instrumentation Tech	x	x	x	x	x
CWEA Grade I/II	Mechanical Tech	x	x	x	x	x
CWEA Grade I/II	Intrumentation Tech	x	x	x	x	x

**Mechanical and Instrumentation Tech positions can be substituted with additional AWTO positions if chosen to do so. This allows adequate staffing to perform maintenance and calibration activities, as well as provide additional entry level operator positions to support succession.*

**If the facility is constructed for 20 mgd capacity, hire 3 additional FTEs (2) AWTO 1-3 and (1) additional Mechanical Technician.*

Figure E.3 8-Hour Day Shift Staffing Schedule

E.4 Suggested Policies and Procedures

A non-inclusive list of suggested policies or procedures follows. The State of California labor laws must be accommodated when developing any policy or procedure. Also, it is crucial that the same nuances apply to the 12-hour and 8-hour plant operators. Inconsistencies will lead to discontent and low morale.

1. Job description criteria to reflect the licensing requirements.
2. Defined work week, start times, and end times.
3. Defined pay periods.
4. Defined compensation, including overtime, shift premium, on-call pay, vacation and holidays:
    a. The schedule has some built in overtime. This is likely less costly than having the additional staff required for either 8- or 10-hour shifts. A schedule that provides 24/7 coverage other than 12 hour would require additional operators. The loaded compensation rate, including benefits, for additional plant operators is likely much greater than the cost of overtime.
    b. Operators working the night shift would likely receive a premium, such as 5 percent increased pay.
    c. Holiday compensation, such as 1.5 times pay, would apply to every operator for every holiday granted.
5. Defined approach to lunch and rest periods. Typically, workers receive an unpaid 30-minute lunch and two paid 15-minute breaks. For 12-hour shift workers, an unpaid lunch would extend the time

an operator is on site to at least 12.5 hours per day. A 30-minute paid lunch is recommended for the 12-hour shift:

   a. If a paid lunch is settled upon, minimum plant staffing criteria must be acknowledged and addressed. This likely means that only one person can leave the site at a time, meaning that the lunch period would be staggered.
   b. Operators on the 8-hour shift would receive a 30-minute unpaid lunch.

6. Minimum staff on site:
   a. It is recommended that two is the minimum number of operators on site for safety and risk response purposes. Due to unforeseen circumstances, it may be that only one operator is on site.
7. The work required to be completed by plant operators in each shift:
   a. This list should reflect the essential work required to accommodate minimum staffing.
   b. Operator-in-Training expectations and duties may affect the minimum staffing.
8. Staff seniority:
   a. Seniority is paramount to most workers. It is typically the basis for shift bidding, vacation bidding, and premium pay holiday work.
9. Define on-call personnel duties and expectations, including compensation:
   a. Responding to a callout may affect the ability of someone to report back to work at their regular scheduled time due to excessive hours worked per day.
   b. Compensation is typically a nominal value per week of duty.
   c. A minimum number of hours (such as two hours) should be set for any call-in. If the worker is on site less than two hours, they get two hours of pay. If the worker is on site greater than two hours, they get overtime commensurate with the time on station.

E.5 Budget Assumptions

Table E.2 and Table E.3 summarize the cost assumptions used to develop operations and maintenance costs used in the overall report for both the 10 mgd and 20 mgd scenarios, respectively.

Table E.2 Staffing Budget Assumptions for the 10 mgd Scenario

Title	FTE Count	Certification Required / Recommended	Wage	Fully Burdened (Assumed 1.6)
Operations Manager	1	T 5, AWTO 5	$200,000	$320,000
Operations Supervisor	1	T 5, AWTO 5	$175,000	$280,000
Water Quality Coordinator	1	Lab Cert	$130,000	$208,000
Water Quality Analyst	1	Lab Cert	$110,000	$176,000
Senior Mechanical Tech	1	CWEA Grade IV	$130,000	$208,000
Senior Instrumentation Tech	1	CWEA Grade IV	$130,000	$208,000
Mechanical Tech	1	CWEA Grade I/II	$100,000	$160,000
Instrumentation Tech	1	CWEA Grade I/II	$100,000	$160,000
Chief/Shift Operator	8	T 5, AWTO 5	$155,000	$248,000

Title	FTE Count	Certification Required / Recommended	Wage	Fully Burdened (Assumed 1.6)
Operator	2	T 3, AWTO 3	$110,000	$176,000
Operator-In-Training	2	AWTO 1-3	$85,000	$136,000
Total	20	-	**$2,705,000**	**$4,328,000**

Notes:
Abbreviations: AWTO - Advanced Water Treatment Operator; CWEA - California Water Environment Association; FTE - full-time equivalent.
(1) Additional funding may be required depending on policies put in place supporting shift differential, overtime, and holiday pay.

Table E.3 Staffing Budget Assumptions for the 20 mgd Scenario

Title	FTE Count	Certification Required / Recommended	Wage	Fully Burdened (assumed 1.6)
Operations Manager	1	T 5, AWTO 5	$200,000	$320,000
Operations Supervisor	1	T 5, AWTO 5	$175,000	$280,000
Water Quality Coordinator	1	Lab Cert	$130,000	$208,000
Water Quality Analyst	1	Lab Cert	$110,000	$176,000
Senior Mechanical Tech	1	CWEA Grade IV	$130,000	$208,000
Senior Instrumentation Tech	1	CWEA Grade IV	$130,000	$208,000
Mechanical Tech	2	CWEA Grade I/II	$100,000	$160,000
Instrumentation Tech	1	CWEA Grade I/II	$100,000	$160,000
Chief/Shift Operator	8	T 5, AWTO 5	$155,000	$248,000
Operator	2	T 3, AWTO 3	$110,000	$176,000
Operator-In-Training	4	AWTO 1-3	$85,000	$136,000
Total	23	-	**$2,975,000**	**$4,760,000**

Notes:
Abbreviations: AWTO - Advanced Water Treatment Operator; CWEA - California Water Environment Association; FTE - full-time equivalent.
(1) Additional funding may be required depending on policies put in place supporting shift differential, overtime, and holiday pay.

E.6 Summarized Recommendations

1. Staff 10 mgd Facility with 20 FTEs; 20 mgd Facility with 23 FTEs with the additional 3 FTEs hired for the 8-hour day shift (2 AWTO 1-3 and 1 Mechanical Tech).
2. Adopt a schedule that includes a blend of 7 days per week 12-hour shifts supplemented with 5 day 8-hour shifts. Note: The preferred schedule may need to be approved by the Department of Industrial Relations (DIR):
   a. Place 10 operators into 12-hour shifts. This staff would be the primary group to operate all processes. This schedule has 2 hours of built-in overtime per operator working every week.
   b. Support day-to-day operations with the operations support team on the 8-hour shift.
3. Develop policies and procedures in advance to explain the opportunities and constraints to any new employee.
4. Investigate and understand State and Federal labor laws that apply to the policies.
5. Monitor the staffing expenses over time. Evaluate the inputs and adjust the approach and policies as needed.

Note: Carollo Engineers, Inc. are not labor or human resources specialists. This document was provided as guidance.