RECYCLED WATER MASTER PLAN UPDATE

EAST BAY MUNICIPAL UTILITY DISTRICT

FINAL INTERIM REPORT

WOODARD & CURRAN

With support from

Brown AND Caldwell

M.CUBED POLICY ANALYSIS FOR THE PUBLIC AND PRIVATE SECTORS

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COMMITMENT & INTEGRITY DRIVE RESULTS

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EBMUD
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ACRONYMS

μS/cm	Micro Siemens per centimeter
AACE	Association for the Advancement of Cost Engineering
ADWF	Average dry weather flow
AF	Acre-feet
AF/MO	Acre-feet per month
AFY	Acre-feet per year
AOP	Advanced oxidation process
AWT	Advanced water treatment
BAC	Biologically activate carbon
BACWA	Bay Area Clean Water Agencies
BAF	Biologically active filtration
BOD	Biochemical oxygen demand
Canal	Contra Costa Canal
CCCSD	Central Contra Costa Sanitary District
CCI	Construction cost index
CCR	California Code of Regulations
CDPH	California Department of Public Health
CECs	Constituents of emerging concern
cfs	cubic feet per second
CIP	Capital improvement program
CNWS	Concord Naval Weapons Station
COC	Cycles of concentration
CSD	Community Services District
CT	Concentration of chlorine x time of contact
DCC	Diablo Country Club
DDW	Division of Drinking Water
DERWA	DSRSD-EBMUD Recycled Water Authority
DERWA/San Ramon	San Ramon Valley Recycled Water Program
District	East Bay Municipal Utility District
DSRSD	Dublin San Ramon Services District
EBDA	East Bay Dischargers Authority
EBMUD	East Bay Municipal Utility District
EBRWF	East Bayshore Recycled Water Facility

EC	Electrical conductivity
EIR	Environmental Impact Report
ENR	Engineering News Record
ESB	Engineered storage buffer
ESP	Engineering Standard Practice
FAT	Full advanced treatment
fps	Feet per second
gpm	gallons per minute
H_2O_2	Hydrogen peroxide
hp	Horsepower
HVAC	Heating, ventilation, and air conditioning
LAVWMA	Livermore-Amador Valley Water Management Agency
LRVs	Log reduction values
MBR	Membrane bioreactor
MCC	Moraga Country Club
MCLs	Maximum contaminant levels
MF	Microfiltration
MG	Million gallons
mg/L	Milligrams per liter
MGD	Million gallons per day
MOU	Memorandum of Understanding
NaOCl	Sodium hypochlorite
NDMA	N-nitrosodimethylamine
NPDES	National Pollutant Discharge Elimination System
NRWRP	North Richmond Water Recycling Plant
O_3	Ozonation
O&M	Operation and maintenance
O&P	Overhead and profit
OLSD	Oro Loma Sanitary District
RARE	Richmond Advanced Recycled Expansion
RCC	Richmond Country Club, Rossmoor Country Club
RO	Reverse osmosis
RRT	Response retention time
RWMP	Recycled Water Master Plan

SAR	Sodium adsorption ratio
SB	Senate Bill
SCC	Sequoyah Country Club
SD-1	EBMUD Main Wastewater Treatment Plant (Special District No. 1)
SLWRF	San Leandro Water Recycling Facility
SRT	Solids residence time
SRWTP	Satellite recycled water treatment plants
SWRCB	State Water Resources Control Board
SWA	Surface water source augmentation
SWTR	Surface Water Treatment Rule
TDS	Total dissolved solids
Title 22	California Recycled Water Regulations – Title 22, California Code of Regulations
TKN	Total Kjeldahl nitrogen
TOC	Total organic carbon
TSS	Total suspended solids
UCB	University of California Berkeley
URT	Underground retention time
UF	Ultrafiltration
USLWTP	Upper San Leandro Water Treatment Plant
UV	Ultraviolet light
VFDs	Variable frequency drives
West County	West County Water District
WCWD	West County Water District
WPCF	Water Pollution Control Facility
WPCP	Water Pollution Control Plant
WSMP	Water Supply Management Program
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

CONVERSION FACTORS

1 million gallons per day (MGD) = 1,120 acre-feet per year (AFY)

1 million gallons (MG) = 3.069 acre-feet (AF)

1. INTRODUCTION

The East Bay Municipal Utility District (District or EBMUD) is a publicly owned multipurpose agency that provides drinking water for 1.4 million customers in Alameda and Contra Costa counties. Approximately 90% of the District's source water comes from the Mokelumne River and is delivered to the District's service area by the Mokelumne Aqueducts. The balance of the District's supply comes from East Bay watersheds and the Freeport Regional Water Project, which delivers water from the Sacramento River during certain drought events. During the period 2009 through 2018, the District produced, on average, about 175 MGD of potable water.

The District's first comprehensive "Water Reclamation Master Plan" was developed in 1991. Its goals were to identify potential water reuse opportunities, develop and rank feasible projects, and provide recommendations for implementing high priority projects. The 1991 plan included irrigation projects as well as cooling tower and industrial use. In 1993 the District implemented the Water Supply Management Program (WSMP) and established a recycled water goal of 14 MGD by 2020. In 2012 the District's WSMP 2040 Plan updated the recycled water goal to a total of 20 MGD by 2040 and an updated "Recycled Water Master Plan" was developed. This new plan identified potential projects that could be implemented to meet the 20 MGD by 2040 recycled water goal.

The District currently has approximately 9 MGD of recycled water capability in place. Water use includes irrigation, office building toilet flushing, cooling towers, and industrial boilers.

1.1 Master Plan Update Goals

The goal of the Recycled Water Master Plan (RWMP) Update is to develop a comprehensive update to the District's 2010 Recycled Water Master Plan. The District's current recycled water goal of 20 million gallons per day (MGD) by 2040 is dependent entirely on non-potable reuse. Given numerous factors, including statewide population growth, climate change, ecosystem challenges, legislative and regulatory pressures, the District envisions that an additional expansion of water recycling efforts may be necessary in the future to ensure continued reliability of the water supply, which may include potable reuse as it becomes more prudent and feasible.

The first phase of the RWMP Update involved identifying and assessing opportunities for both non-potable reuse and potable reuse. It included development of a revised non-potable recycled water project list, prioritized based on feasibility and affordability, and revised non-potable reuse goals. The potable reuse assessment considers impacts on operations of existing conveyance, treatment, storage, and distribution systems. Potential sources of recycled water include the District's Main Wastewater Treatment Plant (Special District No. 1, or SD-1, which treats wastewater collected from a sub-area of the District's much larger potable water service area), as well as other nearby wastewater agencies. The assessment includes an economic evaluation to determine under what conditions potable reuse alternatives may become economically feasible for the District.

The purpose of this report is to define the District's portfolio of non-potable and potable water reuse options, perform a qualitative evaluation of each option, and define a shortlist of options for recycled water implementation. This report is organized as follows:

- Introduction
- Cost estimating approach
- Non-potable reuse alternatives
- Potable reuse alternatives
- Evaluation of alternatives
- Recommended Master Plan Projects

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2. COST EVALUATION APPROACH

This section details the basis of the cost estimates for the potable and non-potable alternatives.

2.1 Scope and Estimate Classification

The Association for the Advancement of Cost Engineering International (AACE International) has developed a cost estimate classification system that provides guidelines for applying the general principles of estimate classification to project cost estimates. The five estimate classes are presented in AACE International Recommended Practice No. 18R-97 (Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries). The guideline establishes a relationship between the project maturity (i.e., project definition as percent of complete definition) and the accuracy and methodology used to produce the cost estimate.

Table 2-1 provides a summary of the estimate classes and expected accuracy range. For Class 5 estimates, the expected accuracy range is -20% to -50% on the low end and +30% to +100% on the high end. The estimates developed for the RWMP Update will be Class 5 cost estimates.

Table 2-1: Cost Estimate Classification Matrix (AACE International)

Estimate Class	Level of Project Definition	Purpose of Estimate	Methodology	Expected Accuracy Range
Class 5	**0% to 2%**	**Concept screening**	**Capacity factored, parametric models, judgement, or analogy**	**Low: -20% to -50% High: +30% to +100%**
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	Low: -15% to -30% High: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	Low: -10% to -20% High: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	Low: -5% to -15% High: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-cost	Low: -3% to -10% High: +3% to +15%

Source: AACE International Recommended Practice No. 18R-97

The expected accuracy range of the Class 5 cost estimates is similar to the "Preliminary" or "Conceptual" category as defined in the District's Engineering Standard Practice (ESP) 020.3, which has an expected accuracy range of -30% to +50% (EBMUD, 2008b).

2.2 Cost Estimating Approach

The RWMP Update includes the assessment of both potable reuse and non-potable reuse project alternatives. Most of the non-potable project descriptions are based on work previously developed by the District and other public water and wastewater agencies. Cost estimates for these projects have been reviewed for any major errors or omissions to the facilities or the unit costs. Once any necessary corrections were made, the raw construction costs were extracted and escalated to December 2017 dollars. The soft costs and allowances defined in this section were then applied to the raw construction costs, resulting in a capital cost estimate for use in the RWMP Update. Variations from this approach are highlighted for each project as needed in Section 3.2.3

For potable reuse project alternatives, cost estimates were based on preliminary facilities plans developed for Oro Loma Sanitary District and Central Contra Costa Sanitary District as well as new potable reuse alternatives developed under this RWMP Update. Construction costs were estimated using unit cost information provided by the District, which were developed from past construction projects and industry costs estimate resources (primarily RS Means Heavy Construction Cost Data). Operation and maintenance (O&M) costs are based on recent estimates at the District's facilities, estimated lab hours, equipment power needs, and chemical and other consumable demands.

2.2.1 Raw Construction Cost

Raw construction costs were estimated for each project component based on estimated unit costs multiplied by quantity take-offs. Unit costs were developed primarily using historical cost data from previous District projects, supplemented with the experience from projects of similar size or configuration. In some cases (i.e., for pumps, storage tanks and pipelines) these unit costs are based on construction bid data, which already include markups for contractor overhead and profit.

Based on the level of detail available for Class 5 estimates, allowances were used for some elements such as site work, as detailed further herein.

Engineering economic factors were utilized to develop and escalate unit costs when required to reflect the current construction cost, industry trends, and project location. These factors are incorporated into the unit costs and are represented in two categories:

- **Engineering News Record's (ENR) Construction Cost Index (CCI)** – The ENR CCI is an index for construction cost inflation that is used to convert historic cost information to current value. The rate of construction cost inflation varies by geographical region and ENR publishes CCI values for major metropolitan cities. The ENR CCI for the 20-city average (10,870 in December 2017) was used for the RWMP Update.
- **RS Means Location Factor** – The unit costs presented in RS Means represent the national average across the United States and Canada. A location factor, also referred to as City Cost Indexes in RS Means, is applied to account for variations in regional costs such as labor, equipment rental, raw materials, and freight. The Oakland, California location factor listed in RS Means is used for this Project, which has a corresponding location factor of 123.1 (RS Means 2017). This location factor represents a weighted average of both materials and labor cost across all divisions of construction. The location factor may be used to adjust cost estimates from other geographic areas (for example, to adjust capital cost estimates for potable reuse treatment trains in Southern California).

Unit costs were factored by the relative difference in CCI to escalate costs to the time of the estimate and the location factor to translate the cost given to an equivalent cost for the District's service area.

2.2.2 Allowances and Contingency

2.2.2.1 Construction Cost Allowances

Several allowances are applied to the raw construction cost subtotal to develop an estimated construction cost. The construction cost allowances used are listed below.

- **Tax on Materials and Equipment Rental = 9%, applied to 50% of raw construction cost** – A Class 5 estimate uses installed unit cost metrics that include both raw materials and installation (i.e., labor and equipment) costs. As of December 2017, the sales tax rate was 8.25% in Contra Costa County and 9.25% in Alameda County. The regionally-averaged tax on materials was estimated as 9.0% (local tax) and applied to 50% of the raw construction cost.

- **Overhead and Profit = 15%** – Overhead and profit (O&P) represents the general contractor's operating costs and estimated profit levels. The O&P factor typically varies between 10% and 25%, depending on the size of the project and market conditions, with larger projects typically having lower O&P factors. An O&P factor of 15% was applied to the raw construction cost.
- **Owner's Reserve for Change Orders = 0%** – Change orders may be a result of the Owner's direction to implement additional work, differing field conditions that requires additional work, or an error in the project contract documents. District standard practice does not include a change order allowance for this level of cost estimate, so these were not included as a line item in RWMP Update cost estimates.

For components costs that were developed based on the historical cost data (bid amount of past projects), construction cost allowances and the estimating contingency were assumed to be included in the bid price and were not applied.

2.2.2.2 Estimating Contingency and Mobilization

In addition to the Construction Cost Allowances, a final estimating contingency was applied to generate the estimated total construction costs. The estimating contingency is defined as unknown costs due to lack of detailed engineering during the preliminary planning phase that are estimated as a percentage of defined project costs (i.e., the construction cost including construction cost implementation cost allowances). As the level of project definition and understanding increases and the level of unknown decreases, the estimating contingency typically decreases. For the RWMP Update, an estimating contingency of 25% was applied to the cost estimates after construction cost and implementation cost allowances were included. The contingency percentage is slightly higher than the maximum contingency of 20% designated for preliminary cost estimates (per ESP 020.3) and matches the cost estimating approach used for the Richmond Advanced Recycled Expansion project (RARE).

Mobilization involves the process of establishing resources at a project site that are to be used over the course of the project such as temporary office trailers, temporary utilities, and other equipment rental. For this project, mobilization was estimated as a fraction of the sum of construction cost with contingency based on the project size as summarized in **Table 2-2**.

Table 2-2: Mobilization Allowances

Project Size (Construction Cost with Contingency)	Mobilization Allowance
< $5M	10%
$5M - $10M	8%
> $10M	5%

For components costs that were developed based on the historical cost data (construction bids from past projects), construction cost allowances and the estimating contingency were assumed to be included in the bid price and were not applied.

2.2.2.3 Implementation Cost Allowances

To generate the estimated capital costs, implementation cost allowances such as environmental review, design, construction management, and other administrative costs associated with the project were included. Implementation costs are typically estimated as a percentage of total construction cost, after including all allowances described in Section 2.2.2.1. The implementation cost allowances used are summarized below and total 30%.

- **Environmental Documentation and Permits = 5%** – Environmental documentation and permits involve producing environmental studies and acquiring any permits necessary to construct a project. A factor of 5% was applied to the total construction cost for environmental documentation and permits.
- **Design Cost = 15%** – Engineering design services include field investigations (e.g., surveys, geotechnical reports, hazard materials investigations), preliminary and final design, contract document development (i.e., plans and specifications), preparation of detailed cost estimates, and project scheduling. An engineering services factor of 15% was applied to the total construction cost.
- **Project Administration and Construction Management = 10%** – Costs for project administration includes planning, funding, design, and construction. Costs for construction management, including inspection, can vary greatly with project size and complexity and whether the Owner performs this work with in-house staff or through a consultant. A construction management factor of 10% was applied to the total construction cost.

2.2.3 Capital Cost Summary

A summary of the Allowances is shown in **Table 2-3**. The table also includes a set of example calculations based on a raw construction subtotal of $1,000,000. All subtotals are rounded up to two significant figures.

Table 2-3: Example of Cost Contingency and Implementation Factors

Category	Factor	Example Cost
Raw Construction Cost Subtotal		**$1,000,000**
Tax on Materials and Rental Equipment (Applied to 50% of raw construction cost)	9%	$45,000
Overhead and Profit	15%	$150,000
Estimated Construction Cost (Including Construction Cost Allowances)		**$1,200,000**
Estimating Contingency	25%	$300,000
Estimated Construction Cost (Including Contingency)		**$1,500,000**
Mobilization	10%	$150,000
Estimated Project Cost (Including Contingency and Mobilization)		**$1,700,000**
Environmental Documentation and Permits	5%	$85,000
Design Cost	15%	$255,000
Administration and Construction Management Cost	10%	$170,000
Estimated Capital Cost (Including Allowances and Contingency)		**$2,200,000**

Note: All line items in Class 5 planning-level estimates will be rounded to two significant figures.

2.2.4 Operations and Maintenance

Annual O&M requirements were derived from experience on similar projects and standard engineering methods. There is the potential for future increases in O&M unit costs, such as energy and labor costs, that are not accounted for in the O&M cost estimates but will be accounted for in the life-cycle cost development. The three components used to develop annual O&M costs were:

- **Labor** – Labor costs associated with the system O&M is calculated on an hourly basis. Where applicable, it was assumed that the maximum number of working hours per year is 2,080 hours. The average hourly cost of O&M personnel, which includes all wages and benefits to the operator, is estimated at $135.

- **Electricity** – The unit cost of electricity used was $0.15/kWh and was based on the average electricity billing rate of new Pacific Gas and Electric customers. All power-intensive equipment in the Project (such as pumps, blowers, and ultraviolet [UV] disinfection lamps) were included in the electricity estimate. Equipment and systems that consume significantly less energy (such as lighting, chemical dosing systems, and valve actuators) are assumed to be negligible and were not included.
- **Consumables** – Consumables are a major component of operation expenditures and include resources that are intended and expected to be used up relatively quickly. Example of consumables include chemicals, gaskets, and potable water. Appropriate consumable costs are discussed for each facility type in Section 2.3.

2.2.5 Life Cycle Costs

Cost estimates were converted to an annualized total cost following District guidance documents ESP 020.1 *Life Cycle Cost Analysis* (EBMUD, 2010b) and ESP 462.1 *Useful Life of Water Facilities* (EBMUD, 2011b) and using the following assumptions:

- Base year: December 2017
- Discount rate: 3% (net of inflation)
- Project service period: 30 years
- Useful life of advanced treatment plants: 30 years
- Useful life of other facilities will vary based on component type based on ESP 462.1 (e.g., 35 years for water treatment plant equipment; 75 years for polyvinyl chloride [PVC] pipelines). Useful life assumptions for equipment not listed on ESP 462.1 will be noted. For facilities with a useful life longer than 30 years, a salvage value with straight-line depreciation will be applied in year 30 where appropriate.

Annualized total costs were divided by projected annual recycled water deliveries to estimate the unit cost per acre-foot of water delivered ($/AF). Financing costs for loan or bond repayment are not included in the annualized total costs, but financing options are discussed as part of the master plan implementation.

2.3 Construction Component Cost

2.3.1 Site Work

Site work includes all work related to the civil construction of the Project such as excavation, off haul and disposal, grading, paving, shoring dewatering and backfill. Assumptions regarding site work are described within each project type (pipeline, pump station, etc.) in the following sections.

2.3.2 Pipelines

Pipeline capital costs were based on construction cost data provided by the District. Pipeline capital costs were determined based on pipe diameter and the development density of the project location. To determine the development density, a spatial analysis was conducted in ArcGIS using available land use data and the pipe alignments. Parcels in the District's service area were reassigned to one of three land use categories – High Density Urban, Low Density Urban, and Non-Urban – based on their 2015 Assessors Land use code. Assessor land use codes were consolidated into these three categories as summarized in **Table 2-4**.

Table 2-4: Land Use Designations

Assessor Land Use Category (EBMUD WSMP 2040)	Land Use Description (Contra Costa County)	Recategorized Land use
EV, EOS	Agricultural, Open Space, Parks and Recreation, Public and Semi-Public, and Watershed	Non-Urban
EHW, EMUR3, EP, EPI, ER, ER1, ER2, ER3, ER4, ERAW, ERW, ES	Commercial, Residential Mixed Use, Business Park, Commercial, Commercial Recreation, Delta Recreation, Downtown/Waterfront, Mobile Homes, non-high density Multiple-Family Residential, Office, Single Family Residential, and all other specific area designations	Low-Density Urban
ER5, ER6, EO, EC, EIL, EOH	Industry, Multiple-Family Residential – Very High Density and Very High Special, and Pleasant Hill BART – Mixed Use	High Density Urban

For the purposes of this master plan, it was assumed that open cut pipeline installation could be used for pipe aligned within urban areas and easily accessible non-urban (non-hilly) areas. Pipeline cost estimates for open cut construction were based on the costs presented in **Table 2-5**.

Table 2-5: Costs for Open Cut Pipeline Construction

Project Location	Unit	Unit Cost
Non-Urban	$ / inch-diameter / linear foot	$30
Urban – Low Density	$ / inch-diameter / linear foot	$40
Urban – High Density	$ / inch-diameter / linear foot	$50

For trenchless installation, the cost estimates were based on the costs presented in **Table 2-6**. For the purposes of this RWMP, it was assumed that trenchless crossings would be microtunneled for all pipelines with a diameter over 24-inches and horizontal directional drilling (HDD) would be used for trenchless crossings for pipelines 24-inches and smaller. Determination about pipeline construction approach (i.e., when to use trenchless construction or tunneling) is discussed in Section 4.6.3. Additionally, District staff identified that the existing San Pablo Tunnel could be rehabilitated and used for recycled water transmission.

Table 2-6: Costs for Trenchless Pipeline Construction

Element	Unit	Unit Cost
San Pablo Tunnel Rehabilitation and new pipe, or new tunnel[1]	Linear foot	$3,500
Microtunnel Launch and Receiving Pit	lump sum	$620,000
Microtunnel Casing and Pipe (> 24-inch diameter)	Linear foot	$2,800
Horizontal Directional Drilling (HDD) (≤ 24-inch diameter)	Linear foot	$2,200

Note:

1. EBMUD, 2018, "San Pablo Tunnel - Full Seismic Retrofit", Cost estimate by District staff based on March 9, 2006 Northern Pipeline cost estimates. An additional 25% contingency was added to the District estimate.

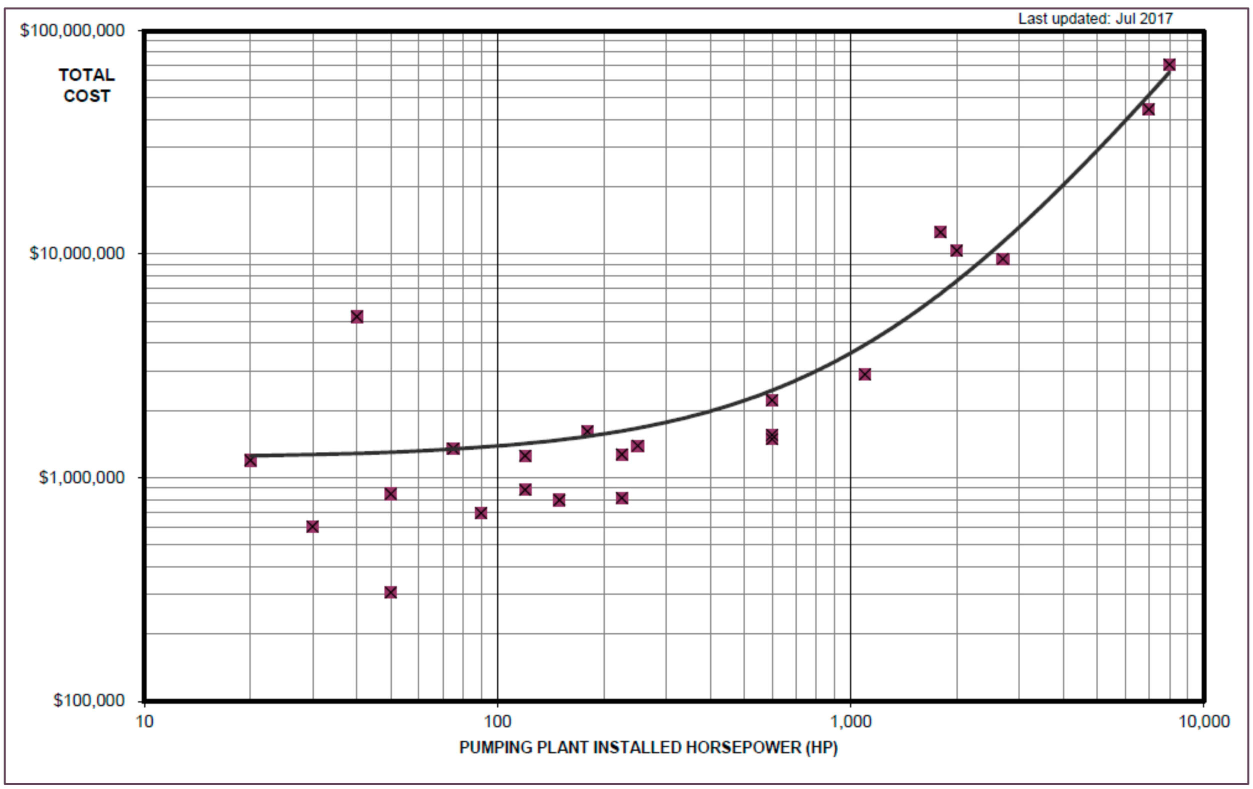
2.3.2.1 Annual Pipeline O&M

Pipelines require a minimal amount of operational labor resources, as most of the operations occur at the pump station or at the discharge point (i.e., reservoir or storage tank). Therefore, it is assumed that there are no operational labor requirements for pipelines. Pipelines would require regularly scheduled maintenance that may include the exercising of valves, appurtenance inspections (including customer turnouts), and flushing procedures at dead ends. It is estimated that it would require two percent of the construction cost for annual maintenance. No consumables or electrical needs are identified specific to pipelines.

2.3.3 Pump Stations

Pump stations include a variety of elements depending on the type of pumps, pump station arrangement, surge control systems, and project characteristics (i.e., wet wells or canned pumps, available layout, pump station turndown, electrical equipment location, etc.). For this RWMP Update, pump station capital costs were based on the construction cost curve provided by the District (**Figure 2-1**). The cost estimates shown below will be marked up using the implementation cost allowances listed in Section 2.2.2.3.

Figure 2-1: Pump Station Construction Costs (with Bid Markups)



Note: Pumping plan horsepower includes spare (standby) installed pumps

2.3.3.1 Annual Pump Station O&M

Pump station operations and maintenance includes labor, electricity, and consumables.

- **Labor** – The annual labor requirements of a pump station mainly depend on the amount of equipment at the pump station, as well as the level of automation that is implemented at the pump station. Other minor factors, such as pump station location, contingency measures, and age of pump station, would also affect the labor demands. Operators are expected to regularly tend to the pump stations to operate valves, start and stop pumps, and examine flow data. Routine maintenance may include the inspection of equipment, exercising of valves, and servicing instrumentation. Estimates for operation and maintenance labor requirements are tabulated below in **Table 2-7**.

Table 2-7: Annual Labor Requirements for Various Pump Station Sizes

Pump Station Capacity (gpm)	Annual Operator Hours	Annual Maintenance Hours	Total Annual O&M Hours
0 to 2,500	400	100	500
2,500 and up	800	200	1,000

- **Electricity** – Pump station electricity consumption is estimated by multiplying the pump design point (in delivered head, feet), average flow (cubic feet per second [cfs]) and the annual hours in operation and dividing by the pump efficiency. The calculation also includes conversion factors to produce a result in kilowatt hour (kWh). An example calculation is shown below:
    - Example Pump Station
    - Flow: 1 MGD (1.55 cfs)
    - Operating Hours: 12 months, constant (8760 hours)
    - Head delivered: 100 ft
    - Pump Efficiency: 80%

$$\frac{1.55\,[cfs] * 100\,[ft] * 62.4\left[\frac{lb}{ft^3}\right] * 0.7457\left[\frac{kWh}{hp}\right] * 8760[hr]}{550\left[\frac{ft * lb}{hp * sec}\right] * 0.8\,[-]} = 143{,}600\,[kWh]$$

- **Consumables** – Pump station consumables are to be estimated as 5% of the estimated construction cost.

2.3.4 Storage Tanks

Storage tanks require significant site work and piping. For this project, the District has provided two construction cost curves for tanks (welded steel and pre-stressed concrete). The welded steel storage tank curve (**Figure 2-2**) includes costs of site work and piping. The pre-stressed concrete tank curve (**Figure 2-3**) does not include site work, piping, contractor overhead, sales tax or estimating contingency. Instead, allowances for those items are defined in **Table 2-8** In addition to the previously described allowances for the contractor overhead, sales tax and estimating contingency. The cost of the storage tank will be based on the lowest generated cost from the two curves for the desired tank size (concrete tanks for a volume of 2 MG or less and steel for 2 MG or more). Tank material will not be indicated at this time as that decision will depend on a more detailed site assessment. The cost estimates will be marked up using the implementation cost allowances listed in Section 2.2.2.3.

Table 2-8: Pre-Stressed Concrete Tank Cost Allowances

Element	Allowance
Site Work	3% of Curve Cost
Site Piping/Fittings	$150,000

2.3.4.1 Annual Storage Tank O&M

The annual O&M requirements of a storage tank are estimated at 1% of capital costs. No consumables or electrical needs are identified specific to storage tanks.

Figure 2-2: Welded Steel Storage Tank Construction Costs (with Bid Markups)

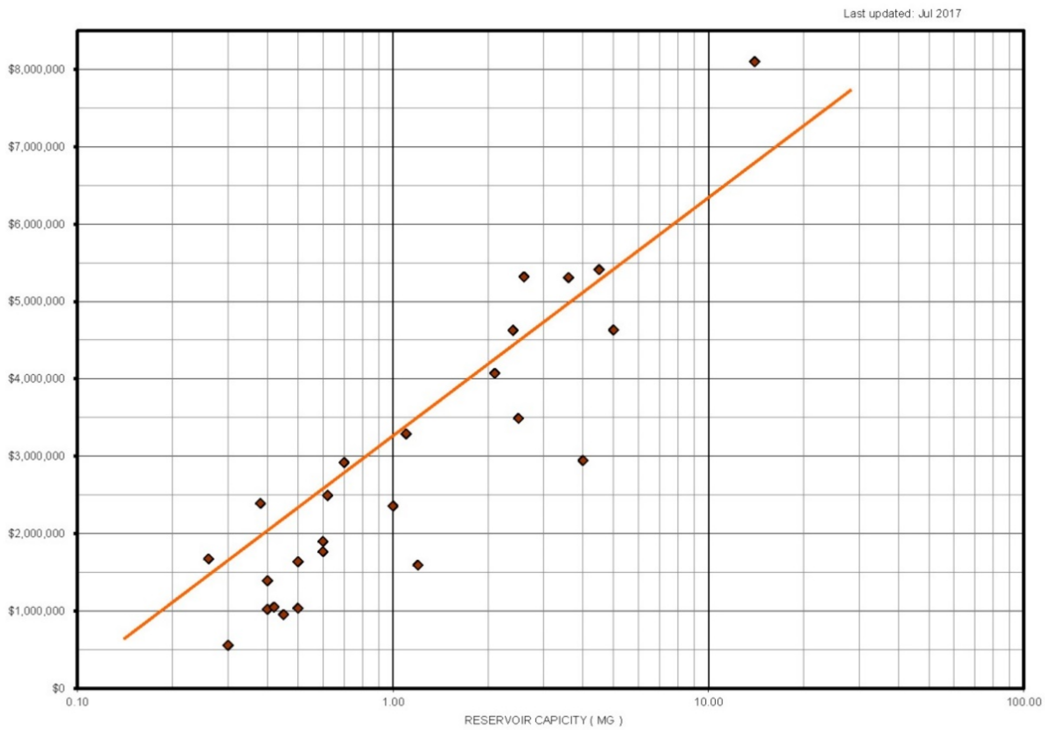
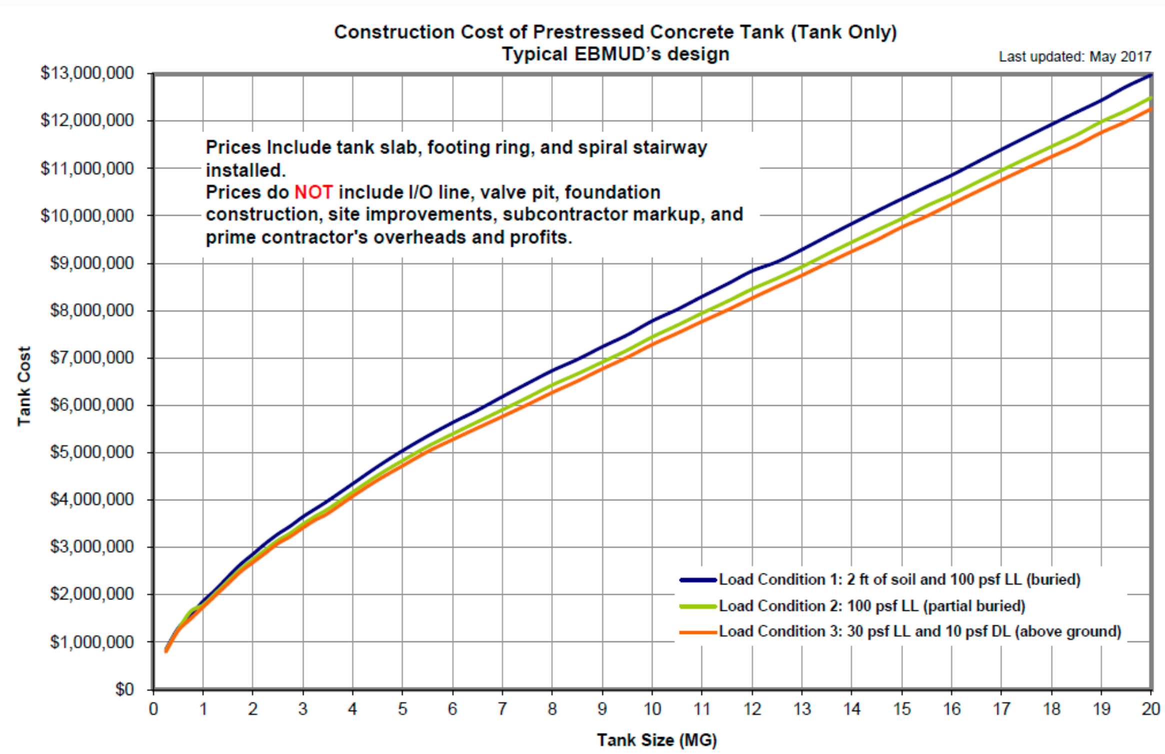


Figure 2-3: Pre-stressed Concrete Storage Tank Construction Costs



2.3.5 Groundwater Wells

Cost estimates for groundwater wells were adapted from the Oro Loma Sanitary District *Recycled Water Feasibility Study* (2016). Preliminary unit costs (escalated from the 2016 study) are presented in **Table 2-9**.

Table 2-9: Costs for Groundwater Wells

Element	Description	Unit Cost
Groundwater Injection Well	Assumes 1 MGD capacity, approx. 400-500 ft deep	$1,679,000
Groundwater Extraction Well	Assumes 2 MGD capacity, approx. 400-500 ft deep and includes wellhead treatment for Manganese	$4,068,000

2.3.5.1 Annual Groundwater Well O&M

Groundwater well operations and maintenance includes labor, electricity, and consumables.

- **Labor** – The annual labor requirements of a groundwater well mainly depend on the type of well: injection or extraction. Other minor factors, such as the well location, contingency measures, and the age of the well, would also affect the labor demands. Operators are expected to regularly tend to the groundwater wells to operate valves, start and stop pumps, and examine flow data. Routine maintenance may include the inspection of equipment, exercising of valves, and servicing instrumentation as well as backwashing for extraction wells. Estimates for operation and maintenance labor requirements are tabulated below in **Table 2-10**.

Table 2-10: Annual Labor Requirements for Groundwater Wells

Well Type	Annual Operator Hours (Backwash)	Annual Maintenance Hours	Total Annual O&M Hours
Injection	0	104	104
Extraction	52	104	156

- **Electricity** – Groundwater well electricity consumption is estimated only for extraction wells, as it is assumed that the injection wells are fed by head provided at the water source pump station. Electricity consumption for extraction wells is estimated by multiplying the pumping design point (in delivered head, feet), average flow (cubic feet per second [cfs]) and the annual hours in operation and dividing by the well efficiency. The calculation also includes conversion factors to produce a result in kilowatt hour (kWh). For this project, it has been assumed that the electricity consumption of the wellhead treatment is small in comparison to the extraction usage and has been accounted for in a conservative estimate of the depth of extraction. An example calculation is shown below:
  - Example Groundwater Extraction Well
  - Flow: 1 MGD (1.55 cfs)
  - Operating Hours: 12 months, constant (8760 hours)
  - Depth of extraction: 100 ft
  - Pump Efficiency: 80%

$$\frac{1.55\,[cfs] * 100\,[ft] * 62.4\left[\frac{lb}{ft^3}\right] * 0.7457\left[\frac{kWh}{hp}\right] * 8760[hr]}{550\left[\frac{ft * lb}{hp * sec}\right] * 0.8\,[-]} = 143{,}600\,[kWh]$$

- **Consumables** – Groundwater well consumables are to be estimated as 0.5% of the estimated construction cost.

2.3.6 Advanced Treatment

The RWMP Update includes an assessment of potable reuse alternatives, each of which will require advanced treatment of municipal wastewater. Unit costs presented in this section for standard treatment processes are based on those developed by the consultant team for other advanced treatment projects, including the Santa Clara Valley Water District, Sacramento Regional County Sanitation District, and others. Preliminary unit costs, presented in **Table 2-11**, are based on a surface water augmentation treatment train, which is one of the alternatives under development for the RWMP Update. Costs for membrane bioreactors (MBRs) were developed differently because MBR technology is not specific to advanced treatment, and there are many facilities already constructed and operating. MBR costs were developed in bins based on facility size due to significant impact of economies of scale on the cost.

Table 2-11: Preliminary Advanced Treatment Processes Unit Costs

Treatment Process	Capital ($M/MGD)
MBR (0.5 - 1 MGD)	16.0
MBR (1 - 5 MGD)	15.0
MBR (5 - 10 MGD)	11.0
MBR (>10 MGD)	10.0
Ozone	0.34
Biologically Activated Carbon (BAC)	0.30
Microfiltration (MF)	1.2
Reverse Osmosis (RO)	1.5
Advanced Oxidation and Disinfection	0.44
Free Chlorine Disinfection	0.25
Chemicals (storage and use)	0.13
Sitework/Piping/Structures	3.2

2.3.6.1 Annual Advanced Treatment O&M

In addition to O&M costs for all the treatment processes (including electricity and consumables), it was assumed that labor requirements for O&M at the facility will be approximately one full-time employee per MGD (or 2,080 hours/MGD). Lastly, for those alternatives which utilize existing water treatment plants, the additional O&M costs for those plants was included based on the District's fiscal year 2016 Annual Energy Report. The O&M costs are presented in below in **Table 2-12**.

Table 2-12: Preliminary Advanced Treatment Annual O&M Costs

Treatment Process	Annual O&M
AWT Facility	
MBR (0.5 - 1 MGD)	0.56 $M/MGD
MBR (1 - 5 MGD)	0.54 $M/MGD
MBR (5 - 10 MGD)	0.46 $M/MGD
MBR (>10 MGD)	0.44 $M/MGD
Ozone	0.09 $M/MGD
Biologically Activated Carbon (BAC)	0.13 $M/MGD
Microfiltration (MF)	0.34 $M/MGD
Reverse Osmosis (RO)	0.57 $M/MGD
Advanced Oxidation and Disinfection	0.07 $M/MGD
Free Chlorine Disinfection	0.03 $M/MGD
Chemicals (storage and use)	0.12 $M/MGD
Labor (assumes 1040 hours/MGD)	0.14 $M/MGD
Major Equipment Maintenance and Repair	2% of applicable capital cost
Surface Water Treatment Plant O&M	
Walnut Creek WTP	0.03 $M/MGD
Orinda WTP	0.03 $M/MGD
Upper San Leandro WTP	0.09 $M/MGD
Sobrante WTP	0.11 $M/MGD

2.3.7 Non-Potable Treatment

Costs for non-potable treatment trains are based on previous study information, where available (adjusted to December 2017 dollars). The unit costs for MBR treatment presented in **Table 2-11** were applied for projects without previously estimated secondary treatment costs.

2.3.7.1 Annual Non-Potable Treatment O&M

O&M costs for non-potable treatment was based on previous study information, where available (adjusted to December 2017 dollars). Unit costs for O&M for MBR treatment were based on those listed in **Table 2-12**. Additionally, it was assumed that labor requirements for O&M at non-potable treatment facilities would be approximately one half of one full-time employee per MGD (or 1,040 hours/MGD).

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3. NON-POTABLE REUSE OPPORTUNITIES

The District has been recycling water for non-potable uses within its water service area since 1971. The District would like to continue to plan, develop and implement recycled water projects throughout the water service area to offset potable water demands. This section evaluates the District's existing non-potable reuse projects, identifies new non-potable reuse projects, and provides an initialize screening and prioritization of projects to evaluate.

3.1 Existing Non-Potable Reuse Demands

The District's current recycled water goal is based on implementing a variety of non-potable reuse projects through 2040. The District has built infrastructure with the capability to provide over 9 MGD of recycled water for irrigation, commercial and industrial uses as summarized below. Full descriptions of each project are provided in Section 3.3.

- **<u>San Ramon Valley Recycled Water Program (DERWA/San Ramon)</u>** – DSRSD and the District created the San Ramon Valley Recycled Water Program in 1995 through a joint powers authority referred to as the DSRSD-EBMUD Recycled Water Authority (DERWA). Phase 1 of the DERWA/San Ramon project currently provides between 0.5 MGD and 0.7 MGD of recycled water for irrigation. The recent completion of Phase 2B brings the total capacity to 0.8 MGD, and Phase 2A (currently in progress) will bring the total capacity to 1.3 MGD.
- **<u>East Bayshore Recycled Water Facility (EBRWF)</u>** – The EBRWF began delivery of recycled water in 2008 and currently supplies recycled water primarily for landscape irrigation in Oakland and Emeryville, with annual average demands in 2017 at 0.14 MGD. The current project capacity is 0.2 MGD.
- **<u>San Leandro Water Reclamation Facility (SLWRF)</u>** – The SLWRF was constructed in 1998 and provides secondary-treated and disinfected recycled water produced for irrigation purposes. The SLWRF has the capacity to supply up to 0.4 MGD of recycled water to customers (0.2 MGD annual average capacity). However, the recycled water demand has decreased in recent years. The SLWRF supply decreased from 0.1 MGD in 2015 to no use by 2017. The Chuck Corica Golf Complex currently uses a combination of surface water and groundwater to satisfy irrigation demands; and the Metropolitan Golf Links currently uses groundwater for irrigation. Therefore, the recycled water facility is not likely to be operated in the next year or two (see Section 3.3.3 for additional details).
- **<u>North Richmond Water Recycling Plant (NRWRP)</u>** – The NRWRP as built in 1996 and currently supplies tertiary recycled water for cooling towers at the Chevron Richmond Refinery. NRWRP has a design capacity of 5.4 MGD, but typically produces about 4 MGD. In 2016 and 2017, the District's NRWRP experienced interruption of influent supply from West County due to construction shutdown. Therefore, the District had to supplement Chevron Richmond Refinery with potable water. The NRWRP is expected to be back in service by late 2018.
- **<u>Richmond Advanced Recycled Expansion (RARE) Project</u>** – The RARE Project, constructed in 2010, supplies high-purity recycled water for boilers at the Chevron Richmond Refinery. RARE can produce up to 3.5 MGD but could easily expand to 4 MGD. A small portion (i.e., <10 percent) of RARE's recycled water demand was also supplemented with potable water due to water supply and water quality issues.

Figure 3-1 shows the annual average consumption for the existing recycled water projects, with corresponding values listed in **Table 3-1**. Capacities shown in Figure 3-1 are average annual production capacities. As shown, the recycled water demand for some projects has decreased in recent years. Other projects have experienced water supply and quality issues, requiring potable water make-up to meet customer demands.

Figure 3-1: Existing Centralized Recycled Water Projects (2013 to 2017)

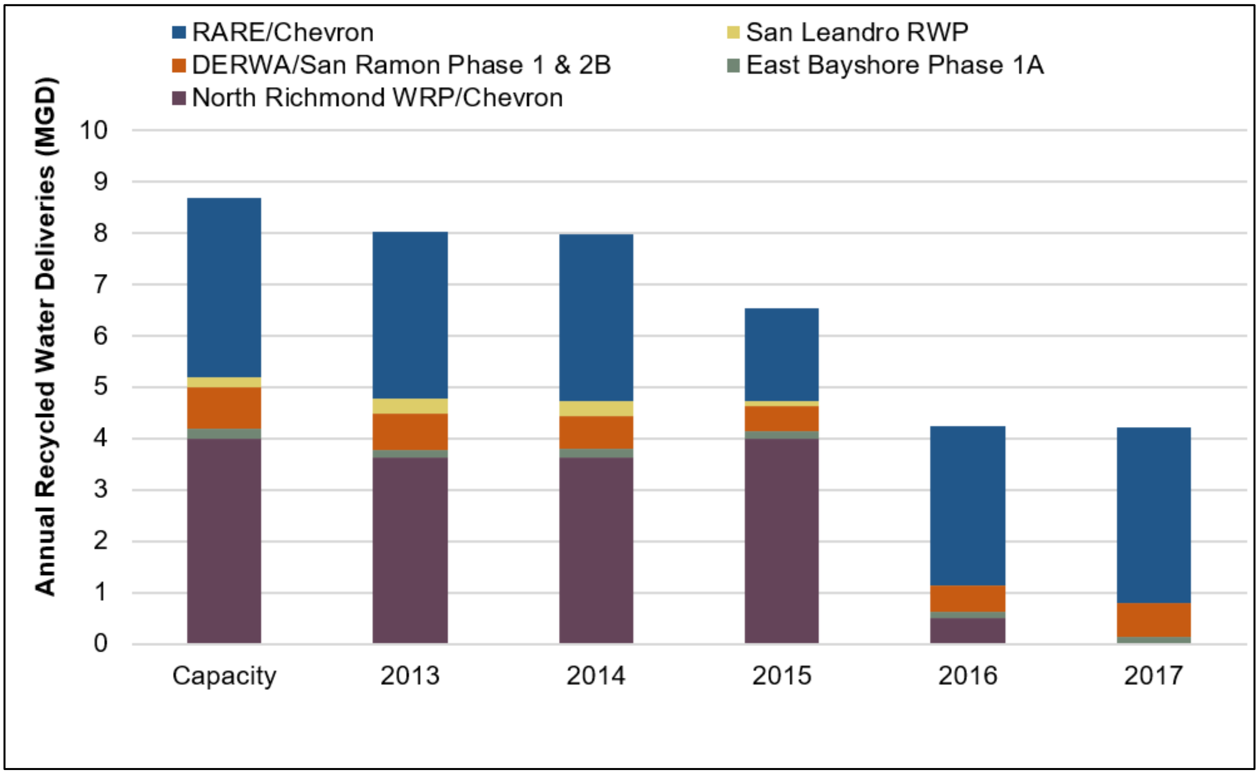


Table 3-1: Recycled Water Deliveries, Annual Averages, 2013-2017

Project	Type of Use	Capacity (MGD)	Recycled Water Delivered (MGD) 2013	2014	2015	2016	2017
DERWA / San Ramon Valley Phase 1 & 2B	Landscape Irrigation	0.8[1]	0.69	0.64	0.5	0.5	0.67
East Bayshore Phase 1A	Irrigation, Toilet Flushing, Industrial	0.2	0.15	0.16	0.14	0.13	0.14
San Leandro WRP	Golf Course and Landscape Irrigation	0.2	0.31	0.29	0.1	0.01	0
North Richmond WRP	Chevron Refinery Cooling Towers	4.0	3.64	3.64	4.0	0.5	0.0
RARE	Chevron Refinery Boiler Makeup	3.5	3.25	3.26	1.8	3.1	3.4
Total		**8.7**	**8.0**	**8.0**	**6.5**	**4.2**	**4.2**

Notes: 1. Capacity will increase to 1.3 MGD upon completion of Phase 2A (in progress). Total capacity will increase to 9.2 MGD.

3.2 Development of Non-Potable Reuse Alternatives

A full range of projects were considered including those that were identified as part of the WSMP 2040 as well as new opportunities that have been identified. The non-potable reuse projects have been categorized into centralized and satellite treatment facilities. Centralized projects consist of locating recycled water treatment facilities (e.g., filtration and disinfection) and distribution (e.g., recycled water pumping station) at a wastewater treatment plant (WWTP). A centralized project assumes that secondary treatment occurs at the WWTP and recycled water treatment facilities would only address processes needed to meet Title 22 regulations and/or customer water quality objectives. A centralized facility also includes the purple pipe distribution system to reach the recycled water customers.

Satellite treatment facilities consist of locating treatment and distribution facilities adjacent or in close proximity to the targeted recycled water customers, typically outside of the WWTP. The development of project alternatives includes consideration and evaluation of satellite treatment facilities in lieu of extending the purple pipe distribution system from a centralized facility.

This section summarizes the key assumptions and planning basis used to develop and evaluate proposed non-potable reuse projects. The assumed wastewater characteristics, water quality objectives and design basis used to size new potential satellite treatment facilities is discussed.

3.2.1 Demand Projections

Recycled water project demands were primarily updated from WSMP 2040 and/or other more recent District studies. In cases where a previous study was not performed, recycled water demands were estimated using historical water meter data, information from District Staff, and/or estimating demands based on irrigated area. When feasible, historical District potable water meter data was reviewed and used to update and/or develop customer irrigation demands. Three (2014 to 2016) to five (2012 to 2016) years of water meter data was used to estimate annual average and peak month demands for each customer. Irrigation water demand varies significantly between winter and summer months. The typical irrigation season is from April through October and it is the highest in July. The peak month demand was also calculated in some cases using a peaking factor of 1.9, which is based on the 95th percentile of daily demand to average annual demand ratios from January 1 to December 31, 2014. This peaking factor was developed for the *East Bayshore Recycled Water Expansion Study Hydraulic Analysis of Future Pipelines and Demands* (EBMUD, 2017a).

Recycled water demand updates were also coordinated with District to reflect new or updated conditions. For example, some customers in recent years have implemented water conservation measures or are using stormwater runoff or groundwater for irrigation in lieu of potable water. In cases where potential customers are currently using alternatives to potable water, the recycled water demands were eliminated and/or adjusted accordingly.

Table 3-2 summarizes project annual average demands in acre-feet per year (AFY) and relevant information sources. Refer to each project description for additional details.

Table 3-2: Sources of Demand Estimates for Development of Non-Potable Project Alternatives

Project	Annual Demand, AFY	Source
DERWA Phase 1. Existing	600 to 800	District Recycled Water Program Data (2013 to 2017)
DERWA Phase 2. Bishop Ranch	800	WSMP 2040
DERWA Phase 3. Danville East	800	DERWA/San Ramon Valley Recycled Water Program Treatment and Distribution Costs (May 2018)
DERWA Phase 4. Blackhawk East	300	DERWA/San Ramon Valley Recycled Water Program
DERWA Phase 5. Blackhawk West	300	DERWA/San Ramon Valley Recycled Water Program
East Bayshore Phase 1A. Existing.	150 to 200	District Recycled Water Program Data (2013 to 2017)
East Bayshore Phase 1A	300 (1)	East Bayshore Recycled Water Quality Improvements Study (Brown and Caldwell, 2018a)
East Bayshore Phase 1B	1,064 (1)	East Bayshore Recycled Water Quality Improvements Study (Brown and Caldwell, 2018a)
East Bayshore Phase 2	2,867(1)	East Bayshore Recycled Water Quality Improvements Study (Brown and Caldwell, 2018a)
San Leandro WRF Expansion	0	District Recycled Water Program Data (2017)

Project	Annual Demand, AFY	Source
Chevron/RARE Expansion	4,284	Supply based on 2016 City of Richmond Facility Plan Demand adjusted based as described in Table 3-9.
Richmond Country Club	100	District Water Meter Data (2015 to 2016)
Point Richmond	120	WSMP 2040
Phillips 66 Refinery	Up to 4,144	ConocoPhillips San Francisco Refinery High-Purity Recycled Water Project Technical Study (Brown and Caldwell, 2007)
Franklyn Canyon	300	WSMP 2040
Lamorinda / Reliez Valley	100	District Water Meter Data (2012 to 2016)
Central San Regional	22,400	CCCSD's Final Comprehensive Wastewater Master Plan (Carollo and CH2M, 2017).
Contra Costa Pipeline in Canal ROW	900	CCWD Final Untreated Water Facilities Improvement Program Plan Update. (Carollo, 2013)
UCB Global Campus, Richmond	1,040	District water supply assessment (EBMUD, 2013).
Rolling Hills Cemetery	200	WSMP 2040
Diablo Country Club	250	Diablo Country Club Satellite Recycled Water Treatment Plant Feasibility Study (Brezack & Associates Planning, LLC, 2013)
Moraga Area[2]	250	District water meter data (2012 to 2016) for MCC and Moraga Commons. Miramonte Highschool and St. Mary's College do not have irrigation-specific accounts. Therefore, irrigation demands were calculated based on grass area.
Orinda Country Club	0	District information (irrigation supply is creek water)
Mountain View/St. Mary's Cemeteries	40	District water meter data (2014 to 2016)
Rossmoor Country Club	90	District water meter data (2012 to 2016)
UCB Main Campus, Berkeley	900	East Bayshore Recycled Water Expansion Study (EBMUD, 2017)
Oakland Hills	350	Oakland Hills Alternative Water Supply Feasibility Study (West Yost, 2017).

Notes:

1. East Bayshore Phase 1B includes Phase 1A demands. East Bayshore Phase 2 includes Phase 1A and Phase 1B demands.
2. Moraga Area customers include the Moraga Country Club (MCC), Moraga Commons, Miramonte High School and St. Mary's College.

3.2.2 Water Quality Objectives

The primary non-potable end use identified for the non-potable reuse alternatives is landscape irrigation; however, there are several projects that consider recycled water for cooling tower makeup water and/or boiler feed water. In the absence of specific customer recycled water quality objectives, it is assumed that recycled water would meet the water quality objectives shown in **Table 3-3**.The values in **Table 3-3** reflect the objectives established as part of the East Bayshore Recycled Water Facility (EBRWF), which assume tertiary treatment and disinfection to meet the Title 22 regulations for non-potable unrestricted reuse as well as total dissolved solids (TDS) and chloride concentrations to meet customer end use requirements (BC, 2018a). Unless otherwise noted, project costs in this study assume that the objectives can be met without additional treatment for salt removal. As shown in **Table 3-3,** the principal recycled water quality constituents of concern for landscape irrigation are total dissolved solids (TDS), chloride, sodium and boron. The sodium adsorption ratio (SAR) is also a concern for irrigation. Recycled water quality criteria vary and are dependent on the type landscape vegetation and the method of irrigation (drip irrigation or sprinkler irrigation). The projects described in Section 3.3 assume, unless noted otherwise, that the focus for landscape irrigation is non-salt sensitive species.

The required recycled water quality characteristics for cooling tower makeup water may vary for different customers and is dependent on the age, materials of construction of the cooling towers, operating characteristics of the cooling towers, and the level of pretreatment currently performed on the circulation water. In general, the primary issues of concern in industrial cooling tower applications are scaling, fouling and corrosion. The cycles of concentration (COC) setpoint is an operating characteristic of the cooling tower and is established based on the makeup water quality and water pretreatment. The COCs are equal to the ratio of circulating cooling water concentrations to fresh makeup water concentration. Since recycled water generally has higher mineral and nutrient level compared to potable water, fewer COCs are recommended. Alternatively, chemical pre-treatment and/or production of higher quality recycled water are alternatives to reducing the COC. The District had previously established water quality objectives based on 3.5 COC (EBMUD, 2016) for light industrial/commercial applications. With heavy industrial customers, such as refineries, water quality objectives were established based on discussions with the industrial customer. Because existing industrial/cooling customers use (high quality) potable water, additional treatment to reduce ammonia, metals and salt concentrations would likely be needed, similar to the District's existing facilities delivering recycled water to the Chevron Richmond Refinery.

Table 3-3: Typical Recycled Water Quality Objectives[1]

Parameter	Irrigation		Industrial Cooling Towers and HVAC[4]
	Grasses[2]	Sensitive Species[3]	
Ammonia (mgN/L)	NA	NA	0.6
Chloride (mg/L)	<350	100	<71
Total Dissolved Solids (mg/L)	<1,670[5]	1,000 to 2,000	<430
Sodium Adsorption Ratio (SAR)	<9	3	NA
Boron (mg/L)	2.0 to 4.0	0.5 to 1.0	NA

Notes:

1. Objectives in this table were used for projects that do not have established customer specific recycled water quality objectives. Based on Brown and Caldwell, 2018a.
2. This includes general turf grasses and native species such as California hairgrass, California melic, and pine bluegrass.
3. This includes butterfly bush, trumpet vine, liquidamber, ginkgo, roses, and Chinese pistache.
4. Industrial uses include industrial cooling (based on 3.5 COCs [EBMUD, 2016a]) and building heating, ventilation, and air conditioning (HVAC).
5. This value assumes a leaching fraction (i.e., the amount of additional irrigation water that must be applied) of 15 percent to flush salt below the root zone and minimize detrimental impacts to the vegetation.

3.2.3 Project Costs

This RWMP Update includes the evaluation of a wide range of potential recycled water projects from a variety of resources, references and authors. Section 2 includes the methods for reviewing and updating costs for projects developed as part of previous work as well as methods for developing costs for new projects for both capital and operations and maintenance (O&M) costs. Specific information developed for each project is included in the cost spreadsheets in Appendix A.

In general, non-potable reuse alternative project descriptions and costs are based on work previously developed by the District and other agencies. Cost estimates for these projects were reviewed for any major omissions and revised if needed. Whenever possible, the raw construction costs were extracted and updated to December 2017 dollars using 20-City Average Engineering News Record's (ENR) Construction Cost Index (CCI) ratios. The soft costs and allowances defined in the Section 2 were then applied to the raw construction costs to estimate capital costs. Adjustments due to location were not necessary for non-potable reuse alternatives.

3.2.4 Raw Wastewater Characteristics

Similar to the demands and project costs, when facility sizing was not available for the non-potable reuse projects, additional evaluation was performed to size the treatment facilities. This primarily was limited to select satellite treatment facilities. **Table 3-4** presents the raw wastewater characteristics assumed for sizing satellite treatment facilities. The data presented in **Table 3-4**, was based on recent data collected from the District's Adeline Interceptor and SD-1 raw influent and used for the EBRWF Water Quality Improvements Project. As part of the EBRWF Water Quality Improvements Project, District staff performed four-day sampling campaigns in February 2016 and October 2017. Samples were collected from the Adeline Interceptor and the SD-1 raw influent using portable composite samplers. Analyses included TDS, total suspended solids (TSS), biochemical oxygen demand (BOD), total Kjeldahl nitrogen (TKN) and ammonia. Recommended sampling parameters were summarized in the *East Bayshore Recycled Water Facility Water Quality Evaluation Draft Technical Memorandum* dated October 2017.

It should be noted that unless sewer system flow data was available at the diversion point for the satellite facility, it was assumed that there was adequate flow in the sewer system for the satellite facility. As the non-potable projects are evaluated and further developed, this assumption should be confirmed.

Table 3-4: Typical Raw WW Quality for Satellite Treatment Facility Sizing

Parameter	Value	Source[1]
Maximum Month Flow, MGD	varies	Max Month condition
Biochemical Oxygen Demand, mg/L	410	90th percentile SD-1 Raw Influent
Ammonia, mgN/L	37.6	90th percentile SD-1 Raw Influent
Total Suspended Solids, mg/L	360	Max. value at Adeline Interceptor
Total Phosphorus, mgP/L	7.0	Assumed
Alkalinity, mg$CaCO_3$/L	330	90th percentile SD-1 Raw Influent
Total Dissolved Solids, mg/L	370	Max. value at Adeline Interceptor
Total Kjeldahl Nitrogen, mgN/L	59.5	90th percentile SD-1 Raw Influent

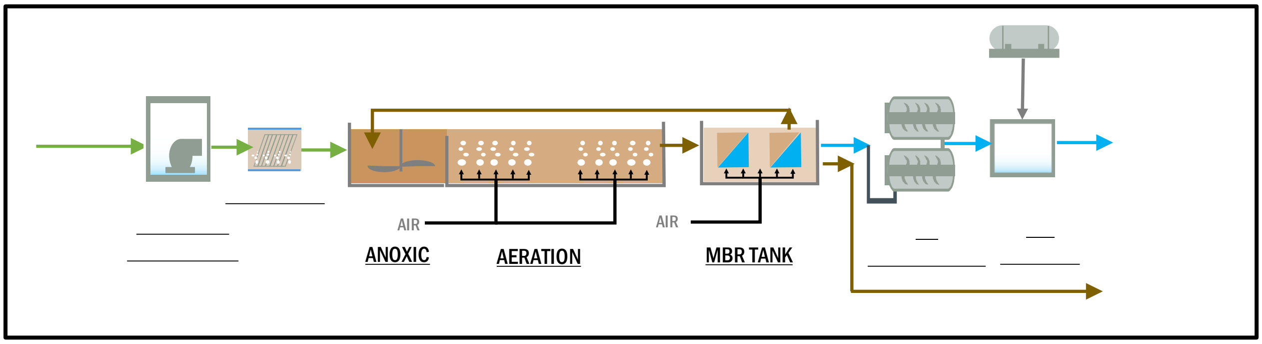
Notes:

1. District data for SD-1 raw influent and Adeline Interceptor, except where noted.

3.2.5 Treatment System

As noted earlier, several non-potable reuse project alternatives have been developed by the District in earlier studies. Facility sizing was developed for those project alternatives that did not have additional information. Recycled water treatment facilities were assumed to operate 24-hours per day and were sized to meet the peak (or maximum) month recycled water demand. It was assumed that potable water could be used as an emergency backup supply such that a fully redundant treatment train was not included for the facilities. Equalization for influent flows was not included but would need to be verified as projects are further developed. For the estimating size and cost of satellite treatment facilities, it was assumed that an MBR followed by UV disinfection would be used. **Figure 3-2** shows a conceptual diagram of the treatment train.

Figure 3-2: Conceptual Satellite Treatment Train Schematic



Note: Raw wastewater would be diverted from sanitary sewer system. Excess sludge would be discharged to the sewer downstream of influent diversion point.

MBR systems are common for satellite treatment facilities because an MBR combines biological treatment with solids-liquid separation and filtration (eliminating the need for separate secondary clarifier and filtration structures), and it produces high quality effluent with a reduced footprint. Fine screening (1 to 3 mm) is placed upstream of the MBR system to prevent clogging of the filters. Waste activated sludge is assumed to be discharged to the local sewer, downstream of the influent diversion point. UV disinfection is assumed because of its small footprint and safety benefits from avoiding the storage of chemicals. The UV system was sized based on a 65 percent UV transmittance and 80 mJ/cm^2 UV dose. To maintain a disinfection residual in the distribution system, an onsite hypochlorite generation system was included. The hypochlorite system was sized to deliver a 5 mg/L chlorine residual at max month conditions.

3.2.6 Distribution System

Recycled water produced would be diverted to a recycled water storage tank, as the treatment system was assumed to operate over a 24-hour period. The distribution system was sized to meet peak hour demands, assuming that irrigation occurs over an 11-hour period. Industrial demands were assumed to occur over a 24-hour period and dual plumbing demands were typically assumed to occur over an 8-hour period. The proposed storage tank was sized to provide one day of storage at max month demands. The addition of booster pumps, on-site customer retrofits, and storage along the distribution system are specific to each project alternative and are noted (if needed) under the project descriptions. **Table 3-5** summarizes recycled water distribution system design criteria, including pipe material and discharge pressure.

Table 3-5: Recycled Water Distribution Design Criteria

Item	Planning Basis
Storage Tank Sizing	1 day of max month demands
Storage Tank Material[1]	Welded Steel or Pre-Stressed Concrete
Distribution System Sizing	Peak Hour
Pump Redundancy Criteria	2 duty, 1 standby unit
Pump Efficiency	50 percent
Demand Period[2] Irrigation Dual Plumbing Industrial	 8 to 11-hours per day 8-hours per day 24-hours per day
Discharge pressure (at customer site)[3]	30 to 50 psi
Pipeline Material	High Density Polyethylene (HDPE)
Assumed Pipeline Headloss	1 foot per 1,00 feet of pipe
Maximum Pipeline Velocity at Peak Hour	5 ft/sec

Notes:

1. The most cost-effective material was selected based on the size of tank (concrete for <2 MG and steel for >2 MG).
2. Typical demand period by customer type assumed unless noted otherwise. An irrigation demand period between 8 to 11 hours per day is assumed. The upper range is based on the peak hour factor of 2.2 (24 hrs/2.2 = 11 hrs per day, average peak hour demand to daily demand ratio) used in the East Bayshore Recycled Water Expansion Study Hydraulic Analysis for Future Pipelines and Demands (EBMUD, 2017a).
3. Assumed recycled water discharge pressure at the customer site unless noted otherwise.

3.3 Centralized Non-Potable Reuse Alternatives

This section summarizes the centralized non-potable reuse alternatives evaluated. Project descriptions include annual average demands, available cost information and non-economic considerations.

3.3.1 San Ramon Valley Recycled Water Program

DSRSD and the District created the multi-phase San Ramon Valley Recycled Water Program in 1995 through a joint powers authority referred to as DERWA. DERWA was established to supply recycled water through the construction and operation of a water recycling facility with a planned capacity of up to 5.7 million gallons per day. The water recycling facility started operation on February 1, 2006. DSRSD currently supplies water to parts of Dublin and the Dougherty Valley, while EBMUD serves recycled water to portions of San Ramon (DERWA/San Ramon).

The project has historically been planned, designed and constructed in a series of numbered phases; Phase 1 is complete while Phase 2 is nearing completion. **Figure 3-3** shows the pipeline alignments and **Table 3-6** summarizes the status for each phase. In 2016, the District completed installation of a pipeline in the Bishop Ranch Business Park area of San Ramon (DERWA/San Ramon Phase 2). Per the current construction schedule, subsequent phases will be constructed in the following order: Phase 3, Phase 5, and Phase 4. In sum, Phases 1 through 5 will serve an annual average of 2.5 MGD (2800 AFY) of recycled water to the District irrigation customers in parts of Blackhawk, Danville and San Ramon.

Table 3-6: DERWA/San Ramon Project Status

Phase	Status[1]	Annual Demand (AFY)
1. Existing	In operation since 2006	600 to 800[2]
2. Bishop Ranch	Near completion	800[3]
3. Danville East	Pipeline construction FY 24-25	800[4]
4. Blackhawk East	Pipeline construction FY 33-34	300[4]
5. Blackhawk West	Pipeline construction FY 28-29	300[4]
	Total	**2,800**

Notes:

1. Based on information provided by District staff. Timing of phases 3 to 5 will depend on securing supplemental supplies.
2. Source: District Recycled Water Consumption Data (2013 to 2017).
3. Source: WSMP 2040.
4. Source: DERWA/San Ramon Valley Recycled Water Program Treatment and Distribution Costs (May 2018).

DERWA is currently expanding its recycled water treatment plant to increase treatment capacity from 9.7 MGD to 16.2 MGD and meet future recycled water demands. The Phase 2 Recycled Water Treatment Plant Expansion Project construction began in 2017 and the new system is expected to be on-line for the 2018 irrigation season. Per the DERWA FY18-19 budget, the partners are allocating capital cost share and any funding secured as follows: DSRSD – 46%, the District – 27%, City of Pleasanton – 27%. The expanded treatment capacity is expected to be fully utilized by 2020 during the summer irrigation season.

DERWA has experienced peak month supply shortfalls during the summer season, requiring supplementation with potable water. Therefore, DERWA is considering requesting customers to reduce use and switching a few customers to potable supply to meet summer demands if needed. DERWA is also exploring other additional supply opportunities, including groundwater, recycled water from CCCSD, and diversion of raw wastewater from CCCSD's adjacent sewerage to supplement DERWA's recycled water supply.

Figure 3-3: DERWA/San Ramon Distribution System

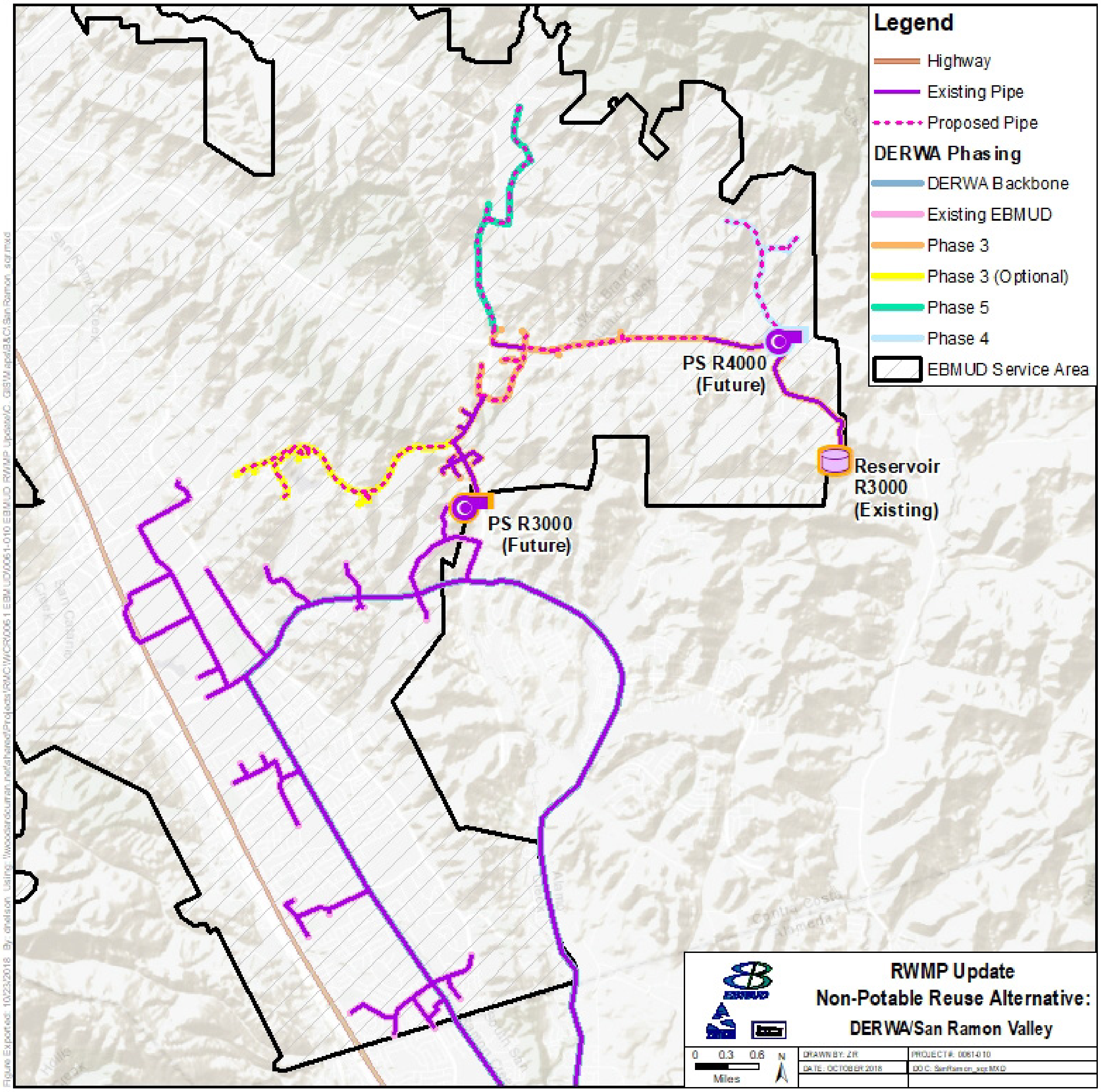


Table 3-7 summarizes EBMUD's share of capital and O&M costs associated with this multiphase project (treatment and distribution). All costs are future costs based on FY 2018 capital improvement projects (CIP) budget (September 2016 dollars updated to December 2017 dollars). For budget purposes, Phases 1 and 2 are complete. Approximately 2.8 miles of distribution pipeline have been completed for Phase 3 with a corresponding investment of $2.6 million. An additional $22 million of future capital will be invested to build 5.4 miles of distribution of pipeline for Phase 3. This assumes that the pipeline in Crow Canyon Rd. west of Dougherty Road (shown as Optional in **Figure 3-3**, above) will not be constructed. The District will also contribute $5.6 million for DERWA Phase 3 Treatment. The District's share of Phase 3 O&M for distribution and treatment are $0.15 million and $0.35 million, respectively. These are the costs to operate the defined project phase and do not include the costs to operate the existing system.

Table 3-7: DERWA/San Ramon Project Costs, District's Share

Phase	2018 Dollars[1]		2017 Dollars[2]			
	Capital Cost ($M)[3]	O&M ($M/yr)	Capital Cost ($M)	O&M ($M/yr)	Annual Demand (AFY)	Annualized Total Cost ($/AF)[4]
Phase 3						
Treatment/Supplemental Supply	2.2	0.35	2.0	0.35		600
Distribution (5.8 miles pipe & Pump Station R3000)	23.9	0.15	23.0	0.15		1,300
Total	**26.1**	**0.50**	**25.0**	**0.50**	**800**	**1,900**
Phase 4						
Treatment Expansion	2.5	0.13	2.0	0.13		400
Distribution (1.4 miles pipe & Pump Station R4000)	15.4	0.05	15.0	0.05		2,500
Total	**17.9**	**0.18**	**17.0**	**0.18**	**300**	**2,900**
Phase 5						
Treatment Expansion	4.1	0.13	4.0	0.13		1,000
Distribution (2.8 miles pipe, no pump station)	4.2	0.02	4.1	0.02		600
Total	**8.3**	**0.15**	**8.1**	**0.15**	**300**	**1,600**

Notes:

1. Source: DERWA/San Ramon Valley Recycled Water Program Treatment and Distribution Costs (September 2018). District's share for capital and O&M are shown. All costs are future costs based on FY2020 CIP budget (September 2018 dollars).
2. Capital and O&M costs (from source) were updated to 2017 dollars using ENR CCI ratios for 20 Cities Average.
3. All capital costs include planning, design, construction of infrastructure and retrofits. Assumes the pipeline in Crow Canyon Rd. west of Dougherty Rd is not constructed.
4. Annualized total cost is calculated using methodology outlined in Section 2.2.

These projects are expansions of committed projects currently in progress or construction. The programs are EIR-certified, and the recycled water is distributed to a wide service area. Overall, this is a well-established program and these projects should continue to be high priority for the District as long as funding and source supply are available. It is worth noting that Phase 4 has the highest unit costs between the three remaining phases as it includes installation of a pump station (R4000, per District nomenclature). Compared with Phase 5, Phase 4 capital and O&M are higher for the same annual demand, resulting in a higher unit cost.

3.3.2 East Bayshore Recycled Water Project

The EBRWF currently supplies recycled water primarily for landscape irrigation in Oakland and Emeryville. The recycled water quality meets DDW Title 22 requirements for unrestricted non-potable reuse. The EBRWF provides microfiltration (MF) and chlorine disinfection of the District's secondary effluent at the Main WWTP (SD-1). A portion of recycled water has been used for cooling tower makeup and for toilet/urinal flushing, but these uses were largely discontinued due to water quality issues. Recycled water is currently used at SD-1 for in-plant uses such as pump seal water and irrigation; SD-1 demands range from 0.5 MGD to 1.0 MGD.

In 2017, annual average recycled water demands outside of SD-1 were 0.14 MGD, which is lower than the initial goal of 0.5 MGD for the first phase of the project (Phase 1A). The District wants to maximize recycled water use in the EBRWF service area by expanding the distribution system to Berkeley, Albany and Alameda and by expanding the customer base to include commercial cooling towers, dual plumbing and other industrial uses.

The *East Bayshore Recycled Water Quality Improvements Study* is evaluating EBRWF expansions and treatment upgrade requirements based on these target end uses. The EBRWF Study has not yet been finalized (as of December 2018), but the draft report identified short-, intermediate- and long-term scenarios to improve recycled water quality and recommended next steps to ultimately identify a path forward for the EBRWF recycled water program (Brown and Caldwell, 2018a).

Two alternatives were developed: Alternative 1 consists of delivering recycled water for landscape irrigation of non-sensitive species only, while Alternative 2 consists of delivering recycled water for both industrial purposes and irrigation. Alternative 1 and Alternative 2 would both require treatment upgrades to improve recycled water quality and meet the established recycled water quality objectives. Alternative 1 would require partial RO to reduce chloride concentrations in the recycled water. Alternative 2 would require ammonia removal and chloride reduction. Two concepts were reviewed for ammonia and chloride reduction; the first concept considers treating tertiary effluent with RO followed by ion exchange (IX). The second concept considers constructing an MBR at SD-1 to treat wastewater from the Adeline Interceptor; an initial review of wastewater quality from the Adeline Interceptor indicates that chloride concentrations are low enough that RO would not be needed downstream of the MBR. Additional characterization of the Adeline Interceptor wastewater is recommended to confirm chloride concentrations and confirm that RO is not needed.

A decision to move forward with Alternative 1 or Alternative 2 has not been made yet. Additional studies and pilot testing are recommended to confirm that recycled water (after the proposed water quality improvements) is suitable for use in the commercial cooling systems. For this reason, a decision on whether to move forward with Alternative 1 or Alternative 2 has not been made and for planning purposes, Alternative 2 is referenced in this report as it is more conservative (i.e., Alternative 2 has higher capital cost estimates than Alternative 1). Alternative 2 also offers the benefit of a more diverse customer base, year-round demands, and requires less distribution system expansion than Alternative 1.

The recommended treatment upgrade for Alternative 2 is the MBR treatment facility at SD-1 capable of producing 4.5 MGD of maximum month flow. This assumes that Adeline Interceptor wastewater quality is such that RO treatment is not needed. The MBR offers the advantage of eliminating the need for RO and it achieves nutrient removal at SD-1 (i.e., nutrients are not returned to the plant in RO waste streams). The MBR can also accommodate variability in influent ammonia loadings while still meeting recycled water quality objectives. The long-term project (Alternative 2, Phase 2) would achieve annual average deliveries of 2.6 MGD to irrigation and industrial customers.

Alternative 2 consists of delivering recycled water to industrial and landscape irrigation customers. The phasing plan targets the following deliveries (not including SD-1 in-plant use):

- **Phase 1A** (Short-term project). 500 AFY (0.44 MGD annual average) to existing distribution system customers (not including SD-1 in-plant use) plus delivery to new customers within the existing distribution network and Frontage Road (I-80) pipeline alignment up to University Village.
- **Phase 1B** (Intermediate-term project). 1,100 AFY (0.95 MGD annual average). This phase includes all facilities in Phase 1A plus minimal expansion of the distribution system in Oakland and Berkeley to reach new irrigation and industrial users.
- **Phase 2** (Long-term project). 2,900 AFY (2.6 MGD annual average). This phase includes all facilities in Phase 1A and Phase 1B plus expansion to UC Berkeley, Albany and Alameda.

Figure 3-4 shows the existing and proposed recycled water distribution system for Phases 1A, 1B and 2, which are discussed in further detail below. **Appendix D** summarizes the list of customers for East Bayshore Alternative 2. The long-term project (Phase 2) includes all customer demands and the associated cost with the ultimate distribution system expansion.

EBRWF Alternative 2 Short-term Project (Phase 1A)

Short-term demands were identified that reach customers along the Frontage Road (I-80) pipeline alignment and adjacent to the existing distribution network to limit recycled water distribution system expansions. In addition to the EBMUD Administration Building, new industrial customers will be connected in Emeryville and an allowance for recycled water use was included for the Sherwin Williams redevelopment site. Treatment upgrades would be required to meet new end user water quality objectives for chloride and ammonia. While the MBR is the recommended alternative in the long-term, cost estimates were not prepared for an MBR in the short-term because the MBR would be implemented as part of the larger project when demands are higher. The cost associated with this phase include treatment upgrades assuming RO and ion exchange as a placeholder. Because full-scale implementation of Alternative 2 will take time, EBMUD could consider early extension of the distribution system to Brooklyn Basin with potable water blending to meet chloride objectives until treatment upgrades are constructed.

EBRWF Alternative 2 Intermediate-Term Project (Phase 1B)

As shown in **Figure 3-4,** Phase 1B would include minimal expansion of the existing recycled water distribution system in Oakland and Berkeley and a new separate recycled water treatment facility sized to meet the projected max month demand of 1.5 MGD (not including SD-1 reuse demands). Note that under the MBR scenario, recycled water for in-plant use at SD-1 is assumed to come from secondary effluent. Recycled water used at SD-1 would not meet Title 22 requirements for unrestricted reuse; SD-1 would use recycled water under the same protocol that is currently used when EBRWF is offline.

A new recycled water treatment facility would be sited at the existing East Bayshore site at SD-1 and would use an MBR to treat raw wastewater from the Adeline Interceptor. A diversion pump station would convey raw water from the Adeline Interceptor to the MBR treatment process at SD-1. Land to the east of SD-1 would have to be acquired from the California Department of Transportation (Caltrans) in order to construct the diversion pump station. The MBR alternative is comprised of screening, grit removal, activated sludge basins, MBR tanks, blowers, and chlorine disinfection. The existing disinfection basins would be repurposed. The MBR effluent would be disinfected, stored and pumped using the existing EBRWF facilities. MBR treatment would address water quality improvements needed to serve irrigation and industrial customers. With this alternative, the existing MF facilities would no longer be needed. **Figure 3-5** shows a schematic for the treatment upgrades assumed in this master plan update.

EBRWF Alternative 2 Long-term Project (Phase 2)

The long-term project includes extension of the distribution system to Powell Street, Channing Way and Alameda. Phase 2 includes a satellite MBR treatment facility at SD-1 with a capacity of 4.5 MGD. Because of the larger footprint required for the long-term MBR facility, the existing EBRWF disinfection facilities would need to be relocated. The MBR facility would be located at the EBRWF location. It is recommended that alternate sites be considered, as there is limited land available and constructability is a potential issue.

The Phase 2 distribution system expansion would require a significant amount of pipeline construction through congested urban areas, so construction challenges are anticipated. Phase 2 will expand service to include University of California Berkeley (UCB). If the UCB Satellite Treatment Project were to be selected for implementation, its demands would have to be subtracted from the EBRWF Phase 2 demands.

The East Bayshore Recycled Water Project Phases 1A, 1B and 2 are expansions of a committed project, and therefore score well with respect to institutional complexity. Because the system serves a large number of customers, it also meets the District's environmental and social objectives.

The proposed satellite treatment at SD-1 would consist of a smaller, separate MBR treatment facility which would require construction and implementation of new processes. The benefit of this option is that recycled water produced at SD-1 would have lower salt and nutrient concentrations which would also facilitate long-term plans for potable reuse. Implementation of new processes like MBR will impact the District from a long-term operational complexity, but could set up the District to gain experience on new processes which may be implemented to address future nutrient regulations.

As noted in the EBRWF study, it is recommended that the District continue to perform outreach to future customers to confirm interest, demands, and recycled water quality requirements. In addition to continued outreach, it is also recommended that the District work with the targeted cities to identify opportunities to provide recycled water connections with new construction and/or upgrades/improvements at public facilities.

Figure 3-4: East Bayshore Distribution System

Figure 3-5: Recycled Water Treatment System Reconfiguration for Satellite Treatment of Adeline Interceptor with MBR

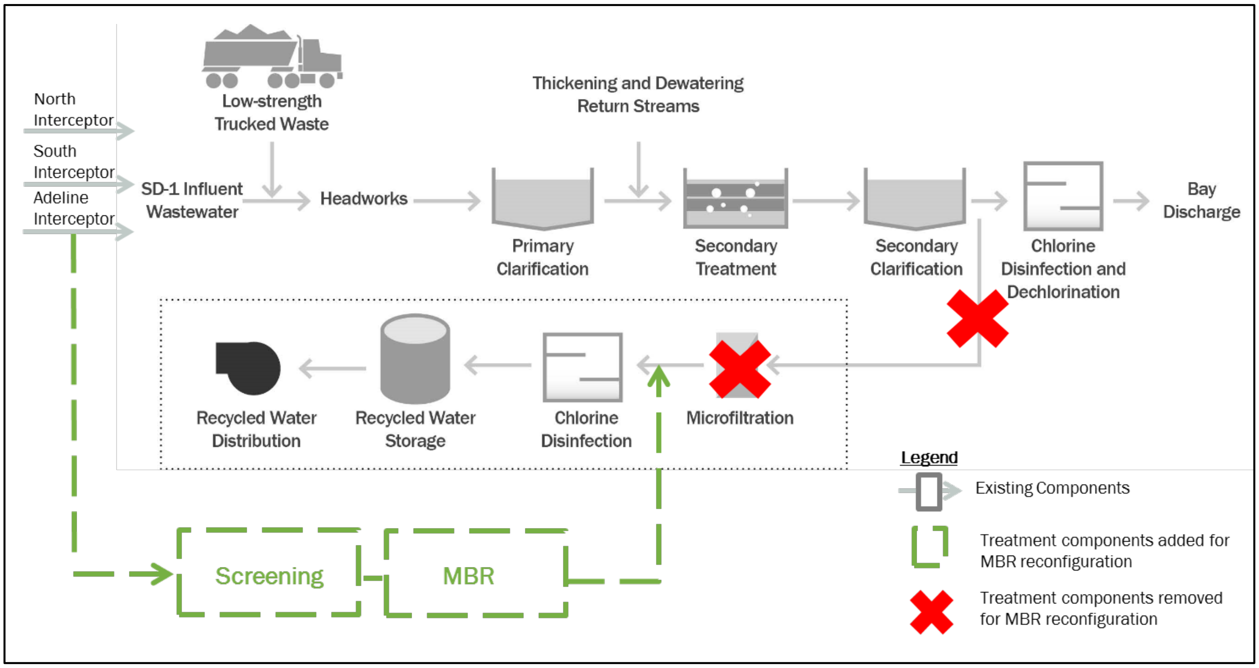


Table 3-8 (next page) shows the costs associated with each of the phases for the EBRWF Water Quality Improvements Project. The cost estimates shown are standalone and do not consider a phased approach for each alternative (i.e., Phase 2 includes Phase 1A and 1B; the costs are not additive).

Table 3-8: East Bayshore Recycled Water Project Costs (2017 dollars)[1]

Phase	Capital Cost ($M)	O&M Cost ($M/yr)	Annual Demand (AFY)[2]	Annualized Total Cost ($/AF)[4]
EBRWP – Alternative 2 Phase 1A				
Treatment Upgrades	6	0.35		1,300
Recycled Water Conveyance	10	0.15		1,100
Phase 1A Total	**16**	**0.50**	**500**	**2,400**
EBRWP – Alternative 2 Phase 1B[3]				
Treatment Upgrades	13	0.38		900
Recycled Water Conveyance	27	0.45		1,500
Phase 1B Total	**40**	**0.83**	**1,100**	**2,400**
EBRWP – Alternative 2 Phase 2[3]				
Treatment Upgrades	22	1.2		800
Recycled Water Conveyance	108	1.7		2,200
Phase 2 Total	**130**	**2.9**	**2,900**	**3,000**

Notes:

1. Source: (Brown and Caldwell, 2018b)
2. Annual demands include existing uses, but do not include in-plant uses at SD-1.
3. Costs for Phase 1B include all costs required to provide recycled water for Phase 1A and Phase 1B customers. Costs for Phase 2 include all costs required to provide recycled water for Phase 1A, Phase 1B and Phase 2 customers.
4. Annualized total cost is calculated using methodology outlined in Section 2.2.

3.3.3 San Leandro Water Reclamation Facility Expansion Project

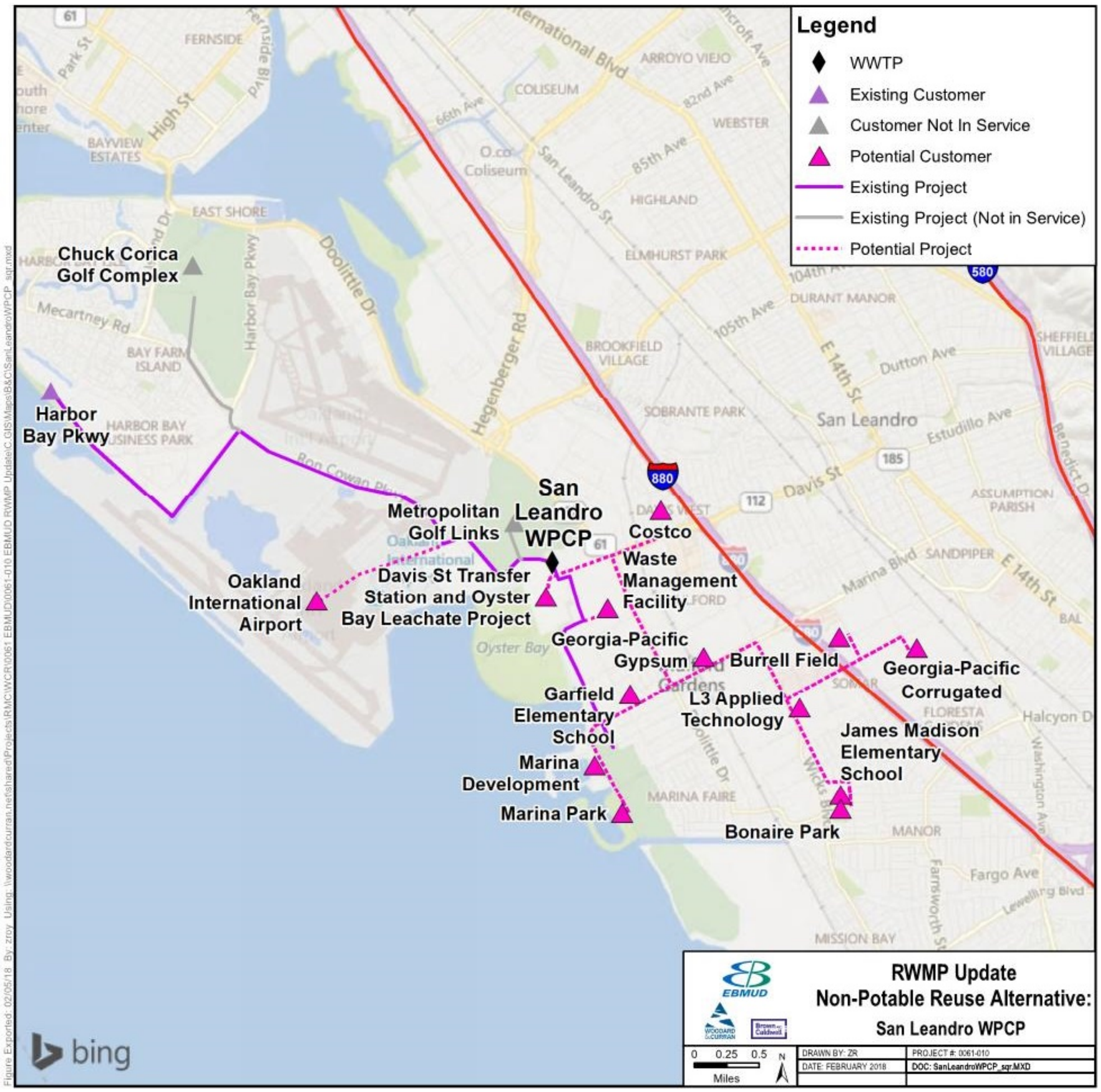
Since 1988, the San Leandro Water Reclamation Facility (SLWRF) has been providing secondary-treated and disinfected recycled water produced by the City of San Leandro's Water Pollution Control Plant (WPCP) to customers for irrigation purposes. The District constructed facilities to convey recycled water to the Chuck Corica Golf Complex and roadway medians along Harbor Bay Parkway in Alameda and to the Metropolitan Golf Links in Oakland. The Monarch Bay Golf Club in San Leandro is also a recycled water customer, but it is supplied directly by the City of San Leandro.

The SLWRF has the capacity to supply up to 0.4 MGD of recycled water to customers. However, the recycled water demand has decreased in recent years from 0.1 MGD in 2015 to 0.01 MGD in 2016. The Chuck Corica Golf Complex has invested in alternative landscaping and stormwater capture, and currently uses a combination of surface water and groundwater to satisfy their irrigation demands. The Metropolitan Golf Links currently uses groundwater to satisfy their irrigation demands. Both golf courses intend to close their recycled water accounts, but the meters will stay in place just in case future use is needed. Harbor Way alone does not create enough demand to warrant turning on the recycled water pump station, therefore, the recycle water facility is likely not to be operated unless a more consistent demand can be identified along the existing recycled water distribution system.

In 2016, the City of San Leandro Recycled Water Market Assessment Study was completed (Carollo, 2016b). Based on 2002 to 2005 water demand data, 15 potential recycled water customers were identified for various uses (irrigation, commercial, food and light industrial). The projected annual average and max month demands were 0.15 MGD (171 AFY) and 0.56 MGD, respectively. However, many potential customers were not interested in non-potable reuse. **Figure 3-6** shows the existing and potential customers for the SLWRF. While the Oakland International Airport is approximately one mile from the SLWRF, demands are low and currently not plumbed with purple pipe. A future expansion of the airport in the form of a third terminal could potentially provide a demand for non-potable reuse (i.e., toilet flushing), but such an expansion is not planned at this time. The Waste Management Facility (Davis Street Resource Recovery Complex and Transfer Station), sited across the street from SLWRF, is another potential customer however, additional facilities would be required to comply with the disinfection requirements (i.e., a contact basin would be required) because of the limited contact time in the distribution system.

There is insufficient customer demand to make this recycled water project viable at this point in time.

Figure 3-6: San Leandro Water Reclamation Facility Expansion Project



3.3.4 Chevron Richmond Refinery Recycled Water Project

Since 1996, the District has delivered recycled water to the Chevron Richmond Refinery. The District currently operates two treatment plants, the Richmond Advanced Recycled Expansion (RARE) Water Project and the NRWRP, both supplied primarily by secondary-treated effluent produced by the West County WPCP. The RARE Water Project supplies high-purity recycled water for the high-pressure boilers and the NRWRP supplies tertiary recycled water for the cooling towers at the refinery. **Figure 3-7** shows the existing recycled water distribution system.

Figure 3-7: Chevron Richmond Refinery Recycled Water Project

The RARE Water Project has a capacity of 3.5 MGD, but the facility can be easily expanded to 4.0 MGD with the installation of additional microfiltration modules. Further expansion would require the construction of additional facilities. The NRWRP is more than 20 years old, requires significant maintenance and is challenged by the variable quality of the secondary effluent it receives making it difficult to meet Chevron's water quality requirements at times. In 2017, the

West County WPCP completed several plant expansion and upgrade projects, including converting the aeration basin configuration to Modified Ludzack-Ettinger (MLE) mode with enhanced nitrification reliability and facilitated denitrification. The expansion and reduced nutrient loads and ultimately improved the water quality of the secondary effluent treated at NRWRP and RARE.

The District is interested in exploring an expansion of recycled water use at the refinery with a goal of 10 MGD, however additional water supply is needed. **Table 3-9** summarizes the current and future recycled water demands and supply. Based on historical data review of the WCWD effluent flows (2011 to 2014), the annual average and minimum month flows are 8 MGD and 6.4 MGD, respectively. During the dry months, there is a projected deficit of 4.5 MGD in meeting future refinery demands. Given the deficit in WCWD effluent supply, the District has identified the refinery WWTP effluent and the City of Richmond's WPCP effluent as potential sources.

Table 3-9: Chevron Richmond Refinery Recycled Water Project Demand Deficit

Demand and Supply	Current (MGD)	Future (MGD)
Chevron Refinery Cooling Towers Demand	3.5	5.0
Chevron Refinery Boilers Demand	3.0	5.0
Total Chevron Refinery Demand	6.5	10.0
Total Supply to NRWRP/RARE[1]	**7.0[1]**	**10.9[1]**
WCWD Effluent[2]	6.4[2]	6.4[2]
Supply Deficit	**0.6**	**4.5**

Notes:

1. The District's RARE system has an overall recovery of 85 percent. To meet current and future boiler demands of 3.0 and 5.0 MGD, the feed flow to RARE would be 3.5 MGD and 5.9 MGD, respectively. Feed flow to NRWRP is 3.5 MGD (current) and 5.0 MGD (future).
2. Value represents the minimum monthly flow between 2011 to 2014. The minimum monthly flow in 2015 was 5.9 MGD.

3.3.4.1 Chevron Refinery WWTP Effluent

In 2016, the District completed a study to evaluate the feasibility of increasing recycled water production at the RARE Water Project to 10 MGD (BC, 2016). The study evaluated the feasibility of using the refinery's process flows or WWTP effluent as an additional influent water source. RO concentrate from the RARE Water Project is currently treated at the refinery's WWTP. Therefore, pilot testing would be required to determine the feasibility of WWTP effluent as a source for the RARE Water Project's MF/RO system, as well as the impacts back at the WWTP from the expanded need for RO concentrate management. In addition, further investigation is needed to determine the potential NPDES permit modifications that would be required. The additional studies needed would require significant input and financial support from Chevron to move forward and is therefore not considered viable at this time.

3.3.4.2 Richmond WPCP Effluent

Another potential source of recycled water for the RARE Water Project is effluent from the City of Richmond WPCP. In 2015, the annual average flow and ADWF were 6 MGD and 4.4 MGD, respectively. Per the 2016 Facility Plan, the projected 2040 ADWF is 7.4 MGD (Carollo, 2016a). In order to use available Richmond WPCP effluent, treatment upgrades would be required to meet the District's RARE influent water quality limits for salinity and ammonia. The 2016 Facility Plan analyzed alternatives for reducing both constituents and identified the need for a 5-MGD MBR followed by RO and UV. A portion of the UV-disinfected effluent would be chlorinated to meet the District's chlorine residual requirement. This project would allow the RARE facility to expand to 5.0 MGD recycled water delivery to Chevron, therefore the costs associated with the RARE Water Project expansion were also included. The Richmond WPCP would be the primary supply for the RARE Water Project and a portion of the flow originally supplied by WCWD could be utilized at the NRWRP. **Figure 3-8** depicts the water balance for the project. As shown, the District would be able to produce up to 10 MGD recycled during months of minimum supply from WCWD with additional supply from Richmond WPCP effluent. **Table 3-10** summarizes the capital costs of the facility improvements at the Richmond WPCP and the conveyance system to the RARE facility. The cost estimates presented assume that Richmond WPCP effluent meets the RARE feed requirements. Impacts to the District's long-term operation are anticipated to be minimal since the new treatment facilities will be operated by the City of Richmond.

It is worth noting that the recycled water project was not a recommended project in the 2016 Facility Plan and therefore was not carried forward into the City of Richmond's capital improvement plan (CIP). The primary reasons for not recommending the project included the need for interagency coordination and financial support for the treatment and distribution facilities. The 2016 Facility Plan stated that these challenges might be resolved when the need for recycled water becomes sufficiently critical.

Other projects competing for the same source of water include the Richmond Country Club and the Rolling Hills Cemetery as discussed below.

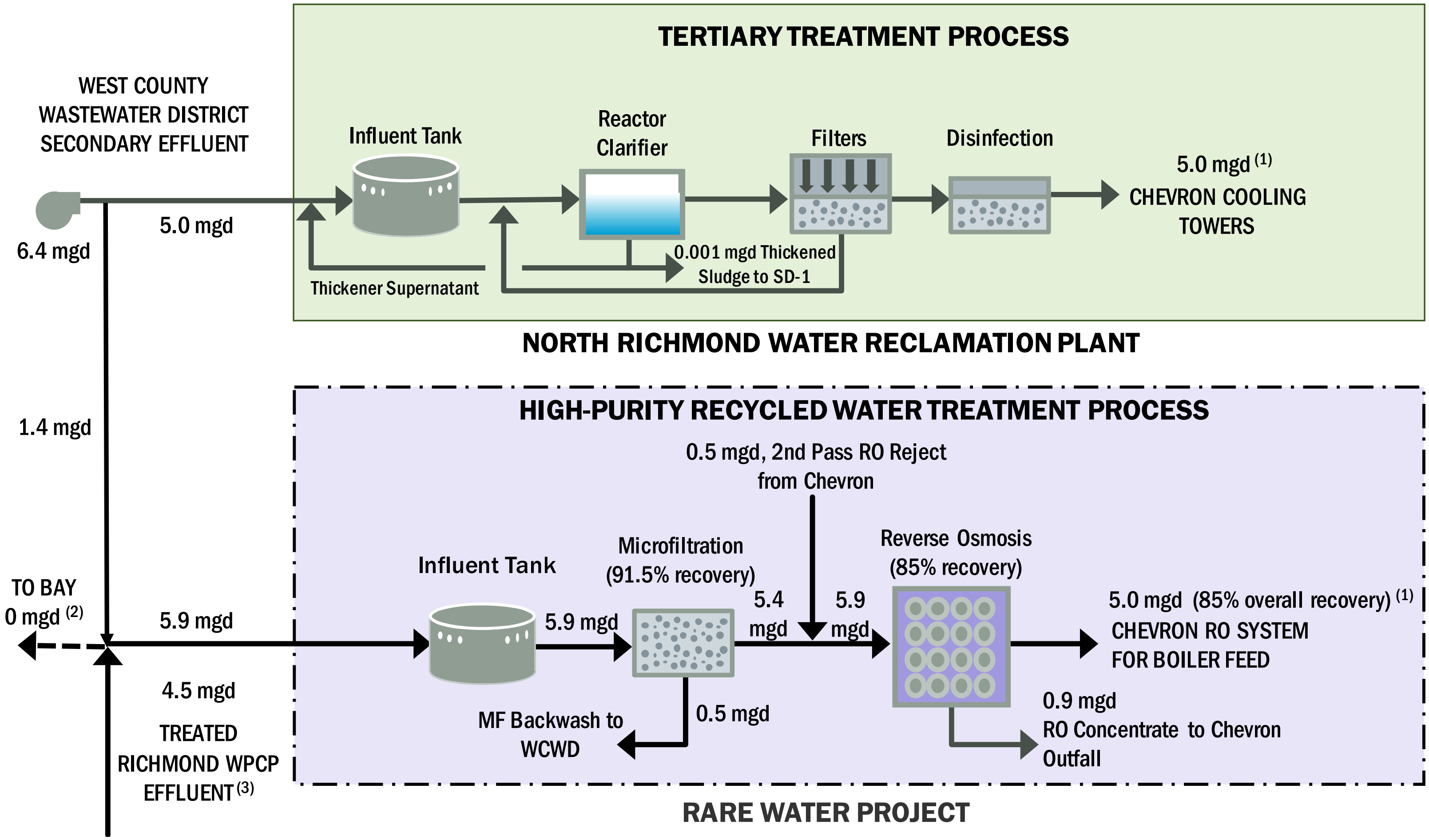
Table 3-10: City of Richmond WPCP Recycled Water Project Capital Costs

Element	2016 Dollars[1]		2017 Dollars[2]		Annual Demand (AFY)[6]	Annualized Total Cost ($/AF)[7]
	Capital Cost ($M)	O&M ($M/yr)	Capital Cost ($M)	O&M ($M/yr)		
Treatment Upgrades[3]	91.2	NA	96	4.8		2,300
RARE Expansion[4]	2.0	0.45	2.1	0.47		
Recycled Water Conveyance[5]	11.4	0.090	11.9	0.44		300
Total	**105**	**0.54**	**110**	**5.7**	**4,300**	**2,600**

Notes:

1. Source: *City of Richmond and Veolia Water WWTP Facility Plan*. Final Draft. September 2016.
2. 2016 capital costs (from source) were updated to December 2017 dollars using ENR CCI ratios for 20 Cities Average.
3. Includes ammonia removal, salinity reduction and disinfection facilities. Two options were presented to meet nutrient removal: expansion of existing conventional activated sludge (CAS) process (aeration basins and secondary clarifiers) and split flow CAS/MBR which includes expansion of existing CAS process and a separate MBR train. The cost for the split CAS/MBR with RO/UV facilities, but without the aeration basin improvements to achieve Level 3 nutrient requirements is shown here. Annual O&M cost were not provided in the original estimate. 2017 O&M cost estimates for this study are presented in Appendix A.
4. Includes costs to expand RARE facilities from 3.5 MGD to 5.0 MGD production rate (Source: BC, 2016).
5. Includes cost for constructing a new pipeline to RARE and a new recycled water pump station to pump secondary effluent to RARE. The annual O&M costs in the original estimate were based on the power required to operate the pump station. The 2017 conveyance O&M for the highest capital alternative was estimated for power and labor to operate and maintain the pump station and the pipeline (see Appendix A).
6. Annual demand is based on delivering Richmond WPCP effluent to RARE to address the 4.5 MGD supply deficit noted in Table 3-9. 4.5 MGD of effluent and 85% recovery rate = 3.8 MGD (4,300 AFY) average annual recycled water delivered to Chevron.
7. Annualized total cost is calculated using methodology outlined in Section 2.2.

Figure 3-8: Chevron Richmond Refinery Recycled Water Project Water Balance



(1) Recycled water production during month with minimum supply of WCWD effluent with additional supply from Richmond WPCP effluent.
(2) WCWD and Richmond WPCP effluent flow in excess of demand for recycling is discharged to San Francisco Bay.
(3) Richmond WPCP effluent will be treated via MBR, RO and UV disinfection to meet the District's RARE influent water quality limits for TDS, ammonia and disinfection.

3.3.5 Richmond Country Club Water Recycling Project

In 1984, the District began operating its first golf course irrigation project at the Richmond Country Club using recycled water supplied from the West County WPCP (see **Figure 3-7**). The Richmond Country Club was using an average of 0.18 MGD of recycled water to irrigate approximately 150 acres. The Richmond Country Club owned the pumped station, transmission pipeline and a 3-acre storage pond on-site and the District was contracting the maintenance and operation of the pump station to WCWD.

Once RARE came online, the Richmond Country Club was returned to potable water service due to the limited WCWD effluent supply during the irrigation season. The Richmond Country Club has expressed interest in returning to recycled water service, if available. The Richmond Country Club irrigation demand has varied from an annual average of 0.19 MGD (2012 to 2014) to 0.10 MGD (2015 to 2016). Due to the small recycled water demands, the limited recycled water supply and the investment the District has made to serve the Chevron Richmond Refinery, the continued operation of the Chevron Richmond Refinery Recycled Water Project is prioritized over the Richmond Country Club Water Recycling Project. Therefore, this project would not be included in the non-potable reuse portfolio at this time. However, this site may be served with recycled water should supply become available or the refinery demand be reduced in the future.

3.3.6 Point Richmond Recycled Water Project

Recycled water service to Point Richmond customers was previously investigated as part of the NRWRP Expansion Study and screened out because of limited supply and distance to recycled water source. As shown in **Figure 3-7**, the closest source of water is the City of Richmond WPCP. Per the WSMP 2040, the annual potential average demand for recycled water was in the range of 0.07 to 0.1 MGD or 80 to 120 AFY.

Potential recycled water customers in the Point Richmond area include the Terminal One Project and Bottoms Property Redevelopment. The Terminal One Project proposes the development of approximately 14 acres of property, including 316 residential units, commercial space, a waterfront park, as well as road, trail, and other improvements. Compared to a conventional development project, the Terminal One Project would use a reduced water demand for irrigation in compliance with the District's Regulations Section 31 (ESA, 2016). On December 13, 2017, a public hearing was held to consider a design review permit for the project. The Bottoms Property Residential Project proposes to build a residential development of 60 dwelling units. The project will be developed within approximately 6 acres of the 25 acre-site. In 2014, the City of Richmond Planning Department prepared a Recirculated Draft EIR for the project.

Like the Richmond Country Club, the Chevron Richmond Refinery recycled water demands are prioritized over the Point Richmond demands. Therefore, this project would not be included in the recycled water portfolio. However, this site may be served with recycled water should supply become available or the refinery demand be reduced in the future

3.3.7 Phillips 66 Refinery Recycled Water Project

The Phillips 66 Recycled Water Project could utilize up to 3.7 MGD of recycled water at the Phillips 66 Refinery (Phillips 66) in Rodeo for use in the refinery high-pressure boilers and cooling towers, if sufficient supply were available. A new recycled water facility would treat disinfected secondary effluent from the Pinole-Hercules and Rodeo treatment plants (see **Figure 3-8**). In 2005, the District and Phillips 66 executed a Memorandum of Understanding (MOU) to evaluate the feasibility of developing this project. A 2007 feasibility study identified alternatives and costs for the treatment and use of recycled water at the refinery (BC, 2007). The project is technically feasible; however, the available water supply has decreased in recent years.

As shown in **Table 3-11**, the combined supply of final effluent from the Pinole-Hercules WPCP and Rodeo Sanitary District treatment plants is large enough (dry weather flow of 2.7 MGD) to produce sufficient supply of 1,340 gpm (1.9 MGD) for the boiler feed water treatment system, assuming a recovery rate of 90% for MF and 85% for RO. Remaining flow, if available, could be used to satisfy a portion of the cooling tower makeup water demand (i.e., 600 gpm or 0.86 MGD) for a total of 2.6 MGD or 2,912 AFY (Project Phase 1). In the future, if sufficient flows were available, the remaining cooling tower demand could be met (Project Phase 2). Cost estimates presented in this study include annual average recycled water delivery of up to 3.7 MGD (4,144 AFY). Under Phase 1 and Phase 2 project scenarios, the final effluent from both facilities would be pumped by the Rodeo Pump Station to Phillips 66.

Table 3-11: Phillips 66 Refinery Recycled Water Project Supply and Demand

Treatment Facility	ADWF, MGD		Minimum Monthly Flow, MGD	
	2004-2005	2016/17	2004-2005	2016/17
Pinole-Hercules WPCP	3.2	2.3	3.0	2.2
Rodeo WWTP	0.6	0.5	0.6	0.5
Total	**3.8**	**2.8**	**3.6**	**2.7**

Source: BACWA, 2017. Group Annual Report. Nutrient Watershed Permit Annual Report. October 2017.

Figure 3-9: Phillips 66 Refinery Recycled Water Project

Table 3-12 summarizes the capital and annual O&M costs for the project. The high-purity recycled water project would consist of the following process units: MF, biological active filtration (BAF), reverse osmosis (RO) and ultraviolet (UV) disinfection. Secondary effluent will be pumped from the Rodeo Pump Station through a new pipe that will deliver water to the refinery fence line. An existing tank will be used for effluent equalization prior to treatment (MF, RO, BAF). A portion of MF filtrate would be treated via RO and another portion would go to a BAF unit. The BAF unit is necessary to remove ammonia to meet water quality requirements for the cooling towers. Effluent from the BAF unit will be disinfected with an in-line UV system to meet Title 22 requirements for disinfected tertiary recycled water. For cost estimating purposes, it was assumed that existing carbon steel pipe would be reused as much as possible for the distribution piping to deliver product water. Capital cost also include site preparation and electrical system. The District is currently exploring options for funding the project.

Table 3-12: Phillips 66 Refinery Recycled Water Project Costs

Phase	2007 Dollars[1] Capital Cost ($M)	2007 Dollars[1] O&M ($M/yr)	2017 Dollars[2] Capital Cost ($M)	2017 Dollars[2] O&M ($M/yr)	Annual Demand (AFY)	Annualized Total Cost ($/AF)[5]
Phase 1. Boilers and Half of Cooling Towers						
Treatment[3]	27	1.2	48	2.0		1,000
Conveyance to Refinery[4]	3.0	0.03	5.4	0.1		100
Phase 2. Remaining Half of Cooling Towers. Provisions included above for future expansion						
Total	30	1.2	53	2.1	4,100	1,100

Notes:
1. Source: BC, 2007. ConocoPhillips Recycled Water Project Technical Study. August 2007.
2. Raw construction costs (from source) were updated to December 2017 dollars using ENR CCI ratios for 20 Cities Average. O&M costs were updated based on current electricity and labor costs.
3. Treatment includes BAF, MF, RO, UV, secondary effluent tank, secondary effluent transfer pumps, secondary effluent piping, utilities and product water piping. O&M includes electrical costs, labor, maintenance, chemicals, UV energy and replacement costs. Brine disposal not included.
4. Conveyance to Refinery includes pipeline and modifications to Rodeo Sanitary District (RSD) pump station. O&M includes RSD pump station electrical cost. Pipe maintenance not included.
5. Annualized total cost is calculated using methodology outlined in Section 2.2.

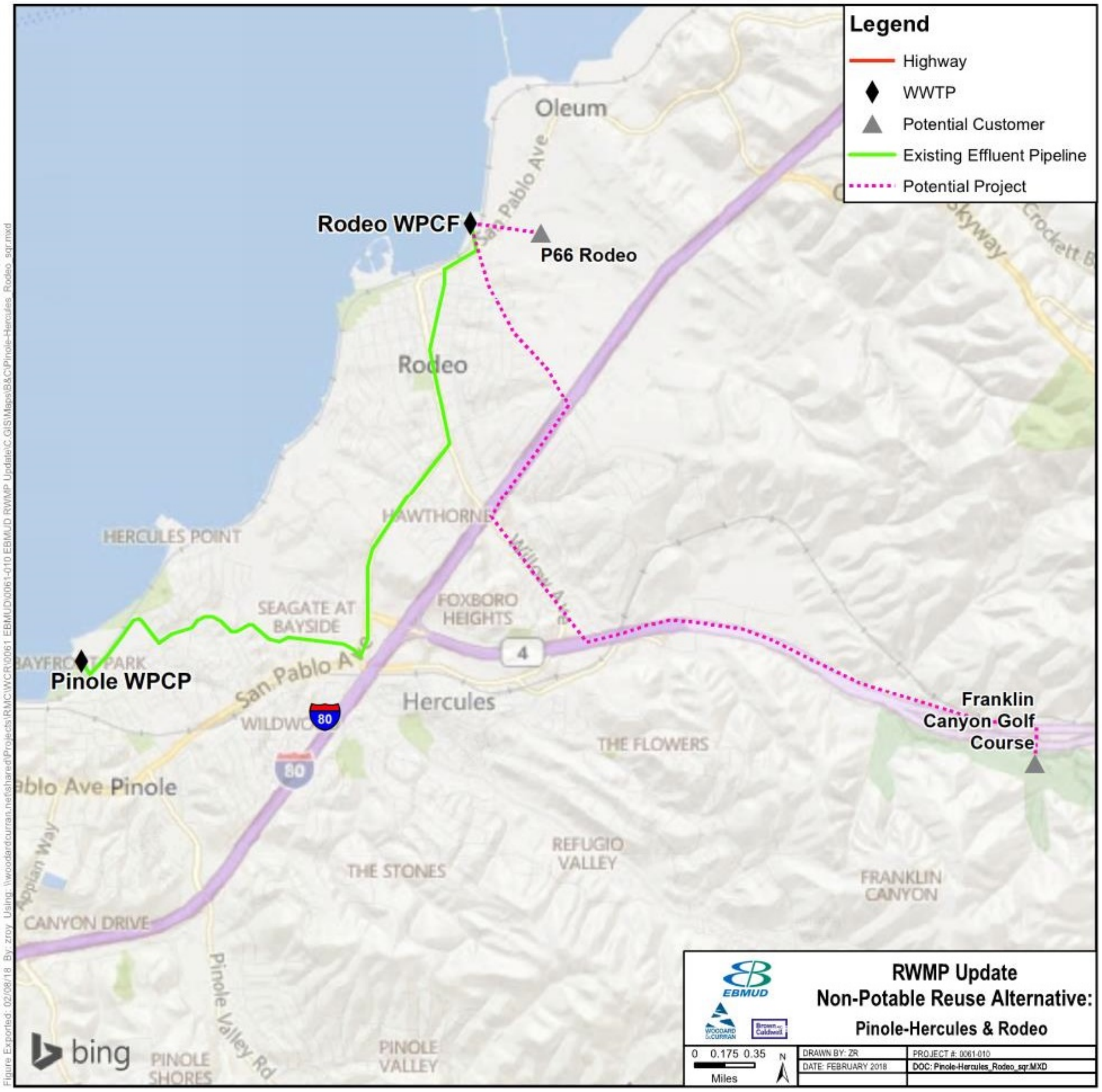
This project is retained for further consideration. The project is technically feasible; however, the available water supply has decreased in recent years. From an implementation complexity and environmental justice, this project is similar to the Chevron/Richmond WPCP alternative. The Refinery has expressed interest in pursuing this project, but additional partnerships with Rodeo and Pinole would be required. The 2005 MOU addressed the technical feasibility of the project, hence new agreements to define responsibility, operation and cost would need to be developed. The District could use the Chevron Richmond Refinery agreement as a reference for this project. The District should continue conversations with the Refinery to further refine this project.

At this time, no other non-potable water projects are competing for the same source of water. However, the treated wastewater from Rodeo WWTP and/or Pinole-Hercules could be used for a potable reuse project as described in Section 4.

3.3.8 Franklin Canyon Recycled Water Project

The proposed project would supply 0.2 to 0.3 MGD (200 to 300 AFY) of recycled water from the Rodeo WPCF through a 4.5-mile pipeline to the Franklyn Canyon Golf Course for irrigation (WSMP, 2040). As shown in **Figure 3-9**, this project would use the same source of water as the Phillips 66 Refinery Recycled Water Project. The project cannot be served directly from the Pinole effluent pipeline, which carries secondary effluent. Due to insufficient flows for both projects and the long pipeline length, it was determined that the Phillips 66 would be prioritized over the Franklin Canyon Recycled Water Project. Other potential sources of wastewater include the Mountain View Sanitary District and Central Contra Costa Sanitary District (CCCSD) however, approximately 9 miles of pipeline would be required to convey the recycled water to the golf course. Therefore, no economically feasible options are available at this time and the project will not be included in the recycled water portfolio.

Figure 3-10: Franklin Canyon Recycled Water Project



3.3.9 Lamorinda Recycled Water Project

The District has considered several variations of a recycled water project to serve customers in Walnut Creek, Pleasant Hill, and the Lafayette, Moraga, and Orinda (Lamorinda) portions of its service area. This would require a partnership with CCCSD for distribution of their recycled water to District customers. The original market assessment and project alternatives for the Lamorinda area was developed in 1996 and proposed an extensive distribution system through the District's service area using the abandoned Shell high-pressure fuel line (purchased by CCCSD) as the major transmission line for the project. At that time, the proposed projects did not move forward as they were cost prohibitive at $7,500 to $13,300 per AF.

In 2004, after a new market assessment was prepared, it was determined that a project to serve wide reaching areas of Lafayette, Moraga and Orinda was likely not cost-effective. In 2015, CCCSD re-evaluated the cost to rehabilitate the

Shell pipeline to serve the Moraga Country Club and the Rossmoor Golf Course. The costs remained prohibitively high and there are no current plans to further evaluate this project. Therefore, a recycled water project using the existing Shell Pipeline is considered not feasible at this time and will not be included in the recycled water portfolio.

Several new smaller alternatives were considered in 2004 around CCCSD's existing recycled water distribution system, including the Reliez Valley Recycled Water Project discussed below. New projects would then be limited to the areas near the northern boundary of the District's water service area and closest to the CCCSD's recycled water system to take advantage of existing infrastructure (see **Figure 3-10**).

3.3.10 Reliez Valley Recycled Water Project

For this project, the District would partner with CCCSD to obtain recycled water from their existing system (Zone 1 pipeline) and distribute it to a limited set of customers in the District's service area in the northern portion of Lafayette. As described in the WSMP, potential landscape irrigation customers included two cemeteries, a golf course, and the City of Pleasant Hill with an estimated recycled water demand of up to 0.2 MGD (250 AFY). **Figure 3-10** shows the proposed distribution system from CCCSD to three potential "anchor" customers. As shown in **Table 3-13**, the combined annual average irrigation demand for the two cemeteries is 0.10 MGD. The Grayson Wood Golf Course is currently not in operation and there is no District irrigation account for this facility. The property is currently on the market for development, but it is unlikely that a new golf course or other project with a substantial irrigation demand will be operated in the future in this property. Other potential irrigation customers within the District's service area, such as Brookwood Park or the Sports Field Complex in Lafayette, do not have significant demands. Without an anchor customer, this project is not viable.

Table 3-13: Reliez Valley Recycled Water Project Annual Average Demand

Customer	Irrigation Demand (MGD)[1]					
	2012	2013	2014	2015	2016	Average
Oakmont Memorial Park	0.07	0.09	0.06	0.04	0.05	0.06
Queen of Heaven Cemetery	0.05	0.04	0.03	0.03	0.03	0.04
Grayson Woods Golf Course	Not in operation					
Total						**0.10**

Notes:

1. Source: District water meter data (2012 to 2016).

Figure 3-11: Reliez Valley Recycled Water Project

3.3.11 CCCSD Regional Project

The CCCSD is planning to expand its recycled water facilities to augment regional water supplies and is exploring wholesale recycled water opportunities such as supplying recycled water to nearby refineries. For this alternative, the District would pay CCCSD to deliver recycled water to nearby refineries which would free up potable water for transfer to the District. This alternative would require agreements between the District, CCCSD and CCWD. It is assumed that CCCSD would enter into agreements with the refineries. A detailed analysis of water resource benefits of this option is outside the scope of this study.

The District can accept water from CCWD at the existing EBMUD-CCWD intertie. The *Los Vaqueros Reservoir Expansion Project Draft Supplement to the Final EIS/EIR* dated June 2017 describes the project components for Los Vaqueros Reservoir Expansion Project. A new high-lift pump station would be required to lift water from CCWD's Los

Vaqueros Pipeline to the District's Mokelumne Aqueduct #2. The District would need to purchase land for the pump station. Variable Frequency Drives (VFDs) would be installed at the District's Walnut Creek Pumping Plant to assist with managing flow rates on the Mokelumne Aqueduct. This would require construction of two new buildings on the District property. Treatment upgrades would also be required to allow the District to treat water from Delta sources which have a different water quality. It is assumed that the costs associated with these facilities are included under a separate project.

CCCSD currently produces an average of 1.6 MGD of recycled water. Most of it is sent to Zone 1 customers for landscape irrigation. The 2035 projected average dry weather flow at CCCSD are 41 MGD and the projected seasonal average Title 22 recycled water demand is 5.5 MGD, hence an average of 35.5 MGD is available for recycled water production in the future. The currently available dry weather flow is approximately 24 MGD (see **Table 4-5**). There are opportunities to offset raw water use at neighboring refineries by supplying high-quality recycled water. The refineries currently use a combined total of 20 MGD of raw canal water supplied by CCWD for their cooling tower, boiler feedwater and other processes. Supplying recycled water to the refineries would require treatment upgrades to remove ammonia, and possibly total nitrogen and dissolved salts. The level of treatment depends on the water quality the refinery will accept. If water quality equivalent to canal raw water is required, chloride would need to be removed. However, the refinery may be able to accept a lower water quality. This would need to be negotiated. The two costs discussed below represent the range of costs based on water quality requirements.

The capital costs to produce 20 MGD of recycled water for the refineries was previously presented in *CCCSD's Recycled Water Wholesale Opportunities Report* dated March 2016, adapted from the *November 2013 Refinery Recycled Water Update*. The report finalized in March 2016 summarizes the capital and O&M costs for tertiary treatment with nitrification, disinfection, cloth filtration, pipeline rehabilitation and modifications to the refineries' facilities, but do not include RO because it assumes a lower water quality would be acceptable. The 2016 capital and O&M costs were $135 million and $11 million per year respectively.

More recently, the *CCCSD's Comprehensive Wastewater Master Plan* dated June 2017, presented the capital costs to produce 20 MGD of recycled water assuming a water quality equivalent to canal water. Planned treatment upgrades include addition of an MBR, UV and RO for refinery recycled water. The MBR/RO system could be expanded in 5 MGD increments according to water demands from the refineries. Recycled water would be disinfected using UV. The cost for the 20-MGD alternative are summarized on the next page in **Table 3-14**. These costs are higher compared to the previous 2016 costs because a higher recycled water quality requirement is assumed. Both costs included costs to rehabilitate the existing distribution pipeline to the refineries.

This is an institutionally complicated project that will require multiple agreements and treatment upgrades to implement. Upgrades at CCCSD are needed to meet refinery water quality objectives. Infrastructure requirements from the District perspective are anticipated to be minimal and are assumed to be included under a separate project. Additionally, financial agreements between CCWD and CCCSD and the District will be needed to address operation of facilities and the cost of water. It is recommended that this project continue to be carried forward so that these details can be further developed to determine the feasibility of the project.

Table 3-14: CCCSD Regional Project Costs

	June 2017 Dollars		Dec. 2017 Dollars[4]			
	Capital Cost ($M)	O&M ($Mil/yr)	Capital Cost ($M)	O&M ($M/yr)	Annual Demand (AFY)	Annualized Total Cost ($/AF)[5]
Treatment[1, 2]	286	8.9	291	7.5		1,000
Recycled Water Conveyance[3]	29	0.1	29	1.6		100
Total	**315**	**9.0**	**320**	**9.1**	**22,400**	**1,100**

Notes:

1. Source: Carollo and CH2M, 2017. Central Contra Costa Sanitary District's Comprehensive Wastewater Master Plan. Final. June 2017.
2. Capital costs include treatment and conveyance to supply 20 MGD of recycled water to refineries. Costs include a 23-MGD MBR/UV, a 14-MGD RO, electrical upgrades, and distribution pipeline rehabilitation.
3. Assume existing distribution system (i.e., CCWD Recycled Water Pipelines to Shell and Tesoro) would be used to convey recycled water to the refineries, but pipeline would require rehabilitation.
4. Capital and O&M costs (from source) were updated to December 2017 dollars using ENR CCI ratios for 20 Cities Average.
5. Annualized total cost is calculated using methodology outlined in Section 2.2.

3.3.12 Contra Costa Pipeline in Canal Right of Way

The Contra Costa Canal (Canal) is an aqueduct in Contra Costa County that is used for agricultural, industrial and non-potable municipal water purposes. Prior to the construction of the Shortcut Pipeline and the Multi-Purpose Pipeline, the Canal was the central conveyance facility. Since 2012, its primary purpose is to provide redundancy to the Shortcut Pipeline and to convey raw water to approximately 40 customers with a total demand of approximately 0.83 MGD. Due to high maintenance costs and relatively low water sales for a 25-mile canal, CCWD is considering alternatives to reduce its operational costs.

The Canal provides water for a portion of the CCWD's service area, but it also borders the District's service area as it crosses through Walnut Creek and Pleasant Hill. According to District Water Conservation staff, Diablo Hills Golf Club is a District customer that has been using water from the canal for irrigation. Since CCWD is looking at decommissioning the Canal, the Diablo Hills Golf Course would need to connect to the District's potable water system.

Instead of repurposing the canal to distribute recycled water from CCCSD, CCWD's preference is to install a new pipeline in the canal right of way. This would prevent the recycled water from ending in Mallard Reservoir. Furthermore, the use of a pipeline would allow the water to be delivered at pressure – eliminating the need for a booster pump at each location along the canal. The new recycled water pipeline could be used to serve the Diablo Hill Golf Course and other nearby District customers such as Heather Farms**. Table 3-15** shows the annual average irrigation demand for the golf course and the portion of Heather Farm Park that is in the District's service area. As shown, the total District customer demand is small (i.e., 51,000 gpd) compared to the total customer demand of 0.83 MGD. **Table 3-16** summarizes the costs for this alternative.

The recycled water pipeline originating in the canal near the CCCSD wastewater treatment plant and ending at the Concord Naval Weapons Station (CNWS), is an attractive alternative if interagency agreements can be reached between the CCWD, CCCSD, and the CNWS developer. This alternative could be implemented independently of the Naval base conversion and be used to help CCWD meet its 2020 water conservation goals. It could also be implemented in a phased approach – an untreated water pipeline can be constructed and then converted to recycled water later. The District would be able to offset approximately 50,000 gpd of potable water use in the area. Without the connection of the recycled water pipeline to the other CCWD customers, this alternative would not be economically feasible due to the low demands.

The project will deliver recycled water to approximately 40 customers. However, District's customers estimated annual average demand is only 51,000 gpd. Therefore, the benefits to the District are limited. Without recycled water delivery to CCWD customers this project would not be economically feasible; the low unit cost indicated in **Table 3-16** is based on participation of numerous CCWD customers. It is recommended that the District continue discussions with CCWD to better define the project.

Table 3-15: Annual Average Irrigation Demands

District Customer	Irrigation Demand (gpd)
Diablo Hills Golf Course	47,000[1]
Heather Farm Park	4,000[2]
Total District Customer Demand	**51,000**

Notes:

1. 2011 Data. Source: Carollo, 2013. Contra Costa Water District Untreated Water Facilities Improvement Program Plan Update. Final. July 2013.
2. 2010 Data. Source: EBMUD, 2016b. Using Water from Contra Costa Canal Preliminary Evaluation Summary. June 2016.

Table 3-16: CCWD Pipeline in Canal ROW Project Costs

	2013 Dollars[1]		2017 Dollars[5]			
	Capital Cost ($M)	O&M ($M/yr)	Capital Cost ($M	O&M ($M/yr)	Annual Demand (AFY)	Annualized Total Cost ($/AF)[7]
Treatment[2]	NA	NA	NA	NA		NA
Recycled Water Conveyance[3, 4]	27	NA	30	0.78		2,000
Total	**27**	**NA**	**30**	**0.78**	**900[6]**	**2,000**

Notes:

1. Source: Carollo, 2013. *Contra Costa Water District Untreated Water Facilities Improvement Program Plan Update*. Final. July 2013.
2. Cost to augment CCCSD tertiary treatment capacity, if needed, is not included.
3. Recycled water conveyance capital costs include 18.5 miles of 28-inch, 18-inch, and 6-inch diameter HDPE pipeline, a pump station and a hydropneumatic tank. Costs do not include shortcut pipeline redundancy alternative. Conversion of Castle Rock Water Company customers to treated water is also not included.
4. Recycled water conveyance O&M costs were not available. Operations and maintenance costs are reduced significantly because the pump station and pipeline maintenance are relatively minimal. Recycled water would be purchase from CCCSD at approximately $200 per acre-foot (compared to current cost of up to $80 per acre-foot). Therefore, an annual cost increase of up to $140,000 would have to be absorbed by CCWD or passed on to customers.
5. Capital costs (from source) were updated to December 2017 dollars using ENR CCI ratios for 20 Cities Average. 2017 O&M cost estimates for the conveyance system were estimated using methodology outline in this study and include labor, electricity and consumables (see Appendix A for details).
6. EBMUD customers make up less than 60 AFY of demand. Unit costs would be considerably higher without CCWD participation.
7. Annualized total cost is calculated using methodology outlined in Section 2.2.

3.3.13 UC Berkeley's Global Campus, Richmond

The UC Berkeley Global Campus at Richmond Bay was originally developed as a project concept with funding from Lawrence Berkeley National Lab and known as the Richmond Bay Campus. The project proposed to serve as a new research and action hub in Richmond with a focus on global issues, culture and collaboration. The proposed project site is approximately 133 acres, it is located in the City of Richmond and within the District's ultimate service area. In 2013, the District prepared a water supply assessment for the Richmond Bay Campus 2013 Long Range Development Plan. At the time, the average water use was approximately 52,000 gallons per day, and future average water demands for the proposed project were approximately 932,000 gpd (EBMUD, 2013). This demand was accounted for in District's Urban Water Management Plan (EBMUD, 2015b).

The District's current recycled water distribution pipeline ends approximately 3 miles from the project site. Due to the proximity to the District's existing recycled water distribution system, projects in this area present opportunities for recycled water uses that can be served by expanding recycled water pipelines in the future.

In 2016, UC Berkeley indefinitely suspended plans to physically develop the Berkeley Global Campus at Richmond Bay due budgetary challenges confronting the University. Therefore, this project will not be included in the recycled water portfolio at this time.

3.4 Satellite Recycled Water Projects

Satellite recycled water treatment plants (SRWTP) take raw sewage from a sewer pipeline and treat it to meet the Title 22 standard required for a specific project. These systems can serve large water users that are located far from a centralized treatment facility. The District has identified several potential satellite recycled water treatment plant projects that could provide recycled water to customers.

3.4.1 Rolling Hills Cemetery

Rolling Hills Memorial Park is a cemetery in Richmond, Contra Costa County. The WSMP 2040 demand estimates were 0.05 to 0.18 MGD (50 to 200 AFY). The cemetery is in WCWD service area and WCWD wastewater flows are dedicated to the Chevron Richmond Refinery Project. Therefore, the main constraint is the wastewater availability in the area. Because of limited supply, the Chevron Richmond Refinery Project would be prioritized over the Rolling Hills Cemetery satellite project. Therefore, this project was not included in the water reuse portfolio.

3.4.2 Diablo Country Club

The Diablo Country Club (DCC) is a 120-acre golf course located in Contra Costa County, California, at the base of Mount Diablo. The District provides potable water service to the DCC and CCCSD provides wastewater collection and treatment services. The DCC's major water use is golf course irrigation. As early as 2004, the DCC has been investigating the use of recycled water for golf course irrigation. The DCC has been proactive in pursing measures to improve irrigation efficiencies, reducing potable water demand and decreasing its operating costs.

In 2012, the District signed a MOU with the DCC and CCCSD in which the parties agreed to cooperate on a feasibility study to evaluate the use of a satellite recycled water treatment plant to provide a portion of the irrigation water for the DCC golf course. Approximately 25 percent of the irrigation demand would continue to be purchased from the District. The feasibility study recommended a satellite project that could recycle up to approximately 0.51 MGD of sewage from the CCCSD collection system to provide water for irrigation. This would be equivalent to an annualized average flow of 0.22 MGD. A second MOU to better define the project, responsibilities, and fees was executed in 2015. In June 2017, the DCC in coordination with CCCSD requested proposals for design-build services to design and construct the Satellite Water Recycling Facility, including the diversion structure, pump station and force main at the club. The RFP also requested proposals for financing options. At the time the RFP was released, the environmental review process was still ongoing. The RFP will be re-issued in 2018. It is worth noting that while the project will be located on DCC property, the project will eventually be owned and operated by CCCSD.

Table 3-17 summarizes the project costs. Capital costs are based on an MBR system sized to provide 100 percent of the irrigation demand. **Figure 3-12** shows the potential location of the satellite facility and points of sewage diversion. Untreated wastewater would be diverted from the sewage diversion station to the satellite facility and would be split into two parallel treatment trains to provide system redundancy. The treatment train also includes fine screen headworks, and UV disinfection. The disinfected irrigation water would be pumped to the existing golf course ponds, where it would be blended with potable water, and potentially surface water flows or groundwater. To reduce regrowth in the recycled water storage and distribution system, minimal chlorine dosing with on-site generated sodium hypochlorite is recommended. Debris from the fine screens would be hauled off-site for disposal. Waste activated sludge would be returned to the sewer collection system.

DCC is pursuing a self-financing model. Their studies have shown that the satellite project would pay for itself, while eliminating the risks associated with drought restrictions.

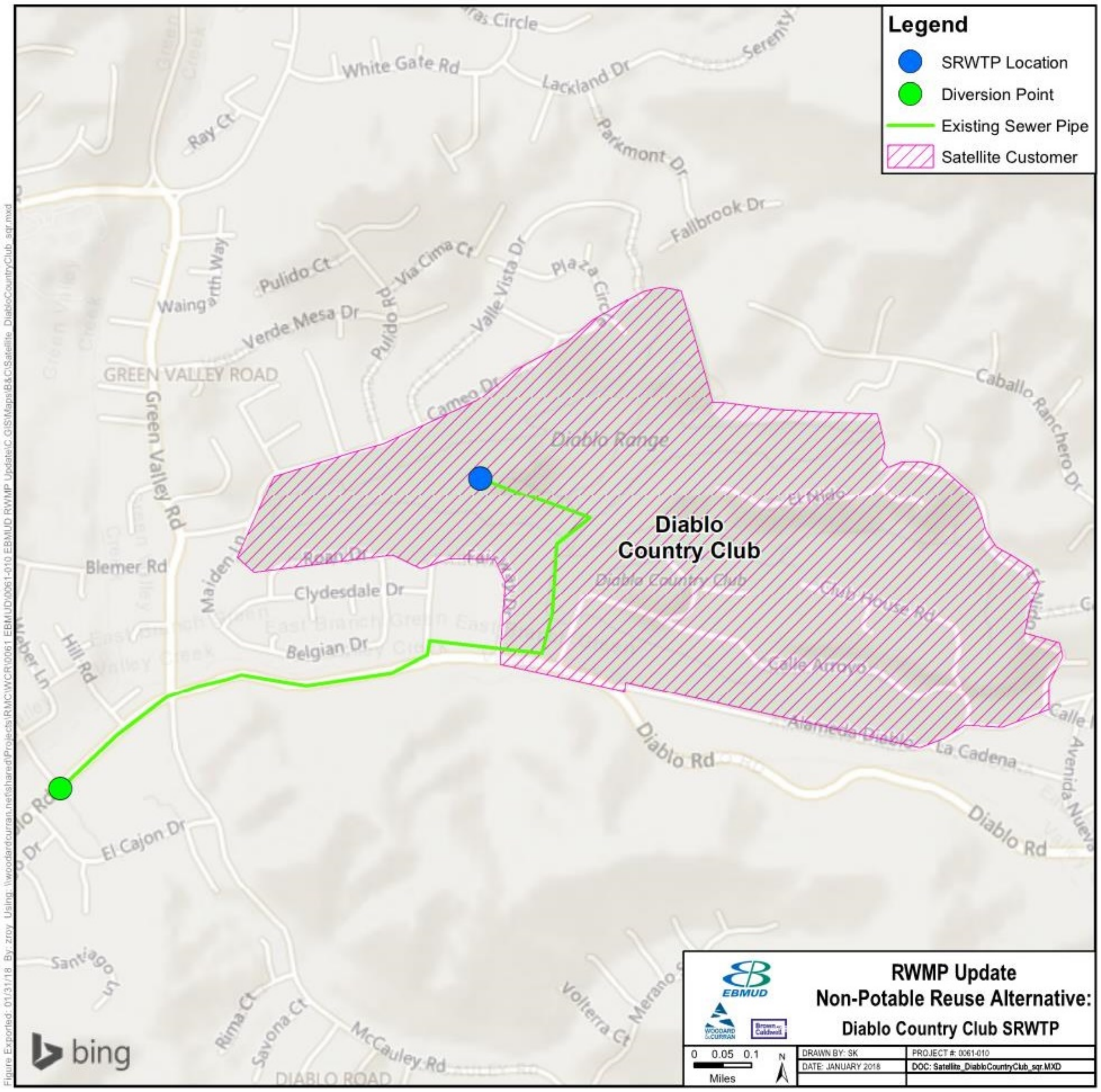
Table 3-17: Diablo Country Club Satellite Project Costs

	2013 Dollars[1]		2017 Dollars[4]			
	Capital Cost ($M)	O&M Cost ($M/yr)	Capital Cost ($M)	O&M Cost ($M/yr)	Annual Demand (AFY)	Annualized Total Cost ($/AF)[6]
Treatment[2]	7.6	0.35	10.4	0.43		3,600
Recycled Water Conveyance[3]	0.4	0.01	0.6	0.02		300
Total	**8.0**	**0.36**	**11**	**0.45**	**250**	**3,900**

Notes:

1. Source: Brezack & Associates Planning, LLC, 2013. Diablo Country Club Satellite Recycled Water Treatment Plant Feasibility Study. September 2013.
2. Treatment capital costs include sewer diversion and treatment process facilities. 2013 O&M costs were based on 5 percent of construction cost.
3. Recycled water conveyance capital costs include recycled water storage, pump station and pipeline.
4. Construction costs (with sales tax and overhead profit) were updated to December 2017 dollars using ENR CCI ratios for 20 Cities Average. O&M costs were updated from original estimate based on ENR ratios and updated energy costs.
5. Annualized total cost is calculated using methodology outlined in Section 2.2. Overall methodology, including the use of a higher discount rate (i.e., 3 percent vs 2 percent) compared to original estimate, results in a higher annualized total cost than presented in the 2013 Feasibility Study.

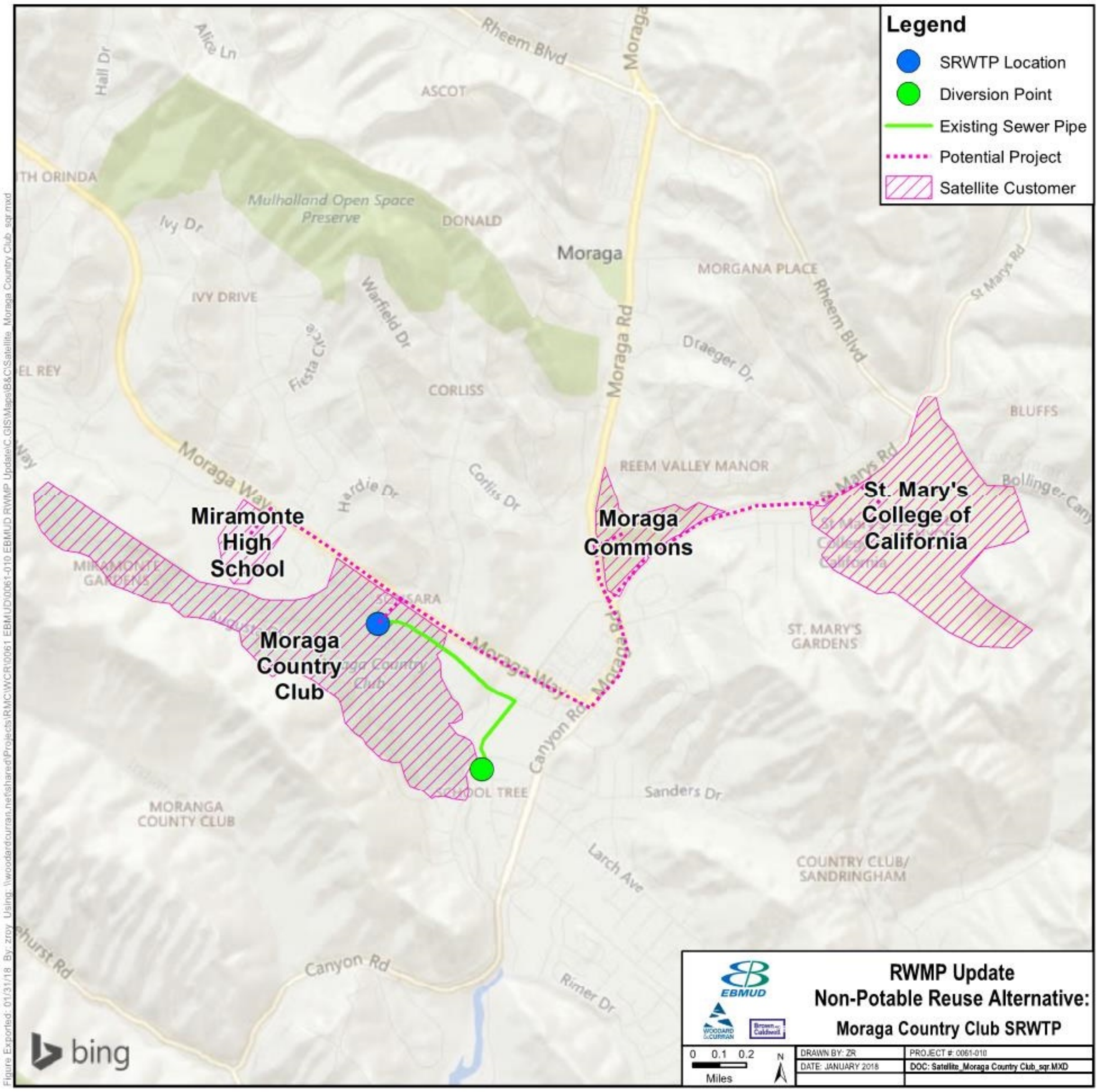
Figure 3-12: Diablo Country Club Satellite Project



3.4.3 Moraga Country Club and Nearby Potential Customers

The District, the Moraga Country Club (MCC) and CCCSD entered into a MOU that set forth principles for the MCC satellite treatment project. The original project was defined to serve only the MCC. Future phases may be implemented to serve other nearby potential recycled water users such as Miramonte High School, Moraga Commons, and St. Mary's College. **Figure 3-13** shows the location of the proposed satellite facility for the MCC and the potential distribution system to other customers. This section descries two alternatives: one for the country club only, and one to serve MCC and nearby users in addition to the country club.

Figure 3-13: Moraga Satellite Project



3.4.3.1 Moraga Country Club

The MCC project would provide up to 0.5 MGD of recycled water for golf course irrigation, to meet the annual average demand of 0.16 MGD (180 AFY). In 2009, MCC completed a feasibility study (RMC, 2009) to determine the preliminary sizing of the satellite facility to serve the golf course. Based on monthly potable water use for golf course irrigation between 2006 and 2008, the peak water demand occurs in the month of July and a 0.5-MGD satellite facility would produce the average day water demand in the peak month. Recycled water storage would be used to satisfy peak day demands. The existing storage ponds, adjacent to Hole 9, are used to store potable water for irrigation. In the future, these ponds could be used for recycled water storage. Based on 2006 to 2008 data provided by CCCSD, the Moraga

Pump Station, has adequate wastewater flow to satisfy the demand. However, hourly flow data would need to be reviewed to confirm these assumptions.

The flow diverted and pumped from the Moraga Pump Station to the satellite facility would be split into two separate trains within the satellite treatment plant. The process train includes fine screening (1 to 3 mm screens), biological process (anoxic and aeration tanks), membrane filtration, and UV disinfection system. Following disinfection, the recycled water would be routed to the Hole 9 storage ponds for distribution using existing system. Screenings would be compacted and hauled offsite. Waste sludge, fine screen washwater and membrane cleaning solutions would be pumped to the sanitary sewer.

Table 3-18 summarizes costs for the satellite project. Capital cost includes two new feed pumps to be installed at the existing Moraga Pump Station, new pipeline alignments (raw wastewater, recycled water and waste), and treatment facilities for a traditional design-bid-build project delivery approach. However, MCC is a private entity and can elect to do a design-build contact, sole-source the project to expedite the design and construction processes and ultimately reduce capital costs. The District is looking for the MCC to self-finance the project.

Construction of a satellite recycled water facility at MCC would require an agreement between the District and MCC defining ownership, operations, and cost responsibilities. There are several examples in the Bay Area of public-private partnerships that could be used as a reference. One example within the District's service area is the DCC. The District provides potable water service to DCC and CCCSD provides wastewater collection and treatment services to the club. If the DCC project moves forward, it is anticipated that CCCSD would eventually own and operate the satellite recycled water treatment plant at DCC. It is worth noting that the annual average demands used in this study are based on District water meter data (2012 to 2016) which are lower than previously evaluated. Current demands are slightly above 150 AFY (0.13 MGD), which is the threshold set in this study to retain projects for further consideration based on the project recycled water demand. Because the recycled water demands have decreased but the capital costs remain the same, the project would have a higher unit cost than presented in previous studies.

Table 3-18: Moraga Country Club Satellite Project Costs

	2009 Dollars[1]		2017 Dollars[5]			
	Capital Cost ($M)	O&M Cost ($M/yr)	Capital Cost ($M)	O&M Cost ($M/yr)	Annual Demand (AFY)[6]	Annualized Total Cost ($/AF)[7]
Treatment[2, 3]	9.9	0.12	14	0.15		4,600
Recycled Water Conveyance[4]	0	0	0	0		0
Total	**10**	**0.12**	**14**	**0.15**	**180**	**4,600**

Notes:

1. Source: RMC, 2009. Moraga Country Club. Satellite Recycled Water Treatment Plant. Detailed Feasibility Study. September 2009.
2. Treatment capital costs includes two submersible pumps, pipeline alignments (raw wastewater, recycled water and waste) and treatment facilities for a traditional design-bid-build project (above ground). Capital costs were $9.9 and $10.2 million for above-ground and below-ground construction, respectively. The cost for above ground are used in this analysis.
3. Treatment O&M costs include energy, chemical use, membrane replacement, UV replacement, and labor.
4. Recycled water to be used on-site. Therefore, conveyance costs are assumed to be minimal compared to treatment.
5. Construction costs (with contingency) and O&M costs were updated to December 2017 dollars using ENR CCI ratios for 20 Cities Average.
6. Annual demands were updated based on (2012 to 2016) District water meter data (see **Table 3-17**).
7. Annualized total cost is calculated using methodology outlined in Section 2.2. Overall methodology and the use of lower demands results in a higher annualized total cost than presented in the 2009 Feasibility Study.

3.4.3.2 Moraga Area Expansion

In the future, the MCC Satellite Recycled Water Treatment Plant could serve other nearby potential recycled water customers such as Miramonte High School, Moraga Commons and St. Mary's College (see **Figure 3-12**). **Table 3-19** summarizes the annual average irrigation demands for each of the potential customers, including MCC, for a total of 0.22 MGD (or 250 AFY). The irrigation water demands for MCC have decreased in recent years. Based on District water meter data, the club uses about 0.16 MGD (annual average) with a peak month consumption of about 0.4 MGD in the month of July. As a result of these decreased demands, a 0.5-MGD MCC satellite facility would produce enough water to meet the estimated peak month demands for both the club and other nearby customers. This would require extension of the recycled water pipeline to serve other customers.

Table 3-20 summarizes the cost for this alternative, including the additional cost to distribute recycled water (i.e., distribution pumps, distribution pipeline and electrical infrastructure). A distribution booster pump at the satellite facility would pump recycled water for delivery to other customers. Electrical infrastructure needed for implementation includes installation of electrical equipment and power distribution. In addition to the recycled water storage provided at the satellite facility site, each customer would need to provide a storage tank for recycled water storage prior to distribution. This alternative assumes adequate wastewater flows are available to satisfy the demand. However, as noted in Section 3.4.3.1, the available wastewater flows (including hourly data) would need to be verified to confirm the assumption that local flows could support a 0.5 MGD facility.

Compared to the MCC satellite facility only serving MCC, service to other customers is a very different model with institutional challenges. MCC is a private entity and the satellite treatment facility would be located on their property, but the recycled water would be distributed to other customers in the area. Similar to other private-public projects, agreement between the District, MCC and other customers would need to define ownership, operations and cost responsibilities. Because of these complexities, this project is rated lower than MCC.

Table 3-19: Moraga Area Distribution Customer Annual Average Demand

Customer	Irrigation Demand (gpd)[1] 2012	2013	2014	2015	2016	Average
MCC	157,900	184,500	165,700	125,900	141,600	155,100
Moraga Commons	13,400	16,300	11,200	9,700	11,100	12,300
Miramonte	No irrigation specific account					16,500[2]
St. Mary's College	No irrigation specific account					34,700[2]
Total						**218,600**

Notes:

1. District water meter data.
2. Based on grass area calculation. Assumes 0.1 in/acre/day irrigation and 95 recycled water percentage.

Table 3-20: Moraga Area Recycled Water Expansion Costs

	2017 Dollars Capital Cost ($M)	2017 Dollars O&M Cost ($M/yr)	Annual Demand (AFY)	Annualized Total Cost ($/AF)
Treatment[1]	19	19		4,500
Recycled Water Conveyance/Storage[2]	4	4		1,200
Total	**23**	**23**	**250**	**5,700**

Notes:

1. Treatment costs were calculated for this alternative using unit costs for MBR/UV/Chlorine train, which resulted in similar unit costs but higher total capital and O&M costs compared with the MCC alternative.
2. Recycled water distribution costs include pump station, piping and storage tanks for each customer location. Capital cost estimates do not include land acquisition. O&M costs include pumping energy and pipeline maintenance.

3.4.4 Orinda Country Club

The Orinda Country Club is a private club located in the foothills east of the San Francisco Bay. The club is sited in a 250-acre property and includes a golf course. The club currently uses creek water for irrigation and recycled water use is not anticipated in the future. Therefore, this project was not retained for further consideration.

3.4.5 Mountain View and St. Mary's Cemeteries

The Mountain View Cemetery and St. Mary's Catholic Cemetery are located adjacent to one another in the foothills of Oakland (see **Figure 3-14**). The Mountain View Cemetery is owned by the Mountain View Cemetery Associated and is the larger of the two cemeteries. The cemeteries were previously evaluated as part of the 2005 Satellite Treatment Feasibility Study. A demonstration satellite project was proposed at the 223 acre-site to develop between 100 and 200 AFY of recycled water for irrigation. No fatal flaws were found. However, at the time, the Mountain View Cemetery was pursuing other potential alternatives to conserve water and was looking to implement lower-cost measures.

Table 3-21 summarizes the annual average irrigation demands for both cemeteries. The 2040 projections were based on demand data from 1999 to 2003. More recent data (2014 to 2016) shows the irrigation demands are lower than previously projected. The Mountain View Cemetery currently uses onsite lakes to collect stormwater runoff. This water is pumped back through the on-site irrigation system to supplement well water irrigation during dry summer months. Because the cemetery is now using surface water runoff and groundwater for irrigation, the current demands have decreased significantly compared to values used in the WSMP 2040. The demands for St. Mary's Cemetery alone would not make this project feasible. Therefore, this project was not included in the recycled water portfolio.

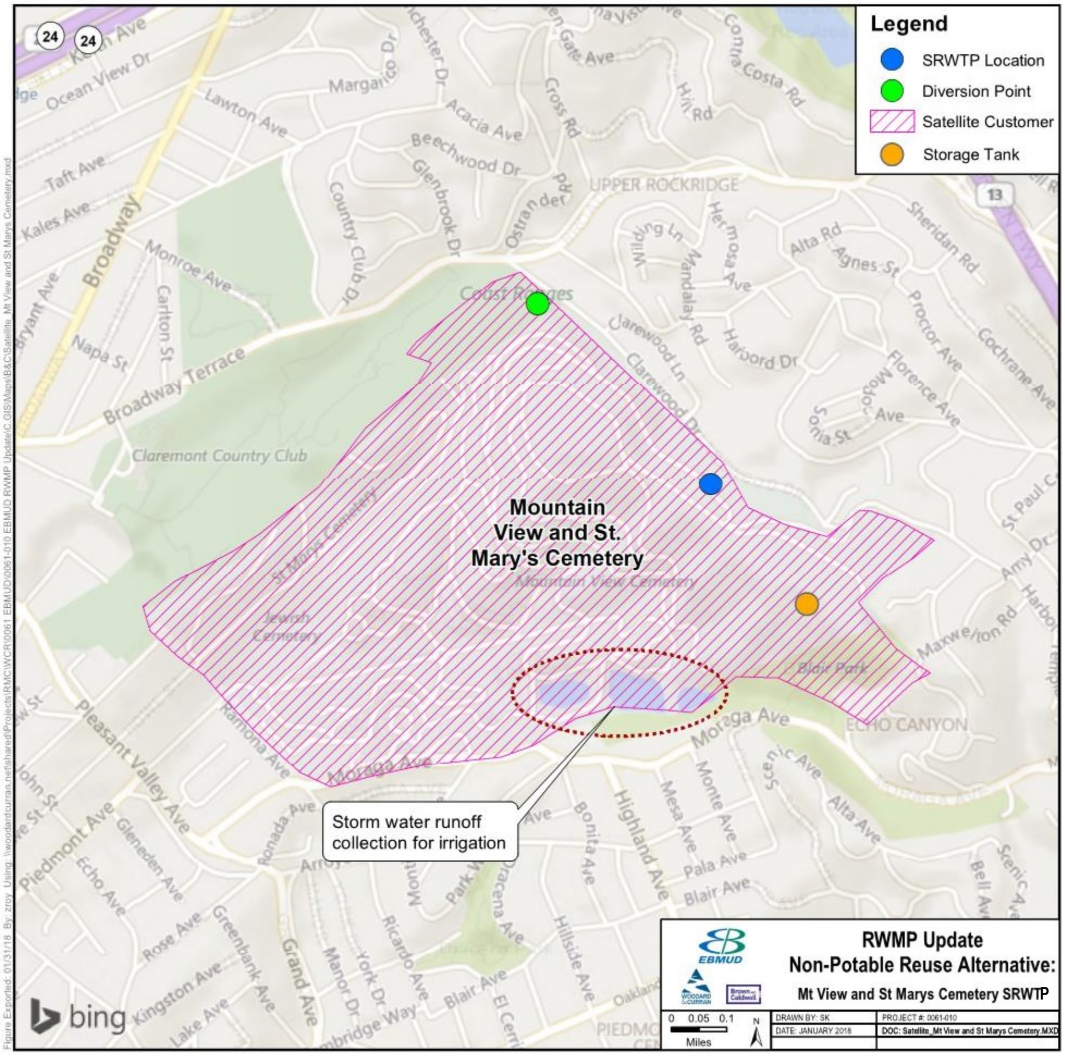
Table 3-21: Mountain View/St. Mary's Cemeteries Satellite Annual Average Demand

Customer	Irrigation Demand (gpd)		
	1999 to 2003[1]	2040 Projections[2]	2014 to 2016[3]
Mt. View Cemetery	160,000	191,000	9,200
St. Mary's Cemetery	40,000	63,774	26,000
Total	**200,000**	**254,774**	**35,200**

Notes:

1. EBMUD, 2005. Satellite Recycled Water Treatment Plant Feasibility Study. Draft.
2. WSMP 2040
3. District water meter data (2014 to 2016).

Figure 3-14: Mountain View/St. Mary's Cemeteries Satellite Project



3.4.6 Rossmoor Country Club

Rossmoor Country Club (RCC) is located in the retirement community of Rossmoor in Walnut Creek. For this master plan update, a brief evaluation was conducted regarding the feasibility of using a satellite treatment facility for irrigation of the RCC golf course, the adjacent Community Gardens (1800 Rossmoor Pkwy) and the adjacent Tice Valley Park. **Figure 3-15** shows the potential location of the satellite facility within the golf course site, the point of sewer diversion and the distribution pipeline to the nearby customers.

District water meter data was reviewed for each of the potential customers. **Table 3-22** summarizes the customers annual average demands (2012 to 2016). On average, all three customers use less than 100,000 gallons per day (or less than 0.1 MGD) of potable water. The maximum month demand during dry weather months (June to August) is approximately 0.3 MGD (compared to 0.35 MGD potable water use previously reported). A small satellite facility could be sized to meet the max month demand of the club and the nearby customers (about 0.3 MGD), with peak flow demands supplemented with supply from the on-site reservoir.

CCCSD's average dry weather sewer flow from the entire Rossmoor Retirement Community was reported to be approximately 0.5 MGD (based on flows measured at the Rossmoor sewer shed outlet as indicated in **Figure 3-15**), which would be sufficient to serve the estimated peak day demands.

Table 3-22: Rossmoor Area Distribution Customer Annual Average Demand

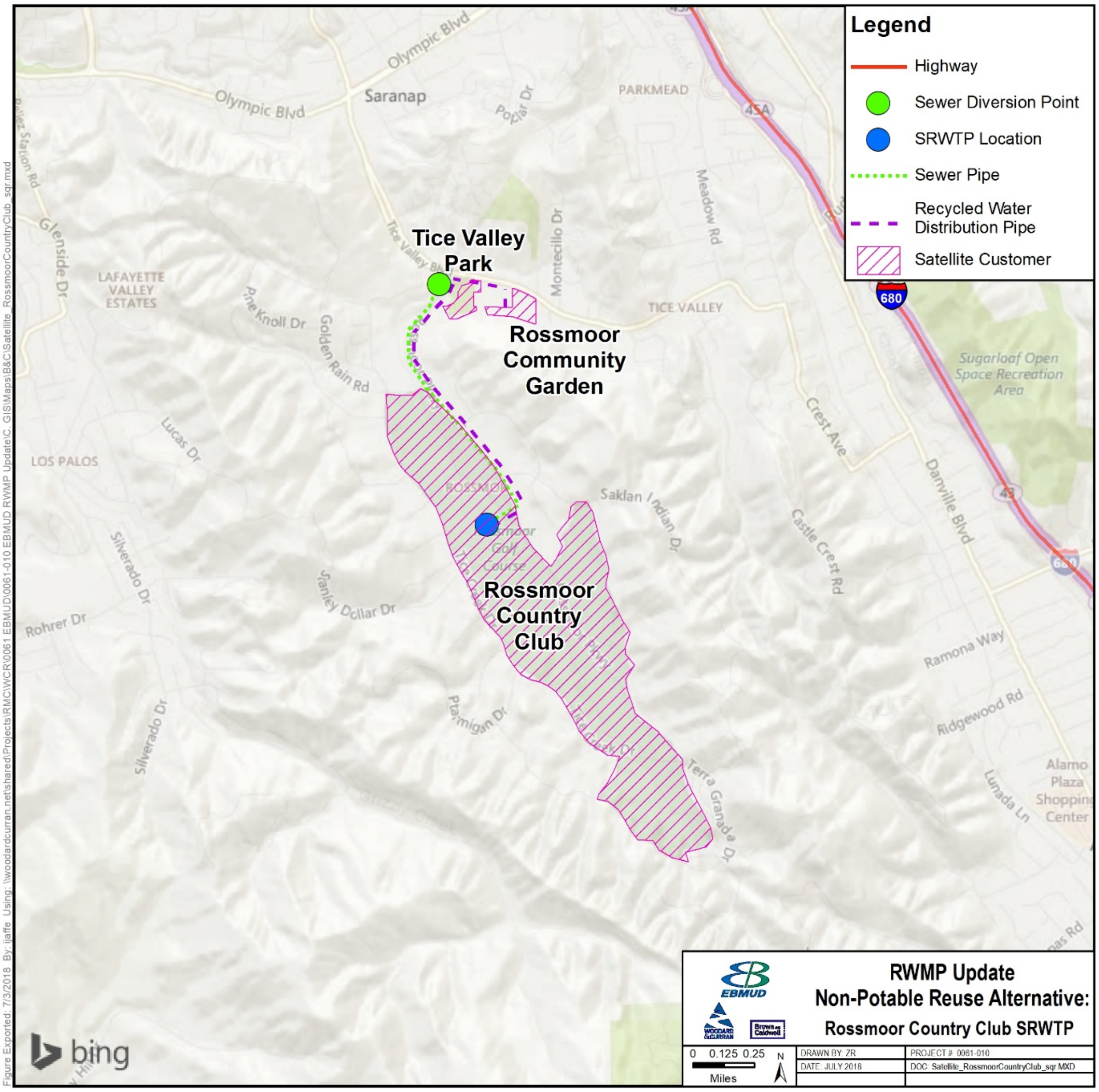
Customer	Irrigation Demand (gpd)[1]					
	2012	2013	2014	2015	2016	Average
RCC[2]	76,100	53,000	55,900	62,300	89,400	67,300
Community Gardens	6,100	6,600	4,700	2,100	7,300	5,400
Tice Valley Park	12,000	14,100	5,700	7,400	10,200	9,900
Total						**82,600**

Notes:

1. District water meter data.
2. Includes all Golden Rain Foundation accounts.

Due to limited cost effectiveness, only users with average annual demand greater than 150 AFY (0.13 MGD) were retained for further consideration in this study. Since the annual demand was below this threshold, this project was not retained for further consideration. However, the District would continue to support this project under a custom self-financing model similar to Diablo Country Club.

Figure 3-15: Rossmoor Country Club Satellite Project



3.4.7 UC Berkeley Main Campus

In 2005, the District completed a study to determine the feasibility of constructing a satellite demonstration project at two alternative service area locations within the University of California Berkeley (UCB) (EBMUD, 2005). Based on the study results, a small-scale demonstration recycled water facility was recommended to be installed at the Berkeley campus. The intend was to gain experience from the operation of a small-scale demonstration project to evaluate if a larger-scale project would be feasible in the future. Due to issues related to siting and unexpected construction costs, the District and UCB jointly decided to stop pursuing the small-scale demonstration project in 2006.

As part of the EBRWF Water Quality Improvements Project, the District is currently evaluating extension of the recycled water pipeline to serve UCB main campus irrigation demands**.** The proposed project will extend the EBRWF distribution system to the UCB main campus. If the UCB Satellite project were to proceed, the EBRWF Phase 2 demands would need to be adjusted to remove deliveries to UCB main campus. **Table 3-23** summarizes the 2040-projected irrigation demands for the entire UCB campus. The annual average and peak month demands are about 0.8 MGD and 1.5 MGD, respectively. The proposed project would divert raw wastewater from the existing local sewers to the new satellite recycled water treatment plant located at UCB. **Figure 3-16** shows the potential location of the satellite facility and sewer diversion point. Sewer trunk lines and property are managed by UCB which makes the potential development of a satellite treatment facility on the UCB campus more straightforward.

Table 3-24 summarizes the costs for the 1.5-MGD satellite facility project. Raw water will be pumped to the satellite facility for treatment. The proposed recycled water facility would be equipped with a fine screen for solids removal, an MBR, UV disinfection and a recycled water storage tank. An onsite hypochlorite generation system will provide sodium hypochlorite for disinfection residual in the recycled water storage tank and for potable water backup addition. To be consistent with the previous (2005) evaluation, it is assumed that land for a pump station, a satellite treatment facility and a storage facility is provided free of charge by UCB.

Table 3-23: UC Berkeley Main Campus Satellite Demand

UC Berkeley Customer	Projected Irrigation Demand (gpd)	
	2040 Average Day	2040 Max Month
UC Berkeley – Hearst Ave.	40,176	76,334
UC Berkeley – Oxford St.	9,829	18,675
UC Berkeley – Warring St.	39,317	74,702
UC Berkeley – Bancroft Way	545,972	1,037,347
UC Berkeley – Clark Kerr	143,157	271,998
Total Irrigation	**778,451**	1,479,056

Source: EBMUD, 2017. East Bayshore Recycled Water Expansion Study. Hydraulic Analysis of Future Pipelines and Demands.

Table 3-24: UC Berkeley Main Campus Satellite Project Costs

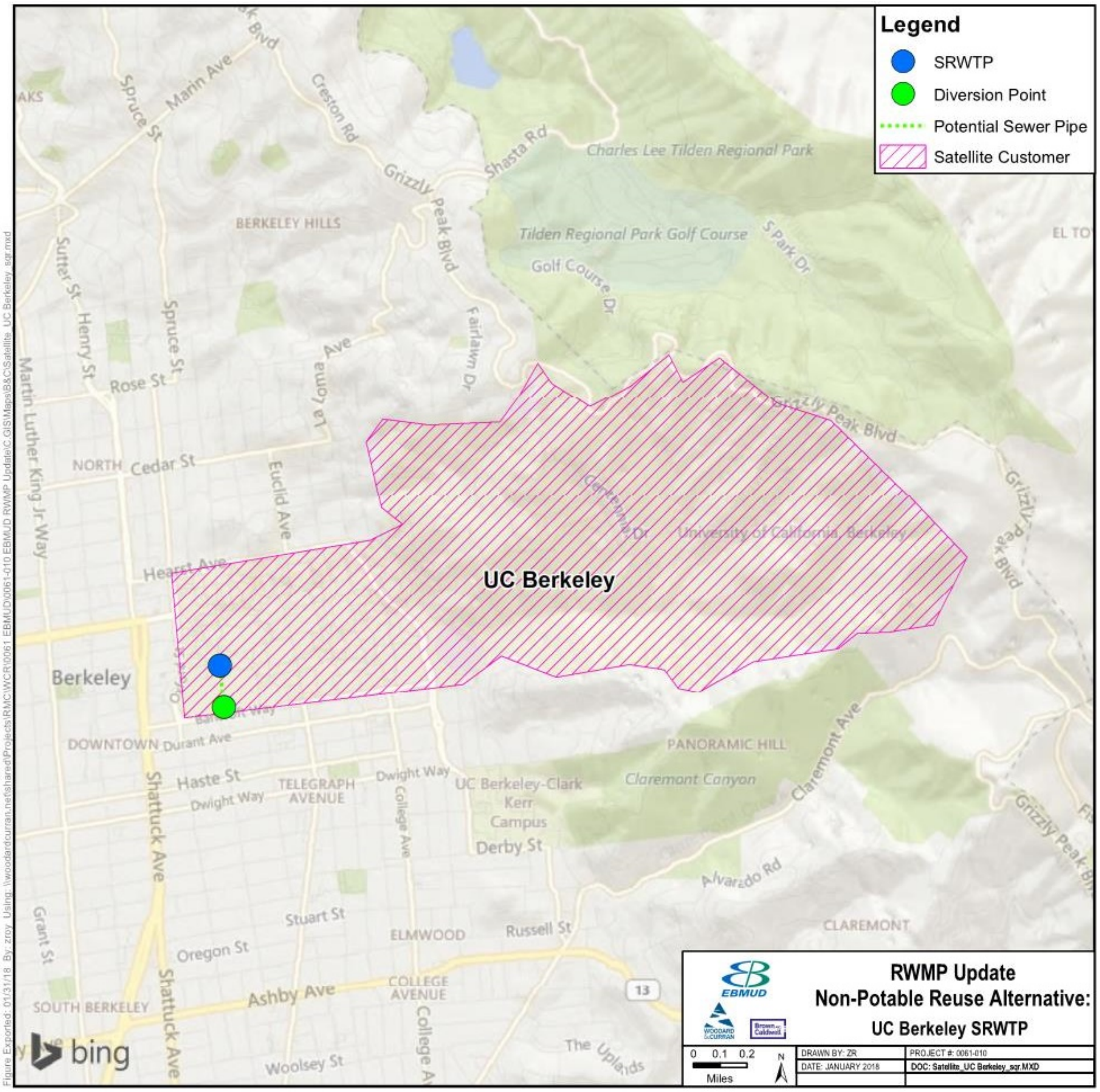
	2017 Dollars			
	Capital Cost ($M)	O&M Cost ($M/yr)	Annual Demand (AFY)	Annualized Total Cost ($/AF)
Treatment[1]	25	0.63		1,900
Recycled Water Conveyance[2]	11	0.21		1,00
Total	**36**	**0.84**	**900**	**2,900**

Notes:

1. Treatment capital cost estimate includes raw wastewater diversion and treatment facilities, and pipelines. Cost of land not included.
2. Recycled water conveyance cost estimate includes recycled water storage tank, pump station and pipeline within UCB campus.

Agreements between the District and UC Berkeley would need to be developed. Similar to the DCC satellite project, the District would be interested in having UC Berkeley self-finance construction of the satellite plant in lieu of paying the standard water rate. The responsibility of operation and maintenance of the treatment and sewer line diversion facilities would need to be discussed.

Figure 3-16: UC Berkeley Main Campus Satellite Project



3.4.8 Oakland Hills

In 2017, the District completed a feasibility study of the Oakland Hills alternative water supply (West Yost, 2017). The project would serve three large irrigation customers: Oakland Zoo, the Sequoyah Country Club (SCC) and the future Oak Knoll Development. A new satellite treatment plant would be located at SCC (highest elevation of the three) and distribute to serve all three customers (see **Figure 3-17).** It is assumed that Lake Chabot Golf Course will continue to use raw water from Lake Chabot for golf course irrigation. This option is one of several potential alternatives discussed in the District's 2017 *Oakland Hills Alternative Water Supply Feasibility Study*.

SCC, a privately-owned golf course and country club, has been interested in obtaining a non-potable water supply for golf course irrigation. In 2005, the District prepared the *Satellite Recycled Water Treatment Plant Feasibility Study* that evaluated a satellite facility to provide recycled water to SCC. The satellite project was technically feasible; however, the project was not implemented due to high cost and lack of financial support. In parallel to the District's latest efforts, SCC conducted its own study to identify recycled water alternatives for SCC. The draft report is on hold as SCC's consultant further investigates site constraints.

The Oakland Zoo is a non-profit organization and has been in its current location since 1936. Oakland Zoo is expanding to nearly double its footprint to encompass up to 100 acres by 2018. With this expansion, it is assumed that the existing irrigation water demand will double. The planned development of Oak Knoll Community would convert approximately 190 acres of land into a mixed-use community with 935 residential units, trails, parks and more. It is assumed that irrigation demand would be equivalent to 50 percent of the total projected water use per the 2016 Project Water Supply Assessment. A master plan for the Oak Knoll development was just approved, but it has not been decided if recycled water will be required and/or that dual plumbing of new buildings will be required.

Table 3-25 summarizes the satellite project non-potable water demand. The annual average and peak month demands are about 0.31 MGD and 0.57 MGD, respectively. The proposed project would divert raw wastewater from a low point in the existing local sewers (i.e., Mountain Boulevard) to the new satellite recycled water treatment plant located at SCC. The estimated average and peak wastewater flows are about 0.58 MGD and 0.93 MGD, respectively. These sewer flows are sufficient to supply SCC and Oakland Zoo, even if the Oak Knoll Development were not to move forward. Nevertheless, sewer flows require confirmation.

Table 3-25: Oakland Hills Satellite Project Non-Potable Water Demand

	Projected Irrigation Demand (gpd)	
Customer	**Annual Average**	**Peak Month**
Sequoyah Country Club[1]	120,400	238,000
Oakland Zoo[2]	87,800	135,000
Future Oak Knoll Development[3]	103,500	198,600
Total	**311,700**	**571,600**

Notes:
1. Based on District meter data (2013 to 2015). Oakland Hills Alternative Water Supply Feasibility Study. April 2017.
2. Based on District meter data (2013 to 2015) and projected demand associated with zoo expansion.
3. Assumed to be fifty percent of the site's projected potable water demand.

Table 3-26 summarizes the costs for the proposed 0.5 MGD satellite project which provides flexibility to treat higher flows in the future if needed. The treatment facilities would be designed to meet the average annual demand, because the peak demand occurs only a few times a year. Capital costs include sewer diversion structure at Mountain Boulevard, diversion pumps, diversion pipeline from sewer to satellite plant at SCC, treatment facilities and recycle storage at SCC. The satellite plant will consist of a screening (bar screen and fine screen to remove debris), packaged MBR system, UV disinfection system and distribution pumps all within an enclosed building. Waste sludge would be returned to SD-1. Tertiary effluent would be stored in a 0.5 MG tank to provide one-day storage at SCC. A booster pump would be required to delivered recycled water to customers. It is assumed that each customer will construct their own recycled water storage tank, hence only the cost for the SCC storage tank is included in the estimates.

Agreements between the District and customers would need to be developed. Similar to the DCC satellite project, the District would be interested in having the Oakland Hills customers self-finance construction of the satellite plant in lieu of paying the standard water rate. The responsibility of operation and maintenance of the treatment and sewer line diversion facilities would need to be discussed. In addition, there may be an opportunity for the District to explore a raw water expansion project from Lake Chabot to the Oakland Zoo.

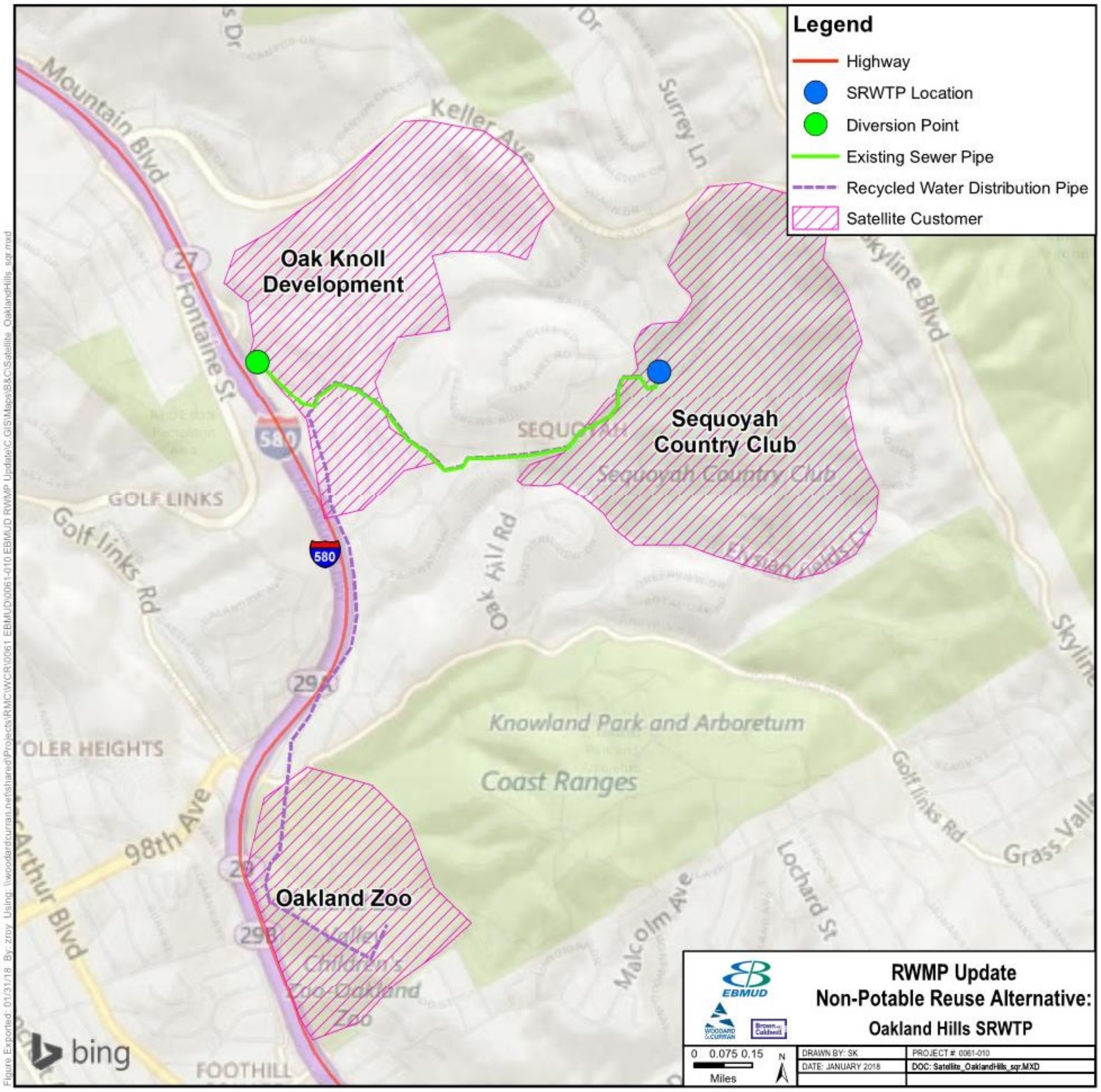
Table 3-26: Oakland Hills Satellite Project Costs

	April 2017 Dollars[1]		December 2017 Dollars[5]			
	Capital ($M)	O&M[4] ($M/yr)	Capital[5] ($M)	O&M ($M/yr)	Annual Demand (AFY)	Annualized Total Cost ($/AF)[6]
Treatment[2]	14.8	0.14	15.8	0.15		2,400
Recycled Water Conveyance[3]	5.8	0.02	6.2	0.02		800
Total	**20.6**	**0.16**	**22.0**	**0.17**	**350**	**3,200**

Notes:

1. Source: West Yost, 2017. Oakland Hills Alternative Water Supply Feasibility Study. April 2017.
2. Treatment cost estimate includes raw wastewater diversion, treatment facilities and electrical infrastructure. Costs do not include land acquisition.
3. Recycled water conveyance cost estimate includes recycled water distribution pumps and pipelines.
4. O&M costs include energy, operations and maintenance for treatment facilities, and pumping energy for conveyance.
5. Construction costs (with sales tax and contractor overhead profit) and O&M costs were updated to December 2017 dollars using ENR CCI ratios for 20 Cities Average.
6. Annualized total costs were calculated using methodology described in Section 2.2. Cost methodology differs from 2017 Feasibility Study. Methodology for this study includes the use of higher markups, salvage value and a 3 percent discount rate (compared to 3.5 discount rate used in the 2017 Feasibility Study), resulting in a lower annualized unit cost.

Figure 3-17: Oakland Hills Satellite Project



3.5 Fill Stations within EBMUD Service Area

There are several commercial and residential recycled water fill stations within the EBMUD service area. Recycled water for trucks is available at EBMUD's SD-1, at CCCSD's WWTP, and at the DSRSD WWTP and recycled water hydrants within their service area. Each purveyor implements a permitting program with specific regulations and applicable fees. The volume of recycled water used by commercial and construction customers is small in comparison to recycled water pipeline projects and fluctuates based on the timing and location of construction.

EBMUD, CCCSD, and DSRSD have all opened residential fill stations since 2014. While the fill stations offered a tremendous opportunity to educate the public on the benefits of recycled water to preserve landscaping during the recent drought, the volume of recycled water distributed from residential fill stations is small, and is not available in all years. DSRSD's Residential Recycled Water Fill Station is currently closed, as the Tri-Valley's water supply has returned to pre-drought status.

3.6 Summary of Non-Potable Project Alternatives

The non-potable reuse alternatives were screened and prioritized based on the size of the project, wastewater supply limitations, cost, and other non-cost factors, such as institutional complexity. Due to limited cost-effectiveness, only projects with average annual demand greater than 150 AFY (0.13 MGD) were considered. **Table 3-27** summarizes the capital, O&M and unit cost for viable alternatives discussed above. These alternatives are retained for further consideration. The results of the non-cost evaluation are included in Section 5.1.1.

Table 3-27: Non-Potable Project Alternatives Cost Summary

Projects	Capital ($M)	O&M ($M/yr)	Annual Demand (AFY)	Unit Cost ($/AF)			
				Treatment	Distribution	Total	Dry Year
Centralized Treatment							
DERWA/San Ramon Valley Phase 3	25	0.49	800	550	1,350	1,900	6,300
DERWA/San Ramon Valley Phase 4	17	0.18	300	400	2,500	2,900	9,700
DERWA/San Ramon Valley Phase 5	8.1	0.15	300	1,000	600	1,600	5,400
East Bayshore Phase 1A	16	0.50	500	1,300	1,100	2,400	7,400
East Bayshore Phase 1B	40	0.83	1,100	940	1,460	2,400	7,800
East Bayshore Phase 2	130	2.9	2,900	800	2,200	3,000	9,400
Chevron Refinery/Richmond WPCP	110	5.7	4,300	2,300	300	2,600	8,600
P66 Rodeo Refinery	53	2.1	4,100	1,000	100	1,100	3,700
Central San Regional Project	320	9.1	22,400	1,000	100	1,100	3,400
CCWD Pipeline in Canal ROW	30	0.78	900	0	2,000	2,000	6,800
Satellite Treatment							
Diablo Country Club	11	0.42	250	3,600	300	3,900	12,000
Moraga Country Club	14	0.15	180	4,600	0	4,600	15,000
Moraga Area Expansion	22	0.26	250	4,500	1,200	5,700	18,000
UC Berkeley Main Campus	36	0.84	880	1,900	1,000	2,900	8,800
Oakland Hills	21	0.17	350	2,400	800	3,200	11,000

Based on limited recycled water demands, competing uses for the same wastewater source, and technical feasibility issues as presented in the project descriptions, the following alternatives were screened out as not viable for further consideration:

- San Leandro Water Reclamation Facility Expansion Project
- Chevron Refinery Process Water or WWTP Effluent
- Richmond Country Club Water Recycling Project
- Point Richmond Recycled Water Project
- Franklyn Canyon Recycled Water Project
- Lamorinda Recycled Water Project
- Reliez Valley Recycled Water Project
- UC Berkeley's Global Campus Richmond Project

- Rolling Hills Cemetery Satellite Recycled Water Project
- Orinda Country Club Satellite Recycled Water Project
- Mountain View and St. Mary's Cemetery Satellite Recycled Water Project
- Rossmoor Country Club Satellite Recycled Water Project

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4. POTABLE REUSE OPPORTUNITIES

4.1 Current State of Potable Reuse Regulations in California

There are four primary types of potable reuse:

- **Groundwater augmentation** through surface spreading or subsurface injection;
- **Reservoir water augmentation** to a surface water reservoir that is used as a potable water supply source;
- **Raw water augmentation** upstream of a surface water treatment plant; and
- **Treated drinking water augmentation** directly to a potable water distribution system**.**

Both groundwater and reservoir water augmentation include the use of an environmental buffer (an aquifer in the case of groundwater augmentation and a surface water reservoir in the case of reservoir water augmentation) and are therefore generally known as indirect potable reuse or IPR. Raw water and treated water augmentation do not use an environmental buffer, relying instead upon engineered storage buffers (ESBs), and therefore considered direct potable reuse of DPR.

The terms "indirect potable reuse" and "direct potable reuse" are used throughout the industry, but the spectrum of possible reuse projects can make it difficult to distinguish between the two. Assembly Bill 574 (Quirk-Hayward), which was signed in October 2017 and went into effect on January 1, 2018, further clarified this distinction by formally establishing the four categories listed above (Note, while AB 574 uses the term "reservoir water augmentation," the recently adopted updates to Title 22 use "surface water augmentation," a term used in this report only when referring to the regulations.) The terms "indirect potable reuse" and "direct potable reuse" will not be used extensively in this report, but the terms are important for historical context.

The overriding regulatory criteria governing wastewater reuse are found in the California Code of Regulations (CCR), Title 22, Division 4, Section 60301, et seq., commonly referred to as Title 22 (Title 22). Title 22 has long established water quality requirements for non-potable reuse. In 2014, the State Water Resources Control Board (SWRCB) revised and adopted uniform recycling criteria for groundwater replenishment.

In 2010, the California Legislature enacted Senate Bill (SB) 918 directing California Department of Public Health (CDPH) (now Division of Drinking Water, or DDW) to establish Surface Water Augmentation Regulations (for Reservoir Water Augmentation) and to investigate the feasibility of developing uniform water recycling criteria for direct potable reuse by December 2016. SB 918 also included the requirements to convene an expert panel. In 2013, the Legislature enacted SB 322 which required an advisory group be convened to advise the expert panel and DDW in the development of the feasibility report for direct potable reuse criteria.

In December 2016, the SWRCB released a primary Report to the Legislature (SWRCB, 2016a) as well as summary reports from the Expert Panel and Advisory Group as follows:

- *Investigation on the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse*
- *Appendix A: Evaluation of the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse. Expert Panel Final Report.*
- *Appendix B: Recommendations of the Advisory Group on the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse. Advisory Group Final Report.*

The Expert Panel determined that "it is feasible to develop uniform water recycling criteria for [Direct Potable Reuse] that would incorporate a level of public health protection as good as or better than what is currently provided in California by conventional drinking water supplies..." The panel noted that the functionality provided by the environmental buffer (i.e., storage, attenuation, and response time) in an indirect potable reuse project must be addressed by other means. The panel also noted that any project that cannot obtain two months of retention in the environmental buffer should be classified as direct potable reuse.

Given the lack of an environmental buffer, the Expert Panel stressed that reliability would be the overarching goal for a direct potable reuse option to consistently achieve the desired water quality in the product water. The panel suggested that direct potable reuse regulations provide "reliability" by:

- Providing multiple, independent treatment barriers;
- Incorporating the frequent monitoring of surrogate parameters at each step to ensure treatment processes are performing properly; and
- Developing and implementing rigorous response protocols (such as a formal Hazard Analysis Critical Control Point system).

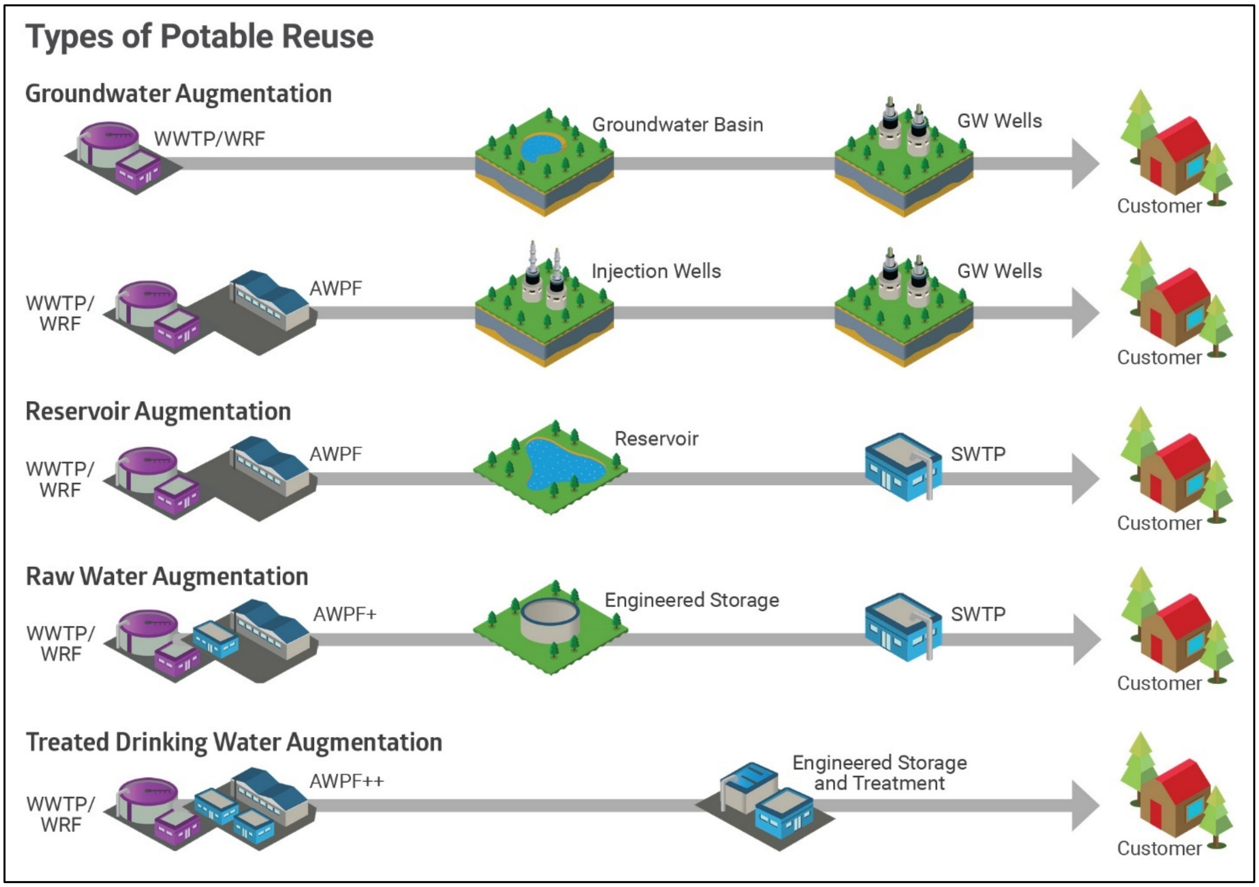
After reviewing the recommendations of the Expert Panel Report and Advisory Group Report, DDW concluded that it is feasible to begin the process of developing direct potable reuse regulations. However, DDW believes the additional research and knowledge gaps identified in the Expert Panel and Advisory Group reports must be addressed prior to the adoption of criteria.

Concurrently, in July 2017, the SWRCB released proposed regulations for public comment that would establish uniform recycling criteria for reservoir water augmentation; the regulations use the term "Surface Water Source Augmentation" rather than reservoir water augmentation. (Note: This report uses the term "reservoir water augmentation," which allows a clearer distinction between projects that go into surface water aqueducts from those that go to surface water reservoirs). After public comment and revisions, the final regulations were adopted and became effective October 1, 2018.

AB 574 requires the SWRCB to establish uniform water recycling criteria for raw water augmentation by the end of 2023. There is currently no timeline for developing recycling criteria for treated drinking water augmentation. Without regulations, the information provided in the Expert Panel and DDW reports were used to develop conceptual requirements for raw water and treated water augmentation alternatives, as further described in Section 4.1.3.

The following sections provide an overview and applicable regulations for each of the four types of potable reuse, shown below in **Figure 4-1**.

Figure 4-1: Spectrum of Potable Reuse Applications



4.1.1 Groundwater Augmentation

Regulations for groundwater augmentation (also called groundwater recharge or replenishment) became effective in June 2014. Groundwater augmentation has been implemented for many years, most notably by the Groundwater Replenishment System in Orange County and the Montebello Forebay Project in Los Angeles County. The groundwater augmentation regulations are organized by type of project:

- Surface application (surface spreading), and
- Subsurface application (injection or vadose zone wells).

Subsurface application (injection) of recycled water directly into the groundwater basin requires full advanced treatment (FAT) that includes RO and an advanced oxidation process (AOP) equivalent to at least 0.5-log reduction of 1,4-dioxane. The regulations specify requirements for the RO process, including bench-scale testing. For surface application via surface spreading, additional treatment is provided through soil aquifer treatment (percolation) and dilution of the recycled water with groundwater in the groundwater basin. Due to space constraints and local hydrogeology, this RWMP Update only considers alternatives with subsurface application via injection wells.

Regarding pathogen control, Title 22 requires that recycled municipal wastewater used for groundwater augmentation goes through a treatment train with at least three separate treatment processes (multiple barriers) to achieve at least:

- 12-log enteric virus reduction;
- 10-log *Giardia* cyst reduction; and
- 10-log *Cryptosporidium* oocyst reduction.

This is commonly referred to as 12/10/10 log reduction. Each barrier must achieve a minimum of 1-log reduction and will not be credited for more than a 6-log reduction for each of the pathogens listed above. Underground retention time (URT) may be credited with 1 log/month for virus reduction. URT must be verified using an added tracer study to receive credit for the full log reduction (1 log/month). Depending on the method used for project planning purposes, the regulations give partial log-reduction credit for intrinsic tracer studies (0.67 log/month), numerical modeling (0.5 log/month), or analytical modeling (0.25 log/month). The regulations require that a tracer study be initiated within three months of project start-up.

For both surface and subsurface applications of advanced treated water to drinking water aquifers, the California Division of Drinking Water requires low levels of total organic carbon (TOC) at 0.5 milligrams per liter (mg/L) and total nitrogen at 10 mg/L.

A minimum of two months of URT is required before extraction for potable use, which provides “response retention time” to monitor water quality and respond to water quality concerns.

Groundwater augmentation criteria are summarized below in **Table 4-1.**

Table 4-1: Groundwater Augmentation Criteria for Potable Water Reuse

Parameter	Surface Application	Subsurface Application
Minimum Treatment	Tertiary Filtration + Disinfection	Full Advanced Treatment
Minimum Retention Time	2 months	
Virus	≥ 12-log reduction	
Giardia	≥ 10-log reduction	
Cryptosporidium	≥ 10-log reduction	
Safe Drinking Water Act Contaminants	Meets all MCLs	
Total Nitrogen	≤ 10 mg/L	
Total Organic Carbon	≤ 0.5 mg/L (after SAT and Dilution)	≤ 0.5 mg/L

4.1.2 Reservoir Water Augmentation

Regulations for reservoir augmentation became effective October 1, 2018. The City of San Diego’s North City Pure Water Project is anticipated to be the first project permitted under the adopted regulations in the near future.

The regulations include the following requirements:

- **Full Advanced Treatment** must include RO and an AOP that achieves at least 0.5-log reduction of 1,4-dioxane, similar to the requirements for groundwater augmentation via injection;

- **Retention time**: a minimum theoretical reservoir retention time of 180 days, which may be reduced to 60 days with additional treatment and SWRCB approval;
- **Dilution requirements**:
  - 1% (1:100) dilution of any 24-hour inflow of advanced treated water, measured at the outlet; or
  - 10% (1:10) dilution any 24-hour inflow of advanced treated water, measured at the outlet, plus one additional independent log-reduction of all three organisms.
- **Pathogen removal requirements:**
  - The regulations state that recycled municipal wastewater delivered to an augmented reservoir with 1% dilution shall go through a treatment train to achieve:
    - 8-log enteric virus reduction;
    - 7-log *Giardia* reduction; and
    - 8-log *Cryptosporidium* reduction.
  - At least two barriers must achieve a minimum of 1-log reduction and no barrier will be credited for more than a 6-log reduction for each of the pathogens listed above.
  - The Surface Water Treatment Rule then requires the surface water treatment plant to provide treatment to remove 4-log virus, 3-log *Giardia*, and minimum 2-log *Cryptosporidium*. The pathogen requirements for recycled water listed for reservoir augmentation projects are less than those required for groundwater augmentation because surface water is further treated through a surface water treatment plant prior to potable use.

The regulations also contained additional criteria on reservoir ownership, operational history, hydrodynamic modeling, and tracer studies. Reservoir water augmentation criteria are summarized on the next page in **Table 4-2.**

Table 4-2: Summary of Reservoir Water Augmentation Criteria

Parameter	1% Dilution in Reservoir	10% Dilution in Reservoir
Minimum Retention Time	6 months (may be reduced to 2 months with DDW approval)	
Virus	≥ 8-log reduction	≥ 9-log reduction
Giardia	≥ 7-log reduction	≥ 8-log reduction
Cryptosporidium	≥ 8-log reduction	≥ 9-log reduction
Safe Drinking Water Act Contaminants	Meets all MCLs	
Total Nitrogen	No requirement in regulations NPDES Permit may limit nitrogen as a biostimulatory substance	
Total Organic Carbon	≤ 0.25 mg/L to be verified during startup	

In addition to meeting Title 22 recycling criteria, reservoir augmentation projects will require a National Pollutant Discharge Elimination System (NPDES) permit for discharge to surface water – the District's reservoirs are named water bodies with beneficial uses listed in the Water Quality Control Plan for the San Francisco Bay Basin ("Basin Plan," San Francisco Bay Regional Water Quality Control Board, 2017). This may result in additional requirements related to protection of aquatic life, including strict limits on residual chlorine in advanced treated water added to a reservoir and limits intended to prevent reservoir eutrophication (i.e., low nitrogen and phosphorus).

4.1.3 Raw Water and Treated Drinking Water Augmentation

Within California, uniform recycling criteria for raw water augmentation are expected by the end of 2023, as required by AB 574. While not in California, raw water augmentation is currently being implemented by the City of Big Springs in Texas.

There is currently no timeline for developing recycling criteria for treated drinking water augmentation in California. Without codified regulations, the information provided in the Expert Panel and DDW reports was used to develop conceptual requirements for raw water and treated drinking water augmentation facilities, as listed in **Table 4-3** (SWRCB, 2016 and 2016a). Log reduction values for pathogens are the sum of the proposed requirements for reservoir water augmentation (10% dilution) and Surface Water Treatment Rule requirements (4-log virus and 3-log *Giardia* and minimum 2-log *Cryptosporidium)*.

Table 4-3: Conceptual Requirements for Raw and Treated Drinking Water Augmentation

Parameter	Criterion
Minimum Retention Time using ESB	> Failure Response Time of Advanced Treatment System
Virus	≥ 13-log reduction
Giardia	≥ 11-log reduction
Cryptosporidium	≥ 11-log reduction

The SWRCB feasibility report (SWRCB, 2016) identifies several key areas requiring additional research to support development of the regulations, including:

- Consideration of a probabilistic method (Quantitative Microbial Risk Assessment) to better quantify treatment train performance and confirm necessary virus, giardia, and cryptosporidium log removal values.
- Improving the understanding of pathogens in raw wastewater to develop better empirical data on concentrations and variability, including during community outbreaks of disease.
- Continued review of the risks of emerging constituents to public health, based on convening the “blue ribbon” panel every 5 years. The focus is intended to be on new compounds that may pose health risks from short term exposures, low molecular-weight compounds that are not rejected by reverse osmosis, and screening for unknown compounds using non-targeted analysis.

More specific research topics include:

- Continuing to evaluate the assignment of log removal credits to specific treatment technologies, such as RO, MBR, and microfiltration, based on periodic integrity testing and real-time validation.
- Investigating the use of surrogate parameters to ensure removal of trace organic compounds and pathogens.

District staff should strongly consider participating in the research supporting development of these regulations, given the numerous opportunities for raw water augmentation and treated drinking water augmentation identified in this RWMP Update.

4.2 Development of Potable Reuse Alternatives

4.2.1 Approach to Development of Alternatives

Potable reuse alternatives were developed using the following three-step process:

- **Identify Sources**. The first step was to identify all possible sources of treated municipal wastewater within or immediately adjacent to the District's water service area (Section 4.3).
- **Identify Targets**. Possible targets based on potable reuse type were:
  - Groundwater augmentation: Targets are groundwater basins in the District's water service area (see Section 4.4.1).
  - Reservoir water augmentation: Targets are District's surface water reservoirs (see Section 4.4.2).
  - Raw water augmentation: Targets are District's surface water treatment plants or aqueducts (see Section 4.4.3).
  - Treated drinking water augmentation: Targets are large pipelines or tanks within the District treated water distribution system (see Section 4.4.4).

  Conveyance needs (i.e., pipeline sizes) were also assessed to connect the sources and targets, as discussed in Section 4.6.
- **Determine Treatment.** Seven treatment trains were developed based on the combination of source and target for each alternative (see Section 4.5). All treatment trains provide Full Advanced Treatment and include reverse osmosis. The production capacity of each treatment train was based on the lower of the source and target capacities. In most cases, the source (i.e., the available wastewater supply) is the limiting factor, except for a few reservoir augmentation alternatives where reservoir operations limit the ability to accept recycled water.

4.2.2 Surface Water Treatment Plant Constraints

Potable reuse alternatives were developed with the goal of minimizing changes needed to the District's existing surface water treatment plants and their operating schedules. Specifically:

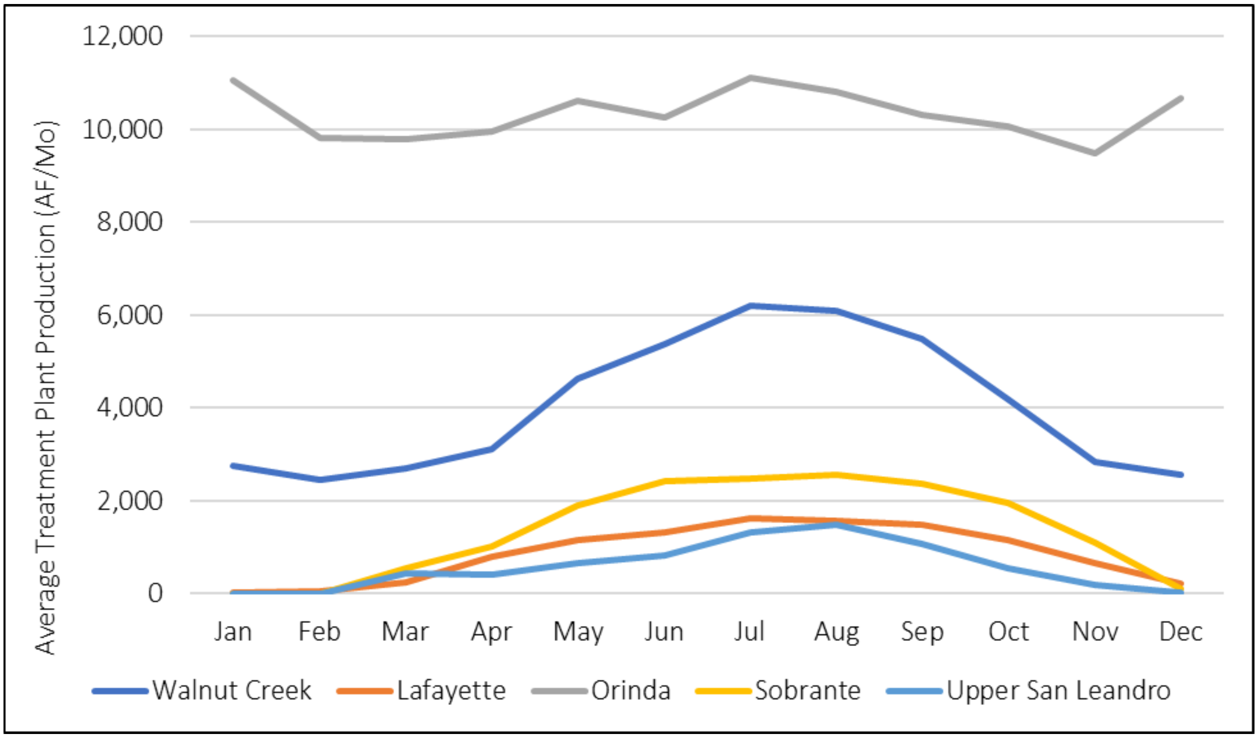
- San Pablo Water Treatment Plant (WTP) was not assumed to be operational.
- Lafayette WTP was not assumed to be a direct target for any potable reuse alternatives since it is not located near any WWTPs to serve as a source or receive treatment byproducts such as RO concentrate. However, it could receive advanced treated water placed in the Mokelumne Aqueduct.
- Water treatment plants supplied by reservoirs with local runoff (Upper San Leandro and Sobrante WTPs) would continue to use these supplies. To the extent practicable, seasonal operation was retained for Upper San Leandro and Sobrante WTPs, because these treatment plants are more expensive to operate, and they are typically not needed to meet winter demands (it is operationally simpler to run fewer WTPs). Alternatives that retained this seasonal use were scored higher than alternatives that require a shift to year-round production.
- The volume of recycled water sent directly to surface water treatment plants via raw water augmentation, or indirectly sent to water treatment plants via reservoir water augmentation, is theoretically limited by water treatment plant production capacity, although in practice this constraint is rarely applied since total treated water demand remains constant.

The capacity and recent production rates for the District's surface water treatment plants is listed for reference in **Table 4-4.** Monthly production at the District's surface water treatment plants is shown for reference in **Figure 4-2.** The ability of surface water treatment plants to accept advanced treated water is discussed further in Section 4.4.3.

Table 4-4: Surface Water Treatment Plant Capacity and Recent Production

Capacity	Walnut Creek	Lafayette	Orinda	Sobrante	Upper San Leandro
Plant Capacity (MGD)	90	25	190	50	45
Average Annual Production, FY08-14 (MGD)	43	9	111	15	6
Plant Capacity (AF/MO)	8,400	2,333	17,733	4,667	4,200
Average Annual Production, FY08-14 (AF/MO)	4,030	860	10,330	1,370	580

Figure 4-2: Seasonality of Surface Water Treatment Plant Production, FY08-14



The cost of treating water at surface water treatment plants was included in the O&M cost estimates for reservoir water augmentation and raw water augmentation alternatives. The conventional surface water treatment plants (USL and Sobrante) are more expensive to operate than the in-line plants (Walnut Creek and Orinda) due to the additional treatment steps included at those plants (see Section 4.4.3.1 and 4.4.3.2) (EBMUD, 2017b), so sending more water to the conventional surface water treatment plants would increase the District's operating costs. Regardless of treatment steps, all the WTPs meet applicable minimum Surface Water Treatment Rule requirements. The additional treatment steps provided at the conventional surface water treatment plants could be beneficial in a potable reuse context -- for example by providing additional pathogen removal and removing taste & odor-causing compounds and other trace organics.

4.3 Sources of Wastewater for Advanced Treatment

4.3.1 Availability of Treated Effluent

Eleven WWTPs in or near the District's water service area were considered as potential water sources for potable reuse, as shown in **Figure 4-3** and listed below in **Table 4-5.** For each WWTP, the estimated firm supply available for potable reuse is based on the dry weather flow discharged to surface water in the summer of 2015, which was an exceptionally dry year. In most cases, these wastewater flows are considerably lower than those listed in the District's WSMP 2040 (Appendix D, TM-4, "Future Recycled Water Potential Analysis") due to increased water conservation and water use efficiency and/or reductions in groundwater infiltration over the last decade. Current commitments for non-potable reuse were also subtracted out to estimate the firm daily supply available on a year-round basis. The following are peak month non-potable demands (approximately double the average annual demand), unless specified, for each potential potable reuse water source.

- **SD-1:** 5 MGD reserved for the EBRWF.
- **City of San Leandro Water Pollution Control Plant (WPCP):** 0.6 MGD reserved for the Monarch Bay Golf Club, and up to 2 MGD reserved for future users of the San Leandro Recycled Water Project. This is a conservative assumption, given that the San Leandro Recycled Water Project is not currently operational (see Section 3.3.3)
- **CCCSD WWTP:** Existing commitments of 3 MGD based on 1.1 MGD for in-plant use, 1.2 MGD for irrigation in Zone 1, and 0.5 MGD for serving the Shell Refinery (CCCSD, 2016). Concord Naval Weapons Station demand was not included, as the project will also produce additional wastewater supplies.
- **DSRSD and Livermore:** These two plants send treated secondary effluent to the Livermore-Amador Valley Water Management Agency (LAVWMA) pipeline, which connects to the East Bay Dischargers Authority (EBDA) deep water outfall (located in the District's water service area). During the summer irrigation season, very little flow is directed to the LAVWMA pipeline. Up to 10 MGD is available in the winter (November through April) from the two plants combined (West Yost 2017).
- **West County WPCP:** Most of the flow from this plant currently goes to the NRWRP and Richmond Advanced Recycled Expansion (RARE) to supply the Chevron Richmond refinery. For the potable reuse evaluation, however, no flow was assumed to go to RARE. The potable reuse alternatives are assumed to be a substitute for RARE in the event that the Refinery is no longer operational.

No recycled water commitments were subtracted from the available supply for Pinole/Hercules WPCP, Richmond WPCP, Oro Loma WPCP, and Crockett Community Services District (CSD) Water Treatment Facility.

Satellite treatment alternatives were also considered using raw wastewater from the District's collection system (including the interceptors). Two locations were identified:

- **Raw wastewater delivered to SD-1:** In lieu of upgrading the entire SD-1 plant to achieve nutrient removal (see next section), a portion of the influent stream could be routed to a new wastewater treatment facility. A 4-MGD and 10-MGD MBR plant were assumed for two alternatives at SD-1. Such a facility could also serve a dual use providing non-potable recycled water for the EBRWF provided the established non-potable recycled water quality objectives are met. A satellite facility would also allow dewatering return streams to be separated out from the plant influent, potentially reducing the load of constituents of concern from the District's biosolids program.
- **Raw wastewater near Albany:** Collection system modeling performed by Woodard & Curran in support of the District's Infiltration/Inflow Control Project Program - Data Assessment and Modeling Project

indicates the following estimated dry weather flow available in or near the North Interceptor in the vicinity of Pt. Isabel:

- **1.5 MGD near Pt. Isabel/Central Ave,** reflecting flows from Stege Sanitary District only.
- **4 MGD near Buchanan Street,** where there are contributions from both Stege Sanitary District and City of Albany. On this basis, a satellite treatment facility was sized at 4 MGD. Since actual flow data was not used, this estimate would have to be confirmed using monitoring data prior to developing a more detailed project description for this alternative.

The estimated firm daily supply for each wastewater source was reduced by 20% to account for advanced treatment train waste streams (approximately 5% for microfiltration or MBR, and 15% for reverse osmosis).

In addition to the 11 WWTP's, the East Bay Discharges Authority (EBDA) disposal system also runs through a portion of EBMUD's service area. As discussed below in Section 4.3.2, it is assumed that secondary treatment upgrades would be required to produce effluent appropriate for advanced treatment. Because EBDA conveys comingled wastewater from numerous agencies and would therefore require upgrades at multiple WWTPs and also conveys the brine concentrate stream from Zone 7's demineralization plant, the EBDA outfall is not considered further.

4.3.2 Water Quality Considerations of Treated Effluent

A high-quality feed water is essential for advanced treatment. Each of the potential wastewater sources for advanced treatment considered in this study currently provides secondary treatment without significant nitrification or denitrification. Additional treatment was assumed to be required to make this feed water suitable for advanced treatment, based on recommendations from the Advisory Group on the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse in California (SWRCB, 2016a). The required additional treatment consists of longer solids residence time (SRT) and partial removal of nitrogen (nitrification/denitrification).

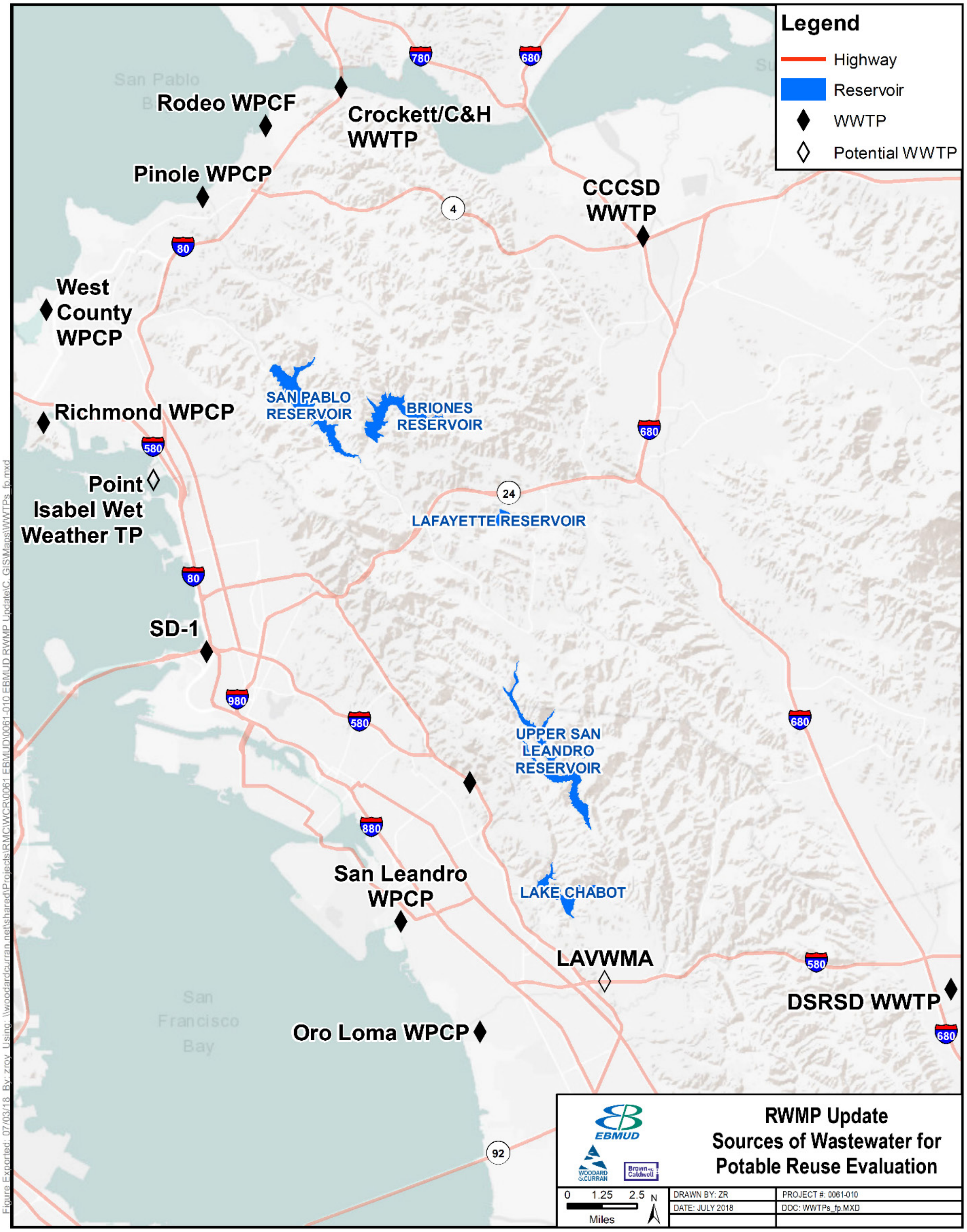
Separately from this study, the Bay Area Clean Water Agencies (BACWA) recently completed a Nutrient Reduction Study that quantifies opportunities for removing nutrients from wastewater discharged to San Francisco Bay, either through optimizing existing operations or upgrading treatment plants (BACWA, 2018). The study includes cost estimates for upgrading each of the 37 municipal wastewater treatment plants to in the Bay area to achieve a total nitrogen concentration below 15 mg/L. This corresponds to "Level 2" nitrogen removal, and for most of the plants in this potable reuse study it will be achieved by adding aeration tankage to allow for Modified Ludzack-Ettinger process (anoxic zone upstream of aeration), while also achieving a longer SRT overall.

"Level 2" nitrogen removal upgrades are used for the potable reuse alternatives because it corresponds to a sufficient long SRT (greater than 5 days, preferably 7-10 days in dry weather), which is known to result in improved effluent quality suitable for advanced treatment and containing fewer trace pollutants (Chemicals of Emerging Concern, or CECs). Lower nitrogen is also a benefit when there is an environmental buffer (groundwater or surface water reservoir).

Upgrades for nutrient removal were assumed to be driven by NPDES permit requirements, so the costs are not included in the capital cost estimates for each alternative. However, they are an important consideration for the timing of implementation – potable reuse treatment trains are more sensibly added on if and when nutrient upgrades have already been completed.

Dissolved solids (expressed as hardness, TDS, salinity, or conductivity) are also a concern for advanced treatment, as they control sizing and design of the RO and chemical feed systems. In the study area, most of the wastewater sources have a specific conductance in the range of about 900-1,300 microSiemens/centimeter (µS/cm), although SD-1 is significantly higher (effluent exceeds 2,000 µS/cm). For cost estimating purposes, all RO systems were sized using the same recovery rate regardless of the wastewater source.

Figure 4-3: Sources of Secondary Effluent for Potable Reuse



Note: City of Livermore is not shown; flows are combined with DSRSD in the LAVWMA pipeline.

Table 4-5: Sources of Secondary Effluent for Potable Reuse

Wastewater Supply Source	Permitted ADWF Treatment Capacity (MGD)	2015 ADWF Discharged to Bay (MGD)	Estimated Supply Available for Reuse (MGD)	Estimated Supply Available for Potable Reuse Supply (MGD)	Effluent Disposal Method	Notes
Oro Loma WPCP	20	10.3	10	8.0	SF Bay via EBDA outfall	1
City of San Leandro WPCP	7.6	4.3	1.7	1.4	SF Bay via EBDA outfall	1, 3, 6
DSRSD WWTP	17	2	Included with Livermore, below	Included with Livermore, below	SF Bay via LAVWMA/EBDA	2, 8
Livermore Water Reclamation Plant	8.5	3.0	0 (summer) 10 (winter)	0 (summer) 8 (winter)	SF Bay via LAVWMA/EBDA	4, 8
Richmond WPCP	16	Included with West County, below	4.5	3.6	SF Bay	4
West County WCPC	12.5	5.6	1.1	0.9	SF Bay via Richmond	4, 6
Crockett CSD Water Treatment Facility (C&H)	1.8	0.8	0.8	0.6	Carquinez Strait	4
EBMUD Main WWTP (SD-1)	120	43	38	30	SF Bay	7
Pinole/Hercules WPCP	4.1	2.1	2.1	1.7	San Pablo Bay via Joint Outfall	7
Rodeo WPCF	1.1	0.5	0.5	0.4	San Pablo Bay via Joint Outfall	7
CCCSD WWTP	54	27	24	19	Suisun Bay	7, 5

Notes:

1. EBDA - NPDES Permit for Common Outfall. Order No. R2-2017-0016, NPDES No. CA0037869. San Francisco Bay Regional Water Quality Control Board, 2017.
2. Dublin San Ramon Services District - NPDES Permit. Order No. R2-2017-0017, NPDES No. CA0037613. San Francisco Bay Regional Water Quality Control Board, 2017.
3. City of San Leandro Recycled Water Market Assessment Study. Prepared by Carollo Engineers for City of San Leandro. Draft, January 2016.
4. CIWQS. Available at http://www.waterboards.ca.gov/water_issues/programs/ciwqs/
5. (CCCSD, 2016)
6. EBMUD Water Supply Management Program 2040 Plan, Appendix D. April 2012.
7. 2016 Nutrient Watershed Permit Group Annual Report.
8. (West Yost, 2017)

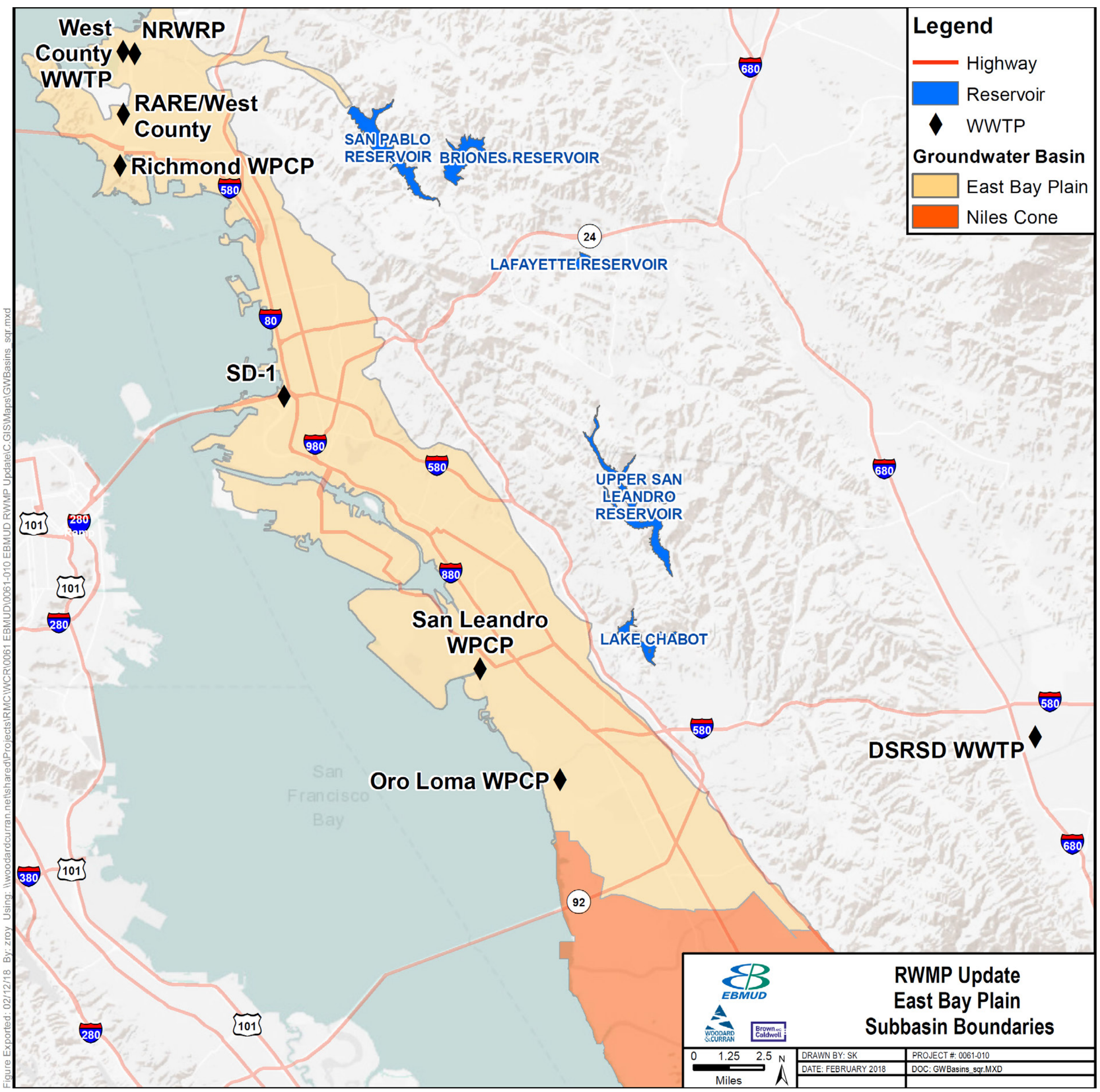
4.4 Targets for Advanced Treated Water

This section presents additional detail on the targets for potable reuse projects within the District's water service area.

4.4.1 Groundwater Augmentation Targets

Both the southern and northern most portions of the East Bay Plain Subbasin were identified as candidates for potable reuse as discussed below (see **Figure 4-4**).

Figure 4-4: Location of East Bay Plain Subbasin



4.4.1.1 Southern portion of the East Bay Plain Subbasin

The East Bay Plain Subbasin extends from the East Bay foothills west to San Francisco Bay, approximately from Richmond south to Hayward. The East Bay Plain Subbasin has three main aquifer units, including the Deep Aquifer which is believed to produce the highest yield and be the most continuous aquifer unit. The Deep Aquifer is located about 500 feet below grade.

As part of the Bayside Groundwater Project, the District constructed a 1-MGD aquifer storage and recovery well facility at the Oro Loma Sanitary District (OLSD) WWTP site in 1997, with the intent of supplementing the groundwater basin with potable water during wet years and extracting the water during dry years (EBMUD, 2005). The facility became operational in 2010, and test injections with potable water most recently occurred in February 2017. When operational, the facility injects and extracts from the deep aquifer unit. Extracted water is treated at a wellhead treatment facility before being conveyed to the potable water distribution system. Wellhead treatment includes manganese removal and disinfection.

For the OLSD Recycled Water Facility Study (OLSD, 2016), the District's Bayside Groundwater Project concept was extended to a series of injection and extraction wells using advanced treated OLSD effluent as the source of water for injection. All wells were assumed to operate year-round at a constant flow rate. This differs from the Bayside Groundwater Project, in which injection and extraction occur at different times. The extracted water would undergo wellhead treatment (manganese removal and disinfection, as in the Bayside Groundwater Project) and then be added directly into the potable water distribution system near the point of extraction.

The OLSD study assumed a project size of 10 MGD for injection and 9 MGD for extraction (90% recovery rate). This study assumes a slightly smaller injection rate (8 MGD) based on new wastewater flow data (the average dry weather flow rate is now about 10 MGD, not 12 MGD as stated in the OLSD study). Pipeline and well facilities and cost estimates from the OLSD study were used after adjusting for flow rates (i.e., 80% of the OLSD costs were used, corresponding to four 2-MGD injection wells and eight 1-MGD extraction wells). Preliminary pipeline and well locations are shown in **Figure 4-13** (see page 4-39)**.**

4.4.1.2 North Richmond Area of the East Bay Plain Subbasin

The East Bay Plain Subbasin in the vicinity of North Richmond is not currently used for potable water production, although there are non-potable wells in the area. This portion of the groundwater basin was historically used for potable water production – for example, the San Pablo Well Field historically produced about 2 MGD before eventually pulling in seawater (EBMUD, 2001). While this is a small amount, it is not known whether the production rate was limited by the technology in use at the time or the inherent properties of the groundwater basin.

The District has identified an area in North Richmond as potentially favorable for the development of new wells, based on local geology and historic groundwater use (EBMUD, 2001). West County Wastewater District is located within this area, and the Richmond WPCP is also located nearby. Either or both of these facilities could theoretically serve as a source of advanced treated water for injection into the groundwater basin. However, there are key unknowns affecting the maximum size of the project, including:

- Accurate characteristics of local groundwater basin, including thickness of aquifer units and properties;
- Available storage capacity;
- Hydrogeology; and
- Water quality data.

The condition of existing groundwater quality including potential contamination sources that could interact with the project is also unknown; as described in the *Regional Hydrogeologic Investigation* completed for the District (EBMUD, 2001), the area is "virtually blanketed with potential shallow water contaminant sites" in addition to a large plume from Chevron that is adjacent to the west side of the basin. Due to the numerous unknowns that directly relate to facility costs, such as well location and depth, it is not possible to develop a cost estimate for this alternative. However, it may be considered for further study in the future.

4.4.2 Reservoir Augmentation Targets

Four of the District's five East Bay terminal reservoirs were considered as targets for reservoir augmentation, due to their larger size and configuration: Briones Reservoir, San Pablo Reservoir, Upper San Leandro Reservoir, and Lake Chabot (see **Figure 4-3** on page 4-11). Lafayette Reservoir was not considered because it is significantly smaller and is not used as a part of routine water supply operations. The amount of recycled water that each reservoir can accept was determined based on the proposed surface water source augmentation regulation (SWRCB, 2017), reservoir storage capacity, and downstream treatment plant capacity. Each reservoir was considered independently due to the unique interaction of these limitations at each proposed location; multi-reservoir options were not included in the initial development of Surface Water Source Augmentation (SWA) project alternatives.

For Briones, San Pablo, and Upper San Leandro Reservoirs, the District's Water Supply Engineering Statistical Reports for fiscal years 2008 through 2014 were used to represent the interaction of advanced treated water with the proposed reservoirs and their associated treatment plants (EBMUD 2009, 2010a, 2011a, 2012b, 2013a, and 2014a). These operations reports were averaged to provide a typical operation pattern for each reservoir, which was then re-evaluated with recycled water as an additional supply.

Simulated reservoir operations were used to estimate dilution and residence time for each alternative considered. Residence times are shortest (i.e., most likely to hit the 6-month minimum) when reservoirs are drawn down at a high rate to meet peak summer demands, typically from June to August. Dilution is lowest (i.e., the least dilution, approaching the 1% dilution criteria) when the reservoir volume is at the annual minimum, typically in the late fall.

Advanced treated water was assumed to be added year-round at a constant flow rate in order to better understand the other limiting factors. For alternative development, this approach minimizes the unit cost of providing advanced treated water, since the treatment trains can be sized to meet just one annual average demand.

The assessment for Lake Chabot was more simplistic, as this reservoir is not currently used for potable water supply.

4.4.2.1 Briones Reservoir

Briones Reservoir was considered as a target for advanced treated water from SD-1, CCCSD, Richmond WPCP, West County WPCP, or Pinole WPCP.

Briones Reservoir was created in 1964 with the construction of Briones Dam on Bear Creek. Briones Reservoir has a storage capacity of 60,500 AF, the largest of the five terminal reservoirs currently operated by the District. Briones has the highest filling priority of the terminal reservoirs, as it holds nearly half of the total standby storage and has sufficient elevation to feed all the District's water treatment plants. Additionally, Briones has the best water quality because it receives so little local inflow from its small watershed (EBMUD, 2014b).

From 2007 to 2014, an average volume of 11,000 AFY of Mokelumne Aqueduct water cycled through Briones Reservoir, and an average volume of 3,600 AFY of watershed runoff reached the reservoir. Advanced treated water sent to Briones Reservoir was assumed to replace the average volume of Mokelumne Aqueduct water.

Advanced treated water sent to Briones Reservoir may be drafted back to Briones and Orinda Centers through the Briones Aqueduct, and then continue to the Orinda WTP. This is the most direct method to connect Briones Reservoir to a WTP for potable reuse. Additionally, water in the Briones and Orinda Centers spills into San Pablo Reservoir, which continues into the Sobrante WTP. Historically, Briones has not spilled water directly into San Pablo Reservoir; although facilities exist for this purpose, they are primarily designed for emergencies. Routine spilling water of water from Briones into San Pablo Reservoir via the Briones Dam drain valve was not considered as part of this study.

From July 2007 to June 2014, Briones Reservoir was maintained with an average monthly volume exceeding 40,300 AF. During this same period, Briones reached a maximum storage capacity of 60,130 AF. The largest possible project that could be developed in Briones Reservoir under the proposed SWA regulations is approximately 58 MGD.

Proposed reservoir augmentation project sizes included in the project alternatives are as follows:

- 30 MGD – the largest project using SD-1, with wastewater supply as the limiting factor. A 30-MGD project would entirely replace all the Mokelumne Aqueduct Water that is currently cycled through the reservoir on an average annual basis (and more – the annual volume cycled through the reservoir would substantially increase).
- 10 MGD – this project would entirely replace the approximate volume of Mokelumne Aqueduct water currently cycling through the reservoir on an average annual basis.

The proposed SWA regulations require a minimum theoretical retention time and a minimum dilution of the recycled water. For Briones Reservoir, the residence time requirement is the more restrictive of these two regulations. Briones Reservoir could accept a maximum of 58 MGD of recycled water under these regulations, compared to the status quo supply from the Mokelumne Aqueduct of about 10 MGD. This larger flow rate was determined by finding the month with the most restrictive residence time parameters and limiting recycled water production to meet this most conservative limit. This larger inflow volume would require drafting from Briones Reservoir at approximately four times the current rate.

Although the largest project alternative is limited by the residence time requirement, the dilution requirement is still a relevant requirement. The actual dilution could be considerably smaller than the predicted dilution achieved due to short circuiting and stratification of the reservoir. The predicted dilution under these operating conditions is 0.45% and the regulatory maximum is 1%, so if actual mixing conditions are far from ideal, this amount of inflow may need to be reduced or additional pathogen LRV credits should be added to increase the allowable dilution requirement up to 10%.

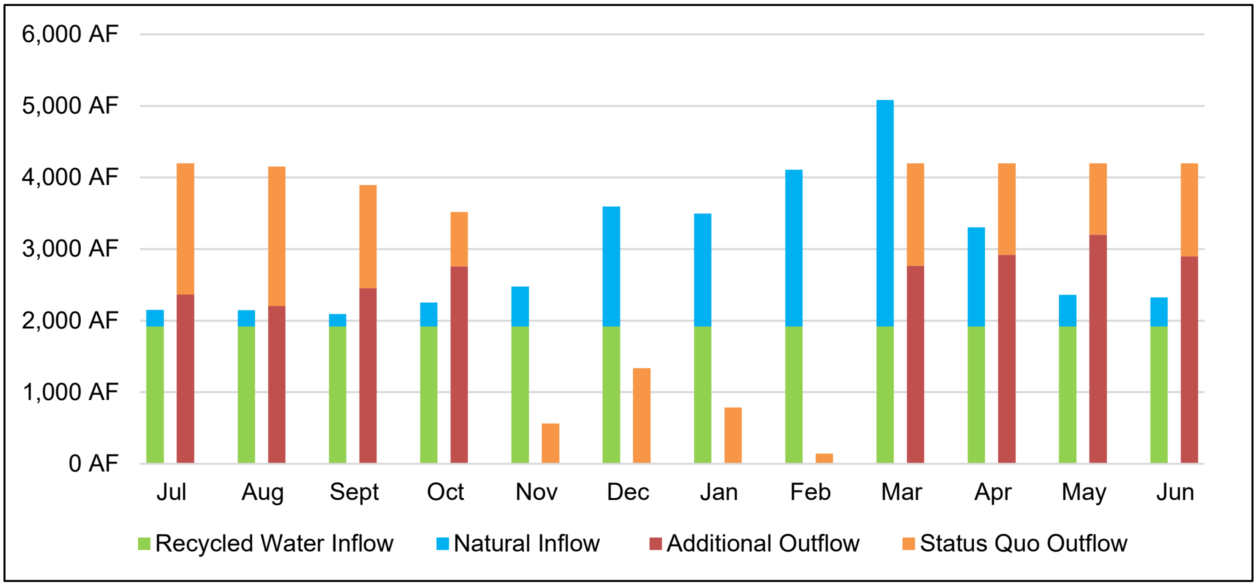
Summary information about each alternative (and the larger 58-MGD project, for reference) is presented below in **Table 4-6.**

Table 4-6: Briones Reservoir Augmentation Project Alternatives

Project Description	Project Size Recycled Water AFY	Project Size Recycled Water MGD	Minimum Residence Time (months)	Estimated Dilution (Max % RW by Volume)	Increased Flow Through Reservoir (AFY)
Largest Possible Project – Limited by SWA Regulations Only	64,900	58	6.4	0.45%	54,000
Limited by Wastewater Supply	33,600	30	10.5	0.23%	21,500
Smaller Size – Approximately equal to current use of Aqueduct Water	11,200	10	23	0.06%	~0

Example simulated inflow and outflow patterns for the 30-MGD project size are presented below in **Figure 4-5.** Simulations were prepared for each of the alternatives for Briones, San Pablo, and USL Reservoirs, but the results are omitted from this report for brevity.

Figure 4-5: Briones Reservoir Operations for 30-MGD Recycled Water Project



To summarize, Briones Reservoir can accept a large volume of recycled water – more than is available from either SD-1 or Central Contra Costa Sanitary District alone – while complying with the SWA regulations. Because of the limited size of the watershed, the reservoir inflows are already highly controlled, and there is very little risk that advanced treated water would be spilled downstream.

The reservoir's ability to be used as an emergency standby storage would not be impaired by the addition of advanced treated water. In an emergency, Briones Reservoir can be used as a supply for all of the District's WTPs, with a maximum drawdown rate of 80 MGD for the auxiliary blow off, 100 MGD for the multi-jet sleeve valve, and 130 MGD for the 36-inch cone valve. These outflow rates result in a residence time less than 6 months. Therefore, in an emergency where Briones Reservoir is rapidly drawn down, it may be necessary to reduce inflows of advanced treated water to continue complying with the proposed SWA project residence time regulations.

4.4.2.2 San Pablo Reservoir

San Pablo Reservoir was considered as a target for advanced treated water from SD-1, Richmond WPCP, West County WPCP, Pinole WPCP, or a new satellite treatment plant near Pt. Isabel.

San Pablo Reservoir was created in 1920 with the construction of the earthen San Pablo Dam on San Pablo Creek. The reservoir has a storage capacity of 38,600 AF (EBMUD, 2014b). San Pablo Dam was reinforced once in 1979, and again in 2008, without increasing the storage of the reservoir during either construction.

San Pablo Reservoir supplies water directly to the Sobrante WTP and receives wash water from the Orinda WTP. Briones Reservoir can supply San Pablo Reservoir with spill water, but historically has not done so. Additionally, San Pablo Reservoir is connected to the San Pablo WTP, which is currently mothballed. From 2007 to 2014, an average volume of 14,000 AFY of Mokelumne Aqueduct water and wash water from Orinda WTP water cycled through San Pablo Reservoir, while an average volume of 12,000 AFY of watershed runoff reached the reservoir. Hydraulically, San

Pablo Reservoir sits at the end of the District's aqueducts, so water spills to the reservoir whenever aqueduct flows exceed the deliveries to the District's other facilities (Orinda and Walnut Creek WTPs, and Briones and Upper San Leandro Reservoirs). Some spillage is operationally necessary for system hydraulics, although an exact volume is not known.

San Pablo Reservoir was maintained with an average monthly volume of at least 18,000 AF between July 2007 and June 2014. During this same period, San Pablo reached a maximum storage of 38,100 AF.

San Pablo Reservoir is potentially limited in the amount of additional water it can accept by several factors including facilities limitations, regulatory guidelines, and operational limitations. The project alternatives developed here include 4 MGD (the maximum amount under Surface Water Augmentation regulations without replacing any of the Aqueduct Inflow) and 12.5 MGD (approximately equal to replacing the amount of aqueduct water currently cycled through the reservoir). Summary information about each alternative is presented in **Table 4-7.**

Table 4-7: San Pablo Reservoir Augmentation Project Alternatives

Project Description	Project Size Recycled Water		Minimum Residence Time (months)	Estimated Dilution (Max % RW by Volume)	Increased Flow Through Reservoir (AFY)
	AFY	MGD			
Limited by SWA Regulation, Downstream WTP, and Current Aqueduct Use	5,000	4	6 months	0.08%	7,000
Approximately equal to current use of Aqueduct Water	14,000	12.5	9 months	0.16%	~0

Under the 4-MGD alternative, recycled water would be supplied to the reservoir in addition to the average amount of water currently supplied by the Mokelumne Aqueduct due to spillage and/or intentional filling. To accommodate the extra water added to the reservoir, Sobrante WTP would have to be operated at higher production rates in the fall and spring. The alternative was developed with the goal of limiting winter (December-March) reservoir outflows to the status quo outflow volume, concentrating the increased production in the spring and fall months (November, April, and May). Running the Sobrante WTP year-round would also be feasible from a Surface Water Augmentationregulatory perspective, though not in line with current District operations. Due to the increased supply from recycled water, annual production at Sobrante WTP would have to increase by approximately 40%.

Entirely replacing the inflow from the Mokelumne Aqueduct with a constant supply of recycled water would result in a 12.5-MGD project. This size requires no dramatic change in the annual production at Sobrante WTP, but reservoir and aqueduct operations would significantly differ from the status quo.

Since there is considerable uncertainty about the District's ability to decrease deliveries from the Mokelumne Aqueduct to San Pablo Reservoir, the alternatives developed for cost and non-cost evaluation were limited to the more easily operable 4-MGD alternative.

One potential benefit of targeting San Pablo Reservoir is the potential to reuse the San Pablo Tunnel, which had been used to convey water from the reservoir to the San Pablo WTP until the plant was decommissioned. For those reservoir augmentation alternatives with Richmond WPCP, SD-1 or the Point Isabel satellite facility as the source, it was assumed that the San Pablo tunnel would be rehabilitated and reused to serve as part of the pipeline alignment.

4.4.2.3 Upper San Leandro

Upper San Leandro Reservoir was considered as a target for advanced treated water from Oro Loma WPCP, San Leandro WPCP, or SD-1.

Upper San Leandro Reservoir was created in 1929 with the construction of the earthen San Leandro Dam on San Leandro Creek. A second dam was constructed in 1978 directly downstream of the first San Leandro Dam, after it was determined to be seismically inadequate. The reservoir has a storage capacity of 38,000 AF (EBMUD, 2014b).

Upper San Leandro Reservoir supplies water directly to the Upper San Leandro Water Treatment Plant (USLWTP). Upper San Leandro Reservoir can also spill to Chabot Reservoir (originally named Lower San Leandro Reservoir), but this has only historically happened during wet months as a form of regulating the storage in the reservoir and is not an annual practice. Upper San Leandro Reservoir stores mainly local runoff, with relatively small amounts of Mokelumne Aqueduct water supplementing the supply. From 2007 to 2014, an average volume of 1,800 AFY of Mokelumne Aqueduct water cycled through the reservoir, compared to more than 12,000 AFY of watershed runoff.

Upper San Leandro was maintained with an average monthly volume of at least 21,120 AF between July 2007 and June 2014. During this same period, Upper San Leandro reached a maximum storage of 37,600 AF, just 6 inches below the top of San Leandro Dam.

The amount of recycled water than can be feasibly added to Upper San Leandro Reservoir is limited by USLWTP capacity and SWA regulatory limits. Upper San Leandro Reservoir is located directly upstream from the USLWTP, which could reliably take on a larger volume of water than it currently does. The maximum amount of water that USLWTP can accept is 4,200 AF/month. The maximum amount of recycled water that Upper San Leandro Reservoir can accept in every month before violating SWA regulations is 3,520 AF/month. This regulatory limit is higher in other months, depending on the amount of storage in the reservoir at the time of the measurement and the monthly flow to USLWTP.

The project alternatives developed here include 34 MGD (the maximum amount under SWA regulations), 20 MGD (a medium-sized project), and 1.6 MGD (the current use of aqueduct water). Summary information about each alternative is presented below in **Table 4-8.**

Table 4-8: Upper San Leandro Reservoir Augmentation Project Alternatives

Project Description	Project Size Recycled Water		Minimum Residence Time (months)	Estimated Dilution (Max % RW by Volume)	Increased Flow Through Reservoir (AFY)
	AFY	MGD			
Limited by SWA Regulation Only	39,000	34	6	0.51%	37,200
Medium Size	23,300	20	6	0.30%	21,500
Approximately equal to current use of Aqueduct Water	1,800	1.6	15	0.02%	~0

The maximum volume of recycled water that could be put into the reservoir and comply with proposed SWA project residence time and dilution requirements is 34 MGD, the largest project size considered. This is about twenty times more water than the amount of Mokelumne Aqueduct water that currently cycles through the reservoir. This alternative exceeds the capacity of USLWTP and was developed primarily to demonstrate the effect of residence time limits. This larger inflow volume requires drafts from the reservoir to increase by about a factor of three to four.

The volume of recycled water that could be added to the reservoir while complying with proposed SWA regulations, staying within the capacity of USLWTP, and staying with the seasonal operation strategy for USLWTP is 20 MGD. For this alternative, USLWTP was assumed to be offline from November through February, and the outflow during this period was limited to the status quo reservoir spill rate. The 20-MGD input of recycled water requires drafts from Upper San Leandro Reservoir to increase by a factor of more than three.

Simply replacing the inflow from the Mokelumne Aqueduct with a constant supply of recycled water would result in a 1.6 MGD project. This size requires no re-working of the draft amounts to the USLWTP, but the storage pattern in the reservoir would differ from the status quo.

Upper San Leandro Reservoir is home to native rainbow trout (*Oncorhynchus mykiss*), whose migration was blocked by the construction of the dam. The rainbow trout in the reservoir are a rare un-hybridized population. Due to the presence of these rainbow trout, Upper San Leandro Reservoir is considered more environmentally sensitive than other reservoir augmentation alternatives.

4.4.2.4 Lake Chabot

Lake Chabot was created in 1874 with the construction of Chabot Dam. The dam was reconstructed and raised in 1980, and a seismic retrofit of the dam was recently completed in late 2017. The lake serves as a standby terminal reservoir to be used in an emergency, during which chlorinated raw lake water would be routed directly into the major distribution systems. However, the reservoir is currently not connected via pipelines to any distribution facilities or Upper San Leandro Reservoir (EBMUD, 2014b). The reservoir has a storage capacity of 10,400 AF.

Lake Chabot receives inflows from rainfall, runoff from a small watershed area of Upper San Leandro Creek, and, in some years, releases from Upper San Leandro Reservoir. It does not receive any water directly from the Mokelumne Aqueduct. The reservoir is currently used to meet three non-potable water demands:

- Irrigation at Lake Chabot Golf Course (123 AFY; West Yost, 2017);
- Irrigation at Redwood Canyon Golf Course (133 AFY; West Yost, 2017);
- Support of in-stream flows for fish habitat in Upper San Leandro Creek downstream of Chabot Dam (Approx. 130 AFY, pers. Comm. M. Tognolini, Nov. 8, 2017).

The April 2017 *Oakland Hills Alternative Water Supply Feasibility Study* (West Yost, 2017) identified Lake Chabot as a possible source of water for additional non-potable irrigation demands at Sequoyah Country Club, the Oakland Zoo, and the planned Oak Knoll Development. However, the report states that Lake Chabot's supply is insufficient to meet these additional demands.

Recycled water could be added to Lake Chabot to support additional in-stream flows in Upper San Leandro Creek, as well as additional non-potable irrigation demands such as those considered in the 2017 Oakland Hills study. Lake Chabot reservoir augmentation was included as a potable (rather than non-potable) reuse project alternative for two main reasons:

- Although Lake Chabot is not currently used for potable water supply, the reservoir is an emergency potable water supply for the region.
- The project could be used as the first phase of a reservoir augmentation project for Upper San Leandro Reservoir, allowing the District to gain experience with operating an advanced water treatment plant prior to adding it to the potable water supply.

Several sources were considered to support the Lake Chabot alternative, including the LAVWMA pipeline, which has about 10 MGD of available secondary-treated wastewater from DSRSD and the City of Livermore. The supply is limited to the winter months, November through April (Figure 5, West Yost Associates, 2017), and there is very little supply available during irrigation season. A satellite treatment facility could be constructed adjacent to the LAVWMA pipeline, with MF and RO concentrate being returned to the pipeline for disposal through the EBDA outfall.

At a flow rate of 10 MGD, the residence time in Lake Chabot, which has a minimum storage volume of about 7,000 AF, would be 7.5 months, comfortably complying with the reservoir augmentation criteria of 6 months. However, Lake Chabot does not currently meet the proposed SWA requirement of operating as an approved surface water source for at least two years. As stated previously, while it is designated as an emergency water supply, it is not currently connected to the District's potable water distribution system and is not operated for water supply at this time.

Advanced treated water sent to Lake Chabot could be used to support:

- Additional non-potable demands;
- In-stream flows; and
- Supply to USLWTP, if and only if Lake Chabot is classified as an approved drinking water source.

No pipelines to connect to non-potable customers or USLWTP were included in the Lake Chabot alternative.

4.4.3 Raw Water Augmentation Targets

For raw water augmentation, advanced treated water could be delivered to the District's raw water aqueducts, or directly to a surface water treatment plant. San Pablo WTP was not considered as a raw water augmentation target since it is currently not in use and Lafayette WTP was not considered because of its location far from any wastewater source.

Advanced treated water can be added to the District's conventional surface water treatments plants or the "in-line" filtration plants. The additional treatment steps (flocculation and sedimentation) provided at the conventional surface water treatment plants are to remove fine particulates from the existing sources (which is not a concern in advanced treated water). These processes must be retained for compliance with the Surface Water Treatment Rule. These processes are not expected to significantly alter the quality of the advanced treated water under normal operating conditions, when the advanced treated water will be essentially particle-free after MF/RO/AOP. However, in the event of a failure of the advanced treatment system, the additional sediment removal and ozonation available at the conventional WTPs would provide more treatment system redundancy than is available at the in-line water treatment plants.

4.4.3.1 Conventional Surface Water Treatment Plants

USLWTP and Sobrante WTP are fed primarily from local runoff and local reservoirs. USLWTP is fed by Upper San Leandro Reservoir, while Sobrante WTP is fed from San Pablo Reservoir. These two WTPs provide full conventional treatment consisting of five basic steps—coagulation, flocculation, sedimentation, filtration, and disinfection, as well as ozonation for taste and odor.

USLWTP was considered as a target for advanced treated water from Oro Loma WPCP, San Leandro WPCP, or SD-1. Sobrante WTP was considered as a target for advanced treated water from Pinole WPCP, Richmond WPCP, or West County WPCP.

4.4.3.2 In-Line Water Treatment Plants

Orinda, Walnut Creek, and Lafayette WTPs, the "in-line filtration" water treatment plants, are fed directly from the Mokelumne Aqueduct, rather than being fed primarily from local runoff and local reservoirs. The process train at the in-line WTPs includes only coagulation, filtration, and disinfection. Flocculation and sedimentation are not needed at the inline filtration plants because they were permitted as alternative technology facilities. Orinda WTP was considered as a target for advanced treated water from SD-1. Walnut Creek WTP was considered as a target for advanced treated water from CCCSD via the Mokelumne Aqueduct, as described below.

4.4.3.3 Mokelumne Aqueduct

Advanced treated water can be added directly to the Mokelumne Aqueduct and used at any of the District's surface water treatment plants. This alternative involves adding water near Mallard Reservoir, consistent with a previous potable reuse study conducted by CCCSD (CCCSD, 2016). The hydraulic grade line of the aqueduct is approximately 400 feet at this location. The water could be added to Mokelumne Aqueduct No. 2, similar to the transmission concept developed for the District to accept deliveries from the Los Vaqueros Reservoir Expansion project (CCWD, 2017). The water could be isolated for delivery to Walnut Creek WTP or distributed throughout the raw water system including Orinda WTP, Lafayette WTP, and the terminal reservoirs.

4.4.4 Treated Water Augmentation Targets

The targets for treated water augmentation are connection points within the treated water distribution system. Potential connection points were identified using a process similar to that described in a 2016 District assessment of potable reuse from SD-1 to the West-of-Hills distribution system (Maggiore, 2016) as well as consultation with District staff. The preliminary assessment presented in the 2016 memo was used as the basis for the siting and sizing of potable water system connections. Potential connections to the potable system were selected based on recommendations provided by District staff to maximize blending and distribution of the treated water within the distribution system while also minimizing negative impacts on the system hydraulics. Potential connection pipelines were sized per the standard maximum velocity for a connection (7 fps). Connections to the potable system would require a new pump station to provide similar head at the connection point as under existing conditions. Alternatively, the connection to the potable system could be routed through an existing treated water tank, requiring a longer connection pipeline but potentially less operational complexity.

A potable water system connection was identified for each of the wastewater sources aside from the CCCSD WWTP, which is not within the District's treated water service area. Connection pipe sizes were based on the velocity criteria discussed in Section 4.6.2. Pump stations were sized based on the approximate head at the connection point, per District pressure zone and hydraulic model figures. Treated water augmentation targets are summarized below in **Table 4-9**.

Table 4-9: Treated Water Augmentation Connections

Wastewater Treatment Facility	Supply (MGD)	Proposed Connection Point	Head Required at Connection Point (ft.)
San Leandro WPCP	1.4	Dunsmuir Reservoir	222
Pinole/Hercules WPCP	1.7	Maloney Reservoir	324
Richmond WPCP	3.6	Wildcat Aqueduct (36-in)	205
West County WPCP	4.7	Wildcat Aqueduct (36-in)	205
Oro Loma WPCP	8.0	South Reservoir	222
SD-1	10 or 30	Claremont Center Distribution Pipeline (36-in)	345

4.5 Advanced Water Treatment Trains

Advanced treatment trains were developed to bridge the gap between the wastewater source and the potable reuse target. Potable reuse treatment technologies have been documented in both demonstration and full-scale applications through years of research and performance monitoring. The treatment trains documented here were developed primarily for cost-estimating purposes and to demonstrate the viability of the potable reuse alternatives. Advanced treatment for potable reuse is still a relatively new application, so additional technologies are expected to be available in coming years – particularly those related to continuous online monitoring that can demonstrate increase levels of pathogen removal and reduced response time.

The unit processes used within the proposed treatment trains are described in the sections below. Pathogen log reduction values (LRVs) are identified for each unit process based on other potable reuse projects currently in planning stages and submitted to DDW for review. A rationale for the sizing of each treatment train component is also provided.

4.5.1 Unit Processes

4.5.1.1 Upgraded Secondary Treatment

Each wastewater source considered for advanced treatment currently has secondary treatment, as discussed in Section 4.3. Secondary improvements to achieve partial denitrification down to 15 mg/L Total Nitrogen and longer SRT were assumed to align with year-round "Level 2" nutrient removal as determined in the BACWA Nutrient Reduction Study. Cost estimates for these improvements are available in the BACWA Nutrient Reduction Study Report (BACWA, 2018). Capital cost estimates range from $19M for the Pinole WPCP to $2.2B for SD-1.

Some facilities (i.e., SD-1, CCCSD WWTP, and others) have existing tertiary filtration systems for production of non-potable recycled water; however, these tertiary filtration systems were not considered to be a component of the advanced treatment trains. This assumption is important from a cost-estimating perspective; the existing tertiary filtration systems are typically smaller than the full treatment capacity, and it is more conservative from a cost estimating perspective to exclude them. The decision to include / exclude existing tertiary treatment an advanced treatment may be re-assessed for a select group of alternatives.

Overall Performance for Pathogen Reduction: A maximum of 2.0 log reduction for virus, 2.0 log for giardia, and 1.0 log reduction for *Cryptosporidium* (2/2/1 LRV) is expected to be available for a secondary treatment system with long solid retention time, based on Table 2-2 in the Expert Panel Report (SWRCB, 2016b). Given uncertainty about DDW granting credits for pathogen removal in secondary treatment, however, the total LRV for each treatment train exceeded the goal by at least the amount credited here (i.e., these are "bonus" removal credits).

Sizing Criteria: In virtually all cases, the full flow of the WWTP was assumed to be upgraded for Level 2 nutrient removal, given the operational difficulty of re-configuring a wastewater plant for split treatment. The only exception was for alternatives at SD-1 with flow rates of 10 MGD or less, which were assumed to use an MBR to produce nitrified and denitrified secondary effluent.

4.5.1.2 Membrane Bioreactor

An MBR is a technology that is typically used to treat BOD, COD, solids (TSS and turbidity), and nitrogen (ammonia and nitrates) in raw wastewater or primary effluent. The process essentially consists of aerobic microbial treatment followed by MF. In the aerobic treatment component of the process, microbes in a suspended growth environment metabolize organic compounds and, depending on the system design, provide nitrification and denitrification. Effluent from the aerobic treatment is then filtered through the MF system. Filtrate from the MF system is conveyed as treated effluent. Solids filtered (both suspended microbes and solids) screened by the MF system are regularly flushed from the membrane surfaces and returned to the front end of the aerobic treatment system. Excess biomass and solids are periodically discharged as a waste stream to maintain a balance of solids inventory of the MBR.

Several of the alternatives start with raw sewage using a satellite treatment plant concept. Those alternatives were assumed to include an MBR to provide biological treatment with nitrification and denitrification at least equivalent to the upgraded secondary treatment, and membrane filtration.

Treatment trains with an MBR do not include separate standalone microfiltration. Note that for treated water augmentation treatment train with MBR providing secondary treatment upstream of ozone and BAC, colloidal material may slough off the BAC, requiring additional maintenance. For this case, additional measures may be required to protect the RO process.

Overall Performance for Pathogen Reduction: A maximum of 1.5/2/2 LRVs for virus/*Giardia*/*Cryptosporidium* is expected to be available for MBR. The LRVs are based on the Australian WaterVal program's recently published Tier 1 validation protocol, which is currently under consideration by DDW, and has recently been approved on an individual project basis. LRVs are more difficult to verify in MBR than in other MF systems, where pressure decay testing is an option, and research on verifiable LRVs in MBR is an area of active research.

Sizing Criteria: Satellite treatment using an MBR was sized by alternative-specific criteria, as follows:

- Satellite treatment at Pt. Isabel was sized according to the available dry weather flow;
- Satellite treatment at SD-1 for reservoir augmentation to San Pablo Reservoir was sized according to the constraints at San Pablo Reservoir (4 MGD);
- Other satellite treatment at SD-1 was sized at 10 MGD – a somewhat arbitrary number that was selected to represent a medium-sized alternative, less than the full 30 MGD available.

The minimum space requirements for MBR treatment were assumed to be approximately 3,700 square feet per MGD.

4.5.1.3 Ozonation with Biologically Active Carbon

Ozonation (O_3) followed by biologically active carbon (BAC) is a treatment process intended to facilitate the breakdown of large, more recalcitrant organic molecules into simpler organic compounds that can be removed more easily through microbial consumption. In this process, O_3 is injected into the feed stream to break down organic compounds and trace pollutants through oxidation. The smaller molecules are then metabolized as a food source by the biofilm developed in the BAC media, which consists of granular activated carbon (GAC). The primary benefits of O_3/BAC treatment are as follows:

- Reduction of TOC and trace pollutants through the mechanism described above.
- Reduction of pathogens, as ozone is a potent disinfectant.
- Improvements to the performance of downstream membrane filtration (MF/RO)

For this RWMP Update, Ozone/BAC was included only for the treated water augmentation alternatives. The treatment trains for groundwater augmentation, reservoir augmentation, and raw water augmentation derive sufficient pathogen removal from groundwater travel or a surface water treatment plant, such that O_3-BAC is not expected to be needed. Although not included in the raw water augmentation alternatives developed for this study, it is possible that the raw water augmentation regulations expected in 2023 will necessitate the addition of O_3-BAC to the treatment train.

Overall Performance for Pathogen Reduction: The LRVs assumed for the O_3-BAC process are as follows:

- O_3 – 6/6/1 LRVs for virus/*Giardia*/*Cryptosporidium* (Trussell, 2015). Higher LRVs for cryptosporidium are achievable with higher dosing.

- BAC – 0/0/0 LRVs for virus/*Giardia*/*Cryptosporidium*. Although 1/2/2 LRVs can be achieved through filtration with an effluent turbidity of 0.1 NTU per the USEPA Long Term 2 Enhanced Surface Water Treatment Rule, this mode of operation was not assumed for this analysis. As the GAC media would be intended for use as a microbial substrate rather than filtration as its primary function, biomass could potentially slough from the media and into the BAC effluent. Therefore, the 0.1 NTU BAC effluent turbidity requirement might not be met during portions of the BAC operation.

Sizing Criteria:

- Preliminary design and planning level information were used as the basis for estimating the equipment requirements for this effort. These sources include the Expedited Purified Water Program, Ford and Coyote Facilities Plan Final Report (Woodard & Curran, 2017a) and Oro Loma Sanitary District Potable Reuse Evaluation (HDR, 2016). Note that the information from these sources was also used to estimate the equipment requirements for the microfiltration, reverse osmosis, and advanced oxidation processes discussed in the sections that follow.
- O_3:TOC ratio of 1:1 and a contact time of 2 minutes for the O_3 contactor.
- Empty bed contact time of 20 minutes for the BAC.

4.5.1.4 Microfiltration

In a conventional FAT train configuration, low pressure membrane filtration (either ultrafiltration (UF) or microfiltration (MF)) systems are typically installed as the first treatment operation of the FAT process. These are physical filters which remove suspended solids and colloidal particulates from the process water upstream of the RO system. If left in the process water, these solids could impair the operation of the RO process by organic fouling or plugging of the RO membrane surfaces.

Membranes used for MF applications have a nominal pore size rating of 0.1 µm, whereas UF membrane have smaller nominal pore rating of 0.01 µm. Both MF and UF membranes are robust technologies that have been proven to be effective to remove *Giardia* and *Cryptosporidium*, algae, and some bacterial species. The notable distinction between MF and UF is that MF is not an effective barrier to viruses, whereas UF has been shown to have some effectiveness with virus removal, although Integrity testing to demonstrate virus removal is an additional technical challenge. MF/UF processes have not been shown to remove a significant amount of chemical pollutants.

Overall Performance for Pathogen Reduction: 0/4/4 LRVs for virus/*Giardia*/*Cryptosporidium*. Both MF and UF have been demonstrated to achieve 4 LRVs for *Giardia* and *Cryptosporidium* (Reardon, 2005). No LRV for virus was assumed for the MF treatment step.

Sizing Criteria:

- Assumed use of MF membranes; hollow fiber configuration; flux of 4-25pprox.. 32 gallons per square foot membrane area per day (gfd) average.

4.5.1.5 Reverse Osmosis

The reverse osmosis (RO) process in a potable reuse treatment train provides for removal of salt (measured as TDS and electrical conductivity (EC)), organics (measured as TOC), and pathogens. RO removes at least 95 percent of incoming salt. This treatment operation in the FAT process is sequenced between the MF/UF system and the AOP. In operation, the TDS and other dissolved components in the RO feed stream are pressurized above the osmotic pressure of the water. Once this threshold is overcome, water begins passing through the RO membrane to become permeate. The bulk of the TDS and dissolved components cannot pass through the RO membrane, and concentrate in the reduced volume of remaining feed water. Upon exiting the RO process, the permeate is conveyed to the AOP process for further treatment. The remaining water exiting the RO system containing the concentrated TDS and dissolved components is discharged to waste as brine. Depending on the feed water quality, RO permeate can have a TDS concentration of less than 50 mg/L.

Overall Performance for Pathogen Reduction: 2/2/2 LRVs for virus/*Giardia*/*Cryptosporidium*. These LRV values were selected based on the minimum values reported in the literature (Trussell, 2015) to ensure a conservative basis when evaluating the overall performance of each alternative treatment process.

Note that the LRV allowable for RO membranes is not governed by the ability of an intact membrane to reject pathogens; it is governed by the ability to monitor the membrane integrity. Worn or damaged seals or membrane damage to the due to oxidization or abrasive from solids can allow pathogens to leak past the RO membrane. The monitoring tools currently used, EC meters and TOC meters, can measure up to 99 percent of both parameters through the RO process. Findings from demonstration tests and existing permitted installations (e.g. the Orange County Water District Groundwater Replenishment System) have demonstrated that these monitoring methods can provide virus/*Giardia*/*Cryptosporidium* LRVs of 2 for each (Trussell, 2015). Furthermore, emerging alternative technologies currently in various stages of testing and development have the potential to provide higher LRVs due to greater levels of accuracy in assessing membrane integrity. For example, Nalco has stated that test findings for their proprietary Trasar® fluorescent dye system can provide sufficient resolution to monitor more than 3 LRV for virus, *Giardia*, and *Cryptosporidium*. The assumption of 2/2/2 LRVs for RO assumes advancements in monitoring methodology will be made prior to implementation of potable reuse by the District, as currently LRVs based on TOC metering are limited to 1.5/1.5/1.5.

Sizing Criteria:

- 8-inch diameter spiral wound RO membranes of thin film composite construction. Assumed low pressure type RO membranes.
- Estimated RO recovery of 85%.

Disposal Considerations:

In addition to TDS and TOC removal, RO removes trace level pollutants such as metals and organic pollutants, including hormones, pharmaceuticals, and personal care products. RO concentrate disposal is a potential concern for NPDES permit compliance due to possible violations of numeric effluent limits, increased monitoring requirements, and/or the presence of chronic toxicity. Therefore, concentrate disposal was included as a factor in the non-cost evaluation in Section 5.1.2.

All of the alternatives involve disposal to a deep-water Bay outfall with dilution of at least 10:1. Alternatives sized to use most of a wastewater treatment plant's available dry weather flow were scored lower due to concerns over concentrate disposal, since less flow would be available for dilution prior to discharge. Alternatives with wastewater available for dilution prior to discharge were scored higher, including those at Oro Loma WPCP (dilution from other EBDA dischargers) and alternatives at SD-1 and CCCSD using less than one half of total wastewater available.

4.5.1.6 Advanced Oxidation Process

AOP is the third treatment operation of the FAT process, sequenced downstream of the RO system. It is intended to provide a high level of disinfection and to break down any trace organic compounds that pass through the RO membrane. The AOP assumed for this analysis consists of ultraviolet light system combined with hydrogen peroxide (UV-H_2O_2), which is the industry standard for FAT processes. For this type of AOP, the H_2O_2 is dosed to the RO permeate entering the UV reactor. Exposure to the intense UV light in the reactor causes the H_2O_2 to form hydroxyl radicals, which are extremely potent oxidizers. They react with any organic compounds and pathogens present in the water, breaking them down into smaller organic molecules and, ultimately, into water and carbon dioxide. Any remaining hydroxyl radicals rapidly recombine to H_2O_2 after the water exits the UV reactor.

Other types of AOP such as UV-Chlorine are also being demonstrated elsewhere for lower cost than UV-H_2O_2 and could be evaluated during the design phase.

Overall Performance for Pathogen Reduction: 6/6/6 LRVs for virus/*Giardia*/*Cryptosporidium* as allowed by DDW (Trussell, 2015).

UV/AOP reliably provides at least 6-log disinfection of both protozoa and virus. The same system is assumed to reduce NDMA to <10 ng/L and destroy at least 0.5-log of 1,4-dioxane, thus also reducing other trace level pollutants. Online dose monitoring systems, using real time inputs of UV, UV intensity, flow, and oxidant dosing, is recommended for continuous confidence in UV AOP performance.

Sizing Criteria: UV dose of 900 mJ/cm^2. Although a UV dose of 235 mJ/cm^2 can provide 6 LRVs for virus, *Giardia*, and *Cryptosporidium*, a higher UV dose is needed to address 1,4-dioxane and NDMA. Although neither currently has a drinking water MCL, DDW requires that at least a 0.5 log reduction of 1,4-dioxane is provided. Additionally, industry practice is to reduce NDMA to below its DDW notification level of 10 ng/L. 900 mJ/cm^2 is an average value needed to photolytically degrade NDMA from approximately 150 ng/L to the DDW notification level of 10 ng/L. The 150 ng/L value was taken from data for the secondary effluent from another treatment plant in the Bay Area and may not be accurate for the wastewater sources considered in this study.

The minimum space requirements for FAT (MF/RO/AOP taken together) were assumed to be approximately 5,000 ft^2 per MGD.

4.5.1.7 Free Chlorine

For the reservoir water augmentation and raw water augmentation alternatives, the use of free chlorine was added to the overall treatment train to ensure that a 13 LRV for virus is achieved across the entire process. The use of free chlorine is an industry standard practice for disinfection, with well-documented methodologies to calculate the contact time (CT) requirements to achieve a desired virus LRV. The LRV for virus could range from 2 to 6, the maximum allowable value. Dechlorination is required prior to discharging for reservoir augmentation, but no dechlorination step would be required for raw water augmentation.

Free chlorine is not expected to be needed to meet pathogen removal requirements for the treated water augmentation alternatives due to the inclusion of the O_3/BAC process, which provides an LRV of 6 for virus. However, it could be included for redundancy without a major impact on the overall treatment cost. The free chlorine contact time of 80 (mg-min)/L used for sizing is conservative for cost estimating purposes. A smaller contact time of 5-10 min may be feasible, and design values would be established during a later phase.

Overall Performance for Pathogen Reduction: 2/0/0 for virus/*Giardia*/*Cryptosporidium*. An LRV of 2 was deemed to be sufficient to ensure that the 13 virus LRV requirement for the overall treatment process can be met.

Sizing Criteria:

- Preliminary design and planning level information from the Expedited Purified Water Program, Direct Potable Reuse Facilities Plan Final Report (Woodard & Curran, 2017b)
- CT of 80 (mg-min)/L (Woodard and Curran, 2017b).
- Contact Tank – 30-minute modal contact time, 70% baffling factor for tank.

4.5.1.8 Engineered Storage Buffers

The raw water and treated water augmentation alternatives include ESBs. For both types of potable reuse, an ESB with a total volume equivalent to 6 hours at peak production was included. Cost estimates for ESBs assume the use of 3 storage tanks, each sized for a storage volume equivalent to 2 hours at peak production. This configuration allows one storage tank to be filled, one storage tank to be tested, and one storage tank to be drained at any given time, consistent with guidance (WRF, 2016). The minimum failure response time required for this configuration is 2 hours. Microfiltration is typically the most difficult process for which to verify pathogen removal, and pressure decay testing is not likely to be feasible every 2 hours. The 2-hour failure response time assumes that an advanced monitoring technique such as particle-counting will become available to allow verification of the MF process within 2 hours. A DDW-approved technology is not currently available but is an area of active research and development.

Raw water augmentation alternatives would have an additional 1 to 3 hours of response time during travel in the transmission pipelines to the closest surface water treatment plant.

The minimum space required for ESB storage tanks were estimated based on a tank height of 30 feet (1400 ft^2 per million gallons of storage).

4.5.1.9 Wellhead Treatment

The treatment train for groundwater augmentation using the Oro Loma WPCP was assumed to include wellhead treatment for manganese and disinfection following extraction and prior to addition to the treated water distribution system (OLSD, 2016).

4.5.2 Treatment Trains

Seven unique treatment trains were developed to meet all possible combinations of sources and targets, as shown in **Figure 4-6** through **Figure 4-12.** These treatment trains are as follows:

- **Treatment Train Type 1 – Groundwater Augmentation:** Partially denitrified secondary effluent treated by the FAT process (MF/RO/AOP) and free chlorine disinfection, followed by well injection to the groundwater basin. Groundwater would be extracted from downgradient potable wells for delivery to the potable water system. Potable groundwater wells would be located sufficiently far enough downgradient of the injection location to meet underground retention time requirements.

- **Treatment Train Type 2 – Reservoir Water Augmentation:** Partially denitrified secondary effluent treated by the FAT process and free chlorine disinfection, followed by dechlorination and discharge to a surface water reservoir. Chlorine disinfection would be for advanced water treatment and to maintain a residual in the conveyance pipeline. Dechlorination would take place at the reservoir site prior to point of discharge. After mixing and a minimum theoretical retention time of 180 days, surface water from the reservoir would be treated at a surface water treatment plant followed by delivery to the potable water system.

- **Treatment Train Type 3 – Reservoir Water Augmentation with New MBR:** Raw wastewater treated by an MBR system followed by RO-AOP, chlorine disinfection, dechlorination, and discharge to a surface water reservoir. Chlorine disinfection would be for advanced water treatment and to maintain a residual in the conveyance pipeline. After mixing and a minimum theoretical retention time of 180 days, surface water from the reservoir would be treated at a surface water treatment plant followed by delivery to the potable water system.

- **Treatment Train Type 4 – Raw Water Augmentation:** Partially denitrified secondary effluent treated by the FAT process and chlorine disinfection, followed by an ESB. Water from the ESB (6-hour volume, 2-hour response time) would be blended with raw water prior to a surface water treatment plant.

- **Treatment Train Type 5 – Raw Water Augmentation with New MBR:** Raw wastewater treated by an MBR system followed by RO-AOP, chlorine disinfection, and an ESB (6-hour volume, 2-hour response time). Water from the ESB would be blended with raw water prior to a surface water treatment plant.

- **Treatment Train Type 6 – Treated Water Augmentation:** Partially denitrified secondary effluent treated by O_3-BAC and FAT processes, followed by addition of a chloramine disinfection residual, and an ESB (6-hour volume, 2-hour response time). Water from the ESB would be delivered directly to the (6-hour volume, 2-hour response time potable water distribution system.

- **Treatment Train Type 7 – Treated Water Augmentation with New MBR:** Raw wastewater treated by an MBR system followed by O_3-BAC, RO-AOP, addition of a chloramine disinfection residual, and an ESB (6-hour volume, 2-hour response time). Water from the ESB would be delivered directly to the potable water distribution system.

The LRVs for virus/*Giardia*/*Cryptosporidium* for each treatment train type is presented in **Table 4-10.** Also presented are the LRVs for virus/*Giardia*/*Cryptosporidium* for each treatment operation, along with the LRV treatment goal for the overall train.

For reservoir augmentation, the LRV requirements are implemented separately for the Advanced Water Treatment and Surface Water Treatment Plant components, as noted in Section 4.1.2. No comparable approach has been established for raw water augmentation or treated water augmentation, so it is not known how those advanced treatment LRV requirements would be implemented.

Table 4-10: Pathogen Removal Credits for Advanced Treatment Trains

Pathogen	2° Treat-ment[1]	MBR	Advanced Water Treatment (AWT)					Cl_2	URT	SAT	SWTP	Total LRV	LRV Goal
			O_3	BAC	MF	RO	AOP						
1. Groundwater Augmentation by Well Injection													
Virus	2	--	--	--	0	2	6	6	2	--	--	**18**	12
Giardia	2	--	--	--	4	2	6	0	0	--	--	**14**	10
Crypto	1	--	--	--	4	2	6	0	0	--	--	**13**	10
2. Reservoir Augmentation													
Virus	2	--	--	--	0	2	6	2[2]	--	--	4	**16**	13
Giardia	2	--	--	--	4	2	6	0	--	--	3	**17**	11
Crypto	1	--	--	--	4	2	6	0	--	--	2[3]	**15**	11
3. Reservoir Augmentation with MBR													
Virus	--	1.5	--	--	--	2	6	2[2]	--	--	4	**15.5**	13
Giardia	--	2	--	--	--	2	6	0	--	--	3	**13**	11
Crypto	--	2	--	--	--	2	6	0	--	--	2[3]	**12**	11
4. Raw Water Augmentation													
Virus	2	--	--	--	0	2	6	2[2]	--	--	4	**16**	13
Giardia	2	--	--	--	4	2	6	0	--	--	3	**17**	11
Crypto	1	--	--	--	4	2	6	0	--	--	2[3]	**15**	11
5. Raw Water Augmentation with MBR													
Virus	--	1.5	--	--	--	2	6	2[2]	--	--	4	**15.5**	13
Giardia	--	2	--	--	--	2	6	0	--	--	3	**13**	11
Crypto	--	2	--	--	--	2	6	0	--	--	2[2]	**12**	11
6. Treated Water Augmentation													
Virus	2	--	6	0	0	2	6	--	--	--	--	**16**	13
Giardia	2	--	6	0	4	2	6	--	--	--	--	**20**	11
Crypto	1	--	1	0	4	2	6	--	--	--	--	**14**	11
7. Treated Water Augmentation with MBR													
Virus	--	1.5	6	0	--	2	6	--	--	--	--	**15.5**	13
Giardia	--	2	6	0	--	2	6	--	--	--	--	**16**	11
Crypto	--	2	1	0	--	2	6	--	--	--	--	**11**	11

Notes:

1. Secondary treatment is assumed to include nutrient removal.
2. Free chlorine for may be designed for 2-6 LRVs.
3. Conventional surface water treatment plants (USLWTP and Sobrante WTP) provide 2.5-LRV for Cryptosporidium.

Figure 4-6: Treatment Train Type 1 - Groundwater Augmentation

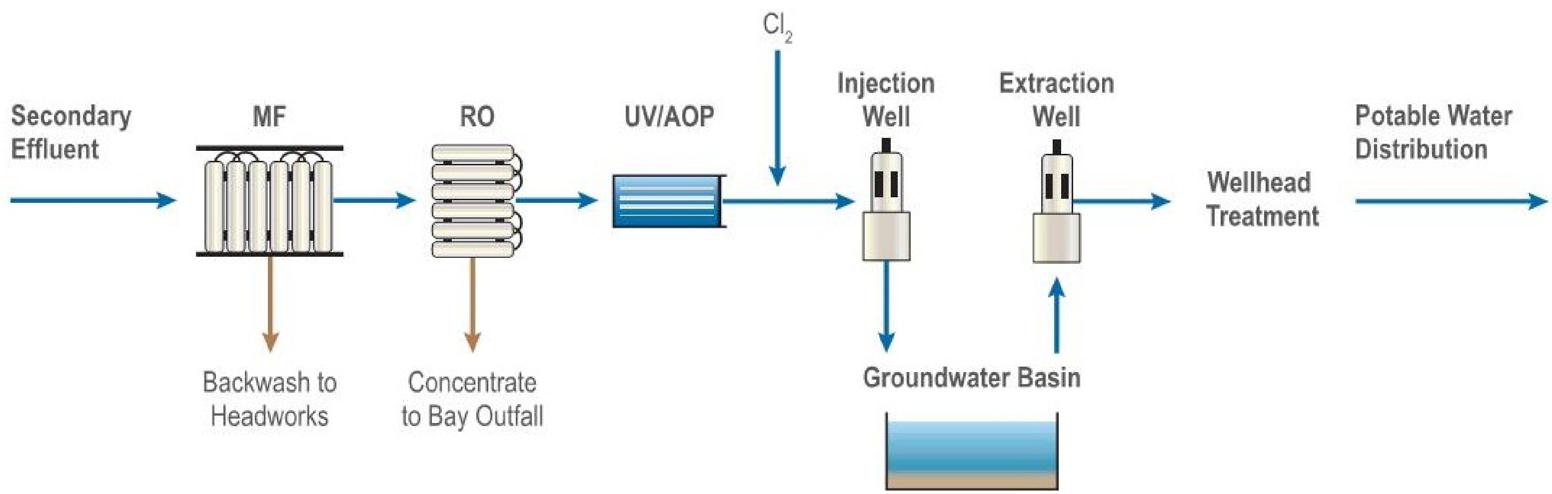


Figure 4-7: Treatment Train Type 2 - Reservoir Water Augmentation

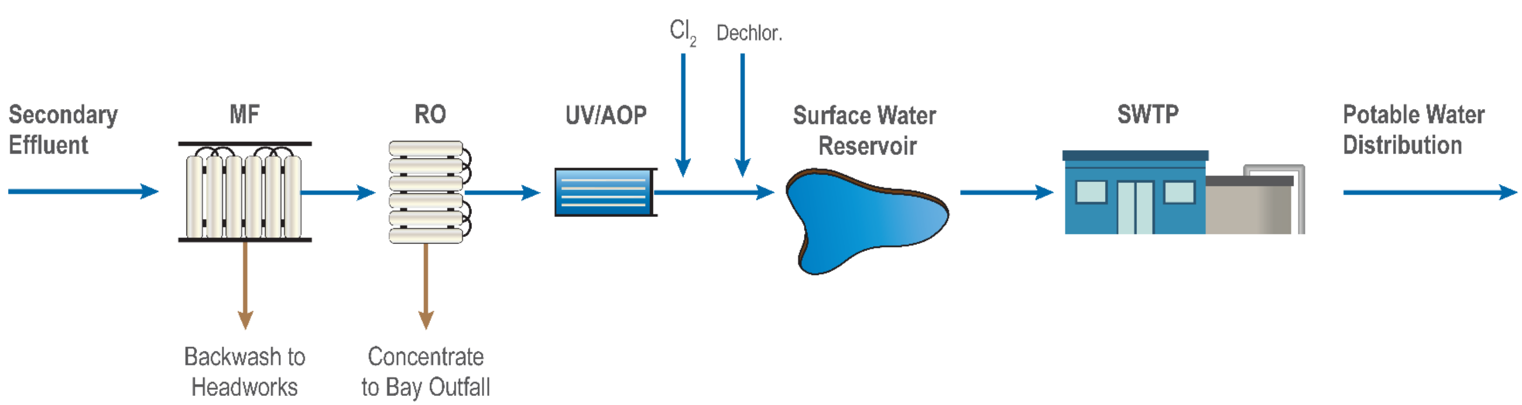


Figure 4-8: Treatment Train Type 3 - Reservoir Augmentation with New MBR

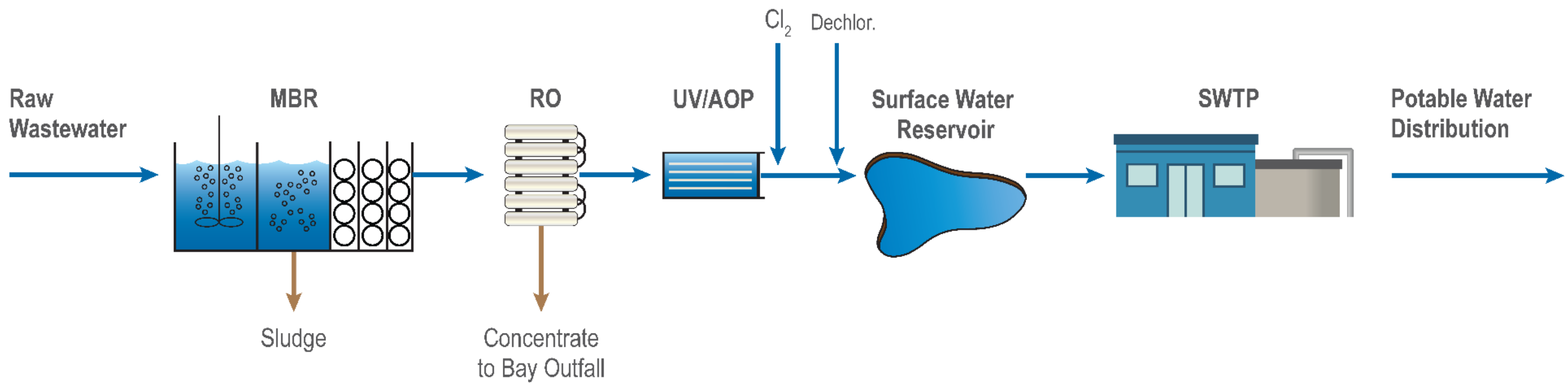


Figure 4-9: Treatment Train Type 4 - Raw Water Augmentation

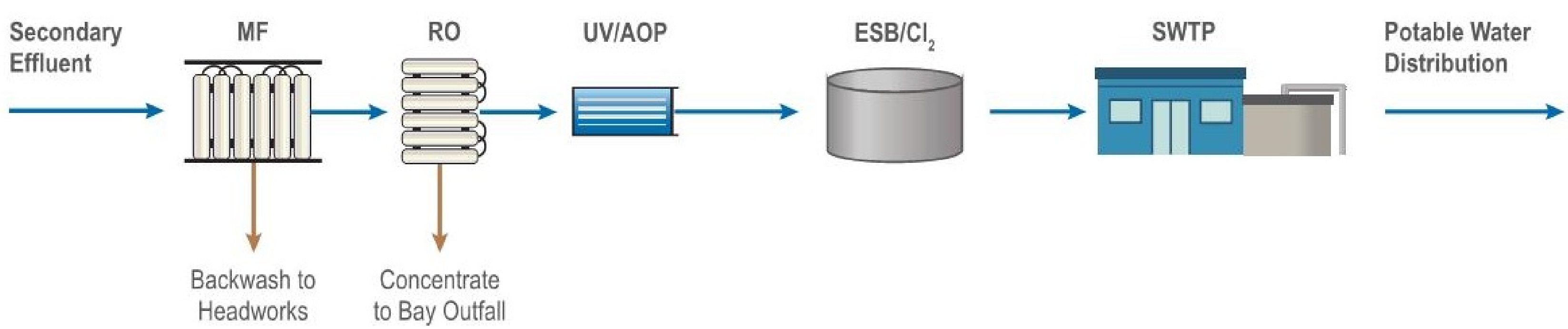


Figure 4-10: Treatment Train Type 5 - Raw Water Augmentation with New MBR

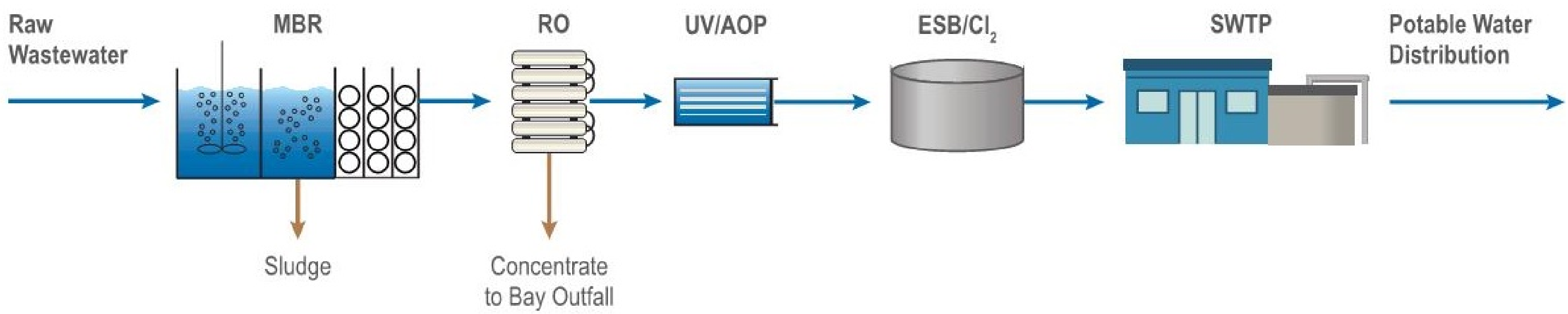


Figure 4-11: Treatment Train Type 6 - Treated Water Augmentation

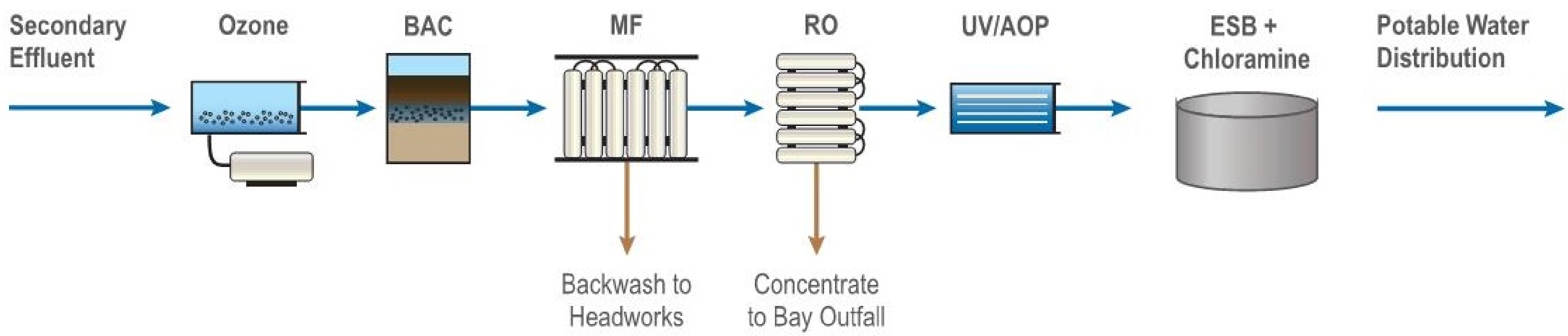
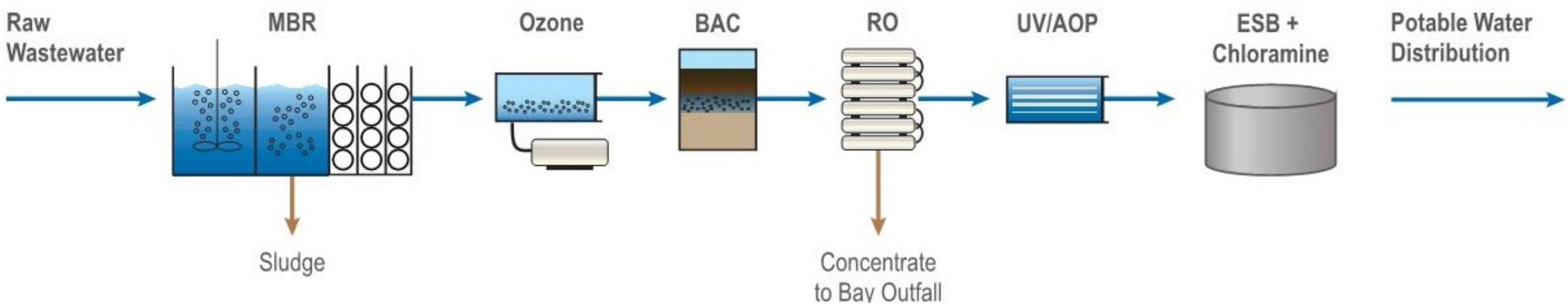


Figure 4-12: Treatment Train Type 7 - Treated Water Augmentation with New MBR



4.5.3 Basis of Cost Estimates

Opinions of probable capital and O&M cost for each of the treatment alternatives were developed following the cost estimating approach as detailed in **Section 2**.

4.6 Conveyance Concepts

This section presents the methods used to develop the transmission pipeline alignments and sizing for all potable reuse alternatives as summarized in **Table 4-11**.

4.6.1 Conveyance Routing

Pipeline routes for potable reuse projects were evaluated in ArcGIS by connecting recycled water sources and corresponding reuse targets with the shortest path between them, as follows:

- **Groundwater Augmentation:** Pipeline lengths and sizing for connecting the Oro Loma WPCP with injection wells were taken from the Oro Loma *Recycled Water Feasibility Study Final Report* (OLSD, 2016). The Oro Loma study did not include facilities required to connect the extraction wells to the District's distribution system, so a new tank, pump station and connection pipeline have been added to the cost estimate for this master plan.
- **Reservoir, Raw Water, and Treated Water Augmentation:** These direct alignment lengths were increased by 25 percent to serve as a preliminary, planning-level, pipeline length. For this RWMP Update, these preliminary alignment lengths could be used for high-level cost comparisons between project alternatives without developing in-depth alignments for each project alternative. Any route that crossed San Francisco Bay or a District reservoir was adjusted to avoid those intersections while maintaining the shortest possible route.
- Alternatives using the CCCSD WWTP as a source were an exception as pipeline alignments for these alternatives were taken from CCCSD's *Recycled Water Wholesale Opportunities* report (CCCSD, 2016) and were not increased by 25 percent.

4.6.2 Basis of Pipeline Sizing

Pipelines for each alternative were sized based on the alternative flowrate and a maximum allowable velocity criterion of 5 fps.

4.6.3 Basis of Trenchless Crossing Analysis and Trenchless Pipeline Construction

The number of trenchless crossings required for each project alternative was estimated by using ArcGIS to assess the number of streams, California Highways, railroads, and BART right of ways that were intersected by the preliminary pipeline alignments. In those cases where a pipeline required multiple trenchless crossings within a short distance (approximately 200 feet), it was assumed that these individual crossings could be combined into one larger trenchless crossing. Other redundant crossings, such as multiple creek crossings due to an alignment running roughly parallel to the meandering creek, were removed following individual analysis.

An estimate of the total length of trenchless crossings required by each project alternative was developed by measuring the approximate alignment length within restricted boundaries of streams, California Highways, railroads, and BART right of ways. A minimum trenchless crossing distance of 200 feet was imposed to consider the limitations of current trenchless technology. Measurements were made based on a review of the ArcGIS alignments and available aerial images.

In addition to including trenchless crossings for streams, California Highways, railroads, and BART right of ways, tunneled lengths were estimated for those projects which would either take advantage of the existing San Pablo Tunnel or could not be easily routed through the coastal hills and would require a new tunnel (i.e., to Upper San Leandro Reservoir). For those alternatives which would utilize the San Pablo Tunnel, it was assumed that the full tunnel length (17,600 feet) would be rehabbed. For those alternatives requiring a new tunnel, a length of 7,000 feet was assumed based on the existing tunnel length at San Pablo Reservoir.

4.6.4 Pump Station Sizing

Pump stations for each alternative were sized based on the project flow and estimated head required. Required head was based on the approximate pipeline starting and ending elevations with the addition of an assumed one foot of friction head per 1,000 feet of pipe and a pump efficiency of 75%. Pump configurations included one standby pump and a minimum of two duty pumps. The maximum allowable individual pump size was set at 600 horsepower (hp).

4.7 Potable Reuse Alternatives Summary

Based on the sources, targets, and treatment trains described above, the potable reuse alternatives carried forward for cost and non-cost evaluation are described in **Table 4-11**. The following summary information is provided for each alternative:

- A short name (for use in other tables);
- The source of wastewater;
- The target for advanced treated wastewater;
- The type of potable reuse;
- The maximum production rate, assumed to be constant year-round exempt for the alternative from LAVWMA as a source. This was used to size treatment processes.
- The total production volume per year (yield)
- The pipeline diameter and length required for conveyance from the source to the target;
- The number and length of trenchless crossings and tunnels required for conveyance;
- The required pump station size for conveyance from the source to the target;
- The treatment train configuration (1 through 7, see **Figure 4-6** through **Figure 4-12**);
- The name of the figure(s) in which the alternative is depicted (see **Figure 4-13** through **Figure 4-30**);
- Notes about sizing of facilities required for the alternative
- Sites with limited space available are identified. San Leandro WPCP, Oro Loma WPCP, West County WPCP, and CCCSD WWTP appear to have space available for advanced treatment. Pinole WPCP, Richmond WPCP, and SD-1 are noticeably space-constrained. This information was used to qualitatively evaluate the alternatives (see Table 5-1 for evaluation criteria).

Table 4-11: Potable Reuse Alternatives

Name	Target	Type	Produc-tion Rate (MGD)	Yield (AFY)	Pipeline Dia. (in)	Total Pipe Length[1] (ft)	Tunneled Length	No. of Trenchless Crossings	Length of Trenchless Crossings	Installed Pump hp	Treatment Train Type	Overview Figure	AWT Facilities Size Figure	Notes
San Leandro WPCP-Based Alternatives														
SL-Raw-1	USL WTP	Raw	1.4	1,570	10	28,500	0	5	3,350	225	4 (Figure 4-9)	Figure 4-15	Figure 4-16	More water (up to 3.4 MGD) is available if current non-potable system is not utilized.
SL-ResU-1	USL Res.	Reservoir	1.4	1,570	10	27,700	7,000	9	3,200	300	2 (Figure 4-7)	Figure 4-15	Figure 4-16	More water (up to 3.4 MGD) is available if current non-potable system is not utilized.
SL-Chabot-1	Lake Chabot	Reservoir	1.4	780	10	26,400	0	7	2,600	120	2 (Figure 4-7)	Figure 4-15	Figure 4-16	Less over-sized than other Lake Chabot alternatives (based on non-potable demand).
SL-Treat-1	Dunsmuir Res.	Treated	1.4	1,570	10	17,300	0	5	2,420	120	6 (Figure 4-11)	Figure 4-15	Figure 4-16	More water (up to 3.4 MGD) is available if current non-potable system is not utilized.
Pinole WPCP-Based Alternatives														**Pinole WPCP site has noticeable space constraints**
Pin-Raw-2	Sobrante WTP	Raw	1.7	1,900	10	29,300	0	3	1,100	180	4 (Figure 4-9)	Figure 4-17	Figure 4-18	Mutually exclusive with Non-Potable Reuse options.
Pin-ResB-2	Briones Res.	Reservoir	1.7	1,900	10	77,800	0	6	1,700	375	2 (Figure 4-7)	Figure 4-17	Figure 4-18	Mutually exclusive with Non-Potable Reuse options.
Pin-ResSP-2	San Pablo Res.	Reservoir	1.7	1,900	10	42,600	0	6	1,700	225	2 (Figure 4-7)	Figure 4-17	Figure 4-18	Mutually exclusive with Non-Potable Reuse options.
Pin-Treat-2	Maloney Res.	Treated	1.7	1,900	10	2,700	0	2	550	225	6 (Figure 4-11)	Figure 4-17	Figure 4-18	Mutually exclusive with Non-Potable Reuse options.
Richmond WPCP-Based Alternatives														**Richmond WPCP site has noticeable space constraints**
Rich-Raw-4	Sobrante WTP	Raw	3.6	4,030	16	49,200	0	8	2,050	375	4 (Figure 4-9)	Figure 4-19	Figure 4-20	
Rich-ResB-4	Briones Res.	Reservoir	3.6	4,030	16	65,900	0	8	2,450	900	2 (Figure 4-7)	Figure 4-19	Figure 4-20	
Rich-ResSP-4	San Pablo Res.	Reservoir	3.6	4,030	16	36,000	0	6	2,050	450	2 (Figure 4-7)	Figure 4-19	Figure 4-20	
Rich-Treat-4	Wildcat Aq.	Treated	3.6	4,030	16	1,600	0	0	0	300	6 (Figure 4-11)	Figure 4-19	Figure 4-20	
West County WPCP-Based Alternatives														
WC-GW	Injection Wells	Ground Water	4.7	5,260	20	n/a	n/a	n/a	n/a	n/a	1 (Figure 4-6)	Figure 4-14	Figure 4-22	Injection and extraction wells from Richmond area of East Bay Plan Groundwater Basin. Technical information for sizing wells is not available, so this alternative was not evaluated further.
WC-Raw-5	Sobrante WTP	Raw	4.7	5,260	20	56,500	0	3	3,400	600	4 (Figure 4-9)	Figure 4-21	Figure 4-22	Mutually exclusive with RARE.
WC-ResB-5	Briones Res.	Reservoir	4.7	5,260	20	99,900	17,600	5	2,200	1200	2 (Figure 4-7)	Figure 4-21	Figure 4-22	Mutually exclusive with RARE.
WC-ResSP-5	San Pablo Res.	Reservoir	4.7	5,260	20	50,500	17,600	3	2,000	600	2 (Figure 4-7)	Figure 4-21	Figure 4-22	Mutually exclusive with RARE.
WC-Treat-5	Wildcat Aq.	Treated	4.7	5,260	20	11,300	0	2	1,200	375	6 (Figure 4-11)	Figure 4-21	Figure 4-22	Mutually exclusive with RARE.
Oro Loma WPCP-Based Alternatives														
Oro-GW	Injection Wells	Ground Water	8	8,060	24	41,200	0	5	1,500		1 (Figure 4-6)	Figure 4-13	Figure 4-24	Injection and extraction wells from South East Bay Plan Groundwater Basin. Similar to 10-MGD "Recommended Project" from Oro Loma Recycled Water Feasibility Study.
Oro-Raw-8	USL WTP	Raw	8	8,960	24	40,400	0	7	3,750	1200	4 (Figure 4-9)	Figure 4-23	Figure 4-24	
Oro-ResU-8	USL Res.	Reservoir	8	8,960	24	57,800	7,000	9	3,450	1500	2 (Figure 4-7)	Figure 4-23	Figure 4-24	
Oro-Chabot-8	Lake Chabot	Reservoir	8	8,960	24	27,500	0	8	2,300	750	2 (Figure 4-7)	Figure 4-23	Figure 4-24	
Oro-Treat-8	South Reservoir	Treated	8	8,960	24	10,200	0	1	300	750	6 (Figure 4-11)	Figure 4-23	Figure 4-24	

Name	Target	Type	Produc-tion Rate (MGD)	Yield (AFY)	Pipeline Dia. (in)	Total Pipe Length[1] (ft)	Tunneled Length	No. of Trenchless Crossings	Length of Trenchless Crossings	Installed Pump hp	Treatment Train Type	Overview Figure	AWT Facilities Size Figure	Notes
CCCSD WWTP-Based Alternatives														
CC-Raw-19	Mokelumne Aq.	Raw	19	21,280	36	18,500	0	3	2,500	2400	4 (Figure 4-9)	Figure 4-25	Figure 4-26	HGL for Mokelumne Aqueduct was estimated as 400 feet.
CC-Raw-10	Mokelumne Aq.	Raw	10	11,200	24	18,500	0	3	2,500	1500	4 (Figure 4-9)	Figure 4-25	Figure 4-26	HGL for Mokelumne Aqueduct was estimated as 400 feet.
CC-ResB-19	Briones Res.	Reservoir	19	21,280	36	54,800	0	8	3,300	3600	2 (Figure 4-7)	Figure 4-25	Figure 4-26	
CC-ResB-10	Briones Res.	Reservoir	10	11,200	24	54,800	0	8	3,300	2000	2 (Figure 4-7)	Figure 4-25	Figure 4-26	
EBMUD Main WWTP (SD-1)-Based Alternatives														**SD-1 site has noticeable space constraints**
SD1-Raw-30	Orinda WTP	Raw	30	33,600	42	58,900	17,600	4	2,200	3600	4 (Figure 4-9)	Figure 4-27	Figure 4-28	At 30 MGD, assume the entire plant is upgraded for nutrient removal.
SD1-Raw-10	Orinda WTP	Raw	10	11,200	24	58,900	17,600	2	2,200	1500	5 (Figure 4-10	Figure 4-27	Figure 4-28	Assumes 10 MGD satellite treatment
SD1-ResU-30	USL Res.	Reservoir	30	33,600	42	48,400	7,000	7	3,550	4200	2 (Figure 4-7)	Figure 4-27	Figure 4-28	At 30 MGD, assumes the entire plant is upgraded for nutrient removal.
SD1-ResB-30	Briones Res.	Reservoir	30	33,600	42	67,800	17,600	4	2,400	5400	2 (Figure 4-7)	Figure 4-27	Figure 4-28	At 30 MGD, assumes the entire plant is upgraded for nutrient removal.
SD1-ResSP-4	San Pablo Res.	Reservoir	4	4,480	16	35,400	17,600	6	2,400	600	3 (Figure 4-8)	Figure 4-27	Figure 4-28	At 4 MGD, assumes satellite treatment, possibly pulling preferentially from the low-salinity Adeline Interceptor (4-5 MGD available).
SD1-ResU-10	USL Res.	Reservoir	10	11,200	24	59,400	0	7	3,550	1800	3 (Figure 4-8)	Figure 4-27	Figure 4-28	Assumes 10 MGD satellite treatment
SD1-ResB-10	Briones Res.	Reservoir	10	11,200	24	67,800	17,600	1	2,400	2000	3 (Figure 4-8)	Figure 4-27	Figure 4-28	Assumes 10 MGD satellite treatment
SD1-Treat-30	Claremont Center	Treated	30	33,600	42	6,300	0	3	1,500	3000	6 (Figure 4-11)	Figure 4-27	Figure 4-28	At 30 MGD, assumes the entire plant is upgraded for nutrient removal.
SD1-Treat-10	Claremont Center	Treated	10	11,200	24	6,300	0	1	1,500	1200	7 (Figure 4-12)	Figure 4-27	Figure 4-28	Assumes 10 MGD satellite treatment
Satellite Treatment Alternatives														
LAVWMA Castro Valley (LA-Chabot-1)	Lake Chabot	Reservoir	10	4,480	24	13,100	0	0	0	225	2 (Figure 4-7)	Figure 4-29	-	Requires both the Livermore and DSRSD plants to be upgraded for nitrogen removal.
Satellite – Pt. Isabel (Sat-ResSP-4)	San Pablo Res.	Reservoir	4	4,480	16	13,700	17,600	5	1,700	600	2 (Figure 4-7)	Figure 4-30	Figure 4-31	This alternative assumes the feed pipeline from San Pablo Reservoir to San Pablo WTP can be re-purposed for advanced treated water.

1. Pipeline length is further categorized by land use type for cost estimating purposes as discussed in Section 2.3.2

Figure 4-13: Potable Reuse Alternative - Oro Loma Groundwater Augmentation

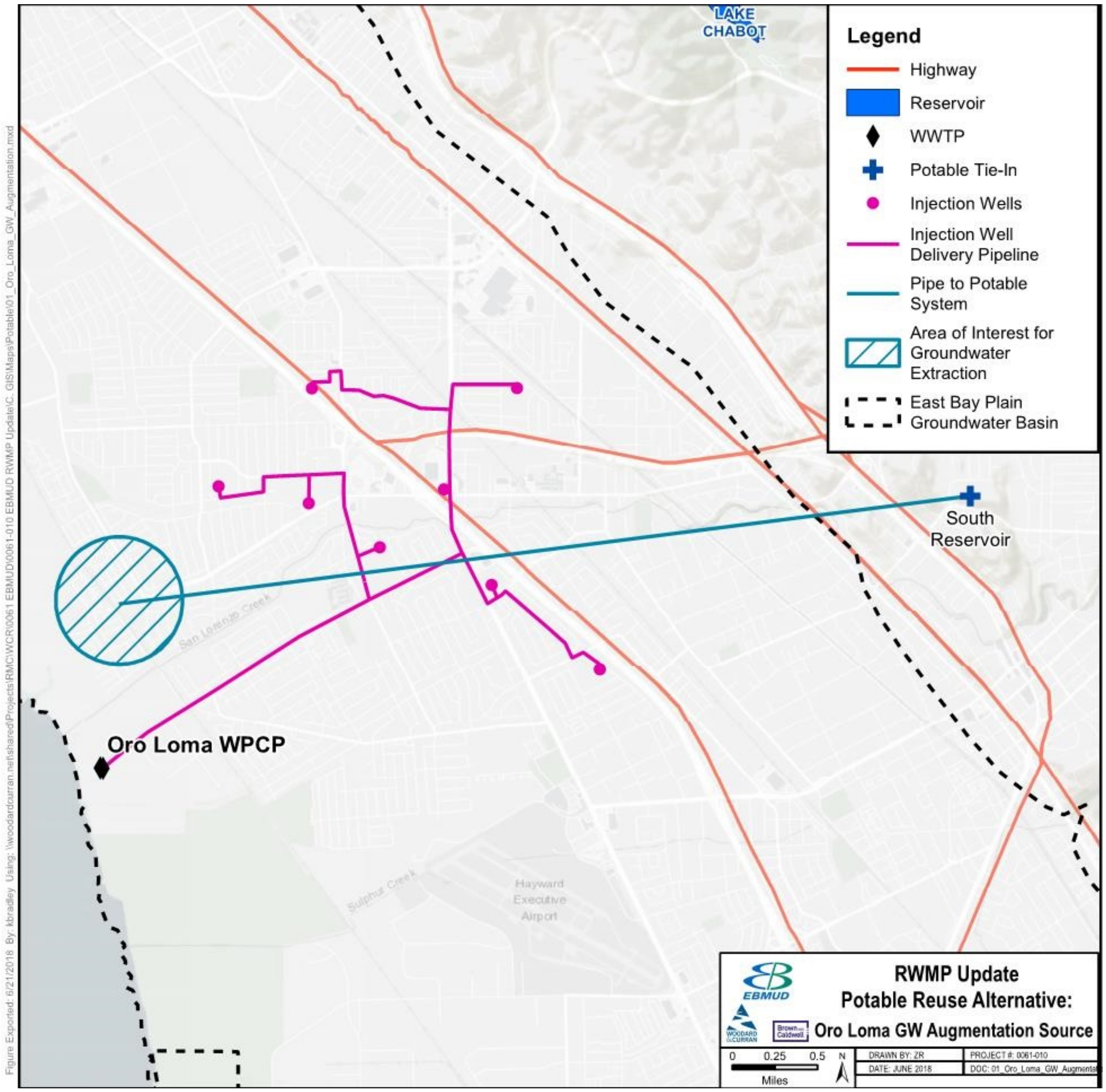


Figure 4-14: Potable Reuse Alternative – Richmond Groundwater Augmentation

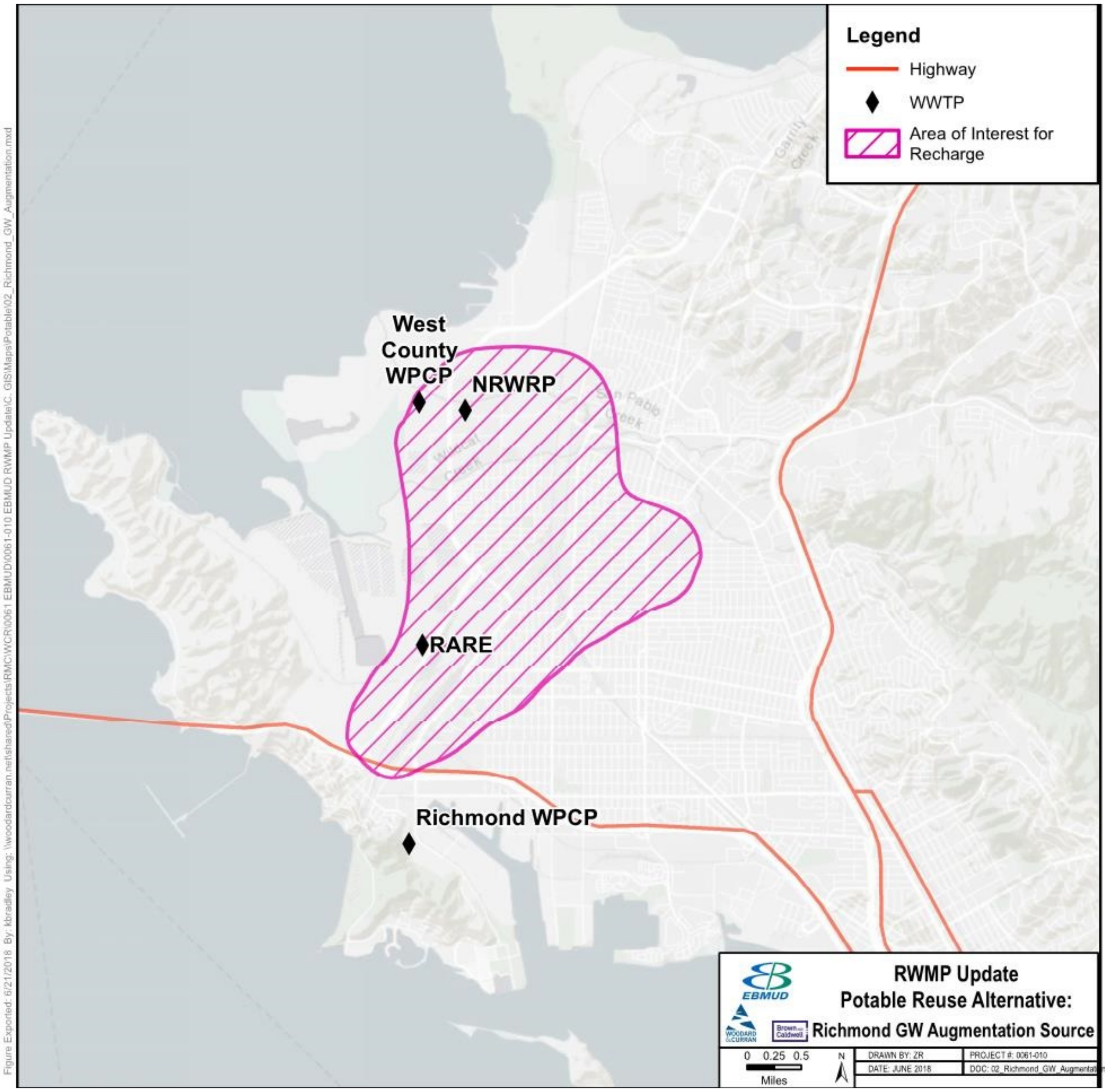


Figure 4-15: Potable Reuse Alternatives - San Leandro WPCP as a Source

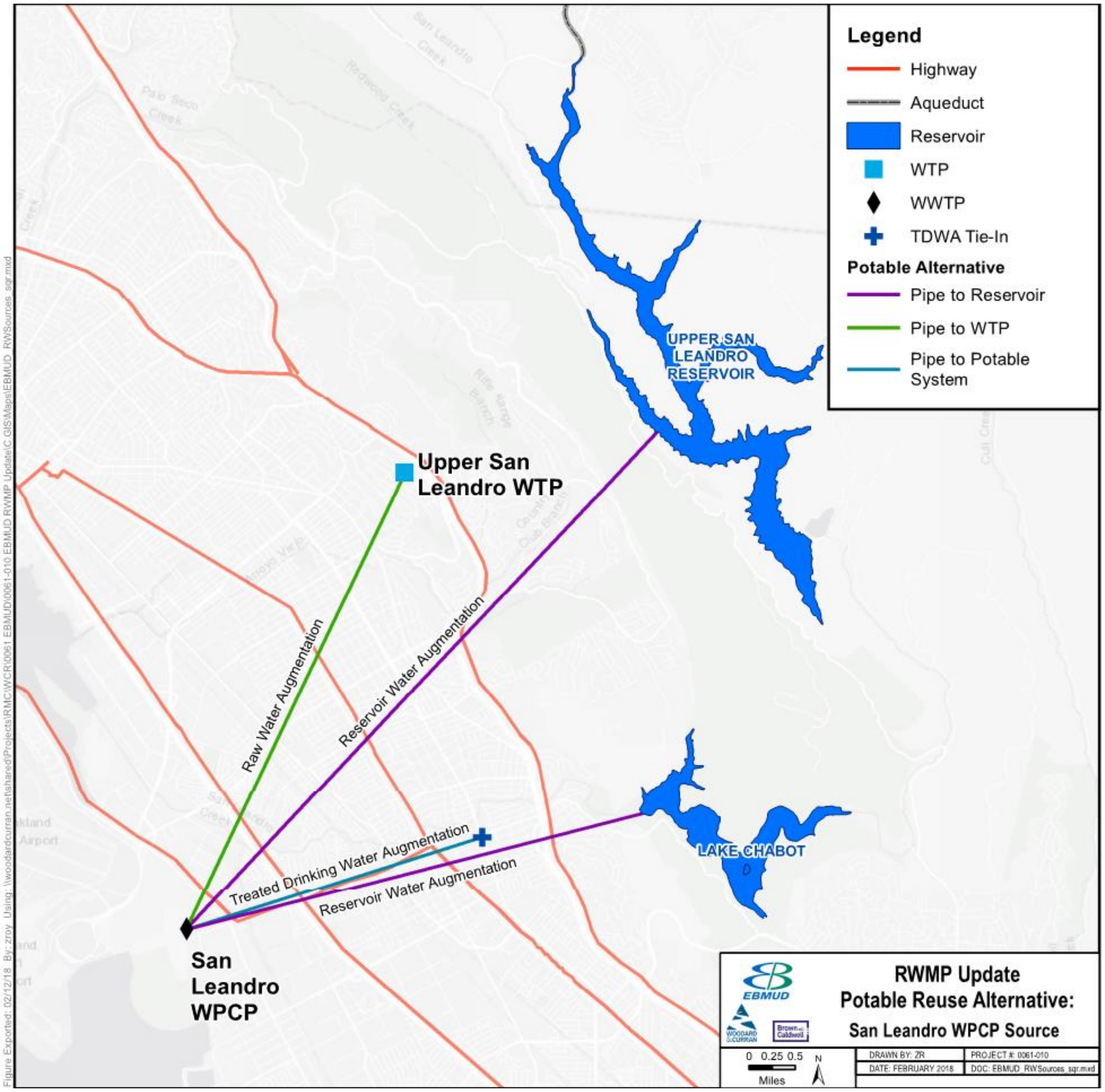


Figure 4-16: Advanced Treatment Footprint at San Leandro WPCP

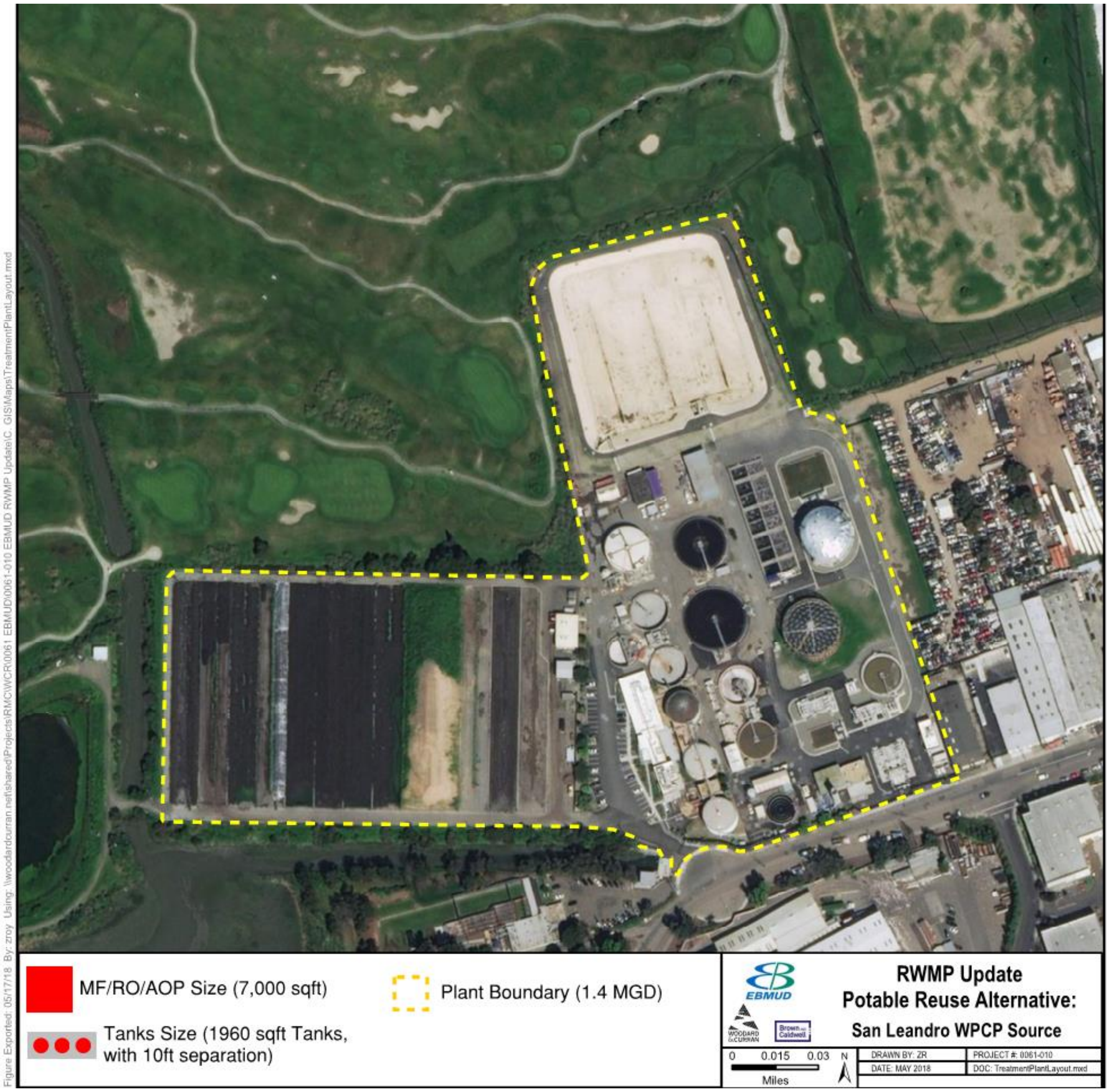


Figure 4-17: Potable Reuse Alternatives - Pinole WPCP as a Source

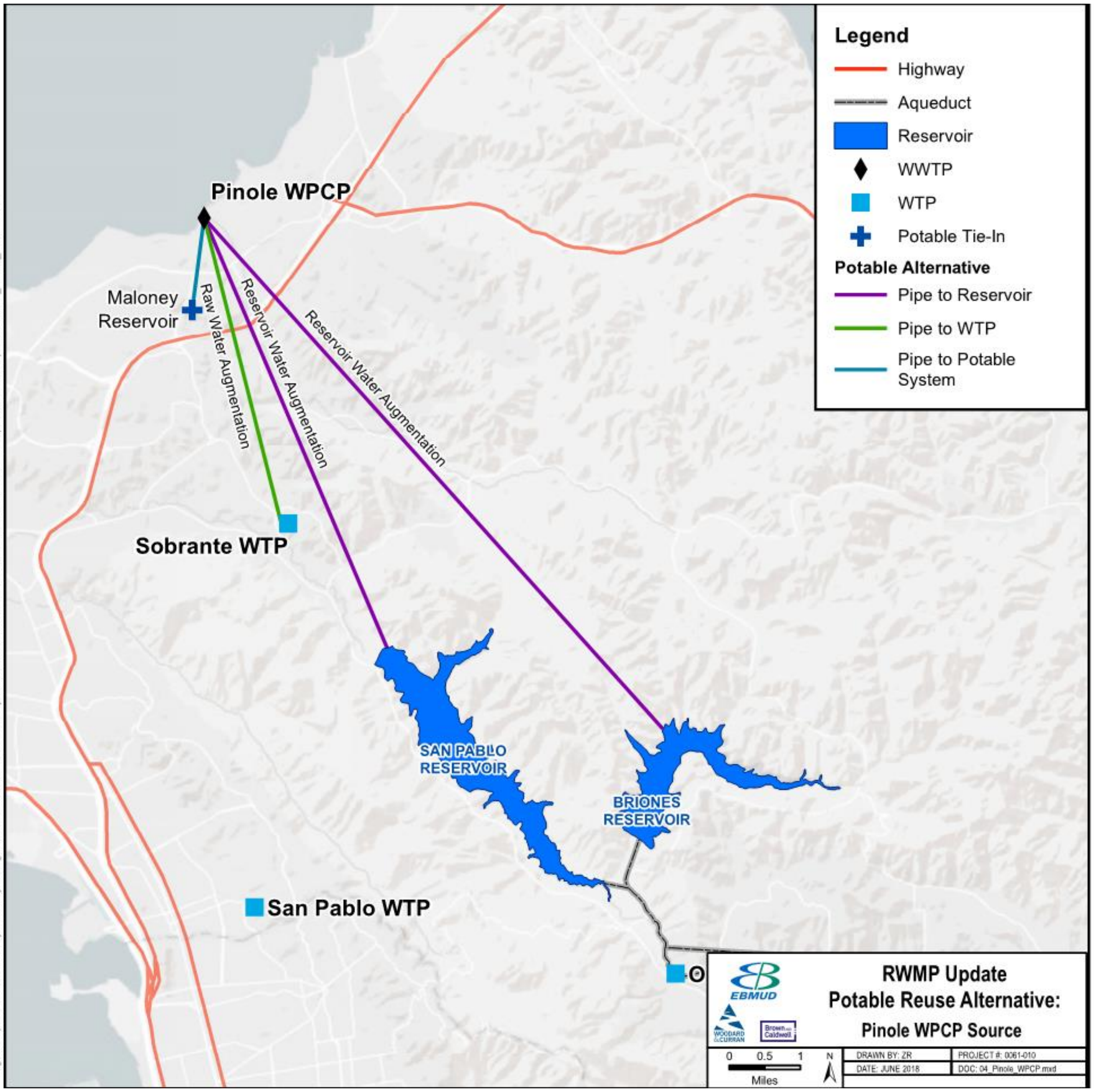


Figure 4-18: Advanced Treatment Footprint at Pinole WPCP

Figure 4-19: Potable Reuse Alternatives - Richmond WPCP as a Source

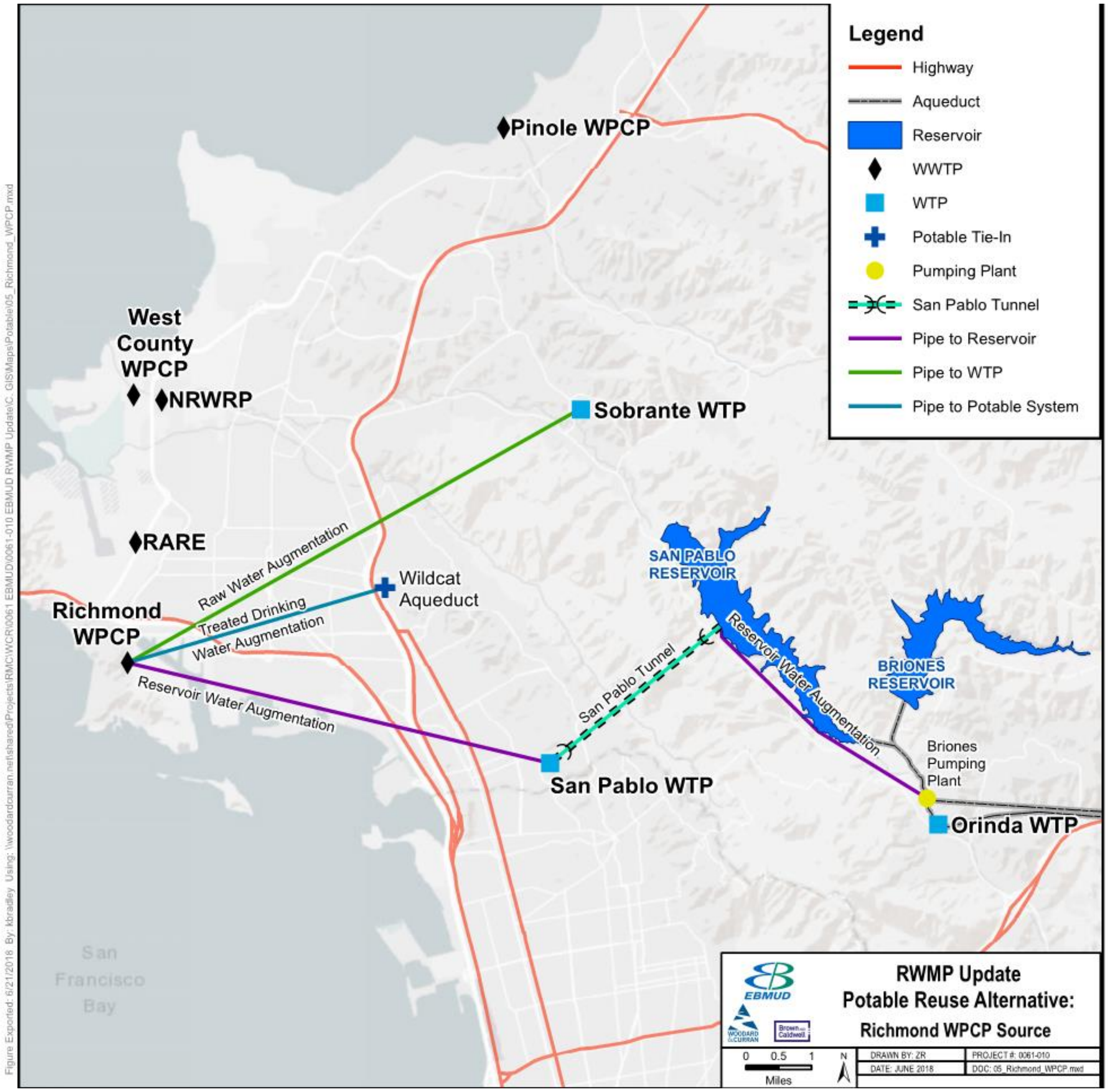


Figure 4-20: Advanced Treatment Footprint at Richmond WPCP

Figure 4-21: Potable Reuse Alternatives - West County WPCP as a Source

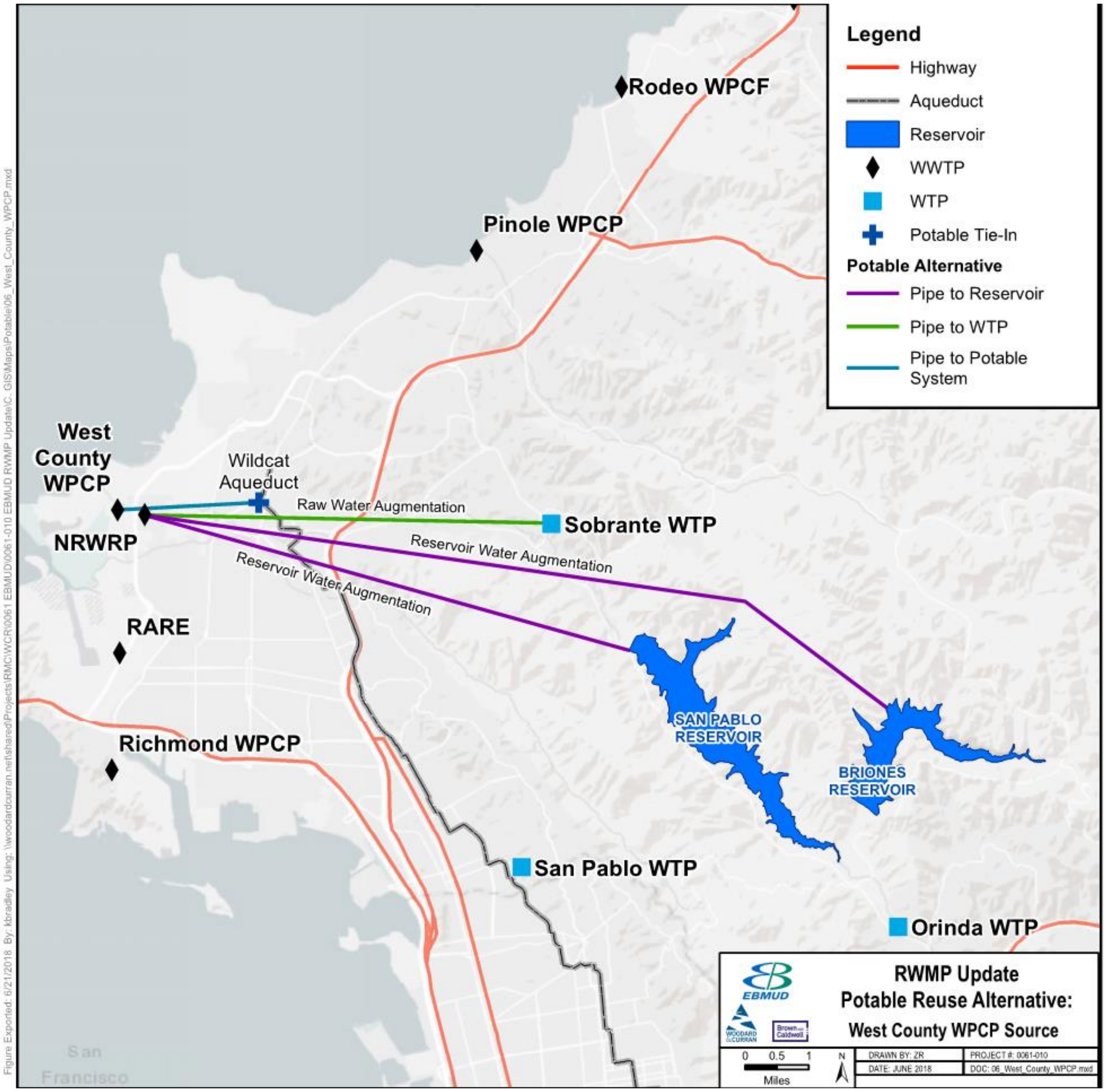


Figure 4-22: Advanced Treatment Footprint at West County WWTP

Figure 4-23: Potable Reuse Alternatives - Oro Loma WPCP as a Source

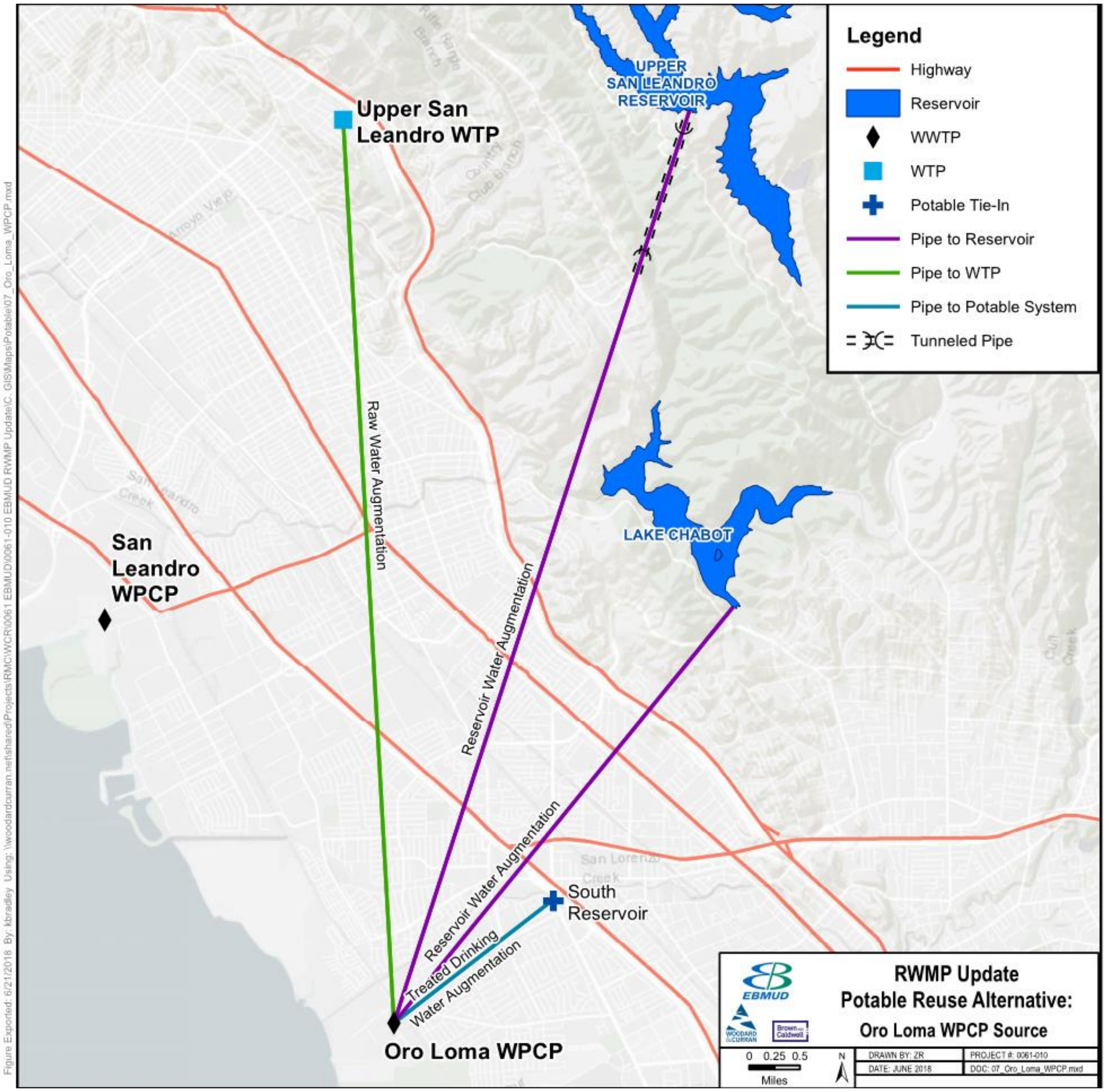


Figure 4-24: Advanced Treatment Footprint at Oro Loma WPCP

Figure 4-25: Potable Reuse Alternatives - CCCSD WWTP as a Source

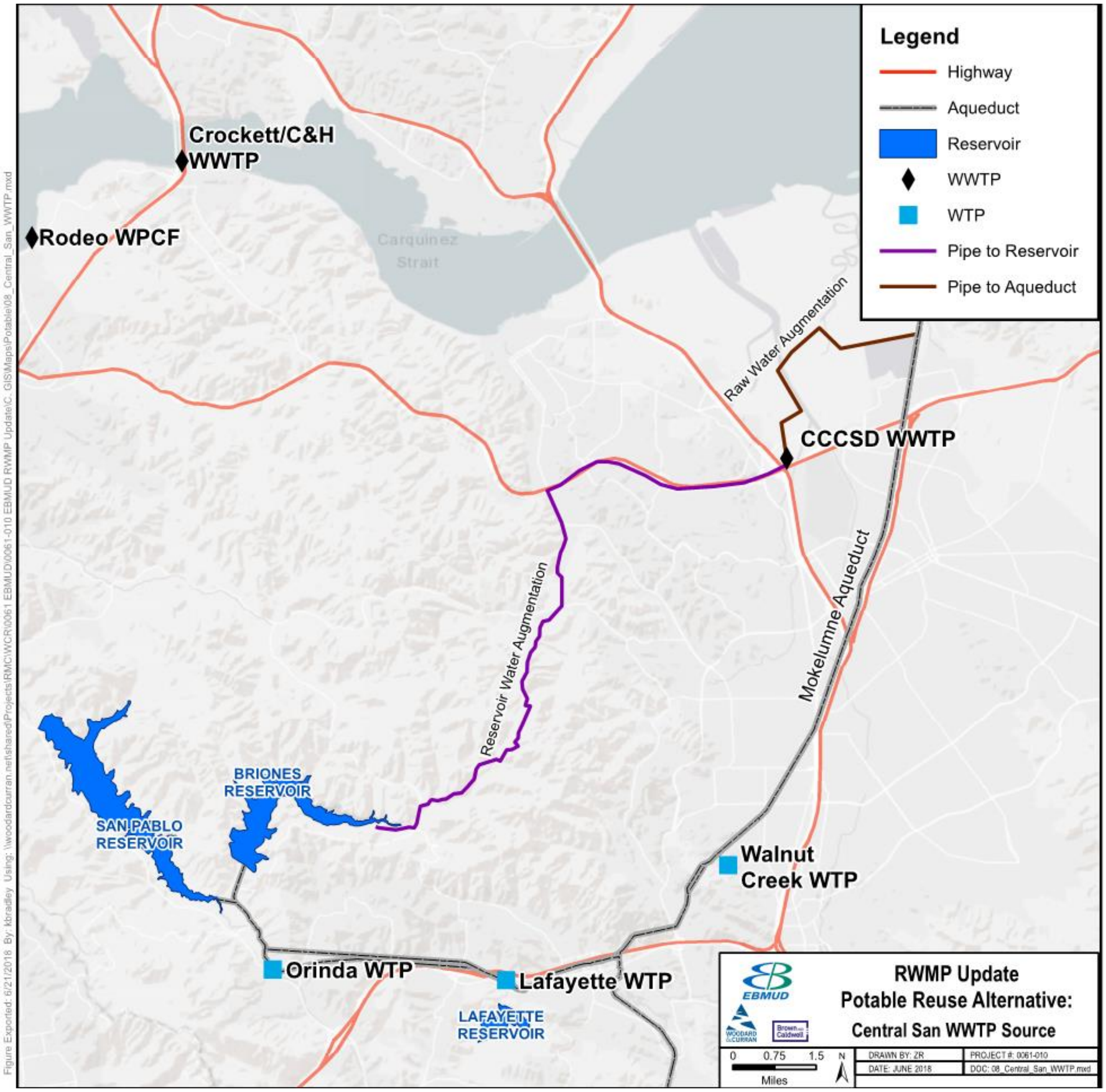


Figure 4-26: Advanced Treatment Footprint at Central San WWTP

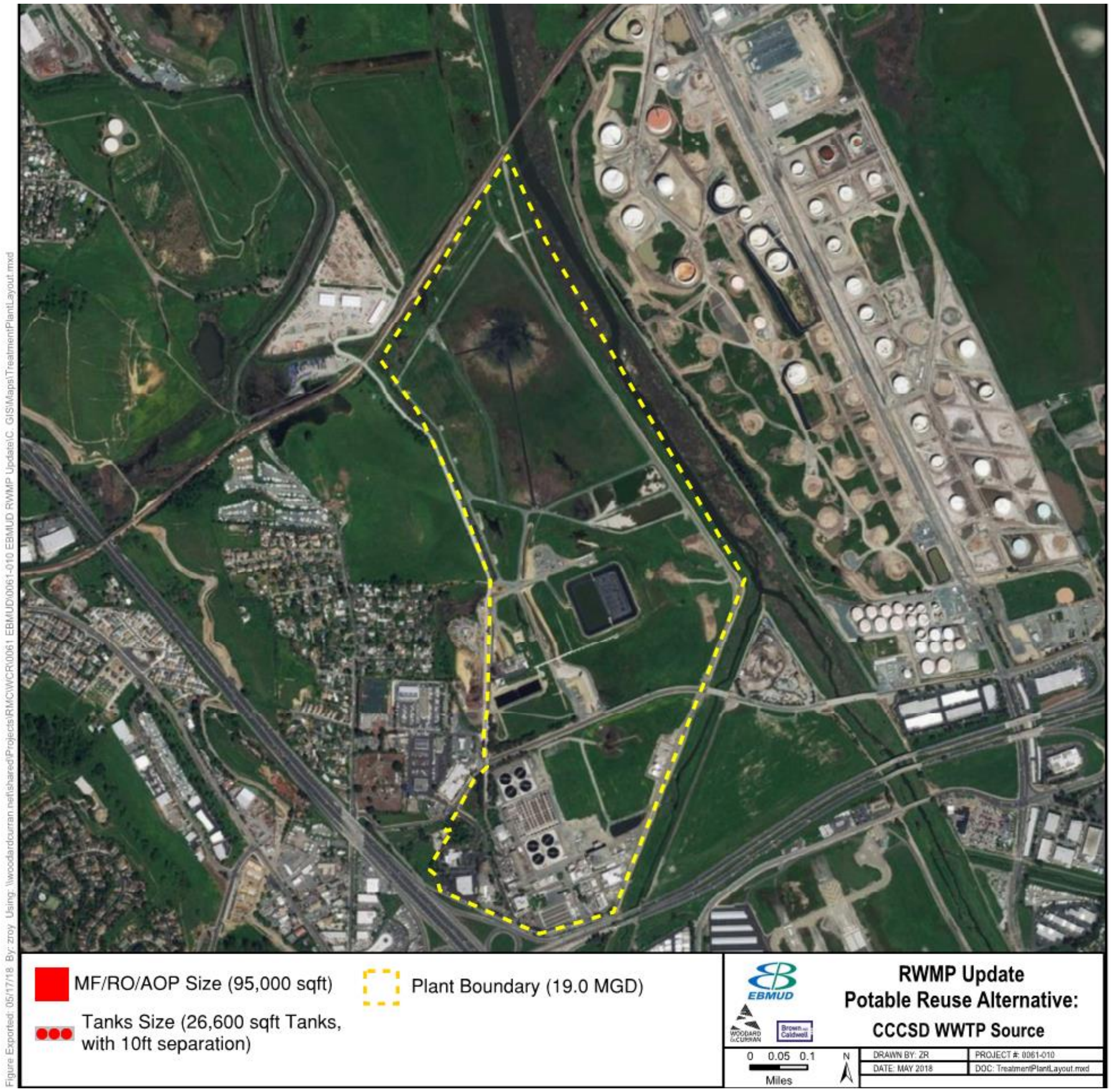


Figure 4-27: Potable Reuse Alternatives - SD-1 as a Source

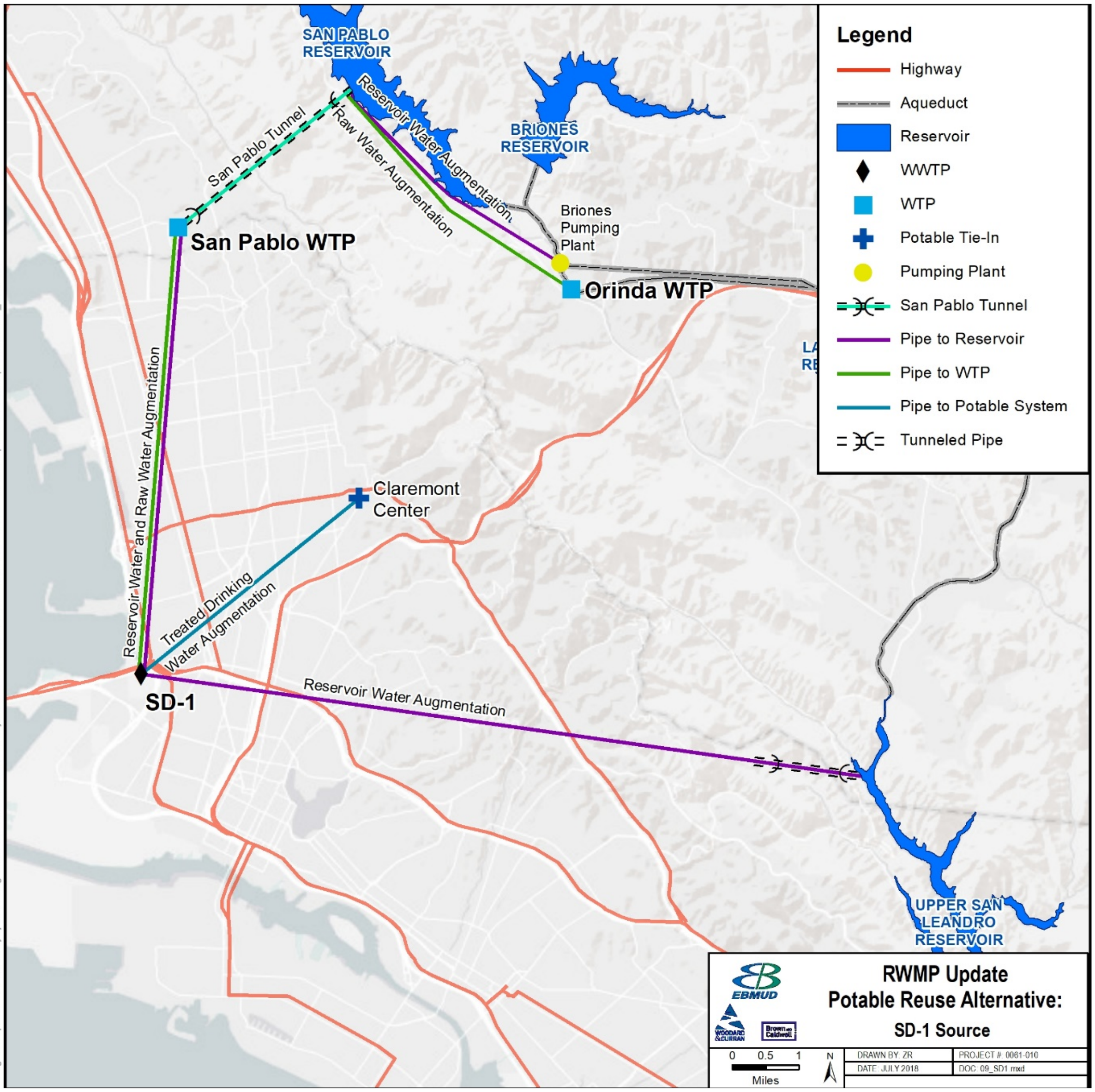


Figure 4-28: Advanced Treatment Footprint at SD-1

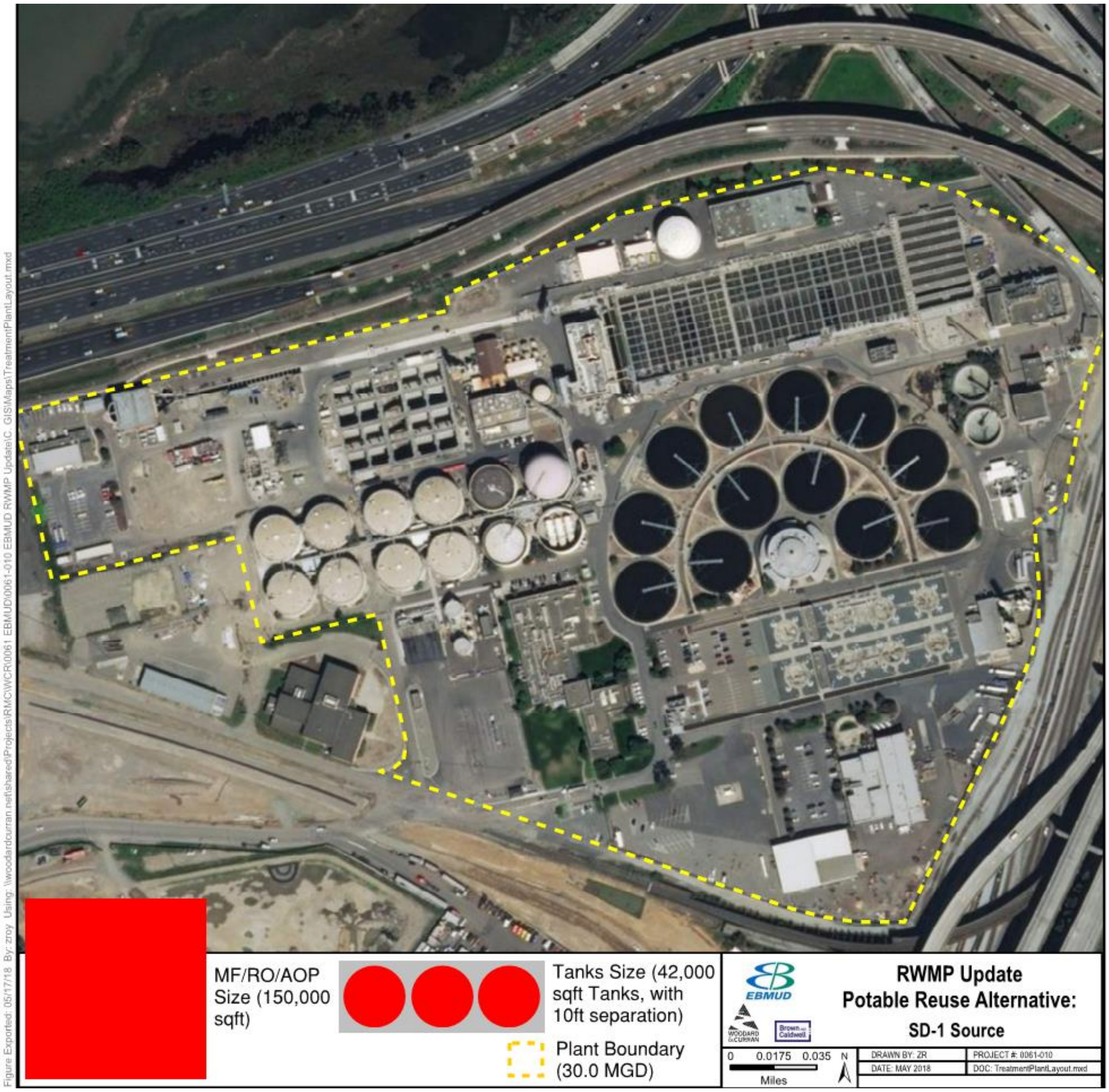


Figure 4-29: Potable Reuse Alternatives - LAVWMA as a Source

Figure 4-30: Potable Reuse Alternative – Pt. Isabel Satellite WWTP as a Source

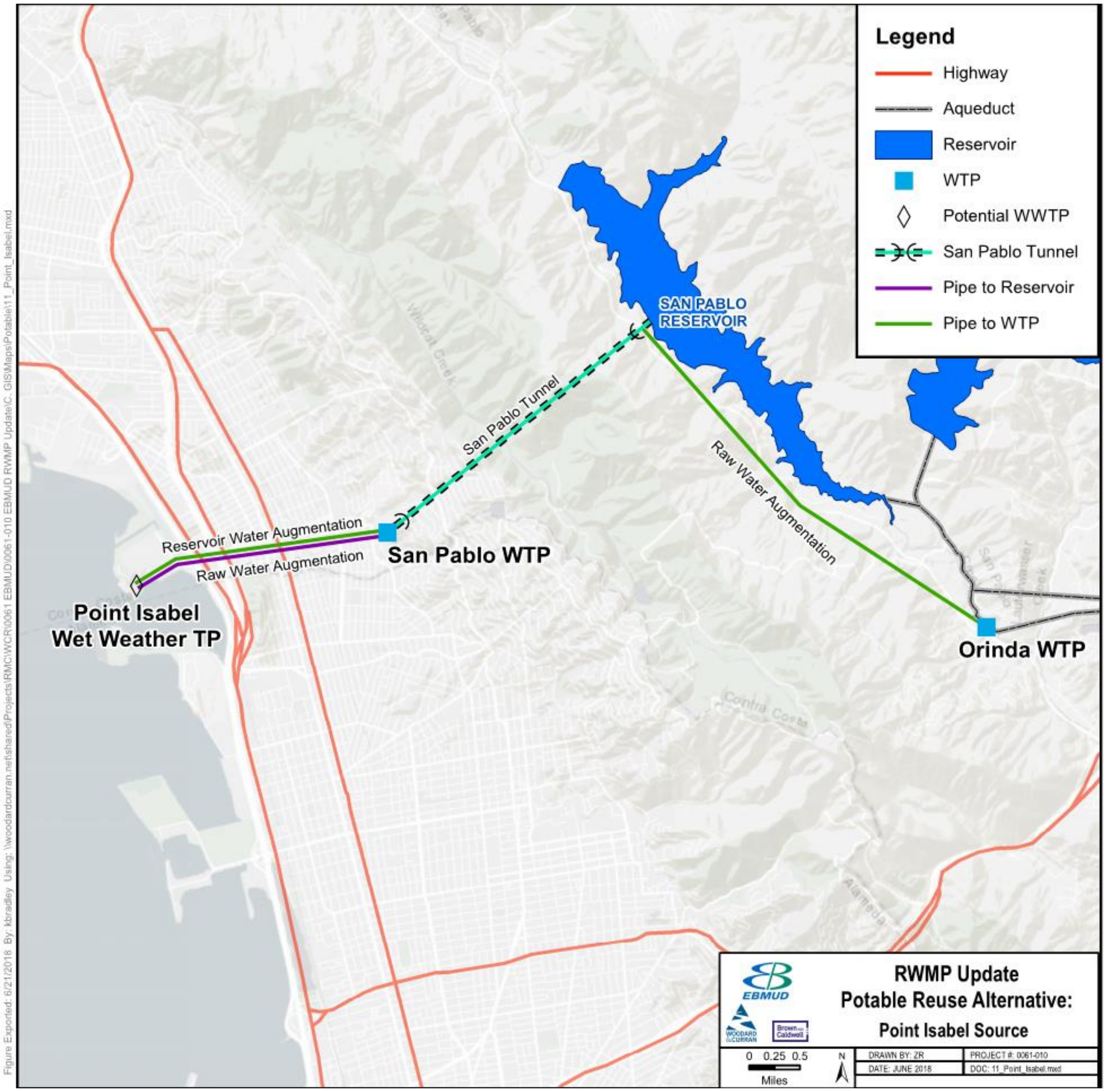


Figure 4-31: Advanced Treatment Footprint at Pt. Isabel

4.8 Cost Evaluation for Potable Reuse Alternatives

Capital and operating costs for each potable alternative were developed based on the methodology presented in Section 2. A summary of project capital, operating and unit costs are presented in **Table 4-12**. More detailed cost estimates for each project can be found in Appendix B.

Table 4-12: Potable Reuse Alternatives Cost Summary

Name	Yield (AFY)	Capital Cost ($M)	Annual O&M ($M/yr.)	Treatment Unit Cost ($/AF)	Conveyance Unit Cost ($/AF)	Total Unit Cost ($/AF)	Dry Year Unit Cost ($/AF)
Oro-GW	8,060	250	15	2,100	1,200	3,300	9,900
SL-Raw-1	1,570	59	3	2,200	1,400	3,600	11,000
SL-ResU-1	1,570	82	3	1,900	2,400	4,300	13,000
SL-Chabot-1	780	44	3	3,800	1,800	5,600	18,000
SL-Treat-1	1,570	51	4	2,700	1,200	3,900	11,000
Pin-Raw-2	1,900	53	4	2,100	1,000	3,100	8,900
Pin-ResB-2	1,900	64	3	1,900	1,400	3,300	10,000
Pin-ResSP-2	1,900	49	3	1,900	900	2,800	8,400
Pin-Treat-2	1,900	40	4	2,600	600	3,200	8,400
Rich-Raw-4	4,030	110	7	2,000	1,000	3,000	8,300
Rich-ResB-4	4,030	110	7	1,900	1,100	3,000	9,100
Rich-ResSP-4	4,030	88	6	2,000	500	2,500	7,700
Rich-Treat-4	4,030	65	7	2,400	100	2,500	7,300
WC-Raw-5	5,260	160	9	1,900	1,100	3,000	8,900
WC-ResB-5	5,260	260	10	1,900	2,100	4,000	13,000
WC-ResSP-5	5,260	220	10	1,900	1,700	3,600	11,000
WC-Treat-5	5,260	98	9	2,300	400	2,700	7,600
Oro-Raw-8	8,960	200	14	1,900	700	2,600	7,400
Oro-ResU-8	8,960	230	14	1,900	900	2,800	8,600
Oro-Chabot-8	8,960	160	13	1,900	400	2,300	6,700
Oro-Treat-8	8,960	160	15	2,200	400	2,600	7,400
CC-Raw-19	21,280	310	31	1,900	300	2,200	6,300
CC-Raw-10	11,200	180	17	2,000	300	2,300	6,500
CC-ResB-19	21,280	380	33	1,900	500	2,400	6,900
CC-ResB-10	11,200	220	17	1,900	500	2,400	7,100
SD1-Raw-30	33,600	650	50	1,900	500	2,400	7,000
SD1-Raw-10	11,200	510	20	2,900	1,000	3,900	12,000
SD1-ResU-30	33,600	570	49	1,800	500	2,300	6,700
SD1-ResB-30	33,600	690	53	1,900	600	2,500	7,300
SD1-ResSP-4	4,480	300	9	3,600	1,500	5,100	16,000
SD1-ResU-10	11,200	430	18	2,800	700	3,500	10,000
SD1-ResB-10	11,200	510	20	2,900	1,000	3,900	12,000
SD1-Treat-30	33,600	480	54	2,100	200	2,300	6,700
SD1-Treat-10	11,200	360	20	3,200	200	3,400	9,800
LA-Chabot-10	4,480	130	12	3,800	200	4,000	12,000
Sat-ResSP-4	4,480	170	8	1,900	1,400	3,300	10,000

5. EVALUATION OF ALTERNATIVES

5.1 Non-Cost Evaluation

In addition to developing cost estimates for each alternative, a non-cost evaluation was conducted to capture the environmental and social objectives and the complexity and risk of the alternatives. The evaluation criteria are detailed in **Table 5-1** as well as the criteria weights developed by District staff.

Table 5-1: Summary of Evaluation Criteria

Criteria	Description	Weight
Environmental and Social Objectives		
Environmental justice	Assessment of what regions/populations are served/impacted by this new supply and how the water quality of different regions/populations impacted by this new supply.	20%
Environmental impacts from construction	Assessment of the potential environmental challenges during construction of the alternative and the mitigation that may be necessary for any impacts.	5%
Energy use	Assessment of the energy usage during operations (GHG impacts).	10%
Wastewater discharge	Assessment of reduced nutrient discharges	5%
Complexity and Risk		
Institutional	Assessment of the time, challenges and requirements to implement the project either internally or in coordination with external partners.	15%
Regulatory	Assessment of the time, challenges and requirements to implement the project from a planning and permitting perspective prior to construction and ongoing as part of operations.	15%
Construction	Assessment of the time, challenges and requirements to design and construct the project.	5%
Operational	Assessment of the impacts of the alternative on existing operation of the District's water and wastewater systems. Assessment of the complexity of the alternative and how challenging it will be for District staff to manage any new processes or operations.	25%
	Total	***100%***

5.1.1 Evaluation of Non-Potable Reuse Alternatives

This section summarizes the results of the non-cost evaluation for non-potable reuse alternatives using the criteria defined above. Scoring rubrics for the non-cost criteria are presented in **Table 5-2**. Proposed recycled water projects were scored 1 to 5 based on how effectively each project met the evaluation criteria. A high score indicated high response to the criteria and a low score indicated a low response to the criteria (5 = Most Favorable, 1 = Least Favorable). The rubric includes a brief description of the metrics used to score each alternative, differentiated for non-potable and potable projects. A final alternative score was then calculated using the scores for each criterion, combined with the criteria weights. **Table 5-3** summarizes the results of the ranking process for non-potable reuse alternatives.

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Table 5-2: Non-Potable Reuse Scoring Rubric

Criteria	(most favorable)		Scoring Rubric		(least favorable)
	5	4	3	2	1
Environmental and Social Objectives					
Environmental justice	Project benefits many different types of customers and/or the potable water use offset provides increased reliability for a significant portion of the District service area.		Project benefits some of customers and/or the potable water use offset provides increased reliability for some of the District service area.		Project does not significantly impact the supply reliability for the District aside from 1-2 (likely private) customers.
Environmental impacts from construction	Project construction will have limited environmental impacts (few, if any, stretches of alignment near streams, wetlands or other habitat).		Project construction will have some environmental impacts (may include some stretches of alignment near streams, wetlands or other habitat).		Project construction will have significant environmental impacts (may include significant stretches of alignment near streams, wetlands or other habitat).
Energy use	Project operation will require low energy for treatment and conveyance.		Project operation will require "average" energy for treatment and conveyance.		Project operation will require significant energy for treatment and conveyance.
Wastewater discharge	Project provides denitrification or serves a large irrigation customer (>2 MGD)		Project provides partial denitrification or serves an irrigation customer		Project provides no denitrification and does not serve an irrigation customer.
Complexity and Risk					
Institutional Complexity	Project serves only District facilities or 1-2 customers.		Project may serve DISTRICT facilities and 3-5 customers.		Project may serve DISTRICT facilities and 5+ customers.
Regulatory Complexity	Project requires limited number of permits, easements, documentation, etc., resulting in less effort to coordinate with state agencies and local stakeholders and minimal required annual monitoring/permitting.		Project requires some permits, easements, documentation, etc., resulting in some effort to coordinate with state agencies and local stakeholders and minimal required annual monitoring/permitting.		Project requires many permits, easements, documentation, etc., resulting in significant effort to coordinate with state agencies and local stakeholders and significant required annual monitoring/permitting.
Construction Risk	Project includes limited number of unique facilities, facility siting concerns, or other special circumstances such as trenchless crossings.		Project includes some unique facilities, facility siting concerns, or other special circumstances such as trenchless crossings.		Project includes many unique facilities, facility siting concerns, or other special circumstances such as trenchless crossings.
Operational Complexity	Project will require limited change to existing District operations (changes are limited to the expansion of an existing treatment facility).		Project will require limited change to existing District operations (changes are limited to some changes to a treatment facility and/or distribution).		Project will require the operation of a new, independent facility and conveyance system.

Table 5-3: Non-Potable Reuse Alternatives Non-Cost Evaluation

Project	Criteria: Environmental and Social Objectives: Environmental Justice	Environmental Impacts from Construction	Energy Use	Wastewater Discharge (Nutrients)	Criteria: Complexity and Risk: Institutional	Regulatory	Construction	Operational Complexity	Normalized Score (out of 100)	Notes
Criteria weights	*20%*	*5%*	*10%*	*5%*	*15%*	*15%*	*5%*	*25%*		
DERWA/San Ramon Phase 3	4	5	5	3	4	5	4	5	**90**	Expansion of committed project in progress/construction, with completion planned FY24-25. Established District partnership with DSRSD. Program is EIR certified
DERWA/San Ramon Phase 5	4	5	5	3	4	5	5	5	**91**	Expansion of committed project with implementation planned FY 28-29. Established District partnership with DSRSD. Potential supply limitations.
DERWA/San Ramon Phase 4	4	5	5	3	4	5	4	5	**90**	Expansion of committed project with implementation planned FY 34-35. Established District partnership with DSRSD. Phase 4. EIR certified. Potential supply limitations.
East Bayshore. Phase 1A	5	4	5	4	5	4	4	4	**89**	Expansion of committed project within existing distribution system and Frontage Road pipeline alignment for irrigation and industrial demands. Adequate supply availability. Requires treatment upgrades to meet water quality objectives and minor expansion of distribution system.
East Bayshore. Phase 1B	5	4	4	4	5	4	3	3	**81**	Expansion of committed project for irrigation and industrial demands. Adequate supply availability. Requires treatment upgrades and expansion of distribution system to Oakland and Berkeley.
East Bayshore. Phase 2	5	3	3	4	5	4	2	2	**72**	Expansion of committed project for irrigation and industrial demands. Adequate supply availability, but limited room for expansion within existing site. Requires treatment upgrades and expansion of the distribution system, including service to UCB and Alameda.
Chevron/Richmond	3	4	2	1	3	3	3	4	**62**	Expansion of committed project. Customer is established District project partner. Requires partnership with City of Richmond. Requires treatment upgrades at City of Richmond and distribution system.
P66 Rodeo Refinery	3	4	4	1	3	3	3	4	**66**	MOU between P66 and EBMUD. Project in planning phase, technically feasible but with supply limitations. District is exploring funding options.

Project	Environmental Justice	Environmental Impacts from Construction	Energy Use	Wastewater Discharge (Nutrients)	Institutional	Regulatory	Construction	Operational Complexity	Normalized Score (out of 100)	Notes
	Criteria									
	Environmental and Social Objectives				**Complexity and Risk**					
Criteria weights	***20%***	***5%***	***10%***	***5%***	***15%***	***15%***	***5%***	***25%***		
Central San Regional	4	4	1	1	1	3	3	3	**51**	Requires agreements w/CCCSD and CCWD. May require CCWD approval from USBR for wheeling. May be able to complete under Cat Ex for CEQA. Assume District would accept water from CCWD at the existing District-CCWD intertie. Requires new high-lift pump station/land purchase and installation of VFDs at WC pumping plant. Assume WTP expansion would address WQ delta (i.e., higher salt content)
CC Pipeline in Canal ROW	2	4	3	3	2	3	4	4	**60**	Total water sales = 0.83 MGD, but only two District customers. Limited benefits to District. Agreements between CCWD, CCCSD and the CNWS developer. Impacts on existing operations on District minimal, but improvement on CCWD's operations. Project phases other potential impediments.
DCC Satellite Project	2	4	5	3	3	5	5	4	**74**	RFP has been issued/re-issued. Most likely to move forward among satellite projects. Wastewater supply availability. Self-financing model.
MCC Satellite Project	2	4	5	3	3	4	4	4	**68**	Project in planning phase. MOU between EBMUD, MCC and CCCSD. Wastewater supply availability. Funding issues. MCC to self-finance/construct/operate satellite facility.
Moraga Area Satellite Project	3	3	5	3	2	2	3	3	**56**	Conceptual phase. Institutional challenging model (various customers). Wastewater supply availability. Moraga customers to self-finance/operate satellite facility.
Oakland Hills Satellite Project	2	3	5	3	2	2	3	3	**54**	Conceptual phase. Institutional challenging model (various customers). Wastewater supply availability. Oakland Hill customers to self-finance/operate satellite facility.
UCB Satellite Project	3	2	4	4	3	3	2	4	**66**	Project in conceptual phase. Previous studies (2005) performed. Site constraints. Difficulty in finding a suitable site for satellite facility. UCB to self-finance/construct/operate satellite facility.

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Table 5-4 provides a summary of the non-cost scoring in ranked order. The normalized non-cost evaluation scores were plotted against the project unit costs to determine the highest ranking, lowest cost alternatives as presented in **Figure 5-1.**

Table 5-4: Ranked Scores for Non-Potable Reuse Alternatives

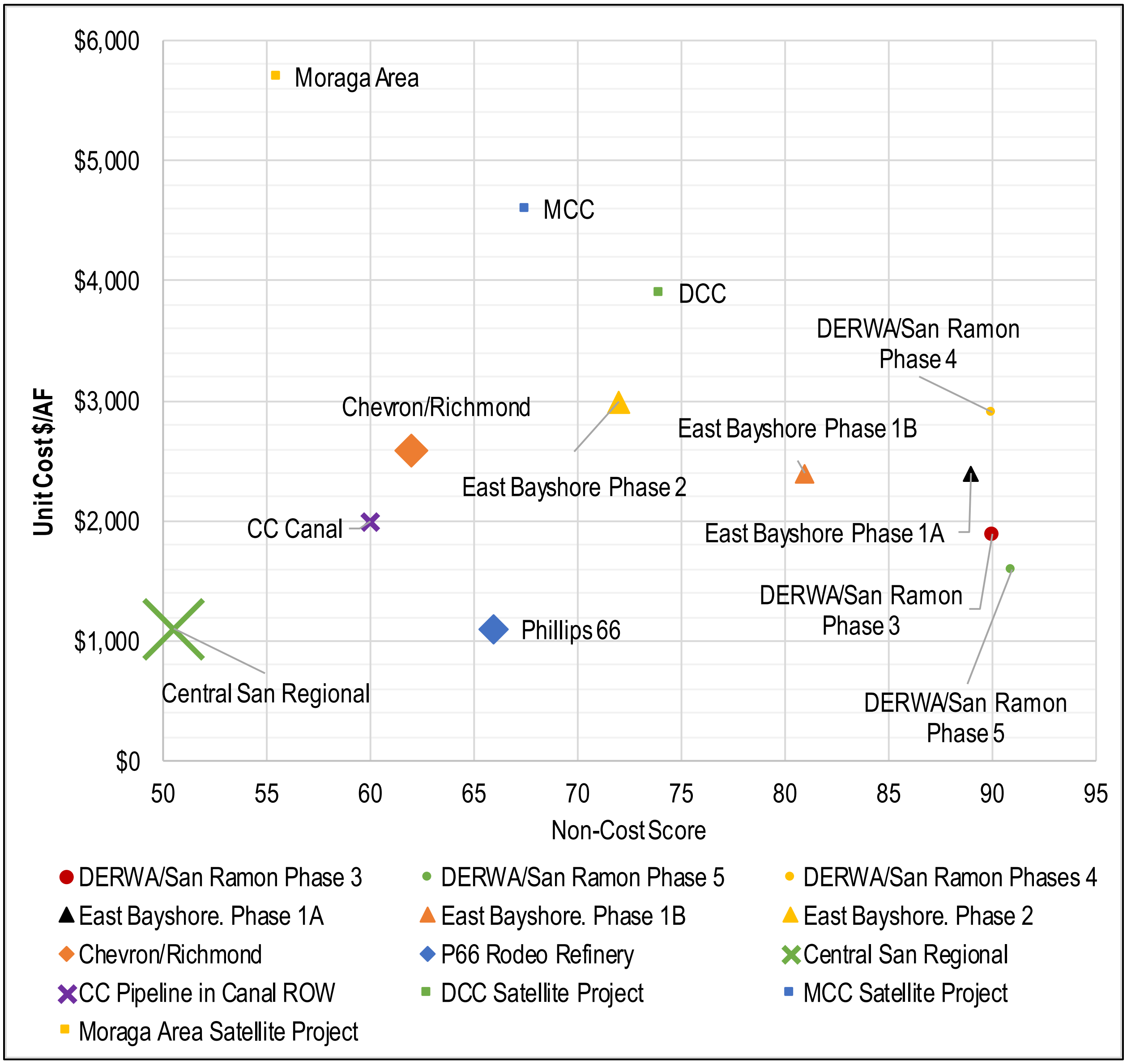
Project	Normalized Score	Project Unit Cost ($/AF)	Dry Year Unit Cost ($/AF)
DERWA/San Ramon Phase 5	91	1,600	5,400
DERWA/San Ramon Phase 3	90	1,900	6,300
DERWA/San Ramon Phase 4	90	2,900	9,700
East Bayshore. Phase 1A	89	2,400	7,400
East Bayshore. Phase 1B	81	2,400	7,800
DCC Satellite Project	74	3,900	12,000
East Bayshore. Phase 2	72	3,000	9,400
MCC Satellite Project	68	4,600	15,000
P66 Rodeo Refinery	66	1,100	3,700
Chevron/Richmond	62	2,600	8,600
UCB Satellite Project	66	2,900	8,800
CC Pipeline in Canal ROW	60	2,000	6,800
Moraga Area Satellite Project	56	5,700	18,000
Oakland Hills Satellite Project	54	3,200	11,000
Central San Regional	51	1,100	3,400

Note: For DERWA/San Ramon Valley Recycled Water Project Phases, unit costs shown are based on District's share for capital and O&M costs.

Committed centralized projects, such as DERWA/San Ramon Valley Recycled Water Projects, ranked the highest. Committed centralized projects are expansion of committed projects in progress/construction, have established partnerships, and the programs are EIR certified. It is important to note that wastewater supply from DSRSD is limited and the DERWA supply agreement currently defines recycled water service to the two-member agencies as first-come, first-served. This means that the availability of water is dependent upon how quickly the District expands its distribution system versus how quickly DSRSD develops its program. An important focus for the DERWA program in the next few years is to secure supplemental supplies.

Satellite recycled water treatment plant projects can cost-effectively serve large water users that are located far from a centralized treatment facility. Satellite treatment projects with agreements in place, technically feasible, and with funding support are rated the highest. Among the satellite treatment recycled water projects, DCC Satellite Project is the most likely to move forward. DCC is pursuing a self-financing model. Their studies have shown that the satellite project would pay for itself, while eliminating the risks associated with drought restrictions.

Figure 5-1: Non-Potable Reuse Alternative Comparison



Note: For DERWA/San Ramon Valley Recycled Water Project Phases, unit costs shown are based on District's share for capital, average O&M and average energy costs.
□ = Satellite RWTP, Δ = East Bayshore RWF, ○ = DERWA/San Ramon, ◊ = Refinery, x = CCCSD and CC Pipeline in Canal ROW.

5.1.2 Evaluation of Potable Reuse Alternatives

Using the scoring rubric presented in **Table 5-5**, the potable reuse alternatives were also scored for each non-cost criteria on a scale of 1 to 5. The criteria scores were combined with the criteria weights to calculate the overall project score (out of 100). A summary of the scores for each alternative and supporting notes on the scoring and any deviation from the rubric is presented in **Table 5-6.**

The non-cost evaluation for potable reuse alternatives does not explicitly include uncertainty associated with the timeline for adoption of state regulations governing raw water augmentation (expected in 2023) and treated drinking water augmentation (no timeline exists). There are currently no regulations for these types of potable reuse, but if the best alternatives are raw water and/or treated water augmentation, then it may be in the District's best interest to wait for regulations to come into effect before implementing potable reuse. Also, the planning horizon for this RWMP Update extends further than the expected timeline for developing these regulations – the District's current recycled water goal is based on a compliance date of 2040. Assigning low scores to these alternatives would remove them from consideration too early in the evaluation. Instead, these factors will be considered as part of the overall phasing for implementation.

Vulnerability of wastewater treatment facilities to sea level rise is also not explicitly included in the non-cost evaluation. All of the alternatives have vulnerability to sea level rise, with the exception of satellite treatment of LAVWMA effluent (LA-Chabot-10). The recently completed BACWA Nutrient Reduction Study (BACWA, 2018) concluded that SD-1 and Richmond WPCP would not be impacted by sea level rise within the next 50 years, although low-lying areas of the collection systems could be vulnerable. The other four wastewater sources considered in this evaluation (San Leandro WPCP, Pinole WPCP, West County WPCP, CCCSD WWTP) are already in the 100-year floodplain, and are vulnerable to sea level rise and other flooding conditions.

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Table 5-5: Potable Reuse Scoring Rubric

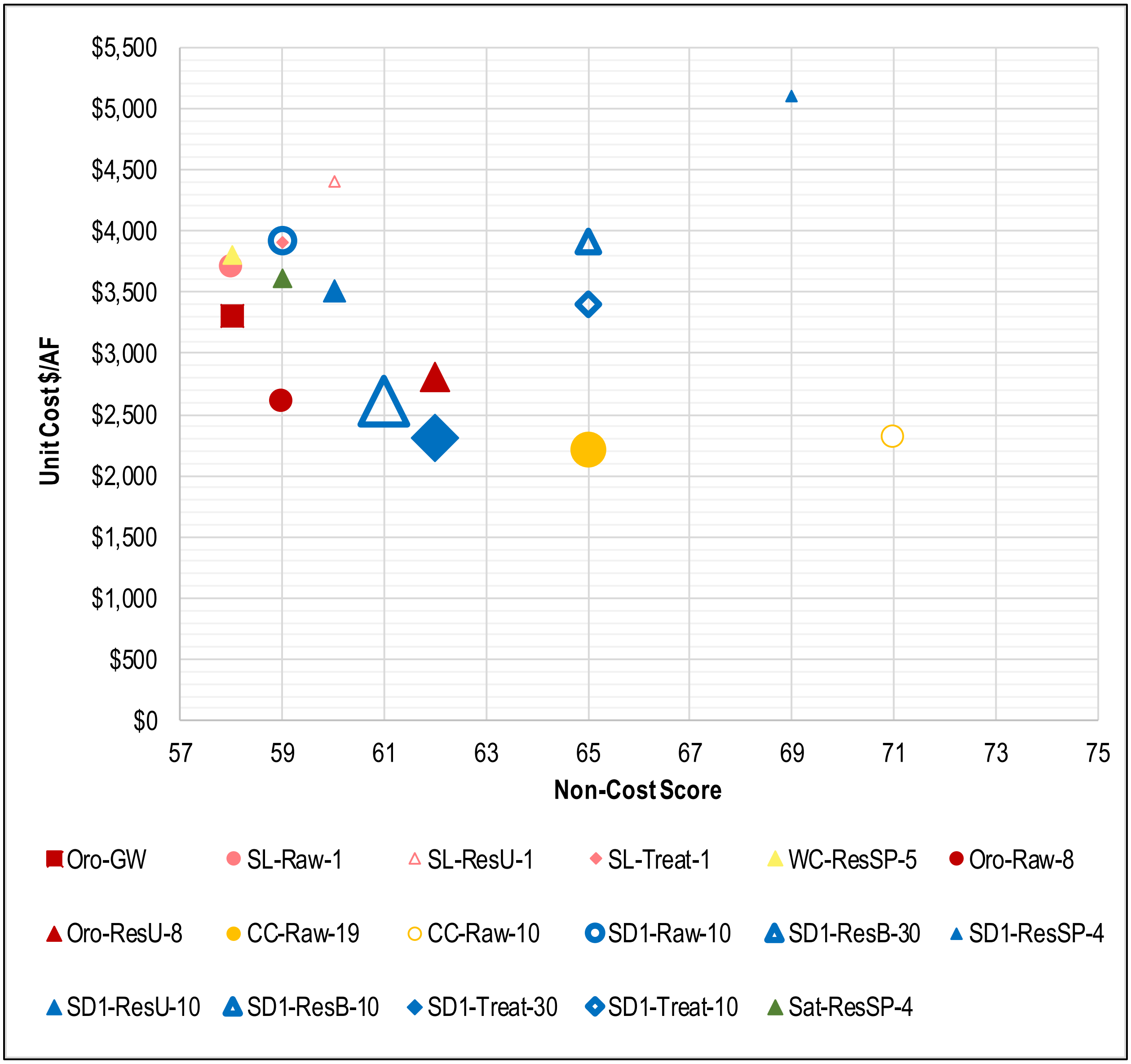
Criteria	(most favorable) 5	4	Scoring Rubric 3	2	(least favorable) 1
Environmental and Social Objectives					
Environmental justice	Project benefits entire service area.		Project benefits around half of the District service area.	Project benefits around 25% of the District service area.	Project benefits a small area (pressure zone) of the District service area.
Environmental impacts from construction	Pipeline alignment does not include any stream crossings.	Pipeline alignment includes 1 stream crossing.	Pipeline alignment includes 2 or 3 stream crossings.	Pipeline alignment includes 4 stream crossings.	Pipeline alignment includes 5+ stream crossings.
Energy use	Alternative requires <200,00 kWh/MGD/year for pumping.	Alternative requires 200,000-400,000 kWh/MGD/year for pumping.	Alternative requires 400,000-600,000 kWh/MGD/year for pumping.	Alternative requires 600,000-800,000 kWh/MGD/year for pumping.	Alternative requires >800,000 kWh/MGD/year for pumping.
Wastewater discharge	WW treatment train includes denitrification.		WW treatment train includes denitrification, but volume of reuse could impact R2 program capability (SD1 only).		
Complexity and Risk					
Institutional Complexity	Project does not require any coordination with partner agencies.	Project does not require any coordination with partner agencies but requires extensive internal coordination between departments.	Project requires coordination with 1 external partner agency.	Project requires coordination with 2-3 external partner agencies.	Project requires coordination with 4+ external partner agencies.
Regulatory Complexity	Project does not require new WDR or NPDES (treated or raw water augmentation) and has sufficient dilution flows for RO concentrate management	Project requires new WDR (groundwater augmentation)	Project requires new NPDES (reservoir augmentation) or has limited ability for RO concentrate management		Project requires new NPDES and has limited ability for RO concentrate management
Construction Risk	WWTP source has ample space for advanced treatment processes.	WWTP source has ample space for advanced treatment processes but tunneling to potable reuse target is required.	WWTP source has some space available for advanced treatment.	WWTP source has some space available for advanced treatment but tunneling to potable reuse target is required. Or WWTP source has no space currently available for advanced treatment processes.	WWTP source has no space currently available for advanced treatment processes and tunneling to potable reuse target is required. Or no satellite site identified for advanced treatment.
Operational Complexity	No impacts on existing operations	Minimal impacts to existing water operations (groundwater and reservoir augmentation utilize existing raw water sources)	Minimal impacts to existing water operations and significant impacts to hydraulics or requires MBR upgrade for secondary treatment.	Significant impacts to existing water operations (raw water or treated water augmentation introduces new water source)	Significant impacts to existing water operations and significant impacts to hydraulics or requires MBR upgrade for secondary treatment.

Table 5-6: Potable Reuse Alternatives Non-Cost Evaluation

Project	Source	Target	Criteria: Environmental and Social Objectives: Environmental Justice	Environmental Impacts from Construction	Energy Use	Wastewater Discharge (Nutrients)	Complexity and Risk: Institutional	Regulatory	Construction	Operational Complexity	Normalized Score (out of 100)
		Criteria weights	*20%*	*5%*	*10%*	*5%*	*15%*	*15%*	*5%*	*25%*	
Oro-GW	Oro Loma WPCP	Injection Wells	2	4	2	5	2	4	4	3	58
SL-Raw-1	San Leandro WPCP	USL WTP	2	4	2	5	3	5	3	2	58
SL-ResU-1	San Leandro WPCP	USL Reservoir	2	3	2	5	3	3	2	4	60
SL-Chabot-1	San Leandro WPCP	Lake Chabot	1	4	4	5	2	3	3	3	54
SL-Treat-1	San Leandro WPCP	Dunsmuir Reservoir	1	5	4	5	3	5	3	2	59
Pin-Raw-2	Pinole WPCP	Sobrante WTP	2	5	3	5	3	3	2	2	54
Pin-ResB-2	Pinole WPCP	Briones Reservoir	3	3	1	5	3	1	2	4	56
Pin-ResSP-2	Pinole WPCP	San Pablo Reservoir.	2	3	3	5	3	1	2	4	56
Pin-Treat-2	Pinole WPCP	Maloney Reservoir	1	5	3	5	3	3	2	2	50
Rich-Raw-4	Richmond WPCP	Sobrante WTP	2	3	3	5	3	3	2	2	52
Rich-ResB-4	Richmond WPCP	Briones Reservoir	3	3	1	5	3	1	2	4	56
Rich-ResSP-4	Richmond WPCP	San Pablo Reservoir	2	4	3	5	3	1	2	4	57
Rich-Treat-4	Richmond WPCP	Wildcat Aqueduct	2	5	4	5	3	3	2	2	56
WC-Raw-5	West County WPCP	Sobrante WTP	2	4	3	5	3	3	3	2	54
WC-ResB-5	West County WPCP	Briones Reservoir	3	3	1	5	3	1	3	4	57
WC-ResSP-5	West County WPCP	San Pablo Reservoir	2	4	3	5	3	1	3	4	58
WC-Treat-5	West County WPCP	Wildcat Aqueduct	2	4	4	5	3	3	3	2	56
Oro-Raw-8	Oro Loma WPCP	USL WTP	2	3	2	5	3	5	5	2	59
Oro-ResU-8	Oro Loma WPCP	USL Reservoir	2	3	2	5	3	3	4	4	62
Oro-Chabot-8	Oro Loma WPCP	Lake Chabot	1	4	4	5	2	3	5	3	56
Oro-Treat-8	Oro Loma WPCP	South Reservoir	1	5	4	5	3	5	5	1	56
CC-Raw-19	CCCSD WWTP	Mokelumne Aqueduct	5	3	2	5	3	3	5	2	65
CC-Raw-10	CCCSD WWTP	Mokelumne Aqueduct	5	3	2	5	3	5	5	2	71
CC-ResB-19	CCCSD WWTP	Briones Reservoir	3	1	1	5	3	1	5	2	47
CC-ResB-10	CCCSD WWTP	Briones Reservoir	3	1	1	5	3	3	5	2	53
SD1-Raw-30	SD1 WWTP	Orinda WTP	2	5	2	3	5	3	2	2	56
SD1-Raw-10	SD1 WWTP	Orinda WTP	2	5	2	5	5	5	2	1	59
SD1-ResU-30	SD1 WWTP	USL Reservoir	2	3	2	3	5	1	1	4	57
SD1-ResB-30	SD1 WWTP	Briones Reservoir	3	4	1	3	5	1	2	4	61
SD1-ResSP-4	SD1 WWTP	San Pablo Reservoir	2	4	3	5	5	3	2	4	69
SD1-ResU-10	SD1 WWTP	USL Reservoir	2	3	2	5	5	3	1	3	60
SD1-ResB-10	SD1 WWTP	Briones Reservoir	3	5	1	5	5	3	2	3	65
SD1-Treat-30	SD1 WWTP	Claremont Center	3	5	3	3	5	3	2	2	62
SD1-Treat-10	SD1 WWTP	Claremont Center	3	5	3	5	5	5	2	1	65
LA-Chabot-10	LAVWMA Castro Valley	Lake Chabot	1	5	5	5	2	3	1	2	50
Sat-ResSP-4	Satellite - Pt. Isabel	San Pablo Reservoir	2	5	3	5	4	1	5	3	59

The normalized non-cost evaluation scores were plotted against the project unit costs to determine the highest ranking, lowest cost alternatives as presented in Figure 5-2. Due to the large number of project alternatives evaluated, only those above the median score of 57 are shown and considered as the most favorable projects for further evaluation.

Figure 5-2: Potable Reuse Alternative Evaluation Summary



Note: Marker symbology was developed to group alternatives by similar characteristics – markers are colored based on water source, sized based on relative project yield and shaped based on project type.
□ = groundwater augmentation, Δ = reservoir water augmentation, ○ = raw water augmentation, ◊ = treated water augmentation.

5.2 Economic Value of Recycled Water Supply

To determine a net benefit for each recycled water project, the project's cost was compared to the avoided cost, alternative supply cost, and the willingness-to-pay for recycled water. All three approaches for valuing new increments of water supply are recognized by the California Water Commission (CWC 2016) and accord with generally accepted economic principles for the valuation of water supply (Young 2005). The following presents an overview of the economic analysis of the value of recycled water for the District.

5.2.1 Avoided Cost

Avoided cost is the reduction in without-project cost that would occur as a result of a proposed project. Avoided cost can be treated as a negative cost in the calculation of a project's net unit supply cost. For example, if the unit cost of a proposed recycled water project is $2,000/AF and implementing the project would allow the District to avoid wastewater discharge costs equal to $400/AF for each AF of recycled water produced, the project's net unit supply cost is $1,600/AF. For this masterplan, the avoided costs of discharge pumping or permit savings for lower volumes discharged are assumed to be de minimis. As discussed in Section 4, it is assumed that nutrient removal would be required regardless if the effluent is discharged as secondary effluent or put to beneficial reuse to meet future discharge requirements. Project costs for nutrient removal have been developed through the BACWA Nutrient Reduction Study under separate cover (BACWA, 2018). Therefore, rather than including costs for nutrient removal within the potable reuse projects and then subtracting them as avoided costs for continued discharge, the costs for nutrient removal upgrades were omitted.

5.2.2 Alternative Supply Cost

Alternative supply cost is the cost of the least-cost means of providing at least the same amount of physical water supply benefit. Alternative supply cost can vary with water year type and this needs to be considered when valuing the water from a recycled water project. For example, in years with normal water supply, a recycled water project may simply displace the use of Mokelumne River water, in which case the alternative supply cost is the incremental cost of acquiring, conveying, treating, and distributing an acre-foot of Mokelumne River water. In dry or critically dry years, on the other hand, the Mokelumne River may be in deficit and the marginal source of supply may be CVP or purchased water delivered through the Freeport Facility. In years when rationing is required, the marginal source of supply is generally going to be water saved via conservation projects. Because the cost of each of these supplies is significantly different, it is necessary to construct a weighted average cost reflecting the annual frequency in which each supply represents the alternative supply cost.

Table 5-7 sets out current alternative supply cost estimates for the District based on four marginal supply sources considered: (1) Mokelumne River water, (2) CVP contract supply, (3) dry-year purchases, and (4) average willingness-to-pay for additional water during years in which water demand is rationed. The last column of **Table 5-7** indicates the annual frequency that each source is expected to be the marginal supply. For example, while the District expects to deliver Mokelumne River water every year, Mokelumne River water is expected to be the marginal supply 78% of the time. The other 32% of the time, one of the other supplies is expected to be the marginal supply. In years with rationing, the relevant cost is what customers would be willing to pay for additional water if it could be made available.

The frequency with which a supply is expected to be the marginal source of water is derived from the W-E model simulation results for WSMP 2040 Portfolio E3 for the 2010-2040 planning horizon. The W-E model simulates the District's supplies, demands, and rationing levels through 2040 using historical hydrology spanning the years 1921 to 2003. The W-E model and WSMP 2040 portfolios are described in Appendix D of the WSMP 2040. The marginal cost of each supply is based on cost data compiled from District sources as described in the notes in **Table 5-7**. The rationing willingness-to-pay estimate is derived in the next section of this memorandum.

The alternative supply cost for new baseload supply operated continuously is the weighted-average of the four marginal supply sources. This is $681/AF and represents the cost per acre-foot that District customers would avoid by implementing a new recycled water project that operated continuously. The alternative supply cost for new dry-year supply is the weighted-average alternative supply cost in years the District expects to operate the Freeport facility or implement demand rationing. This cost is $1,774/AF and represents the cost per AF that District customers would avoid by implementing a new recycled water project operated in dry years only.

Table 5-7: EBMUD Weighted-Average Alternative Water Supply Cost Estimate (2017 dollars)

Marginal Supply Source	Alternative supply cost ($/AF)	Annual Frequency [1]
Mokelumne River	$166 [2]	68%
Freeport + CVP contract supply	$553 [3]	19%
Dry-year purchases	$1,215 [4]	4%
Rationing Willingness-to-Pay	$4,600 [5]	9%
Alternative supply cost of Supply for Baseload Water	**$681** [6]	
Alternative supply cost of Supply for Dry Year Water	**$1,774** [7]	

Notes:

1. Annual frequencies based on W-E model simulation results for WSMP 2040 Portfolio E3 for 2025-2040 levels of demand.
2. Source of estimate is Chapter 5 of the Water Supply and Economic Modeling Report, Appendix D of WSMP 2040. The cost is comprised of: 1) Mokelumne system raw water O&M cost, 2) variable treatment cost, and 3) variable distribution cost. Pumping is required under some conditions to move raw water through the Mokelumne Aqueducts to the terminal reservoir system. WSMP 2040 assumed an average of 720 kwh/AF of water pumped through the aqueducts at a cost of $0.115/kwh (2008 $), or approximately $83/AF. WSMP 2040 also assumed that water originating from the Mokelumne River is clean enough to require in-line treatment only. In-line treatment was assumed to require 25 kwh/AF of energy, $9/AF for chemicals, and $1/AF for disposal, for a total cost of approximately $13/AF. WSMP 2040 assumed an average distribution energy requirement of 265 kwh/AF at a cost of $0.153/kwh, for a total cost of approximately $41/AF. The cost in 2008 dollars is $137/AF. Updating to 2017 dollars, the total cost is $166/AF.
3. Source of estimate is Freeport Project operation cost summaries prepared by District staff for 2014 and 2015. The cost is comprised of 1) CVP purchase cost of $75/AF, 2) Freeport transmission costs of $225/AF, and 3) water treatment costs of $175/AF. Variable distribution costs are assumed to be the same as for Mokelumne River water. The cost in 2015 dollars is $522/AF. Updating to 2017 dollars, the total cost is $553/AF.
4. Source of estimate is dry-year purchase cost summaries prepared by District staff for 2015. The cost is comprised of 1) marginal purchase cost of $700/AF for 13 TAF purchased from RD 1004 and Sycamore Mutual Water Company, 2) Freeport transmission costs of $225/AF, and 3) water treatment costs of $175/AF. Variable distribution costs are assumed to be the same as for Mokelumne River water. The total cost in 2015 dollars is $1,147/AF. Updating to 2017 dollars, the estimated cost is $1,215/AF.
5. Source of estimate is average willingness-to-pay in years with rationing >=10% shown in Table 4 below.
6. Weighted-average cost across all years.
7. Weighted-average cost for years with CVP contract, dry-year purchases or rationing.

5.2.3 Marginal Willingness-to-Pay

Willingness-to-pay is the dollar amount that water users would be willing to pay for the physical water supply benefit. In years when demand is unconstrained, and customers can freely purchase whatever amount of water they want, the willingness-to-pay for water at the margin is the same as the commodity charge, which currently is $2,113/AF for potable water and $1,647/AF for non-potable water. However, in years when rationing is required, willingness-to-pay can be several times larger. For example, estimates of willingness-to-pay for recycled water exceed $4,500/AF at rationing levels above 20%. As with alternative supply cost, it is therefore necessary to construct a weighted average of willingness-to-pay that reflects the expected annual frequency of different rationing levels, including years in which no rationing is needed.

To estimate willingness-to-pay in years in which rationing is required, we use the methodology developed in Griffin (1990) to estimate consumer willingness-to-pay for the increment of water forgone by water users due to restrictions on water use during a water shortage. This is a widely used methodology for valuing increments (or decrements) of water supply. For example, it provides the basis for the calculation of water supply benefits for the California Water Fix (Sunding, et al., 2013; Sunding, et al., 2015), the economic cost of the state conservation mandate (M.Cubed, et al., 2015; M.Cubed, et al., 2016), as well as numerous other statewide and regional water resources benefit-cost assessments, including the WSMP 2040 (e.g., Jenkins, et al., 1999; Jenkins, et al., 2003; Appendix D of EBMUD, 2012a).

Urban water use can be classified into several broad categories, each with a different priority of use, and the willingness-to-pay for water by utility customers depends on the intended use of each unit of water. The willingness-to-pay for water used for drinking and basic sanitation, for example, is greater than the willingness-to-pay for water used for bathing and laundry, which in turn is greater than the willingness-to-pay for water used for washing cars, for filling swimming pools, and for irrigating landscape. When faced with a water use restriction, utility customers have the choice of which types of water uses to curtail, and the framework for measuring willingness-to-pay incorporates the idea that utility customers respond to a water use restriction by eliminating less valuable water uses before eliminating more valuable water uses, for instance by reducing water used for irrigating landscape prior to reducing water used for personal hygiene.

Figure 5-3 depicts a schedule of willingness-to-pay for different units of water as a demand curve for water that orders these units from highest valued uses to lowest valued uses. Under normal conditions, a customer facing a volumetric water rate of P* demands units of water for which willingness-to-pay exceeds P*. In **Figure 5-3**, this quantity is Q* units. Units of water beyond Q* have value to the customer, but their value is less than their cost, P*, so a rational customer would choose to forego purchasing units beyond Q*. Note that when demand is unconstrained, P* represents the willingness-to-pay for an additional unit of water at the margin.

Suppose instead a quantity restriction is placed on water use so that a customer can purchase no more than Q^R units of water. The customer must forego $Q^*- Q^R$ units of water. The value of these foregone units of water is measured by the shaded area in **Figure 5-3**. Mathematically, this shaded area is calculated as the integral of the demand function evaluated between Q^R and Q*:

$$Total\ WTP\ for\ Q^* - Q^R\ units\ of\ water = \int_{Q^R}^{Q^*} D(Q)dQ$$

The customer will also avoid having to directly pay for $Q^*- Q^R$. Thus, the customer initially avoids utility bills equal to $P^*(Q^*- Q^R)$. However, most utilities set P* to recover both their variable operating costs and a portion of their fixed costs. Since utilities operate on a break-even basis, they will still need to recoup the fixed costs that would have been recovered by selling the $Q^*- Q^R$ units of water. Denoting V as the portion of P* that covers the variable costs of production, the utility will still need to recover $(P^*-V)(Q^*- Q^R)$ from the customer to cover its fixed costs. While the customer initially avoids $P^*(Q^*- Q^R)$, the utility will seek to recover $(P^*-V)(Q^*- Q^R)$ in the future, and the net cost avoided by the customer is therefore only $V(Q^*- Q^R)$.

The economic loss to the customer of foregoing $Q^*- Q^R$ units of water is therefore:

$$L(Q^*, Q^R) = \int_{Q^R}^{Q^*} D(Q)dQ - V(Q^* - Q^R)$$

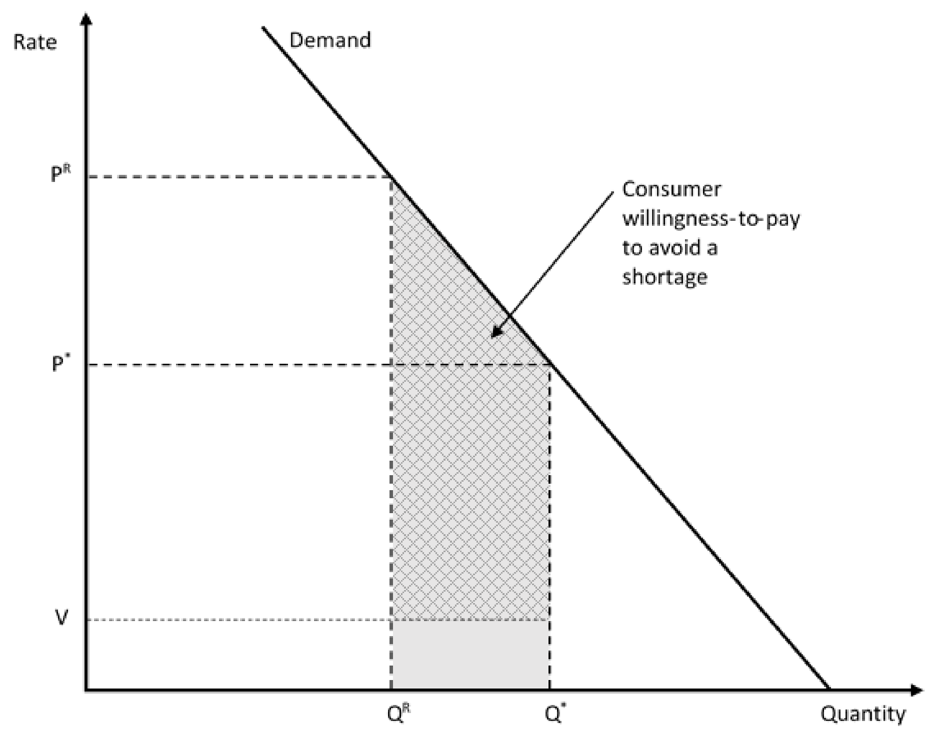
Viewed in the other direction, $L(Q^*, Q^R)$ measures what the customer would be willing to pay not to forego Q*- Q^R units of water. On a per unit basis, the average willingness-to-pay for Q*- Q^R units of water is $L(Q^*, Q^R) \div (Q^* - Q^R)$ while the marginal willingness-to-pay is $D(Q^R) - V$. The marginal value corresponds to P^R-V in **Figure 5-3**.

It is convenient to represent Q^R as a multiple of Q*. Let r be the corresponding percentage reduction in Q* that yields Q^R. Then Q^R = (1-r)Q* and the economic loss function becomes:

$$L(Q^*, r) = \int_{(1-r)Q^*}^{Q^*} D(Q)dQ - rVQ^*$$

Operationalizing the economic loss function requires assigning a functional form to D(Q). It is conventional to use a constant elasticity of demand (CED) specification, $D(Q)=AQ^{1/e}$, where A is equal to $P^*/(Q^{*1/e})$. For example, this is the specification recommended in the California Water Commission's Water Storage Investment Program Technical Reference (CWC 2016). It is also the functional form used for the economic analyses of the California Water Fix (Sunding, et al., 2013; Sunding, 2015) and the state conservation mandate (M.Cubed, et al., 2015; M.Cubed, et al., 2016).

Figure 5-3: Consumer Willingness to Pay to Avoid a Water Shortage



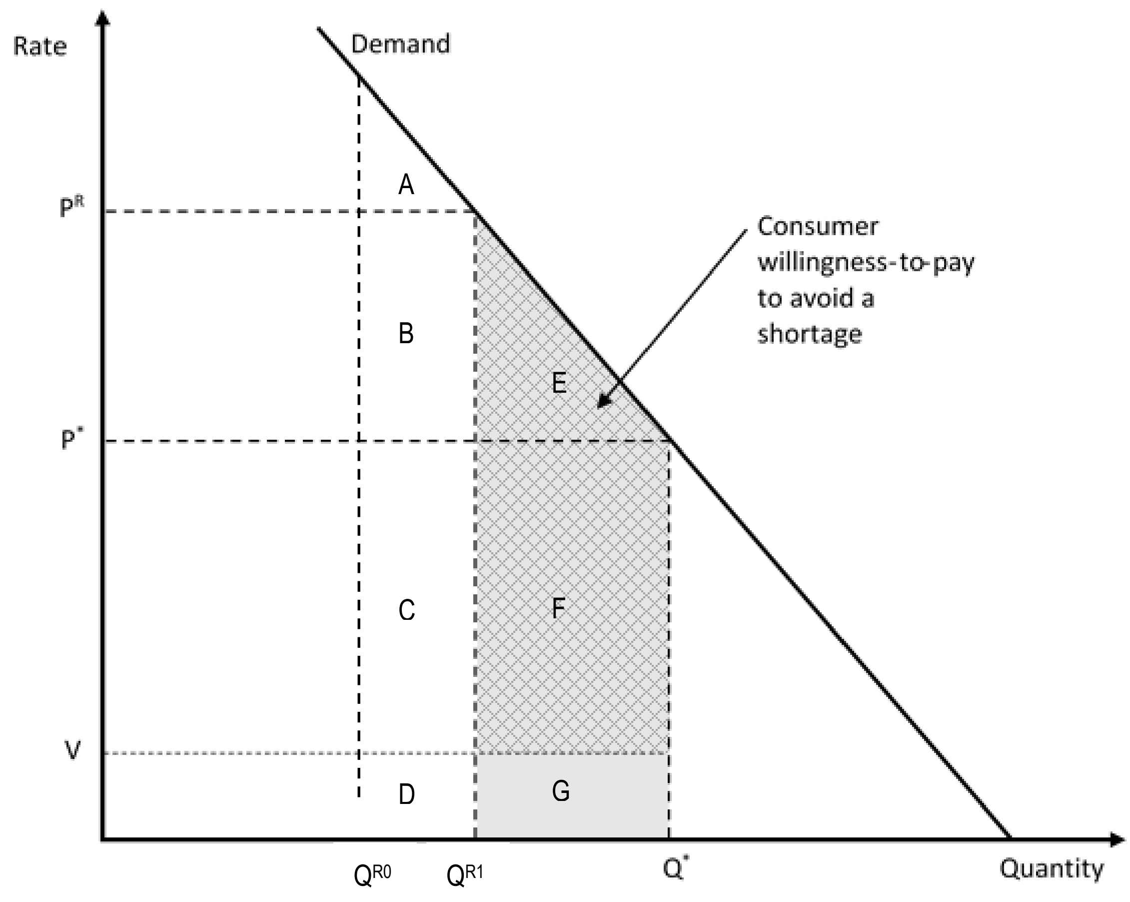
Under the CED specification, the economic loss function for rationing level r is given by

$$CED\ Loss\ Function: L(r|Q^*, P^*, e, V) = \frac{e}{1+e} P^* Q^* \left[1 - (1-r)^{\frac{1+e}{e}}\right] - rVQ^*$$

where e is the price elasticity of demand. $L(r|Q^*, P^*, e, V)$ is the monetized loss of foregoing rQ* units of water.

The willingness-to-pay for additional increments of recycled water supply in years in which water is rationed is equal to the difference in the monetized loss with the additional increment of recycled water supply versus without it. This is depicted in **Figure 5-4**. Q^{R0} in **Figure 5-4** is the restricted demand level without the new increment of recycled water while Q^{R1} is the restricted level with the new increment of recycled water. The monetized shortage loss without the new increment of recycled water is equal to the area A+B+C+E+F-D-G in **Figure 5-4**. With the new increment of recycled water, the monetized shortage loss is equal to the area E+F-G in **Figure 5-4**. The willingness-to-pay for the new increment of recycled water is the difference between these two values, which is the area A+B+C-D. Dividing this value by the increment of new supply, Q^{R1}-Q^{R0}, yields the average per unit willingness-to-pay for the new increment recycled water.

Figure 5-4. Willingness-to-Pay for New Increment of Recycled Water under Rationing



This value can be computed using the CED loss function as:

$$WTP\ for\ Increment\ of\ Recycled\ Water = \left[\frac{e}{1+e}P^{*}Q^{*}\left[(1-r_1)^{\frac{1+e}{e}}-(1-r_0)^{\frac{1+e}{e}}\right]-(r_0-r_1)VQ^{*}\right]\div(r_0-r_1)\cdot Q^{*}$$

where r_0 is the rationing percentage without the new increment of recycled water and r_1 is the rationing percentage with it.

5.2.3.1 Estimates of Willingness-to-Pay for New Increments of Recycled Water

The projected growth in new recycled water supply is taken from Table 4-1 of the District's 2015 Urban Water Management Plan. This also corresponds to the recycled water growth projection used in WSMP 2040 Portfolio E3. This projection is summarized in **Table 5-8**.

Table 5-8. Projected Growth in Recycled Water Capacity per 2015 UWMP (MGD)

Recycled Water Capacity	2015	2020	2025	2030	2035	2040
Existing	9	9	9	9	9	9
New (post 2015)	0	2	5	8	9	11
Total	**9**	**11**	**14**	**17**	**18**	**20**

The increments of new recycled water capacity in Table 2 are used with the W-E model results for WSMP 2040 Portfolio E3 to calculate the rationing percentages with (r_0) and without (r_1) the new recycled water capacity. These percentages are provided in Appendix C, Attachment 1 for each hydrologic base year in the W-E model. The values for P*, Q*, and *e* are given in **Table 5-9**. P* is the current volumetric rate for potable water. Q* is the planning level of demand used in WSMP 2040 Portfolio E3. The elasticity value of -0.2 is the average of the demand elasticities for Bay Area urban water suppliers used in the state's economic analysis of the California Water Fix (Sunding, et al., 2013; Sunding, 2015).

Table 5-9. Parameters Used to Calculate Willingness-to-Pay for Increments of New Recycled Water Capacity

Willingness-to-Pay Parameters	2020	2025	2030	2035	2040
P* ($/AF)	$2,113	$2,113	$2,113	$2,113	$2,113
Q* (AF)	257,633	260,994	264,354	260,994	257,633
e	-0.2	-0.2	-0.2	-0.2	-0.2

The values in **Table 5-9** were used in combination with the shortage percentages in Appendix C, Attachment 1 to calculate the willingness-to-pay for the additional increments of recycled water capacity shown in **Table 5-8**. The willingness-to-pay estimates for each hydrologic base year in the W-E model are provided in Appendix C, Attachment 2.

Table 5-10 summarizes these estimates for potable reuse projects and non-potable recycled water projects. The only difference between potable reuse and non-potable recycled water is the willingness-to-pay in years when there is no rationing. In these years, the willingness-to-pay is equal to the volumetric rate. Currently, the District sells non-potable recycled water at a discount of close to $500/AF to compensate customers for diminished water quality. This analysis assumes the District will maintain this discount in the future. Thus, the willingness-to-pay in years without rationing is assumed to be $2,113/AF for potable reuse and $1,647/AF for non-potable recycled water. The maximum willingness-to-pay ranges between $5,100 and $5,400/AF and corresponds to years with maximum rationing. Under WSMP 2040 Portfolio E3, the maximum rationing percentage with the new recycled water capacity is 20%; without the new capacity the maximum rationing level is 24% by 2040.

The last two rows in each section show the average willingness-to-pay for the 83 hydrologic base years in the W-E model. Across all years, these values are approximately $2,400/AF for potable reuse and $2,000/AF for non-potable recycled water. Across only years with rationing of 10% or more, these values are approximately $4,600/AF. This represents what District customers would be willing to pay for additional increments of potable reuse and non-potable recycled water given current water rates and projections of future water demands and supplies as represented in WSMP 2040 Portfolio E3.

Table 5-10. Willingness-to-Pay for Increments of Potable Reuse Water ($/AF)

Willingness-to-Pay Estimates	2020	2025	2030	2035	2040	*Approximate Average*
Potable Reuse Water						
Minimum	$2,113	$2,113	$2,113	$2,113	$2,113	
Maximum	$5,094	$5,197	$5,298	$5,337	$5,413	
Average for:						
All Years	$2,366	$2,364	$2,402	$2,397	$2,401	*$2,400*
Rationing >= 10%	$4,499	$4,529	$4,640	$4,604	$4,784	*$4,600*
Non-Potable Recycled Water						
Minimum	$1,647	$1,647	$1,647	$1,647	$1,647	
Maximum	$5,094	$5,197	$5,298	$5,337	$5,413	
Average for:						
All Years	$1,979	$1,977	$2,020	$2,016	$2,013	*$2,000*
Rationing >= 10%	$4,499	$4,529	$4,640	$4,604	$4,784	*$4,600*

5.3 Comparison of Recycled Water Project Unit Costs to Other Supplies

It is useful to compare recycled water project unit costs to the alternative supply cost and willingness-to-pay estimates. The monetized value of the recycled water produced by the project is the lesser of the alternative supply cost and the willingness-to-pay for additional water supply. The net benefit of a recycled water project is equal to its monetized value minus its net unit supply cost. **Table 5-11** provides a summary of the alternative supply costs and willingness-to-pay estimates.

Table 5-11: Summary of Economic Evaluation Parameters

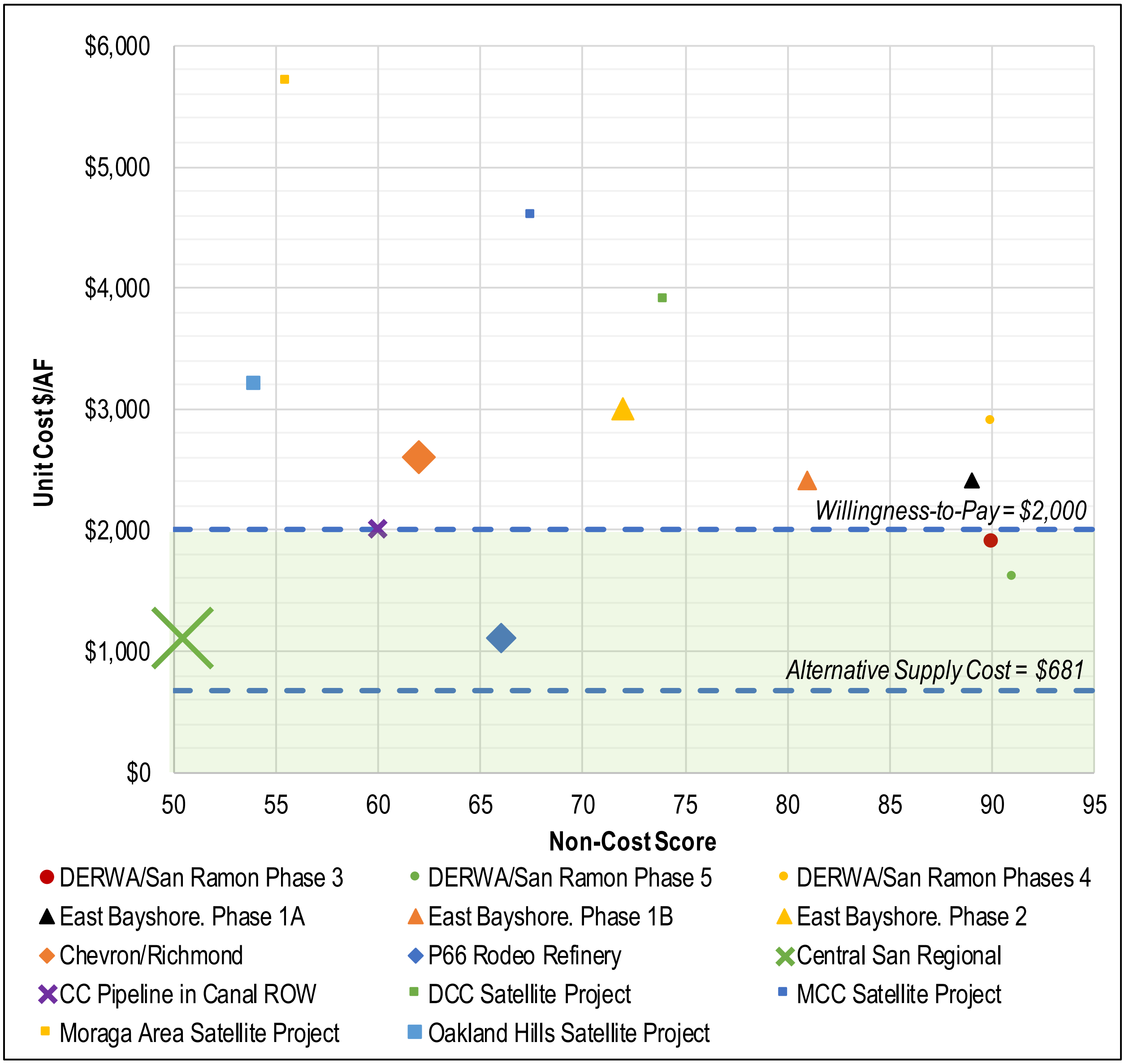
Parameter	Value ($/AF)
Alternative Supply Cost	
Dry Year Purchases (see Table 5-7)	$1,215
Alternative supply cost for Baseload Water	$681
Alternative supply cost for Dry Year Water	$1,774
Willingness-to-Pay	
All years – Non-potable Reuse	$2,000
All years – Potable Reuse	$2,400
Dry Years	$4,600

5.3.1 All Years (Baseload) Comparison

5.3.1.1 Non-Potable Reuse Alternatives

Figure 5-5 compares the alternative supply cost and willingness-to-pay to unit costs for the viable non-potable reuse alternatives. While all of the project unit costs exceed the alternative supply cost, four projects are less than customer willingness-to-pay for non-potable reuse and four are slightly above the customer willingness-to-pay.

Figure 5-5: Economic Comparison of Non-Potable Reuse Alternatives

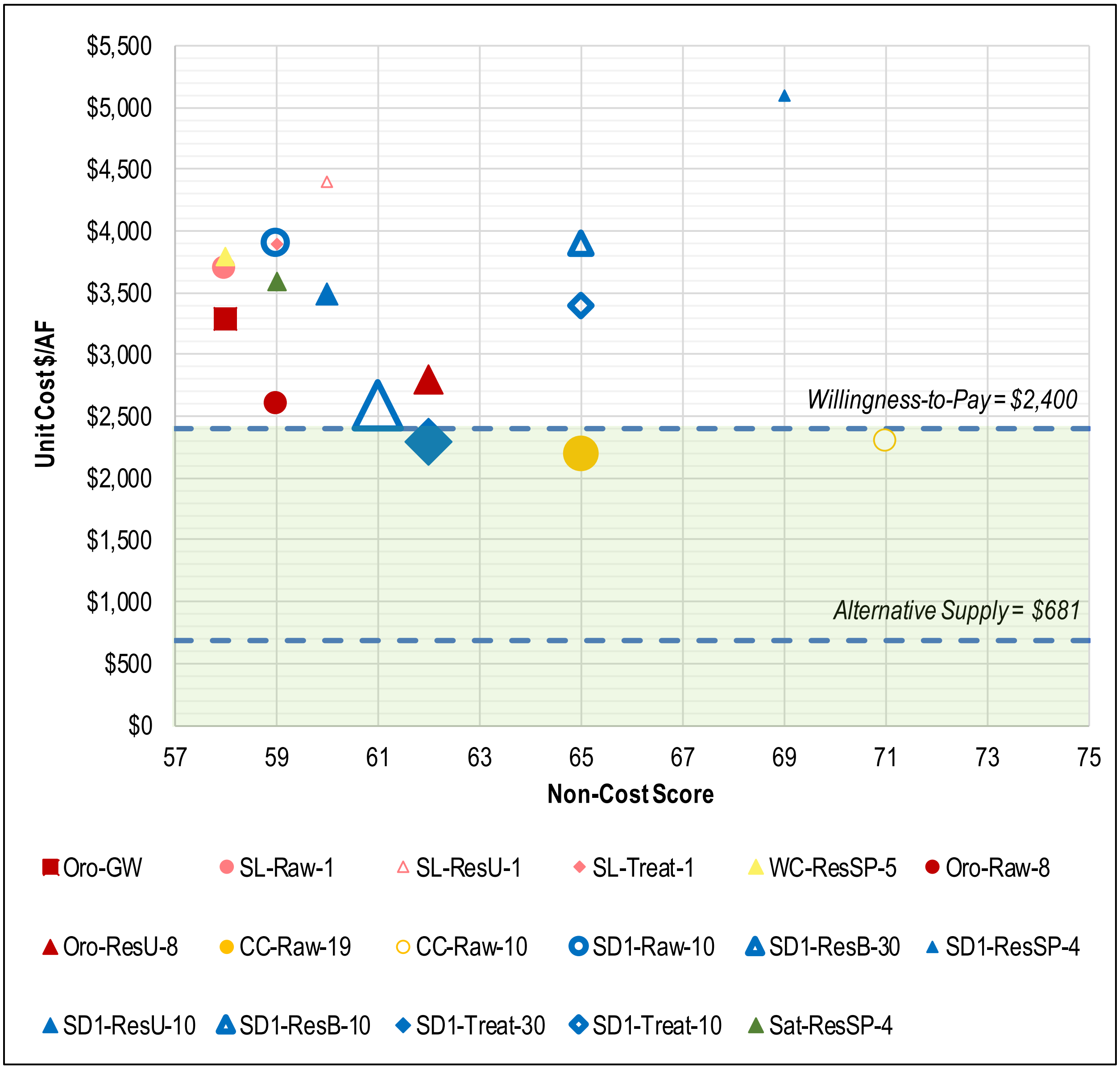


Note: Marker symbology was developed to group alternatives by similar source and/or project type.
□ = Satellite RWTP, Δ = East Bayshore RWF, ○ = DERWA/San Ramon, ◊ = Refinery, x = CCCSD and CC Pipeline in Canal ROW.

5.3.1.2 Potable Reuse Alternatives

Figure 5-6 compares the alternative supply cost and willingness-to-pay to unit costs for the potable reuse projects with a non-cost evaluation score of 60 or greater. All of the potable reuse projects have unit costs that exceed the alternative supply cost. Five projects are less than customer willingness-to-pay for potable reuse and two are slightly above the customer willingness-to-pay.

Figure 5-6: Economic Comparison of Potable Reuse Alternatives



Note: Marker symbology was developed to group alternatives by similar characteristics – markers are colored based on water source, sized based on relative project yield and shaped based on project type.
□ = groundwater augmentation, ∆ = reservoir water augmentation, ○ = raw water augmentation, ◊ = treated water augmentation.

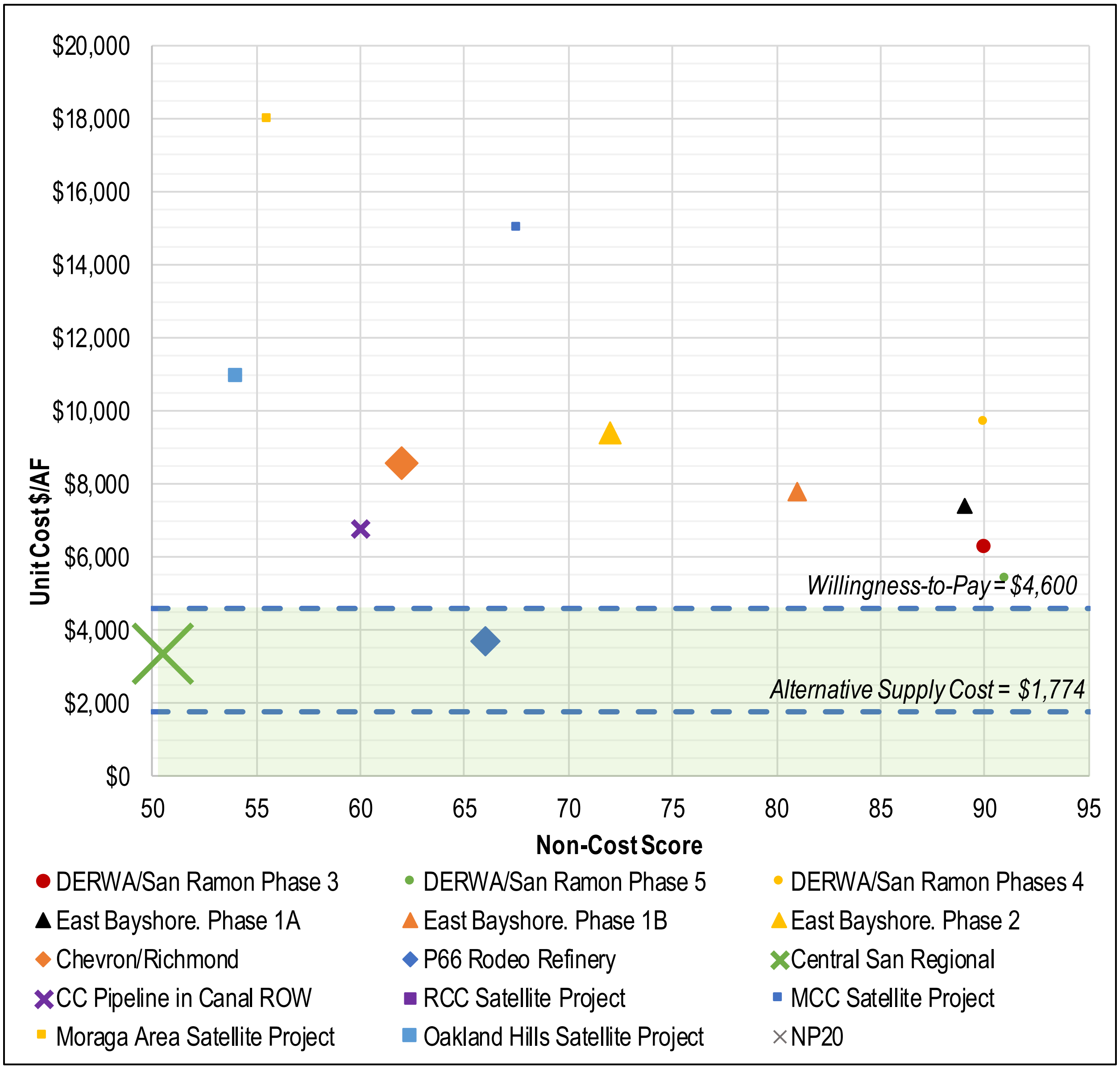
5.3.2 Dry Year Comparison

As noted previously, in most years (68%) there is adequate supply from the Mokelumne River to meet the Districts water demands. Therefore, potable reuse would be a marginal supply implemented only in dry years. To further evaluate the potable reuse alternatives, dry year unit costs were developed. Capital costs, labor, and maintenance were held constant while electricity and chemical costs and project life-cycle yield were reduced to 30% reflecting a usage rate of 3 out of every 10 years.

5.3.2.1 Non-Potable Reuse Alternatives

Figure 5-7 compares the dry year alternative supply cost and dry year willingness-to-pay to dry year unit costs for the non-potable reuse projects. If operated as a dry year supply, all non-potable reuse projects exceed both the alternative supply costs and only two projects are less than the willingness-to-pay.

Figure 5-7: Dry Year Economic Comparison of Non-Potable Reuse Alternatives

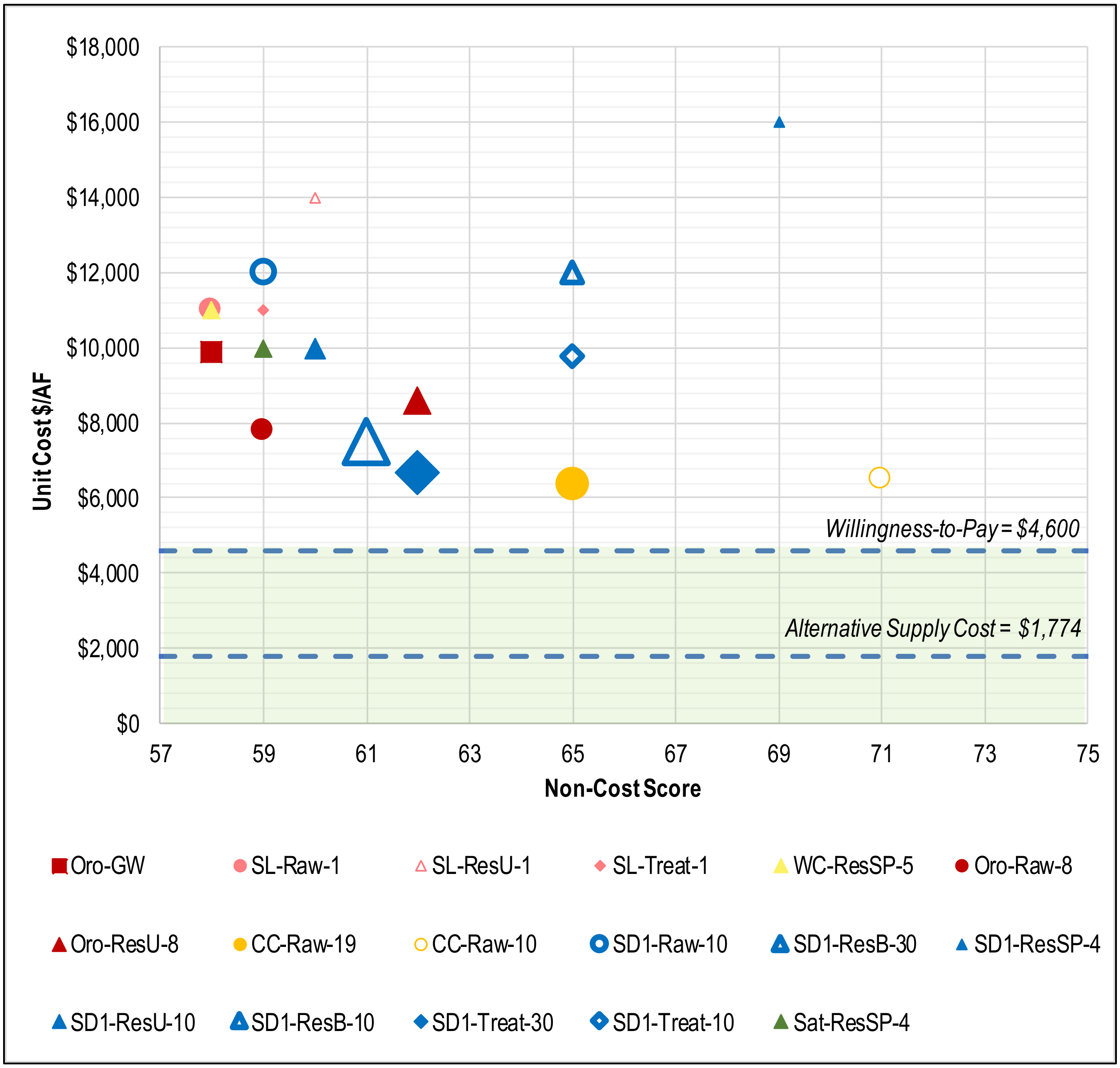


Note: Marker symbology was developed to group alternatives by similar source and/or project type.
□ = Satellite RWTP, Δ = East Bayshore RWF, ○ = DERWA/San Ramon, ◊ = Refinery, x = CCCSD.

5.3.2.2 Potable Reuse Alternatives

Figure 5-8 compares the dry year alternative supply cost and dry year willingness-to-pay to dry year unit costs for the potable reuse projects with a non-cost evaluation score of 60 or greater. If operated as a dry year supply, all potable reuse projects exceed both the alternative supply costs and the willingness-to-pay.

Figure 5-8: Dry Year Economic Comparison of Potable Reuse Alternatives



Note: Marker symbology was developed to group alternatives by similar characteristics – markers are colored based on water source, sized based on relative project yield and shaped based on project type.
□ = groundwater augmentation, Δ = reservoir water augmentation, ○ = raw water augmentation, ◊ = treated water augmentation.

5.4 Summary of Alternatives Evaluation

Based on the economic evaluation, there is no net economic benefit to implementing additional non-potable or potable reuse projects at this time as all projects exceed the alternative water supply costs. While there are a number of potable reuse options with comparable unit costs to non-potable reuse, the total capital investment needed is significantly greater as summarized in **Table 5-12.**

Table 5-12: Highest Ranking, Lowest Cost Alternatives

Project	Yield (AFY)	Unit Cost ($/AF)	Dry Year Unit Cost ($/AF)	Capital Cost ($M)
Non-Potable Reuse				
DERWA/San Ramon Phase 3	800	1,900	6,300	25
DERWA/San Ramon Phase 5	300	1,600	5,400	8
DERWA/San Ramon Phase 4	300	2,900	9,700	17
East Bayshore Phase 1A only	500	2,400	7,400	16
East Bayshore Phase 1A and 1B	1,100	2,400	7,800	40
East Bayshore Phase 1A, 1B, and 2[1]	2,900	3,000	9,400	130
Chevron/Richmond	4,300	2,600	8,600	110
Phillips 66	4,100	1,100	3,700	53
Potable Reuse				
SD-1 to Claremont Center, 10 MGD (SD1-Treat-10)	11,200	3,400	9,800	360
SD-1 to Claremont Center, 30 MGD (SD1-Treat-30)	33,600	2,300	6,700	480
SD-1 to Briones Reservoir, 10 MGD (SD1-ResB-10)	11,200	3,900	12,000	460
SD-1 to Briones Reservoir, 30 MGD (SD1-ResB-30)	33,600	2,600	7,500	690
CCCSD to Mokelumne Aq., 19 MGD (CC-Raw-19)	21,820	2,200	6,400	310
CCCSD to Mokelumne Aq., 10 MGD (CC-Raw-10)	11,200	2,300	6,500	180
Oro Loma to USL Res., 8 MGD (Oro-ResU-8)	8,960	2,800	8,600	230

The recommended plan is to continue progress to meet the District's current goal of 20 MGD by 2040 with the highest-ranking, lowest-cost alternatives looking at both project unit costs and total capital outlay. The recommended projects are East Bayshore Phases 1A,1B and 2, DERWA/San Ramon Phases 3 through 5, Chevron Richmond, and Phillips 66, totaling 11 MGD as shown in **Table 5-13** and **Figure 5-9**. Diablo Country Club is also included since the project is expected to go forward under a self-financing model.

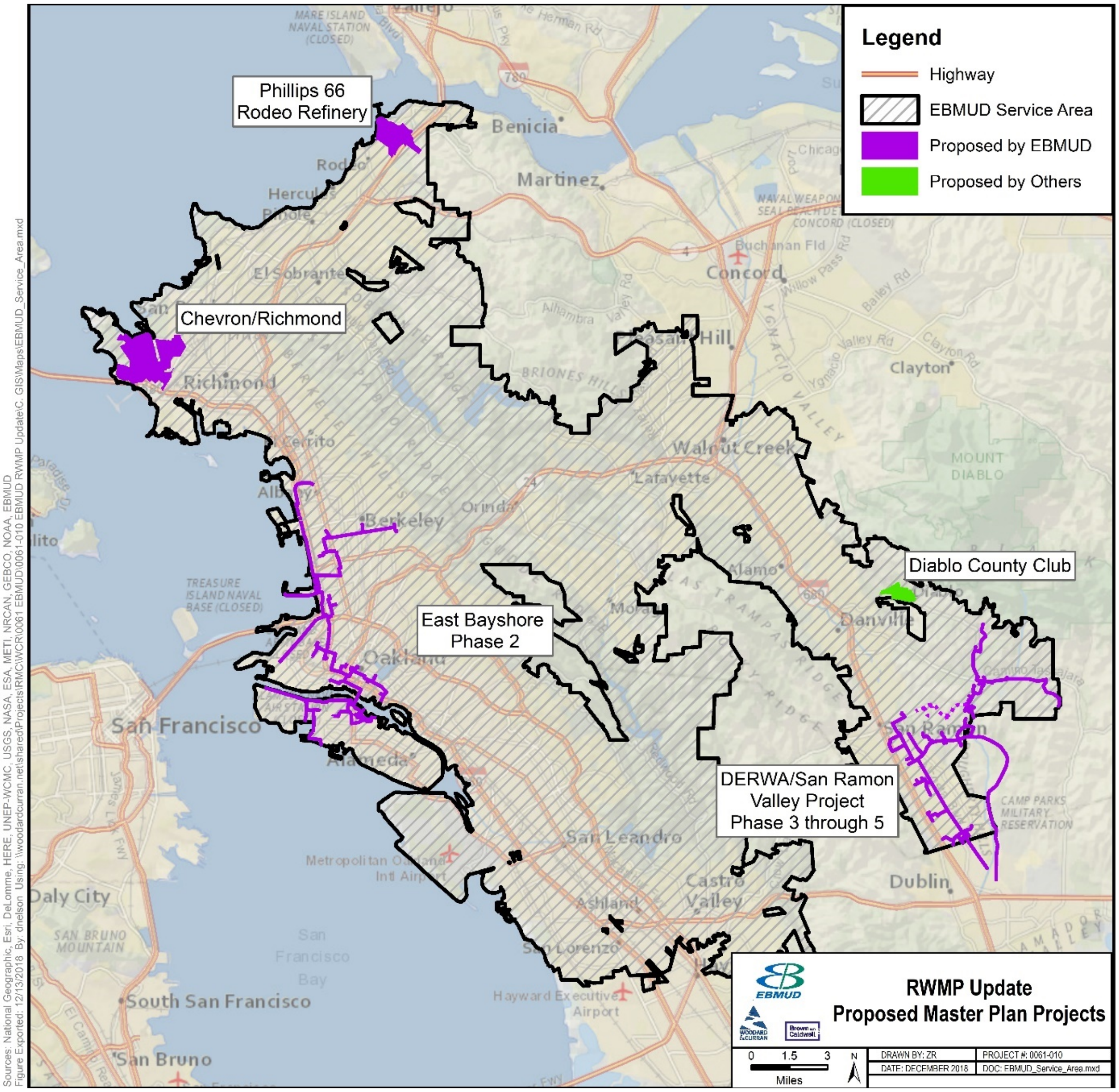
Table 5-13: Recommend Non-Potable Reuse Projects to Meet 20 MGD by 2040

Project	Yield (AFY)	Yield (MGD)
Diablo Country Club	250	0.2
DERWA/San Ramon – Phase 3	800	0.7
DERWA/San Ramon – Phase 4	300	0.3
DERWA/San Ramon – Phase 5	300	0.3
East Bayshore – Phase 2[1]	2,900	2.4
Chevron/Richmond	4,300	3.8
P66 Rodeo Refinery	4,100	3.7
TOTAL	**12,500**	**11.1**

Notes:

1. East Bayshore Phase 2 costs include Phase 1A and 1B costs.

Figure 5-9: Recommend Recycled Water Projects



6. RECOMMENDED PROJECTS

As noted in Section 5.4, it is recommended that the District pursue a suite of non-potable reuse projects to continue working toward the current recycled water goal of 20 MGD by 2040. The primary projects include continued expansion and implementation of the DERWA/San Ramon and the East Bayshore Recycled Water Project as well as providing recycled water to the refineries in Richmond and Rodeo. The recommended projects are discussed in greater detail below and a summary of capital costs is provided.

At this time, the District can meet its potable water demand with available supplies. The capital costs for implementing potable reuse are very large and if the projects would only be operated as dry-year supply, the unit costs are greater than $6,000/AF. While it is therefore not recommended to implement any potable reuse projects in the near-term, it is recommended that the District continue to engage in the state's efforts to develop potable reuse regulations and operator training for future long-term needs. The District should revisit the most favorable potable reuse alternatives as the treatment costs come down and the need for water supply increases in the future. To guide these future efforts, a discussion of the most promising potable reuse projects is also included in this section.

6.1 DERWA/San Ramon Valley Recycled Water Project Phases 3 through 5

Phase 1 and 2 of the DERWA/San Ramon Project are near completion, and portions of the Phase 3 recycled water pipeline and the R3000 recycled water reservoir are already constructed. While all remaining portions of the DERWA/San Ramon project scored highly in the non-cost evaluation, Phase 4 serving eastern Blackhawk scored lower and it is less cost-effective than Phase 3 or 5, and is therefore planned for implementation after Phase 3 and 5. Although they are relatively small projects, this well-established landscape irrigation program should continue to be a high priority project as long as funding and source supply are available.

6.1.1 Project Overview

The DERWA/San Ramon project requires both distribution infrastructure solely funded and constructed by the District and recycled water treatment plant expansion co-funded by the District, DSRSD, and the City of Pleasanton. **Figure 6-1** provides a summary overview of the distribution infrastructure for two phases.

Phase 3 distribution infrastructure includes the following components:

- Distribution pipelines along Dougherty Rd., Crow Canyon Rd. (optional) and Camino Tassajara corridors, ranging in size from 4 to 16 inches (partially completed);
- R3000 pump station along Dougherty Rd. (currently in planning);
- Customer retrofits.

Phase 5 distribution infrastructure builds on Phase 3 and includes the following components:

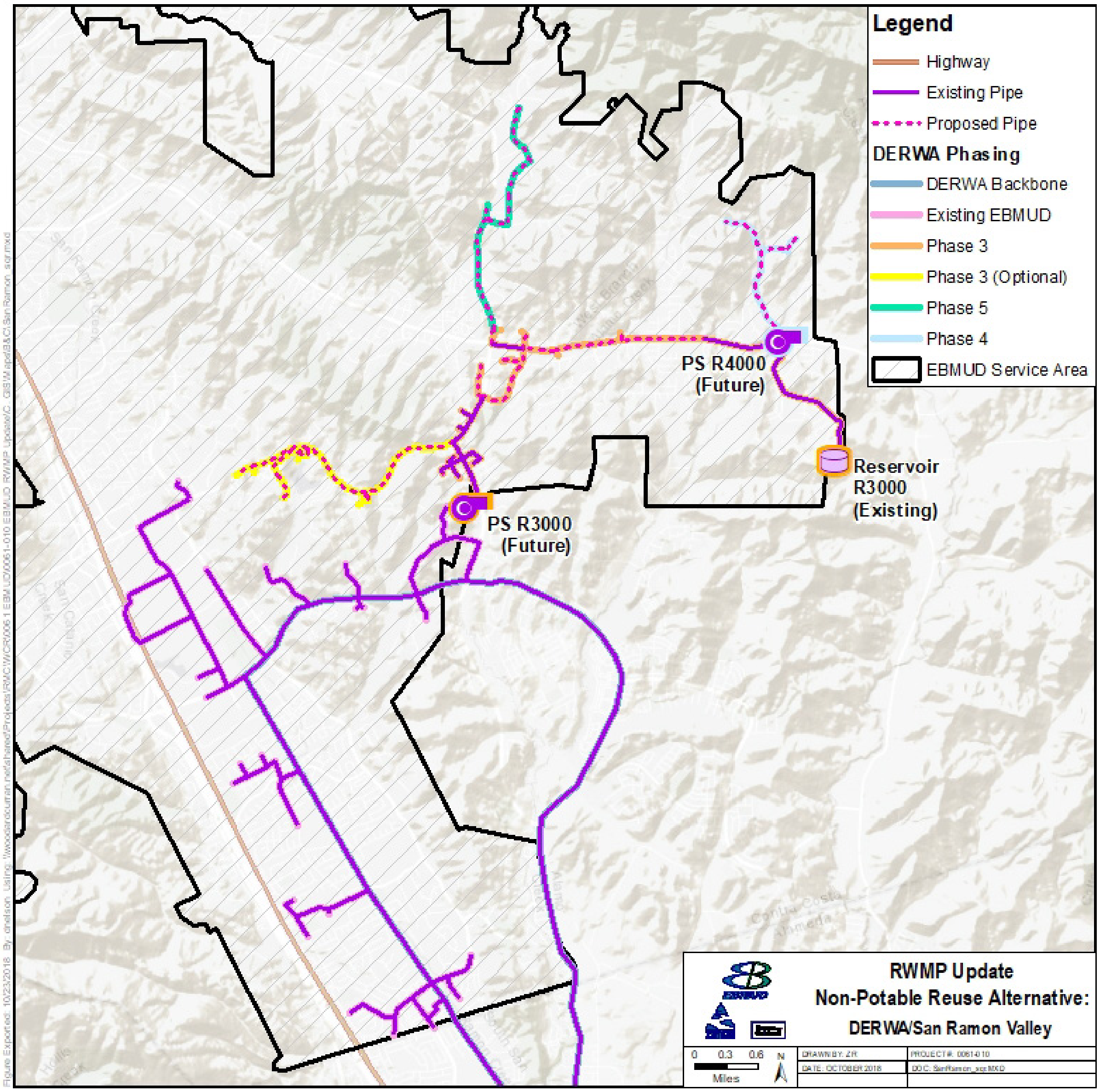
- Distribution pipelines extending along Blackhawk Rd. to the western portion of Blackhawk Country Club;
- Customer retrofits.

Phase 4 distribution infrastructure also builds on Phase 3, and includes the following components:

- Distribution pipelines extending along Blackhawk Dr. to the eastern portion of Blackhawk Country Club;
- Pump station R4000;
- Customer retrofits.

To meet these additional customer demands a number of treatment plant upgrades and expansions are also planned. In 2016, Phase 1 of the treatment plant expansion was completed adding a sixth sand filter. Phase 2 was completed in 2018 and added influents pumps, flocculation basins, UV modules and recycled water distribution pumps. This will improve the water quality of the filter feed and expand the facility's peak production capacity to 16.2 MGD. Additional expansion of the recycled water treatment facility will be dependent on timing of customers demand and source water availability.

Figure 6-1: DERWA/San Ramon Phases 3 through 5 Expansion



6.1.2 Additional Considerations

DERWA has experienced peak month supply shortfalls during summer season, requiring potable water supplement. DERWA is also exploring other additional supply opportunities, including groundwater, recycled water from CCCSD, and diversion of raw wastewater from CCCSD's adjacent sewerage collection system to supplement DERWA's recycled water supply. It is important to note that wastewater supply from DSRSD is limited and the DERWA supply agreement defines recycled water service to the two-member agencies as first-come, first-served. This means that the availability of water is dependent upon how quickly the District expands its distribution system versus how quickly DSRSD develops its program. Therefore, the District should continue to expand its recycled water infrastructure while working through DERWA to secure the needed wastewater supply to meet the increasing demand.

6.2 East Bayshore Phase 2

6.2.1 Project Overview

The East Bayshore Phase 2 project (which includes expanding the customer base along existing infrastructure in Phase 1A, then adding Phase 1B and Phase 2 pipelines) is included as a recommended project because it builds on an existing District recycled water project and it serves non-potable water to a relatively large and diverse group of customers.

The District has been evaluating alternatives for East Bayshore under a separate effort. The *Final East Bayshore Recycled Water Facility Water Quality Evaluation Technical Memorandum No. 1* dated March 2018 (TM1) summarized water quality issues experienced at EBRWF and recycled water demands (BC, 2018). The initial portion of the study, concluded that the existing water quality may not be ideal for irrigating sensitive species, and is not suitable for industrial use (i.e., cooling towers and boilers) or toilet flushing. The second phase of the EBRWF Study is currently underway. Its objective is to identify short-, intermediate-, and long-term alternatives to improve recycled water quality for non-potable reuse and ultimately identify a path forward for the EBRWF recycled water program. While the preferred alternative from the study has not yet been selected, the recommended buildout plan for this program is a new 4.5-MGD MBR treatment facility at SD-1.

The MBR treatment system offers improved recycled water quality, thereby allowing for expansion of the customer base to year-round industrial customers. The MBR treatment system can be designed for a phased approach to reach buildout capacity. Annual average recycled water demand is anticipated to be around 2,867 AFY (2.6 MGD average annual demand, 4.5 MGD max month demand). An additional 0.8 MGD of in-plant reuse at SD-1 is also anticipated and included in the facility sizing, but not in the project yield. The Phase 1A (short-term) pipeline expansion would serve new customers within the existing distribution area and the Frontage Road pipeline alignment. The Phase 1B (intermediate-term) pipeline expansion would serve new customers in Oakland and Berkeley, as shown in **Figure 6-2**, while the long-term Phase 2 pipeline expansion would serve additional customers in Alameda and Albany, the UCB campus, and customers along the Powell Street and Channing Way Pipeline alignment. As discussed previously, the EBRWF Phase 2 was prioritized over the UCB Satellite Treatment Project, which only serves the demands at the UCB campus.

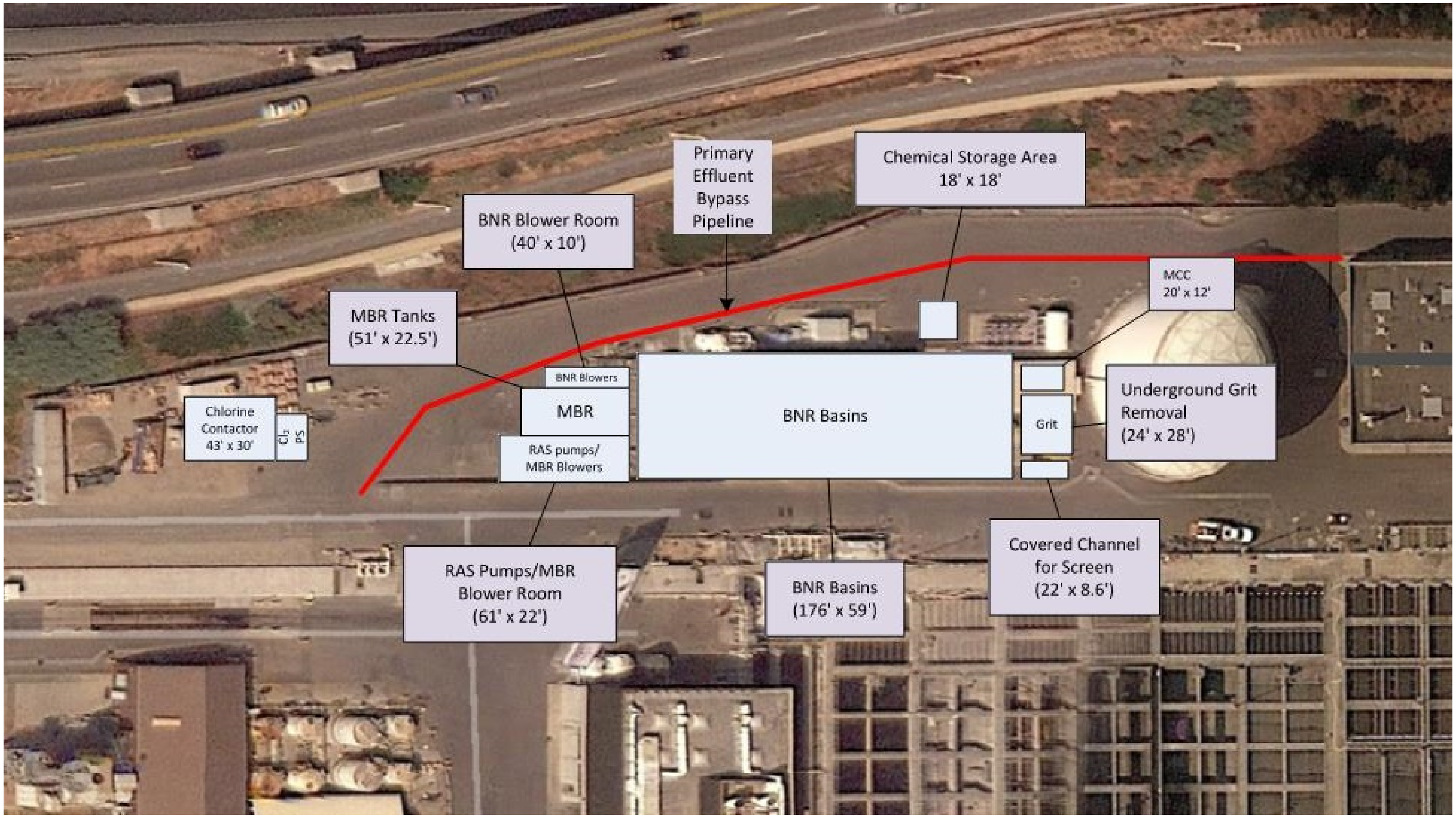
The new MBR treatment alternative would replace the existing tertiary membrane filters and would include screening, grit removal, activated sludge basins and membrane tanks located at SD-1. The 4.5-MGD MBR project would improve recycled water quality by treating influent flows with lower total dissolved salt concentrations (from the Adeline interceptor) and would also provide biological nutrient removal (BNR). The existing recycled water storage tank and distribution pumps have enough capacity to convey the additional flows and can be repurposed. The chlorine contactor would be demolished, and a new one would be built. Recycled water would be stored and distributed using the existing EBRWF facilities.

Figure 6-3 shows the site layout for the 4.5-MGD MBR alternative. Recycled water would be stored and distributed using the existing EBRWF facilities. This alternative would require land acquisition east of SD-1 from the California Department of Transportation (Caltrans) to construct a pump station capable of delivering influent from the Adeline Interceptor to an MBR process. The cost of land was not included in the cost estimate.

As shown in the site layout, the identified location for the EBRWF facilities has limited space and constructability is a potential issue. The current proposed location of the MBR facility is within the existing EBRWF footprint and does not provide adequate land for expansions of the MBR system if needed in the future. An alternate location at the treatment plant may be desirable to allow for expansion and/or to facilitate construction of the new MBR facilities.

Figure 6-2: East Bayshore Phase 1A, 1B and Phase 2 Project

Figure 6-3: Proposed 4.5-MGD MBR Layout at EBRWF

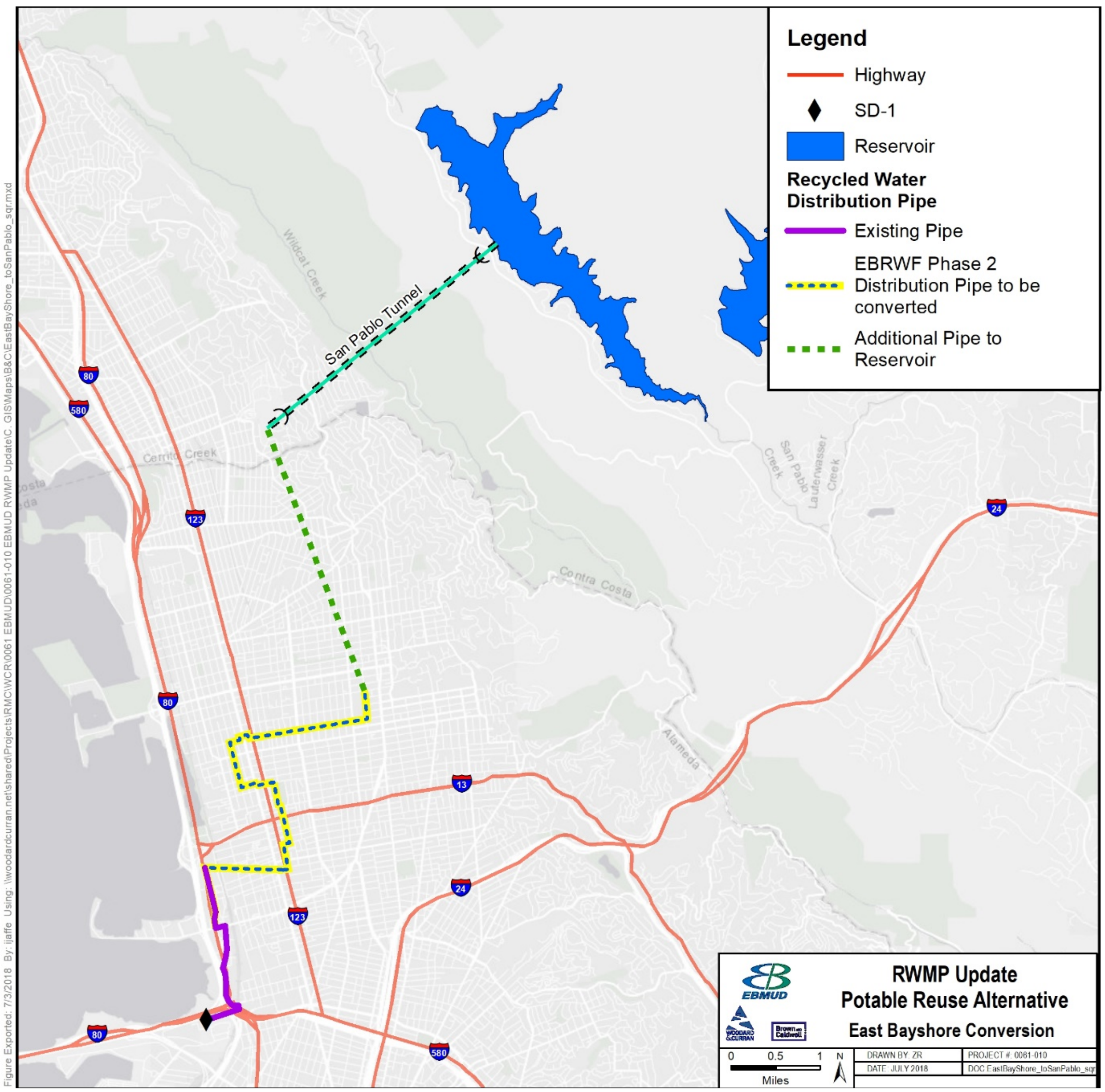


Note: The red line indicates the location of the existing primary effluent bypass pipeline.

6.2.2 Additional Considerations

As described in Section 4, a number of projects were evaluated using SD-1 as a supply source for a potable ruse project, including a 4-MGD reservoir augmentation project to San Pablo Reservoir, a 10-MGD reservoir augmentation project to Briones Reservoir, and a 10-MGD treated water augmentation to Claremont Center. In the future, the MBR for the EBRWF could be repurposed and/or expanded to meet potable reuse demands. Additional space would be required for advanced treatment. As shown in **Figure 6-4**, the existing distribution system could also be expanded to the San Pablo WTP for raw water augmentation or to San Pablo Reservoir for reservoir water augmentation. This would require approximately 10,000 linear feet of additional pipeline from the currently proposed pipeline expansion to serve Albany to San Pablo WTP. The East Bayshore Phase 2 pipelines in central Berkeley are preliminarily sized at 20 inches, which is adequate capacity for at least 7 MGD of flow at a maximum velocity of 5 fps.

Figure 6-4: Potential Alignment to Expand EBRWF to San Pablo WTP



6.3 Chevron Refinery/Richmond WPCP Recycled Water Project

6.3.1 Project Overview

This project would produce additional recycled water to serve the Chevron Richmond refinery from the Richmond WPCP is included as a recommended project because it builds on the District's successful partnership with Chevron on the RARE and North Richmond project. Both Chevron and the District have made significant investments to serve recycled water from the West County WPCP to the refinery for cooling tower makeup water and boiler feed systems.

Upgrading all or part of the Richmond WPCP to provide suitable water quality is one of the major components of the project. The 2016 Richmond Facilities Plan evaluated treatment upgrades at the Richmond WPCP and new pipelines to RARE, as shown in **Figure 6-5.** The proposed treatment layout, shown in **Figure 6-6**, includes split treatment using MBR for recycled water production and conventional activated sludge for the flows discharged to the Bay. The recycled water project ultimately was not the recommended master plan alternative due to the uncertainty in the need and economic feasibility of producing recycled water suitable for diversion to the District's RARE facility. In addition to the technical water quality and distribution issues, interagency coordination and financial support would be required. As stated in the 2016 Richmond Facility Plan, these challenges might be resolved when the need for recycled water becomes sufficiently critical. In the meantime, the City of Richmond can implement upgrades identified in the master plan; these upgrades would not preclude future recycled water delivery to the RARE facility. The District should engage with the City of Richmond on treatment plant upgrades as they progress, since the completion of upgrades (and their eventual performance) could have a major bearing on the timing for implementation of the recycled water project.

6.3.2 Additional Considerations

If the Richmond Refinery were to close in the future, the West County WPCP and Richmond WPCP effluent could provide advanced-treated water suitable for potable reuse in a number of ways, including reservoir water augmentation at Briones or San Pablo Reservoir, raw water augmentation at the Sobrante WTP; or treated water augmentation at the Wildcat Aqueduct. If groundwater augmentation is determined to be feasible in the area, it could be an additional potable reuse option. However, the combination of reduced demand in the Richmond area, and the location of the advanced-treated water in Richmond, would make it difficult to reach a large number of existing potable water customers without constructing significant new transmission pipelines. Converting the project from non-potable reuse to potable reuse would require significant additional investment, since very little infrastructure would be available for re-purposing (i.e., no conveyance and only a portion of the treatment system could be re-purposed).

Figure 6-5: Chevron Refinery/Richmond WPCP Pipeline to RARE

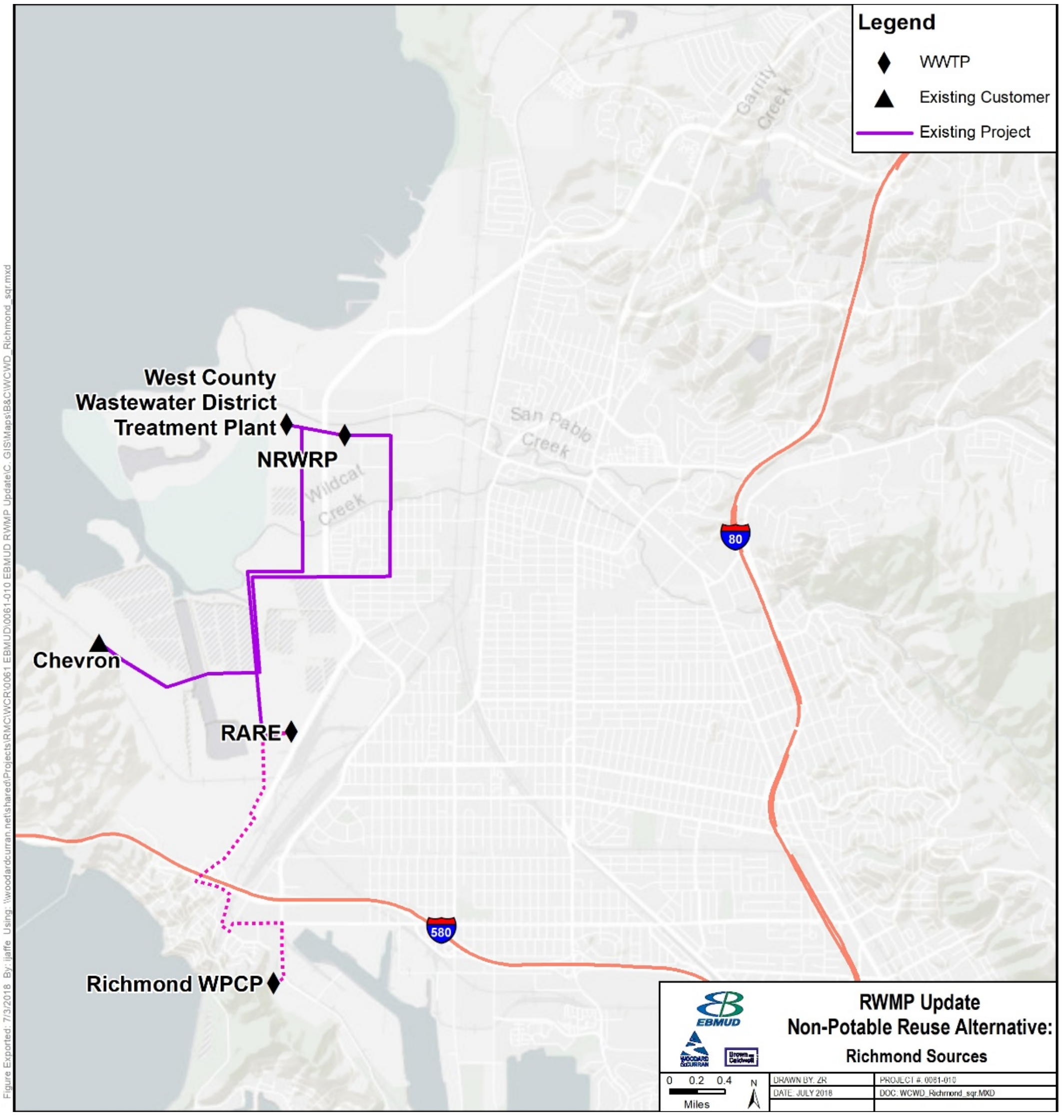
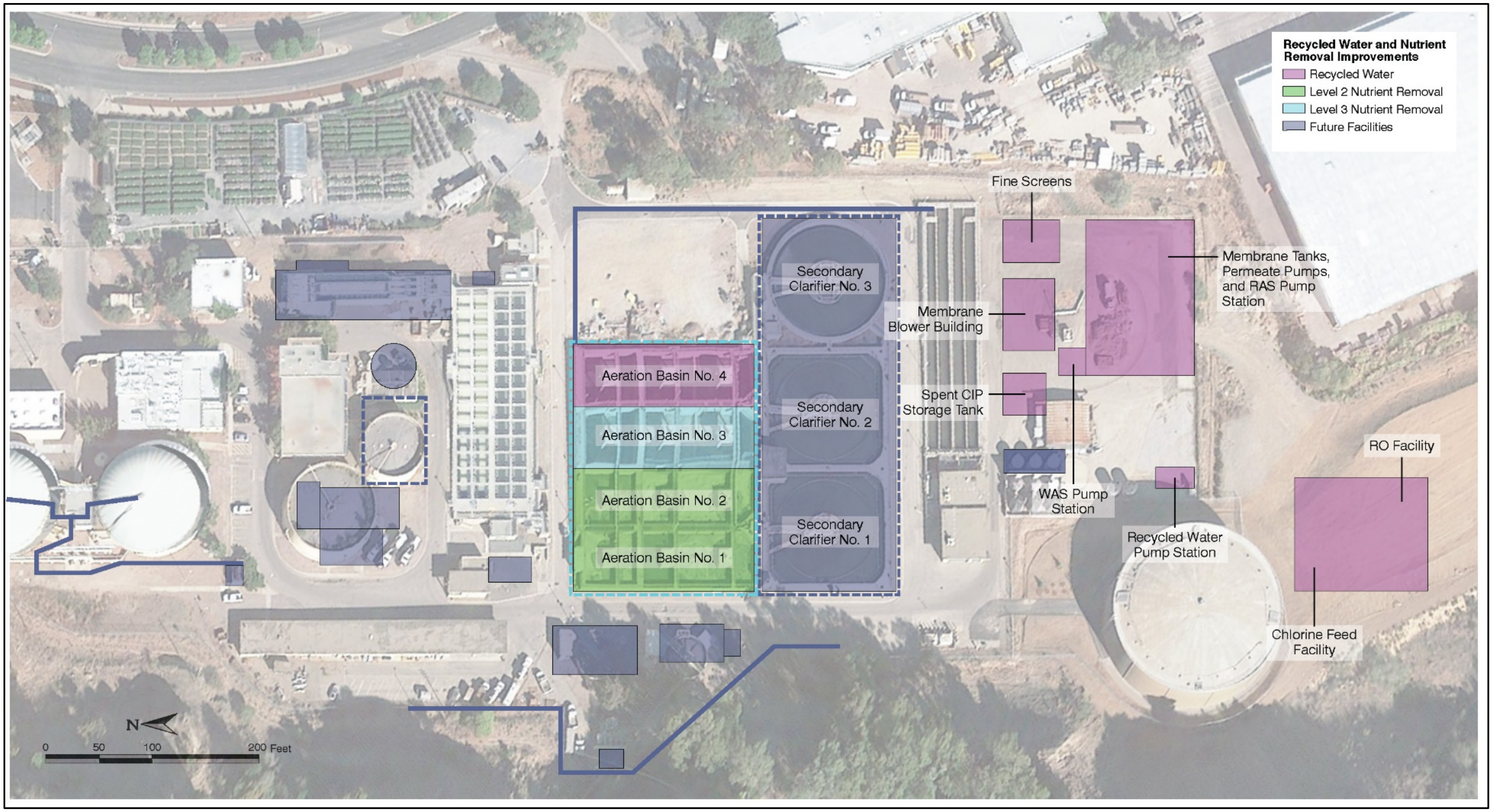


Figure 6-6: Chevron Refinery/Richmond WPCP Site Layout



Source: Adapted from (Carollo, 2016a), Figure 9.4. "Site Layout of Split Flow CAS/MBR Alternative"

6.4 Phillips 66 Refinery Recycled Water Project

6.4.1 Project Overview

The Phillips 66 Recycled Water Project is included as a recommended project because it would deliver a large amount of recycled water (up to 3.7 MGD) to a single customer, with comparatively few pipelines required due to the short distance between the sources of wastewater and the Phillips 66 Refinery.

The source of water for this project is the Pinole-Hercules WPCP (providing most of the supply) and Rodeo WPCF (providing a fraction of the supply). The combined supply is currently large enough to produce 1,340 gpm (1.9 MGD) for the boiler feed water treatment system. Remaining flow could be used to satisfy a portion of the cooling tower makeup water demand (i.e., 600 gpm or 0.86 MGD) for a total of 2.6 MGD or 2,912 AFY (Project Phase 1). In the future, if sufficient flows were available, the remaining cooling tower demand could be met (Project Phase 2). Cost estimates presented in this study include annual average recycled water delivery of up to 3.7 MGD (4,144 AFY).

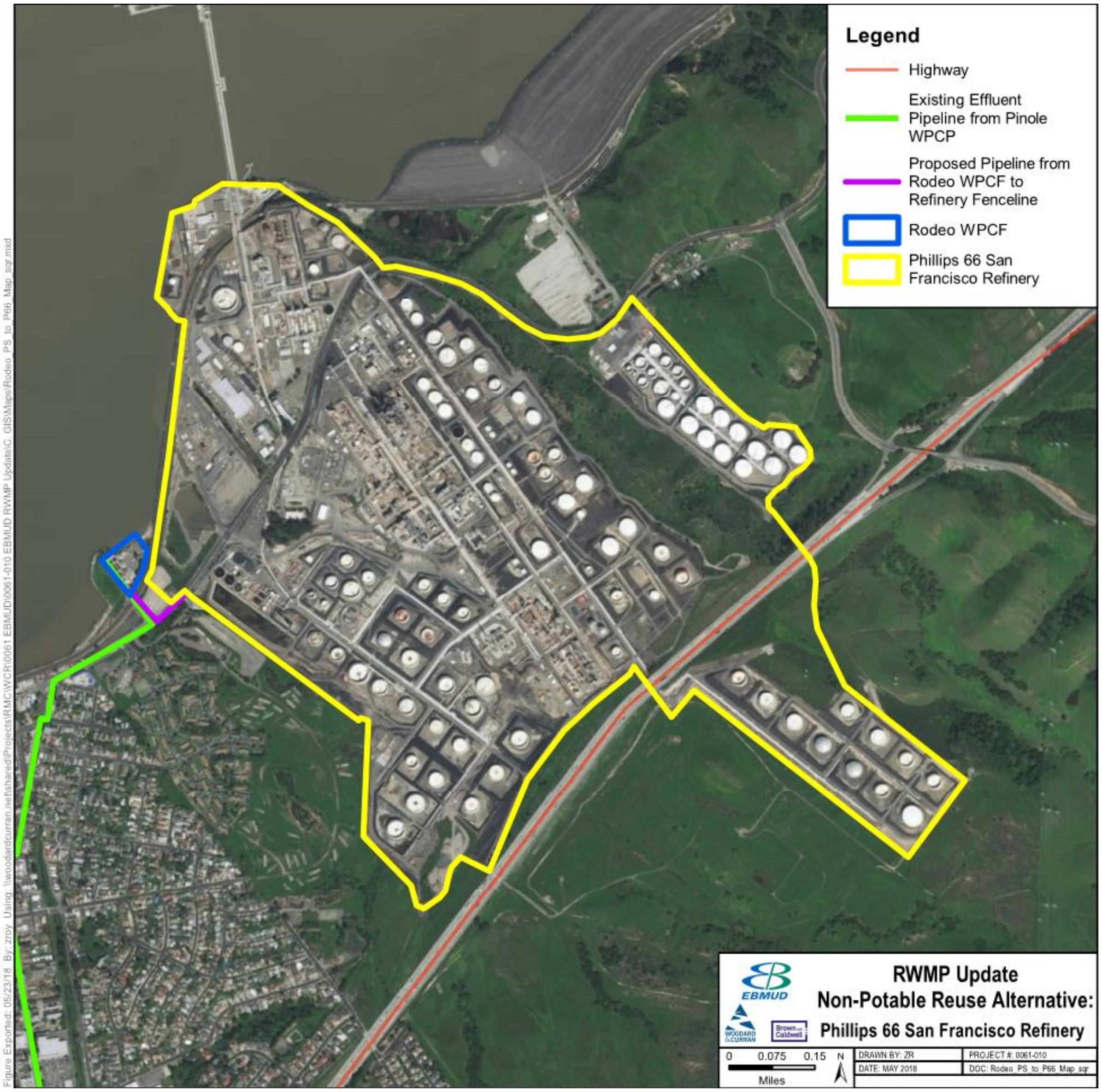
As shown in **Figure 6-7**, the combined final disinfected effluent from both treatment plants would be pumped at the Rodeo Pump Station to the refinery fence line for treatment. A new pipeline would be needed to convey treated effluent from the Rodeo Pump Station to the refinery fence line and an existing pipeline would be used to convey treated effluent from the fence line to new treatment facilities. This configuration was used to develop the cost estimates for the project. Alternatively, the treatment facilities could be constructed on a vacant lot immediately outside the refinery fence line, adjacent to the Rodeo WPCF.

The new treatment facilities include membrane filtration (MF), biological aerated filter (BAF), reverse osmosis (RO) and ultraviolet (UV) disinfection. **Figure 6-8** provides a process flow diagram for this alternative. An existing (1.2 MG) tank would be used for equalization. All flows would be filtered through the MF. Following the MF, a BAF and UV disinfection would provide ammonia removal and disinfection for the cooling tower makeup water. The RO system would treat the remaining portion of the MF filtrate to produce recycled water for the boiler pre-treatment system (RO followed by mixed bed demineralizers). RO permeate would be sufficient to feed directly to the demineralizers in place of potable water. The BAF/RO blend will provide a higher quality feed water to the existing RO system. From the treatment system, the recycled water would be routed to the process areas through existing pipelines, as feasible. Allowances for new pipe segments were included in the construction cost estimates. For the cooling tower makeup water, new pipe segments were assumed to be carbon steel. For the boiler feed water, new pipe segments were assumed to be stainless steel due to the corrosive nature of the RO permeate water.

Waste streams from the recycled water treatment facility (filter backwash and RO concentrate) would be ultimately discharged to the Bay via the Refinery's permitted outfall (NPDES Permit No. CA 0005053, Order No. R2-2016-0044). The MF/BAF backwash would be discharged to the refinery's sewer system and treated at the refinery's wastewater treatment plant prior to discharge to the refinery's deep-water outfall (Discharge Point No. 002). RO concentrate would be discharged through existing pipelines to the refinery's deep-water outfall. Chemical waste streams would be routed to the existing refinery waste stream via catch basins after neutralization.

The refinery's current NPDES permit specifies a procedure for adjustment of concentration-based and mass-based effluent limits to reflect the use of recycled water, which may contain increased pollutant concentrations compared to other sources. The permit may require further modification to account for loading from the reject waste streams. Ultimately, the refinery may need to perform additional monitoring, testing and evaluations to confirm permit compliance, in particular for effluent toxicity.

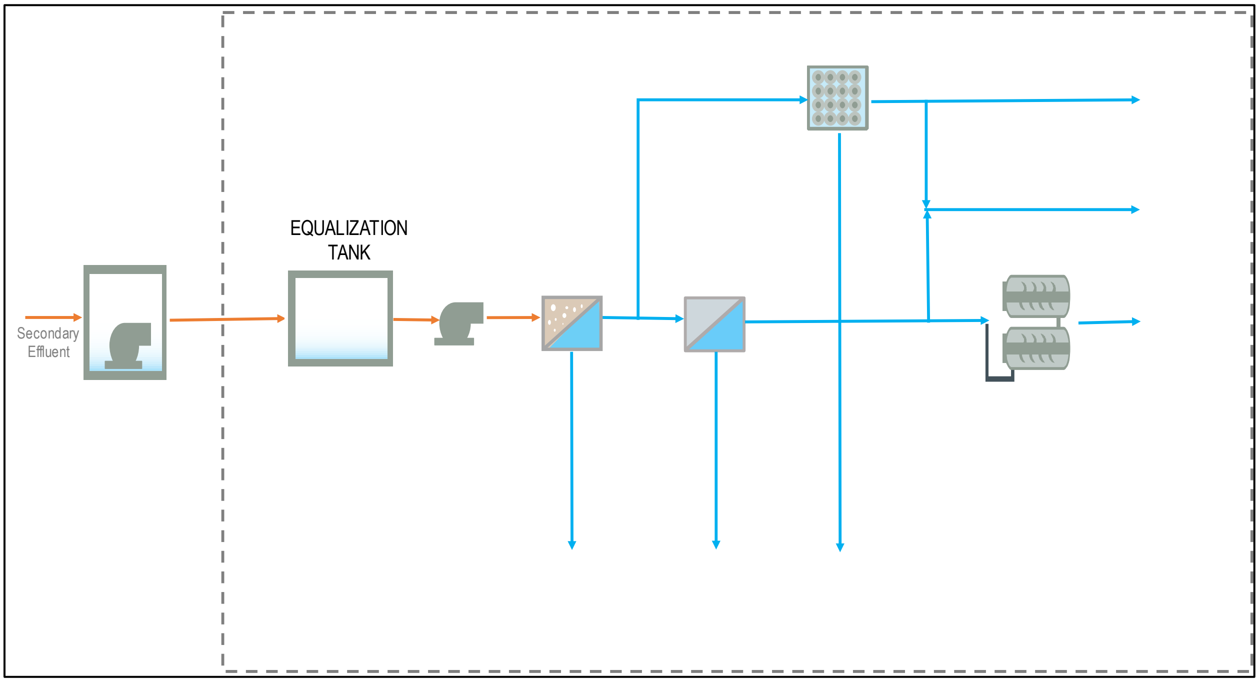
Figure 6-7: P66 Refinery Alternative Site Location



6.4.2 Additional Considerations

Funding and implementation of this project could be complex because the treatment plant would be located on Refinery property. In addition, the location of the treatment plant within the refinery would likely make it difficult to adapt the treatment train for potable reuse. The project does not include any major conveyance infrastructure that could be repurposed for potable reuse (indeed, the short pipeline length is the major driver for the project's comparatively low cost), but the treated wastewater from Rodeo WPCF and/or Pinole-Hercules WPCP could be used for a potable reuse project as described in Section 4.

Figure 6-8: Phillips 66 Refinery Alternative Process Flow Diagram



Recovery Rates: 90 percent MF, 85 percent RO and 95 percent BAF.

6.5 Cost of Recommended Projects

Estimated capital and operating costs for the recommended project list are shown below in **Table 6-1.** Satellite treatment at Diablo Country Club is not included in the cost summary because it is expected to go forward under a self-financing model. More detailed cost estimates are included in **Appendix A.**

Table 6-1: Capital and O&M Costs of Recommended Projects

Project	Yield (AFY)	Capital Cost ($M)	O&M ($M/yr)
DERWA/San Ramon Phase 3	800	25	0.49
DERWA/San Ramon Phase 5	300	8.1	0.15
P66 Rodeo Refinery	4,100	53	2.1
DERWA/San Ramon Phase 4	300	17	0.18
East Bayshore. Phase 2	2,900	130	2.9
Chevron/Richmond	4,300	110	5.7
Total	**12,700 AFY**	**$ 343 M**	**$ 11.5 M/yr**

6.6 Future Potable Reuse Consideration

Due to the large capital costs and the current availability of alternate potable water sources, potable reuse is not recommended in the near-term but may become more favorable in the next 10-20 years as secondary wastewater treatment upgrades are implemented, advanced-treatment costs come down, and the need for water supply increases.

Potable reuse will only be cost effective when it is implemented as a large project operated in all years, not as a marginal water supply alternative operated only in dry years.

Nearly all of the alternatives for potable reuse evaluated in this report would require secondary treatment upgrades for nutrient removal as a precursor to advanced treatment. As stated previously, BACWA recently completed a Nutrient Reduction Study to quantify opportunities for removing nutrients from wastewater discharged to San Francisco Bay, either through optimizing existing operations or upgrading treatment plants (BACWA, 2018). The study provided cost estimates for upgrading each of the 37 municipal wastewater treatment plants in the Bay Area to achieve an annual or seasonal average total nitrogen concentration below 15 mg/L (corresponding to "Level 2" nitrogen removal). Of the alternatives listed below in **Table 6-2**, Oro Loma WPCP has the lowest cost for Level 2 nitrogen removal per unit of water available for potable reuse (present value of $56M for 8 MGD of potable reuse), while SD-1 has the highest cost (present value $2.6B for 30 MGD of potable reuse).

The timing for the nutrient regulations and associated upgrades is uncertain but is expected to be at least 10 years away (2029). Therefore, potable reuse should be revaluated during the planning and design of the WWTP upgrades. Furthermore, by including beneficial reuse of WWTP effluent, the projects may be eligible for greater funding opportunities through state and federal grant and loan programs.

The most promising potable reuse alternatives are listed below in **Table 6-2** and discussed in greater detail following the table, as a starting point for future consideration. Several of the projects were evaluated at different sizes (i.e., 10 MGD and 30 MGD) to evaluate the potential for economy of scale.

Table 6-2: Highest Ranking, Lowest Cost Potable Reuse Alternatives

Project	Yield (AFY)	Unit Cost ($/AF)	Dry Year Unit Cost ($//AF)	Capital Cost ($M)
Reservoir Augmentation				
SD-1 to Briones Reservoir, 10 MGD	11,200	3,900	12,000	510
SD-1 to Briones Reservoir, 30 MGD	33,600	2,500	7,300	690
Oro Loma to USL Reservoir, 8 MGD	8,960	2,800	8,600	230
Raw Water Augmentation				
CCCSD to Mokelumne Aqueduct, 10 MGD	11,200	2,300	6,500	180
CCCSD to Mokelumne Aqueduct, 19 MGD	21,820	2,200	6,300	310
Treated Water Augmentation				
SD-1 to Claremont Center, 10 MGD	11,200	3,400	9,800	360
SD-1 to Claremont Center, 30 MGD	33,600	2,300	6,700	480

6.6.1 Surface Water Augmentation at Briones Reservoir from SD-1

Reservoir augmentation to Briones Reservoir is identified as a promising alternative for future consideration because of three main factors:

- Briones Reservoir is a more suitable site for reservoir augmentation than other District reservoirs (Upper San Leandro and San Pablo Reservoirs) because it has a large volume and a small watershed. As a result, Briones Reservoir can accept a large amount of advanced-treated water while complying with the state's newly crafted regulations for reservoir augmentation.

- Use of Briones Reservoir for reservoir augmentation is more equitable than similar projects at Upper San Leandro and San Pablo Reservoirs, which serve a smaller portion of the District's water customers.

- A large amount of water is potentially available from SD-1, although the future quality of the treated wastewater is uncertain. If SD-1 is upgraded to provide nutrient removal for the full plant flow, the effluent would become more suitable for potable reuse. Without these full-plant upgrades, a separate split treatment system (such as an MBR) would be required to treat a portion of the flow.

A project from SD-1 to Briones Reservoir could be relatively large, nearing the full capacity of SD-1. The need for water, and continued operation of Resource Recovery at SD-1 are expected to govern the sizing. Reservoir capacity is not a limiting factor.

6.6.2 Reservoir Water Augmentation at Upper San Leandro from Oro Loma WPCP

Reservoir augmentation from Oro Loma WPCP to Upper San Leandro Reservoir is identified as a promising alternative for future consideration primarily because of the large treatment facility site in comparison to SD-1, which is a highly constrained site. In addition, Oro Loma Sanitary District is already moving forward with secondary treatment upgrades for nutrient removal that are expected produce a secondary effluent quality appropriate for advanced treatment. These factors also contribute to a relatively high score for groundwater augmentation using Oro Loma WPCP, but the difficulty of using the groundwater near the extraction site lead to a relatively lower score compared to reservoir augmentation. RO concentrate disposal is not likely to pose a challenge, as the RO concentrate would be combined with other wastewater prior to being discharged through the EBDA deep water outfall.

6.6.3 Raw Water Augmentation of Mokelumne Aqueduct from CCCSD WWTP

Raw water augmentation from CCCSD WWTP to the Mokelumne Aqueduct is identified as a promising alternative for future consideration because of two main factors:

- It is an equitable project, because the advanced-treated water would enter the District's raw water system at a point where it could reach the largest possible number of the District's water customers (i.e., all of them), and

- It requires a relatively small investment in pipelines, since the CCCSD plant is located close to the Mokelumne Aqueduct in North Concord. This short pipeline alignment results in lower capital costs and environmental impacts. After entering the Mokelumne Aqueduct, the water would be conveyed to Walnut Creek WTP, Orinda WTP, or a surface water reservoir before undergoing further treatment and entering the treated water system.

CCCSD is actively pursuing other end uses for recycled water, including serving the Martinez refineries (as discussed in Section 3.3.11), which are likely to be more cost-effective than potable reuse in the near term. However, potable reuse could ultimately replace the refinery recycled water project if the refineries no longer needed the water in the future.

This project is best sized at less than the full capacity of the CCCSD plant, as RO concentrate disposal is likely to pose a challenge if the full flow is used.

6.6.4 Treated Water Augmentation at Claremont Center from SD-1

Treated water augmentation from SD-1 to Claremont Center is identified as a promising alternative because of two main factors:

- It is an equitable project compared to other treated water augmentation sources such as Richmond WPCP, Oro Loma WPCP, or West County WPCP, since the advanced-treated water would be distributed widely to West-of-Hills water customers.
- It requires the least investment in pipeline infrastructure than any other comparably sized project originating at SD-1. Claremont Center is the closest location that a large amount (~30 MGD) of water could be added to the distribution system. Smaller amounts of water could be added to the distribution system closer to SD-1 but would reach a smaller array of water customers.

The major drawback of this alternative are site constraints at SD-1.

7. IMPLEMENTATION PLAN

7.1 Project Phasing

Phasing for implementation of the recommended project list is shown below in **Table 7-1**.

Table 7-1: Phasing for Recommended Projects

Project	Yield (AFY)	Construction Period	Year Online	Implementation Notes
DCC Satellite Project	250	2019-2020	2020	RFP for Design-Build expected in mid-2018.
DERWA Phase 3	800	2024-2025	2025	Requires supplemental supply
DERWA Phase 5	300	2028-2029	2030	Requires supplemental supply
P66 Rodeo Refinery	4,100	2025-2030	2030+	Funding agreements with P66 Refinery are critical path. Insufficient water is available in the near term; assumes 2.6 MGD in 2030 and expansion to 3.7 MGD by 2040.
DERWA Phase 4	300	2033-2034	2034	Requires supplemental supply
East Bayshore Phase 2	2,900	2030-2035	2035	Significant capital investment required and customer outreach needed for implementation.
Chevron/Richmond	4,300	2035-2040	2040	Plant upgrades at Richmond WPCP are primary constraint.

DCC Satellite Project. This project is listed first because it is expected to be completed by 2020; an RFP for design and construction is expected in 2018. The project is proceeding under a self-financing model, and the schedule is not under District control.

DERWA Phase 3 and 5. The DERWA Phase 3 and Phase 5 expansions are listed as the first District-funded project in Table 6-1 because it is an expansion of an existing project, and because the recycled water is available on a first-come, first-serve basis. Total DERWA deliveries would expand from current deliveries of up to 0.8 MGD (existing Phase 1 and 2B) to 1.3 MGD (with Phase 2A implementation) in 2020 to about 2.3 MGD (with implementation of Phases 3 and 5) in 2030.

Phillips 66. The Phillips 66 project is listed second for implementation, to be implemented in two phases. Due to supply limitations, it is assumed that the Phillips 66 project will deliver 2.6 MGD of recycled water in 2030 and up to 3.7 MGD by 2040. Although the Phillips 66 project is not indicated for completion until after 2030, there are several tasks to complete in the intervening years, including re-initiating discussions with Phillips 66, confirming recycled water demands and recycled water quality requirements, and confirming supply from Pinole-Hercules WPCP and Rodeo WPCF.

DERWA Phase 4. The DERWA Phase 4 expansion would bring total DERWA deliveries to 2.5 MGD by 2034. This phase is listed after Phase 3 and Phase 5 because it is more expensive on a unit cost basis.

East Bayshore. The District's East Bayshore project currently delivers approximately 0.2 MGD (existing Phase 1A). With additional customer outreach, deliveries are expected to increase by an additional 0.2 MGD by 2025. Significant capital investment and customer outreach is necessary to connect recycled water demands of 2.6 MGD (Phase 2) by 2035. Even though the East Bayshore project is shown with a later start date for construction (2030), the District can begin customer outreach and implement strategies to maximize existing assets. For example, the District could improve water quality at East Bayshore through treatment upgrades to deliver recycled water to more customers with minimal pipeline expansion. In the short-term, before treatment upgrades are constructed to address chloride water quality objectives, the District could extend select pipeline networks to serve irrigation customers that do not require significant water quality improvements.

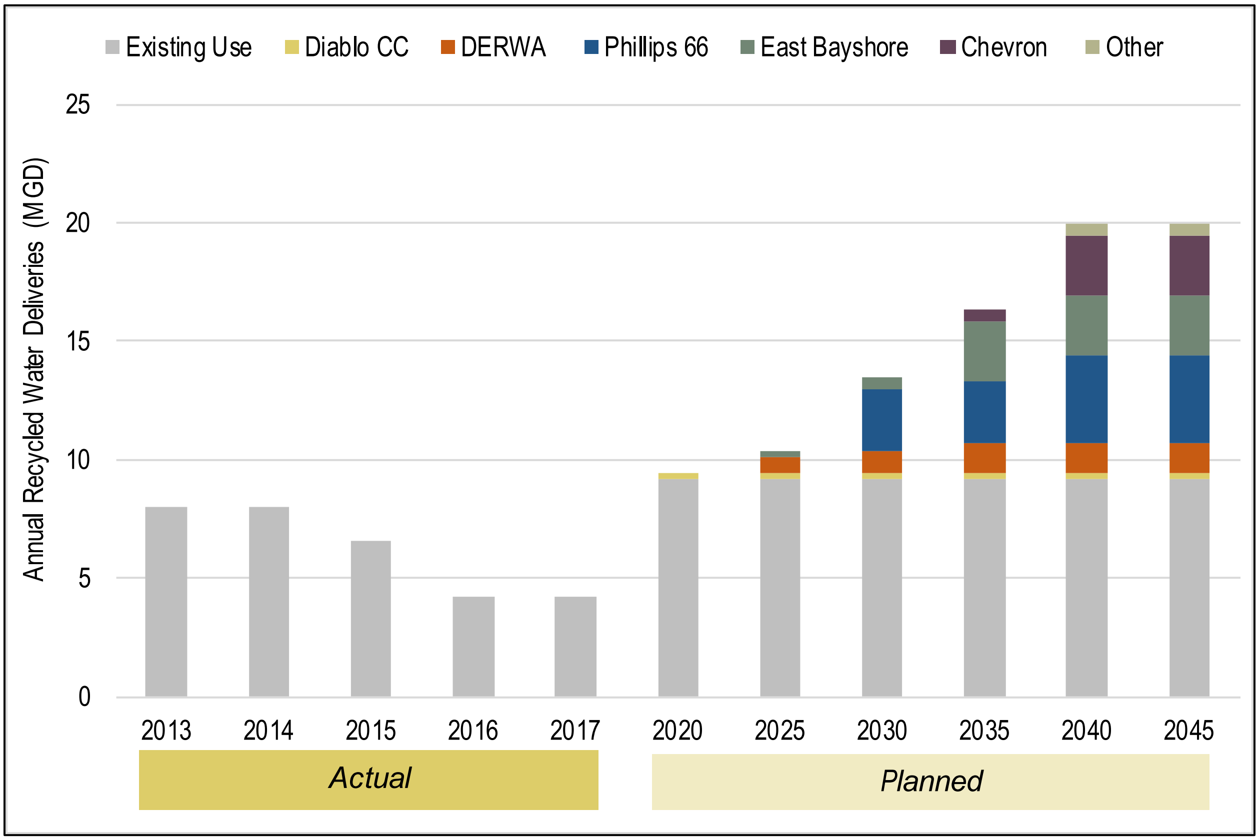
Chevron Richmond. The proposed expansion of recycled water service to Chevron Richmond Refinery could begin by 2035. Treatment upgrades required for this recycled water project are not included in the City of Richmond's CIP. The City of Richmond is preparing for treatment upgrades that align with its long-term master plan based on current understanding of anticipated nutrient regulations. It is assumed that the recycled water project could be implemented following Level 2 nutrient upgrades (i.e., ammonia limit of 2 mg/L, total nitrogen limit of 15 mg/L) within the next 20 years. This regulatory uncertainty is the reason why this project is listed last for implementation. Nonetheless, it is recommended that the District initiate discussions with the City of Richmond to confirm timing for treatment and collection system upgrades and interest in producing recycled water for the RARE facility.

Projected recycled water deliveries for the recommended projects are shown in **Figure 7-1** for the planning horizon (2020 to 2045). Recent deliveries over the period 2013-2017 are also shown for reference. In 2016 and 2017, recycled water deliveries were significantly impacted by water supply and quality. The District's NRWRP experienced interruption of influent supply from West County due to construction shutdown. Therefore, the District had to supplement Chevron Richmond Refinery with potable water. The District's RARE recycled water demand was also supplemented with potable water due to water supply and quality issues.

In **Figure 7-1**, deliveries in 2020 include an "Existing Use" category equal to 9.2 MGD. This reflects the full capacity of each existing recycled water project, as listed in **Table 3-1**, plus an additional 0.5 MGD of capacity expected upon completion of DERWA / San Ramon Valley Phase 2A. This approach is consistent with the goal of fully utilizing all available recycled water through increased customer outreach. The "existing use" category includes 0.2 MGD of deliveries from the San Leandro WRP, even though the recycled water facility has not been operating in recent years (see Section 3.3.3 for additional details).

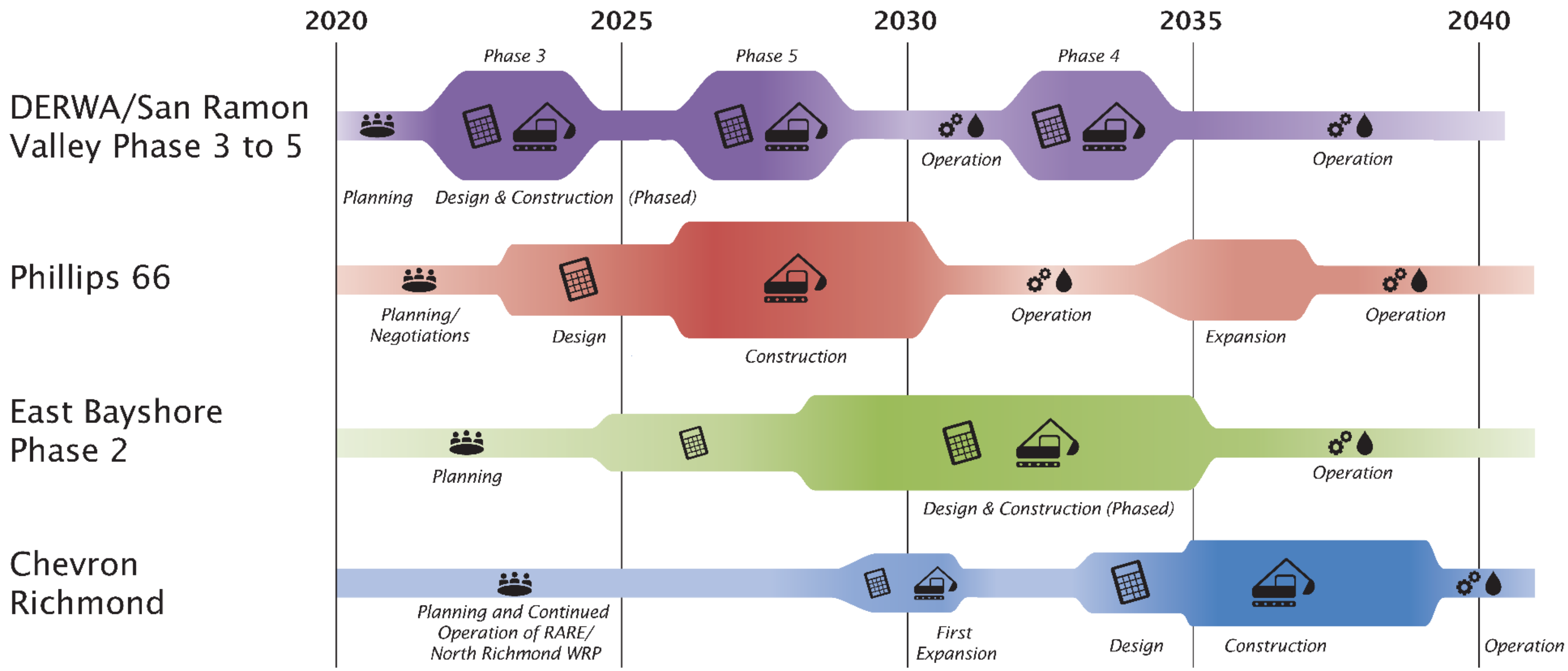
The total planned 2040 recycled water deliveries add up to 19.5 MGD, which is slightly below the goal of 20 MGD. This highlights the importance of customer outreach and project development to confirm the technical and economic feasibility of the recommended projects.

Figure 7-1: Planned Recycled Water Deliveries from Recommended Project List



The effort required to implement the projects according to the proposed timeline in **Figure 7-1** is illustrated on the next page in **Figure 7-2.** The cost and effort for the two most expensive projects in the portfolio (East Bayshore and Chevron) are borne in the last 10 years of the planning period (2030-2040) rather than in the first 10 years.

Figure 7-2: Proposed Phasing of Recommended Projects



7.2 Institutional Needs and Customer Outreach

With exception of East Bayshore which would be sourced from SD-1, the other recommended projects require institutional arrangements with other wastewater providers to secure effluent for recycled water treatment and beneficial use. The East Bayshore Project has sufficient supplies for any build-out scenario, including the recommended Phase 2, and the supply from SD1 is secured.

DSRSD and the District currently work together under the DERWA Joint Powers Authority. By using operational storage in Tassajara Reservoir, the San Ramon Valley Recycled Water Project met summer demands in 2018 without the addition of potable water on peak days. However, further expansion of the San Ramon Valley Project will require supplemental supplies to meet peak summer demands due to reduced wastewater flows from water conservation practices. The District should work to secure supplies including the use of groundwater to meet peaking demands; diverting wastewater flows from Central Contra Costa Sanitary District into the DSRSD system; and engaging with the City of Livermore to discuss supply opportunities. In addition, the District should continue public and developer outreach in the region to promote the use of recycled water.

A future Chevron recycled water expansion could use up to an additional 3 MGD of recycled water. The Richmond WPCP has sufficient dry weather flow (4.4 MGD) to meet this demand. Since the District is the water purveyor in the area, the City of Richmond does not have the legal authority to purvey water unless approved by the District. Also, the City would benefit from a potential partnership with the District that would reduce treated wastewater discharge to the bay. In addition, the refinery's effluent could also be a supply.

The Phillips 66 refinery has sufficient demand (3.7 MGD) to utilize all of the available wastewater flow from the Pinole-Hercules WPCP and the Rodeo WPCF (approximately 2.7 MGD combined). The District is the water purveyor for the Pinole, Hercules, and Rodeo vicinity and the wastewater agencies do not have the legal authority to purvey water without the District's approval. The wastewater agencies would benefit from a partnership with the District that would reduce their treated wastewater discharge to the bay. The District should begin planning level evaluations now, including working with the wastewater agencies to evaluate long-term wastewater trends. Between 2005 and 2015 wastewater flows decreased by about 25%, with a portion of that reduction likely the result of water conservation practices.

7.3 Funding Opportunities

Typically, recycled water projects are financed through a combination of grants, partnerships with project beneficiaries, and at times, the Clean Water State Revolving Fund (CWSRF). Federal, state and regional funding sources are available to help implement recycled water projects. These potential funding sources include:

- **USBR Title XVI Water Reuse Grant Program**. This federal grant program provides funding for 25% of a project's capital cost, up to $20M. To receive funding, projects must be authorized by Congress. None of the recommended projects in the Master Plan are currently authorized under the Title XVI program.

- **USBR Water Infrastructure Improvement for the Nation (WIIN)**. Under the WIIN Act, USBR is providing a new funding opportunity for Title XVI water recycling projects. Unlike other Title XVI funding opportunities, projects do not need authorization by Congress to be eligible for WIIN. The opportunity may provide up to 25% of the total cost of planning, design and/or construction, up to $20M. Applications for the latest round of funding were due in July 2018 and future rounds of WIIN funding are anticipated.

- **SWRCB Water Recycling Funding Program (WRFP) Construction Grants**. This state grant program provides funding for 35% of a project's construction costs, up to $15M. WRFP grants are currently oversubscribed, but it is anticipated that interest groups and legislators will work to secure provide additional funding through a new water bond.

- **SWRCB Clean Water State Revolving Fund Loan (CWSRF) Program**. This state loan program provides low-interest loans (half of the General Obligation bond) for water quality infrastructure projects. This program is currently oversubscribed, and the SWRCB is holding workshops to discuss potential changes to the program and solicit input on funding priorities.

- **DWR Integrated Regional Water Management (IRWM) Program**. This state grant program provides funding for implementation of projects that are coordinated at a regional level. The recommended Master Plan projects are within the San Francisco Bay Area IRWM region, which has supported construction of the East Bayshore and the DERWA/San Ramon Valley recycled water projects. The current funding source for IRWM program is Proposition 1, which had the first round of solicitation for implementation projects in summer of 2018 and is expected to have a second round in 2019. Phase 3 of the DERWA/San Ramon Valley project is the most eligible among the recommended Master Plan projects for this funding source, which prioritizes construction-ready projects.

The funding opportunities listed above are available to public water and wastewater agencies to fund projects with public benefits such as reduction of wastewater discharges or potable water offsets. While the refinery projects serve a single private entity, the projects may be eligible for grant funding if owned and operated by the District or another partner public agency.

Costs were summarized as part of Section 6, with unit cost for water for the recommended projects ranging from $3,600-$7,500/AF. As projects move forward and grants and loans become available to the District, rates and charges will be refined.

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APPENDIX A: COST ESTIMATE DETAILS FOR NON-POTABLE REUSE ALTERNATIVES

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DERWA/San Ramon Valley Recycled Water Project Phase 3 Cost Update

EBMUD Recycled Water Master Plan Update

Last Updated:	1-Nov-18	Discount Rate	Project Life
Updated by:	C. De Las Casas	3%	30 Years

Original Project Information

Project Source:	DERWA/SRVRWP Treatment and Distribution Costs (September 2018)		
Project Source CCI Date:	September 2018	Project Source Location:	San Francisco Area
Project Source 20-Cities Avg ENR CCI:	11,170	Location Multiplier:	1.00
December 2017 20-Cities Avg ENR CCI:	10,870	Historical Multiplier:	0.97

Item	Size	Qty	Unit	Original Project Cost	Adjusted Project Cost	Useful Life	Salvage Value
Capital Costs							
Treatment							
DERWA Treatment/Supplemental Supply (EBMUD Share)		1	LS	$ 2,200,000	$2,141,000	35 yrs	$310,000
Conveyance							
SRVRWP Distribution (2.8 miles completed)		14,784 LF		$ 2,600,000	$2,600,000	75 yrs	$1,600,000
SRVRWP Distribution (3 miles to be completed)		15,840 LF		$ 14,330,000	$13,945,000	75 yrs	$8,400,000
Pump Station							
Pump Station (R3000)				$ 6,958,000	$6,771,000	50 yrs	$2,700,000
Estimated Total Construction Cost including Implementation and Contingency					**$25,000,000**		**$13,000,000**
					Present Worth of Salvage Value		**$5,300,000**
O&M Costs (Annual)							
General O&M							
Treatment Share			yr	$ 350,000	$340,000		
Distribution Share			yr	$ 135,000	$130,000		
Pump Stations							
Labor Costs		0	hrs	$ 135	$0		
Electricity	100,515	kWh	kWh/yr	$ 0.15	$15,000		
Pump Station Consumables		5% of pump station construction cost			$0		
			Total O&M Costs ($/yr)		$490,000		

Annualized Costs ($ / Year)			
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*	$1,300,000	
Annualized Salvage Value	*Annualized value of present worth*	-$270,000	
Annual O&M Costs		$490,000	
Total Annualized Cost		$1,500,000	
Deliveries of Recycled Water	800 AFY		
Estimated Unit Cost ($/AF)		**$1,900**	
Breakdown of Estimated Unit Cost ($/AF)	**Treatment $550**	**Distribution $1,350**	
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***		
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*	$1,300,000	*Same as constant use.*
Annualized Salvage Value	*Annualized value of present worth*	-$270,000	*Same as constant use.*
Annual O&M Costs		$474,500	
Total Annualized Cost		$1,500,000	
Annual Average Deliveries of Recycled Wate	240 AFY		
Estimated Unit Cost ($/AF)		**$6,300**	
Breakdown of Estimated Unit Cost ($/AF)	**Treatment $1,800**	**Distribution $4,500**	

DERWA/San Ramon Valley Recycled Water Project Phase 5 Cost Update						EBMUD Recycled Water Master Plan Update		
Last Updated:	1-Nov-18				Discount Rate		Project Life	
Updated by:	C. De Las Casas				3%		30 Years	
Original Project Information								
Project Source:		EBMUD/DERWA						
Project Source CCI Date:		September 2018				Project Source Location:	San Francisco Area	
Project Source 20-Cities Avg ENR CCI:		11,170				Location Multiplier:	1.00	
December 2017 20-Cities Avg ENR CCI:		10,870				Historical Multiplier:	0.97	

Item	Size	Qty	Unit	Original Project Cost	Adjusted Project Cost	Useful Life	Salvage Value
Capital Costs							
Treatment							
DERWA Treatment/Supplemental Supply (EBMUD Share)		1	LS	$ 4,100,000	$3,989,800	35 yrs	$570,000
Conveyance							
SRVRWP Distribution (2.8 miles to be completed)		14,784 LF		$ 4,226,800	$4,113,198	75 yrs	$2,500,000
Estimated Total Construction Cost including Implementation and Contingency					**$8,100,000**		**$3,100,000**
					Present Worth of Salvage Value		**$1,300,000**
O&M Costs (Annual)							
General O&M							
Treatment Share			yr	$ 130,000	$126,500		
Distribution Share			yr	$ 20,000	$19,500		
			Total O&M Costs ($/yr)		$150,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$410,000		
Annualized Salvage Value	*Annualized value of present worth*				-$66,000		
Annual O&M Costs					$150,000		
Total Annualized Cost					$490,000		
Deliveries of Recycled Water	300 AFY						
Estimated Unit Cost ($/AF)					**$1,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,000**	**Distribution**	**$600**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$410,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$66,000	*Same as constant use.*	
Annual O&M Costs					$146,000		
Total Annualized Cost					$490,000		
Annual Average Deliveries of Recycled Water	90 AFY						
Estimated Unit Cost ($/AF)					**$5,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$3,400**	**Distribution**	**$2,000**		

DERWA/San Ramon Valley Recycled Water Project Phase 4 Cost Update					EBMUD Recycled Water Master Plan Update		
Last Updated:	1-Nov-18				Discount Rate		Project Life
Updated by:	C. De Las Casas				3%		30 Years
Original Project Information							
Project Source:	EBMUD/DERWA						
Project Source CCI Date:	September 2018				Project Source Location:		San Francisco Area
Project Source 20-Cities Avg ENR CCI:	11,170				Location Multiplier:		1.00
December 2017 20-Cities Avg ENR CCI:	10,870				Historical Multiplier:		0.97
Item	**Size**	**Qty**	**Unit**	**Original Project Cost**	**Adjusted Project Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment							
DERWA Treatment Plant Expansion (EBMUD Share)		1	LS	$2,500,000	$2,433,000	35 yrs	$350,000
Conveyance							
SRVRWP Distribution (1.4 miles to be completed)		7,392 LF		$ 9,606,000	$9,348,000	75 yrs	$5,600,000
Pump Station							
Pump Station (4000)		1	LS	$ 5,787,000	$5,631,000	50 yrs	$2,300,000
Estimated Total Construction Cost including Implementation and Contingency					**$17,000,000**		**$8,300,000**
					Present Worth of Salvage Value		**$3,400,000**
O&M Costs (Annual)							
General O&M							
Treatment Share			yr	$ 130,000	$127,000		
Distribution Share			yr	$ 50,000	$49,000		
			Total O&M Costs ($/yr)		$180,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$860,000		
Annualized Salvage Value	*Annualized value of present worth*				-$170,000		
Annual O&M Costs					$180,000		
Total Annualized Cost					$870,000		
Deliveries of Recycled Water	300 AFY						
Estimated Unit Cost ($/AF)					**$2,900**		
Breakdown of Estimated Unit Cost ($/AF)	**Treatment**	**$400**		**Distribution**	**$2,500**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$860,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$170,000	*Same as constant use.*	
Annual O&M Costs					$176,000		
Total Annualized Cost					$870,000		
Annual Average Deliveries of Recycled Wat	90 AFY						
Estimated Unit Cost ($/AF)					**$9,700**		
Breakdown of Estimated Unit Cost ($/AF)	**Treatment**	**$1,200**		**Distribution**	**$8,500**		

East Bayshore Recycled Water Project Phase 1A					EBMUD Recycled Water Master Plan Update		
Last Updated:	5-Dec-18				Discount Rate		Project Life
Updated by:	M. Romero				3%		30 Years
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
RO and MF System (0.77MGD Max Month)	0.77		MGD	$ 2,031,451	$2,000,000	35 yrs	$290,000
IX System	0.77		MGD	$ 421,757	$400,000	35 yrs	$57,000
Electrical	1		LS	$ 258,886	$260,000	35 yrs	$37,000
Sitework	1		LS	$ 466,323	$470,000	35 yrs	$67,000
			Raw Construction Cost Subtotal		**$3,100,000**		**$450,000**
Contractor Overhead & Profit				15%	$470,000		$68,000
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$140,000		$20,000
		Estimated Installed Equipment Cost for Treatment			**$3,700,000**		**$540,000**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$3,700,000**		**$540,000**
Estimating Contingency				25%	$930,000		$140,000
		Estimated Subtotal Cost including Contingency			**$4,600,000**		**$680,000**
Capital Costs							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
High-Density Urban Pipeline	12-in	4,000 LF	in-LF	$ 50	$2,400,000	75 yrs	$1,400,000
High-Density Urban Pipeline	16-in	3,000 LF	in-LF	$ 50	$2,400,000	75 yrs	$1,400,000
Irrigation Customer Connection Costs		6	EA	$ 100,000	$600,000	75 yrs	$360,000
Industrial Customer Connection Costs		8	EA	$ 200,000	$1,600,000	75 yrs	$960,000
Extra pipeline allowance for industrial customers		8	EA	$ 50,000	$400,000	75 yrs	$240,000
		Estimated Subtotal Cost (2) including Contingency			**$7,400,000**		**$4,400,000**
Mobilization							
Estimated Subtotal Construction Cost including Contingency					**$12,000,000**		**$5,100,000**
Mobilization				5%	$600,000		
Estimated Subtotal Construction Cost including Contingency and Mobilization					$12,600,000		$5,100,000
Implementation							
Planning / Environmental				5%	$630,000		
Design Cost				15%	$1,900,000		
Project Administration and Construction Management Cost				10%	$1,300,000		
Estimated Total Construction Cost including Implementation and Contingency					**$16,430,000**		**$5,100,000**
					Present Worth of Salvage Value		**$2,100,000**
O&M Costs (Annual)							
Recycled Water Treatment							
RO Electricity	0.44	615,805	kWh/yr	$ 0.15	$92,400		
IX Electricity	0.44	107,861	kWh/yr	$ 0.15	$16,200		
Chemicals	0.44		MGD	$ 33,843	$33,800		
Replacement Costs	0.77		MGD	$ 68,638	$68,600		
Labor	1.0	1,040	hrs/MGD	$ 135	$140,400		
Conveyance							
Annual O&M			2% of construction cost		$148,000		
			Total O&M Costs ($/yr)		$499,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$830,000		
Annualized Salvage Value	*Annualized value of present worth*				-$110,000		
Annual O&M Costs					$499,000		
Total Annualized Cost					$1,200,000		
Deliveries of Recycled Water	493 AFY						
Estimated Unit Cost ($/AF)					**$2,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,300**	**Distribution**	**$1,100**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$830,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$110,000	*Same as constant use.*	
Annual O&M Costs					$389,580		
Total Annualized Cost					$1,100,000		
Annual Average Deliveries of Recycled Water	148 AFY						
Estimated Unit Cost ($/AF)					**$7,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$3,700**	**Distribution**	**$3,700**		

East Bayshore Recycled Water Project Phase 1B					EBMUD Recycled Water Master Plan Update		
Last Updated:	5-Dec-18				Discount Rate		Project Life
Updated by:	M. Romero				3%		30 Years
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MBR System 1.6 MGD (Max Month) capacity	1.6		MGD	$ 3,098,474	$3,100,000	35 yrs	$440,000
Diversion Pump Station	1.6		MGD	$ 1,300,000	$1,300,000	50 yrs	$520,000
Electrical Allowance	1		MGD	$ 485,487	$490,000	35 yrs	$70,000
Sitework	1		LS	$ 1,471,949	$1,470,000	35 yrs	$210,000
Chemicals (Storage and Use)	1		LS	$ 32,789	$33,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$6,400,000**		**$1,200,000**
Contractor Overhead & Profit				15%	$960,000		$180,000
Sales Tax	**50%**	% of Subtotal Cost Applicable		9%	$290,000		$54,000
			Estimated Installed Equipment Cost for Treatment		**$7,700,000**		**$1,400,000**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$7,700,000**		**$1,400,000**
Estimating Contingency				25%	$1,900,000		$350,000
			Estimated Subtotal Cost including Contingency		**$9,600,000**		**$1,800,000**
Capital Costs							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
High-Density Urban Pipeline	6-in	4,900 LF	in-LF	$ 50	$1,470,000	75 yrs	$880,000
High-Density Urban Pipeline	8-in	13,300 LF	in-LF	$ 50	$5,320,000	75 yrs	$3,200,000
High-Density Urban Pipeline	12-in	4,000 LF	in-LF	$ 50	$2,400,000	75 yrs	$1,400,000
High-Density Urban Pipeline	16-in	3,000 LF	in-LF	$ 50	$2,400,000	75 yrs	$1,400,000
Irrigation Customer Connection Costs		10	EA	$ 100,000	$1,000,000	75 yrs	$600,000
Industrial Customer Connection Costs		13	EA	$ 200,000	$2,600,000	75 yrs	$1,600,000
Pipeline Crossing Allowance(Brooklyn Basin and Schnitzer)		1	LS	$ 2,700,000	$2,700,000	75 yrs	$1,600,000
Extra pipeline allowance for industrial customers		13	EA	$ 50,000	$650,000	75 yrs	$390,000
			Estimated Subtotal Cost (2) including Contingency		**$19,000,000**		**$11,000,000**
Mobilization							
Estimated Subtotal Construction Cost including Contingency					**$29,000,000**		**$13,000,000**
Mobilization				5%	$1,500,000		
Estimated Subtotal Construction Cost including Contingency and Mobilization					$31,000,000		$13,000,000
Implementation							
Planning / Environmental				5%	$1,600,000		
Design Cost				15%	$4,700,000		
Project Administration and Construction Management Cost				10%	$3,100,000		
Estimated Total Construction Cost including Implementation and Contingency					**$40,000,000**		**$13,000,000**
						Present Worth of Salvage Value	**$5,300,000**
O&M Costs (Annual)							
Recycled Water Treatment							
MBR Electricity	0.95	778,571	kWh/yr	$ 0.15	$116,800		
Free Chlorine	0.95		MGD	$ 11,000	$11,000		
Replacement Costs	1.6		MGD	$ 28,075	$28,100		
Labor	1.6	1,040	hrs/MGD	$ 135	$224,600		
Conveyance							
Annual O&M			2% of construction cost		$370,000		
Pump Stations							
Labor Costs		0	hrs	$ 135	$0		
Electricity		72,623	kWh/yr	$ 0.15	$10,900		
Pump Station Consumables			5% of pump station construction cost		$65,000		
			Total O&M Costs ($/yr)		$830,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$270,000		
Annual O&M Costs					$830,000		
Total Annualized Cost					$2,600,000		
Deliveries of Recycled Water	1,064 AFY						
Estimated Unit Cost ($/AF)					**$2,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$940**	**Distribution**	**$1,460**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$270,000	*Same as constant use.*	
Annual O&M Costs					$729,310		
Total Annualized Cost					$2,500,000		
Annual Average Deliveries of Recycled Water	319 AFY						
Estimated Unit Cost ($/AF)					**$7,800**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,900**	**Distribution**	**$4,900**		

East Bayshore Recycled Water Project Phase 2					EBMUD Recycled Water Master Plan Update		
Last Updated:	5-Dec-18				Discount Rate		Project Life
Updated by:	M. Romero				3%		30 Years

Item	Size	Qty	Unit	Unit Cost	Total Cost	Useful Life	Salvage Value
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MBR System (4.5MGD MMcapacity)	4.5		MGD	$ 5,979,853	$6,000,000	35 yrs	$860,000
Diversion Pump Station	4.5		MGD	$ 1,419,005	$1,400,000	50 yrs	$560,000
Electrical Allowance	1		LS	$ 601,543	$600,000	35 yrs	$86,000
Sitework	1		LS	$ 2,040,297	$2,000,000	35 yrs	$290,000
Chemicals (Storage and Use)	1		LS	$ 72,879	$100,000	30 yrs	$0
Chlorine Contactor	1		LS	$ 686,063	$700,000	35 yrs	$100,000
				Raw Construction Cost Subtotal	**$11,000,000**		**$1,900,000**
Contractor Overhead & Profit				15%	$1,700,000		$290,000
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$500,000		$86,000
				Estimated Installed Equipment Cost for Treatment	**$13,000,000**		**$2,300,000**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$13,000,000**		**$2,300,000**
Estimating Contingency				25%	$3,300,000		$580,000
				Estimated Subtotal Cost (1) including Contingency	**$16,000,000**		**$2,900,000**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
High-Density Urban Pipeline	6-in	4,900 LF	in-LF	$ 50	$1,470,000	75 yrs	$880,000
High-Density Urban Pipeline	8-in	58,214 LF	in-LF	$ 50	$23,285,600	75 yrs	$14,000,000
High-Density Urban Pipeline	12-in	16,670 LF	in-LF	$ 50	$10,002,000	75 yrs	$6,000,000
High-Density Urban Pipeline	16-in	8,000 LF	in-LF	$ 50	$6,400,000	75 yrs	$3,800,000
High-Density Urban Pipeline	20-in	21,285 LF	in-LF	$ 50	$21,285,000	75 yrs	$13,000,000
Irrigation Customer Connection Costs		68	EA	$ 100,000	$6,800,000	75 yrs	$4,100,000
Industrial Customer Connection Costs		18	EA	$ 200,000	$3,600,000	75 yrs	$2,200,000
Pipeline Crossing Allowance(Brooklyn Basin and Schnitzer)		1	LS	$ 2,700,000	$2,700,000	75 yrs	$1,600,000
Extra pipeline allowance for industrial customers		18	EA	$ 50,000	$900,000	75 yrs	$540,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	90 HP		EA (Cost Curve based on total installed HP)	$ 1,500,000	$1,500,000	75 yrs	$900,000
				Estimated Subtotal Cost (2) including Contingency	**$78,000,000**		**$47,000,000**
Mobilization							
Estimated Subtotal Construction Cost including Contingency					**$94,000,000**		**$50,000,000**
Mobilization				5%	$4,700,000		
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$99,000,000**		**$50,000,000**
Implementation							
Planning / Environmental				5%	$5,000,000		
Design Cost				15%	$15,000,000		
Project Administration and Construction Management Cost				10%	$9,900,000		
Estimated Total Construction Cost including Implementation and Contingency					**$130,000,000**		**$50,000,000**
					Present Worth of Salvage Value		**$20,000,000**
O&M Costs (Annual)							
Recycled Water Treatment							
MBR	2.5	3,024,140	kWh/yr	$ 0.15	$453,600		
Free Chlorine	2.5		MGD	$ 52,900	$52,900		
Replacement Costs	4.5		MGD	$ 76,118	$80,000		
Labor	4.5	1,040	hrs/MGD	$ 135	$631,800		
Conveyance							
Annual O&M			2% of construction cost		$1,530,000		
Pump Stations							
Labor Costs		0	hrs	$ 135	$0		
Electricity		347,925	kWh/yr	$ 0.15	$52,200		
Pump Station Consumables		5% of pump station construction cost			$70,000		
			Total O&M Costs ($/yr)		$2,900,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$6,600,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,000,000		
Annual O&M Costs					$2,900,000		
Total Annualized Cost					$8,500,000		
Deliveries of Recycled Water	2,867 AFY						
Estimated Unit Cost ($/AF)					**$3,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$800**	**Distribution**	**$2,200**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$6,600,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,000,000	*Same as constant use.*	
Annual O&M Costs					$2,479,410		
Total Annualized Cost					$8,100,000		
Annual Average Deliveries of Recycled Water	860 AFY						
Estimated Unit Cost ($/AF)					**$9,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,200**	**Distribution**	**$7,200**		

Chevron/City of Richmond WPCP Recycled Water Project Cost Update

EBMUD Recycled Water Master Plan Update

Last Updated:	9-Jul-18	Discount Rate	Project Life
Updated by:	C. De Las Casas	3%	30 Years
Original Project Information			
Project Source:	2016 City of Richmond Facility Plan		
Project Source CCI Date:	September 2016	Project Source Location:	San Francisco Area
Project Source 20-Cities Avg ENR CCI:	10,403	Location Multiplier:	1.00
December 2017 20-Cities Avg ENR CCI:	10,870	Historical Multiplier:	1.04

Item	Size	Qty	Unit	Original Project Cost	Adjusted Project Cost	Useful Life	Salvage Value
Capital Costs							
Treatment							
MBR (2016 Facilities Plan)	5.0		MGD	$ 62,600,000	$65,000,000	35 yrs	$9,300,000
UV Disinfection	5.0		MGD	$ 8,900,000	$9,300,000	35 yrs	$1,300,000
RO System	5.0		MGD	$ 19,700,000	$21,000,000	35 yrs	$3,000,000
RARE MF/RO expansion from 3.5 to 5 mgd	1.5		MGD	$ 2,000,000	$2,100,000	35 yrs	$300,000
Conveyance							
Pipeline to RARE	24in	12,850 LF	in-LF	$ 9,800,000	$10,200,000	75 yrs	$6,100,000
Pump Station							
Pump Station	200 HP	5	MGD	$ 1,600,000	$1,700,000	50 yrs	$680,000
Estimated Total Capital Cost including Implementation and Contingency					**$110,000,000**		**$21,000,000**
						Present Worth of Salvage Value	**$8,600,000**
O&M Costs (Annual)							
Recycled Water Treatment							
MBR	5.0	$ 460,000	$/MGD	$ 2,300,000	$2,300,000		
UV maintenance (2% UV const. costs)	5.0		MGD	$ 112,700	$118,000		
RO	5.0	$ 480,000	$/MGD	$ 2,400,000	$2,400,000		
RARE MF/RO Upgrades	1.5		MGD	$ 450,000	$470,000		
Conveyance (Pipeline and Pump Station)							
Annual O&M			2% of construction cost		$200,000		
Pump Stations							
Labor Costs (5MGD)	3475 gpm	1,000	hrs	$ 135	$140,000		
Electricity (143,600 KWh/MGD)	4.5 MGD	646,200	kWh/yr	$ 0.15	$97,000		
Pump Station Consumables			5% of pump station construction cost		$0		
				Total O&M Costs ($/yr)	$5,700,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$5,600,000		
Annualized Salvage Value	*Annualized value of present worth*				-$440,000		
Annual O&M Costs					$5,700,000		
Total Annualized Cost					$11,000,000		
Deliveries of Recycled Water	4,284 AFY						
Estimated Unit Cost ($/AF)					**$2,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,300**	**Distribution $300**			
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$5,600,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$440,000	*Same as constant use.*	
Annual O&M Costs					$5,657,100		
Total Annualized Cost					$11,000,000		
Annual Average Deliveries of Recycled Water	1,285 AFY						
Estimated Unit Cost ($/AF)					**$8,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$7,600**	**Distribution**	**$1,000**		

Phillips 66 Refinery Recycled Water Project Cost Update

EBMUD Recycled Water Master Plan Update

Last Updated:	18-May-18				Discount Rate		Project Life
Updated by:	M. Romero				3%		30 Years
Original Project Information							
Project Source:	Recycled Water Technical Study, 2007						
Project Source CCI Date:	August 2007				Project Source Location:		San Francisco Area
Project Source 20-Cities Average ENR CCI:	8,007				Location Multiplier:		1.00
December 2017 20-Cities Average ENR CCI:	10,870				Historical Multiplier:		1.36

Item	Size	Qty	Unit	Original Project Cost	Adjusted Project Cost	Useful Life	Salvage Value
Capital Costs							
Treatment							
BAF/MF/RO Treatment	1.7	1	MGD	$ 14,012,600	$19,000,000	35 yrs	$2,700,000
UV Treatment	1.7	1	MGD	$ 297,700	$400,000	35 yrs	$57,000
Electrical/Instrumentation		1	LS	$ 2,783,400	$3,800,000	35 yrs	$540,000
Conveyance							
Pipeline to Refinery	2"-12" Dia	3,565 LF	in-LF	$ 618,200	$840,000	75 yrs	$500,000
Pump Station							
Rodeo Pump Station	61HP			$ 1,333,744	$1,800,000	50 yrs	$720,000
				Raw Construction Cost Subtotal	**$26,000,000**		**$4,500,000**
Contractor Overhead & Profit				15%	$3,900,000		$680,000
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$1,200,000		$200,000
				Estimated Subtotal Construction Cost	**$31,000,000**		**$5,400,000**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$31,000,000**		**$5,400,000**
Estimating Contingency				25%	$7,800,000		$1,400,000
				Estimated Subtotal Construction Cost including Contingency	**$39,000,000**		**$6,800,000**
Mobilization				5%	$2,000,000		
				Estimated Subtotal Construction Cost including Contingency and Mobilization	**$41,000,000**		**$6,800,000**
Construction Cost Including Implementation							
Planning / Environmental				5%	$2,100,000		
Design Cost				15%	$6,200,000		
Project Administration and Construction Management Cost				10%	$4,100,000		
Estimated Total Construction Cost including Implementation and Contingency					**$53,000,000**		**$6,800,000**
						Present Worth of Salvage Value	**$2,800,000**
O&M Costs (Annual)							
Recycled Water Treatment							
BAF/MF/RO/UV System Energy			EA	$ 327,400	$613,900		
Replacement and Maintenace			EA	$ 549,756	$746,300		
Miscellaneous, chemicals			EA	$ 175,000	$237,600		
Labor Costs			EA	$ 133,000	$394,700		
Pump Stations							
Labor Costs					$0		
Electricity		1	EA	$ 32,000	$60,000		
Pump Station Consumables		5% of pump station construction cost			$0		
				Total O&M Costs ($/yr)	$2,100,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,700,000		
Annualized Salvage Value	*Annualized value of present worth*				-$140,000		
Annual O&M Costs					$2,100,000		
Total Annualized Cost					$4,700,000		
Deliveries of Recycled Water	4,144 AFY						
Estimated Unit Cost ($/AF)					**$1,100**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,000**	**Distribution**	**$100**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,700,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$140,000	*Same as constant use.*	
Annual O&M Costs					$2,010,500		
Total Annualized Cost					$4,600,000		
Annual Average Deliveries of Recycled Water	1,243 AFY						
Estimated Unit Cost ($/AF)					**$3,700**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$3,500**	**Distribution**	**$200**		

Central San Regional Recycled Water Project Cost Update

EBMUD Recycled Water Master Plan Update

Last Updated:	23-May-18	Discount Rate	Project Life
Updated by:	C. De Las Casas	3%	30 Years

Original Project Information

Project Source:	CCCSD Comprehensive Wastewater Master Plan		
Project Source CCI Date:	June 2017	Project Source Location:	San Francisco Area
Project Source 20-Cities Average ENR CCI:	10,703	Location Multiplier:	1.00
December 2017 20-Cities Average ENR CCI:	10,870	Historical Multiplier:	1.02

Item	Size	Qty	Unit	Original Project Cost	Adjusted Project Cost	Useful Life	Salvage Value
Capital Costs							
Treatment							
MBR (Aeration Basins, Membrane Tanks, Fine Screens)	23		MGD	$ 190,423,000	$190,000,000	35 yrs	$27,000,000
UV Disinfection	23		MGD	$ 21,876,000	$22,000,000	35 yrs	$3,100,000
RO	14		MGD	$ 56,813,000	$58,000,000	35 yrs	$8,300,000
Electrical Feed Upgrade	1		LS	$ 17,303,000	$18,000,000	75 yrs	$11,000,000
Conveyance							
Pipeline R&R			LS	$ 28,659,000	$29,000,000	75 yrs	$17,000,000
				Subtotal	**$320,000,000**		**$66,000,000**
Contractor Overhead & Profit	*Apply as needed*			15%	$0		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$0		$0
			Estimated Subtotal Construction Cost		**$320,000,000**		**$66,000,000**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$320,000,000**		**$66,000,000**
Estimating Contingency	*Apply as needed*			25%	$0		$0
			Estimated Subtotal Cost (1) including Contingency		**$320,000,000**		**$66,000,000**
Construction Cost Including Implementation							
Estimated Total Construction Cost including Implementation and Contingency					**$320,000,000**		**$66,000,000**
					Present Worth of Salvage Value		**$27,000,000**
O&M Costs (Annual)							
General O&M							
Treatment O&M ($114,500/MGD)	20		MGD	$ 114,500	$2,300,000		
Refinery O&M ($260,600/MGD)	20		MGD	$ 260,600	$5,200,000		
Conveyance							
Annual O&M	1		LS	$ 108,100	$109,800		
Pump Stations							
Labor Costs			hrs	$ 135	$0		
Electricity		10,320,178	kWh/yr	$ 0.15	$1,500,000		
Pump Station Consumables		5% of pump station construction cost			$0		
			Total O&M Costs ($/yr)		$9,100,000		

Annualized Costs ($ / Year)				
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*		$16,000,000	
Annualized Salvage Value	*Annualized value of present worth*		-$1,400,000	
Annual O&M Costs			$9,100,000	
Total Annualized Cost			$24,000,000	
Deliveries of Recycled Water	22,400 AFY			
Estimated Unit Cost ($/AF)			**$1,100**	
Breakdown of Estimated Unit Cost ($/AF)	**Treatment** **$980**	**Distribution**	**$120**	
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***			
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*		$16,000,000	*Same as constant use.*
Annualized Salvage Value	*Annualized value of present worth*		-$1,400,000	*Same as constant use.*
Annual O&M Costs			$8,059,800	
Total Annualized Cost			$23,000,000	
Annual Average Deliveries of Recycled Water	6,720 AFY			
Estimated Unit Cost ($/AF)			**$3,400**	
Breakdown of Estimated Unit Cost ($/AF)	**Treatment** **$3,300**	**Distribution**	**$100**	

CCWD Pipeline in Canal ROW Recycled Water Project Cost Update								EBMUD Recycled Water Master Plan Update
Last Updated:	16-May-18				Discount Rate		Project Life	
Updated by:	M. Romero				3%		30 Years	
Original Project Information								
Project Source:	2013 CCWD Facilities Improvement Plan Update							
Project Source CCI Date:		July 2013			Project Source Location:		San Francisco Area	
Project Source 20-Cities Average ENR CCI:		9,552			Location Multiplier:		1.00	
December 2017 20-Cities Average ENR CCI:		10,870			Historical Multiplier:		1.14	

Item	Size	Qty	Unit	Original Project Cost	Adjusted Project Cost	Useful Life	Salvage Value
Capital Costs							
Conveyance							
Distribution Pipeline	28", 18" and 6"	97,680 LF	in-LF	$ 18,500,000	$21,000,000	75 yrs	$13,000,000
Pump Station							
Pump Station			LS	$ 7,500,000	$8,500,000	50 yrs	$3,400,000
Storage Tanks							
Welded Steel Storage Tank		1	EA	$ 500,000	$570,000	75 yrs	$340,000
Estimated Total Construction Cost including Implementation and Contingency					**$30,000,000**		**$17,000,000**
						Present Worth of Salvage Value	**$7,000,000**
O&M Costs (Annual)							
Conveyance							
Annual O&M		2% of construction cost			$323,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$67,500		
Electricity		114,669	kWh/yr	$ 0.15	$17,200		
Pump Station Consumables		5% of pump station construction cost			$372,000		
Storage Tanks							
Annual O&M		1% of construction cost			$5,000		
			Total O&M Costs ($/yr)		$780,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$1,500,000		
Annualized Salvage Value	*Annualized value of present worth*				-$360,000		
Annual O&M Costs					$780,000		
Total Annualized Cost					$1,900,000		
Deliveries of Recycled Water	930 AFY						
Estimated Unit Cost ($/AF)					**$2,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$0**	**Distribution**	**$2,000**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$1,500,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$360,000	*Same as constant use.*	
Annual O&M Costs					$772,660		
Total Annualized Cost					$1,900,000		
Annual Average Deliveries of Recycled Water	279 AFY						
Estimated Unit Cost ($/AF)					**$6,800**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$0**	**Distribution**	**$6,800**		

Diablo Country Club Satellite Treatment Recycled Water Project Cost Update					EBMUD Recycled Water Master Plan Update		
Last Updated:		18-May-18			Discount Rate		Project Life
Updated by:		M. Romero			3%		30 Years
Original Project Information							
Project Source:		2013 Feasibility Study					
Project Source CCI Date:		September 2013			Project Source Location:	San Francisco Area	
Project Source 20-Cities Average ENR CCI:		9,552			Location Multiplier:	1.00	
December 2017 20-Cities Average ENR CCI:		10,870			Historical Multiplier:	1.14	

Item	Size	Qty	Unit	Original Project Cost	Adjusted Project Cost	Useful Life	Salvage Value
Capital Costs							
Treatment							
MBR/UV/Chlorine	0.5		MGD	$ 3,278,295	$3,700,000	35 yrs	$530,000
Wastewater Diversion, 12HP	1		EA	$ 99,474	$113,000	50 yrs	$45,000
Wastewater Diversion Pipeline, 8" diam, 4700LF	1		EA	$ 972,900	$1,110,000	75 yrs	$670,000
Disinfection for Chlorine Residual	1		EA	$ 15,431	$18,000	35 yrs	$2,600
Return Solids Pump Station	1		EA	$ 34,937	$40,000	50 yrs	$16,000
Return Solids Force Main, 5,000LF	1		EA	$ 945,000	$1,080,000	75 yrs	$650,000
Conveyance							
Non-urban Pipeline		1,000 LF	in-LF	$ 189,000	$220,000	75 yrs	$130,000
Pump Station							
Pump Station				$ 20,833	$24,000	50 yrs	$9,600
Storage Tanks							
Welded Steel Storage Tank		1	EA	$ 52,848	$60,000	75 yrs	$36,000
				Subtotal	**$6,400,000**		**$2,100,000**
				Estimated Subtotal Construction Cost	**$6,400,000**		**$2,100,000**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$6,400,000**		**$2,100,000**
Estimating Contingency				25%	$1,600,000		$530,000
				Estimated Subtotal Cost including Contingency	**$8,000,000**		**$2,600,000**
Mobilization				8%	$640,000		
				Estimated Subtotal Cost including Contingency	**$8,600,000**		**$2,600,000**
Construction Cost Including Implementation							
Planning / Environmental				5%	$430,000		
Design Cost				15%	$1,300,000		
Project Administration and Construction Management Cost				10%	$860,000		
Estimated Total Construction Cost including Implementation and Contingency					**$11,000,000**		**$2,600,000**
						Present Worth of Salvage Value	**$1,100,000**
O&M Costs (Annual)							
Recycled Water Treatment							
MBR,UV, chlorine disinfection			MGD	$ 322,820	$370,000		
Electricity	401,500		kWh/yr	$ 59,422	$60,000		
Conveyance							
Annual O&M		1,000 LF		$ 18,782	$21,000		
				Total O&M Costs ($/yr)	$450,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$560,000		
Annualized Salvage Value	*Annualized value of present worth*				-$56,000		
Annual O&M Costs					$450,000		
Total Annualized Cost					$950,000		
Deliveries of Recycled Water	246 AFY						
Estimated Unit Cost ($/AF)					**$3,900**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$3,600**	**Distribution**	**$300**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$560,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$56,000	*Same as constant use.*	
Annual O&M Costs					$409,000		
Total Annualized Cost					$910,000		
Annual Average Deliveries of Recycled Water	74 AFY						
Estimated Unit Cost ($/AF)					**$12,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$11,000**	**Distribution**	**$1,000**		

Moraga Country Club Satellite Recycled Water Project Cost Update					EBMUD Recycled Water Master Plan Update		
Last Updated:	24-Jan-18				Discount Rate		Project Life
Updated by:	M. Romero				3%		30 Years
Original Project Information							
Project Source:	MCC SRWTP Detailed FS						
Project Source CCI Date:	September 2009				Project Source Location:		San Francisco Area
Project Source 20-Cities Average ENR CCI:	8,586				Location Multiplier:		1.00
December 2017 20-Cities Average ENR CCI:	10,870				Historical Multiplier:		1.27
Item	**Size**	**Qty**	**Unit**	**Original Project Cost**	**Adjusted Project Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment							
MBR/UV/Chlorine	0.5		MGD	$ 7,900,000	$10,000,000	35 yrs	$1,400,000
Construction Cost Including Contingency							
				Estimated Subtotal Cost including Contingency	**$10,000,000**		**$1,400,000**
Mobilization				5%	$500,000		
				Estimated Subtotal Cost including Contingency and Mobilization	**$11,000,000**		**$1,400,000**
Construction Cost Including Implementation							
Planning / Environmental				5%	$550,000		
Design Cost				15%	$1,700,000		
Project Administration and Construction Management Cost				10%	$1,100,000		
Estimated Total Construction Cost including Implementation					**$14,000,000**		**$1,400,000**
					Present Worth of Salvage Value		**$570,000**
O&M Costs (Annual)							
Recycled Water Treatment							
Energy	0.5		MGD	$ 56,057	$71,000		
Chemical Use	0.5		MGD	$ 1,190	$1,500		
Membrane Replacement Cost	0.5		MGD	$ 25,000	$32,000		
UV Lamp Replacement Cost	0.5		MGD	$ 4,160	$5,300		
Labor Costs	0.5		MGD	$ 33,800	$43,000		
			Total O&M Costs ($/yr)		$150,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$710,000		
Annualized Salvage Value	*Annualized value of present worth*				-$29,000		
Annual O&M Costs					$150,000		
Total Annualized Cost					$830,000		
Deliveries of Recycled Water	179 AFY						
Estimated Unit Cost ($/AF)					**$4,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$4,600**	**Distribution**	**$0**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$710,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$29,000	*Same as constant use.*	
Annual O&M Costs					$152,800		
Total Annualized Cost					$830,000		
Annual Average Deliveries of Recycled Water	54 AFY						
Estimated Unit Cost ($/AF)					**$15,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$15,000**	**Distribution**	**$0**		

Moraga Area Satellite Treatment Recycled Water Project Cost							EBMUD Recycled Water Master Plan Update
Last Updated:	20-May-18				Discount Rate		Project Life
Updated by:	M. Romero				3%		30 Years
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MBR/UV/Chlorine	0.5		MGD	$ 17,700,000	$8,900,000	35 yrs	$1,300,000
				Subtotal	**$8,900,000**		**$1,300,000**
Contractor Overhead & Profit				15%	$1,335,000		$200,000
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$401,000		$59,000
				Estimated Installed Equipment Cost for Treatment	**$11,000,000**		**$1,600,000**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$11,000,000**		**$1,600,000**
Estimating Contingency				25%	$2,750,000		$400,000
				Estimated Subtotal Cost (1) including Contingency	**$14,000,000**		**$2,000,000**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Low-Density Urban Pipeline (<12")	2-in	3,100 LF	in-LF	$ 40	$248,000	75 yrs	$150,000
Low-Density Urban Pipeline (<12")	3-in	5,150 LF	in-LF	$ 40	$618,000	75 yrs	$370,000
Low-Density Urban Pipeline (<12")	4-in	4,600 LF	in-LF	$ 40	$736,000	75 yrs	$440,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Distribution Pumps (2+1, 20 hp)		3		$ 17,500	$52,500	35 yrs	$7,500
Pump Station (Total installed HP, including standby)	60 HP		EA (Cost Curve based on total installed HP)	$ 1,300,000	$1,300,000	50 yrs	$520,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on $2/gallon*						
Welded Steel Storage Tank (<40 MG)	0.03 MG	1		$ 2	$60,000	75 yrs	$36,000
Welded Steel Storage Tank (<40 MG)	0.04 MG	1		$ 2	$70,000	75 yrs	$42,000
Welded Steel Storage Tank (<40 MG)	0.06 MG	1		$ 2	$120,000	75 yrs	$72,000
				Estimated Subtotal Cost (2) including Contingency	**$3,200,000**		**$1,600,000**
Mobilization							
Estimated Subtotal Construction Cost including Contingency					**$17,000,000**		**$3,600,000**
Mobilization				5%	$850,000		
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$18,000,000**		**$3,600,000**
Implementation							
Planning / Environmental				5%	$900,000		
Design Cost				15%	$2,700,000		
Project Administration and Construction Management Cost				10%	$1,800,000		
Estimated Total Construction Cost including Implementation and Contingency					**$23,000,000**		**$3,600,000**
						Present Worth of Salvage Value	**$1,500,000**
O&M Costs (Annual)							
Recycled Water Treatment							
MBR/UV (chemical, power, maintenance)	0.2		MGD	$ 424,000	$93,000		
Labor	0.5	1,040	hrs/MGD	$ 135	$70,000		
Electricity	0.2	1,130,000	kWh/yr	$ 0.15	$37,300		
Conveyance							
Annual O&M			2% of construction cost		$32,000		
Pump Stations							
Labor Costs		0	hrs	$ 135	$0		
Electricity		135,596	kWh/yr	$ 0.15	$20,300		
Pump Station Consumables		5% of pump station construction cost			$0		
Storage Tanks							
Annual O&M			1% of construction cost		$2,500		
			Total O&M Costs ($/yr)		$260,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$1,200,000		
Annualized Salvage Value	*Annualized value of present worth*				-$76,000		
Annual O&M Costs					$260,000		
Total Annualized Cost					$1,400,000		
Deliveries of Recycled Water	246 AFY						
Estimated Unit Cost ($/AF)					**$5,700**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$4,500**	**Distribution**	**$1,200**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$1,200,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$76,000	*Same as constant use.*	
Annual O&M Costs					$214,780		
Total Annualized Cost					$1,300,000		
Annual Average Deliveries of Recycled Water	74 AFY						
Estimated Unit Cost ($/AF)					**$18,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$15,000**	**Distribution**	**$3,000**		

Oakland Hills Satellite Treatment Recycled Water Project Cost Update

EBMUD Recycled Water Master Plan Update

Last Updated:	20-May-18	Discount Rate	Project Life
Updated by:	M. Romero	3%	30 Years

Original Project Information

Project Source:	Oakland Hills FS, 2017		
Project Source CCI Date:	April 2017	Project Source Location:	San Francisco Area
Project Source 20-Cities Average ENR CCI:	10,678	Location Multiplier:	1.00
December 2017 20-Cities Average ENR CCI:	10,870	Historical Multiplier:	1.02

Item	Size	Qty	Unit	Original Project Cost	Adjusted Project Cost	Useful Life	Salvage Value
Capital Costs							
Treatment							
MBR System (0.5 MGD capacity)	0.5		MGD	$ 5,401,000	$5,500,000	35 yrs	$790,000
UV System	0.5		MGD	$ 426,000	$430,000	35 yrs	$61,000
Diversion Structure	1		EA	$ 168,000	$170,000	50 yrs	$68,000
Diversion Pumps	1		EA	$ 126,000	$130,000	50 yrs	$52,000
Diversion Pipeline (12" diam, 6,800LF)	1		EA	$ 2,568,000	$2,600,000	75 yrs	$1,600,000
Electrical Infrastructure	1		EA	$ 420,000	$430,000	75 yrs	$260,000
Conveyance							
Low-Density Urban Pipeline	4" to 8"	14,250 LF	in-LF	$ 2,364,000	$2,400,000	75 yrs	$1,400,000
Pump Station							
Pump Station (n=1+1, 1.5HP each)	1.5HP	2	HP	$ 7,000	$7,100	50 yrs	$2,800
Storage Tanks							
Welded Steel Storage Tank	0.5 MG	1	EA	$ 1,200,000	$1,200,000	75 yrs	$720,000
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$13,000,000**		**$5,000,000**
Estimating Contingency	*Apply as needed*			25%	$3,300,000		$1,300,000
				Estimated Subtotal Cost including Contingency	**$16,000,000**		**$6,300,000**
Mobilization				5%	$800,000		
				Estimated Subtotal Cost including Contingency and Mobilization	**$17,000,000**		**$6,300,000**
Construction Cost Including Implementation							
Planning / Environmental				5%	$850,000		
Design Cost				15%	$2,600,000		
Project Administration and Construction Management Cost				10%	$1,700,000		
Estimated Total Construction Cost including Implementation					**$22,000,000**		**$6,300,000**
						Present Worth of Salvage Value	**$2,600,000**
O&M Costs (Annual)							
Recycled Water Treatment							
MBR/UV/Chlorine (Maintenance/Energy)	0.5		MGD	$ 82,000	$83,000		
Operation Costs	0.5		MGD	$ 66,000	$67,000		
Pump Stations							
Labor Costs				$ -	$0		
Electricity				$ 16,000	$16,000		
Pump Station Consumables		5% of pump station construction cost			$0		
				Total O&M Costs ($/yr)	$170,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$1,100,000		
Annualized Salvage Value	*Annualized value of present worth*				-$130,000		
Annual O&M Costs					$170,000		
Total Annualized Cost					$1,100,000		
Deliveries of Recycled Water	347 AFY						
Estimated Unit Cost ($/AF)					**$3,200**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,400**	**Distribution**	**$800**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$1,100,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$130,000	*Same as constant use.*	
Annual O&M Costs					$154,800		
Total Annualized Cost					$1,100,000		
Annual Average Deliveries of Recycled Water	104 AFY						
Estimated Unit Cost ($/AF)					**$11,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$8,100**	**Distribution**	**$2,900**		

UCB Satellite Treatment Recycled Water Project Cost

EBMUD Recycled Water Master Plan Update

Last Updated:	20-May-18				Discount Rate		Project Life
Updated by:	M. Romero				3%		30 Years
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MBR System (1.5-mgd capacity)	1.5		MGD	$ 4,652,300	$4,652,300	35 yrs	$660,000
UV system	1.5		MGD	$ 1,212,000	$1,212,000	35 yrs	$170,000
On-site hypochlorite generation system	1.5		MGD	$ 1,350,000	$1,350,000	35 yrs	$190,000
Diversion Structure (pumps, structure)	1		EA	$ 458,000	$458,000	50 yrs	$180,000
Diversion Pipeline (100LF, 10" diameter)	1		EA	$ 50,000	$50,000	75 yrs	$30,000
Site Work and electrical (includes piping)	1		EA	$ 1,325,802	$1,325,802	50 yrs	$530,000
UV/MCC/Blowers Building	1		EA	$ 3,000,000	$3,000,000	50 yrs	$1,200,000
				Subtotal	**$12,000,000**		**$3,000,000**
Contractor Overhead & Profit				15%	$1,800,000		$450,000
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$540,000		$140,000
		Estimated Installed Equipment Cost for Treatment			**$14,000,000**		**$3,600,000**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$14,000,000**		**$3,600,000**
Estimating Contingency				25%	$3,500,000		$900,000
		Estimated Subtotal Cost (1) including Contingency			**$18,000,000**		**$4,500,000**
Capital Costs							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
High-Density Urban Pipeline	15-in	5,000 LF	in-LF	$ 50	$3,750,000	75 yrs	$2,300,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	450 HP	EA (Cost Curve based on total installed HP)		$ 2,100,000	$2,100,000	50 yrs	$840,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Pre-stressed Concrete Storage Tank (<20 MG)	1.5 MG	1	EA (Cost Curve by Volume)	$ 2,400,000	$2,400,000	100 yrs	$1,700,000
Pre-stressed Concrete Tank Allowances			3% of Line Above + $0.15M		$220,000		
		Estimated Subtotal Cost (2) including Contingency			**$8,500,000**		**$4,800,000**
Mobilization							
Estimated Subtotal Construction Cost including Contingency					$27,000,000		$9,300,000
Mobilization				5%	$1,400,000		
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$28,000,000**		**$9,300,000**
Implementation							
Planning / Environmental				5%	$1,400,000		
Design Cost				15%	$4,200,000		
Project Administration and Construction Management Cost				10%	$2,800,000		
Estimated Total Construction Cost including Implementation and Contingency					**$36,000,000**		**$9,300,000**
					Present Worth of Salvage Value		**$3,800,000**
O&M Costs (Annual)							
Recycled Water Treatment							
MBR	0.8	1130000	kWh/MGD	$ 0.15	$135,600		
UV	0.8	162,500	kWh/MGD	$ 0.15	$19,013		
WW Diversion Pumping	28,667		kWh	$ 0.15	$4,300		
Maintenance and Repair		2% of MBR/UV construction cost			$117,286		
Free Chlorine	0.8		MGD	$ 49,000	$39,000		
Chemicals	0.8		MGD	$ 120,000	$96,000		
Labor	1.6	1,040	hrs/MGD	$ 135	$220,000		
Conveyance							
Annual O&M			2% of construction cost		$75,000		
Pump Stations							
Labor Costs (1.6 MGD/1,100 gpm)		500	hrs	$ 135	$68,000		
Electricity		298,138	kWh/yr	$ 0.15	$45,000		
Pump Station Consumables		5% of pump station construction cost			$0		
Storage Tanks							
Annual O&M		1% of construction cost			$24,000		
			Total O&M Costs ($/yr)		$840,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$1,800,000		
Annualized Salvage Value	*Annualized value of present worth*				-$190,000		
Annual O&M Costs					$840,000		
Total Annualized Cost					$2,500,000		
Deliveries of Recycled Water	874 AFY						
Estimated Unit Cost ($/AF)					**$2,900**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$1,000**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$1,800,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$190,000	*Same as constant use.*	
Annual O&M Costs					$714,189		
Total Annualized Cost					$2,300,000		
Annual Average Deliveries of Recycled Water	262 AFY						
Estimated Unit Cost ($/AF)					**$8,800**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$6,100**	**Distribution**	**$2,700**		

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APPENDIX B: COST ESTIMATE DETAILS FOR POTABLE REUSE ALTERNATIVES

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Alternative Oro-GW					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MBR	0		MGD	$ 17,700,000	$0	30 yrs	$0
Ozone	0		MGD	$ 335,300	$0	30 yrs	$0
BAC	0		MGD	$ 300,900	$0	30 yrs	$0
MF/UF system	8		MGD	$ 1,225,000	$9,800,000	30 yrs	$0
RO System	8		MGD	$ 1,475,000	$12,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	8		MGD	$ 437,500	$3,500,000	30 yrs	$0
Chemicals (Storage and Use)	8			$ 125,000	$1,000,000	30 yrs	$0
Sitework/Piping/Structures	8		MGD	$ 3,187,500	$26,000,000	30 yrs	$0
Groundwater Wells							
Injection Well	1 MG	8		$ 1,679,000	$13,000,000	50 yrs	$5,200,000
Extraction Well *(includes wellhead treatment)*	2 MG	4		$ 4,068,000	$16,000,000	50 yrs	$6,400,000
				Raw Construction Cost Subtotal	**$81,000,000**		**$12,000,000**
Contractor Overhead & Profit				15%	$12,000,000		$1,800,000
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$3,600,000		$540,000
				Estimated Subtotal Construction Cost	**$97,000,000**		**$14,000,000**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$97,000,000**		**$14,000,000**
Estimating Contingency				25%	$24,000,000		$3,500,000
				Estimated Subtotal Cost (1) including Contingency	**$120,000,000**		**$18,000,000**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	100 LF	in-LF	$ 30	$72,000	75 yrs	$43,000
Low-Density Urban Pipeline	24-in	35,100 LF	in-LF	$ 40	$33,696,000	75 yrs	$20,000,000
High-Density Urban Pipeline	24-in	6,000 LF	in-LF	$ 50	$7,200,000	75 yrs	$4,300,000
Trenchless Crossings							
HDD (All Inclusive)		1,500	LF	$ 2,200	$3,300,000	75 yrs	$2,000,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station - Treatment to Injection (Total installed HP, including standby)	1,500 HP	EA (Cost Curve based on total installed HP)		$ 5,300,000	$5,300,000	50 yrs	$2,100,000
Pump Station - Extraction to Distribution (Total installed HP, including standby)	750 HP			$ 2,800,000	$2,800,000	50 yrs	$1,100,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (at extraction well site) (material determined during pre-design)	0.1 MG	1	EA (Cost Curve by Volume)	$ 2,200,000	$2,200,000	75 yrs	$1,300,000
				Estimated Subtotal Cost (2) including Contingency	**$55,000,000**		**$31,000,000**
Estimated Subtotal Construction Cost including Contingency					$180,000,000		$49,000,000
Mobilization				5%	$9,000,000		$2,500,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$190,000,000**		**$52,000,000**
Implementation							
Planning / Environmental				5%	$9,500,000		$2,600,000
Design Cost				15%	$29,000,000		$7,800,000
Project Administration and Construction Management Cost				10%	$19,000,000		$5,200,000
Estimated Total Capital Cost including Implementation and Contingency					**$250,000,000**		**$68,000,000**
					Present Worth of Salvage Value		**$28,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
RO System	8		MGD	$ 480,000	$3,800,000		
Advanced Oxidation and Disinfection	8		MGD	$ 49,000	$390,000		
Free Chlorine	8		MGD	$ 32,000	$260,000		
Chemicals	8		MGD	$ 120,000	$960,000		
Labor	8	2,080	hrs/MGD	$ 135	$2,200,000		
Electricity		7,240,000	kWh/yr	$ 0.15	$1,100,000		
Monitoring			$/year	$ 100,000	$100,000		
Groundwater Wells							
Labor Costs		1,456	hrs	$ 135	$200,000		
Electricity		5,733,000	kWh/yr	$ 0.15	$860,000		
Well Consumables		0.5% of well construction cost			$150,000		
Conveyance							
Annual O&M			2% of construction cost		$890,000		
Pump Stations							
Labor Costs		1,000	hrs	$ 135	$140,000		
Electricity		8,930,000	kWh/yr	$ 0.15	$1,300,000		
Pump Station Consumables		5% of pump station construction cost			$410,000		
Storage Tanks							
Annual O&M		1% of construction cost			$22,000		
			Total O&M Costs ($/yr)		$15,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$13,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,400,000		
Annual O&M Costs					$15,000,000		
Total Annualized Cost					$27,000,000		
Deliveries of Recycled Water	8,060 AFY						
Estimated Unit Cost ($/AF)					**$3,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,100**	**Distribution**	**$1,200**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$13,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,400,000	*Same as constant use.*	
Annual O&M Costs					$12,176,000		
Total Annualized Cost					$24,000,000		
Annual Average Deliveries of Recycled Water	2,418 AFY						
Estimated Unit Cost ($/AF)					**$9,900**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$6,200**	**Distribution**	**$3,700**		

Alternative SL-Raw-1					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	1		MGD	$ 1,225,000	$1,700,000	30 yrs	$0
RO System	1		MGD	$ 1,475,000	$2,100,000	30 yrs	$0
Advanced Oxidation and Disinfection	1		MGD	$ 437,500	$610,000	30 yrs	$0
Chemicals (Storage and Use)	1			$ 125,000	$180,000	30 yrs	$0
Sitework/Piping/Structures	1		MGD	$ 3,187,500	$4,500,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$9,100,000**		**$0**
Contractor Overhead & Profit				15%	$1,400,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$410,000		$0
			Estimated Subtotal Construction Cost		**$11,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$11,000,000**		**$0**
Estimating Contingency				25%	$2,800,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$14,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	10-in	300 LF	in-LF	$ 30	$90,000	75 yrs	$54,000
Low-Density Urban Pipeline	10-in	18,600 LF	in-LF	$ 40	$7,440,000	75 yrs	$4,500,000
High-Density Urban Pipeline	10-in	9,600 LF	in-LF	$ 50	$4,800,000	75 yrs	$2,900,000
Trenchless Crossings							
HDD (All Inclusive)		3,350	LF	$ 2,200	$7,400,000	75 yrs	$4,400,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	225 HP	EA (Cost Curve based on total installed HP)		$ 1,600,000	$1,600,000	50 yrs	$640,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.2 MG	3	EA (Cost Curve by Volume)	$ 2,500,000	$7,500,000	75 yrs	$4,500,000
			Estimated Subtotal Cost (2) including Contingency		**$29,000,000**		**$17,000,000**
Estimated Subtotal Construction Cost including Contingency					$43,000,000		$17,000,000
Mobilization				5%	$2,200,000		$850,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$45,000,000**		**$18,000,000**
Implementation							
Environmental Documentation & Permits				5%	$2,300,000		$900,000
Design Cost				15%	$6,800,000		$2,700,000
Project Administration and Construction Management Cost				10%	$4,500,000		$1,800,000
Estimated Total Capital Cost including Implementation and Contingency					**$59,000,000**		**$23,000,000**
					Present Worth of Salvage Value		**$9,400,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	1		MGD	$ 325,000	$460,000		
RO System	1		MGD	$ 480,000	$670,000		
Advanced Oxidation and Disinfection	1		MGD	$ 49,000	$69,000		
Free Chlorine	1		MGD	$ 32,000	$45,000		
Chemicals	1		MGD	$ 120,000	$170,000		
Labor	1	2,080	hrs/MGD	$ 135	$390,000		
Electricity		1,267,000	kWh/yr	$ 0.15	$190,000		
Monitoring			$/year	$ 500,000	$500,000		
Conveyance							
Annual O&M			2% of construction cost		$390,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		823,000	kWh/yr	$ 0.15	$120,000		
Pump Station Consumables		5% of pump station construction cost			$80,000		
Storage Tanks							
Annual O&M		1% of construction cost			$75,000		
			Total O&M Costs ($/yr)		$3,200,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$3,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$480,000		
Annual O&M Costs					$3,200,000		
Total Annualized Cost					$5,700,000		
Deliveries of Recycled Water	1,570 AFY						
Estimated Unit Cost ($/AF)					**$3,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,200**	**Distribution**	**$1,400**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$3,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$480,000	*Same as constant use.*	
Annual O&M Costs					$2,509,500		
Total Annualized Cost					$5,000,000		
Annual Average Deliveries of Recycled Water	471 AFY						
Estimated Unit Cost ($/AF)					**$11,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,900**	**Distribution**	**$5,100**		

Alternative SL-ResU-1						EBMUD Recycled Water Master Plan Update	
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	1		MGD	$ 1,225,000	$1,700,000	30 yrs	$0
RO System	1		MGD	$ 1,475,000	$2,100,000	30 yrs	$0
Advanced Oxidation and Disinfection	1		MGD	$ 437,500	$610,000	30 yrs	$0
Chemicals (Storage and Use)	1			$ 125,000	$180,000	30 yrs	$0
Sitework/Piping/Structures	1		MGD	$ 3,187,500	$4,500,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$9,100,000**		**$0**
Contractor Overhead & Profit				15%	$1,400,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$410,000		$0
				Estimated Subtotal Construction Cost	**$11,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$11,000,000**		**$0**
Estimating Contingency				25%	$2,800,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$14,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	10-in	1,800 LF	in-LF	$ 30	$540,000	75 yrs	$320,000
Low-Density Urban Pipeline	10-in	20,900 LF	in-LF	$ 40	$8,360,000	75 yrs	$5,000,000
High-Density Urban Pipeline	10-in	5,000 LF	in-LF	$ 50	$2,500,000	75 yrs	$1,500,000
Trenchless Crossings							
Microtunnel Xings (1 jack & 1 receiv. pit)		9	EA	$ 620,000	$5,600,000		
Microtunnel Pipe		7,000	LF	$ 2,800	$20,000,000	75 yrs	$12,000,000
HDD (All Inclusive)		3,200	LF	$ 2,200	$7,000,000	75 yrs	$4,200,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	300 HP	EA (Cost Curve based on total installed HP)		$ 1,800,000	$1,800,000	50 yrs	$720,000
				Estimated Subtotal Cost (2) including Contingency	**$46,000,000**		**$24,000,000**
Estimated Subtotal Construction Cost including Contingency					$60,000,000		$24,000,000
Mobilization				5%	$3,000,000		$1,200,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$63,000,000**		**$25,000,000**
Implementation							
Environmental Documentation & Permits				5%	$3,200,000		$1,300,000
Design Cost				15%	$9,500,000		$3,800,000
Project Administration and Construction Management Cost				10%	$6,300,000		$2,500,000
Estimated Total Capital Cost including Implementation and Contingency					**$82,000,000**		**$33,000,000**
						Present Worth of Salvage Value	**$14,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	1		MGD	$ 325,000	$460,000		
RO System	1		MGD	$ 480,000	$670,000		
Advanced Oxidation and Disinfection	1		MGD	$ 49,000	$69,000		
Free Chlorine	1		MGD	$ 32,000	$45,000		
Chemicals	1		MGD	$ 120,000	$170,000		
Labor	1	2,080	hrs/MGD	$ 135	$390,000		
Electricity		1,267,000	kWh/yr	$ 0.15	$190,000		
Conveyance							
Annual O&M			2% of construction cost		$880,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		963,000	kWh/yr	$ 0.15	$140,000		
Pump Station Consumables		5% of pump station construction cost			$90,000		
				Total O&M Costs ($/yr)	$3,200,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$4,200,000		
Annualized Salvage Value	*Annualized value of present worth*				-$710,000		
Annual O&M Costs					$3,200,000		
Total Annualized Cost					$6,700,000		
Deliveries of Recycled Water	1,570 AFY						
Estimated Unit Cost ($/AF)					**$4,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$2,400**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$4,200,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$710,000	*Same as constant use.*	
Annual O&M Costs					$2,790,500		
Total Annualized Cost					$6,300,000		
Annual Average Deliveries of Recycled Water	471 AFY						
Estimated Unit Cost ($/AF)					**$13,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,700**	**Distribution**	**$7,300**		

Alternative SL-Chabot-1							EBMUD Recycled Water Master Plan Update
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	1		MGD	$ 1,225,000	$1,700,000	30 yrs	$0
RO System	1		MGD	$ 1,475,000	$2,100,000	30 yrs	$0
Advanced Oxidation and Disinfection	1		MGD	$ 437,500	$610,000	30 yrs	$0
Chemicals (Storage and Use)	1			$ 125,000	$180,000	30 yrs	$0
Sitework/Piping/Structures	1		MGD	$ 3,187,500	$4,500,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$9,100,000**		**$0**
Contractor Overhead & Profit				15%	$1,400,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$410,000		$0
				Estimated Subtotal Construction Cost	**$11,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$11,000,000**		**$0**
Estimating Contingency				25%	$2,800,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$14,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	10-in	4,400 LF	in-LF	$ 30	$1,320,000	75 yrs	$790,000
Low-Density Urban Pipeline	10-in	14,500 LF	in-LF	$ 40	$5,800,000	75 yrs	$3,500,000
High-Density Urban Pipeline	10-in	7,500 LF	in-LF	$ 50	$3,750,000	75 yrs	$2,300,000
Trenchless Crossings							
HDD (All Inclusive)		2,600	LF	$ 2,200	$5,700,000	75 yrs	$3,400,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	120 HP		EA (Cost Curve based on total installed HP)	$ 1,400,000	$1,400,000	50 yrs	$560,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.0 MG	0	EA (Cost Curve by Volume)	$ 2,300,000	$0	75 yrs	$0
				Estimated Subtotal Cost (2) including Contingency	**$18,000,000**		**$11,000,000**
Estimated Subtotal Construction Cost including Contingency					$32,000,000		$11,000,000
Mobilization				5%	$1,600,000		$550,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$34,000,000**		**$12,000,000**
Implementation							
Environmental Documentation & Permits				5%	$1,700,000		$600,000
Design Cost				15%	$5,100,000		$1,800,000
Project Administration and Construction Management Cost				10%	$3,400,000		$1,200,000
Estimated Total Capital Cost including Implementation and Contingency					**$44,000,000**		**$16,000,000**
					Present Worth of Salvage Value		**$6,500,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	1		MGD	$ 325,000	$460,000		
RO System	1		MGD	$ 480,000	$670,000		
Advanced Oxidation and Disinfection	1		MGD	$ 49,000	$69,000		
Free Chlorine	1		MGD	$ 32,000	$45,000		
Chemicals	1		MGD	$ 120,000	$170,000		
Labor	1	2,080	hrs/MGD	$ 135	$390,000		
Electricity		1,267,000	kWh/yr	$ 0.15	$190,000		
Conveyance							
Annual O&M			2% of construction cost		$330,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		482,000	kWh/yr	$ 0.15	$72,000		
Pump Station Consumables		5% of pump station construction cost			$70,000		
			Total O&M Costs ($/yr)		$2,500,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,200,000		
Annualized Salvage Value	*Annualized value of present worth*				-$330,000		
Annual O&M Costs					$2,500,000		
Total Annualized Cost					$4,400,000		
Deliveries of Recycled Water	780 AFY						
Estimated Unit Cost ($/AF)					**$5,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$3,800**	**Distribution**	**$1,800**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,200,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$330,000	*Same as constant use.*	
Annual O&M Costs					$2,200,100		
Total Annualized Cost					$4,100,000		
Annual Average Deliveries of Recycled Water	234 AFY						
Estimated Unit Cost ($/AF)					**$18,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$12,000**	**Distribution**	**$6,000**		

Alternative SL-Treat-1					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
Ozone	1		MGD	$ 335,300	$470,000	30 yrs	$0
BAC	1		MGD	$ 300,900	$420,000	30 yrs	$0
MF/UF system	1		MGD	$ 1,225,000	$1,700,000	30 yrs	$0
RO System	1		MGD	$ 1,475,000	$2,100,000	30 yrs	$0
Advanced Oxidation and Disinfection	1		MGD	$ 437,500	$610,000	30 yrs	$0
Chemicals (Storage and Use)	1			$ 125,000	$180,000	30 yrs	$0
Sitework/Piping/Structures	1		MGD	$ 3,187,500	$4,500,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$10,000,000**		**$0**
Contractor Overhead & Profit				15%	$1,500,000		$0
Sales Tax	**50%**	% of Subtotal Cost Applicable		9%	$450,000		$0
			Estimated Subtotal Construction Cost		**$12,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$12,000,000**		**$0**
Estimating Contingency				25%	$3,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$15,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	10-in	1,000 LF	in-LF	$ 30	$300,000	75 yrs	$180,000
Low-Density Urban Pipeline	10-in	6,900 LF	in-LF	$ 40	$2,760,000	75 yrs	$1,700,000
High-Density Urban Pipeline	10-in	9,400 LF	in-LF	$ 50	$4,700,000	75 yrs	$2,800,000
Trenchless Crossings							
HDD (All Inclusive)		2,420	LF	$ 2,200	$5,300,000	75 yrs	$3,200,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	120 HP	EA (Cost Curve based on total installed HP)		$ 1,400,000	$1,400,000	50 yrs	$560,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.2 MG	3	EA (Cost Curve by Volume)	$ 2,500,000	$7,500,000	75 yrs	$4,500,000
			Estimated Subtotal Cost (2) including Contingency		**$22,000,000**		**$13,000,000**
Estimated Subtotal Construction Cost including Contingency					$37,000,000		$13,000,000
Mobilization				5%	$1,900,000		$650,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$39,000,000**		**$14,000,000**
Implementation							
Environmental Documentation & Permits				5%	$2,000,000		$700,000
Design Cost				15%	$5,900,000		$2,100,000
Project Administration and Construction Management Cost				10%	$3,900,000		$1,400,000
Estimated Total Capital Cost including Implementation and Contingency					**$51,000,000**		**$18,000,000**
					Present Worth of Salvage Value		**$7,400,000**
O&M Costs (Annual)							
Advanced Water Treatment							
Ozone	1		MGD	$ 57,000	$80,000		
BAC	1		MGD	$ 116,000	$160,000		
MF/UF system	1		MGD	$ 325,000	$460,000		
RO System	1		MGD	$ 480,000	$670,000		
Advanced Oxidation and Disinfection	1		MGD	$ 49,000	$69,000		
Free Chlorine	1		MGD	$ 32,000	$45,000		
Chemicals	1		MGD	$ 120,000	$170,000		
Labor	1	2,080	hrs/MGD	$ 135	$390,000		
Electricity		1,740,200	kWh/yr	$ 0.15	$260,000		
Monitoring			$/year	$ 1,000,000	$1,000,000		
Surface Water Treatment							
SWT O&M (Orinda)	511		MG	$ 70	$36,000		
Conveyance							
Annual O&M			2% of construction cost		$260,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		462,000	kWh/yr	$ 0.15	$69,000		
Pump Station Consumables		5% of pump station construction cost			$70,000		
Storage Tanks							
Annual O&M		1% of construction cost			$75,000		
			Total O&M Costs ($/yr)		$3,900,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,600,000		
Annualized Salvage Value	*Annualized value of present worth*				-$380,000		
Annual O&M Costs					$3,900,000		
Total Annualized Cost					$6,100,000		
Deliveries of Recycled Water	1,570 AFY						
Estimated Unit Cost ($/AF)					**$3,900**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,700**	**Distribution**	**$1,200**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,600,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$380,000	*Same as constant use.*	
Annual O&M Costs					$2,776,000		
Total Annualized Cost					$5,000,000		
Annual Average Deliveries of Recycled Water	471 AFY						
Estimated Unit Cost ($/AF)					**$11,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$7,000**	**Distribution**	**$4,000**		

Alternative Pin-Raw-2					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	2		MGD	$ 1,225,000	$2,100,000	30 yrs	$0
RO System	2		MGD	$ 1,475,000	$2,500,000	30 yrs	$0
Advanced Oxidation and Disinfection	2		MGD	$ 437,500	$740,000	30 yrs	$0
Chemicals (Storage and Use)	2			$ 125,000	$210,000	30 yrs	$0
Sitework/Piping/Structures	2		MGD	$ 3,187,500	$5,400,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$11,000,000**		**$0**
Contractor Overhead & Profit				15%	$1,700,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$500,000		$0
			Estimated Subtotal Construction Cost		**$13,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$13,000,000**		**$0**
Estimating Contingency				25%	$3,300,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$16,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	10-in	6,800 LF	in-LF	$ 30	$2,040,000	75 yrs	$1,200,000
Low-Density Urban Pipeline	10-in	22,100 LF	in-LF	$ 40	$8,840,000	75 yrs	$5,300,000
High-Density Urban Pipeline	10-in	400 LF	in-LF	$ 50	$200,000	75 yrs	$120,000
Trenchless Crossings							
HDD (All Inclusive)		1,100	LF	$ 2,200	$2,400,000	75 yrs	$1,400,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	180 HP	EA (Cost Curve based on total installed HP)		$ 1,600,000	$1,600,000	50 yrs	$640,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.2 MG	3	EA (Cost Curve by Volume)	$ 2,500,000	$7,500,000	75 yrs	$4,500,000
			Estimated Subtotal Cost (2) including Contingency		**$23,000,000**		**$13,000,000**
Estimated Subtotal Construction Cost including Contingency					$39,000,000		$13,000,000
Mobilization				5%	$2,000,000		$650,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$41,000,000**		**$14,000,000**
Implementation							
Environmental Documentation & Permits				5%	$2,100,000		$700,000
Design Cost				15%	$6,200,000		$2,100,000
Project Administration and Construction Management Cost				10%	$4,100,000		$1,400,000
Estimated Total Capital Cost including Implementation and Contingency					**$53,000,000**		**$18,000,000**
					Present Worth of Salvage Value		**$7,400,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	2		MGD	$ 325,000	$550,000		
RO System	2		MGD	$ 480,000	$820,000		
Advanced Oxidation and Disinfection	2		MGD	$ 49,000	$83,000		
Free Chlorine	2		MGD	$ 32,000	$54,000		
Chemicals	2		MGD	$ 120,000	$200,000		
Labor	2	2,080	hrs/MGD	$ 135	$480,000		
Electricity		1,538,500	kWh/yr	$ 0.15	$230,000		
Monitoring			$/year	$ 500,000	$500,000		
Conveyance							
Annual O&M			2% of construction cost		$270,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		658,000	kWh/yr	$ 0.15	$99,000		
Pump Station Consumables		5% of pump station construction cost			$80,000		
Storage Tanks							
Annual O&M		1% of construction cost			$75,000		
			Total O&M Costs ($/yr)		$3,500,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,700,000		
Annualized Salvage Value	*Annualized value of present worth*				-$380,000		
Annual O&M Costs					$3,500,000		
Total Annualized Cost					$5,800,000		
Deliveries of Recycled Water	1,900 AFY						
Estimated Unit Cost ($/AF)					**$3,100**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,100**	**Distribution**	**$1,000**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,700,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$380,000	*Same as constant use.*	
Annual O&M Costs					$2,750,900		
Total Annualized Cost					$5,100,000		
Annual Average Deliveries of Recycled Water	570 AFY						
Estimated Unit Cost ($/AF)					**$8,900**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,800**	**Distribution**	**$3,100**		

Alternative Pin-ResB-2							EBMUD Recycled Water Master Plan Update
Last Updated:	30-May-18				Discount Rate	Project Life	
Updated by:	I. Jaffe				3%	30 Years	
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	2		MGD	$ 1,225,000	$2,100,000	30 yrs	$0
RO System	2		MGD	$ 1,475,000	$2,500,000	30 yrs	$0
Advanced Oxidation and Disinfection	2		MGD	$ 437,500	$740,000	30 yrs	$0
Chemicals (Storage and Use)	2			$ 125,000	$210,000	30 yrs	$0
Sitework/Piping/Structures	2		MGD	$ 3,187,500	$5,400,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$11,000,000**		**$0**
Contractor Overhead & Profit				15%	$1,700,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$500,000		$0
			Estimated Subtotal Construction Cost		**$13,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$13,000,000**		**$0**
Estimating Contingency				25%	$3,300,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$16,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	10-in	62,900 LF	in-LF	$ 30	$18,870,000	75 yrs	$11,000,000
Low-Density Urban Pipeline	10-in	14,100 LF	in-LF	$ 40	$5,640,000	75 yrs	$3,400,000
High-Density Urban Pipeline	10-in	800 LF	in-LF	$ 50	$400,000	75 yrs	$240,000
Trenchless Crossings							
HDD (All Inclusive)		1,700	LF	$ 2,200	$3,700,000	75 yrs	$2,200,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	375 HP	EA (Cost Curve based on total installed HP)		$ 1,900,000	$1,900,000	50 yrs	$760,000
			Estimated Subtotal Cost (2) including Contingency		**$31,000,000**		**$18,000,000**
Estimated Subtotal Construction Cost including Contingency					$47,000,000		$18,000,000
Mobilization				5%	$2,400,000		$900,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$49,000,000**		**$19,000,000**
Implementation							
Environmental Documentation & Permits				5%	$2,500,000		$950,000
Design Cost				15%	$7,400,000		$2,900,000
Project Administration and Construction Management Cost				10%	$4,900,000		$1,900,000
Estimated Total Capital Cost including Implementation and Contingency					**$64,000,000**		**$25,000,000**
					Present Worth of Salvage Value		**$10,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	2		MGD	$ 325,000	$550,000		
RO System	2		MGD	$ 480,000	$820,000		
Advanced Oxidation and Disinfection	2		MGD	$ 49,000	$83,000		
Free Chlorine	2		MGD	$ 32,000	$54,000		
Chemicals	2		MGD	$ 120,000	$200,000		
Labor	2	2,080	hrs/MGD	$ 135	$480,000		
Electricity		1,538,500	kWh/yr	$ 0.15	$230,000		
Surface Water Treatment							
SWT O&M (Orinda)	621		MG	$ 70	$43,000		
Conveyance							
Annual O&M			2% of construction cost		$570,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		1,559,000	kWh/yr	$ 0.15	$230,000		
Pump Station Consumables		5% of pump station construction cost			$95,000		
			Total O&M Costs ($/yr)		$3,400,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$3,300,000		
Annualized Salvage Value	*Annualized value of present worth*				-$510,000		
Annual O&M Costs					$3,400,000		
Total Annualized Cost					$6,200,000		
Deliveries of Recycled Water		1,900 AFY					
Estimated Unit Cost ($/AF)					**$3,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$1,400**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$3,300,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$510,000	*Same as constant use.*	
Annual O&M Costs					$2,893,100		
Total Annualized Cost					$5,700,000		
Annual Average Deliveries of Recycled Water		570 AFY					
Estimated Unit Cost ($/AF)					**$10,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,600**	**Distribution**	**$4,400**		

Alternative Pin-ResSP-2					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	2		MGD	$ 1,225,000	$2,100,000	30 yrs	$0
RO System	2		MGD	$ 1,475,000	$2,500,000	30 yrs	$0
Advanced Oxidation and Disinfection	2		MGD	$ 437,500	$740,000	30 yrs	$0
Chemicals (Storage and Use)	2			$ 125,000	$210,000	30 yrs	$0
Sitework/Piping/Structures	2		MGD	$ 3,187,500	$5,400,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$11,000,000**		**$0**
Contractor Overhead & Profit				15%	$1,700,000		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$500,000		$0
			Estimated Subtotal Construction Cost		**$13,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$13,000,000**		**$0**
Estimating Contingency				25%	$3,300,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$16,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	10-in	21,800 LF	in-LF	$ 30	$6,540,000	75 yrs	$3,900,000
Low-Density Urban Pipeline	10-in	20,800 LF	in-LF	$ 40	$8,320,000	75 yrs	$5,000,000
Trenchless Crossings							
HDD (All Inclusive)		1,700	LF	$ 2,200	$3,700,000	75 yrs	$2,200,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	225 HP	EA (Cost Curve based on total installed HP)		$ 1,600,000	$1,600,000	50 yrs	$640,000
			Estimated Subtotal Cost (2) including Contingency		**$20,000,000**		**$12,000,000**
Estimated Subtotal Construction Cost including Contingency					$36,000,000		$12,000,000
Mobilization				5%	$1,800,000		$600,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$38,000,000**		**$13,000,000**
Implementation							
Environmental Documentation & Permits				5%	$1,900,000		$650,000
Design Cost				15%	$5,700,000		$2,000,000
Project Administration and Construction Management Cost				10%	$3,800,000		$1,300,000
Estimated Total Capital Cost including Implementation and Contingency					**$49,000,000**		**$17,000,000**
					Present Worth of Salvage Value		**$7,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	2		MGD	$ 325,000	$550,000		
RO System	2		MGD	$ 480,000	$820,000		
Advanced Oxidation and Disinfection	2		MGD	$ 49,000	$83,000		
Free Chlorine	2		MGD	$ 32,000	$54,000		
Chemicals	2		MGD	$ 120,000	$200,000		
Labor	2	2,080	hrs/MGD	$ 135	$480,000		
Electricity		1,538,500	kWh/yr	$ 0.15	$230,000		
Surface Water Treatment							
SWT O&M (Sobrante WTP)	621		MG	$ 254	$160,000		
Conveyance							
Annual O&M			2% of construction cost		$370,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		853,000	kWh/yr	$ 0.15	$130,000		
Pump Station Consumables		5% of pump station construction cost			$80,000		
			Total O&M Costs ($/yr)		$3,200,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,500,000		
Annualized Salvage Value	*Annualized value of present worth*				-$360,000		
Annual O&M Costs					$3,200,000		
Total Annualized Cost					$5,300,000		
Deliveries of Recycled Water	1,900 AFY						
Estimated Unit Cost ($/AF)					**$2,800**		
Breakdown of Estimated Unit Cost ($/AF)	**Treatment**		**$1,900**	**Distribution**	**$900**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,500,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$360,000	*Same as constant use.*	
Annual O&M Costs					$2,683,200		
Total Annualized Cost					$4,800,000		
Annual Average Deliveries of Recycled Water	570 AFY						
Estimated Unit Cost ($/AF)					**$8,400**		
Breakdown of Estimated Unit Cost ($/AF)	**Treatment**		**$5,600**	**Distribution**	**$2,800**		

Alternative Pin-Treat-2					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
Ozone	2		MGD	$ 335,300	$570,000	30 yrs	$0
BAC	2		MGD	$ 300,900	$510,000	30 yrs	$0
MF/UF system	2		MGD	$ 1,225,000	$2,100,000	30 yrs	$0
RO System	2		MGD	$ 1,475,000	$2,500,000	30 yrs	$0
Advanced Oxidation and Disinfection	2		MGD	$ 437,500	$740,000	30 yrs	$0
Chemicals (Storage and Use)	2			$ 125,000	$210,000	30 yrs	$0
Sitework/Piping/Structures	2		MGD	$ 3,187,500	$5,400,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$12,000,000**		**$0**
Contractor Overhead & Profit				15%	$1,800,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$540,000		$0
			Estimated Subtotal Construction Cost		**$14,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$14,000,000**		**$0**
Estimating Contingency				25%	$3,500,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$18,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	10-in	1,600 LF	in-LF	$ 30	$480,000	75 yrs	$290,000
Low-Density Urban Pipeline	10-in	1,100 LF	in-LF	$ 40	$440,000	75 yrs	$260,000
Trenchless Crossings							
HDD (All Inclusive)		550	LF	$ 2,200	$1,200,000	75 yrs	$720,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	225 HP		EA (Cost Curve based on total installed HP)	$ 1,600,000	$1,600,000	50 yrs	$640,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.2 MG	3	EA (Cost Curve by Volume)	$ 2,500,000	$7,500,000	75 yrs	$4,500,000
			Estimated Subtotal Cost (2) including Contingency		**$11,000,000**		**$6,400,000**
Estimated Subtotal Construction Cost including Contingency					$29,000,000		$6,400,000
Mobilization				5%	$1,500,000		$320,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$31,000,000**		**$6,700,000**
Implementation							
Environmental Documentation & Permits				5%	$1,600,000		$340,000
Design Cost				15%	$4,700,000		$1,000,000
Project Administration and Construction Management Cost				10%	$3,100,000		$670,000
Estimated Total Capital Cost including Implementation and Contingency					**$40,000,000**		**$8,700,000**
					Present Worth of Salvage Value		**$3,600,000**
O&M Costs (Annual)							
Advanced Water Treatment							
Ozone	2		MGD	$ 57,000	$97,000		
BAC	2		MGD	$ 116,000	$200,000		
MF/UF system	2		MGD	$ 325,000	$550,000		
RO System	2		MGD	$ 480,000	$820,000		
Advanced Oxidation and Disinfection	2		MGD	$ 49,000	$83,000		
Free Chlorine	2		MGD	$ 32,000	$54,000		
Chemicals	2		MGD	$ 120,000	$200,000		
Labor	2	2,080	hrs/MGD	$ 135	$480,000		
Electricity		2,113,100	kWh/yr	$ 0.15	$320,000		
Monitoring			$/year	$ 1,000,000	$1,000,000		
Conveyance							
Annual O&M			2% of construction cost		$42,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		780,000	kWh/yr	$ 0.15	$120,000		
Pump Station Consumables		5% of pump station construction cost			$80,000		
Storage Tanks							
Annual O&M		1% of construction cost			$75,000		
			Total O&M Costs ($/yr)		$4,200,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$180,000		
Annual O&M Costs					$4,200,000		
Total Annualized Cost					$6,000,000		
Deliveries of Recycled Water	1,900 AFY						
Estimated Unit Cost ($/AF)					**$3,200**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,600**	**Distribution**	**$600**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$2,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$180,000	*Same as constant use.*	
Annual O&M Costs					$3,003,200		
Total Annualized Cost					$4,800,000		
Annual Average Deliveries of Recycled Water	570 AFY						
Estimated Unit Cost ($/AF)					**$8,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$6,800**	**Distribution**	**$1,600**		

Alternative Rich-Raw-4					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	4		MGD	$ 1,225,000	$4,400,000	30 yrs	$0
RO System	4		MGD	$ 1,475,000	$5,300,000	30 yrs	$0
Advanced Oxidation and Disinfection	4		MGD	$ 437,500	$1,600,000	30 yrs	$0
Chemicals (Storage and Use)	4			$ 125,000	$450,000	30 yrs	$0
Sitework/Piping/Structures	4		MGD	$ 3,187,500	$11,000,000	30 yrs	$0
Other (Specify)		0	EA	$ 500	$0	30 yrs	$0
				Raw Construction Cost Subtotal	**$23,000,000**		**$0**
Contractor Overhead & Profit				15%	$3,500,000		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$1,000,000		$0
				Estimated Subtotal Construction Cost	**$28,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$28,000,000**		**$0**
Estimating Contingency				25%	$7,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$35,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	16-in	11,400 LF	in-LF	$ 30	$5,472,000	75 yrs	$3,300,000
Low-Density Urban Pipeline	16-in	30,100 LF	in-LF	$ 40	$19,264,000	75 yrs	$12,000,000
High-Density Urban Pipeline	16-in	7,700 LF	in-LF	$ 50	$6,160,000	75 yrs	$3,700,000
Trenchless Crossings							
HDD (All Inclusive)		2,050	LF	$ 2,200	$4,500,000	75 yrs	$2,700,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	375 HP	EA (Cost Curve based on total installed HP)		$ 1,900,000	$1,900,000	50 yrs	$760,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.3 MG	3	EA (Cost Curve by Volume)	$ 2,600,000	$7,800,000	75 yrs	$4,700,000
				Estimated Subtotal Cost (2) including Contingency	**$45,000,000**		**$27,000,000**
Estimated Subtotal Construction Cost including Contingency					$80,000,000		$27,000,000
Mobilization				5%	$4,000,000		$1,400,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$84,000,000**		**$28,000,000**
Implementation							
Environmental Documentation & Permits				5%	$4,200,000		$1,400,000
Design Cost				15%	$13,000,000		$4,200,000
Project Administration and Construction Management Cost				10%	$8,400,000		$2,800,000
Estimated Total Capital Cost including Implementation and Contingency					**$110,000,000**		**$36,000,000**
					Present Worth of Salvage Value		**$15,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	4		MGD	$ 325,000	$1,200,000		
RO System	4		MGD	$ 480,000	$1,700,000		
Advanced Oxidation and Disinfection	4		MGD	$ 49,000	$180,000		
Free Chlorine	4		MGD	$ 32,000	$120,000		
Chemicals	4		MGD	$ 120,000	$430,000		
Labor	4	2,080	hrs/MGD	$ 135	$1,000,000		
Electricity		3,258,000	kWh/yr	$ 0.15	$490,000		
Monitoring			$/year	$ 500,000	$500,000		
Conveyance							
Annual O&M			2% of construction cost		$710,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		1,445,000	kWh/yr	$ 0.15	$220,000		
Pump Station Consumables		5% of pump station construction cost			$95,000		
Storage Tanks							
Annual O&M		1% of construction cost			$78,000		
			Total O&M Costs ($/yr)		$6,800,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$5,600,000		
Annualized Salvage Value	*Annualized value of present worth*				-$760,000		
Annual O&M Costs					$6,800,000		
Total Annualized Cost					$12,000,000		
Deliveries of Recycled Water	4,030 AFY						
Estimated Unit Cost ($/AF)					**$3,000**		
Breakdown of Estimated Unit Cost ($/AF)	**Treatment**	**$2,000**		**Distribution**	**$1,000**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$5,600,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$760,000	*Same as constant use.*	
Annual O&M Costs					$5,559,000		
Total Annualized Cost					$10,000,000		
Annual Average Deliveries of Recycled Water	1,209 AFY						
Estimated Unit Cost ($/AF)					**$8,300**		
Breakdown of Estimated Unit Cost ($/AF)	**Treatment**	**$5,700**		**Distribution**	**$2,600**		

Alternative Rich-ResB-4					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	4		MGD	$ 1,225,000	$4,400,000	30 yrs	$0
RO System	4		MGD	$ 1,475,000	$5,300,000	30 yrs	$0
Advanced Oxidation and Disinfection	4		MGD	$ 437,500	$1,600,000	30 yrs	$0
Chemicals (Storage and Use)	4			$ 125,000	$450,000	30 yrs	$0
Sitework/Piping/Structures	4		MGD	$ 3,187,500	$11,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$23,000,000**		**$0**
Contractor Overhead & Profit				15%	$3,500,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$1,000,000		$0
			Estimated Subtotal Construction Cost		**$28,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$28,000,000**		**$0**
Estimating Contingency				25%	$7,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$35,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	16-in	38,800 LF	in-LF	$ 30	$18,624,000	75 yrs	$11,000,000
Low-Density Urban Pipeline	16-in	18,000 LF	in-LF	$ 40	$11,520,000	75 yrs	$6,900,000
High-Density Urban Pipeline	16-in	9,100 LF	in-LF	$ 50	$7,280,000	75 yrs	$4,400,000
Trenchless Crossings							
HDD (All Inclusive)		2,450	LF	$ 2,200	$5,400,000	75 yrs	$3,200,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	900 HP	EA (Cost Curve based on total installed HP)		$ 3,300,000	$3,300,000	50 yrs	$1,300,000
			Estimated Subtotal Cost (2) including Contingency		**$46,000,000**		**$27,000,000**
Estimated Subtotal Construction Cost including Contingency					$81,000,000		$27,000,000
Mobilization				5%	$4,100,000		$1,400,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$85,000,000**		**$28,000,000**
Implementation							
Environmental Documentation & Permits				5%	$4,300,000		$1,400,000
Design Cost				15%	$13,000,000		$4,200,000
Project Administration and Construction Management Cost				10%	$8,500,000		$2,800,000
Estimated Total Capital Cost including Implementation and Contingency					**$110,000,000**		**$36,000,000**
					Present Worth of Salvage Value		**$15,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	4		MGD	$ 325,000	$1,200,000		
RO System	4		MGD	$ 480,000	$1,700,000		
Advanced Oxidation and Disinfection	4		MGD	$ 49,000	$180,000		
Free Chlorine	4		MGD	$ 32,000	$120,000		
Chemicals	4		MGD	$ 120,000	$430,000		
Labor	4	2,080	hrs/MGD	$ 135	$1,000,000		
Electricity		3,258,000	kWh/yr	$ 0.15	$490,000		
Surface Water Treatment							
SWT O&M (Orinda)	1,314		MG	$ 70	$92,000		
Conveyance							
Annual O&M			2% of construction cost		$860,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		3,199,000	kWh/yr	$ 0.15	$480,000		
Pump Station Consumables		5% of pump station construction cost			$170,000		
			Total O&M Costs ($/yr)		$6,800,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$5,600,000		
Annualized Salvage Value	*Annualized value of present worth*				-$760,000		
Annual O&M Costs					$6,800,000		
Total Annualized Cost					$12,000,000		
Deliveries of Recycled Water		4,030 AFY					
Estimated Unit Cost ($/AF)					**$3,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$1,100**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$5,600,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$760,000	*Same as constant use.*	
Annual O&M Costs					$5,661,600		
Total Annualized Cost					$11,000,000		
Annual Average Deliveries of Recycled Water		1,209 AFY					
Estimated Unit Cost ($/AF)					**$9,100**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,600**	**Distribution**	**$3,500**		

Alternative Rich-ResSP-4							EBMUD Recycled Water Master Plan Update
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	4		MGD	$ 1,225,000	$4,400,000	30 yrs	$0
RO System	4		MGD	$ 1,475,000	$5,300,000	30 yrs	$0
Advanced Oxidation and Disinfection	4		MGD	$ 437,500	$1,600,000	30 yrs	$0
Chemicals (Storage and Use)	4			$ 125,000	$450,000	30 yrs	$0
Sitework/Piping/Structures	4		MGD	$ 3,187,500	$11,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$23,000,000**		**$0**
Contractor Overhead & Profit				15%	$3,500,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$1,000,000		$0
				Estimated Subtotal Construction Cost	**$28,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$28,000,000**		**$0**
Estimating Contingency				25%	$7,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$35,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	16-in	7,700 LF	in-LF	$ 30	$3,696,000	75 yrs	$2,200,000
Low-Density Urban Pipeline	16-in	19,200 LF	in-LF	$ 40	$12,288,000	75 yrs	$7,400,000
High-Density Urban Pipeline	16-in	9,100 LF	in-LF	$ 50	$7,280,000	75 yrs	$4,400,000
Trenchless Crossings							
HDD (All Inclusive)		2,050	LF	$ 2,200	$4,500,000	75 yrs	$2,700,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	450 HP	EA (Cost Curve based on total installed HP)		$ 2,100,000	$2,100,000	50 yrs	$840,000
				Estimated Subtotal Cost (2) including Contingency	**$30,000,000**		**$18,000,000**
Estimated Subtotal Construction Cost including Contingency					$65,000,000		$18,000,000
Mobilization				5%	$3,300,000		$900,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$68,000,000**		**$19,000,000**
Implementation							
Environmental Documentation & Permits				5%	$3,400,000		$950,000
Design Cost				15%	$10,000,000		$2,900,000
Project Administration and Construction Management Cost				10%	$6,800,000		$1,900,000
Estimated Total Capital Cost including Implementation and Contingency					**$88,000,000**		**$25,000,000**
					Present Worth of Salvage Value		**$10,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	4		MGD	$ 325,000	$1,200,000		
RO System	4		MGD	$ 480,000	$1,700,000		
Advanced Oxidation and Disinfection	4		MGD	$ 49,000	$180,000		
Free Chlorine	4		MGD	$ 32,000	$120,000		
Chemicals	4		MGD	$ 120,000	$430,000		
Labor	4	2,080	hrs/MGD	$ 135	$1,000,000		
Electricity		3,258,000	kWh/yr	$ 0.15	$490,000		
Surface Water Treatment							
SWT O&M (Sobrante WTP)	1,314		MG	$ 254	$330,000		
Conveyance							
Annual O&M			2% of construction cost		$560,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		1,703,000	kWh/yr	$ 0.15	$260,000		
Pump Station Consumables		5% of pump station construction cost			$110,000		
			Total O&M Costs ($/yr)		$6,400,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$4,500,000		
Annualized Salvage Value	*Annualized value of present worth*				-$510,000		
Annual O&M Costs					$6,400,000		
Total Annualized Cost					$10,000,000		
Deliveries of Recycled Water		4,030 AFY					
Estimated Unit Cost ($/AF)					**$2,500**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,000**	**Distribution**	**$500**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$4,500,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$510,000	*Same as constant use.*	
Annual O&M Costs					$5,307,000		
Total Annualized Cost					$9,300,000		
Annual Average Deliveries of Recycled Water		1,209 AFY					
Estimated Unit Cost ($/AF)					**$7,700**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,700**	**Distribution**	**$2,000**		

Alternative Rich-Treat-4					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
Ozone	4		MGD	$ 335,300	$1,200,000	30 yrs	$0
BAC	4		MGD	$ 300,900	$1,100,000	30 yrs	$0
MF/UF system	4		MGD	$ 1,225,000	$4,400,000	30 yrs	$0
RO System	4		MGD	$ 1,475,000	$5,300,000	30 yrs	$0
Advanced Oxidation and Disinfection	4		MGD	$ 437,500	$1,600,000	30 yrs	$0
Chemicals (Storage and Use)	4			$ 125,000	$450,000	30 yrs	$0
Sitework/Piping/Structures	4		MGD	$ 3,187,500	$11,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$25,000,000**		**$0**
Contractor Overhead & Profit				15%	$3,800,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$1,100,000		$0
			Estimated Subtotal Construction Cost		**$30,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$30,000,000**		**$0**
Estimating Contingency				25%	$7,500,000		$0
		Estimated Subtotal Cost (1) including Contingency			**$38,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	16-in	1,600 LF	in-LF	$ 30	$768,000	75 yrs	$460,000
Low-Density Urban Pipeline	16-in	0 LF	in-LF	$ 40	$0	75 yrs	$0
High-Density Urban Pipeline	16-in	0 LF	in-LF	$ 50	$0	75 yrs	$0
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	300 HP	EA (Cost Curve based on total installed HP)		$ 1,800,000	$1,800,000	50 yrs	$720,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.3 MG	3	EA (Cost Curve by Volume)	$ 2,600,000	$7,800,000	75 yrs	$4,700,000
		Estimated Subtotal Cost (2) including Contingency			**$10,000,000**		**$5,900,000**
Estimated Subtotal Construction Cost including Contingency					$48,000,000		$5,900,000
Mobilization				5%	$2,400,000		$300,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$50,000,000**		**$6,200,000**
Implementation							
Environmental Documentation & Permits				5%	$2,500,000		$310,000
Design Cost				15%	$7,500,000		$930,000
Project Administration and Construction Management Cost				10%	$5,000,000		$620,000
Estimated Total Capital Cost including Implementation and Contingency					**$65,000,000**		**$8,100,000**
					Present Worth of Salvage Value		**$3,300,000**
O&M Costs (Annual)							
Advanced Water Treatment							
Ozone	4		MGD	$ 57,000	$210,000		
BAC	4		MGD	$ 116,000	$420,000		
MF/UF system	4		MGD	$ 325,000	$1,200,000		
RO System	4		MGD	$ 480,000	$1,700,000		
Advanced Oxidation and Disinfection	4		MGD	$ 49,000	$180,000		
Free Chlorine	4		MGD	$ 32,000	$120,000		
Chemicals	4		MGD	$ 120,000	$430,000		
Labor	4	2,080	hrs/MGD	$ 135	$1,000,000		
Electricity		4,474,800	kWh/yr	$ 0.15	$670,000		
Monitoring			$/year	$ 1,000,000	$1,000,000		
Conveyance							
Annual O&M			2% of construction cost		$15,400		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		980,000	kWh/yr	$ 0.15	$150,000		
Pump Station Consumables		5% of pump station construction cost			$90,000		
Storage Tanks							
Annual O&M		1% of construction cost			$78,000		
			Total O&M Costs ($/yr)		$7,300,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$3,300,000		
Annualized Salvage Value	*Annualized value of present worth*				-$170,000		
Annual O&M Costs					$7,300,000		
Total Annualized Cost					$10,000,000		
Deliveries of Recycled Water	4,030 AFY						
Estimated Unit Cost ($/AF)					**$2,500**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,400**	**Distribution**	**$100**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$3,300,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$170,000	*Same as constant use.*	
Annual O&M Costs					$5,672,400		
Total Annualized Cost					$8,800,000		
Annual Average Deliveries of Recycled Water	1,209 AFY						
Estimated Unit Cost ($/AF)					**$7,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$6,600**	**Distribution**	**$700**		

Alternative WC-Raw-5

EBMUD Recycled Water Master Plan Update

Last Updated:	30-May-18		Discount Rate	Project Life
Updated by:	I. Jaffe		3%	30 Years
CCI (20 City, Dec 2017): 10870.06				

Item	Size	Qty	Unit	Unit Cost	Total Cost	Useful Life	Salvage Value
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	5		MGD	$ 1,225,000	$5,800,000	30 yrs	$0
RO System	5		MGD	$ 1,475,000	$6,900,000	30 yrs	$0
Advanced Oxidation and Disinfection	5		MGD	$ 437,500	$2,100,000	30 yrs	$0
Chemicals (Storage and Use)	5			$ 125,000	$590,000	30 yrs	$0
Sitework/Piping/Structures	5		MGD	$ 3,187,500	$15,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$30,000,000**		**$0**
Contractor Overhead & Profit				15%	$4,500,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$1,400,000		$0
			Estimated Subtotal Construction Cost		**$36,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$36,000,000**		**$0**
Estimating Contingency				25%	$9,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$45,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	20-in	5,000 LF	in-LF	$ 30	$3,000,000	75 yrs	$1,800,000
Low-Density Urban Pipeline	20-in	44,100 LF	in-LF	$ 40	$35,280,000	75 yrs	$21,000,000
High-Density Urban Pipeline	20-in	7,400 LF	in-LF	$ 50	$7,400,000	75 yrs	$4,400,000
Trenchless Crossings							
HDD (All Inclusive)		3,400	LF	$ 2,200	$7,500,000	75 yrs	$4,500,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	600 HP		EA (Cost Curve based on total installed HP)	$ 2,400,000	$2,400,000	50 yrs	$960,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.4 MG	3	EA (Cost Curve by Volume)	$ 2,700,000	$8,100,000	75 yrs	$4,900,000
			Estimated Subtotal Cost (2) including Contingency		**$64,000,000**		**$38,000,000**
Estimated Subtotal Construction Cost including Contingency					$110,000,000		$38,000,000
Mobilization				5%	$5,500,000		$1,900,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$120,000,000**		**$40,000,000**
Implementation							
Environmental Documentation & Permits				5%	$6,000,000		$2,000,000
Design Cost				15%	$18,000,000		$6,000,000
Project Administration and Construction Management Cost				10%	$12,000,000		$4,000,000
Estimated Total Capital Cost including Implementation and Contingency					**$160,000,000**		**$52,000,000**
						Present Worth of Salvage Value	**$21,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	5		MGD	$ 325,000	$1,500,000		
RO System	5		MGD	$ 480,000	$2,300,000		
Advanced Oxidation and Disinfection	5		MGD	$ 49,000	$230,000		
Free Chlorine	5		MGD	$ 32,000	$150,000		
Chemicals	5		MGD	$ 120,000	$560,000		
Labor	5	2,080	hrs/MGD	$ 135	$1,300,000		
Electricity		4,253,500	kWh/yr	$ 0.15	$640,000		
Monitoring			$/year	$ 500,000	$500,000		
Conveyance							
Annual O&M			2% of construction cost		$1,060,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		2,021,000	kWh/yr	$ 0.15	$300,000		
Pump Station Consumables			5% of pump station construction cost		$120,000		
Storage Tanks							
Annual O&M			1% of construction cost		$81,000		
			Total O&M Costs ($/yr)		$8,800,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$8,100,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,100,000		
Annual O&M Costs					$8,800,000		
Total Annualized Cost					$16,000,000		
Deliveries of Recycled Water		5,260 AFY					
Estimated Unit Cost ($/AF)					**$3,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$1,100**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$8,100,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,100,000	*Same as constant use.*	
Annual O&M Costs					$7,304,000		
Total Annualized Cost					$14,000,000		
Annual Average Deliveries of Recycled Water		1,578 AFY					
Estimated Unit Cost ($/AF)					**$8,900**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,700**	**Distribution**	**$3,200**		

Alternative WC-ResB-5					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate	Project Life	
Updated by:	I. Jaffe				3%	30 Years	
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	5		MGD	$ 1,225,000	$5,800,000	30 yrs	$0
RO System	5		MGD	$ 1,475,000	$6,900,000	30 yrs	$0
Advanced Oxidation and Disinfection	5		MGD	$ 437,500	$2,100,000	30 yrs	$0
Chemicals (Storage and Use)	5			$ 125,000	$590,000	30 yrs	$0
Sitework/Piping/Structures	5		MGD	$ 3,187,500	$15,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$30,000,000**		**$0**
Contractor Overhead & Profit				15%	$4,500,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$1,400,000		$0
				Estimated Subtotal Construction Cost	**$36,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$36,000,000**		**$0**
Estimating Contingency				25%	$9,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$45,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	20-in	60,600 LF	in-LF	$ 30	$36,360,000	75 yrs	$22,000,000
Low-Density Urban Pipeline	20-in	33,000 LF	in-LF	$ 40	$26,400,000	75 yrs	$16,000,000
High-Density Urban Pipeline	20-in	6,300 LF	in-LF	$ 50	$6,300,000	75 yrs	$3,800,000
Trenchless Crossings							
San Pablo Tunnel Rehab		17,600	LF	$ 3,500	$62,000,000	75 yrs	$37,000,000
HDD (All Inclusive)		2,200	LF	$ 2,200	$4,800,000	75 yrs	$2,900,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	1,200 HP	EA (Cost Curve based on total installed HP)		$ 4,200,000	$4,200,000	50 yrs	$1,700,000
				Estimated Subtotal Cost (2) including Contingency	**$140,000,000**		**$83,000,000**
Estimated Subtotal Construction Cost including Contingency					$190,000,000		$83,000,000
Mobilization				5%	$9,500,000		$4,200,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$200,000,000**		**$87,000,000**
Implementation							
Environmental Documentation & Permits				5%	$10,000,000		$4,400,000
Design Cost				15%	$30,000,000		$13,000,000
Project Administration and Construction Management Cost				10%	$20,000,000		$8,700,000
Estimated Total Capital Cost including Implementation and Contingency					**$260,000,000**		**$110,000,000**
						Present Worth of Salvage Value	**$45,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	5		MGD	$ 325,000	$1,500,000		
RO System	5		MGD	$ 480,000	$2,300,000		
Advanced Oxidation and Disinfection	5		MGD	$ 49,000	$230,000		
Free Chlorine	5		MGD	$ 32,000	$150,000		
Chemicals	5		MGD	$ 120,000	$560,000		
Labor	5	2,080	hrs/MGD	$ 135	$1,300,000		
Electricity		4,253,500	kWh/yr	$ 0.15	$640,000		
Surface Water Treatment							
SWT O&M (Orinda)	1,716		MG	$ 70	$120,000		
Conveyance							
Annual O&M			2% of construction cost		$2,700,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		4,514,000	kWh/yr	$ 0.15	$680,000		
Pump Station Consumables		5% of pump station construction cost			$210,000		
			Total O&M Costs ($/yr)		$10,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$13,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$2,300,000		
Annual O&M Costs					$10,000,000		
Total Annualized Cost					$21,000,000		
Deliveries of Recycled Water	5,260 AFY						
Estimated Unit Cost ($/AF)					**$4,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$2,100**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$13,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$2,300,000	*Same as constant use.*	
Annual O&M Costs					$8,953,000		
Total Annualized Cost					$20,000,000		
Annual Average Deliveries of Recycled Water	1,578 AFY						
Estimated Unit Cost ($/AF)					**$13,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,600**	**Distribution**	**$7,400**		

Alternative WC-ResSP-5

EBMUD Recycled Water Master Plan Update

Last Updated:	30-May-18	Discount Rate	Project Life
Updated by:	I. Jaffe	3%	30 Years
CCI (20 City, Dec 2017): 10870.06			

Item	Size	Qty	Unit	Unit Cost	Total Cost	Useful Life	Salvage Value
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	5		MGD	$ 1,225,000	$5,800,000	30 yrs	$0
RO System	5		MGD	$ 1,475,000	$6,900,000	30 yrs	$0
Advanced Oxidation and Disinfection	5		MGD	$ 437,500	$2,100,000	30 yrs	$0
Chemicals (Storage and Use)	5			$ 125,000	$590,000	30 yrs	$0
Sitework/Piping/Structures	5		MGD	$ 3,187,500	$15,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$30,000,000**		**$0**
Contractor Overhead & Profit				15%	$4,500,000		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$1,400,000		$0
			Estimated Subtotal Construction Cost		**$36,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$36,000,000**		**$0**
Estimating Contingency				25%	$9,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$45,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	20-in	21,400 LF	in-LF	$ 30	$12,840,000	75 yrs	$7,700,000
Low-Density Urban Pipeline	20-in	22,500 LF	in-LF	$ 40	$18,000,000	75 yrs	$11,000,000
High-Density Urban Pipeline	20-in	6,600 LF	in-LF	$ 50	$6,600,000	75 yrs	$4,000,000
Trenchless Crossings							
San Pablo Tunnel Rehab		17,600	LF	$ 3,500	$62,000,000	75 yrs	$37,000,000
HDD (All Inclusive)		2,000	LF	$ 2,200	$4,400,000	75 yrs	$2,600,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	600 HP	EA (Cost Curve based on total installed HP)		$ 2,400,000	$2,400,000	50 yrs	$960,000
			Estimated Subtotal Cost (2) including Contingency		**$110,000,000**		**$63,000,000**
Estimated Subtotal Construction Cost including Contingency					$160,000,000		$63,000,000
Mobilization				5%	$8,000,000		$3,200,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$170,000,000**		**$66,000,000**
Implementation							
Environmental Documentation & Permits				5%	$8,500,000		$3,300,000
Design Cost				15%	$26,000,000		$9,900,000
Project Administration and Construction Management Cost				10%	$17,000,000		$6,600,000
Estimated Total Capital Cost including Implementation and Contingency					**$220,000,000**		**$86,000,000**
						Present Worth of Salvage Value	**$35,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	5		MGD	$ 325,000	$1,500,000		
RO System	5		MGD	$ 480,000	$2,300,000		
Advanced Oxidation and Disinfection	5		MGD	$ 49,000	$230,000		
Free Chlorine	5		MGD	$ 32,000	$150,000		
Chemicals	5		MGD	$ 120,000	$560,000		
Labor	5	2,080	hrs/MGD	$ 135	$1,300,000		
Electricity		4,253,500	kWh/yr	$ 0.15	$640,000		
Surface Water Treatment							
SWT O&M (Sobrante WTP)	1,716		MG	$ 254	$440,000		
Conveyance							
Annual O&M			2% of construction cost		$2,100,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		2,358,000	kWh/yr	$ 0.15	$350,000		
Pump Station Consumables		5% of pump station construction cost			$120,000		
			Total O&M Costs ($/yr)		$9,800,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$11,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,800,000		
Annual O&M Costs					$9,800,000		
Total Annualized Cost					$19,000,000		
Deliveries of Recycled Water	5,260 AFY						
Estimated Unit Cost ($/AF)					**$3,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$1,700**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$11,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,800,000	*Same as constant use.*	
Annual O&M Costs					$8,260,000		
Total Annualized Cost					$17,000,000		
Annual Average Deliveries of Recycled Water	1,578 AFY						
Estimated Unit Cost ($/AF)					**$11,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,700**	**Distribution**	**$5,300**		

Alternative WC-Treat-5					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
Ozone	5		MGD	$ 335,300	$1,600,000	30 yrs	$0
BAC	5		MGD	$ 300,900	$1,400,000	30 yrs	$0
MF/UF system	5		MGD	$ 1,225,000	$5,800,000	30 yrs	$0
RO System	5		MGD	$ 1,475,000	$6,900,000	30 yrs	$0
Advanced Oxidation and Disinfection	5		MGD	$ 437,500	$2,100,000	30 yrs	$0
Chemicals (Storage and Use)	5			$ 125,000	$590,000	30 yrs	$0
Sitework/Piping/Structures	5		MGD	$ 3,187,500	$15,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$33,000,000**		**$0**
Contractor Overhead & Profit				15%	$5,000,000		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$1,500,000		$0
				Estimated Subtotal Construction Cost	**$40,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$40,000,000**		**$0**
Estimating Contingency				25%	$10,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$50,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	20-in	1,100 LF	in-LF	$ 30	$660,000	75 yrs	$400,000
Low-Density Urban Pipeline	20-in	5,400 LF	in-LF	$ 40	$4,320,000	75 yrs	$2,600,000
High-Density Urban Pipeline	20-in	4,800 LF	in-LF	$ 50	$4,800,000	75 yrs	$2,900,000
Trenchless Crossings							
HDD (All Inclusive)		1,200	LF	$ 2,200	$2,600,000	75 yrs	$1,600,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	375 HP		EA (Cost Curve based on total installed HP)	$ 1,900,000	$1,900,000	50 yrs	$760,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.4 MG	3	EA (Cost Curve by Volume)	$ 2,700,000	$8,100,000	75 yrs	$4,900,000
				Estimated Subtotal Cost (2) including Contingency	**$22,000,000**		**$13,000,000**
Estimated Subtotal Construction Cost including Contingency					$72,000,000		$13,000,000
Mobilization				5%	$3,600,000		$650,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$76,000,000**		**$14,000,000**
Implementation							
Environmental Documentation & Permits				5%	$3,800,000		$700,000
Design Cost				15%	$11,000,000		$2,100,000
Project Administration and Construction Management Cost				10%	$7,600,000		$1,400,000
Estimated Total Capital Cost including Implementation and Contingency					**$98,000,000**		**$18,000,000**
						Present Worth of Salvage Value	**$7,400,000**
O&M Costs (Annual)							
Advanced Water Treatment							
Ozone	5		MGD	$ 57,000	$270,000		
BAC	5		MGD	$ 116,000	$550,000		
MF/UF system	5		MGD	$ 325,000	$1,500,000		
RO System	5		MGD	$ 480,000	$2,300,000		
Advanced Oxidation and Disinfection	5		MGD	$ 49,000	$230,000		
Free Chlorine	5		MGD	$ 32,000	$150,000		
Chemicals	5		MGD	$ 120,000	$560,000		
Labor	5	2,080	hrs/MGD	$ 135	$1,300,000		
Electricity		5,842,100	kWh/yr	$ 0.15	$880,000		
Monitoring			$/year	$ 1,000,000	$1,000,000		
Conveyance							
Annual O&M			2% of construction cost		$250,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		1,415,000	kWh/yr	$ 0.15	$210,000		
Pump Station Consumables			5% of pump station construction cost		$95,000		
Storage Tanks							
Annual O&M			1% of construction cost		$81,000		
			Total O&M Costs ($/yr)		$9,400,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$5,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$380,000		
Annual O&M Costs					$9,400,000		
Total Annualized Cost					$14,000,000		
Deliveries of Recycled Water	5,260 AFY						
Estimated Unit Cost ($/AF)					**$2,700**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,300**	**Distribution**	**$400**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$5,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$380,000	*Same as constant use.*	
Annual O&M Costs					$7,484,000		
Total Annualized Cost					$12,000,000		
Annual Average Deliveries of Recycled Water	1,578 AFY						
Estimated Unit Cost ($/AF)					**$7,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$6,300**	**Distribution**	**$1,300**		

Alternative Oro-Raw-8					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	8		MGD	$ 1,225,000	$9,800,000	30 yrs	$0
RO System	8		MGD	$ 1,475,000	$12,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	8		MGD	$ 437,500	$3,500,000	30 yrs	$0
Chemicals (Storage and Use)	8			$ 125,000	$1,000,000	30 yrs	$0
Sitework/Piping/Structures	8		MGD	$ 3,187,500	$26,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$52,000,000**		**$0**
Contractor Overhead & Profit				15%	$7,800,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$2,300,000		$0
			Estimated Subtotal Construction Cost		**$62,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$62,000,000**		**$0**
Estimating Contingency				25%	$16,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$78,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	7,900 LF	in-LF	$ 30	$5,688,000	75 yrs	$3,400,000
Low-Density Urban Pipeline	24-in	29,000 LF	in-LF	$ 40	$27,840,000	75 yrs	$17,000,000
High-Density Urban Pipeline	24-in	3,500 LF	in-LF	$ 50	$4,200,000	75 yrs	$2,500,000
Trenchless Crossings							
HDD (All Inclusive)		3,750	LF	$ 2,200	$8,300,000	75 yrs	$5,000,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	1,200 HP	EA (Cost Curve based on total installed HP)		$ 4,200,000	$4,200,000	50 yrs	$1,700,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.7 MG	3	EA (Cost Curve by Volume)	$ 3,000,000	$9,000,000	75 yrs	$5,400,000
			Estimated Subtotal Cost (2) including Contingency		**$59,000,000**		**$35,000,000**
Estimated Subtotal Construction Cost including Contingency					$140,000,000		$35,000,000
Mobilization				5%	$7,000,000		$1,800,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$150,000,000**		**$37,000,000**
Implementation							
Environmental Documentation & Permits				5%	$7,500,000		$1,900,000
Design Cost				15%	$23,000,000		$5,600,000
Project Administration and Construction Management Cost				10%	$15,000,000		$3,700,000
Estimated Total Capital Cost including Implementation and Contingency					**$200,000,000**		**$48,000,000**
					Present Worth of Salvage Value		**$20,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	8		MGD	$ 325,000	$2,600,000		
RO System	8		MGD	$ 480,000	$3,800,000		
Advanced Oxidation and Disinfection	8		MGD	$ 49,000	$390,000		
Free Chlorine	8		MGD	$ 32,000	$260,000		
Chemicals	8		MGD	$ 120,000	$960,000		
Labor	8	2,080	hrs/MGD	$ 135	$2,200,000		
Electricity		7,240,000	kWh/yr	$ 0.15	$1,100,000		
Monitoring			$/year	$ 500,000	$500,000		
Conveyance							
Annual O&M			2% of construction cost		$920,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		4,816,000	kWh/yr	$ 0.15	$720,000		
Pump Station Consumables		5% of pump station construction cost			$210,000		
Storage Tanks							
Annual O&M		1% of construction cost			$90,000		
			Total O&M Costs ($/yr)		$14,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$10,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,000,000		
Annual O&M Costs					$14,000,000		
Total Annualized Cost					$23,000,000		
Deliveries of Recycled Water	8,960 AFY						
Estimated Unit Cost ($/AF)					**$2,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$700**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$10,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,000,000	*Same as constant use.*	
Annual O&M Costs					$11,340,000		
Total Annualized Cost					$20,000,000		
Annual Average Deliveries of Recycled Water	2,688 AFY						
Estimated Unit Cost ($/AF)					**$7,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,600**	**Distribution**	**$1,800**		

Alternative Oro-ResU-8					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate	Project Life	
Updated by:	I. Jaffe				3%	30 Years	
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	8		MGD	$ 1,225,000	$9,800,000	30 yrs	$0
RO System	8		MGD	$ 1,475,000	$12,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	8		MGD	$ 437,500	$3,500,000	30 yrs	$0
Chemicals (Storage and Use)	8			$ 125,000	$1,000,000	30 yrs	$0
Sitework/Piping/Structures	8		MGD	$ 3,187,500	$26,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$52,000,000**		**$0**
Contractor Overhead & Profit				15%	$7,800,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$2,300,000		$0
				Estimated Subtotal Construction Cost	**$62,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$62,000,000**		**$0**
Estimating Contingency				25%	$16,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$78,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	25,300 LF	in-LF	$ 30	$18,216,000	75 yrs	$11,000,000
Low-Density Urban Pipeline	24-in	29,000 LF	in-LF	$ 40	$27,840,000	75 yrs	$17,000,000
High-Density Urban Pipeline	24-in	3,500 LF	in-LF	$ 50	$4,200,000	75 yrs	$2,500,000
Trenchless Crossings							
Microtunnel Xings (1 jack & 1 receiv. pit)		9	EA	$ 620,000	$5,600,000		
Microtunnel Pipe		7,000	LF	$ 2,800	$20,000,000	75 yrs	$12,000,000
HDD (All Inclusive)		3,450	LF	$ 2,200	$7,600,000	75 yrs	$4,600,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	1,500 HP		EA (Cost Curve based on total installed HP)	$ 5,300,000	$5,300,000	50 yrs	$2,100,000
				Estimated Subtotal Cost (2) including Contingency	**$89,000,000**		**$49,000,000**
Estimated Subtotal Construction Cost including Contingency					$170,000,000		$49,000,000
Mobilization				5%	$8,500,000		$2,500,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$180,000,000**		**$52,000,000**
Implementation							
Environmental Documentation & Permits				5%	$9,000,000		$2,600,000
Design Cost				15%	$27,000,000		$7,800,000
Project Administration and Construction Management Cost				10%	$18,000,000		$5,200,000
Estimated Total Capital Cost including Implementation and Contingency					**$230,000,000**		**$68,000,000**
						Present Worth of Salvage Value	**$28,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	8		MGD	$ 325,000	$2,600,000		
RO System	8		MGD	$ 480,000	$3,800,000		
Advanced Oxidation and Disinfection	8		MGD	$ 49,000	$390,000		
Free Chlorine	8		MGD	$ 32,000	$260,000		
Chemicals	8		MGD	$ 120,000	$960,000		
Labor	8	2,080	hrs/MGD	$ 135	$2,200,000		
Electricity		7,240,000	kWh/yr	$ 0.15	$1,100,000		
Conveyance							
Annual O&M			2% of construction cost		$1,670,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		5,848,000	kWh/yr	$ 0.15	$880,000		
Pump Station Consumables		5% of pump station construction cost			$270,000		
			Total O&M Costs ($/yr)		$14,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$12,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,400,000		
Annual O&M Costs					$14,000,000		
Total Annualized Cost					$25,000,000		
Deliveries of Recycled Water		8,960 AFY					
Estimated Unit Cost ($/AF)					**$2,800**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$900**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$12,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,400,000	*Same as constant use.*	
Annual O&M Costs					$11,958,000		
Total Annualized Cost					$23,000,000		
Annual Average Deliveries of Recycled Water		2,688 AFY					
Estimated Unit Cost ($/AF)					**$8,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,600**	**Distribution**	**$3,000**		

Alternative Oro-Chabot-8							EBMUD Recycled Water Master Plan Update
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	8		MGD	$ 1,225,000	$9,800,000	30 yrs	$0
RO System	8		MGD	$ 1,475,000	$12,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	8		MGD	$ 437,500	$3,500,000	30 yrs	$0
Chemicals (Storage and Use)	8			$ 125,000	$1,000,000	30 yrs	$0
Sitework/Piping/Structures	8		MGD	$ 3,187,500	$26,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$52,000,000**		**$0**
Contractor Overhead & Profit				15%	$7,800,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$2,300,000		$0
			Estimated Subtotal Construction Cost		**$62,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$62,000,000**		**$0**
Estimating Contingency				25%	$16,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$78,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	7,700 LF	in-LF	$ 30	$5,544,000	75 yrs	$3,300,000
Low-Density Urban Pipeline	24-in	14,200 LF	in-LF	$ 40	$13,632,000	75 yrs	$8,200,000
High-Density Urban Pipeline	24-in	5,600 LF	in-LF	$ 50	$6,720,000	75 yrs	$4,000,000
Trenchless Crossings							
HDD (All Inclusive)		2,300	LF	$ 2,200	$5,100,000	75 yrs	$3,100,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	750 HP	EA (Cost Curve based on total installed HP)		$ 2,800,000	$2,800,000	50 yrs	$1,100,000
			Estimated Subtotal Cost (2) including Contingency		**$34,000,000**		**$20,000,000**
Estimated Subtotal Construction Cost including Contingency					$110,000,000		$20,000,000
Mobilization				5%	$5,500,000		$1,000,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$120,000,000**		**$21,000,000**
Implementation							
Environmental Documentation & Permits				5%	$6,000,000		$1,100,000
Design Cost				15%	$18,000,000		$3,200,000
Project Administration and Construction Management Cost				10%	$12,000,000		$2,100,000
Estimated Total Capital Cost including Implementation and Contingency					**$160,000,000**		**$27,000,000**
					Present Worth of Salvage Value		**$11,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	8		MGD	$ 325,000	$2,600,000		
RO System	8		MGD	$ 480,000	$3,800,000		
Advanced Oxidation and Disinfection	8		MGD	$ 49,000	$390,000		
Free Chlorine	8		MGD	$ 32,000	$260,000		
Chemicals	8		MGD	$ 120,000	$960,000		
Labor	8	2,080	hrs/MGD	$ 135	$2,200,000		
Electricity		7,240,000	kWh/yr	$ 0.15	$1,100,000		
Conveyance							
Annual O&M			2% of construction cost		$620,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		2,752,000	kWh/yr	$ 0.15	$410,000		
Pump Station Consumables		5% of pump station construction cost			$140,000		
			Total O&M Costs ($/yr)		$13,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$8,100,000		
Annualized Salvage Value	*Annualized value of present worth*				-$560,000		
Annual O&M Costs					$13,000,000		
Total Annualized Cost					$21,000,000		
Deliveries of Recycled Water	8,960 AFY						
Estimated Unit Cost ($/AF)					**$2,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$400**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$8,100,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$560,000	*Same as constant use.*	
Annual O&M Costs					$10,637,000		
Total Annualized Cost					$18,000,000		
Annual Average Deliveries of Recycled Water	2,688 AFY						
Estimated Unit Cost ($/AF)					**$6,700**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,600**	**Distribution**	**$1,100**		

Alternative Oro-Treat-8

EBMUD Recycled Water Master Plan Update

Last Updated:	30-May-18	Discount Rate	Project Life
Updated by:	I. Jaffe	3%	30 Years
CCI (20 City, Dec 2017): 10870.06			

Item	Size	Qty	Unit	Unit Cost	Total Cost	Useful Life	Salvage Value
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
Ozone	8		MGD	$ 335,300	$2,700,000	30 yrs	$0
BAC	8		MGD	$ 300,900	$2,400,000	30 yrs	$0
MF/UF system	8		MGD	$ 1,225,000	$9,800,000	30 yrs	$0
RO System	8		MGD	$ 1,475,000	$12,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	8		MGD	$ 437,500	$3,500,000	30 yrs	$0
Chemicals (Storage and Use)	8			$ 125,000	$1,000,000	30 yrs	$0
Sitework/Piping/Structures	8		MGD	$ 3,187,500	$26,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$57,000,000**		**$0**
Contractor Overhead & Profit				15%	$8,600,000		$0
Sales Tax	**50%**	% of Subtotal Cost Applicable		9%	$2,600,000		$0
			Estimated Subtotal Construction Cost		**$68,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$68,000,000**		**$0**
Estimating Contingency				25%	$17,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$85,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	700 LF	in-LF	$ 30	$504,000	75 yrs	$300,000
Low-Density Urban Pipeline	24-in	8,100 LF	in-LF	$ 40	$7,776,000	75 yrs	$4,700,000
High-Density Urban Pipeline	24-in	1,400 LF	in-LF	$ 50	$1,680,000	75 yrs	$1,000,000
Trenchless Crossings							
HDD (All Inclusive)		300	LF	$ 2,200	$660,000	75 yrs	$400,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	750 HP		EA (Cost Curve based on total installed HP)	$ 2,800,000	$2,800,000	50 yrs	$1,100,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.7 MG	3	EA (Cost Curve by Volume)	$ 3,000,000	$9,000,000	75 yrs	$5,400,000
			Estimated Subtotal Cost (2) including Contingency		**$22,000,000**		**$13,000,000**
Estimated Subtotal Construction Cost including Contingency					$110,000,000		$13,000,000
Mobilization				5%	$5,500,000		$650,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$120,000,000**		**$14,000,000**
Implementation							
Environmental Documentation & Permits				5%	$6,000,000		$700,000
Design Cost				15%	$18,000,000		$2,100,000
Project Administration and Construction Management Cost				10%	$12,000,000		$1,400,000
Estimated Total Capital Cost including Implementation and Contingency					**$160,000,000**		**$18,000,000**
					Present Worth of Salvage Value		**$7,400,000**
O&M Costs (Annual)							
Advanced Water Treatment							
Ozone	8		MGD	$ 57,000	$460,000		
BAC	8		MGD	$ 116,000	$930,000		
MF/UF system	8		MGD	$ 325,000	$2,600,000		
RO System	8		MGD	$ 480,000	$3,800,000		
Advanced Oxidation and Disinfection	8		MGD	$ 49,000	$390,000		
Free Chlorine	8		MGD	$ 32,000	$260,000		
Chemicals	8		MGD	$ 120,000	$960,000		
Labor	8	2,080	hrs/MGD	$ 135	$2,200,000		
Electricity		9,944,000	kWh/yr	$ 0.15	$1,500,000		
Monitoring			$/year	$ 1,000,000	$1,000,000		
Conveyance							
Annual O&M			2% of construction cost		$210,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		2,523,000	kWh/yr	$ 0.15	$380,000		
Pump Station Consumables		5% of pump station construction cost			$140,000		
Storage Tanks							
Annual O&M		1% of construction cost			$90,000		
			Total O&M Costs ($/yr)		$15,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$8,100,000		
Annualized Salvage Value	*Annualized value of present worth*				-$380,000		
Annual O&M Costs					$15,000,000		
Total Annualized Cost					$23,000,000		
Deliveries of Recycled Water	8,960 AFY						
Estimated Unit Cost ($/AF)					**$2,600**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,200**	**Distribution**	**$400**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$8,100,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$380,000	*Same as constant use.*	
Annual O&M Costs					$12,118,000		
Total Annualized Cost					$20,000,000		
Annual Average Deliveries of Recycled Water	2,688 AFY						
Estimated Unit Cost ($/AF)					**$7,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$6,700**	**Distribution**	**$700**		

Alternative CC-Raw-19					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	19		MGD	$ 1,225,000	$23,000,000	30 yrs	$0
RO System	19		MGD	$ 1,475,000	$28,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	19		MGD	$ 437,500	$8,300,000	30 yrs	$0
Chemicals (Storage and Use)	19			$ 125,000	$2,400,000	30 yrs	$0
Sitework/Piping/Structures	19		MGD	$ 3,187,500	$61,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$120,000,000**		**$0**
Contractor Overhead & Profit				15%	$18,000,000		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$5,400,000		$0
			Estimated Subtotal Construction Cost		**$140,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$140,000,000**		**$0**
Estimating Contingency				25%	$35,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$180,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	36-in	15,300 LF	in-LF	$ 30	$16,524,000	75 yrs	$9,900,000
High-Density Urban Pipeline	36-in	3,200 LF	in-LF	$ 50	$5,760,000	75 yrs	$3,500,000
Trenchless Crossings							
Microtunnel Xings (1 jack & 1 receiv. pit)		3	EA	$ 620,000	$1,900,000		
Microtunnel Pipe		2,500	LF	$ 2,800	$7,000,000	75 yrs	$4,200,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	2,400 HP	EA (Cost Curve based on total installed HP)		$ 9,500,000	$9,500,000	50 yrs	$3,800,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	1.6 MG	3	EA (Cost Curve by Volume)	$ 4,000,000	$12,000,000	75 yrs	$7,200,000
			Estimated Subtotal Cost (2) including Contingency		**$53,000,000**		**$29,000,000**
Estimated Subtotal Construction Cost including Contingency					$230,000,000		$29,000,000
Mobilization				5%	$12,000,000		$1,500,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$240,000,000**		**$31,000,000**
Implementation							
Environmental Documentation & Permits				5%	$12,000,000		$1,600,000
Design Cost				15%	$36,000,000		$4,700,000
Project Administration and Construction Management Cost				10%	$24,000,000		$3,100,000
Estimated Total Capital Cost including Implementation and Contingency					**$310,000,000**		**$40,000,000**
					Present Worth of Salvage Value		**$16,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	19		MGD	$ 325,000	$6,200,000		
RO System	19		MGD	$ 480,000	$9,100,000		
Advanced Oxidation and Disinfection	19		MGD	$ 49,000	$930,000		
Free Chlorine	19		MGD	$ 32,000	$610,000		
Chemicals	19		MGD	$ 120,000	$2,300,000		
Labor	19	2,080	hrs/MGD	$ 135	$5,300,000		
Electricity		17,195,000	kWh/yr	$ 0.15	$2,600,000		
Monitoring			$/year	$ 500,000	$500,000		
Surface Water Treatment							
SWT O&M (Walnut Creek)	6,935		MG	$ 76	$530,000		
Conveyance							
Annual O&M			2% of construction cost		$620,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		10,621,000	kWh/yr	$ 0.15	$1,600,000		
Pump Station Consumables		5% of pump station construction cost			$480,000		
Storage Tanks							
Annual O&M		1% of construction cost			$120,000		
			Total O&M Costs ($/yr)		$31,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$16,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$810,000		
Annual O&M Costs					$31,000,000		
Total Annualized Cost					$46,000,000		
Deliveries of Recycled Water	21,280 AFY						
Estimated Unit Cost ($/AF)					**$2,200**		
Breakdown of Estimated Unit Cost ($/AF)	**Treatment**	**$1,900**		**Distribution**	**$300**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$16,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$810,000	*Same as constant use.*	
Annual O&M Costs					$25,260,000		
Total Annualized Cost					$40,000,000		
Annual Average Deliveries of Recycled Water	6,384 AFY						
Estimated Unit Cost ($/AF)					**$6,300**		
Breakdown of Estimated Unit Cost ($/AF)	**Treatment**	**$5,500**		**Distribution**	**$800**		

Alternative CC-Raw-10					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	10		MGD	$ 1,225,000	$12,000,000	30 yrs	$0
RO System	10		MGD	$ 1,475,000	$15,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	10		MGD	$ 437,500	$4,400,000	30 yrs	$0
Chemicals (Storage and Use)	10			$ 125,000	$1,300,000	30 yrs	$0
Sitework/Piping/Structures	10		MGD	$ 3,187,500	$32,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$65,000,000**		**$0**
Contractor Overhead & Profit				15%	$9,800,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$2,900,000		$0
			Estimated Subtotal Construction Cost		**$78,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$78,000,000**		**$0**
Estimating Contingency				25%	$20,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$98,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	15,300 LF	in-LF	$ 30	$11,016,000	75 yrs	$6,600,000
High-Density Urban Pipeline	24-in	3,200 LF	in-LF	$ 50	$3,840,000	75 yrs	$2,300,000
Trenchless Crossings							
HDD (All Inclusive)		2,500	LF	$ 2,200	$5,500,000	75 yrs	$3,300,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	1,500 HP	EA (Cost Curve based on total installed HP)		$ 5,300,000	$5,300,000	50 yrs	$2,100,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.9 MG	3	EA (Cost Curve by Volume)	$ 3,200,000	$9,600,000	75 yrs	$5,800,000
			Estimated Subtotal Cost (2) including Contingency		**$35,000,000**		**$20,000,000**
Estimated Subtotal Construction Cost including Contingency					$130,000,000		$20,000,000
Mobilization				5%	$6,500,000		$1,000,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$140,000,000**		**$21,000,000**
Implementation							
Environmental Documentation & Permits				5%	$7,000,000		$1,100,000
Design Cost				15%	$21,000,000		$3,200,000
Project Administration and Construction Management Cost				10%	$14,000,000		$2,100,000
Estimated Total Capital Cost including Implementation and Contingency					**$180,000,000**		**$27,000,000**
					Present Worth of Salvage Value		**$11,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	10		MGD	$ 325,000	$3,300,000		
RO System	10		MGD	$ 480,000	$4,800,000		
Advanced Oxidation and Disinfection	10		MGD	$ 49,000	$490,000		
Free Chlorine	10		MGD	$ 32,000	$320,000		
Chemicals	10		MGD	$ 120,000	$1,200,000		
Labor	10	2,080	hrs/MGD	$ 135	$2,800,000		
Electricity		9,050,000	kWh/yr	$ 0.15	$1,400,000		
Monitoring			$/year	$ 500,000	$500,000		
Surface Water Treatment							
SWT O&M (Walnut Creek)	3,650		MG	$ 76	$280,000		
Conveyance							
Annual O&M			2% of construction cost		$410,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		5,590,000	kWh/yr	$ 0.15	$840,000		
Pump Station Consumables		5% of pump station construction cost			$270,000		
Storage Tanks							
Annual O&M		1% of construction cost			$96,000		
			Total O&M Costs ($/yr)		$17,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$9,100,000		
Annualized Salvage Value	*Annualized value of present worth*				-$560,000		
Annual O&M Costs					$17,000,000		
Total Annualized Cost					$26,000,000		
Deliveries of Recycled Water	11,200 AFY						
Estimated Unit Cost ($/AF)					**$2,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,000**	**Distribution**	**$300**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$9,100,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$560,000	*Same as constant use.*	
Annual O&M Costs					$13,596,000		
Total Annualized Cost					$22,000,000		
Annual Average Deliveries of Recycled Water	3,360 AFY						
Estimated Unit Cost ($/AF)					**$6,500**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,700**	**Distribution**	**$800**		

Alternative CC-ResB-19					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate	Project Life	
Updated by:	I. Jaffe				3%	30 Years	
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	19		MGD	$ 1,225,000	$23,000,000	30 yrs	$0
RO System	19		MGD	$ 1,475,000	$28,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	19		MGD	$ 437,500	$8,300,000	30 yrs	$0
Chemicals (Storage and Use)	19			$ 125,000	$2,400,000	30 yrs	$0
Sitework/Piping/Structures	19		MGD	$ 3,187,500	$61,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$120,000,000**		**$0**
Contractor Overhead & Profit				15%	$18,000,000		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$5,400,000		$0
			Estimated Subtotal Construction Cost		**$140,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$140,000,000**		**$0**
Estimating Contingency				25%	$35,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$180,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	36-in	27,600 LF	in-LF	$ 30	$29,808,000	75 yrs	$18,000,000
Low-Density Urban Pipeline	36-in	27,200 LF	in-LF	$ 40	$39,168,000	75 yrs	$24,000,000
Trenchless Crossings							
Microtunnel Xings (1 jack & 1 receiv. pit)		8	EA	$ 620,000	$5,000,000		
Microtunnel Pipe		3,300	LF	$ 2,800	$9,200,000	75 yrs	$5,500,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	3,600 HP	EA (Cost Curve based on total installed HP)		$ 17,000,000	$17,000,000	50 yrs	$6,800,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.0 MG	0	EA (Cost Curve by Volume)	$ 2,300,000	$0	75 yrs	$0
			Estimated Subtotal Cost (2) including Contingency		**$100,000,000**		**$54,000,000**
Estimated Subtotal Construction Cost including Contingency					$280,000,000		$54,000,000
Mobilization				5%	$14,000,000		$2,700,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$290,000,000**		**$57,000,000**
Implementation							
Environmental Documentation & Permits				5%	$15,000,000		$2,900,000
Design Cost				15%	$44,000,000		$8,600,000
Project Administration and Construction Management Cost				10%	$29,000,000		$5,700,000
Estimated Total Capital Cost including Implementation and Contingency					**$380,000,000**		**$74,000,000**
					Present Worth of Salvage Value		**$30,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	19		MGD	$ 325,000	$6,200,000		
RO System	19		MGD	$ 480,000	$9,100,000		
Advanced Oxidation and Disinfection	19		MGD	$ 49,000	$930,000		
Free Chlorine	19		MGD	$ 32,000	$610,000		
Chemicals	19		MGD	$ 120,000	$2,300,000		
Labor	19	2,080	hrs/MGD	$ 135	$5,300,000		
Electricity		17,195,000	kWh/yr	$ 0.15	$2,600,000		
Surface Water Treatment							
SWT O&M (Orinda)	6,935		MG	$ 70	$490,000		
Conveyance							
Annual O&M			2% of construction cost		$1,660,000		
Pump Stations							
Labor Costs		1000	hrs	$ 135	$140,000		
Electricity		16,613,000	kWh/yr	$ 0.15	$2,500,000		
Pump Station Consumables		5% of pump station construction cost			$850,000		
			Total O&M Costs ($/yr)		$33,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$19,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,500,000		
Annual O&M Costs					$33,000,000		
Total Annualized Cost					$51,000,000		
Deliveries of Recycled Water	21,280 AFY						
Estimated Unit Cost ($/AF)					**$2,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$500**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$19,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,500,000	*Same as constant use.*	
Annual O&M Costs					$26,730,000		
Total Annualized Cost					$44,000,000		
Annual Average Deliveries of Recycled Water	6,384 AFY						
Estimated Unit Cost ($/AF)					**$6,900**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,500**	**Distribution**	**$1,400**		

Alternative CC-ResB-10					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	10		MGD	$ 1,225,000	$12,000,000	30 yrs	$0
RO System	10		MGD	$ 1,475,000	$15,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	10		MGD	$ 437,500	$4,400,000	30 yrs	$0
Chemicals (Storage and Use)	10			$ 125,000	$1,300,000	30 yrs	$0
Sitework/Piping/Structures	10		MGD	$ 3,187,500	$32,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$65,000,000**		**$0**
Contractor Overhead & Profit				15%	$9,800,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$2,900,000		$0
			Estimated Subtotal Construction Cost		**$78,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$78,000,000**		**$0**
Estimating Contingency				25%	$20,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$98,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	27,600 LF	in-LF	$ 30	$19,872,000	75 yrs	$12,000,000
Low-Density Urban Pipeline	24-in	27,200 LF	in-LF	$ 40	$26,112,000	75 yrs	$16,000,000
Trenchless Crossings							
HDD (All Inclusive)		3,300	LF	$ 2,200	$7,300,000	75 yrs	$4,400,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	2,000 HP	EA (Cost Curve based on total installed HP)		$ 7,500,000	$7,500,000	50 yrs	$3,000,000
			Estimated Subtotal Cost (2) including Contingency		**$61,000,000**		**$35,000,000**
Estimated Subtotal Construction Cost including Contingency					$160,000,000		$35,000,000
Mobilization				5%	$8,000,000		$1,800,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$170,000,000**		**$37,000,000**
Implementation							
Environmental Documentation & Permits				5%	$8,500,000		$1,900,000
Design Cost				15%	$26,000,000		$5,600,000
Project Administration and Construction Management Cost				10%	$17,000,000		$3,700,000
Estimated Total Capital Cost including Implementation and Contingency					**$220,000,000**		**$48,000,000**
					Present Worth of Salvage Value		**$20,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	10		MGD	$ 325,000	$3,300,000		
RO System	10		MGD	$ 480,000	$4,800,000		
Advanced Oxidation and Disinfection	10		MGD	$ 49,000	$490,000		
Free Chlorine	10		MGD	$ 32,000	$320,000		
Chemicals	10		MGD	$ 120,000	$1,200,000		
Labor	10	2,080	hrs/MGD	$ 135	$2,800,000		
Electricity		9,050,000	kWh/yr	$ 0.15	$1,400,000		
Surface Water Treatment							
SWT O&M (Orinda)	3,650		MG	$ 70	$260,000		
Conveyance							
Annual O&M			2% of construction cost		$1,070,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		8,743,000	kWh/yr	$ 0.15	$1,300,000		
Pump Station Consumables		5% of pump station construction cost			$380,000		
			Total O&M Costs ($/yr)		$17,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$11,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,000,000		
Annual O&M Costs					$17,000,000		
Total Annualized Cost					$27,000,000		
Deliveries of Recycled Water	11,200 AFY						
Estimated Unit Cost ($/AF)					**$2,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$500**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$11,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,000,000	*Same as constant use.*	
Annual O&M Costs					$14,252,000		
Total Annualized Cost					$24,000,000		
Annual Average Deliveries of Recycled Water	3,360 AFY						
Estimated Unit Cost ($/AF)					**$7,100**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,700**	**Distribution**	**$1,400**		

Alternative SD1-Raw-30					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	30		MGD	$ 1,225,000	$37,000,000	30 yrs	$0
RO System	30		MGD	$ 1,475,000	$44,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	30		MGD	$ 437,500	$13,000,000	30 yrs	$0
Chemicals (Storage and Use)	30			$ 125,000	$3,800,000	30 yrs	$0
Sitework/Piping/Structures	30		MGD	$ 3,187,500	$96,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$190,000,000**		**$0**
Contractor Overhead & Profit				15%	$29,000,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$8,600,000		$0
			Estimated Subtotal Construction Cost		**$230,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$230,000,000**		**$0**
Estimating Contingency				25%	$58,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$290,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	42-in	26,700 LF	in-LF	$ 30	$33,642,000	75 yrs	$20,000,000
Low-Density Urban Pipeline	42-in	19,500 LF	in-LF	$ 40	$32,760,000	75 yrs	$20,000,000
High-Density Urban Pipeline	42-in	12,700 LF	in-LF	$ 50	$26,670,000	75 yrs	$16,000,000
Trenchless Crossings							
San Pablo Tunnel Rehab		17,600	LF	$ 3,500	$62,000,000	75 yrs	$37,000,000
Microtunnel Xings (1 jack & 1 receiv. pit)		4	EA	$ 620,000	$2,500,000		
Microtunnel Pipe		2,200	LF	$ 2,800	$6,200,000	75 yrs	$3,700,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	3,600 HP		EA (Cost Curve based on total installed HP)	$ 17,000,000	$17,000,000	50 yrs	$6,800,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	2.5 MG	3	EA (Cost Curve by Volume)	$ 4,500,000	$14,000,000	75 yrs	$8,400,000
			Estimated Subtotal Cost (2) including Contingency		**$190,000,000**		**$110,000,000**
Estimated Subtotal Construction Cost including Contingency					$480,000,000		$110,000,000
Mobilization				5%	$24,000,000		$5,500,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$500,000,000**		**$120,000,000**
Implementation							
Environmental Documentation & Permits				5%	$25,000,000		$6,000,000
Design Cost				15%	$75,000,000		$18,000,000
Project Administration and Construction Management Cost				10%	$50,000,000		$12,000,000
Estimated Total Capital Cost including Implementation and Contingency					**$650,000,000**		**$160,000,000**
					Present Worth of Salvage Value		**$65,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	30		MGD	$ 325,000	$9,800,000		
RO System	30		MGD	$ 480,000	$14,000,000		
Advanced Oxidation and Disinfection	30		MGD	$ 49,000	$1,500,000		
Free Chlorine	30		MGD	$ 32,000	$960,000		
Chemicals	30		MGD	$ 120,000	$3,600,000		
Labor	30	2,080	hrs/MGD	$ 135	$8,400,000		
Electricity		27,150,000	kWh/yr	$ 0.15	$4,100,000		
Monitoring			$/year	$ 500,000	$500,000		
Conveyance							
Annual O&M			2% of construction cost		$3,300,000		
Pump Stations							
Labor Costs		1000	hrs	$ 135	$140,000		
Electricity		18,060,000	kWh/yr	$ 0.15	$2,700,000		
Pump Station Consumables		5% of pump station construction cost			$850,000		
Storage Tanks							
Annual O&M		1% of construction cost			$140,000		
			Total O&M Costs ($/yr)		$50,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$33,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$3,300,000		
Annual O&M Costs					$50,000,000		
Total Annualized Cost					$80,000,000		
Deliveries of Recycled Water	33,600 AFY						
Estimated Unit Cost ($/AF)					**$2,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$500**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$33,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$3,300,000	*Same as constant use.*	
Annual O&M Costs					$41,688,000		
Total Annualized Cost					$71,000,000		
Annual Average Deliveries of Recycled Water	10,080 AFY						
Estimated Unit Cost ($/AF)					**$7,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,600**	**Distribution**	**$1,400**		

Alternative SD1-Raw-10								EBMUD Recycled Water Master Plan Update
Last Updated:	30-May-18				Discount Rate		Project Life	
Updated by:	I. Jaffe				3%		30 Years	
CCI (20 City, Dec 2017): 10870.06								
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**	
Capital Costs								
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*							
MBR	10		MGD	$ 11,100,000	$110,000,000	30 yrs	$0	
RO System	10		MGD	$ 1,475,000	$15,000,000	30 yrs	$0	
Advanced Oxidation and Disinfection	10		MGD	$ 437,500	$4,400,000	30 yrs	$0	
Chemicals (Storage and Use)	10			$ 125,000	$1,300,000	30 yrs	$0	
Sitework/Piping/Structures	10		MGD	$ 3,187,500	$32,000,000	30 yrs	$0	
				Raw Construction Cost Subtotal	**$160,000,000**		**$0**	
Contractor Overhead & Profit				15%	$24,000,000		$0	
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$7,200,000		$0	
				Estimated Subtotal Construction Cost	**$190,000,000**		**$0**	
Construction Cost Including Contingency								
				Estimated Subtotal Construction Cost	**$190,000,000**		**$0**	
Estimating Contingency				25%	$48,000,000		$0	
				Estimated Subtotal Cost (1) including Contingency	**$240,000,000**		**$0**	
Capital Costs (from Bids)								
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*							
Non-urban Pipeline	24-in	26,700 LF	in-LF	$ 30	$19,224,000	75 yrs	$12,000,000	
Low-Density Urban Pipeline	24-in	19,500 LF	in-LF	$ 40	$18,720,000	75 yrs	$11,000,000	
High-Density Urban Pipeline	24-in	12,700 LF	in-LF	$ 50	$15,240,000	75 yrs	$9,100,000	
Trenchless Crossings								
San Pablo Tunnel Rehab		17,600	LF	$ 3,500	$62,000,000	75 yrs	$37,000,000	
HDD (All Inclusive)		2,200	LF	$ 2,200	$4,800,000	75 yrs	$2,900,000	
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*							
Pump Station (Total installed HP, including standby)	1,500 HP		EA (Cost Curve based on total installed HP)	$ 5,300,000	$5,300,000	50 yrs	$2,100,000	
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*							
Storage Tanks (material determined during pre-design)	0.9 MG	3	EA (Cost Curve by Volume)	$ 3,200,000	$9,600,000	75 yrs	$5,800,000	
				Estimated Subtotal Cost (2) including Contingency	**$130,000,000**		**$80,000,000**	
Estimated Subtotal Construction Cost including Contingency					$370,000,000		$80,000,000	
Mobilization				5%	$19,000,000		$4,000,000	
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$390,000,000**		**$84,000,000**	
Implementation								
Environmental Documentation & Permits				5%	$20,000,000		$4,200,000	
Design Cost				15%	$59,000,000		$13,000,000	
Project Administration and Construction Management Cost				10%	$39,000,000		$8,400,000	
Estimated Total Capital Cost including Implementation and Contingency					**$510,000,000**		**$110,000,000**	
					Present Worth of Salvage Value		**$45,000,000**	
O&M Costs (Annual)								
Advanced Water Treatment								
MBR	10		MGD	$ 292,000	$2,900,000			
RO System	10		MGD	$ 480,000	$4,800,000			
Advanced Oxidation and Disinfection	10		MGD	$ 49,000	$490,000			
Free Chlorine	10		MGD	$ 32,000	$320,000			
Chemicals	10		MGD	$ 120,000	$1,200,000			
Labor	10	2,080	hrs/MGD	$ 135	$2,800,000			
Electricity		19,230,000	kWh/yr	$ 0.15	$2,900,000			
Monitoring			$/year	$ 500,000	$500,000			
Conveyance								
Annual O&M			2% of construction cost		$2,400,000			
Pump Stations								
Labor Costs		500	hrs	$ 135	$68,000			
Electricity		6,020,000	kWh/yr	$ 0.15	$900,000			
Pump Station Consumables		5% of pump station construction cost			$270,000			
Storage Tanks								
Annual O&M		1% of construction cost			$96,000			
			Total O&M Costs ($/yr)		$20,000,000			
Annualized Costs ($ / Year)								
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$26,000,000			
Annualized Salvage Value	*Annualized value of present worth*				-$2,300,000			
Annual O&M Costs					$20,000,000			
Total Annualized Cost					$44,000,000			
Deliveries of Recycled Water	11,200 AFY							
Estimated Unit Cost ($/AF)					**$3,900**			
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,900**	**Distribution**	**$1,000**			
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$26,000,000	*Same as constant use.*		
Annualized Salvage Value	*Annualized value of present worth*				-$2,300,000	*Same as constant use.*		
Annual O&M Costs					$15,570,000			
Total Annualized Cost					$39,000,000			
Annual Average Deliveries of Recycled Water	3,360 AFY							
Estimated Unit Cost ($/AF)					**$12,000**			
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$8,300**	**Distribution**	**$3,700**			

Alternative SD1-ResU-30					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							

Item	Size	Qty	Unit	Unit Cost	Total Cost	Useful Life	Salvage Value
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	30		MGD	$ 1,225,000	$37,000,000	30 yrs	$0
RO System	30		MGD	$ 1,475,000	$44,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	30		MGD	$ 437,500	$13,000,000	30 yrs	$0
Chemicals (Storage and Use)	30			$ 125,000	$3,800,000	30 yrs	$0
Sitework/Piping/Structures	30		MGD	$ 3,187,500	$96,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$190,000,000**		**$0**
Contractor Overhead & Profit				15%	$29,000,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$8,600,000		$0
			Estimated Subtotal Construction Cost		**$230,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$230,000,000**		**$0**
Estimating Contingency				25%	$58,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$290,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	42-in	17,800 LF	in-LF	$ 30	$22,428,000	75 yrs	$13,000,000
Low-Density Urban Pipeline	42-in	26,800 LF	in-LF	$ 40	$45,024,000	75 yrs	$27,000,000
High-Density Urban Pipeline	42-in	3,800 LF	in-LF	$ 50	$7,980,000	75 yrs	$4,800,000
Trenchless Crossings							
Microtunnel Xings (1 jack & 1 receiv. pit)		7	EA	$ 620,000	$4,300,000		
Microtunnel Pipe		10,550	LF	$ 2,800	$30,000,000	75 yrs	$18,000,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	4,200 HP	EA (Cost Curve based on total installed HP)		$ 22,000,000	$22,000,000	50 yrs	$8,800,000
			Estimated Subtotal Cost (2) including Contingency		**$130,000,000**		**$72,000,000**
Estimated Subtotal Construction Cost including Contingency					$420,000,000		$72,000,000
Mobilization				5%	$21,000,000		$3,600,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$440,000,000**		**$76,000,000**
Implementation							
Environmental Documentation & Permits				5%	$22,000,000		$3,800,000
Design Cost				15%	$66,000,000		$11,000,000
Project Administration and Construction Management Cost				10%	$44,000,000		$7,600,000
Estimated Total Capital Cost including Implementation and Contingency					**$570,000,000**		**$98,000,000**
						Present Worth of Salvage Value	**$40,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	30		MGD	$ 325,000	$9,800,000		
RO System	30		MGD	$ 480,000	$14,000,000		
Advanced Oxidation and Disinfection	30		MGD	$ 49,000	$1,500,000		
Free Chlorine	30		MGD	$ 32,000	$960,000		
Chemicals	30		MGD	$ 120,000	$3,600,000		
Labor	30	2,080	hrs/MGD	$ 135	$8,400,000		
Electricity		27,150,000	kWh/yr	$ 0.15	$4,100,000		
Conveyance							
Annual O&M			2% of construction cost		$2,200,000		
Pump Stations							
Labor Costs		1000	hrs	$ 135	$140,000		
Electricity		21,500,000	kWh/yr	$ 0.15	$3,200,000		
Pump Station Consumables		5% of pump station construction cost			$1,100,000		
			Total O&M Costs ($/yr)		$49,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$29,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$2,000,000		
Annual O&M Costs					$49,000,000		
Total Annualized Cost					$76,000,000		
Deliveries of Recycled Water	33,600 AFY						
Estimated Unit Cost ($/AF)					**$2,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,800**	**Distribution**	**$500**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$29,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$2,000,000	*Same as constant use.*	
Annual O&M Costs					$40,698,000		
Total Annualized Cost					$68,000,000		
Annual Average Deliveries of Recycled Water	10,080 AFY						
Estimated Unit Cost ($/AF)					**$6,700**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,600**	**Distribution**	**$1,100**		

Alternative SD1-ResB-30					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	30		MGD	$ 1,225,000	$37,000,000	30 yrs	$0
RO System	30		MGD	$ 1,475,000	$44,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	30		MGD	$ 437,500	$13,000,000	30 yrs	$0
Chemicals (Storage and Use)	30			$ 125,000	$3,800,000	30 yrs	$0
Sitework/Piping/Structures	30		MGD	$ 3,187,500	$96,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$190,000,000**		**$0**
Contractor Overhead & Profit				15%	$29,000,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$8,600,000		$0
				Estimated Subtotal Construction Cost	**$230,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$230,000,000**		**$0**
Estimating Contingency				25%	$58,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$290,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	42-in	36,400 LF	in-LF	$ 30	$45,864,000	75 yrs	$28,000,000
Low-Density Urban Pipeline	42-in	19,600 LF	in-LF	$ 40	$32,928,000	75 yrs	$20,000,000
High-Density Urban Pipeline	42-in	11,800 LF	in-LF	$ 50	$24,780,000	75 yrs	$15,000,000
Trenchless Crossings							
San Pablo Tunnel Rehab		17,600	LF	$ 3,500	$62,000,000	75 yrs	$37,000,000
Microtunnel Xings (1 jack & 1 receiv. pit)		4	EA	$ 620,000	$2,500,000		
Microtunnel Pipe		2,400	LF	$ 2,800	$6,700,000	75 yrs	$4,000,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	5,400 HP	EA (Cost Curve based on total installed HP)		$ 33,000,000	$33,000,000	50 yrs	$13,000,000
				Estimated Subtotal Cost (2) including Contingency	**$210,000,000**		**$120,000,000**
Estimated Subtotal Construction Cost including Contingency					$500,000,000		$120,000,000
Mobilization				5%	$25,000,000		$6,000,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$530,000,000**		**$130,000,000**
Implementation							
Environmental Documentation & Permits				5%	$27,000,000		$6,500,000
Design Cost				15%	$80,000,000		$20,000,000
Project Administration and Construction Management Cost				10%	$53,000,000		$13,000,000
Estimated Total Capital Cost including Implementation and Contingency					**$690,000,000**		**$170,000,000**
					Present Worth of Salvage Value		**$70,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	30		MGD	$ 325,000	$9,800,000		
RO System	30		MGD	$ 480,000	$14,000,000		
Advanced Oxidation and Disinfection	30		MGD	$ 49,000	$1,500,000		
Free Chlorine	30		MGD	$ 32,000	$960,000		
Chemicals	30		MGD	$ 120,000	$3,600,000		
Labor	30	2,080	hrs/MGD	$ 135	$8,400,000		
Electricity		27,150,000	kWh/yr	$ 0.15	$4,100,000		
Surface Water Treatment							
SWT O&M (Orinda)	10,950		MG	$ 70	$770,000		
Conveyance							
Annual O&M			2% of construction cost		$3,500,000		
Pump Stations							
Labor Costs		1000	hrs	$ 135	$140,000		
Electricity		27,090,000	kWh/yr	$ 0.15	$4,100,000		
Pump Station Consumables		5% of pump station construction cost			$1,700,000		
			Total O&M Costs ($/yr)		$53,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$35,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$3,600,000		
Annual O&M Costs					$53,000,000		
Total Annualized Cost					$84,000,000		
Deliveries of Recycled Water	33,600 AFY						
Estimated Unit Cost ($/AF)					**$2,500**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$600**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$35,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$3,600,000	*Same as constant use.*	
Annual O&M Costs					$43,099,000		
Total Annualized Cost					$74,000,000		
Annual Average Deliveries of Recycled Water	10,080 AFY						
Estimated Unit Cost ($/AF)					**$7,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,700**	**Distribution**	**$1,600**		

Alternative SD1-ResSP-4							EBMUD Recycled Water Master Plan Update
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MBR	4		MGD	$ 16,600,000	$66,000,000	30 yrs	$0
RO System	4		MGD	$ 1,475,000	$5,900,000	30 yrs	$0
Advanced Oxidation and Disinfection	4		MGD	$ 437,500	$1,800,000	30 yrs	$0
Chemicals (Storage and Use)	4			$ 125,000	$500,000	30 yrs	$0
Sitework/Piping/Structures	4		MGD	$ 3,187,500	$13,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$87,000,000**		**$0**
Contractor Overhead & Profit				15%	$13,000,000		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$3,900,000		$0
				Estimated Subtotal Construction Cost	**$100,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$100,000,000**		**$0**
Estimating Contingency				25%	$25,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$130,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	16-in	5,300 LF	in-LF	$ 30	$2,544,000	75 yrs	$1,500,000
Low-Density Urban Pipeline	16-in	18,300 LF	in-LF	$ 40	$11,712,000	75 yrs	$7,000,000
High-Density Urban Pipeline	16-in	11,800 LF	in-LF	$ 50	$9,440,000	75 yrs	$5,700,000
Trenchless Crossings							
San Pablo Tunnel Rehab		17,600	LF	$ 3,500	$62,000,000	75 yrs	$37,000,000
HDD (All Inclusive)		2,400	LF	$ 2,200	$5,300,000	75 yrs	$3,200,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	600 HP	EA (Cost Curve based on total installed HP)		$ 2,400,000	$2,400,000	50 yrs	$960,000
				Estimated Subtotal Cost (2) including Contingency	**$93,000,000**		**$55,000,000**
Estimated Subtotal Construction Cost including Contingency					$220,000,000		$55,000,000
Mobilization				5%	$11,000,000		$2,800,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$230,000,000**		**$58,000,000**
Implementation							
Environmental Documentation & Permits				5%	$12,000,000		$2,900,000
Design Cost				15%	$35,000,000		$8,700,000
Project Administration and Construction Management Cost				10%	$23,000,000		$5,800,000
Estimated Total Capital Cost including Implementation and Contingency					**$300,000,000**		**$75,000,000**
						Present Worth of Salvage Value	**$31,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MBR	4		MGD	$ 402,000	$1,600,000		
RO System	4		MGD	$ 480,000	$1,900,000		
Advanced Oxidation and Disinfection	4		MGD	$ 49,000	$200,000		
Free Chlorine	4		MGD	$ 32,000	$130,000		
Chemicals	4		MGD	$ 120,000	$480,000		
Labor	4	2,080	hrs/MGD	$ 135	$1,100,000		
Electricity		7,692,000	kWh/yr	$ 0.15	$1,200,000		
Surface Water Treatment							
SWT O&M (Sobrante WTP)	1,460		MG	$ 254	$370,000		
Conveyance							
Annual O&M			2% of construction cost		$1,820,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		1,949,000	kWh/yr	$ 0.15	$290,000		
Pump Station Consumables		5% of pump station construction cost			$120,000		
			Total O&M Costs ($/yr)		$9,300,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$15,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,600,000		
Annual O&M Costs					$9,300,000		
Total Annualized Cost					$23,000,000		
Deliveries of Recycled Water	4,480 AFY						
Estimated Unit Cost ($/AF)					**$5,100**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$3,600**	**Distribution**	**$1,500**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$15,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,600,000	*Same as constant use.*	
Annual O&M Costs					$7,549,000		
Total Annualized Cost					$21,000,000		
Annual Average Deliveries of Recycled Water	1,344 AFY						
Estimated Unit Cost ($/AF)					**$16,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$11,000**	**Distribution**	**$5,000**		

Alternative SD1-ResU-10					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate	Project Life	
Updated by:	I. Jaffe				3%	30 Years	
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MBR	10		MGD	$ 11,100,000	$110,000,000	30 yrs	$0
RO System	10		MGD	$ 1,475,000	$15,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	10		MGD	$ 437,500	$4,400,000	30 yrs	$0
Chemicals (Storage and Use)	10			$ 125,000	$1,300,000	30 yrs	$0
Sitework/Piping/Structures	10		MGD	$ 3,187,500	$32,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$160,000,000**		**$0**
Contractor Overhead & Profit				15%	$24,000,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$7,200,000		$0
				Estimated Subtotal Construction Cost	**$190,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$190,000,000**		**$0**
Estimating Contingency				25%	$48,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$240,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	28,800 LF	in-LF	$ 30	$20,736,000	75 yrs	$12,000,000
Low-Density Urban Pipeline	24-in	26,800 LF	in-LF	$ 40	$25,728,000	75 yrs	$15,000,000
High-Density Urban Pipeline	24-in	3,800 LF	in-LF	$ 50	$4,560,000	75 yrs	$2,700,000
Trenchless Crossings							
HDD (All Inclusive)		3,550	LF	$ 2,200	$7,800,000	75 yrs	$4,700,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	1,800 HP	EA (Cost Curve based on total installed HP)		$ 6,500,000	$6,500,000	50 yrs	$2,600,000
				Estimated Subtotal Cost (2) including Contingency	**$65,000,000**		**$37,000,000**
Estimated Subtotal Construction Cost including Contingency					$310,000,000		$37,000,000
Mobilization				5%	$16,000,000		$1,900,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$330,000,000**		**$39,000,000**
Implementation							
Environmental Documentation & Permits				5%	$17,000,000		$2,000,000
Design Cost				15%	$50,000,000		$5,900,000
Project Administration and Construction Management Cost				10%	$33,000,000		$3,900,000
Estimated Total Capital Cost including Implementation and Contingency					**$430,000,000**		**$51,000,000**
					Present Worth of Salvage Value		**$21,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MBR	10		MGD	$ 292,000	$2,900,000		
RO System	10		MGD	$ 480,000	$4,800,000		
Advanced Oxidation and Disinfection	10		MGD	$ 49,000	$490,000		
Free Chlorine	10		MGD	$ 32,000	$320,000		
Chemicals	10		MGD	$ 120,000	$1,200,000		
Labor	10	2,080	hrs/MGD	$ 135	$2,800,000		
Electricity		19,230,000	kWh/yr	$ 0.15	$2,900,000		
Conveyance							
Annual O&M			2% of construction cost		$1,180,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		7,310,000	kWh/yr	$ 0.15	$1,100,000		
Pump Station Consumables		5% of pump station construction cost			$330,000		
			Total O&M Costs ($/yr)		$18,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$22,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,100,000		
Annual O&M Costs					$18,000,000		
Total Annualized Cost					$39,000,000		
Deliveries of Recycled Water	11,200 AFY						
Estimated Unit Cost ($/AF)					**$3,500**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,800**	**Distribution**	**$700**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$22,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,100,000	*Same as constant use.*	
Annual O&M Costs					$14,224,000		
Total Annualized Cost					$35,000,000		
Annual Average Deliveries of Recycled Water	3,360 AFY						
Estimated Unit Cost ($/AF)					**$10,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$8,300**	**Distribution**	**$1,700**		

Alternative SD1-ResB-10					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MBR	10		MGD	$ 11,100,000	$110,000,000	30 yrs	$0
RO System	10		MGD	$ 1,475,000	$15,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	10		MGD	$ 437,500	$4,400,000	30 yrs	$0
Chemicals (Storage and Use)	10			$ 125,000	$1,300,000	30 yrs	$0
Sitework/Piping/Structures	10		MGD	$ 3,187,500	$32,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$160,000,000**		**$0**
Contractor Overhead & Profit				15%	$24,000,000		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$7,200,000		$0
			Estimated Subtotal Construction Cost		**$190,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$190,000,000**		**$0**
Estimating Contingency				25%	$48,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$240,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	36,400 LF	in-LF	$ 30	$26,208,000	75 yrs	$16,000,000
Low-Density Urban Pipeline	24-in	19,600 LF	in-LF	$ 40	$18,816,000	75 yrs	$11,000,000
High-Density Urban Pipeline	24-in	11,800 LF	in-LF	$ 50	$14,160,000	75 yrs	$8,500,000
Trenchless Crossings							
San Pablo Tunnel Rehab		17,600	LF	$ 3,500	$62,000,000	75 yrs	$37,000,000
HDD (All Inclusive)		2,400	LF	$ 2,200	$5,300,000	75 yrs	$3,200,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	2,000 HP	EA (Cost Curve based on total installed HP)		$ 7,500,000	$7,500,000	50 yrs	$3,000,000
			Estimated Subtotal Cost (2) including Contingency		**$130,000,000**		**$79,000,000**
Estimated Subtotal Construction Cost including Contingency					$370,000,000		$79,000,000
Mobilization				5%	$19,000,000		$4,000,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$390,000,000**		**$83,000,000**
Implementation							
Environmental Documentation & Permits				5%	$20,000,000		$4,200,000
Design Cost				15%	$59,000,000		$12,000,000
Project Administration and Construction Management Cost				10%	$39,000,000		$8,300,000
Estimated Total Capital Cost including Implementation and Contingency					**$510,000,000**		**$110,000,000**
						Present Worth of Salvage Value	**$45,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MBR	10		MGD	$ 292,000	$2,900,000		
RO System	10		MGD	$ 480,000	$4,800,000		
Advanced Oxidation and Disinfection	10		MGD	$ 49,000	$490,000		
Free Chlorine	10		MGD	$ 32,000	$320,000		
Chemicals	10		MGD	$ 120,000	$1,200,000		
Labor	10	2,080	hrs/MGD	$ 135	$2,800,000		
Electricity		19,230,000	kWh/yr	$ 0.15	$2,900,000		
Surface Water Treatment							
SWT O&M (Orinda)	3,650		MG	$ 70	$260,000		
Conveyance							
Annual O&M			2% of construction cost		$2,500,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		9,030,000	kWh/yr	$ 0.15	$1,400,000		
Pump Station Consumables		5% of pump station construction cost			$380,000		
			Total O&M Costs ($/yr)		$20,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$26,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$2,300,000		
Annual O&M Costs					$20,000,000		
Total Annualized Cost					$44,000,000		
Deliveries of Recycled Water	11,200 AFY						
Estimated Unit Cost ($/AF)					**$3,900**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,900**	**Distribution**	**$1,000**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$26,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$2,300,000	*Same as constant use.*	
Annual O&M Costs					$15,762,000		
Total Annualized Cost					$39,000,000		
Annual Average Deliveries of Recycled Water	3,360 AFY						
Estimated Unit Cost ($/AF)					**$12,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$8,300**	**Distribution**	**$3,700**		

Alternative SD1-Treat-30							**EBMUD Recycled Water Master Plan Update**
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
Ozone	30		MGD	$ 335,300	$10,000,000	30 yrs	$0
BAC	30		MGD	$ 300,900	$9,000,000	30 yrs	$0
MF/UF system	30		MGD	$ 1,225,000	$37,000,000	30 yrs	$0
RO System	30		MGD	$ 1,475,000	$44,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	30		MGD	$ 437,500	$13,000,000	30 yrs	$0
Chemicals (Storage and Use)	30			$ 125,000	$3,800,000	30 yrs	$0
Sitework/Piping/Structures	30		MGD	$ 3,187,500	$96,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$210,000,000**		**$0**
Contractor Overhead & Profit				15%	$32,000,000		$0
Sales Tax	**50%**	% of Subtotal Cost Applicable		9%	$9,500,000		$0
				Estimated Subtotal Construction Cost	**$250,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$250,000,000**		**$0**
Estimating Contingency				25%	$63,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$310,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	42-in	2,600 LF	in-LF	$ 30	$3,276,000	75 yrs	$2,000,000
Low-Density Urban Pipeline	42-in	1,200 LF	in-LF	$ 40	$2,016,000	75 yrs	$1,200,000
High-Density Urban Pipeline	42-in	2,500 LF	in-LF	$ 50	$5,250,000	75 yrs	$3,200,000
Trenchless Crossings							
Microtunnel Xings (1 jack & 1 receiv. pit)		3	EA	$ 620,000	$1,900,000		
Microtunnel Pipe		1,500	LF	$ 2,800	$4,200,000	75 yrs	$2,500,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	3,000 HP		EA (Cost Curve based on total installed HP)	$ 13,000,000	$13,000,000	50 yrs	$5,200,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	2.5 MG	3	EA (Cost Curve by Volume)	$ 4,500,000	$14,000,000	75 yrs	$8,400,000
				Estimated Subtotal Cost (2) including Contingency	**$44,000,000**		**$23,000,000**
Estimated Subtotal Construction Cost including Contingency					$350,000,000		$23,000,000
Mobilization				5%	$18,000,000		$1,200,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$370,000,000**		**$24,000,000**
Implementation							
Environmental Documentation & Permits				5%	$19,000,000		$1,200,000
Design Cost				15%	$56,000,000		$3,600,000
Project Administration and Construction Management Cost				10%	$37,000,000		$2,400,000
Estimated Total Capital Cost including Implementation and Contingency					**$480,000,000**		**$31,000,000**
						Present Worth of Salvage Value	**$13,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
Ozone	30		MGD	$ 57,000	$1,700,000		
BAC	30		MGD	$ 116,000	$3,500,000		
MF/UF system	30		MGD	$ 325,000	$9,800,000		
RO System	30		MGD	$ 480,000	$14,000,000		
Advanced Oxidation and Disinfection	30		MGD	$ 49,000	$1,500,000		
Free Chlorine	30		MGD	$ 32,000	$960,000		
Chemicals	30		MGD	$ 120,000	$3,600,000		
Labor	30	2,080	hrs/MGD	$ 135	$8,400,000		
Electricity		37,290,000	kWh/yr	$ 0.15	$5,600,000		
Monitoring			$/year	$ 1,000,000	$1,000,000		
Surface Water Treatment							
SWT O&M (Orinda)	10,950		MG	$ 70	$770,000		
Conveyance							
Annual O&M			2% of construction cost		$330,000		
Pump Stations							
Labor Costs		1000	hrs	$ 135	$140,000		
Electricity		14,620,000	kWh/yr	$ 0.15	$2,200,000		
Pump Station Consumables		5% of pump station construction cost			$650,000		
Storage Tanks							
Annual O&M			1% of construction cost		$140,000		
				Total O&M Costs ($/yr)	$54,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$24,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$660,000		
Annual O&M Costs					$54,000,000		
Total Annualized Cost					$77,000,000		
Deliveries of Recycled Water	33,600 AFY						
Estimated Unit Cost ($/AF)					**$2,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$2,100**	**Distribution**	**$200**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$24,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$660,000	*Same as constant use.*	
Annual O&M Costs					$44,399,000		
Total Annualized Cost					$68,000,000		
Annual Average Deliveries of Recycled Water	10,080 AFY						
Estimated Unit Cost ($/AF)					**$6,700**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$6,300**	**Distribution**	**$400**		

Alternative SD1-Treat-10							EBMUD Recycled Water Master Plan Update
Last Updated:	30-May-18				Discount Rate	Project Life	
Updated by:	I. Jaffe				3%	30 Years	
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MBR	10		MGD	$ 11,100,000	$110,000,000	30 yrs	$0
Ozone	10		MGD	$ 335,300	$3,400,000	30 yrs	$0
BAC	10		MGD	$ 300,900	$3,000,000	30 yrs	$0
RO System	10		MGD	$ 1,475,000	$15,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	10		MGD	$ 437,500	$4,400,000	30 yrs	$0
Chemicals (Storage and Use)	10			$ 125,000	$1,300,000	30 yrs	$0
Sitework/Piping/Structures	10		MGD	$ 3,187,500	$32,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$170,000,000**		**$0**
Contractor Overhead & Profit				15%	$26,000,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$7,700,000		$0
				Estimated Subtotal Construction Cost	**$200,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$200,000,000**		**$0**
Estimating Contingency				25%	$50,000,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$250,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	2,600 LF	in-LF	$ 30	$1,872,000	75 yrs	$1,100,000
Low-Density Urban Pipeline	24-in	1,200 LF	in-LF	$ 40	$1,152,000	75 yrs	$690,000
High-Density Urban Pipeline	24-in	2,500 LF	in-LF	$ 50	$3,000,000	75 yrs	$1,800,000
Trenchless Crossings							
HDD (All Inclusive)		1,500	LF	$ 2,200	$3,300,000	75 yrs	$2,000,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	1,200 HP	EA (Cost Curve based on total installed HP)		$ 4,200,000	$4,200,000	50 yrs	$1,700,000
Storage Tanks	*Cost Estimates for Storage Tanks are based on EBMUD Construction Bid Costs*						
Storage Tanks (material determined during pre-design)	0.9 MG	3	EA (Cost Curve by Volume)	$ 3,200,000	$9,600,000	75 yrs	$5,800,000
				Estimated Subtotal Cost (2) including Contingency	**$23,000,000**		**$13,000,000**
Estimated Subtotal Construction Cost including Contingency					$270,000,000		$13,000,000
Mobilization				5%	$14,000,000		$650,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$280,000,000**		**$14,000,000**
Implementation							
Environmental Documentation & Permits				5%	$14,000,000		$700,000
Design Cost				15%	$42,000,000		$2,100,000
Project Administration and Construction Management Cost				10%	$28,000,000		$1,400,000
Estimated Total Capital Cost including Implementation and Contingency					**$360,000,000**		**$18,000,000**
						Present Worth of Salvage Value	**$7,400,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MBR	10		MGD	$ 292,000	$2,900,000		
Ozone	10		MGD	$ 57,000	$570,000		
BAC	10		MGD	$ 116,000	$1,200,000		
RO System	10		MGD	$ 480,000	$4,800,000		
Advanced Oxidation and Disinfection	10		MGD	$ 49,000	$490,000		
Free Chlorine	10		MGD	$ 32,000	$320,000		
Chemicals	10		MGD	$ 120,000	$1,200,000		
Labor	10	2,080	hrs/MGD	$ 135	$2,800,000		
Electricity		22,610,000	kWh/yr	$ 0.15	$3,400,000		
Monitoring			$/year	$ 1,000,000	$1,000,000		
Surface Water Treatment							
SWT O&M (Orinda)	3,650		MG	$ 70	$260,000		
Conveyance							
Annual O&M			2% of construction cost		$186,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		4,873,000	kWh/yr	$ 0.15	$730,000		
Pump Station Consumables			5% of pump station construction cost		$210,000		
Storage Tanks							
Annual O&M			1% of construction cost		$96,000		
			Total O&M Costs ($/yr)		$20,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$18,000,000		
Annualized Salvage Value	*Annualized value of present worth*				-$380,000		
Annual O&M Costs					$20,000,000		
Total Annualized Cost					$38,000,000		
Deliveries of Recycled Water	11,200 AFY						
Estimated Unit Cost ($/AF)					**$3,400**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$3,200**	**Distribution**	**$200**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$18,000,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$380,000	*Same as constant use.*	
Annual O&M Costs					$15,393,000		
Total Annualized Cost					$33,000,000		
Annual Average Deliveries of Recycled Water	3,360 AFY						
Estimated Unit Cost ($/AF)					**$9,800**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$9,500**	**Distribution**	**$300**		

Alternative LA-Chabot-10							EBMUD Recycled Water Master Plan Update
Last Updated:	30-May-18				Discount Rate	Project Life	
Updated by:	I. Jaffe				3%	30 Years	
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	8		MGD	$ 1,225,000	$9,800,000	30 yrs	$0
RO System	8		MGD	$ 1,475,000	$12,000,000	30 yrs	$0
Advanced Oxidation and Disinfection	8		MGD	$ 437,500	$3,500,000	30 yrs	$0
Chemicals (Storage and Use)	8			$ 125,000	$1,000,000	30 yrs	$0
Sitework/Piping/Structures	8		MGD	$ 3,187,500	$26,000,000	30 yrs	$0
			Raw Construction Cost Subtotal		**$52,000,000**		**$0**
Contractor Overhead & Profit				15%	$7,800,000		$0
Sales Tax	**50%** % of Subtotal Cost Applicable			9%	$2,300,000		$0
			Estimated Subtotal Construction Cost		**$62,000,000**		**$0**
Construction Cost Including Contingency							
			Estimated Subtotal Construction Cost		**$62,000,000**		**$0**
Estimating Contingency				25%	$16,000,000		$0
			Estimated Subtotal Cost (1) including Contingency		**$78,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	24-in	2,100 LF	in-LF	$ 30	$1,512,000	75 yrs	$910,000
Low-Density Urban Pipeline	24-in	9,700 LF	in-LF	$ 40	$9,312,000	75 yrs	$5,600,000
High-Density Urban Pipeline	24-in	1,300 LF	in-LF	$ 50	$1,560,000	75 yrs	$940,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	225 HP		EA (Cost Curve based on total installed HP)	$ 1,600,000	$1,600,000	50 yrs	$640,000
			Estimated Subtotal Cost (2) including Contingency		**$14,000,000**		**$8,100,000**
Estimated Subtotal Construction Cost including Contingency					$92,000,000		$8,100,000
Mobilization				5%	$4,600,000		$410,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$97,000,000**		**$8,500,000**
Implementation							
Environmental Documentation & Permits				5%	$4,900,000		$430,000
Design Cost				15%	$15,000,000		$1,300,000
Project Administration and Construction Management Cost				10%	$9,700,000		$850,000
Estimated Total Capital Cost including Implementation and Contingency					**$130,000,000**		**$11,000,000**
					Present Worth of Salvage Value		**$4,500,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	8		MGD	$ 325,000	$2,600,000		
RO System	8		MGD	$ 480,000	$3,800,000		
Advanced Oxidation and Disinfection	8		MGD	$ 49,000	$390,000		
Free Chlorine	8		MGD	$ 32,000	$260,000		
Chemicals	8		MGD	$ 120,000	$960,000		
Labor	8	2,080	hrs/MGD	$ 135	$2,200,000		
Electricity		7,240,000	kWh/yr	$ 0.15	$1,100,000		
Conveyance							
Annual O&M			2% of construction cost		$250,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		803,000	kWh/yr	$ 0.15	$120,000		
Pump Station Consumables		5% of pump station construction cost			$80,000		
			Total O&M Costs ($/yr)		$12,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$6,600,000		
Annualized Salvage Value	*Annualized value of present worth*				-$230,000		
Annual O&M Costs					$12,000,000		
Total Annualized Cost					$18,000,000		
Deliveries of Recycled Water	4,480 AFY						
Estimated Unit Cost ($/AF)					**$4,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$3,800**	**Distribution**	**$200**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$6,600,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$230,000	*Same as constant use.*	
Annual O&M Costs					$10,120,000		
Total Annualized Cost					$16,000,000		
Annual Average Deliveries of Recycled Water	1,344 AFY						
Estimated Unit Cost ($/AF)					**$12,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$11,000**	**Distribution**	**$1,000**		

Alternative Sat-ResSP-4					EBMUD Recycled Water Master Plan Update		
Last Updated:	30-May-18				Discount Rate		Project Life
Updated by:	I. Jaffe				3%		30 Years
CCI (20 City, Dec 2017): 10870.06							
Item	**Size**	**Qty**	**Unit**	**Unit Cost**	**Total Cost**	**Useful Life**	**Salvage Value**
Capital Costs							
Treatment	*Cost Estimates for Treatment are based on Unit Costs for Each Treatment Process*						
MF/UF system	4		MGD	$ 1,225,000	$4,900,000	30 yrs	$0
RO System	4		MGD	$ 1,475,000	$5,900,000	30 yrs	$0
Advanced Oxidation and Disinfection	4		MGD	$ 437,500	$1,800,000	30 yrs	$0
Chemicals (Storage and Use)	4			$ 125,000	$500,000	30 yrs	$0
Sitework/Piping/Structures	4		MGD	$ 3,187,500	$13,000,000	30 yrs	$0
				Raw Construction Cost Subtotal	**$26,000,000**		**$0**
Contractor Overhead & Profit				15%	$3,900,000		$0
Sales Tax		**50%** % of Subtotal Cost Applicable		9%	$1,200,000		$0
				Estimated Subtotal Construction Cost	**$31,000,000**		**$0**
Construction Cost Including Contingency							
				Estimated Subtotal Construction Cost	**$31,000,000**		**$0**
Estimating Contingency				25%	$7,800,000		$0
				Estimated Subtotal Cost (1) including Contingency	**$39,000,000**		**$0**
Capital Costs (from Bids)							
Conveyance	*Cost Estimates for Pipelines are based on EBMUD construction bid cost + estimating contingency*						
Non-urban Pipeline	16-in	1,900 LF	in-LF	$ 30	$912,000	75 yrs	$550,000
Low-Density Urban Pipeline	16-in	5,900 LF	in-LF	$ 40	$3,776,000	75 yrs	$2,300,000
High-Density Urban Pipeline	16-in	5,900 LF	in-LF	$ 50	$4,720,000	75 yrs	$2,800,000
Trenchless Crossings							
San Pablo Tunnel Rehab		17,600	LF	$ 3,500	$62,000,000	75 yrs	$37,000,000
HDD (All Inclusive)		1,700	LF	$ 2,200	$3,700,000	75 yrs	$2,200,000
Pump Stations	*Cost Estimates for Pump Stations are based on EBMUD Construction Bid Costs*						
Pump Station (Total installed HP, including standby)	600 HP		EA (Cost Curve based on total installed HP)	$ 2,400,000	$2,400,000	50 yrs	$960,000
				Estimated Subtotal Cost (2) including Contingency	**$78,000,000**		**$46,000,000**
Estimated Subtotal Construction Cost including Contingency					$120,000,000		$46,000,000
Mobilization				5%	$6,000,000		$2,300,000
Estimated Subtotal Construction Cost including Contingency and Mobilization					**$130,000,000**		**$48,000,000**
Implementation							
Environmental Documentation & Permits				5%	$6,500,000		$2,400,000
Design Cost				15%	$20,000,000		$7,200,000
Project Administration and Construction Management Cost				10%	$13,000,000		$4,800,000
Estimated Total Capital Cost including Implementation and Contingency					**$170,000,000**		**$62,000,000**
					Present Worth of Salvage Value		**$25,000,000**
O&M Costs (Annual)							
Advanced Water Treatment							
MF/UF system	4		MGD	$ 325,000	$1,300,000		
RO System	4		MGD	$ 480,000	$1,900,000		
Advanced Oxidation and Disinfection	4		MGD	$ 49,000	$200,000		
Free Chlorine	4		MGD	$ 32,000	$130,000		
Chemicals	4		MGD	$ 120,000	$480,000		
Labor	4	2,080	hrs/MGD	$ 135	$1,100,000		
Electricity		3,620,000	kWh/yr	$ 0.15	$540,000		
Surface Water Treatment							
SWT O&M (Sobrante WTP)	1,460		MG	$ 254	$370,000		
Conveyance							
Annual O&M			2% of construction cost		$1,500,000		
Pump Stations							
Labor Costs		500	hrs	$ 135	$68,000		
Electricity		1,892,000	kWh/yr	$ 0.15	$280,000		
Pump Station Consumables		5% of pump station construction cost			$120,000		
			Total O&M Costs ($/yr)		$8,000,000		
Annualized Costs ($ / Year)							
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$8,600,000		
Annualized Salvage Value	*Annualized value of present worth*				-$1,300,000		
Annual O&M Costs					$8,000,000		
Total Annualized Cost					$15,000,000		
Deliveries of Recycled Water	4,480 AFY						
Estimated Unit Cost ($/AF)					**$3,300**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$1,900**	**Distribution**	**$1,400**		
Annualized Costs ($ / Year)	***Dry Year Adjustment (Supply used 3/10 years)***						
Annualized Capital Costs ($/Year)	*Two payments per year, spread over Project Life*				$8,600,000	*Same as constant use.*	
Annualized Salvage Value	*Annualized value of present worth*				-$1,300,000	*Same as constant use.*	
Annual O&M Costs					$6,728,000		
Total Annualized Cost					$14,000,000		
Annual Average Deliveries of Recycled Water	1,344 AFY						
Estimated Unit Cost ($/AF)					**$10,000**		
Breakdown of Estimated Unit Cost ($/AF)		**Treatment**	**$5,700**	**Distribution**	**$4,300**		

APPENDIX C: ECONOMIC EVALUATION – WILLINGNESS-TO-PAY AND SHORTAGE ESTIMATES

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Attachment 1

W-E Model Simulation of Demand Rationing for WSMP 2040 Portfolio E3

W-E Model Simulation of Demand Rationing with Increments of New Recycled Water Capacity for WSMP 2040 Portfolio E3

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1921	8%	0%	0%	0%	0%
1922	0%	0%	0%	0%	0%
1923	0%	0%	0%	0%	0%
1924	0%	0%	0%	0%	0%
1925	0%	0%	0%	0%	0%
1926	0%	0%	0%	0%	0%
1927	0%	0%	0%	0%	0%
1928	0%	0%	0%	0%	0%
1929	0%	0%	0%	0%	0%
1930	0%	0%	0%	0%	0%
1931	0%	0%	0%	0%	8%
1932	0%	0%	0%	0%	0%
1933	0%	0%	0%	0%	0%
1934	0%	0%	0%	0%	0%
1935	0%	0%	0%	0%	0%
1936	0%	0%	0%	17%	0%
1937	0%	0%	0%	0%	0%
1938	0%	0%	0%	0%	0%
1939	0%	0%	0%	0%	0%
1940	0%	0%	1%	0%	0%
1941	0%	0%	17%	0%	0%
1942	0%	0%	0%	0%	0%
1943	0%	0%	0%	0%	0%
1944	0%	0%	0%	0%	0%
1945	0%	0%	0%	0%	0%
1946	0%	8%	0%	0%	5%
1947	0%	0%	0%	0%	20%
1948	0%	0%	0%	0%	20%
1949	0%	0%	0%	0%	18%
1950	0%	0%	0%	0%	0%
1951	8%	0%	0%	5%	0%
1952	0%	0%	0%	20%	0%
1953	0%	0%	0%	20%	0%
1954	0%	0%	0%	18%	0%

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1955	0%	0%	0%	0%	0%
1956	0%	0%	5%	0%	0%
1957	0%	0%	20%	0%	2%
1958	0%	0%	20%	0%	17%
1959	0%	0%	18%	0%	13%
1960	0%	0%	0%	0%	15%
1961	0%	5%	0%	0%	17%
1962	0%	20%	0%	2%	19%
1963	0%	20%	0%	17%	0%
1964	0%	18%	0%	11%	2%
1965	0%	0%	0%	14%	0%
1966	5%	0%	0%	17%	0%
1967	20%	0%	2%	18%	0%
1968	20%	0%	17%	0%	0%
1969	18%	0%	13%	1%	0%
1970	0%	0%	15%	0%	0%
1971	0%	0%	17%	0%	0%
1972	0%	2%	18%	0%	0%
1973	0%	17%	0%	0%	0%
1974	0%	12%	1%	0%	0%
1975	0%	14%	0%	0%	0%
1976	0%	17%	0%	0%	0%
1977	2%	18%	0%	0%	4%
1978	17%	0%	0%	0%	0%
1979	15%	1%	0%	0%	0%
1980	15%	0%	0%	0%	0%
1981	17%	0%	0%	0%	0%
1982	18%	0%	0%	3%	0%
1983	0%	0%	0%	0%	0%
1984	1%	0%	0%	0%	3%
1985	0%	0%	0%	0%	0%
1986	0%	0%	0%	0%	0%
1987	0%	0%	4%	0%	0%
1988	0%	0%	0%	0%	0%
1989	0%	0%	0%	2%	0%
1990	0%	0%	0%	0%	0%
1991	0%	0%	0%	0%	0%
1992	0%	3%	0%	0%	0%
1993	0%	0%	0%	0%	0%
1994	0%	0%	3%	0%	0%

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1995	0%	0%	0%	0%	0%
1996	0%	0%	0%	0%	0%
1997	3%	0%	0%	0%	0%
1998	0%	0%	0%	0%	0%
1999	0%	2%	0%	0%	0%
2000	0%	0%	0%	0%	0%
2001	0%	0%	0%	0%	0%
2002	0%	0%	0%	0%	0%
2003	0%	0%	0%	0%	0%

W-E Model Simulation of Demand Rationing without Increments of New Recycled Water Capacity for WSMP 2040 Portfolio E3

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1921	9%	0%	0%	0%	0%
1922	0%	0%	0%	0%	0%
1923	0%	0%	0%	0%	0%
1924	0%	0%	0%	0%	0%
1925	0%	0%	0%	0%	0%
1926	0%	0%	0%	0%	0%
1927	0%	0%	0%	0%	0%
1928	0%	0%	0%	0%	0%
1929	0%	0%	0%	0%	0%
1930	0%	0%	0%	0%	0%
1931	0%	0%	0%	0%	12%
1932	0%	0%	0%	0%	0%
1933	0%	0%	0%	0%	0%
1934	0%	0%	0%	0%	0%
1935	0%	0%	0%	4%	0%
1936	0%	0%	0%	20%	0%
1937	0%	0%	0%	0%	0%
1938	0%	0%	0%	0%	0%
1939	0%	0%	0%	0%	0%
1940	0%	0%	4%	0%	0%
1941	0%	0%	19%	0%	0%
1942	0%	0%	0%	0%	0%
1943	0%	0%	0%	0%	0%
1944	0%	0%	0%	0%	0%

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1945	0%	0%	0%	0%	0%
1946	0%	10%	0%	0%	10%
1947	0%	0%	0%	0%	24%
1948	0%	0%	0%	0%	24%
1949	0%	0%	0%	0%	22%
1950	0%	0%	0%	0%	0%
1951	9%	0%	0%	9%	0%
1952	0%	0%	0%	23%	0%
1953	0%	0%	0%	23%	0%
1954	0%	0%	0%	21%	0%
1955	0%	0%	0%	0%	0%
1956	0%	0%	8%	0%	0%
1957	0%	0%	23%	0%	7%
1958	0%	0%	23%	0%	21%
1959	0%	0%	21%	0%	17%
1960	0%	0%	0%	0%	19%
1961	0%	7%	0%	0%	21%
1962	0%	22%	0%	6%	22%
1963	0%	22%	0%	20%	0%
1964	0%	20%	0%	15%	6%
1965	0%	0%	0%	17%	0%
1966	6%	0%	0%	20%	0%
1967	21%	0%	5%	21%	0%
1968	21%	0%	20%	0%	0%
1969	18%	0%	16%	5%	0%
1970	0%	0%	18%	0%	0%
1971	0%	0%	20%	0%	0%
1972	0%	4%	21%	0%	0%
1973	0%	19%	0%	0%	0%
1974	0%	14%	5%	0%	0%
1975	0%	16%	0%	0%	0%
1976	0%	19%	0%	0%	0%
1977	2%	20%	0%	0%	8%
1978	17%	0%	0%	0%	0%
1979	16%	3%	0%	0%	0%
1980	16%	0%	0%	0%	0%
1981	18%	0%	0%	0%	0%
1982	19%	0%	0%	7%	0%
1983	0%	0%	0%	0%	0%
1984	2%	0%	0%	0%	7%

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1985	0%	0%	0%	0%	0%
1986	0%	0%	0%	0%	0%
1987	0%	0%	7%	0%	0%
1988	0%	0%	0%	0%	0%
1989	0%	0%	0%	6%	0%
1990	0%	0%	0%	0%	0%
1991	0%	0%	0%	0%	0%
1992	0%	5%	0%	0%	0%
1993	0%	0%	0%	0%	0%
1994	0%	0%	6%	0%	0%
1995	0%	0%	0%	0%	0%
1996	0%	0%	0%	0%	0%
1997	4%	0%	0%	0%	0%
1998	0%	0%	0%	0%	0%
1999	0%	4%	0%	0%	0%
2000	0%	0%	0%	0%	0%
2001	0%	0%	0%	0%	0%
2002	0%	0%	0%	0%	0%
2003	0%	0%	0%	0%	0%

Attachment 2

Willingness-to-Pay for New Increments of Recycled Water Supply under WSMP 2040 Portfolio E3

Willingness-to-Pay in $/AF for New Increments of Potable Reuse Water Supply under WSMP 2040 Portfolio E3

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
Mean	$2,366	$2,365	$2,402	$2,398	$2,401
1921	$2,865	$2,113	$2,113	$2,113	$2,113
1922	$2,113	$2,113	$2,113	$2,113	$2,113
1923	$2,113	$2,113	$2,113	$2,113	$2,113
1924	$2,113	$2,113	$2,113	$2,113	$2,113
1925	$2,113	$2,113	$2,113	$2,113	$2,113
1926	$2,113	$2,113	$2,113	$2,113	$2,113
1927	$2,113	$2,113	$2,113	$2,113	$2,113
1928	$2,113	$2,113	$2,113	$2,113	$2,113
1929	$2,113	$2,113	$2,113	$2,113	$2,113
1930	$2,113	$2,113	$2,113	$2,113	$2,113
1931	$2,113	$2,113	$2,113	$2,113	$3,061
1932	$2,113	$2,113	$2,113	$2,113	$2,113
1933	$2,113	$2,113	$2,113	$2,113	$2,113
1934	$2,113	$2,113	$2,113	$2,113	$2,113
1935	$2,113	$2,113	$2,113	$2,088	$2,113
1936	$2,113	$2,113	$2,113	$4,506	$2,113
1937	$2,113	$2,113	$2,113	$2,113	$2,113
1938	$2,113	$2,113	$2,113	$2,113	$2,113
1939	$2,113	$2,113	$2,113	$2,113	$2,113
1940	$2,113	$2,113	$2,128	$2,113	$2,113
1941	$2,113	$2,113	$4,492	$2,113	$2,113
1942	$2,113	$2,113	$2,113	$2,113	$2,113
1943	$2,113	$2,113	$2,113	$2,113	$2,113
1944	$2,113	$2,113	$2,113	$2,113	$2,113
1945	$2,113	$2,113	$2,113	$2,113	$2,113
1946	$2,113	$2,915	$2,113	$2,113	$2,684
1947	$2,113	$2,113	$2,113	$2,113	$5,414
1948	$2,113	$2,113	$2,113	$2,113	$5,414
1949	$2,113	$2,113	$2,113	$2,113	$4,907
1950	$2,113	$2,113	$2,113	$2,113	$2,113
1951	$2,850	$2,113	$2,113	$2,612	$2,113
1952	$2,113	$2,113	$2,113	$5,337	$2,113
1953	$2,113	$2,113	$2,113	$5,337	$2,113

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1954	$2,113	$2,113	$2,113	$4,726	$2,113
1955	$2,113	$2,113	$2,113	$2,113	$2,113
1956	$2,113	$2,113	$2,615	$2,113	$2,113
1957	$2,113	$2,113	$5,299	$2,113	$2,342
1958	$2,113	$2,113	$5,299	$2,113	$4,700
1959	$2,113	$2,113	$4,801	$2,113	$3,835
1960	$2,113	$2,113	$2,113	$2,113	$4,225
1961	$2,113	$2,508	$2,113	$2,113	$4,722
1962	$2,113	$5,197	$2,113	$2,271	$5,054
1963	$2,113	$5,197	$2,113	$4,570	$2,113
1964	$2,113	$4,700	$2,113	$3,482	$2,271
1965	$2,113	$2,113	$2,113	$3,900	$2,113
1966	$2,459	$2,113	$2,113	$4,656	$2,113
1967	$5,095	$2,113	$2,272	$4,923	$2,113
1968	$5,095	$2,113	$4,587	$2,113	$2,113
1969	$4,488	$2,113	$3,718	$2,203	$2,113
1970	$2,113	$2,113	$4,134	$2,113	$2,113
1971	$2,113	$2,113	$4,586	$2,113	$2,113
1972	$2,113	$2,176	$4,847	$2,113	$2,113
1973	$2,113	$4,445	$2,113	$2,113	$2,113
1974	$2,113	$3,528	$2,191	$2,113	$2,113
1975	$2,113	$3,934	$2,113	$2,113	$2,113
1976	$2,113	$4,476	$2,113	$2,113	$2,113
1977	$2,124	$4,753	$2,113	$2,113	$2,480
1978	$4,305	$2,113	$2,113	$2,113	$2,113
1979	$3,974	$2,093	$2,113	$2,113	$2,113
1980	$3,999	$2,113	$2,113	$2,113	$2,113
1981	$4,414	$2,113	$2,113	$2,113	$2,113
1982	$4,621	$2,113	$2,113	$2,413	$2,113
1983	$2,113	$2,113	$2,113	$2,113	$2,113
1984	$2,048	$2,113	$2,113	$2,113	$2,363
1985	$2,113	$2,113	$2,113	$2,113	$2,113
1986	$2,113	$2,113	$2,113	$2,113	$2,113
1987	$2,113	$2,113	$2,420	$2,113	$2,113
1988	$2,113	$2,113	$2,113	$2,113	$2,113
1989	$2,113	$2,113	$2,113	$2,299	$2,113
1990	$2,113	$2,113	$2,113	$2,113	$2,113
1991	$2,113	$2,113	$2,113	$2,113	$2,113
1992	$2,113	$2,328	$2,113	$2,113	$2,113
1993	$2,113	$2,113	$2,113	$2,113	$2,113

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1994	$2,113	$2,113	$2,305	$2,113	$2,113
1995	$2,113	$2,113	$2,113	$2,113	$2,113
1996	$2,113	$2,113	$2,113	$2,113	$2,113
1997	$2,285	$2,113	$2,113	$2,113	$2,113
1998	$2,113	$2,113	$2,113	$2,113	$2,113
1999	$2,113	$2,218	$2,113	$2,113	$2,113
2000	$2,113	$2,113	$2,113	$2,113	$2,113
2001	$2,113	$2,113	$2,113	$2,113	$2,113
2002	$2,113	$2,113	$2,113	$2,113	$2,113
2003	$2,113	$2,113	$2,113	$2,113	$2,113

Willingness-to-Pay in $/AF for New Increments of Non-Potable Recycled Water under WSMP 2040 Portfolio E3

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
Mean	$1,979	$1,977	$2,020	$2,016	$2,013
1921	$2,865	$1,647	$1,647	$1,647	$1,647
1922	$1,647	$1,647	$1,647	$1,647	$1,647
1923	$1,647	$1,647	$1,647	$1,647	$1,647
1924	$1,647	$1,647	$1,647	$1,647	$1,647
1925	$1,647	$1,647	$1,647	$1,647	$1,647
1926	$1,647	$1,647	$1,647	$1,647	$1,647
1927	$1,647	$1,647	$1,647	$1,647	$1,647
1928	$1,647	$1,647	$1,647	$1,647	$1,647
1929	$1,647	$1,647	$1,647	$1,647	$1,647
1930	$1,647	$1,647	$1,647	$1,647	$1,647
1931	$1,647	$1,647	$1,647	$1,647	$3,061
1932	$1,647	$1,647	$1,647	$1,647	$1,647
1933	$1,647	$1,647	$1,647	$1,647	$1,647
1934	$1,647	$1,647	$1,647	$1,647	$1,647
1935	$1,647	$1,647	$1,647	$2,088	$1,647
1936	$1,647	$1,647	$1,647	$4,506	$1,647
1937	$1,647	$1,647	$1,647	$1,647	$1,647
1938	$1,647	$1,647	$1,647	$1,647	$1,647
1939	$1,647	$1,647	$1,647	$1,647	$1,647
1940	$1,647	$1,647	$2,128	$1,647	$1,647
1941	$1,647	$1,647	$4,492	$1,647	$1,647
1942	$1,647	$1,647	$1,647	$1,647	$1,647

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1943	$1,647	$1,647	$1,647	$1,647	$1,647
1944	$1,647	$1,647	$1,647	$1,647	$1,647
1945	$1,647	$1,647	$1,647	$1,647	$1,647
1946	$1,647	$2,915	$1,647	$1,647	$2,684
1947	$1,647	$1,647	$1,647	$1,647	$5,414
1948	$1,647	$1,647	$1,647	$1,647	$5,414
1949	$1,647	$1,647	$1,647	$1,647	$4,907
1950	$1,647	$1,647	$1,647	$1,647	$1,647
1951	$2,850	$1,647	$1,647	$2,612	$1,647
1952	$1,647	$1,647	$1,647	$5,337	$1,647
1953	$1,647	$1,647	$1,647	$5,337	$1,647
1954	$1,647	$1,647	$1,647	$4,726	$1,647
1955	$1,647	$1,647	$1,647	$1,647	$1,647
1956	$1,647	$1,647	$2,615	$1,647	$1,647
1957	$1,647	$1,647	$5,299	$1,647	$2,342
1958	$1,647	$1,647	$5,299	$1,647	$4,700
1959	$1,647	$1,647	$4,801	$1,647	$3,835
1960	$1,647	$1,647	$1,647	$1,647	$4,225
1961	$1,647	$2,508	$1,647	$1,647	$4,722
1962	$1,647	$5,197	$1,647	$2,271	$5,054
1963	$1,647	$5,197	$1,647	$4,570	$1,647
1964	$1,647	$4,700	$1,647	$3,482	$2,271
1965	$1,647	$1,647	$1,647	$3,900	$1,647
1966	$2,459	$1,647	$1,647	$4,656	$1,647
1967	$5,095	$1,647	$2,272	$4,923	$1,647
1968	$5,095	$1,647	$4,587	$1,647	$1,647
1969	$4,488	$1,647	$3,718	$2,203	$1,647
1970	$1,647	$1,647	$4,134	$1,647	$1,647
1971	$1,647	$1,647	$4,586	$1,647	$1,647
1972	$1,647	$2,176	$4,847	$1,647	$1,647
1973	$1,647	$4,445	$1,647	$1,647	$1,647
1974	$1,647	$3,528	$2,191	$1,647	$1,647
1975	$1,647	$3,934	$1,647	$1,647	$1,647
1976	$1,647	$4,476	$1,647	$1,647	$1,647
1977	$2,124	$4,753	$1,647	$1,647	$2,480
1978	$4,305	$1,647	$1,647	$1,647	$1,647
1979	$3,974	$2,093	$1,647	$1,647	$1,647
1980	$3,999	$1,647	$1,647	$1,647	$1,647
1981	$4,414	$1,647	$1,647	$1,647	$1,647
1982	$4,621	$1,647	$1,647	$2,413	$1,647

	Development Year				
Hydrologic Base Year	2020	2025	2030	2035	2040
1983	$1,647	$1,647	$1,647	$1,647	$1,647
1984	$2,048	$1,647	$1,647	$1,647	$2,363
1985	$1,647	$1,647	$1,647	$1,647	$1,647
1986	$1,647	$1,647	$1,647	$1,647	$1,647
1987	$1,647	$1,647	$2,420	$1,647	$1,647
1988	$1,647	$1,647	$1,647	$1,647	$1,647
1989	$1,647	$1,647	$1,647	$2,299	$1,647
1990	$1,647	$1,647	$1,647	$1,647	$1,647
1991	$1,647	$1,647	$1,647	$1,647	$1,647
1992	$1,647	$2,328	$1,647	$1,647	$1,647
1993	$1,647	$1,647	$1,647	$1,647	$1,647
1994	$1,647	$1,647	$2,305	$1,647	$1,647
1995	$1,647	$1,647	$1,647	$1,647	$1,647
1996	$1,647	$1,647	$1,647	$1,647	$1,647
1997	$2,285	$1,647	$1,647	$1,647	$1,647
1998	$1,647	$1,647	$1,647	$1,647	$1,647
1999	$1,647	$2,218	$1,647	$1,647	$1,647
2000	$1,647	$1,647	$1,647	$1,647	$1,647
2001	$1,647	$1,647	$1,647	$1,647	$1,647
2002	$1,647	$1,647	$1,647	$1,647	$1,647
2003	$1,647	$1,647	$1,647	$1,647	$1,647

APPENDIX D: CUSTOMER LIST FOR EAST BAYSHORE RECYCLED WATER PROJECT

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Table D-1. List of Short Term Industrial Customers and Associated Recycled Water Demands (Phase 1A)		
Customer Name	Annual Average Demand, gpd	Maximum Month Demand, gpd
Oakland -- Raimondi Park	11,733	22,293
Oakland -- Mandela Parkway / 34th St.	980	1,862
Oakland -- Mandela Parkway / 32th St.	2,646	5,027
Oakland -- Mandela Parkway /W. Grant	7,615	14,469
Oakland -- Mandela Parkway / 14th St.	9,105	17,300
Oakland -- Lowell Park	15,099	28,688
Oakland -- DeFremery Park	7,355	13,975
Oakland -- Madison Park	916	1,740
Oakland -- Lafayette Square	1,469	2,791
Oakland -- Wade Johnson Park	3,005	5,710
EBALDG - Jack London Gateway Sr. Housing	1,835	3,487
Age Song at Bayside	466	885
Lake Merritt Boathouse & C. Stanford House	21,738	41,302
Peralta College - Admin Building Area	1,363	2,590
Peralta College - Laney Campus	4,314	8,197
Emeryville -- Park Ave. Streetscape	1,099	2,088
Oakland -- Willow Mini Park	616	1,170
Extended Stay America Hotel	1,899	3,608
Oakland -- Museum of California	4,117	7,822
Caltrans - Emeryville Segment 2 Bikeway	1,381	2,624
Caltrans - Bay Bridge - Segment 2 Bikeway	10,716	20,360
Preservation Park - Oakland	4,622	19,993
Sherwin Williams Redevelopment[1]	15,000	28,500
EBMUD Administration Building[2]	22,000	28,600
IKEA[2]	23,000	29,900
Pacific Park Plaza[2]	30,000	39,000
Pixar Corporation[2]	21,000	32,000
Allowance for 6 additional HVAC Customers in Emeryville[2, 3]	51,000	66,300
Frontage Road Pipeline Alignment		
Target Store - Albany	9,100	17,290
Caltrans I-80 Landscape (Eastshore Hwy)	13,100	24,890
Golden Gate Fields(Pacific Racing Assn)	13,160	25,004
Caltrans I-80 Landscape (Frontage Rd)	7,479	14,210
University Village	123,500	234,650
Total Demands	443,000	769,000
[1] Estimated demand for a future development.		
[2] Industrial Demand		
[3] Assumption for cooling tower demands		

Table D-2. List of Intermediate Term Industrial Customers and Associated Recycled Water Demands (Phase 1B)		
Customer Name	Annual Average Demand, gpd	Maximum Month Demand, gpd
Oakland -- Raimondi Park	11,733	22,293
Oakland -- Mandela Parkway / 34th St.	980	1,862
Oakland -- Mandela Parkway / 32th St.	2,646	5,027
Oakland -- Mandela Parkway /W. Grant	7,615	14,469
Oakland -- Mandela Parkway / 14th St.	9,105	17,300
Oakland -- Lowell Park	15,099	28,688
Oakland -- DeFremery Park	7,355	13,975
Oakland -- Madison Park	916	1,740
Oakland -- Lafayette Square	1,469	2,791
Oakland -- Wade Johnson Park	3,005	5,710
EBALDG - Jack London Gateway Sr. Housing	1,835	3,487
Age Song at Bayside	466	885
Lake Merritt Boathouse & C. Stanford House	21,738	41,302
Peralta College - Admin Building Area	1,363	2,590
Peralta College - Laney Campus	4,314	8,197
Emeryville -- Park Ave. Streetscape	1,099	2,088
Oakland -- Willow Mini Park	616	1,170
Extended Stay America Hotel	1,899	3,608
Oakland -- Museum of California	4,117	7,822
Caltrans - Emeryville Segment 2 Bikeway	1,381	2,624
Caltrans - Bay Bridge - Segment 2 Bikeway	10,716	20,360
Preservation Park - Oakland	4,622	19,993
Oakland Housing Authority	3,190	6,062
Additional Customers on Existing Alignment		
Middleshore Harbor Park	54,238	103,052
Sherwin Williams Redevelopment[1]	15,000	28,500
Oakland Army Base Redevelopment[1]	47,768	90,759
EBMUD Administration Building[2]	22,000	28,600
Chiron Corporation[2]	51,700	66,730
Bayer[2]	180,000	220,000
Cool Port[2]	35,000	42,000
IKEA[2]	23,000	29,900
Pacific Park Plaza[2]	30,000	39,000
Pixar Corporation[2]	21,000	32,000
Allowance for additional 6 HVAC Customers in Emeryville[2, 3]	51,000	66,300
Additional Customers South of I-880		
Brooklyn Basin	82,500	156,750
Schnitzer Steel[2]	28,190	33,828
Digital Realty[2]	20,730	24,876
Frontage Road Pipeline Alignment		
Target Store - Albany	9,100	17,290

Table D-2. List of Intermediate Term Industrial Customers and Associated Recycled Water Demands (Phase 1B)		
Customer Name	Annual Average Demand, gpd	Maximum Month Demand, gpd
Caltrans I-80 Landscape (Eastshore Hwy)	13,100	24,890
Golden Gate Fields(Pacific Racing Assn)	13,160	25,004
Caltrans I-80 Landscape (Frontage Rd)	7,479	14,210
University Village	123,500	234,650
Total Demands	946,000	1,513,000
[1] Estimated demand for a future development.		
[2] Industrial Demand		
[3] Assumption for cooling tower demands		

Table D-3. List of Long Term Industrial Customers and Associated Recycled Water Demands (Phase 2)		
Customer Name	Annual Average Demand, gpd	Maximum Month Demand, gpd
Oakland -- Raimondi Park	11,733	22,293
Oakland -- Mandela Parkway / 34th St.	980	1,862
Oakland -- Mandela Parkway / 32th St.	2,646	5,027
Oakland -- Mandela Parkway /W. Grant	7,615	14,469
Oakland -- Mandela Parkway / 14th St.	9,105	17,300
Oakland -- Lowell Park	15,099	28,688
Oakland -- DeFremery Park	7,355	13,975
Oakland -- Madison Park	916	1,740
Oakland -- Lafayette Square	1,469	2,791
Oakland -- Wade Johnson Park	3,005	5,710
EBALDG - Jack London Gateway Sr. Housing	1,835	3,487
Age Song at Bayside	466	885
Lake Merritt Boathouse & C. Stanford House	21,738	41,302
Peralta College - Admin Building Area	1,363	2,590
Peralta College - Laney Campus	4,314	8,197
Emeryville -- Park Ave. Streetscape	1,099	2,088
Oakland -- Willow Mini Park	616	1,170
Extended Stay America Hotel	1,899	3,608
Oakland -- Museum of California	4,117	7,822
Caltrans - Emeryville Segment 2 Bikeway	1,381	2,624
Caltrans - Bay Bridge - Segment 2 Bikeway	10,716	20,360
Preservation Park - Oakland	4,622	19,993
Oakland Housing Authority	3,190	6,062
Additional Customers on Existing Alignment		
Middleshore Harbor Park	54,238	103,052
Sherwin Williams Redevelopment[1]	15,000	28,500
Oakland Army Base Redevelopment[1]	47,768	90,759
EBMUD Administration Building[2]	22,000	28,600
Chiron Corporation[2]	51,700	66,730
Bayer[2]	180,000	220,000
Cool Port[2]	35,000	42,000
IKEA[2]	23,000	29,900
Pacific Park Plaza[2]	30,000	39,000
Pixar Corporation[2]	21,000	32,000
Allowance for additional 6 HVAC Customers in Emeryville[2, 3]	51,000	66,300
Additional Customers South of I-880		
Brooklyn Basin	82,500	156,750
Schnitzer Steel[2]	28,190	33,828
Digital Realty[2]	20,730	24,876
Powell Pipeline Alignment		
Spieker Properties	14,982	28,466

Table D-3. List of Long Term Industrial Customers and Associated Recycled Water Demands (Phase 2)		
Customer Name	Annual Average Demand, gpd	Maximum Month Demand, gpd
Watergate HOA	42,891	81,493
Eastshore State Park - Powell St, Emeryville	15,727	29,881
Marina Park	22,875	43,463
Channing Way Pipeline Alignment		
Berkeley High School	6,499	12,348
Martin Luther King Jr. Park	4,457	8,468
People's Park	5,493	10,437
UC Berkeley - Hearst Ave, Berkeley	40,176	76,334
UC Berkeley - Oxford St, Berkeley	9,829	18,675
UC Berkeley - Warring St, Berkeley	39,317	74,702
UC Berkeley - Bancroft Way, Berkeley	545,972	1,037,347
UC Berkeley - Clark Kerr, Berkeley	143,157	271,998
UC Berkeley[2]	6,400	7,680
Alameda East Alignment		
993 Atlantic Ave	2,681	5,094
1090 Atlantic Ave # I	1,698	3,226
701 Atlantic Ave	5,630	10,697
1 Courageous Ct	3,753	7,131
1 Invincible Ct	3,128	5,943
1059 Independence Dr	1,787	3,395
989 Independence Dr	1,608	3,055
848 Marina Village Pky	2,055	3,905
915 Marina Village Pky	9,472	17,997
1001 Marina Village Pky	8,936	16,978
1119 Atlantic Ave	8,221	15,620
950 Independence Dr	6,970	13,243
1305 Marina Village Pky # A	6,881	13,074
1101 Marina Village Pky	5,004	9,508
1055 Marina Village Pky	4,110	7,809
2061 Challenger Dr	4,021	7,640
1090 Marina Village Pky	4,021	7,640
1010 Atlantic Ave	3,842	7,300
2061 Challenger Dr	3,574	6,791
850 Marina Village Pky	3,396	6,452
1080 Marina Village Pky	3,396	6,452
841 Marina Village PKY	3,396	6,452
1015 Atlantic Ave	2,323	4,414
813 Atlantic Ave	3,842	7,300
Alameda Beltline	22,451	42,657
Ralph Appezzato Memorial Beltline	6,059	11,512
Alameda Center Alignment		
2351 Webster St	7,774	14,771

Table D-3. List of Long Term Industrial Customers and Associated Recycled Water Demands (Phase 2)		
Customer Name	**Annual Average Demand, gpd**	**Maximum Month Demand, gpd**
College of Alameda	58,469	111,091
Neptune Park	8,980	17,062
Alameda West Alignment		
Alameda Naval Complex	4,194	7,969
US Coast Guard Housing	10,846	20,607
Ploughshares Nursery	6,161	11,706
Alameda Point	281,926	535,659
Multipurpose Field and Soccer Fields	22,389	42,539
Michaan Auction House	2,787	5,295
Alameda City Public Works	2,371	4,505
American Bus Repairs	2,633	5,003
Alameda Naval Complex	25,267	48,007
West Essex Dr Green Belt	2,061	3,916
Alameda Naval Complex	1,277	2,426
Ferry Point Green Belt	3,696	7,022
USS Hornet Museum	25,267	48,007
Alameda Naval Complex	2,996	5,692
Veteran's Administration	32,050	54,165
Hornet Field	19,133	36,353
Encinal High	10,200	19,380
Bayship and Yacht Co[2]	12,000	14,400
Allowance for additional HVAC Customers in Alameda[2, 3]	42,000	54,600
Frontage Road Pipeline Alignment		
Target Store - Albany	9,100	17,290
Caltrans I-80 Landscape (Eastshore Hwy)	13,100	24,890
Golden Gate Fields(Pacific Racing Assn)	13,160	25,004
Caltrans I-80 Landscape (Frontage Rd)	7,479	14,210
University Village	123,500	234,650
Total Demands	2,561,000	4,536,000

[1] Estimated demand for a future development.

[2] Industrial Demand

[3] Assumption for cooling tower demands