San Francisco Public Utilities Commission
Daly City Recycled Water Expansion Alternatives Investigation Project

Technical Memorandum
FEASIBLE ALTERNATIVES EVALUATION

FINAL | January 2022

San Francisco Water Power Sewer

Services of the San Francisco Public Utilities Commission

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Abbreviations

$/AF	dollars per acre-foot
%	percent
AACE	Association for the Advancement of Cost Estimating
AF	acre foot
AFY	acre-feet per year
AOP	advanced oxidation process
AWPF	advanced water purification facility
AWTO	Advanced Water Treatment Operator
BAC	biologically activated carbon
BAF	biological aerated filter
BOD	biochemical oxygen demand
Cal Water	California Water Service Company
Carollo	Carollo Engineers, Inc.
CCI	Construction Cost Index
CEC	constituents of emerging concern
CIP	clean in place
CT	concentration times
DBP	disinfection by-product
DOC	dissolved organic carbon
DPR	direct potable reuse
EBCT	empty bed contact time
ft	feet
gfd	gallons per square foot of membrane per day
GAC	granular activated carbon
GOX	gaseous oxygen
gpm	gallons per minute
gpm/sq ft	gallons per minute per square foot
GSR	groundwater storage and recovery
hp	horsepower
HPO	high purity oxygen
IPR	indirect potable reuse
kW	kilowatts
kWh	kilowatt hours
LF	linear feet (foot)
LRV	log removal value
m^3	cubic meters

MCL	maximum contaminant level
MG	million gallons
mgd	million gallons per day
mg/L	milligrams per liter
ml	milliliter
NDMA	nitrosodimethylamine
ng/L	nanograms per liter
NL	notification level
NPDES	National Pollutant Discharge Elimination System
O_3	ozone
O&M	operations and maintenance
PDR	Preliminary Design Report
Project	Daly City Recycled Water Expansion Alternatives Investigation Project
QSS	quasi steady-state
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board
RWSS	Regional Water Supply System
SFPUC	San Francisco Public Utilities Commission
SOC	synthetic organic chemical
sq ft	square foot (feet)
SRF	state revolving fund
TDS	total dissolved solids
TM	technical memorandum
TOC	total organic carbon
UF	ultrafiltration
µm	micrometer
UV	ultraviolet
UV AOP	Ultraviolet Advanced Oxidation Process
WIFIA	Water Infrastructure and Finance Innovation Act
WWTP	wastewater treatment plant

Section 1

PURPOSE

The purpose of this technical memorandum (TM) is to summarize the Feasible Alternatives Evaluation performed for the San Francisco Public Utilities Commission's (SFPUC) Daly City Recycled Water Expansion Alternatives Investigation Project (Project). The Feasible Alternatives Evaluation included the following:

- Develop conceptual level designs of the feasible alternatives treatment facilities to evaluate site impacts at the Daly City Wastewater Treatment Plant (WWTP), treatment process, develop conceptual cost estimates and evaluate other implementation considerations.
- Develop a conceptual level design of the distribution system for each feasible alternative.
- Identify general locations and number of the injection wells for each alternative.
- Evaluate the water supply benefits to the groundwater basin of each feasible alternative over the design drought cycle.
- Summarize the implementation risks of each alternative.
- Develop conceptual level cost estimates of each alternative.
- Compare the feasible alternatives to the baseline project, which is the Expanded Tertiary Recycled Water Facilities Project.

The feasible alternatives were identified in the Conceptual Alternatives Evaluation which was a previous phase of this Project. The Conceptual Alternatives Evaluation identified six alternatives based on how well they meet the project goals. Carollo Engineers, Inc. (Carollo) and the SFPUC selected three feasible alternatives to carry forward for further investigation during the Conceptual Alternatives Evaluation.

Section 2

BACKGROUND

2.1 Expanded Tertiary Recycled Water Facilities Project

The City of Daly City operates a recycled water treatment facility (composed of tertiary filtration and disinfection) that is owned by the North San Mateo County Sanitation District in Daly City, California. The recycled water treatment facility currently produces a maximum of 2.77 million gallons per day (mgd) of recycled water for irrigation of nearby golf courses, parks, and medians. Daly City currently serves recycled water to the San Francisco Golf Club, Olympic Club, Lake Merced Golf Club, and Harding Park Golf Club. Effluent that is not used for recycling is discharged to the Pacific Ocean under Daly City's National Pollutant Discharge Elimination System (NPDES) permit (R2-2017-0026).

The SFPUC partnered with Daly City to develop the preliminary design of the Feasibility of Expanded Tertiary Recycled Water Facilities Project (Daly City Recycled Water Expansion Project) with the goal of using Daly City's tertiary treated effluent to meet the irrigation demands currently being met with potable water from the Westside Groundwater Basin. The Daly City Recycled Water Expansion Project would provide a local, sustainable, drought-proof irrigation supply for the region by increasing Daly City's WWTP recycled water treatment capacity by approximately 3 mgd to 5.77 mgd. Carollo led the preliminary design of the project and finalized the Feasibility of Expanded Tertiary Recycled Water Facilities Preliminary Design Report (PDR, Carollo 2017).

Figure 1 shows an overview of the Expanded Tertiary Recycled Water Facilities Project, which is referred to as the baseline project in this report. The baseline project includes a new recycled water treatment facility at the Daly City WWTP to supply water for irrigation to cemeteries, schools, parks, and other facilities in the Town of Colma, City of South San Francisco, and City of Daly City. The PDR identified 22 potential customers for this new flow with a total estimated average annual of irrigation demand of 1,190 acre-feet per year (AFY), which corresponds to 1.1 mgd of average annual demand. The dry weather demand, however, is significantly higher than the wet weather demand. The peak month demand is estimated to be 75 million gallons, corresponding to an average of 2.5 mgd, which is currently met by the following sources:

- Private wells that withdraw from the southern Westside Basin: approximately 2 mgd.
- Cal Water (potable water distribution system): 0.44 mgd.
- Daly City Water (potable water distribution system): 0.06 mgd.

The Expanded Tertiary Recycled Water Facilities Project could provide an average of 1,190 AFY of year for irrigation customers. Of the 1,190 AFY, approximately 950 AFY would replace groundwater pumping, while the rest would replace municipal sources. The process of reducing groundwater pumping by substituting an alternative supply of water is known as "in-lieu recharge".

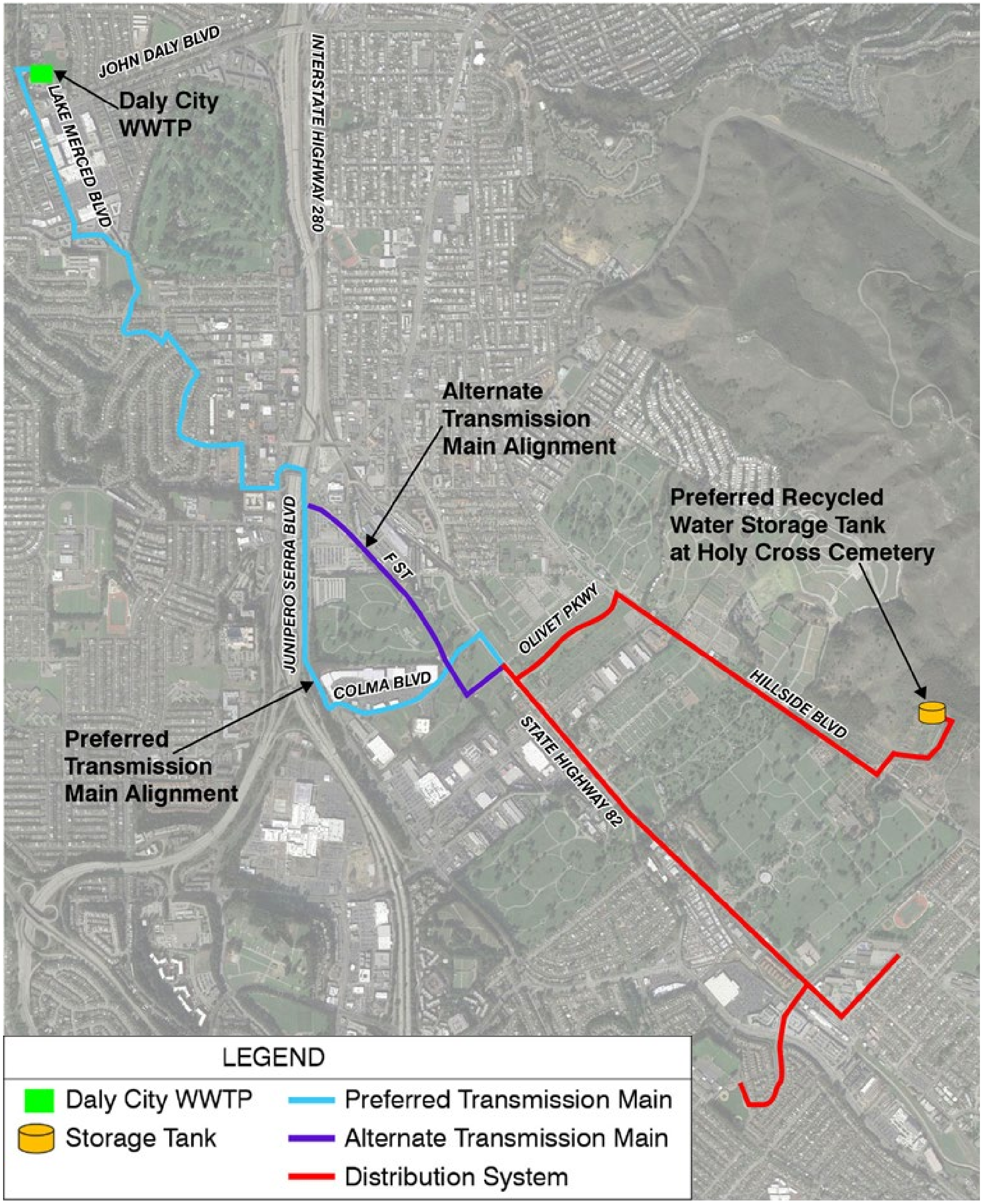

Figure 1 Expanded Tertiary Recycled Water Facilities Project (Baseline Project) Map

2.2 Purpose of the Daly City Recycled Water Expansion Alternatives Investigation

Prior to moving forward with final design of the Expanded Tertiary Recycled Water Facilities Project, SFPUC requested that Carollo evaluate additional project alternatives that may lower the unit cost of recycled water, increase drought supply, or reduce implementation risk. Implementation risks are those that could impede or hinder the implementation of the project alternative, such as the user acceptance of recycled water, public support, and regulatory certainty. SFPUC has also constructed a portion of the Regional Groundwater Storage and Recovery (GSR) project since Carollo developed the preliminary design of the Daly City Recycled Water Expansion Project in 2017. This alternatives analysis considers synergies with the GSR project and potentially utilizing the Westside Groundwater Basin for storage.

The(Project includes defining the recycled water project goals; developing and evaluating six conceptual recycled water project alternatives; and developing and evaluating the feasibility of three project alternatives. Figure 2 shows the project workflow. This report constitutes the results of the feasible alternatives analysis (highlighted in yellow in Figure 2).

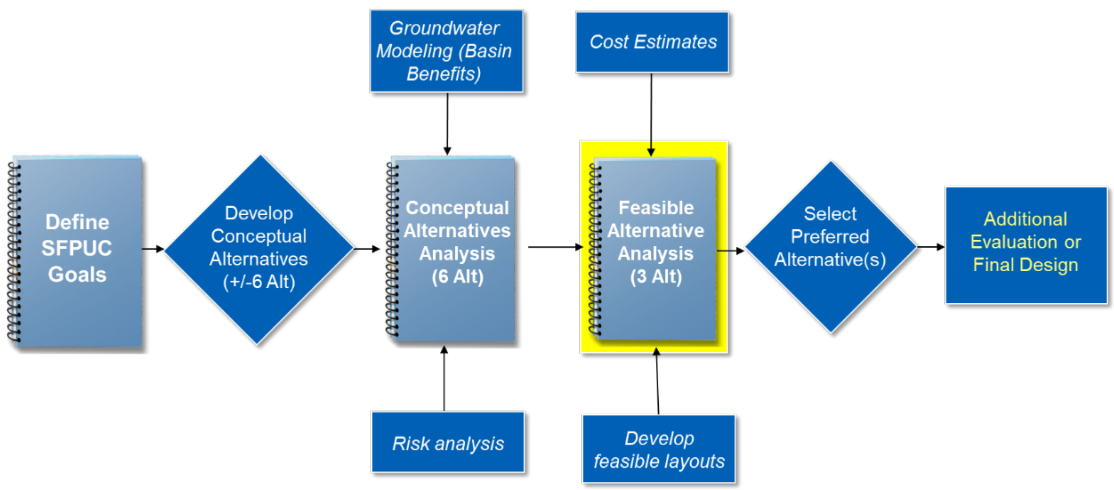

Figure 2 Daly City Recycled Water Expansion Alternatives Investigation Project Workflow

2.3 Project Goals and Drivers

The goals and drivers for this Project were developed by the SFPUC in a workshop on September 17, 2020 and summarized in the Project Goals and Drivers technical memorandum, dated October 21, 2020. The following summarizes SFPUC's goals and drivers for this project:

1. To improve supply reliability during a prolonged drought.
2. To increase the volume of water stored in the Westside Groundwater Basin.
3. To minimize the risk of triggering the mitigation measures associated with the Regional GSR project.

The following attributes would be considered favorable, but are not primary project goals:

1. To improve supply reliability during times of non-drought.
2. To maximize use of available recycled water supplies.
3. To maximize use of existing infrastructure.

2.4 Conceptual Alternatives Descriptions and Evaluations

The project team developed six conceptual alternatives as described in the Conceptual Alternatives Evaluation TM, and evaluated the alternatives based on their ability to meet the primary project goals. The Daly City Recycled Water Expansion Project (Tertiary Expansion) was included in the analysis as Conceptual Alterative 1 and was also referred to as the "baseline alternative". The TM considered alternatives for adding advanced water purification facilities (AWPFs) to provide indirect potable reuse (IPR) or direct potable reuse (DPR). The conceptual alternatives are listed below.

- **Conceptual Alternative 1:** Tertiary Expansion (Baseline Alternative).
- **Conceptual Alternative 2:** IPR Treatment Allows Groundwater Injection (travel time >2 months) and Cemetery Irrigation.
- **Conceptual Alternative 3:** DPR Permitting Allows Groundwater Injection (travel time <2 months) and Cemetery Irrigation.
- **Conceptual Alternative 4:** Increased AWPF Capacity Maximizes Wet Weather Injection and Provides Cemetery Irrigation.
- **Conceptual Alternative 5:** "Fit for Purpose" Treatment Tailors Water Quality for Irrigation and Injection for Potable Reuse.
- **Conceptual Alternative 6:** Hybrid Project with 1 mgd IPR Wells Located Near Daly City WWTP.

As summarized in Table 1 below, the six conceptual alternatives were evaluated qualitatively based on implementation risks and quantitatively based on modeled basin benefits. The Conceptual Alternatives Evaluation Workshop was held over the course of two meetings: one in November 2020 for initial screening and one in March 2021 to review alternatives. The alternatives with the highest basin benefit and lowest implementation risks were recommended for further evaluation along with the baseline project. A summary evaluation of each of the conceptual alternatives is provided in Table 1.

SFPUC modeled the Westside Basin to evaluate changes in water levels and storage in the basin due to each of the alternatives. Table 1 summarizes the results of the SFPUC modeling, which are also detailed in the Conceptual Alternatives TM. The SFPUC performed additional modeling of the three IPR-only scenarios to estimate their basin benefits, as summarized in Table 2.

Table 1 Summary of Basin Benefits and Implementation Risks for Each Conceptual Alternative (Refer to the Conceptual Alternatives TM for Additional Details)

	Implementation Risk for Conceptual Alternatives					
	Alt 1: Tertiary Expansion	Alt 2: 3 mgd advanced treated water for IPR and irrigation	Alt 3: 3 mgd advanced treated water for DPR and irrigation	Alt 4: 6 mgd advanced treated water for IPR and irrigation	Alt 5: Tertiary Expansion & 3 mgd IPR (Hybrid Treatment)	Alt 6: Tertiary Expansion & 1 mgd IPR
	Carried forward as baseline alt	*Carried forward as Feas Alt 2*	*Not carried forward*	*Not carried forward*	*Not carried forward*	*Carried forward as Feas Alt 1*
Basin Benefits						
Average Annual Basin Benefit(1) (AFY)	780	2,460	2,400	4,060	2,460	1,480
Project Efficiency(2) (%)	92	82	80	83	82	75
Cumulative Basin Benefit at the end of a GSR Cycle(1) (acre-feet)	14,500	46,450	45,450	76,520	46,450	28,290
Implementation Risks						
Risk of Triggering Mitigation Measure	Low	Low	Low	Low	Low	Low
Water Delivery Infrastructure & Well Siting	Low	Medium	Medium	High	Medium	Low
Treatment Plant Size and Siting	Low	High	High	High	High	Medium
RO Concentrate Disposal	N/A	Medium	Medium	High	Medium	Low
Operations and Maintenance Complexity	Low	Medium	Medium	Medium	Medium	Medium
User Acceptance of Water	Medium	Medium	Medium	Medium	Medium	Medium
Regulatory Certainty	Low	Low	Medium	Low	Low	Low

Notes:
(1) Modeled basin benefit compared to the no-project alternative.
(2) Calculated as the average basin benefit divided by the average volume recharged (using the QSS results)
Abbreviations:
RO = reverse osmosis

Table 2 Summary of Basin Benefits for Three IPR-only Project Alternatives (Not Included in Conceptual Alternatives TM)

	1 mgd IPR only with four wells located near Daly City WWTP	1 mgd IPR only with four wells located near the cemeteries	3 mgd IPR only with wells located between Daly City WWTP and the cemeteries
Average Annual Basin Benefit(1) (AFY)	700	980	3,400
Average Annual Basin Benefit(1) (mgd)	0.6	0.9	3.0
Project Efficiency(2) (percent)	62	87	101
Cumulative Basin Benefit at the end of thirty year(1) (acre-feet)	20,970	29,300	101,840

Notes:
(1) Modeled basin benefit, compared to the no-project alternative, over a 30-year period. Results shown are derived from a quasi-steady state (QSS) analysis.
(2) Calculated as the average basin benefit divided by the average volume recharged (using the QSS results)

This modeled project is evaluated herein as Feasible Alternative 3.

2.4.1.1 Conceptual Alternative 1: Tertiary Expansion (Baseline Alternative)

Carried Forward as the Baseline Alternative

The baseline alternative provides the lowest basin benefit of the conceptual alternatives since the basin benefit is captured seasonally; however, this project also has the lowest implementation risks. This project also appears to have the highest efficiency – for each gallon of recycled water produced, approximately 92 percent of that gallon remains in the basin to contribute to basin benefit. The baseline alternative project is carried forward and compared against the three feasible alternatives in the next phase of evaluation.

2.4.1.2 Conceptual Alternative 2: IPR Treatment Allows Groundwater Injection (travel time >2 months) and Cemetery Irrigation

Carried Forward as Feasible Alternative 2

By consistently recharging the basin with 3 mgd of in-lieu recharge or injection, this project provides significantly more basin benefit than the baseline alternative. The most challenging risk with this project is the ability to site approximately 12 wells throughout the southern Westside Basin. Additionally, siting a 3 mgd advanced treatment facility for potable reuse on or near Daly City's WWTP will likely prove challenging and costly. Still, this project will likely be less challenging than the other 3 mgd options and certainly less challenging than the 6 mgd option. This project is carried forward as Feasible Alternative 2.

2.4.1.3 Conceptual Alternative 3: DPR Permitting Allows Groundwater Injection (travel time <2 months) and Cemetery Irrigation

While this alternative might reduce the challenges associated with locating wells, the additional risk of regulatory unknowns complicates the project delivery. If SFPUC decides to move forward with a potable reuse project using groundwater injection, a key next step will be identifying potential groundwater well sites. If there are some potentially viable well sites that are found to be <2-month travel time limit from extraction wells, the DPR permitting option could be explored further. Alternative to the DPR permitting option, nearby injection and extraction wells could operate in an inject-hold-extract pattern that would result in less overall water use but avoid the added requirements of a DPR project.

If SFPUC pursues a potable reuse alternative, the DPR permitting option remains a viable option if necessary, to develop the project; however, this alternative is not carried forward as a feasible alternative.

2.4.1.4 Conceptual Alternative 4: Increased AWPF Capacity Maximizes Wet Weather Injection and Provides Cemetery Irrigation

This alternative provides the highest benefit to the groundwater basin but includes a high amount of implementation risk. The implementation risks of siting a 6 mgd advanced treatment facility on or near Daly City WWTP and finding 24 injection well site locations is too great to justify further evaluation of this alternative. This option is not carried forward as a feasible alternative.

2.4.1.5 Conceptual Alternative 5: "Fit for Purpose" Treatment Tailors Water Quality for Irrigation and Injection for Potable Reuse

While this project provides the same basin benefit as Conceptual Alternative 2, the added operational complexity, infrastructure costs, and space requirements of two separate treatment trains, and water delivery systems makes this alternative less attractive. Delivering the right water quality for the right demand is compelling; however, the cost savings provided by less treatment of the irrigation water are unlikely to outweigh the cost incurred from the additional infrastructure, operations, and maintenance of two parallel treatment systems, pipelines, and pump stations. This alternative is not carried forward as a feasible alternative.

2.4.1.6 Conceptual Alternative 6: Hybrid Project with 1 mgd IPR Wells Located Near Daly City WWTP

Carried Forward as Feasible Alternative 1

Similar to Conceptual Alterative 5, this alternative includes a hybrid treatment train. Unlike Conceptual Alternative 5, only 1 mgd is required for the advanced treatment (potable reuse) portion of the treatment facility. Additionally, if SFPUC can secure four injection well sites near Daly City WWTP, the project will avoid the cost of two lengthy parallel pipelines delivering water south to the cemeteries. Rather, one shorter northern pipeline will provide purified water for injection and another longer southern pipeline will provide tertiary treated water to the cemeteries. Still, the additional treatment processes and two pump stations will add operational complexity. This alternative is carried forward as Feasible Alternative 1.

Section 3

FEASIBLE ALTERNATIVES OVERVIEW

Based on the outcome of the Workshops, the Conceptual Alternatives TM, and groundwater basin modeling performed by the SFPUC, the following project alternatives were carried forward for further evaluation in the feasible alternatives investigation and compared to the baseline alternative:

1. 3 mgd Tertiary Treatment for Irrigation with 1 mgd Advanced Treatment for IPR
2. 3 mgd Advanced Treatment for both Irrigation and IPR
3. 1 mgd Advanced Treatment for IPR only (not evaluated as a conceptual alternative)

The baseline project and three feasible alternatives are described in more detail below.

3.1 Baseline Project: Expanded Tertiary Recycled Water Facilities Project

The baseline project is summarized in detail in the PDR (Carollo, 2017). This alternative includes a 3 mgd tertiary treatment train consisting of ultrafiltration (UF), ultraviolet (UV) disinfection, and chlorination. The finished recycled water is delivered to cemeteries in Colma, along with several other recycled water users, for irrigation. Figure 1 above shows the overview map of the Baseline Project.

Figure 3 shows a schematic of the treatment train. The treatment train meets requirements set forth in California for tertiary recycled water for non-potable uses. The treatment train was piloted as part of Carollo 2017 and will fit at Daly City's WWTP site.

While the treatment train is sized to meet 3 mgd of recycled water demand, the peak demand is seasonal with less demand in the winter months. On average, the non-potable demand is estimated to be approximately 1,190 AFY, which corresponds to 1.1 mgd.

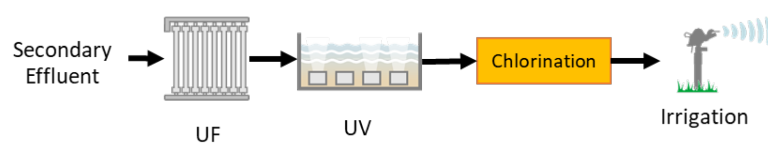

Figure 3 Baseline Project Treatment Schematic

3.2 Feasible Alternative 1: 3 mgd Tertiary Treatment for Irrigation with 1 mgd Advanced Treatment for IPR

This alternative includes a hybrid treatment train to create fit for purpose water qualities for IPR and irrigation. The first three treatment processes include ozone, biological aerated filter (BAF) and UF. Following UF, water to be used for IPR would undergo treatment through RO, UV advanced oxidation process (AOP), and stabilization prior to being pumped to four northern groundwater wells. Water to be used for irrigation would be split off after UF and treated through UV and chlorination, and subsequently pumped through the tertiary treated water distribution system to be used for irrigation.

The pure water portion of the treatment train would produce 1 mgd (1,120 AFY) year-round for IPR. Irrigation demands fluctuate throughout the year and are expected to be as high as 3 mgd in peak summer months and potentially as low as 0 mgd in the winter months (Carollo 2017). On average, the annual irrigation demand is expected to be 1190 AFY (equates to 1.1 mgd). The tertiary treatment portion of the train for this alternative is assumed to produce up to 2 mgd, with the additional 1 mgd for peak demands either coming from Daly City's existing unused tertiary capacity or from the purified water treatment train. Note that the basin benefit modeling assumes a steady year-round injection of 1 mgd in addition to meeting irrigation demand. Since Daly City operates their existing recycled water facility on a seasonal basis, year-round operation of recycled water facilities would be a change in operational practices. SFPUC has approached Daly City about this concept during this study; however, further conversations would be required to confirm that Daly City would operate the recycled water facilities year-round.

While producing fit for purpose water qualities appears efficient, producing and distributing two types of water creates additional complexities, processes, operations and maintenance, and infrastructure.

Figure 4 shows an overview map of the purified water and tertiary treated water distribution systems for this alternative. The tertiary recycled water distribution system follows the alignment designed for the baseline alternative as part of the Preliminary Design Report (PDR, Carollo, 2017). The injection well locations and purified water pipeline were selected assuming injection well criteria described in detail in the Conceptual Alternatives TM. The feasibility of these injection well sites has not been confirmed as part of this analysis.

Figure 5 shows a schematic of the treatment train. The conceptual IPR treatment train meets the requirements set forth in California; however, the treatment processes would need to be piloted with Daly City WWTP effluent treatability.

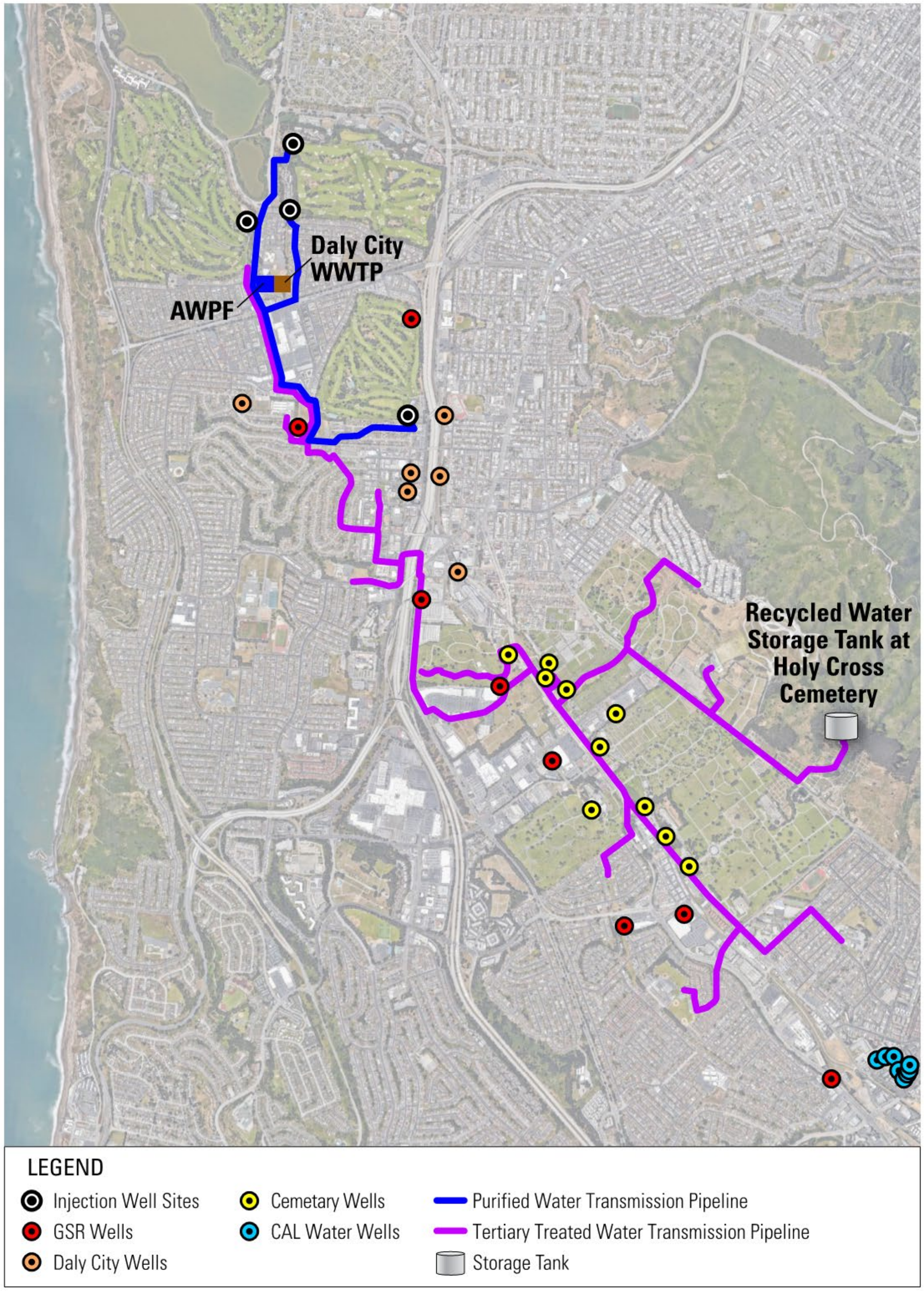

Figure 4 Feasible Alternative 1 Overview

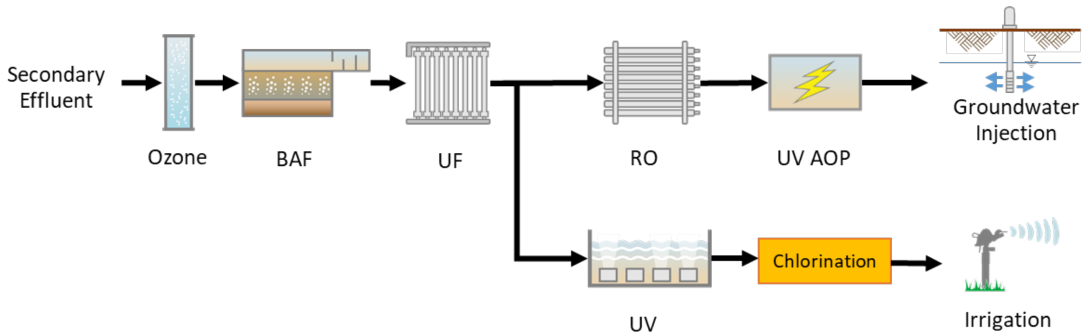

Figure 5 Feasible Alternative 1 Treatment Schematic

3.3 Feasible Alternative 2: 3 mgd Advanced Treatment for both Irrigation and IPR

Feasible Alternative 2 would produce purified water suitable for multiple end uses. This would allow for a single treatment train and a single distribution system and would produce up to 3 mgd of purified water. Irrigation demand would be prioritized and met as needed; injection wells would turn on and off according to unused water. With an estimated average annual irrigation demand of 1,190 AFY (1.1 mgd), 2,130 AFY (1.9 mgd) of purified water is available for injection.

The treatment train consists of ozone, BAF, UF, RO, UV AOP, and stabilization prior to irrigation and/or injection through up to 12 wells. The map of the distribution system and 12 injection wells is shown in Figure 6. The treatment schematic is provided on Figure 7.

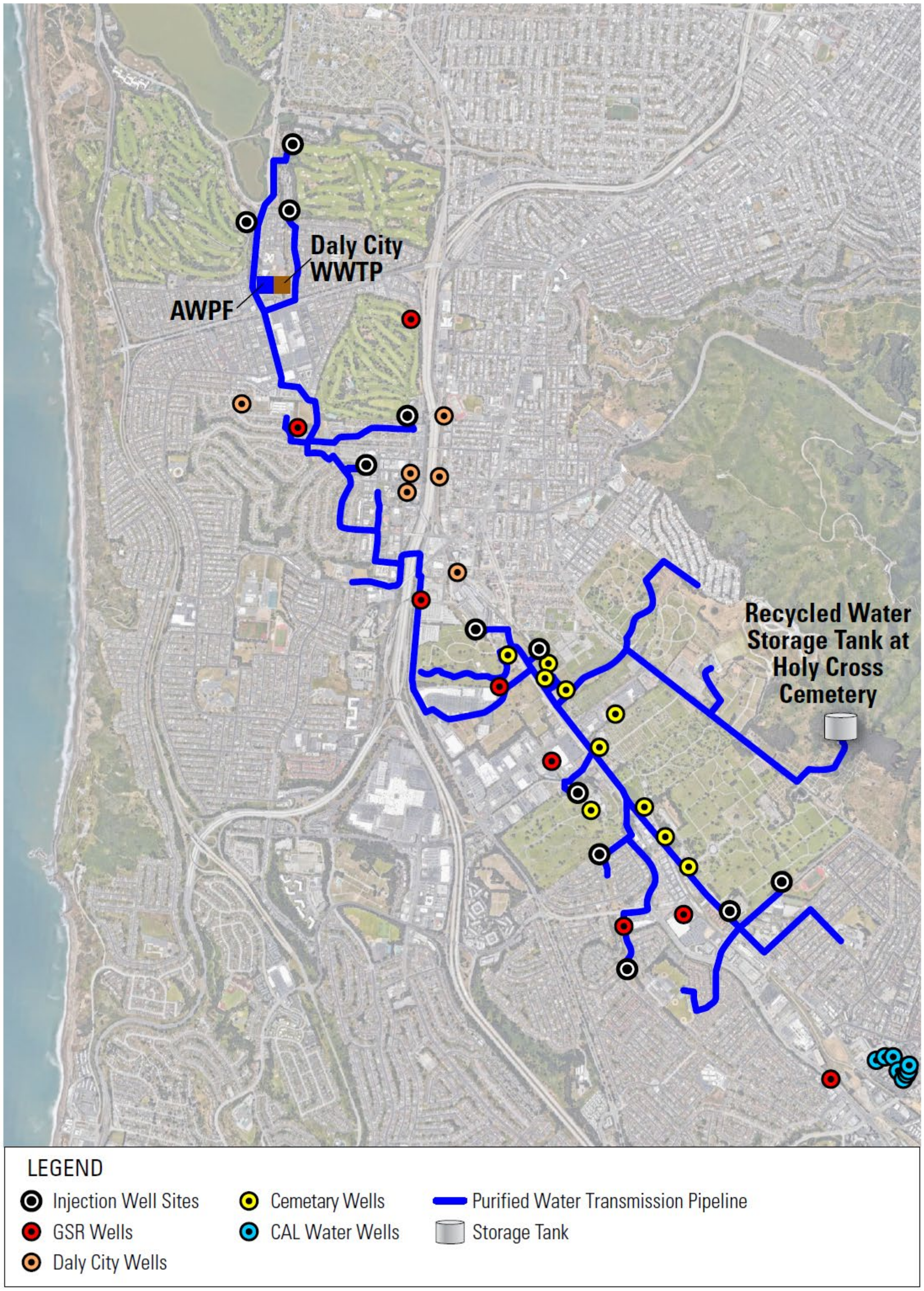

Figure 6 Feasible Alternative 2 Overview

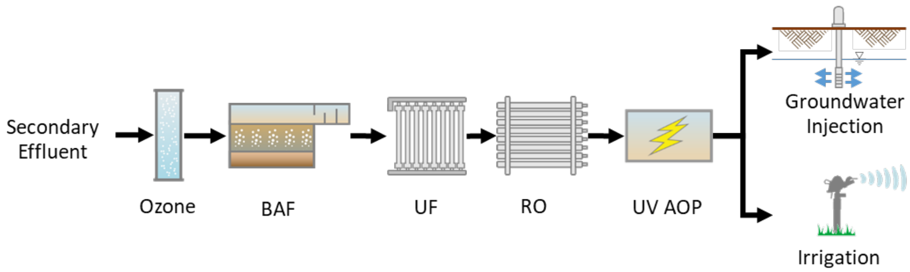

Figure 7 Feasible Alternative 2 Treatment Schematic

3.4 Feasible Alternative 3: 1 mgd Advanced Treatment for IPR only

Feasible Alternative 3 consists of a 1 mgd advanced treatment train that produces purified water for groundwater injection only. The alternative provides 1 mgd of purified water to the four northern injection wells throughout the year. This alternative does not provide water for irrigation of the cemeteries, and therefore does not replace the need for pumping from the South Westside Groundwater Basin.

The treatment train includes ozone, BAF, UF, RO, UV AOP, and stabilization prior to groundwater injection through four wells. Key features of this alternative include operational simplicity and a shorter distribution system.

The infrastructure map for this alternative is shown in Figure 8. The treatment train schematic is provided in Figure 9.

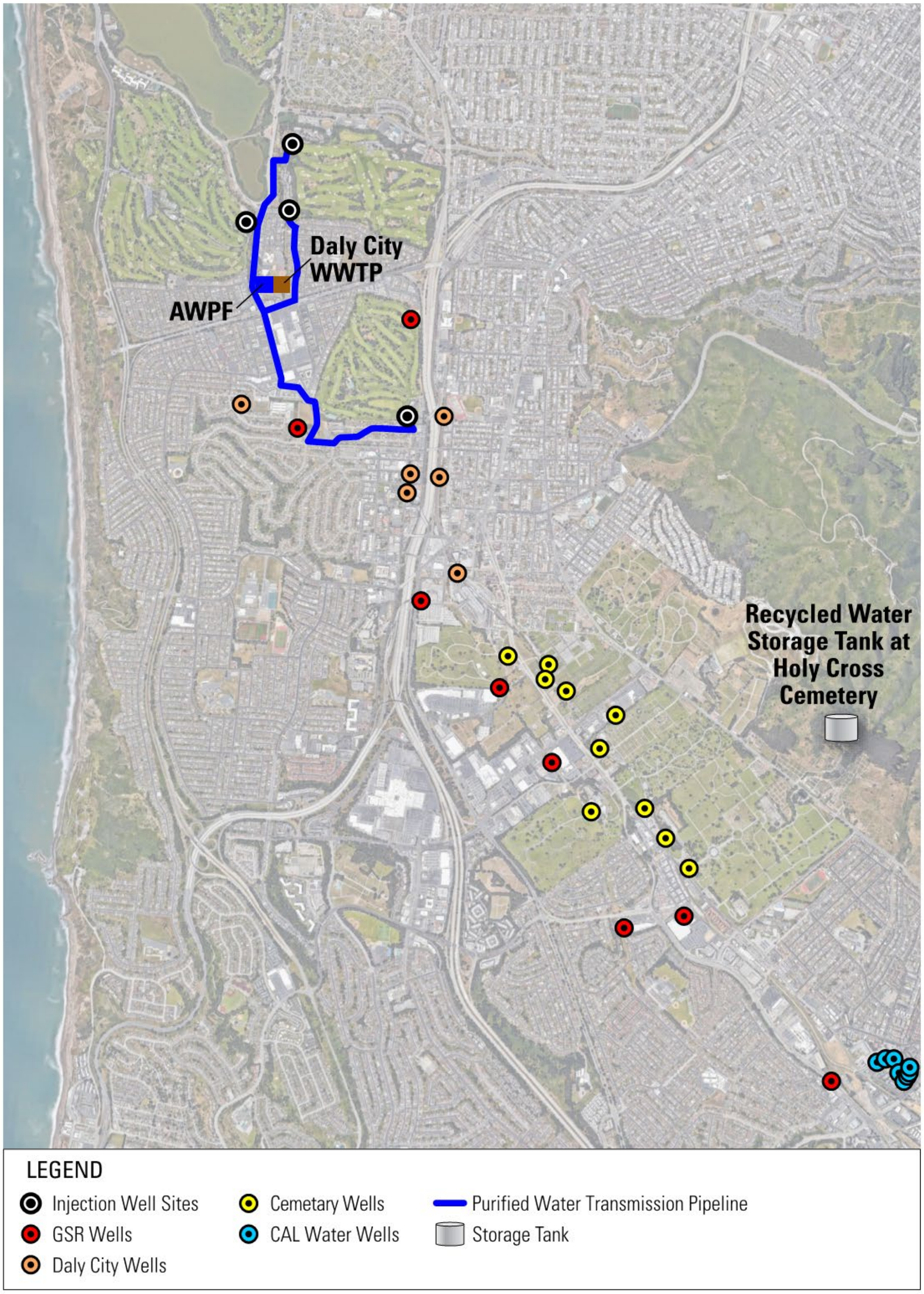

Figure 8 Feasible Alternative 3 Infrastructure Map

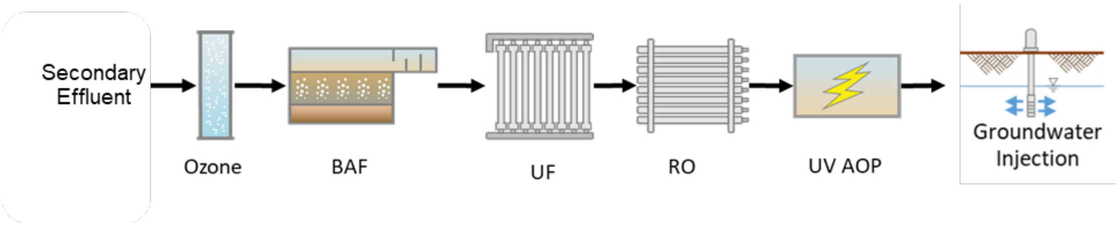

Figure 9 Feasible Alternative 3 Treatment Schematic

Section 4

FEASIBLE ALTERNATIVES - INFRASTRUCTURE

Table 3 summarizes the infrastructure requirements for the three feasible alternatives. The injection wells are assumed to have a capacity of 0.25 mgd each, as described in the Conceptual Alternatives TM. The injection well capacity is based on the SFPUC's recent experience with the Groundwater Storage and Recovery Project. The distribution system storage tank is designed to meet peak hourly irrigation demands, as described in the PDR of the baseline project (Carollo, 2017).

The injection well site locations were selected as representative locations for the IPR well sites. The feasibility of the injection well sites should be investigated in a future study. The study should include a siting analysis to determine property availability, location within the groundwater basin, site size, proximity to other utilities, and other site constraints. If different injection well locations are selected, the pipeline alignment and requirements would also need to change, which could result in increased project costs.

The distribution system shown for each alternative follows the alignment selected for the PDR (Carollo 2017) as shown in Figure 1. Pipeline alignments for IPR wells were selected to follow streets and avoid use of the SFPUC's easement for its Regional Water Supply System (RWSS) pipelines to avoid adding risk to those pipelines. The pipeline diameters for each pipe segment were selected to optimize pumping and material costs.

The pump stations were sized to provide flows to customers and IPR wells given the selected pipe diameters and lengths. The pump station sizing is based on preliminary hydraulic modeling.

Table 3 Distribution System Design Criteria

	Unit	Feasible Alternative		
		1	2	3
Injection Wells				
IPR wells	each	4	12	4
Pump Stations				
Pure Water	hp	75	435	75
Tertiary Treated Water	hp	409	-	-
Distribution System Storage Tank	MG	2.4	2.4	

	Unit	Feasible Alternative		
		1	2	3
Conveyance System				
1.5 inch diameter	LF	2,900	900	-
2 inch diameter	LF	1,600	900	-
4 inch diameter	LF	20,900	26,900	12,200
6 inch diameter	LF	6,400	4,200	2,000
8 inch diameter	LF	7,100	6,900	200
12 inch diameter	LF	3,500	3,500	-
14 inch diameter	LF	24,800	24,800	-

Abbreviations:
hp = horsepower; MG = million gallons; LF = linear feet

Section 5

FEASIBLE ALTERNATIVES – TREATMENT

This section summarizes the treatment process design criteria for each of the feasible alternatives. The feasible alternatives must meet Title 22 requirements and produce purified water that is suitable for injection into groundwater wells for IPR. Table 4 summarizes key Title 22 criteria for IPR treatment.

Table 5 summarizes design capacities and key design parameters for each treatment process. The processes are sized to provide desired purified flow rate given the recoveries of upstream processes.

Figure 10 provides an overview summary of the treatment processes for each feasible alternative:

- Alternative 1 is a 3 mgd hybrid treatment train with shared treatment through ozone, BAF and UF. Following UF, water to be used for IPR would undergo treatment through RO, UV AOP, and stabilization prior to being pumped to four northern groundwater wells. Water to be used for irrigation would be split off after UF and treated through UV and chlorination, and subsequently pumped through the tertiary treated water distribution system to be used for irrigation.
- Alternative 2 is a single 3 mgd treatment train consisting of ozone, BAF, UF, RO, UV AOP, and stabilization prior to irrigation and/or injection through up to 12 wells.
- Alternative 3 is a 1 mgd treatment train for IPR only consisting of ozone, BAF, UF, RO, UV AOP, and stabilization prior to groundwater injection through four wells.

The following sections provide additional detail on each process.

Table 4 Title 22 Requirements for IPR via Groundwater Injection

Requirement	Description
Use of RO	Treatment of flow through a reverse osmosis process.
Advanced oxidation	Use of an AOP that can oxidize 1,4-dioxane by 0.5-LRV.
Pathogen reduction	Pathogen reduction as follows: 12 LRV of virus, 10 LRV of *Cryptosporidium* and *Giardia*, treated through at least three treatment mechanisms with no individual process receiving credit for more than 6 LRV.
Pathogen monitoring	The reduction of pathogens through the treatment processes must be continuously monitored using a reliable surrogate.
TOC	The total organic carbon (TOC) levels must be less than 0.5 mg/L.
Drinking Water Limits	Purified water meets all Federal and California maximum contaminant levels (MCLs) and secondary MCLs found in Title 22 Tables 64431-A, 64442 and 64443, 64444-A, 64533-A, 64449-A and 64449-B
Notification Levels	Purified water meets all California notification levels (NLs) including for nitrosodimethylamine (NDMA) (10 nanograms per liter [ng/L]). NDMA removal can drive the dose of the UV in the UV AOP system.
CEC monitoring	Facility conducts regular monitoring for constituents of emerging concern (CECs) according to the latest Recycled Water Policy, which is updated every 5 years.
Subsurface travel time	The purified water that is injected into the ground must remain in the ground for at least 2 months prior to extraction. The subsurface travel time must be confirmed via a full-scale tracer study.

Table 5 Summary of Process Criteria for each Feasible Alternative

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Ozone + BAF				
Rated Capacity (Effluent)	mgd	3.61	4.17	1.39
UF				
Avg. Feed Flow	mgd	3.61	4.17	1.39
Net Filtrate Capacity	mgd	3.25	3.75	1.25
Recovery	percent	90	90	90
RO				
Avg. Feed Flow	mgd	1.25	3.75	1.25
Net Permeate Capacity	mgd	1	3	1
Recovery	percent	80	80	80
UV AOP				
Rated Capacity (Effluent)	mgd	1	3	1
Dose	mJ/cm^2	1,000	1,000	1,000
Calcite Contactor				
Capacity	mgd	1	3	1
UV (Irrigation)				
Capacity	mgd	2	N/A	N/A
Dose	mJ/cm^2	80	N/A	N/A

Abbreviations:
mJ/cm^2 = millijoules per square centimeter; N/A = nonapplicable.

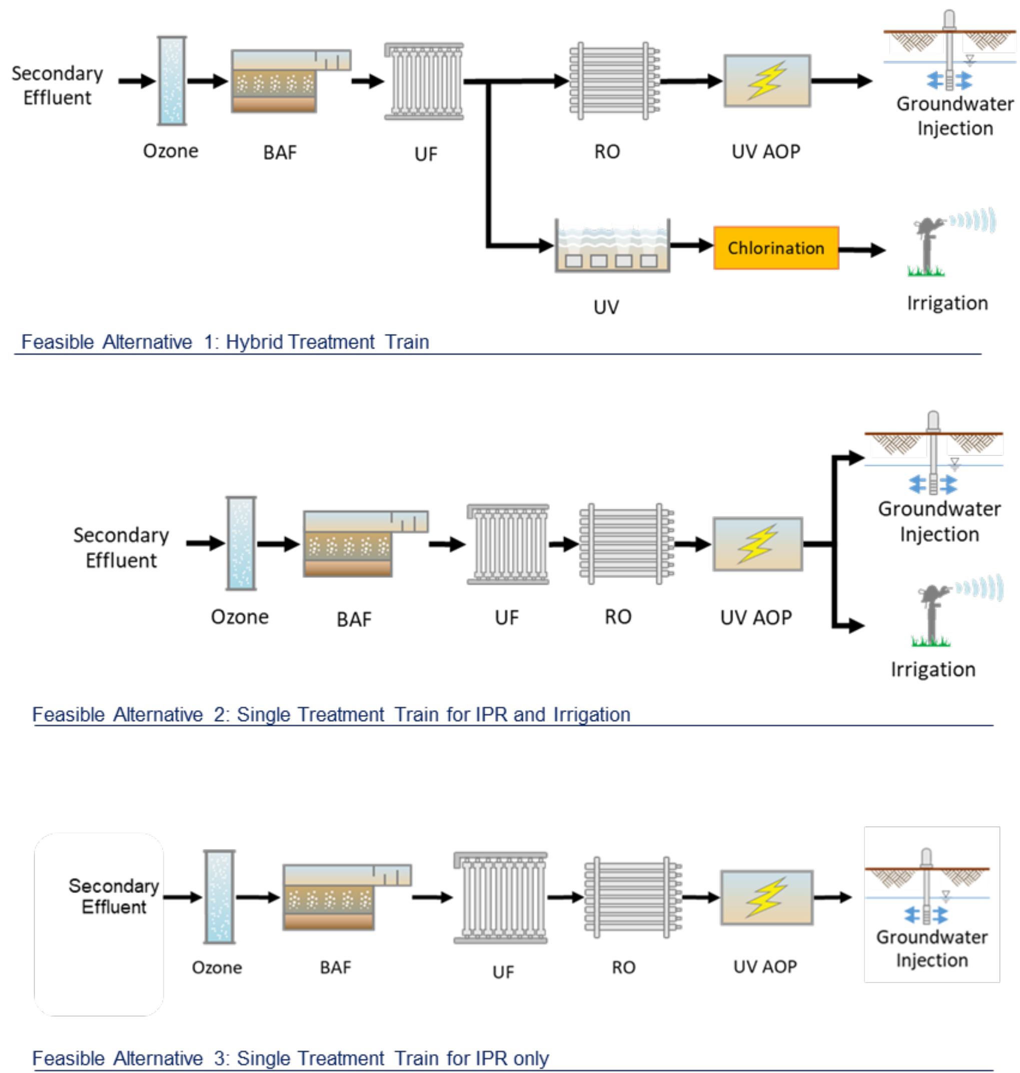

Figure 10 Feasible Alternative Treatment Schematics

5.1 Ozone

Ozone followed by biologically activated carbon (BAC) provides virus reduction, reduces TOC, NDMA, and trace organics, and improves downstream UF performance. The ozone system provides pathogen disinfection and chemical oxidation to reduce trace organics concentrations. Ozonation also breaks down organic molecules to increase their bioavailability, thereby allowing improved removal via biological degradation through BAC filtration.

Ozone gas must be generated on site from an available gaseous oxygen (GOX), either vaporized from LOX, oxygen generated onsite, or ambient oxygen. Daly City's WWTP already has LOX onsite for its high purity oxygen (HPO) secondary treatment process; however, there is little available capacity in the LOX system for additional uses. If one of the feasible alternatives were to move into a more detailed design phase, the designers should investigate the possibility of upgrading the existing LOX system to one that can support both the secondary process and the ozone generation process.

The ozone gas is injected through a bulk flow system to keep the gas-to-liquid ratio as low as possible. The bulk flow enters the ozone contactor where the ozonation occurs. The ozone contactor can be in the form of a pipeline contactor or a serpentine tank contactor.

Ozone off-gas removal must be connected at each high point and sludge drains provided at each low point of the contactor. Off-gas can be treated through a thermal catalytic destruction unit.

Ozone can be dosed via either a concentration times (CT) time method or according to an ozone to TOC ratio (after accounting for nitrite). While the CT method relies on the existence of an ozone residual, the ozone to TOC method does not rely on residual and may lower formation of disinfection byproducts (DBPs) and will use less energy. The ozone system designed herein assumes the use of an ozone to TOC ratio of 0.85. Ozone to TOC ratios are effective between 0.6 and 1.5. The optimal ozone to TOC ratio should be selected by conducting jar testing and confirming pathogen disinfection. Daly City's WWTP effluent contains particularly high TOC (average of 21 mg/L), so effective disinfection at lower ratios will be cost saving. Typically up to 15 millimeters (ml) of ozone can be transferred into water using one ozone injection point. To reach an ozone dose of 18 mg/L or higher, two ozone injection points might be required. Nitrite is also known to exert an ozone demand and must be accounted for when using the ozone to TOC dosing method; however, lacking nitrite data for Daly City, nitrite concentrations are assumed to be negligible. Ozone design criteria are summarized in Table 6. **The optimal ozone dose, ozone transfer efficiency, and number of ozone injection points required must be confirmed through pilot testing.**

Table 6 Ozone Design Criteria

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Feed Flow	gpm	2,726	3,145	1,048
Average Influent TOC(1)	mg/L	21	21	21
Ozone Dose	mg-min/L	1	1	1
Ozone Production				
Ozone Transferred Dose	mg/L	18.0	18.0	18.0
Ozone MTE	percent	90	90	90
Ozone Applied Dose	mg/L	20.0	20.0	20.0
Ozone Production	ppd	734	847	282
Power Consumption	kW	152.8	176.4	58.8
Ozone wt%	percent	12	12	12
Ozone Contactor				
HRT	minutes	10	10	10
No. of contactors	No.	2	2	2
Volume of each contactor	ft^3	1,822	2,102	701
Depth	ft	12	12	12
Pass Width	ft	3	3	3
Length	ft	51	58	19

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Oxygen Production				
Oxygen Production	ppd	6,114	7,054	2,351
Oxygen Required	m^3/day	3.2	3.7	1.2
LOX Storage	days	10	11	12
LOX Tank Size	m^3	31.6	40.2	14.6
Height	m	7.0	8.0	4.0
Diameter	m	2.4	2.5	2.2

Notes:
(1) Based on grab samples collected during pilot testing. TOC ranged 14 - 36 mg/L.
(2) Dose to achieve 5 virus LRV
Abbreviations:
gpm = gallons per minute; ft = feet (foot); mg-min/L = milligrams – minute per liter; ppd = pounds per day; kW = kilowatts; m^3 = cubic meters; LRV = log removal value.

5.2 Biologically Activated Carbon Filtration

It is typical to follow a tertiary ozonation process with BAC for two reasons: (1) to re-stabilize the water and (2) further remove chemical pollutants. Ozonation of tertiary filtered effluent breaks down dissolved organic substances, including trace constituents, into smaller fractions and, as a result, significantly increases their bioavailability. The organic content of the effluent, once relatively stable after the secondary treatment process, is now readily available for biometabolism. When a water quality such as Daly City's is fed directly to a membrane filtration process without pretreatment, the membranes experience rapid biofouling and lower sustainable flux rates. This impact was documented in prior pilot testing of membranes at the site.

The BAC process can remove organic matter, including trace constituents and their ozonation byproducts, via the microbial communities that develop on the surface of the media. This process also takes advantage of the elevated levels of dissolved oxygen (often super-saturated) that remain in the effluent after ozonation. The resulting BAC filtrate is more biostable and causes less fouling on downstream membranes.

The BAC can be in the form of a gravity or pressurized filter. In the case of Alternatives 1 and 2, gravity filters are assumed for space efficiency; for Alternative 3, pressurize vessels are used. These types of filters were selected to optimize the footprint of each design; however, the type of filter should be refined during final design.

As the filtration run time increases over a period of days, the solids and biomass build on the filter media and the filter headloss increases. Once the maximum headloss trigger has been reached, a filter backwash process automatically begins. The backwash process includes draining the filter, agitating the media with air scour, backwashing the media with a fluidized wash, and then refilling the filter and returning it to service. The entire backwash process typically lasts from 30 to 60 minutes.

A key design criteria for BAC is the empty bed contact time (EBCT), or the amount of time that the water resides with the filter media, allowing for continued degradation. Higher EBCT results in better biological degradation and TOC removal but increases capital and operational costs. The optimal EBCT should be selected through piloting; however, EBCTs of between 10 and 30 minutes are typical for wastewater effluents. The filtration systems for the three alternatives are sized to maintain an EBCT of at least 15 minutes at the design flow rates with one filter in backwash. When no filters are in backwash, the EBCTs increase to over 20 minutes.

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

BAC design criteria are summarized in Table 7.

Table 7 BAC Design Criteria

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Filter type		gravity	gravity	gravity
Media type		GAC	GAC	GAC
No. of Filters	No.	4	4	3
No. of Filters in Service	No.	3	3	2
Filter Loading				
Flow per filter	gpm	909	1048	524
Filter Area	sq ft	216	264	112
Hydraulic loading rate	gpm/sq ft	4.2	4.0	4.7
Filter Dimensions				
Length	ft	18.0	22.0	14.0
Width	ft	12.0	12.0	8.0
Media Depth		9.0	8.0	10.0
EBCT				
1 filter out of service	minutes	16.0	15.1	16.0
All filters in service	minutes	21.3	20.1	24.0

Abbreviations:
sq ft = square foot (feet); gpm/sq ft = gallons per minute per square foot

5.3 Ultrafiltration

The UF system is a low pressure membrane filtration system that removes particulate matter from BAC filtrate in order to enhance downstream RO membrane performance and provide removal of pathogens. Chloramine is added ahead of the UF system to minimize biofouling of the membranes.

The UF feed tank will store BAC filtrate for equalization between the two systems and the required BAC backwash storage. UF feed pumps will pressurize flow from the UF feed tank through the UF system. The UF modules and rack sizing was provided by WesTech based on a design flux of 50 gallons per square foot of membrane per day (gfd); however, following an ozone/BAC process, UF flux may be higher (e.g., 70 gfd). The achievable flux rate should be confirmed through pilot testing.

The UF filtrate/RO feed tank must provide sufficient backwash volume for the UF system and provide feed flow rate for the RO. The UF clean-in-place (CIP) and neutralization tanks are designed to allow adequate water for conducting clean-in-place maintenance on membranes followed by neutralization of cleaned membranes before being put back into use. Design criteria for the UF system are summarized in Table 8.

Table 8 UF Design Criteria

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
UF Process				
Flow rate	gpm	3.25	1.25	3.75
Number of units in operation	No.	2	1	2
Number of modules	No.	42	49	32
Membrane nominal pore size	µm	0.01	0.01	0.01
Membrane area per module	sq ft	969	969	969
Normalized Flux Rate (20 degrees C)	gfd	50	50	50
Flow Rates				
Instantaneous	gpm	2,822	3,256	1,085
Average	gpm	2,472	2,853	951
Backwash	gpm	2,540	2,931	868
Recovery	percent	90	90	90
UF Feed tank				
No. of tanks	No.	1	1	1
Volume	gallons	118,200	136,300	55,400
Length	ft	19	19	23
Width	ft	52	59	23
Depth	ft	18.00	18.25	16
Working Depth	ft	16.00	16.25	14
UF Filtrate Tank/RO Feed Tank				
Backwash Volume Required				
Volume per backwash	gallons	2769	3195	2130
No. of Backwash volumes stored	No.	2	2	2
Volume required for BW storage	gal	5538	6390	4260
RO Buffer Volume Required				
RO Buffer Time	min	12	12	12
RO Buffer Volume	gallons	27083	31250	10417

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Tank Dimensions				
Volume	gal	34588	39261	15080
Depth - Actual	ft	18	18.25	16
Depth - Working	ft	16	16.25	14
Length	ft	17	17	12
Width	ft	17	19	12
UF CIP Tank				
Diameter	ft	6.5	6.5	6.5
Height	ft	8.0	8.0	8.0
Volume	gallons	2000	2000	2000
UF Neutralization Tank				
Number	No.	1	1	1
Diameter	ft	9.5	9.5	9.5
Height	ft	12.0	12.0	12.0
Volume	gallons	6400	6400	6400

Abbreviations:
µm = micrometer;

5.4 Reverse Osmosis

Reverse osmosis is well established and used for treating secondary or tertiary wastewater effluent to remove contaminants that remain after the low pressure membrane system. The RO process uses semi-permeable membranes and a driving force of hydraulic pressure to remove dissolved contaminants, making it a physical separation process that can reject constituents as small as 0.0001 µm. The process is considered to be diffusion controlled, since the mass-transfer of ions through RO membranes is achieved through diffusion. Consequently, RO can remove dissolved salts, total dissolved solids (TDS), hardness, dissolved organic carbon (DOC), synthetic organic chemicals (SOCs), and DBP precursors.

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

The basic unit of an RO system is the spiral-wound RO element, which consists of several layers of RO membranes wound around a central permeate collection tube, and enclosed in a cylindrical housing. This space-efficient configuration allows for feed flow that is tangential to the membrane surface ("cross-flow" configuration), which reduces fouling by continually sweeping the surface of the membrane. As feed water flows along the length of the element, water passes through the membrane leaving behind most dissolved constituents, resulting in a progressively decreasing flow to carry the same mass of dissolved constituents. At the end of the element, the feed flow becomes the concentrate. The ratio of the permeate production to the feed flow is known as the RO system recovery. RO trains are typically designed in stages, the number of which depends on the water supply and the design recovery. In a typical advanced wastewater treatment RO system operating at 75 to 85 percent recovery, a two stage system with RO elements per vessel is typical. In a two stage system, the concentrate from the pressure vessels in the first stage is combined and fed to a smaller number of pressure vessels in a second stage. This approach increases the RO system's recovery while maintaining concentrate velocity in the downstream elements. This is important as low concentrate velocity can result in organic fouling and mineral scaling on the RO membranes, which reduces the performance and increases operating costs.

The RO transfer pump located in the RO feed tank supplies UF filtrate to the RO feed pump, which provides the pressure needed for the RO train, UV reactor, and chlorine contactor. Solids, such as fine sands or organic debris, will result in RO membrane fouling and may cause mechanical damage to the RO membrane elements. Although the UF system will provide exceptionally high-quality water that is free of suspended solids, cartridge filters are still required to protect against membrane damage from suspended material that may be introduced into the RO feed tank, leftover construction debris, or other unexpected solids. Disposable cartridge filters are provided as the final barrier to protect the valuable RO membrane elements against fouling or damage from these particulates. Table 9 summarizes RO design criteria.

Table 9 RO Design Criteria

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Reverse Osmosis				
Number of Membrane Trains	No.	2	2	2
Design Feed Flowrate	gpm	1.25	3.75	1.25
Design Feed Flowrate Per Train	gpm	0.625	1.875	0.625
Recovery (Design)	percent	80	80	80
Concentrate Flow per Train	gpm	0.125	0.375	0.125
Permeate Flowrate per Train	gpm	0.5	1.5	0.5
Number of Array Stages per Train	No.	2	2	2
Pressure Vessels per Train				
First Stage	No.	10	30	10
Second Stage	No.	5	15	5
Pressure Vessels per Train	No.	15	45	15
Total Number of Pressure Vessels	No.	30	90	30
Train Dimensions				
Width per Train	ft	9	15.5	9
Length per Train	ft	25	25	25

5.5 Ultraviolet Disinfection / Advanced Oxidation

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

The AOP is achieved by introducing an oxidant into the system with UV light, which reacts with the oxidant to produce hydroxyl radicals. Hydroxyl radicals react rapidly with organics and lower the concentrations of a broad range of organic compounds. Table 10 summarizes UV AOP system design criteria.

Table 10 UV AOP Design Criteria

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Type	(-)	Closed-Vessel, LPHO	Closed-Vessel, LPHO	Closed-Vessel, LPHO
Number of Vessels				
In-Service	No.	1	1	1
Reliability	No.	1	1	1
Total	No.	2	2	2
Flow Rate	mgd	1	3	2
Fouling Factor	(-)	0.80	0.80	0.80
End of Lamp Life	(-)	0.85	0.85	0.85
Design UVT	percent	96	96	96
Dose(1)	mJ/cm^2	1000	1000	1000
1,4-Dioxane Design LRV	LRV	0.5	0.5	0.5
Oxidant type	hydrogen peroxide	H_2O_2	H_2O_2	H_2O_2
Oxidant Dose	mg/L	4.95	4.95	4.95

Notes:
(1) Assumed dose for NDMA reduction. Bench scale testing required to confirm NDMA in RO permeate.
Abbreviations: UVT = ultraviolet transmittance; LPHO = low pressure high output.

5.6 Ultraviolet Disinfection

Alternative 1 has a hybrid treatment train which shares the initial processes of ozone, BAC, and UF. Following UF, the water to be purified for IPR undergoes treatment by RO, UV AOP and stabilization. The water to be used for irrigation undergoes UV disinfection after UF. UV is also used for the Baseline Project for disinfection prior to irrigation. The UV disinfects pathogens at a lower dose without providing the additional chemical destruction that occurs with the high UV dose and oxidant addition of a UV AOP system

Table 11 UV Design Criteria

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Type	(-)	Closed-Vessel, LPHO	N/A	N/A
Number of Vessels			N/A	N/A
In-Service	No.	1	N/A	N/A
Reliability	No.	1	N/A	N/A
Total	No.	2	N/A	N/A
Flow Rate	mgd	1	N/A	N/A
Fouling Factor	(-)	0.80	N/A	N/A
End of Lamp Life	(-)	0.85	N/A	N/A
Design UVT	percent	55[1]	N/A	N/A
Dose	mJ/cm^2	80	N/A	N/A

Notes:
(1) Lower 5th percentile of data collected during UF Pilot Test.

5.7 Product Water Stabilization

Water that has undergone treatment by reverse osmosis is exceedingly low in salts and minerals with a low pH. Without the addition of minerals back into the water, RO permeate water can be aggressive and corrosive and should not be sent directly into a distribution system.

Adding calcium carbonate through calcite contactors is one method to stabilize the water, preparing it to put into pipelines and distribution systems. To reduce the footprint of the calcite contactor system, a portion of the overall flow can be treated through the calcite contactor, with the two streams blended in the product water tank. With only 30-50 percent of the stream being treated through the calcite contactors, more minerals can be dissolved by adding sulfuric acid added ahead of the calcite contactors to depress the pH even further and facilitate calcium carbonate dissolution into the water.

While lime addition can be used in place of calcite contactors, lime can increase the turbidity of the water, which could hinder public perception of the water being used for irrigation. Lime addition can also be challenging to operate. The preferred stabilization method should be refined during detailed design. Table 12 provides stabilization criteria.

Table 12 Stabilization Design Criteria: Calcite Contactors

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Proportion of Flow through Contactors	percent	50	50	50
Flow through contactors	mgd	0.5	1.5	0.5
Contactor type		gravity	gravity	gravity
Media type		calcite	calcite	calcite
No. of Contactors	No.	2	3	2

Process and Criteria	Unit	Feasible Alternative		
		1	2	3
Contactor Loading				
Flow per Contactor	gpm	174	347	174
Contactor Area	sq ft	50	113	50
Hydraulic loading rate, all in service	gpm/sq ft	3.5	3.1	3.5
Hydraulic loading rate, one in backwash	gpm/sq ft	6.9	4.6	6.9
Contactor Dimensions		gravity	gravity	gravity
Diameter	ft	8	12	8
Media Depth	ft	3	3	3
Media Depth, Expanded	ft	4.5	4.5	4.5
EBCT				
All Contactors in Service	minutes	10	11	10
1 Contactor out of Service	minutes	5	7	5

5.8 Product Water Storage Tank

A wet well is required for product water storage to allow for pump station cycling. Equalization storage for demand fluctuation is not required for any of the alternatives. Storage is provided offsite to provide peak irrigation demands. IPR wells have a constant demand unless they are down for maintenance such as backflushing. Design criteria for the IPR and tertiary product water tanks are provided in Table 13.

Table 13 Product Water Tank Design Criteria

	Unit	Feasible Alternative		
		1	2	3
IPR Product Water Tank				
Flow rate	mgd	1	3	1
Product Water Wet Well				
Detention Time	min	15	15	15
Volume	gal	10417	31250	10417
Height	ft	12.0	16.0	12.0
Width	ft	12.0	20.0	12.0
Length	ft	9.7	13.1	9.7
Tertiary Recycled Water Product Water Tank				
Flow rate	mgd	2	n/a	n/a
Product Water Wet Well				
Detention Time	min	15	n/a	n/a
Volume	gal	20833	n/a	n/a
Height	ft	12.0	n/a	n/a
Width	ft	15.0	n/a	n/a
Length	ft	15.5	n/a	n/a

5.9 Chemicals

Chemicals are used throughout the treatment train as described in the previous subsections. Table 14 summarizes the chemicals and storage required for each alternative.

Table 14 Chemical Storage Design Criteria

Chemical	Purpose		Feasible Alternative		
		Unit	1	2	3
Aluminum Chloride Hydroxide	Pretreatment	gallons	TBD(1)	TBD(1)	TBD(1)
Antiscalant	RO Influent	gallons	250	250	250
Citric Acid	UF MCs and CIPs	gallons	330	330	330
Gypsum	Post-Treatment	gallons	TBD(1)	TBD(1)	TBD(1)
Hydrochloric acid	UF MCs, CIPs, and neutralize clean	gallons	330	330	330
Hydrogen peroxide	UV AOP	gallons	330	660	330
Sodium Bisulfite	Ozone Quench, neutralize clean	gallons	TBD(1)	TBD(1)	TBD(1)
Sodium Hydroxide	UF MC, CIP, and neutralize clean	gallons	1,000	1,000	1,000
Sodium Hypochlorite	Pretreatment, UF MC, CIP, and residual disinfectant	gallons	4,136	4,136	4,136
Sulfuric Acid	RO influent, calcite contactor influent	gallons	1,100	3,300	1,100

Notes:
(1) Chemical storage requirements to be determined during final design.

Section 6

FEASIBLE ALTERNATIVES – CONCEPTUAL SITE PLANS

Carollo developed conceptual site layouts for each of the feasible alternatives. Considering the limited space at the existing WWTP, the alternatives are shown in the City-owned parking lot adjacent to Daly City's WWTP. The feasibility of locating the treatment facilities within the City-owned parking lot needs to be determined by Daly City and the SFPUC. Siting the treatment facilities in the parking lot will impact visitor parking at the adjacent baseball field. It is likely visitors to the baseball field would need to use the larger community center parking lot, located slightly to the south. The project may also be required to mitigate the parking impacts.

It should be noted that Alternatives 1 and 3 require installing a permanent shoring wall to provide additional space for the treatment facilities. We recommend performing geotechnical and structural investigations as a next step to determine the feasibility of constructing the permanent shoring wall as shown.

The conceptual site plans show that some existing wastewater treatment equipment will need to be relocated, including the plant switch gear for Daly City's existing WWTP. Figure 11 shows the vicinity of the recycled water facilities, the larger community center parking lot, the existing Daly City WWTP, the fire station, and the hillslope area. Figure 12 shows a close-up isometric view of the baseball parking lot.

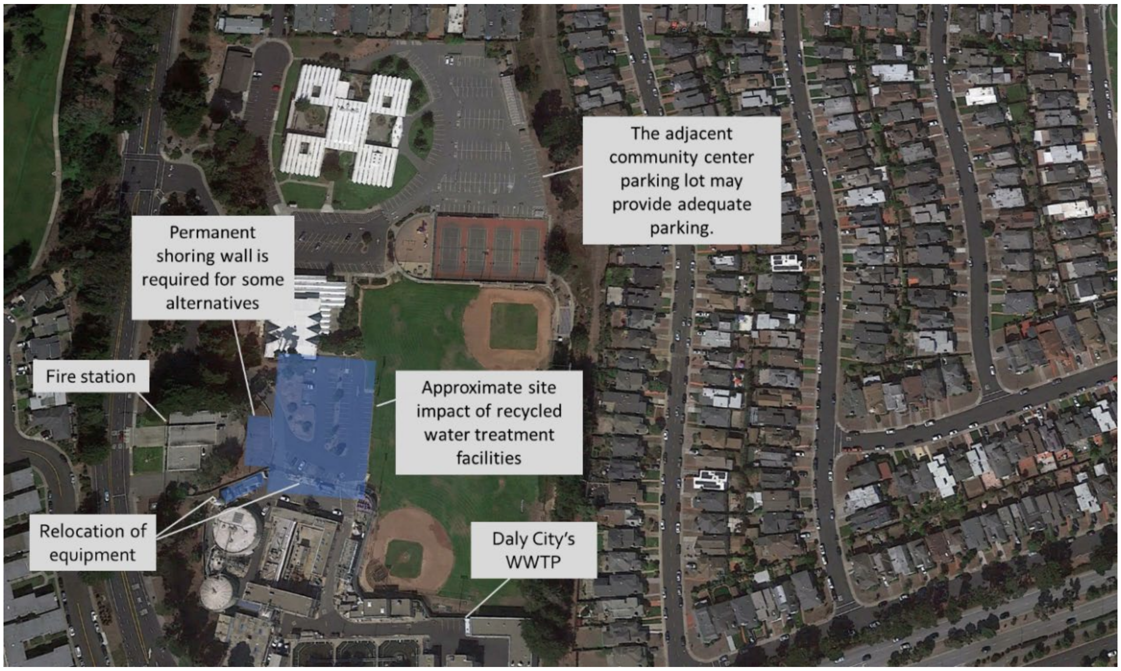

Figure 11 Aerial View of the Vicinity of the Recycled Water Treatment Facilities and Adjacent Sites

Figure 12 Vicinity of the Recycled Water Treatment Facilities (Currently the Baseball Parking Lot)

The project team developed a 3D models of the conceptual site layouts to demonstrate the site impacts of each alternative. The site layouts show the treatment building, site access, etc. The construction staging is likely to be challenging for all alternatives. Additionally, existing wastewater treatment plant equipment may need to be relocated to allow for semi-trailer truck access and turn-around into the WWTP.

6.1 Feasible Alternative 1

The treatment facility conceptual layout for Feasible Alternative 1 is shown in Figure 13. The alternative includes a two-story building with oxygen and ozone generation, UF, RO, UV AOP, and UV facilities, and electrical/control equipment. The UF process is located upstairs with MC and CIP tanks and equipment below. The gravity BAC filters are located on the outside of the building. The pressurized calcite contactors, ozone injection, and ozone contactor are located outside where there is currently a steep slope to the adjacent fire station. A permanent shoring wall would need to be constructed to allow for this space to be used. The chemical storage and feed station abuts an existing fence separating the WWTP from the fire station. Existing equipment, including the plant switch gear, would need to be relocated.

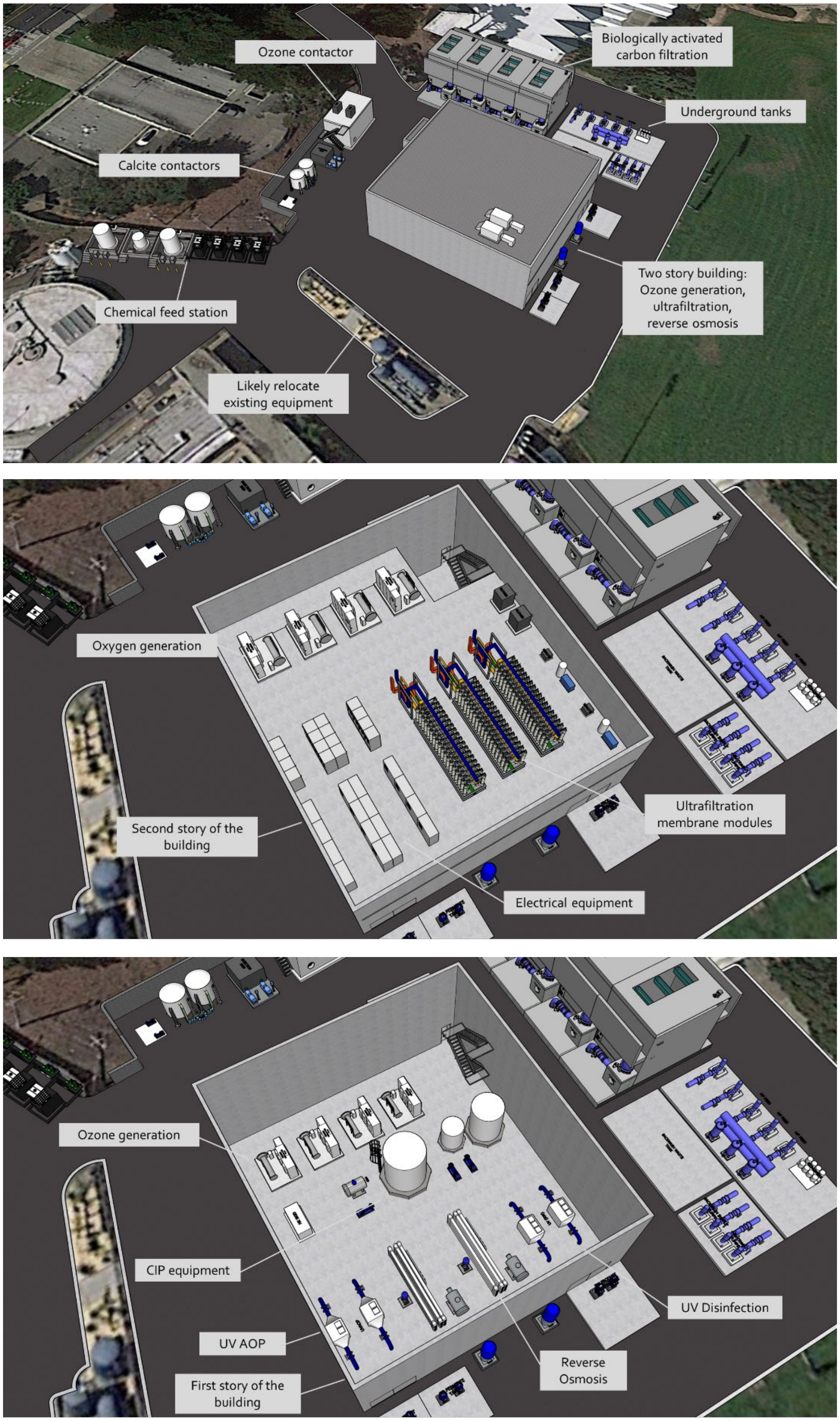

Figure 13 Feasible Alternative 1: Treatment Facilities Layout

6.2 Feasible Alternative 2

The conceptual facility layout for Feasible Alternative 2 (shown in Figure 14) is similar to the layout for Alternative 1. A two-story building contains oxygen and ozone generation, UF, RO, and UV AOP facilities, and electrical equipment. Similar to Alternative 1, the UF is upstairs with MC and CIP tanks and equipment below. The gravity BAC filters stand alone on the outside. The pressurized calcite contactors, ozone injection, and ozone contactor are built into the hillslope adjacent to the fire station, requiring a retaining wall. The chemical storage and feed station abuts an existing fence separating the WWTP from the fire station. Existing equipment located here would need to be relocated.

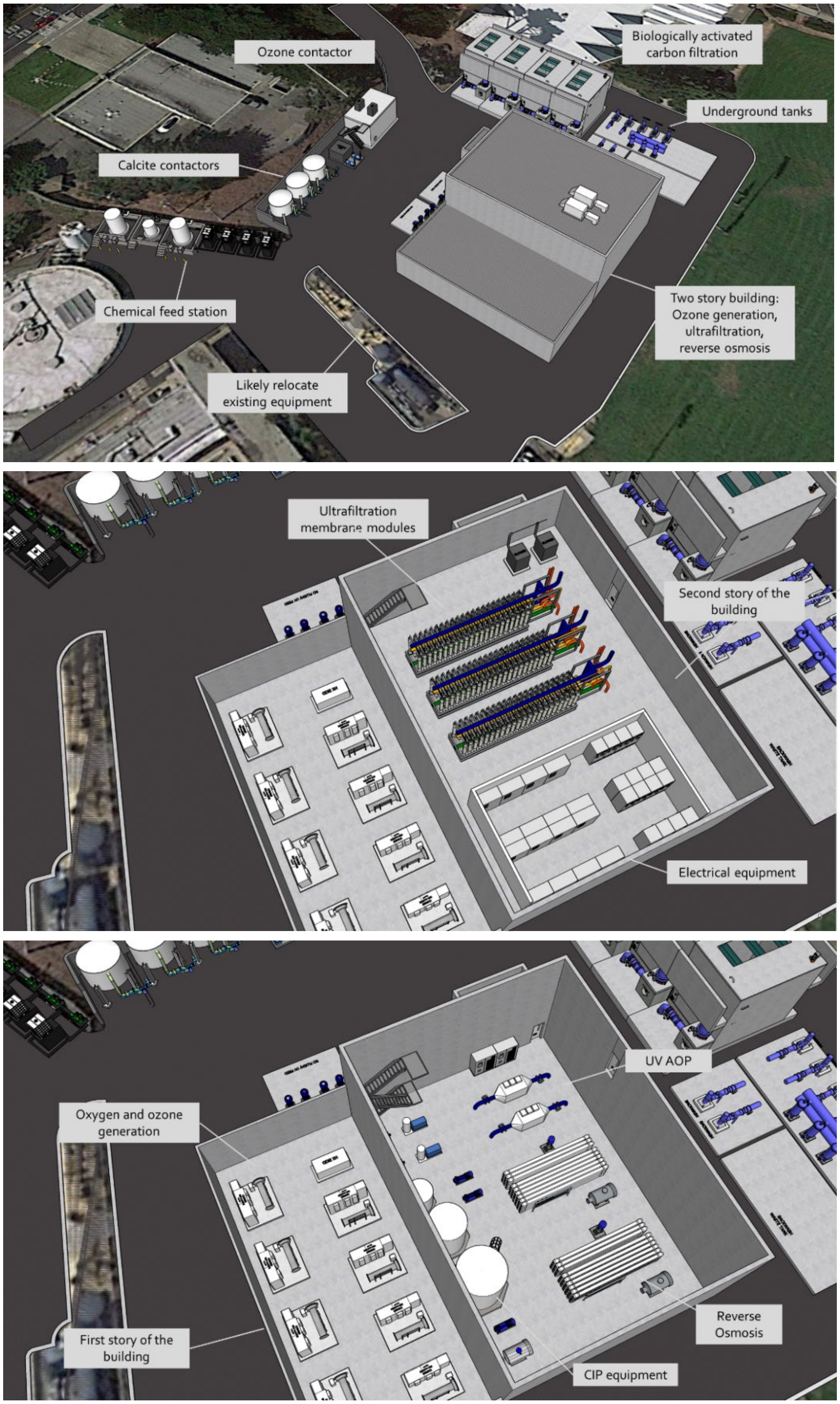

Figure 14 Feasible Alternative 2: Treatment Facilities Layout

6.3 Feasible Alternative 3

Feasible Alternative 3 has a smaller overall footprint than Alternatives 1 and 2; however, the footprint cannot fit within the existing Daly City WWTP. A two story building contains UF, RO, UV AOP, electrical equipment, and CIP equipment. A separate one story building contains oxygen and ozone generation facilities. The BAC filters are in stand-alone pressure vessels. The chemical storage facilities are adjacent to the hillslope but would likely not require a retaining wall to stabilize the hillslope and fire station. The chemical storage facilities in this alternative may not need to displace the plant's switch gear. Figure 15 presents the layout of Feasible Alterative 3.

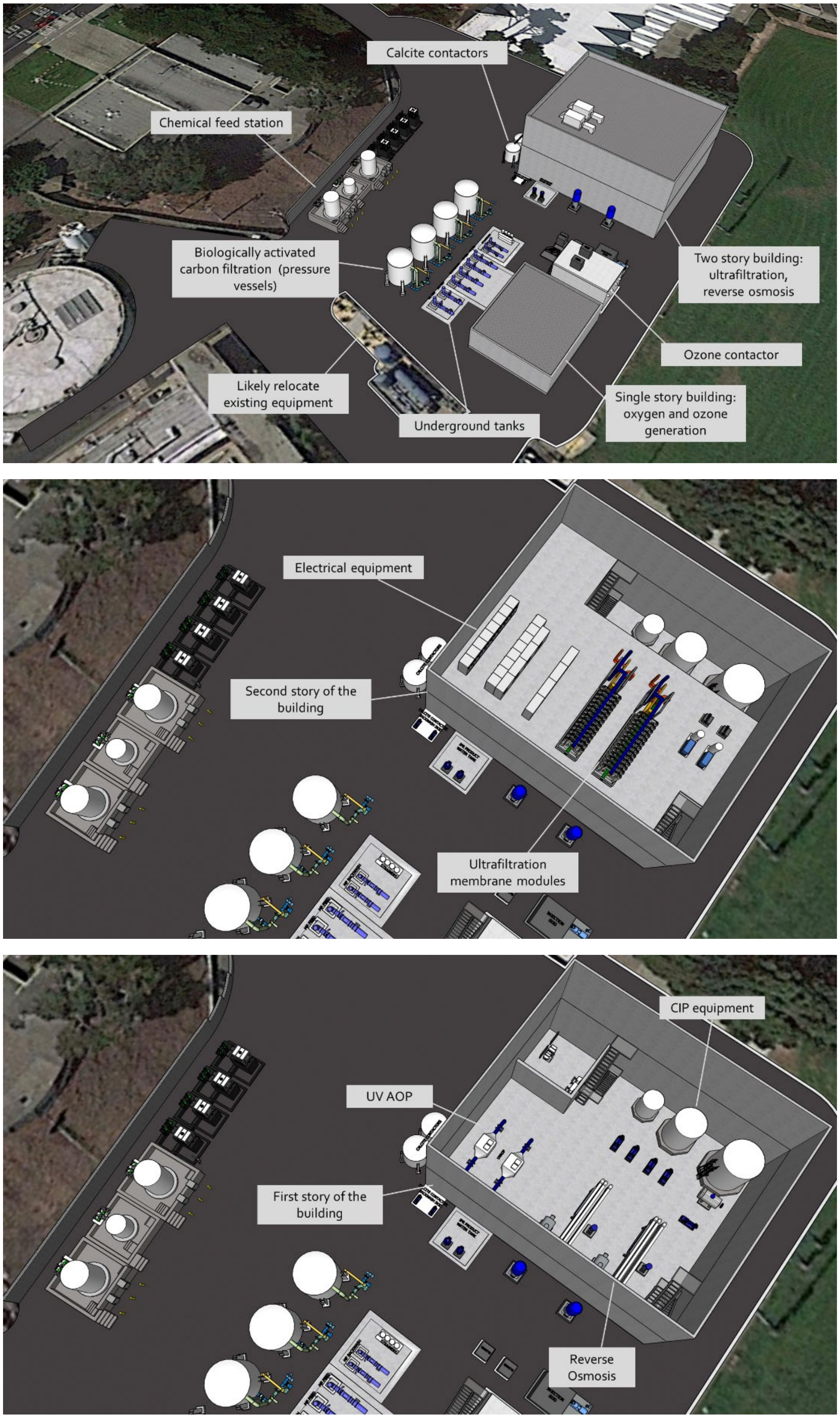

Figure 15 Feasible Alternative 3: Treatment Facilities Layout

Section 7

FEASIBLE ALTERNATIVE PROJECT COST ESTIMATES

The project team developed capital, operations and maintenance (O&M), and life cycle costs for each feasible alternative. From the life cycle costs, the unit cost of water was also calculated in dollars per acre-foot ($/AF). The following subsections provide additional details on the cost estimates.

7.1 Basis of Cost

Carollo developed conceptual cost estimates based on the Association for the Advancement of Cost Estimating (AACE) International Recommended Practice No. 18R-97, Class 5 estimate level for the three feasible alternatives. Class 5 estimates can use historical costs from recent projects, cost curves, and vendor quoted information. Based on the AACE standards, the accuracy range for Class 5 estimates are -20 percent to -50 percent on the low side and +30 percent to +100 percent on the high side.

The cost of the baseline alternative was estimated during the PDR (Carollo 2017). A range of costs was estimated based on a range of pipeline and treatment system designs. These costs were updated in the Feasibility of Expanded Tertiary Treatment Facilities Project Cost Estimate Update (Carollo, 2020) according to the August 2020 Construction Cost Index (CCI) for San Francisco. The baseline alternative construction cost estimates were consistent with an AACE International Class 4 budget estimate with an accuracy range of +50 percent to -30 percent of the actual project cost.

Table 15 summarizes the estimating accuracy range for the baseline project and the three feasible alternatives.

Table 15 AACE Estimate Class for the Baseline Project and the 3 Alternatives

	Baseline Project	Three Feasible Alternatives
AACE Estimate Class	Class 4	Class 5
Level of Project Definition	1 to 15%	0 to 2%
End Usage	Preliminary Design	Concept screening
Accuracy Range	-30 to +50%	-30 to +50%

The cost estimates of the feasible alternatives were developed using historical costs from recent Carollo projects, proprietary cost curves, and vendor quoted information. Construction cost markups include contractor office overhead and profit at 12 percent, escalation to the project mid-point at 14.7 percent, sales tax at 9 percent (applied to 50 percent of the direct costs), and general conditions at 12 percent. To calculate the total project costs, additional markups include engineering, legal, and administrative costs at 20 percent, owner's reserve for change orders at 5 percent. Storage tank and injection well land acquisition costs and the cost to retrofit irrigation systems to accept recycled water were also included in the total estimated project cost.

The following costs were excluded from the cost estimates:

- Land acquisition of the baseball parking lot to fit the treatment facilities.
- RO concentrate treatment, which might be necessary
- Historical or cultural impacts to construction activities, including mitigation for the community center.
- Construction of a parking facility that may be required to mitigate impacts to the baseball field parking.
- Costs associated with the identification/mitigation of hazardous waste material.
- Variances in the cost of labor, materials, equipment, services provided by others, competitive bidding or market conditions.
- Recent market volatility spurred by supply chain and other market conditions related to the pandemic.

The cost estimates herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers has no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices or bidding strategies. Carollo Engineers cannot and does not warrant or guarantee that proposals, bids or actual construction costs will not vary from the costs presented as shown.

7.2 Cost Estimate Summary Compared to Baseline Alternative

Table 16 summarizes the estimated total project costs for the three feasible alternatives compared against the estimated costs for the baseline project. Table 17 presents the estimated annual O&M costs compared against the baseline project. Table 18 shows the total cost per acre-foot of water produced by each project.

Table 16 Summary of Estimated Capital Costs for Feasible Alternatives and Baseline Project[(2)]

Item	Baseline Project[(1)]		Feasible Alternative		
	Low Estimate	High Estimate	1	2	3
Distribution System	$34,386,000	$43,738,000	$55,220,000	$89,220,000	$21,910,000
Treatment Facilities	$32,448,000	$32,448,000	$80,710,000	$76,870,000	$48,290,000
Land Acquisition	$6,964,000	$6,964,000	$7,964,000	$15,964,000	$1,000,000
Irrigation System Retrofits	$2,990,000	$2,990,000	$2,990,000	$2,990,000	-
Total Project Cost	**$76,788,000**	**$86,140,000**	**$146,884,000**	**$185,044,000**	**$71,200,000**

Notes:
(1) Baseline project cost estimates developed in Carollo 2017 an updated in Carollo 2020. The high and low estimates of the baseline project provide the range of estimated costs for various treatment train options and pipeline alignments.
(2) Cost estimates do not consider current market volatility.
(3) The cost estimates are AACE Level 5 estimates and have an accuracy of -30% - +50%.

Table 17 Summary of Estimated O&M Costs for Feasible Alternatives and Baseline Project[(1)(3)]

Item	Baseline project[(2)]		Feasible Alternative		
	Low Estimate	High Estimate	1	2	3
Distribution System	$518,000	$737,000	$1,022,000	$1,545,000	$332,000
Treatment Facilities	$1,137,000	$1,149,000	$2,400,000	$3,200,000	$1,800,000
Total O&M	**$1,655,000**	**$1,886,000**	**$3,422,000**	**$4,745,000**	**$2,132,000**

Notes:
(1) Annual average O&M costs are provided in 2021 dollars. Actual O&M costs will increase annually with inflation.
(2) Baseline project cost estimates were developed by Carollo 2017 and updated in Carollo 2020. The high and low estimates of the baseline project provide the range of estimated costs for various treatment train options and pipeline alignments. Treatment facility O&M costs include an additional $320,000 annually for O&M personnel, to align with the Feasible Alternative costs.
(3) Cost estimates do not consider current market volatility.

Table 18 Life Cycle Costs and Unit Cost of Water[(1)]

	Baseline		Feasible Alternative		
	Low	High	1	2	3
Total Capital Cost	$77 M	$86 M	$147 M	$185 M	$71 M
Average O&M Cost	$1.7 M	$1.9 M	$3.4 M	$4.7 M	$2.1 M
Life cycle cost, present value (50 years)	$169 M	$191 M	$336 M	$444 M	$188 M
Annual Water Produced (AFY)[(2)]	1,187	1,187	2,307	3,360	1,120

Notes:
(1) Cost estimates do not consider current market volatility.
(2) Average annual water produced does not necessarily equate to the water used or the basin benefit.

7.3 Distribution System Costs

Table 19 presents the costs estimated for the distribution system infrastructure, including pipelines, storage tanks, and injection wells described in Section 4. Pump stations cost estimated are presented in Section 5 alongside treatment facilities costs to correspond better with the cost categories of the baseline project.

Table 19 Summary of Estimated Distribution System Costs

Item	Feasible Alternative		
	1	2	3
Pump Station (Pure Water)	*Included in Treatment Facility Costs*		
Pump Station (Tertiary)			
Pipelines	$13,587,000	$13,748,000	$2,123,000
Injection Wells	$7,000,000	$21,000,000	$7,000,000
Irrigation Distribution Tank	$2,410,000	$2,410,000	N/A
Total Direct Cost	***$22,997,000***	***$37,158,000***	**$9,123,000**
Estimating Contingency at 30%	$6,899,000	$11,147,000	$2,737,000
Subtotal	*$29,896,000*	*$48,305,000*	$11,860,000
Contractor Overhead & Profit at 12%	$3,588,000	$5,797,000	$1,423,000
Subtotal	*$33,484,000*	*$54,102,000*	$13,283,000
Escalation to mid-point at 14.7%(1)	$4,922,000	$7,953,000	$1,953,000
Subtotal	*$38,406,000*	*$62,055,000*	$15,236,000
Sales Tax at 9%(2)	$1,035,000	$1,672,000	$ 411,000
Subtotal	*$39,441,000*	*$63,727,000*	$15,647,000
General Conditions at 12%	$4,733,000	$7,647,000	$1,878,000
Total Construction Cost	***$44,174,000***	***$71,374,000***	**$17,525,000**
Engineering, Legal, and Administrative at 20%	$8,835,000	$14,275,000	$3,505,000
Owners Reserve for Change Orders at 5%	$2,209,000	$3,569,000	$876,000
Total Distribution System Project Cost(3)	**$55,220,000**	**$89,220,000**	**$21,910,000**

Notes:

(3) Costs were escalated to the midpoint of construction, assuming a compound annual escalation rate of 4%, design duration of 18 months starting in August 2021, and a construction duration of 24 months starting in February 2023 – for a total escalation of 14.7%

(4) Sales Tax applied on 50% of subtotal to represent tax on equipment and materials only.

(5) The cost estimates are AACE Level 5 estimates and have an accuracy of -30% - +50%.

7.4 Treatment Facility Costs

Table 20 summarizes the costs for the treatment facilities described in Section 5.

Table 20 Summary of Estimated Treatment Facilities Costs

Item	Feasible Alternative		
	1	2	3
Secondary Effluent Pump Station	$481,000	$556,000	$185,000
Ozone + BAF	$3,300,000	$3,300,000	$2,350,000
Ozone Contactor (tank)	$90,000	$100,000	$70,000
UF	$1,912,000	$1,780,000	$1,230,000
RO	$1,250,000	$1,000,000	$1,000,000
UV AOP	$550,000	$940,000	$550,000
Chemical Systems	$330,000	$380,000	$300,000
UV Disinfection	$540,000	N/A	N/A
Subtotal, Process Equipment	**$8,453,000**	**$8,056,000**	**$ 5,685,000**
Equipment Installation, at 15%	$2,113,250	$2,014,000	$1,421,000
Sitework at 15%	$1,267,950	$1,208,000	$852,750
Electrical & I/C at 25%	$2,113,250	$2,014,000	$1,421,250
Mechanical at 15%	$1,267,950	$1,208,000	$852,750
Piping and valves at 20%	$1,690,600	$1,611,000	$1,137,000
Treatment Building	$5,400,000	$5,440,000	$5,110,000
Plant Switchgear Replacement and Relocation	$3,000,000	$3,000,000	$2,500,000
Ancillary Equipment Relocation	$2,500,000	$2,500,000	$1,421,000
Pump Station (Pure Water)	$1,134,000	$4,965,000	$1,134,000
Pump Station (Tertiary)	$4,672,000	N/A	$1,134,000
Total Direct Cost	***$33,612,000***	***$32,016,000***	***$ 20,113,750***
Estimating Contingency at 30%	$10,084,000	$9,605,000	$6,034,000
Subtotal	*$43,696,000*	*$41,621,000*	*$26,147,750*
Contractor Overhead & Profit at 12%	$5,244,000	$4,995,000	$3,138,000
Subtotal	*48,940,000*	*$46,616,000*	*$29,285,750*
Escalation to mid-point at 14.7%(1)	$7,194,000	$6,853,000	$4,305,000
Subtotal	*$56,134,000*	*$53,469,00*	*$33,590,750*
Sales Tax at 9%(2)	$1,513,000	$1,441,000	$905,000
Subtotal	*$57,647,000*	*$54,910,000*	*$34,495,750*
General Conditions at 12%	$6,918,000	$6,589,000	$4,139,000
Total Construction Cost	***$64,565,000***	***$61,499,000***	***$38,634,750***
Engineering, Legal, and Administrative at 20%	$12,913,000	$12,300,000	$7,727,000
Owners Reserve for Change Orders at 5%	$3,228,000	$3,075,000	$1,932,000
Total Treatment Facilities Cost(3)	**$80,710,000**	**$76,870,000**	**$48,290,000**

Notes:

(1) Costs were escalated to the midpoint of construction, assuming a compound annual escalation rate of 4%, design duration of 18 months starting in August 2021, and a construction duration of 24 months starting in February 2023 – for a total escalation of 14.7%.

(2) Sales Tax applied on 50% of subtotal to represent tax on equipment and materials only.

(3) The cost estimates are AACE Level 5 estimates and have an accuracy of -30% - +50%.

7.5 Operation and Maintenance Cost Summary

The O&M costs were calculated by using the design criteria developed specifically for the distribution system and AWPF described in this report based on similar facilities.

7.5.1 Treatment Facilities Labor Cost Estimate

The labor cost estimate is based on the staffing levels required for distribution and treatment facilities described within Sections 4 and 5. Since labor was not estimated for the baseline project as part of Carollo, 2017, that labor is estimated herein. Annual salaries for each staffing level are shown in Table 21. The cost estimate was calculated using job classification, fully recoverably annual salary, and assuming a year of full time work at 40 hours a week with no overtime. This labor cost accounts for permanent staffing, it does not include supplemental labor needs that may occur, e.g. landscaping.

Staffing needs assume the advanced treatment facilities are operated 24/7 with staff present 12 hours per day, 7 days per week. Tertiary treatment facilities are assumed to be operated 24 hours per day, 7 days per week, 7 months out of the year with staff present 8 hours per day, 5 days per week.

Table 21 Treatment Facility Annual Labor Cost Estimate

Job Classification	Annual Salary	Baseline Alternative	Feasible Alternative		
			1	2	3
Advanced Treatment Operator (AWTO 5)	$175,000	-	1	1	1
WWTP 3	$150,000	1.75	2	2	2
WWTP 2	$120,000	-	1	1	1
Maintenance	$100,000	0.6	2	2	2
I&C Technician	$150,000	-	2.5	2	2
Regulatory & Compliance	$120,000	-	1	1	1
Total staff		**2.3**	**9.5**	**9**	**9**
Total Annual Staffing Costs		**$320,833**	**1,290,000**	**$1,215,000**	**$1,215,000**

7.5.2 Treatment Facility Electricity and Consumables Cost Estimate

Electricity costs were estimated by using equipment operating load, assumed time in operation, and cost of electricity. The cost of electricity used in the estimate is $0.23 per kilowatt-hour (kWh) for the San Francisco region. Table 22 shows the consumables and power consumption cost of the treatment facilities. Consumables were calculated using reference treatment facilities.

Table 22 Treatment Facility Electricity and Consumables Cost Estimate

	Feasible Alternative		
	1	2	3
Ozone generation(1)	$519,000	$599,000	$200,000
MF membrane replacement	$125,000	$108,300	$41,70
MF power	$35,600	$30,900	$11,900
RO membrane replacement	$33,000	$100,000	$33,000
RO power	$166,500	$499,500	$166,500
UV AOP reactor power	$159,600	$638,300	$159,600
UV AOP peroxide	$4,600	$13,700	$13,700
UV disinfection reactor power	$42,700	-	-
Total Annual Consumables and Electricity Cost	**$1,086,000**	**$1,990,000**	**$626,000**

7.5.3 Distribution System O&M Cost Estimate

Pipeline and injection well maintenance costs were calculated assuming a unit cost of 1% of the total distribution system capital costs. Labor was not included as a line item, but is assumed to be included as part of the 1%. Pumping energy was estimated at a cost of $0.23/kWh. The distribution system O&M costs are summarized in Table 23.

Table 23 Distribution System Annual O&M Cost Estimate

	Feasible Alternative		
	1	2	3
Annual Maintenance Costs	$550,000	$892,000	$219,000
Pump Station Energy Cost (purified water)	$113,000	$653,000	$113,000
Pump Station Energy Cost (tertiary)	$359,000	-	-
Total Distribution System O&M Cost	**$1,022,000**	**$1,545,000**	**$332,000**

7.6 Life Cycle and Unit Water Costs

Life cycle costs for the project were calculated assuming a 50-year project life and a 30 year loan period to cover capital costs. After 50 years, the facilities are assumed to require either replacement or major upgrades. A 2.5 percent interest rate for the loan was assumed, which represents half of the loan from a low interest source such as California's state revolving fund (SRF) or Water Infrastructure and Finance Innovation Act (WIFIA), and the other half of the loan derived from issuing bonds. Payments on the loan were assumed to occur annually.

Net present value was calculated over the course of 50 years, with the loan repayment only required during the first 30 years. Annual O&M costs occurred over the duration of the 50 year period. O&M costs were assumed to increase by 1.8 percent each year to account for inflation. The present value of summed loan repayments and O&M costs was calculated assuming a discount rate equivalent to inflation, 1.8 percent.

The unit cost of water was calculated by dividing the average annual cost by the average annual volume of water produced.

Life cycle and unit water costs are presented in Table 24. Costs of the baseline project are also present herein for comparison. Feasible Alternative 2 (3 mgd for irrigation and IPR) has the highest total life cycle cost, but also has the least expensive unit cost of water. Feasible Alternative 3 (1 mgd for IPR only) has a slightly higher life cycle and unit cost as the baseline project. Feasible Alternative 3 has a similar unit cost as the baseline project but has a significantly higher life cycle cost.

Table 24 Life Cycle Costs and Unit Cost of Water

	Baseline		Feasible Alternative		
	Low	High	1	2	3
Life cycle cost, present value (50 years)	$169 M	$191 M	$336 M	$444 M	$188 M
Annual Water Produced (AFY)(1)	1,187	1,187	2,307	3,360	1,120
Volume produced over 50 years (AF)	59,360	59,360	115,360	168,000	56,000

Notes:
(1) Average annual water produced does not necessarily equate to the water used or the basin benefit.

Section 8

FEASIBLE ALTERNATIVES IMPLEMENTATION RISKS

This section summarizes the implementation risks for each of the three feasible alternatives compared to the baseline project. A more detailed discussion on implementation risks can be found in the Conceptual Alternatives TM (Carollo 2021).

8.1 Cemetery Participation

One of the key risks of the baseline project, and Alternatives 1 and 2, is the need for cemeteries to become recycled water users. Without their participation, there would not a be a use for the majority of the recycled water, nor would there be reduction in groundwater pumping. The potential water supply benefits generated by the baseline project and Alternatives 1 and 2 are based on the assumption that all cemeteries would use recycled water. Water supply benefits from Feasible Alternative 3, which would produce water for IPR only would not rely on cemetery participation.

It may be possible to minimize the risk of the cemeteries not participating by performing the following efforts:

- **Customer Outreach and Workshops:** Customer outreach and workshops have the potential to demonstrate the acceptability of irrigation through lateral conversations between the potential cemetery users and other turf irrigators (such as other cemeteries and golf courses that have successfully used recycled water).
- **Groundwater Supply Education:** Review of the future water supply challenges for the basin and the region due to climate change and future regulations.

8.2 Challenging Source Water Quality

Daly City's WWTP effluent, which is the product of a high-purity oxygen process, is a challenging source water for advanced treatment processes. Being high in biochemical oxygen demand (BOD), TOC, and ammonia, the effluent presents both operational challenges (membrane fouling) and regulatory challenges (total nitrogen and TOC in RO permeate). For the baseline project, which utilizes chemical addition, low pressure membranes, and UV disinfection for non-potable recycled water production, these challenges are mitigated. For projects that include groundwater recharge, piloting would be necessary to confirm the processes recommended and designed herein and to determine if potential adjustments may be needed.

It may be possible to mitigate the challenging source water quality risk with the following efforts:

- **Pilot Testing:** Pilot testing of the baseline system for non-potable reuse was previously completed and no further work is needed. However, additional pilot testing of the potable reuse treatment train (ozone [O_3], BAC, UF, and RO (and likely UV AOP) is needed to confirm the performance of the treatment processes.

8.3 Limited Treatment Facility Space

A key risk for all three feasible alternatives is the need for space for treatment facilities. The feasibility of using the parking lot adjacent to the Daly City WWTP has not been confirmed. Even if use of the parking lot is confirmed, the site is constrained for the three feasible alternatives, resulting in the need to place facilities within a two-story building. The constrained site is reflected in the construction, operations, and maintenance costs of the facility. If RO concentrate treatment be needed, space will be further constrained.

The baseline project, which has been piloted and developed to a 30 percent design level, fits at the Daly City's WWTP site, so this alternative does not have risk related to the site constraints.

It may be possible to mitigate the limited treatment facility space risk with the following:

- **Pilot Testing:** Pilot testing of the potable water reuse treatment train may reduce the required site footprint.
- **Evaluate Siting the Treatment Facility in the Existing Parking Lot:** The treatment facility layouts of the feasible alternatives presented herein assume the parking lot adjacent to the Daly City WWTP is available for use. This may require special agreements with Daly City, evaluation of the parking impacts at the existing baseball field, and/or mitigation of the parking impacts. The feasibility of utilizing the parking lot should be investigated in further detail with Daly City.

8.4 Limited Well Site Locations

The project is located in a dense urban environment with little open space available for the new injection well sites. Injection well sites assumed for the three feasible alternatives were not confirmed as part of this analysis and might not be available for purchase or might have other implementation concerns. There is a significant risk that lack of well sites might drive up the cost of land acquisition or inhibit the project.

The baseline project does not require well sites, so there is no associated risk.

Mitigating injection well location risks can include the following efforts:

- **Injection Well Siting Study:** The SFPUC could perform an injection well siting study to identify potential groundwater injection well sites. The siting study would consider property availability, existing agreements, underground utilities, location within the groundwater basin, proximity to the transmission pipeline alignment, and other key features.

8.5 RO Concentrate Disposal

The use of RO presents the challenge of needing to dispose of the resulting RO concentrate, which—for potable reuse projects—typically constitutes 15 to 20 percent of the influent flow and contains 5 to 7 times the concentrations of chemical contaminants as the influent flow. The increased concentrations of chemicals can pose challenges to meeting water quality objectives set forth in the California Ocean Plan; however, the decreased flow rate and potentially better mixing can mitigate these challenges by increasing the overall dilution in the ocean.

It is important to note that discharging RO concentrate in place of secondary effluent will not increase the overall mass of pollutants going to the ocean. Toxicity studies and mixing studies can be done to document potential compliance challenges. Nevertheless, it is possible that treatment of RO concentrate prior to discharging to the ocean could be required, particularly for ammonia.

As described in more detail in the Conceptual Alternatives TM, Alternatives 1 and 3, which only treat 1 mgd through RO are likely to be permittable without additional treatment of RO concentrate; however, alternative 2 which treats 3 mgd through RO could require special treatment of the RO concentrate, which would increase the overall project costs.

Mitigating RO concentrate disposal risks can include the following efforts:

- **Dilution modeling in tandem with Regional Water Quality Control Board (RWQCB) discussions:** To better understand the risk of meeting objectives set forth in the Ocean Plan, dilution modeling and discussions with the RWQCB are recommended.
- **Toxicity testing:** Toxicity testing of RO concentrate would provide insight into the ability for the facility to meet acute and chronic toxicity requirements.

8.6 Summary of Risks Compared to Costs

Table 25 summarizes the costs and risks for each feasible alternative compared to the baseline project.

Table 25 Summary of Risks Compared to Project Costs

	Baseline Project	Feasible Alternative		
		1	2	3
Costs				
Life cycle cost, present value (50 years)	$169-191 M	$336 M	$444 M	$188 M
Annual Water Produced (AFY)(1)	1,187	2,307	3,360	1,120
Unit water cost ($/AF)	$2,800-$3,200	$2,900	$2,600	$3,300
Key Implementation Risks(1)				
Cemetery participation	Medium	Medium	Medium	N/A
Challenging source water	Low	Medium	Medium	Medium
Limited Treatment Facility Space	Low	Medium	Medium	Medium
Limited Well Site Locations	N/A	Low	Medium	Low
RO Concentrate Disposal	N/A	Low	Medium	Low

Notes:
(1) A risk designation of low indicates that the risk can be readily overcome with a low level of cost and effort. A risk designation of medium indicates that the risk can be overcome with a high level of cost and effort

Section 9

RECOMMENDATION AND PROJECT IMPLEMENTAITON

9.1 Recommendation

We recommend implementing the Expanded Tertiary Recycled Water Facilities Project (i.e., baseline alternative) project initially and designing the project to be expandable to a purified water project in the future. This recommendation is based on discussions with the SFPUC, Daly City, and California Water Services Company (Cal Water) along with the feasible alternative implementation risks identified in Section 8.

9.2 Project Implementation

It is feasible to design the Expanded Tertiary Recycled Water Facilities Project to enable future expansion from tertiary recycled water production (i.e., baseline alternative) to purified water production. We recommend performing a detailed analysis during preliminary design of the Baseline Alternative to optimize the expansion approach. The investigation would likely include upfront planning of the IPR facility to confirm preliminary treatment process sizing, facility locations, and key interconnection points.

The key considerations for a phased approach are as follows:

- Phase 1 would consist of tertiary facilities located within a two-story building within the perimeter of the existing Daly City WWTP, as designed by Carollo, 2017.
- Phase 2 would likely consist of ozone, BAC, RO, oxidant addition, and stabilization facilities, located offsite either in the adjacent baseball parking lot or on another offsite location. The ozone and/or the BAC may not be necessary.
- The phased approach would require inter-connections between the two-story tertiary facilities building and the Phase 2 IPR facilities, as shown in Figure 16. The Phase 1 design should provide valving and tees to allow for tie-ins.
- Due to the loss of water through RO, the UF may need to be sized to allow for additional membranes to be added during Phase 2. The increased flux through the UF due to addition of ozone and BAC could partially offset the need for additional membranes.
- With ozone and BAC, chemical addition ahead of UF would likely be unnecessary and could be removed as part of Phase 2.
- A UV reactor for the Phase 1 tertiary facilities can be selected to allow for both treatment of low UVT water at a low UV dose (Phase 1 condition), and high UVT water at a high UV dose (Phase 2 condition). The addition of an oxidant (i.e. hydrogen peroxide or chlorine) ahead of the UV reactor will enable the UV disinfection process to become a UV advanced oxidation process.

Figure 16 provides a schematic of the phased approach to develop a future IPR facility utilizing phase 1 tertiary processes.

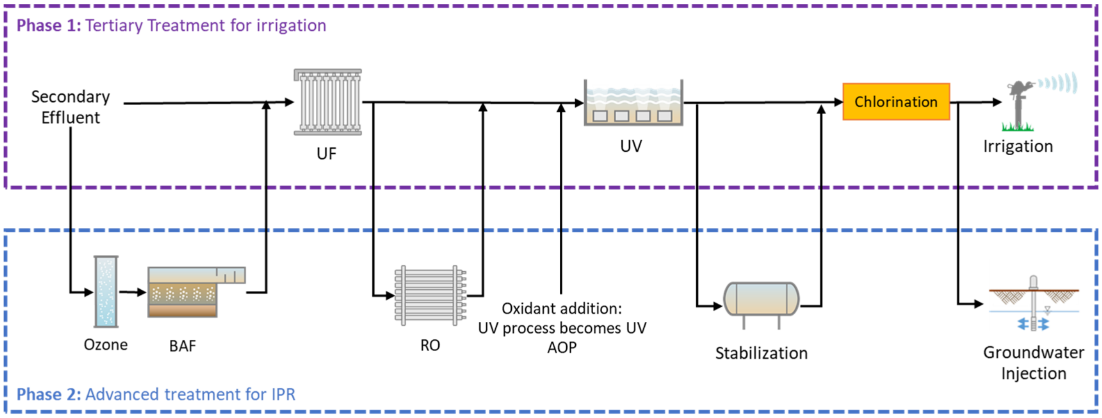

Figure 16 Phased Approach: Tertiary Treatment for Irrigation to Advanced Treatment for IPR

Section 10

NEXT STEPS

We recommend the following next steps to implement the Expanded Tertiary Recycled Water Facilities Project (baseline project):

- Begin discussions with the key partner agencies (SFPUC, Daly City, Cal Water) to discuss ownership and operations of the project facilities. The project includes facilities located at the Daly City WWTP and within the Cal Water service area.
- Evaluate the future water demands of the cemeteries and impacts to the recycled water system by considering the future expansion of the cemeteries. Confirm the design flow rate of the tertiary expansion.
- Evaluate future seasonal variation of cemetery demands to determine if Daly City would need to operate tertiary facilities year-round. Discuss year-round operation of recycled water facilities with Daly City as needed.
- As an initial task in the design of a tertiary facility, determine design criteria to allow for potential future expansion to IPR.

Table 26 summarizes the recommended actions to be taken to pursue each feasible alternative and the baseline project, grouped by risk.

Table 26 Recommended Actions for each Alternative

Risk Category	Baseline Project	Feasible Alternative 1	Feasible Alternative 2	Feasible Alternative 3
Cemetery Participation	• Confirm future cemetery demand • Negotiate a recycled water cost with cemeteries • Sign contracts with cemeteries confirming them as recycled water users.			N/A
Challenging Source Water Quality	N/A	• Pilot advanced treatment processes at Daly City WWTP		
Limited Site Space	N/A	• Determine if the parking lot adjacent to the Daly City WWTP is available for the Project. • Determine potential mitigation measures to parking impacts • Investigate the possibility of upgrading the existing LOX system to one that can support both the secondary process and the ozone generation process.		
Injection Well Sites	N/A	• Confirm the three injection well sites located in the golf courses near the Daly City WWTP are available for use. • Perform a siting study to identify potential injection well sites. The siting study would include property availability, existing utilities, location within the groundwater basin, proximity to the transmission pipeline alignment, and other key features.		
RO Concentrate Disposal	N/A	• Conduct ocean dilution modeling with different RO concentrate scenarios and blends of effluent • Conduct a reasonable potential analysis of Ocean Plan water quality objectives • Utilize RO concentrate from the pilot to conduct toxicity testing • Discuss alternatives with RWQCB		
Additional	N/A	• Confirm with Daly City year-round operation of recycled water facilities		

Section 11

REFERENCES

Carollo, 2017. Feasibility of Expanded Tertiary Recycled Water Facilities Preliminary Design Report.

Carollo, 2020. Daly City Recycled Water Expansion Alternatives Investigation Project: Feasibility of Expanded Tertiary Treatment Facilities Project Cost Estimate Update. December 2020.

Carollo, 2021. Daly City Recycled Water Expansion Alternatives Investigation Project: Conceptual Alternatives Evaluation. July 2021.

SFPUC, 2002. Agreement for purchase and sale of recycled water: between the City of Daly City, and the North San Mateo County Sanitation District, Olympic Club, Lake Merced Golf Club, San Francisco Golf Club, and the City and County of San Francisco, by and through the San Francisco Public Utilities Commission. March 2002.