Marin Municipal Water District

Draft Report

Appendix D. Water Management Alternatives

January 2023

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APPENDIX D

Water Management Alternatives Development

D.1 Introduction

The Marin Municipal Water District (MMWD or District) serves the populous eastern corridor of Marin County from the Golden Gate Bridge northward up to, but not including Novato. The district covers approximately 147 square miles and serves a population of approximately 190,000 customers with surface water supplies from seven local reservoirs, augmented with Russian River supplies imported from the Sonoma County Water Agency (Sonoma Water). Historically, MMWD has successfully met demands during periods of extreme drought with a combination of rationing, conservation, and increased Sonoma Water supplies. However, recent drought conditions that severely threatened water supply reliability have prompted MMWD to explore various water supply options to enhance resiliency for its customers.

As part of the Strategic Water Supply Assessment (SWSA), the project team was tasked with developing water supply alternatives that could be considered for addressing dry year conditions in the future. Through review of previous reports and investigations, and through discussions with MMWD staff, a range of water management alternatives were developed to support the SWSA. Over thirty individual water management alternative options were developed across six categories:

1. Water Conservation
2. Sonoma-Marin Partnerships
3. Local Surface Storage
4. Water Purchases with Conveyance through Bay Interties
5. Desalination, and
6. Water Reuse.

A list of the water management alternatives developed and considered in the SWSA is shown in Table D-1.

Table D-1. Water Supply Adaptation Concepts Synthesized from Workshops

Category	Alternative
Water Conservation	Water Conservation Program
Water Conservation	Regulatory Conservation Program
Sonoma-Marin Partnerships	Maximize Use of Sonoma Water with Existing Facilities
Sonoma-Marin Partnerships	Maximize Use of Sonoma Water Resolving System Bottlenecks
Sonoma-Marin Partnerships	Maximize Use of Sonoma Water with South Transmission System
Sonoma-Marin Partnerships	Maximize Use of Sonoma Water with Connection from Stafford to Nicasio/Soulajule reservoirs, no STS
Sonoma-Marin Partnerships	Maximize Use of Sonoma Water with Dedicated Conveyance from Aqueduct to MMWD Storages with STS
Sonoma-Marin Partnerships	Maximize Use of Sonoma Water with Dedicated Conveyance from Cotati to Hicks Valley
Sonoma-Marin Partnerships	Regional Groundwater Bank
Local Surface Storage	Soulajule Enlargement
Local Surface Storage	Nicasio Enlargement
Local Surface Storage	Kent Enlargement
Local Surface Storage	Halleck Site
Local Surface Storage	Devil's Gulch Site
Local Surface Storage	Movable Spillway Gates
Local Surface Storage	Soulajule Electrification
Local Surface Storage	Phoenix-Bon Temple Connection
Water Purchases with Conveyance through Bay Interties	East Bay Municipal Utility District (EBMUD) Intertie
Water Purchases with Conveyance through Bay Interties	Contra Costa Water District (CCWD) Intertie
Water Purchases with Conveyance through Bay Interties	North Bay Aqueduct (NBA) Intertie
Water Purchases with Conveyance through Bay Interties	San Francisco Public Utilities Commission (SPFUC) Intertie
Desalination	Marin Permanent Regional Desalination Plant (MPRDP)

Category	Alternative
Desalination	Marin Containerized Regional Desalination Plant (CRDP)
Desalination	Bay Area Regional Desalination Project (BARDP)
Desalination	Petaluma Brackish Groundwater Desalination Project (PBGDP)
Water Reuse	Non-Potable Recycled Water Expansion
Water Reuse	Regional Indirect Potable Reuse
Water Reuse	Central Marin Sanitation Agency Direct Potable Reuse
Water Reuse	Regional Direct Potable Reuse

Each of the water management alternatives is described in more detail in the following sections.

In general, the potential yield of the water management alternatives is developed from the project definition, modeling analysis, or simplified analysis. For new, alternative supplies, the yield was derived from the capacity of the plant with assumptions of maximum operability during drought periods. For other supplies, it was necessary to make assumptions on storage or transfer of water, regulation within MMWD's system, and eventual delivery during drought years. For some of the alternatives, it was only possible to evaluate the yield with preliminary modeling analysis and integration within MMWD's system.

Unless indicated otherwise, the yields are estimates of the water made available during a drought period (4-year drought) and is the nominal size of the project, without potential limitations related to system operation or other system limitations. For example, for an alternative that proposes a reservoir expansion adding 10,000 AF of storage in an existing reservoir, the alternative description will list a potential yield of 2,500 AFY. The 2,500 AFY yield corresponds to the 10,000 AF of additional storage divided in 4 years of drought. However, this alternative yield will be subjected to system limitations such as variability of reservoir inflow and operation of the reservoir in conjunction to other water supplies. The alternative yield subjected to system limitations depends on modeling analysis for specific climate scenarios and could vary significantly. These yields will be further refined in the portfolio analysis.

D.2 Water Conservation

The District has an established, ongoing Water Efficiency Program to support the goal of reducing water demands. For the SWSA water supply planning process, two water conservation options were developed as water management alternatives, which are a subset to the ongoing Water Efficiency Program. These water conservation options developed for the water supply planning effort are separate and distinct from developing a long-term conservation plan. The 2023 Water Efficiency Master Plan, currently under development, will provide a framework to progress towards the highest level of water savings supported by the community and untimely be the long-term plan for achieving additional water savings beyond the two water conservation options. These two options, the Water Conservation Element and the Regulatory Driven Program, are described in the following subsections. In each of these options it is assumed that passive savings, due to natural replacement of inefficient fixtures along with code efficiencies, will occur to achieve water savings. Water savings beyond the passive level are achievable using incentives, policies, regulations, and innovative initiatives.

D.2.1 Water Conservation Program

D.2.1.1 Description

The intent of the Water Conservation Element (WCE) is to develop a suite of incentive programs and associated quantifiable savings, using an anticipated level of participation, which provides a high level of confidence the water savings will be achieved. Since the water savings associated with the WCE option would reduce the water supply deficit, it is important that the level of participation and associated water savings have a high degree of confidence. It is broadly recognized that community engagement and public outreach result in an increased water awareness, and reduction in demands, yet the water savings are non-quantifiable. As noted above, the Water Efficiency Master Plan will provide a framework to maximize the community water saving potential.

This WCE was developed after extensive review of historic incentives, considering market saturation and the most recent drought response. Table D-2 is a comparison of prior levels of participation and the proposed WCE annual participation. The Pre-Drought levels of participation are based on the average annual participation in each program between 2016-2020. The 2021 Drought Participation levels are based on activities between June 2021 and May 2022, when the water shortage emergency was lifted. The analysis provides confidence the WCE participation levels will be achieved, as a minimum, and while additional water savings will be pursued and may be achieved, there is nevertheless uncertainty and risk associated with increasing the amount of projected water savings.

Table D-2. Historical Program Participation and the WCE Annual Participation

	Water Conservation Element (Annual Participation)	Past Annual Participation	
		Pre-Drought	2021 Drought
AMI Leak Letter Notifications (/yr)	1,250	1,140	1,601
Non-Functional Turf Conversion (sqft/yr)	70,000	0	0
Turf Conversion (sqft/yr)	100,000	7,736	410,000
Pool Covers (/yr)	90	12	399
SMART Irrigation Controllers (/yr)	100	50	480

Conservation Assistance Program (/yr)	500	195	667
Laundry to Landscape Graywater Kits (/yr)	40	5	44
Rain Barrels (gallons/yr)	15,000	460	43,497

The WCE assessment established a baseline of 2020 and projected implementation and savings through 2045. Utilizing a baseline of 2020 allows the investments made in demand reductions during the 2021 Drought are counted towards the overall reductions made by the community. The WCE results in a cumulative water savings of 22,515 AF and a savings in 2045 of 4,009 AFY.

The cost and savings for each incentive was analyzed using the Alliance for Water Efficiency's Conservation Tracking Tool. The evaluation completed for development of the WCE include programs launched during the 2021 Drought Response (ie: Drought Program Mulch Madness), programs that are projected to be sunset as new technology is incorporated (Ie: Flume ending with AMI implementation) and programs projected to continue. Table D-3 provides the programmatic details and the total WCE program cost of $1,792/AF. The annual investment in this WCE is approximately $1,552,000 per year. This cost does not reflect the full cost for the entire Water Efficiency Program, nor does it include costs for pursuing additional water savings as developed in the forthcoming Water Efficiency Master Plan.

Table D-3: Cost and Savings for Each Initiative within the Water Conservation Element

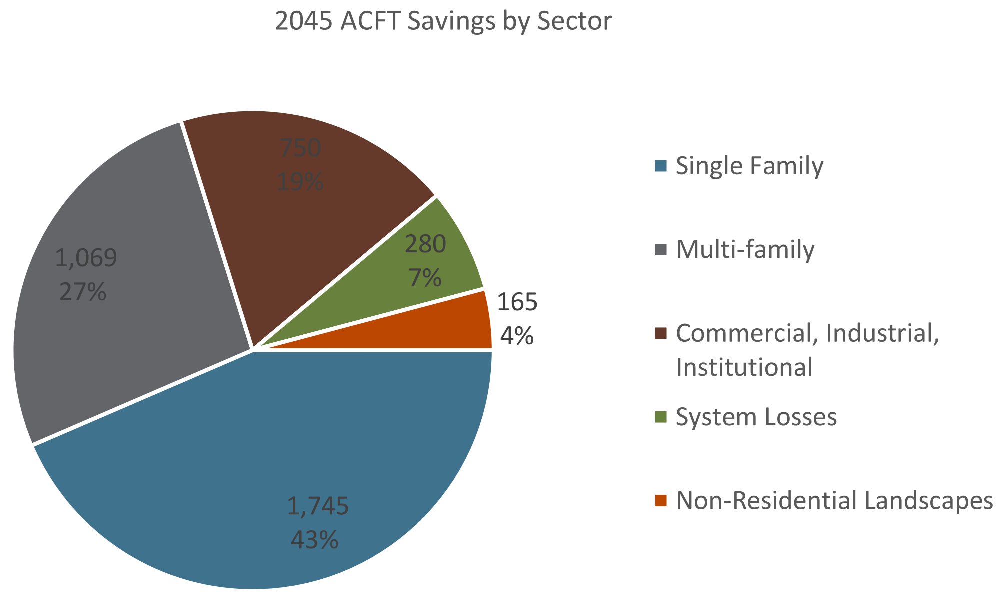
Activity Name	Unit Cost ($/AF)	Cumulative Water Savings in 2045 (AF)
High Efficiency Toilets	$2,435	6
Residential Clothes Washer Rebate	$732	116
Smart Irrigation Controller Programs	$1,035	586
Laundry-to-Landscape System Kit Distribution	$4,988	154
Rain Barrel Rebate Program	$8,820	58
Flume Rebates	$442	904
Drought Program Turf Conversion $3/sqft	$2,024	780
Hot Water Recirculating System Rebates	$1,677	17

Pool Cover Rebates	$877	642
Drought Program-Mulch Madness	$3,116	97
Residential Surveys (CAPs)	$13,763	378
Turf Conversion – Post Drought Programs	$1,985	4,282
AMI Leak Detection Notifications	$287	9,990
Non-Functional Turf Conversion	$2,132	4,505
Total (Program Incentives)	**$1,378**	**22,515**
Program Overhead	$414	22,515
Total	**$1,792**	**22,515**

In addition to the water saving presented for established incentive programs there are water savings also attributed to a reduction in system water loss. The WCE has projected water loss to be an ongoing initiative, resulting in a 10% reduction of the 2020 calculated losses being achieved in 2045. This equates to 280 AF in 2045.

The reduction in demands from implementing the WCE in 2045 are 4,009 AF. These savings would be obtained by reducing water demands in all sectors across the District, shown in Figure D-1, resulting in a district-wide gallons per capita per day (GPCD) of 106 in 2045.

Figure D-1: Saving by Sector in 2045



The WCE received two peer reviews, one from Maddaus Water Management on November 15, 2022 and the other from Peter Mayer, Water Demand Management on September 6, 2022. Both peer reviews concluded the WCE is reasonable, achievable, and appropriate for the water supply planning efforts currently underway. They acknowledged additional water saving could be achieved by the District if participation exceeded the assumed levels and/or if the District took a more regulatory approach to reducing demands.

D.2.1.2 Yield and Costs

A summary of the cost associated with the Water Conservation Element option is included in Table D-4. O&M costs include the staff time for implementing programs, outreach and marketing costs associated with the programs and the cost for incentives provided to customers for implementing the water savings action. The annual cost of the WCE from 2021 to 2045 is $1,552,000. The cumulative savings are 22,515 AF with a total reduction in demands of 4,009 AF in 2045.

Table D-4. Cost estimate for Water Conservation Element

Capital Cost	$0
Annual O&M Total, $/year	$1,552,000
Total Annualized Cost	$1,552,000
2045 Yield (AF)	4,009
Total Cost per AF	$1,792

D.2.2 Regulatory Conservation Program

D.2.2.1 Description

The intent of the Regulatory Driven Program is to estimate the additional water savings that could be achieved if water saving regulations were adopted and enforced. The Regulatory option assumes the Water Conservation Element Option would be implemented in its entirety and a strong regulatory program would be developed to maximize water savings. The specific regulations would include strict landscape codes and associated enforcement. A sample of the regulatory programs which would need to be considered include:

- Enforcement of water budgets and penalties
- Expanded Water Efficient Landscape Ordinance regulations
- Limit turf installations in all new development and remodels
- Only allow low water use plants, drip irrigation in all new development and remodels
- Prohibit non-functional turf in existing non-residential sites
- Prohibit turf in front yards and limit allowable turf area in existing single-family homes
- Indoor fixture standards/requirements
- Retrofit on Resale and/or Change of Customer
- Ensure fixture, landscape, and irrigation requirements are met.

The final package of regulations will need to be developed and the water savings resulting in implementation of the regulations would vary based on how stringent the policies are, the impacted sectors and the level of enforcement. For example, the Regulatory Driven Program could expedite the removal of Non-Functional Turf through the Board enacting a policy requiring the non-functional turf be removed by a set deadline, resulting in the same projected water savings included in the WCE yet those savings would be achieved in fewer years.

The peer review process estimated the water savings from implementing a Regulatory Drive Program would be a reduction in per capita water use from 106 to 100 GPCD, District-wide. This equates to an estimated cumulative savings of 30,000 AF in 2045 and a reduction of 2045 demands by 5,500 AF. The staffing costs associated with enforcement of the regulations would be the primary cost increase for the Regulatory Driven Option. It is estimated that four (4) additional staff would be needed to cover these administrative and enforcement tasks.

D.2.2.2 Yield and Costs

A summary of the cost associated with the Regulatory Driven option is included in Table D-5. O&M costs include the implementation of the Water Conservation Element and additional staff time for developing and enforcing the water saving policies. The annual cost of the Regulatory Driven Program is estimated to be $3,200,000. The cumulative savings are estimated to be 30,000 AF with a total reduction in demands of 5,500 AF in 2045.

Table D-5. Planning-level cost estimate for the Regulatory Driven Program

Capital Cost	$0

Annual O&M Total, $/year	$3,200,000
Total Annualized Cost	$3,200,000
2045 Yield (AF)	5,500
Total Cost per AF	$4,000

D.3 Sonoma-Marin Partnerships

MMWD currently receives supplemental Russian River supply from Sonoma Water. The use of existing facilities (pipes and pump stations) to import Sonoma Water supplies into MMWD system can be limited by contractual agreements and physical system capacity. MMWD can currently import a maximum of 14,300 AFY from Sonoma Water based on current agreement (Fourth Amended Offpeak Water Supply Agreement, 2015). Also, according with the agreement, MMWD has a minimum fiscal year annual purchase of 5,300 AFY (take or pay).

MMWD may experience limitations on imported high volumes of imported water due to hydraulic limitations in either Sonoma Water transmission system, from the Russian River collectors to the MMWD system. Sonoma Water diverts water from the Russian River through a series of collectors at Mirabel and Wohler. Water is diverted at the collectors subject to water availability, water rights (75,000 AFY), instream flows, and collector capacity (129.1 mgd). Diverted water is chlorinated and conveyed to MMWD through the Sonoma Water transmission system (Cotati and Petaluma aqueducts). Hydraulic limitations on imported water can occur at or downstream of Ely Booster Station (EBS) on the Petaluma Aqueduct, Kastania Pump Station (KPS) on the North Marin Aqueduct, and Ignacio Pump Station (IPS) within MMWD's system (Figure D-1). The current pumping capacities at these stations are:

- Ely Booster Station (31.6 mgd)
- Kastania Pump Station (21.5 mgd, 2022 rehabilitation)
- Ignacio Pump Station, Ignacio WTP (16 mgd), and downstream distribution pipelines (14.8 mgd)

The Ely Booster Station is used to deliver water to Petaluma, North Marin, and MMWD demands. The Kastania Pump Station is used to deliver water to North Marin and MMWD demands. The Ignacio Pump Station is the final pump station that supports delivery of imported water into the MMWD system. Currently, Sonoma Water imports are only delivered to the MMWD's distributions and cannot be delivered to MMWD's reservoirs for storage.

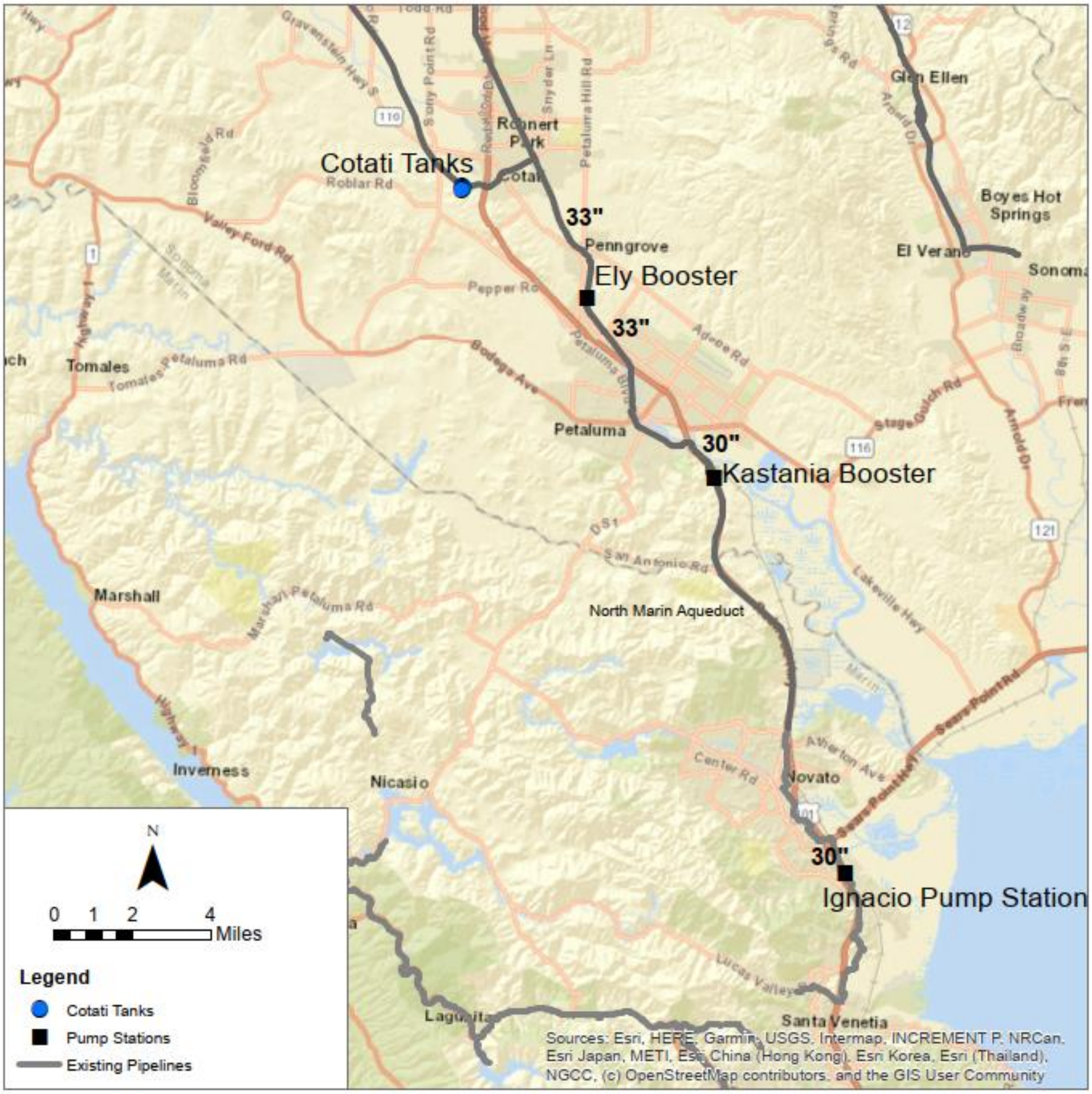
Historical MMWD water imports from Sonoma Water have been in the order of 5,000 AFY, fulfilling the minimum contractual "take or pay" amount.

Several options are available to increase imports from Sonoma Water:

- Maximize imported water during winter months when Russian River is under surplus conditions and there is available capacity at the Sonoma Water collectors
- Prioritize take of imported water supply over local supply based on hydrological triggers that include storage and forecast of seasonal inflows and demands.
- Maximize contract, give priority to Sonoma water up to the contractual amount 14,300 AFY
- Eliminate system bottlenecks that could limit the conveyance of imported water to MMWD
- Increase system capacity to import water into MMWD's system and provide conveyance to storage

The following project alternatives explore the potential to improve the Sonoma-Marin partnership to improve system reliability during droughts.

Figure D-1. Potential flow bottlenecks at pump stations to impact MMWD imported water flow



D.3.1 Maximize Use of Sonoma Water with Existing Facilities

D.3.1.1 Description

This alternative considers opportunities to import more water from Sonoma Water (up to maximum current contract of 14,300 AFY) with existing facilities. Operational changes by MMWD would prioritize the take of imported water in order to preserve local supply in MMWD reservoirs. These operational changes would be based on specific seasonal and hydrological triggers, such as seasonal runoff forecasts and storage conditions, and when available Russian

River flows (above minimum instream flow requirements) permit ability of Sonoma Water to divert flows from the river. This opportunity of strategically importing more water from Sonoma Water could keep MMWD reservoirs full for a longer period of time and provide a hedge for a subsequent dry spring and summer. However, in some years, this operational change could increase the spill of local water supply from MMWD reservoirs if the spring hydrological conditions are above average.

Operational rules would need to be developed to optimize under which storage and hydrological forecasts MMWD should prioritize take of Sonoma Water to minimize spills from MMWD local supplies and reducing water purchase costs. At present, this alternative does not include an optimized operational rule set. Rather, for analysis purposes, the alternative assumes MMWD will prioritize imported water under all conditions and thus gain higher storage conditions in MMWD reservoirs for subsequent dry conditions.

Imported water can be limited by physical conditions or MMWD demands. The physical limitations include all the Sonoma Water transmission line from Russian River collectors to MMWD Ignacio water treatment plant and MMWD water distribution network downstream of Ignacio water treatment plant. MMWD demands could be limiting imported water purchases since the current system configuration does not allow for imported water to reach any of the seven MMWD surface reservoirs.

Kastania Pump Station was recently upgraded and is able to convey up to 21.5 mgd. A recent study (W&C, 2022) indicates that the next hydraulic constraint on imported water into the MMWD system would be downstream of Ignacio Pump Station with a capacity of 14.8 mgd. The modeling for this alternative considers this capacity as the maximum rate at which Sonoma Water could be imported to MMWD during winter. Future improvements to the modeling will include operating rules to optimize the timing and amount of imported supplies to minimize local storage spills and maintain MMWD storage levels above minimum values.

D.3.1.2 Yield and Costs

This alternative is anticipated to yield 2,000 AFY of additional dry year water supply. The associated cost is the cost of additional imported water from Sonoma water, currently priced at approximately $1,300 per AF.

D.3.2 Maximize Use of Sonoma Water Resolving System Bottlenecks

The main difference between this alternative and the previous alternative that proposes to maximize current facilities is that under this alternative MMWD could exceed its current 14,300 AFY maximum imported water volume from Sonoma Water (subject to contract negotiations) or could receive its current 14,300 AFY in a shorter amount of time, being able to fulfill system demands with imported water more frequently than in a scenario where bottlenecks are in place.

D.3.2.1 Description

This alternative seeks to maximize use of Sonoma Water supply through improvements to reduce hydraulic limitations related to pump stations and boosters. The hydraulic limitations are generally at Ely Booster Station, Kastania Pump Station, and Ignacio Pump Station (Figure D-1). Kastania Pump Station has been recently rehabilitated and capacity has been increased. Resolving remaining hydraulic limitations downstream of Ignacio Pump Station and downstream of Ely Booster Station would enable increased imports into MMWD's service area. Based on current pipe diameters (Figure D-1) and a maximum velocity of 9 feet per second, the following improvements were assumed:

- Ignacio Pump Station – increase capacity at the WTP by 5.5 mgd (16 mgd to 21.5 mgd) and downstream distribution pipelines (14.8 mgd to bottleneck study ranges of improvements)
- Ely Booster Station – increase conveyance capacity by 2.9 mgd (from 31.6 mgd to 34.5 mgd)
- Kastania Pump Station - no new improvements due to a recent increase in capacity (21.5 mgd)

A recent study (W&C 2022) described potential improvements downstream of IPS within MMWD's distribution system that could improve imported water conveyance. The potential improvements, which were focused on facilitating the use of more imported water throughout MMWD entire system during the winter when demands are low, include North Redwood Highway Booster, Santa Margarita, Forbes Hill, and San Quentin conveyance improvements. For the purposes of this assessment, it was assumed that the North Redwood Highway Booster and Santa Margarita conveyance improvements would be included, along with improvements at EBS and IPS.

D.3.2.2 Yield and Costs

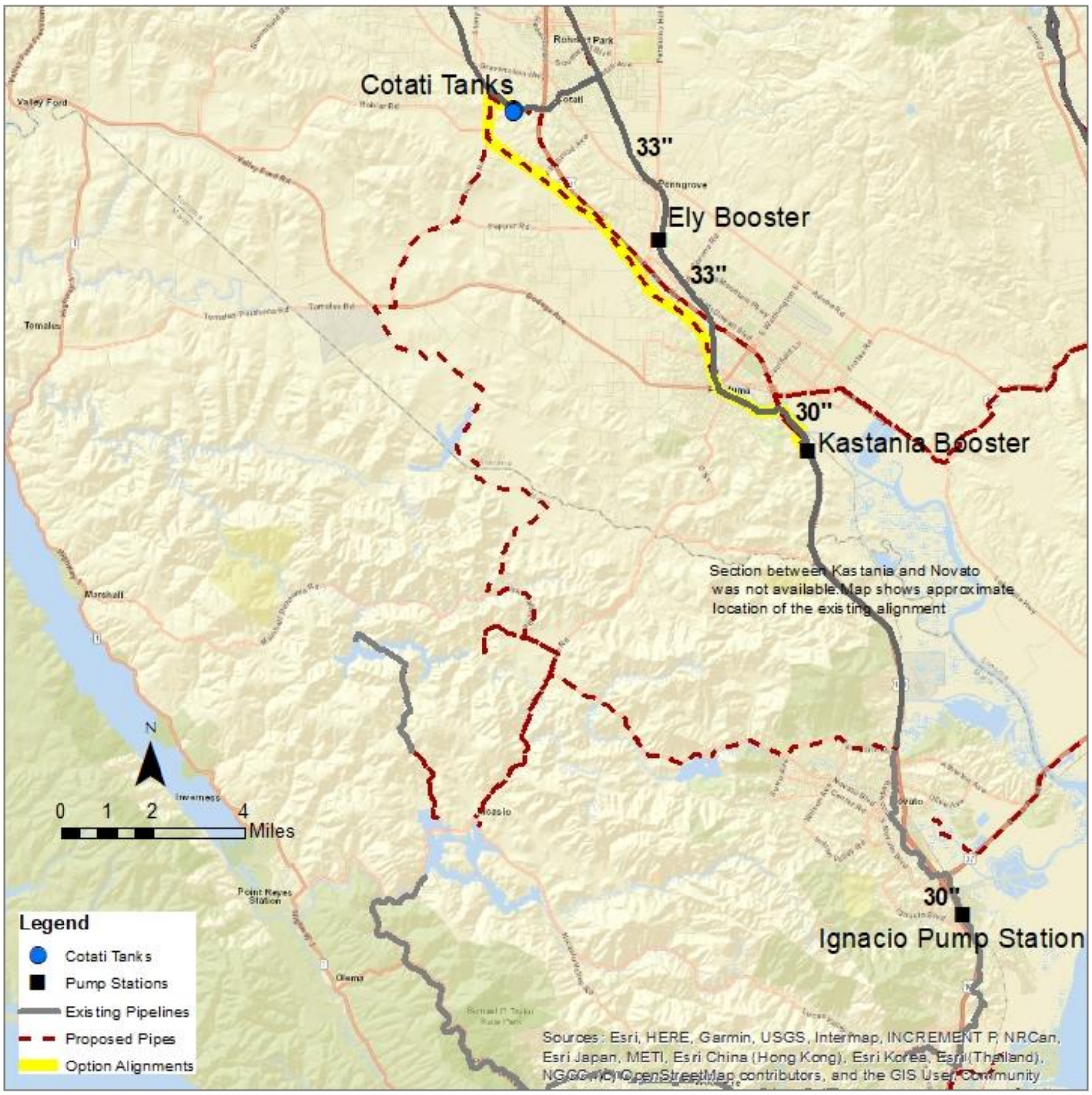
This alternative could increase the amount of imported supply by approximately 2,500 AFY. Cost assumptions related to this alternative are based on the recent Kastania Pump Station rehabilitation costs (prorated) and Water Conveyance Bottleneck Study cost estimates. The associated cost of these improvements at Ignacio Pump Station and Ely Booster Station is approximately $4.5 million, plus over $40 million in recommended improvements downstream of IPS. The unit cost of water provided by this alternative is estimated at $2,400 - $3,400 per AF depending on the level of needed improvements downstream of IPS.

D.3.3 Maximize Use of Sonoma Water with South Transmission System

D.3.3.1 Description

This alternative seeks to resolve hydraulic limitations on importation of Sonoma Water through the construction of the South Transmission System (STS) pipeline, a connection that has been considered by Sonoma Water to reduce flow constraints and high velocities in the Petaluma Aqueduct. The proposed transmission system pipeline would provide a second transmission line between the Sonoma Water's existing Cotati storage tanks just west of the City of Cotati and the existing Kastania storage tank just south of the City of Petaluma. The STS pipeline would improve the ability of Sonoma Water to supply water for North Marin and MMWD during either peak demand periods or when excess Russian River water is available for delivery during winter. The STS could have different alignments, along the highway 101 or following local surface streets (Figure D-2).

Figure D-2. South Transmission System potential alternative alignment



D.3.3.2 Yield and Costs

This alternative uses the STS alignment that follows local surface streets to avoid costs related to the use of a major highway right-of-way (highway 101). It was assumed that the cost of the STS would be shared with Sonoma Water and its contractors. MMWD share is assumed to be

50% of the total cost. This alternative is anticipated to yield up to 2,700 AFY of additional dry period water supply for MMWD. The associated cost to MMWD is approximately $50 to $75 million, depending on pipeline sizing, alignment, and storage capacity. Annual O&M costs are estimated at approximately $6 million. The unit cost of water for this alternative is estimated at $3,400 – 3,800 per AF.

D.3.4 Maximize Use of Sonoma Water with Connection from Stafford to Nicasio and Soulajule Reservoirs

D.3.4.1 Description

This alternative seeks to maximize use of Sonoma Water through use of exiting NMWD's network of pipelines to store water in NMWD's Lake Stafford, and subsequently convey water through a new pipeline via Hicks Valley to MMWD's Nicasio and Soulajule reservoirs. This alternative is subject to agreement with NMWD and the available capacity of their distribution system and Lake Stafford operation to store water. From Lake Stafford, water would be conveyed through Hicks Valley and delivered to either Soulajule or Nicasio reservoirs (Figure D-3). An approximately 5-mile pipeline would convey water from Lake Stafford to Hicks Valley, from which water could be delivered to Soulajule by gravity. Alternatively, water could be delivered from Hicks Valley to Nicasio Reservoir. Likely operation of such a connection would be to preference storage of water in Nicasio over Soulajule.

Based on recent operations, up to 7.3 mgd of additional capacity could be available move water from the Petaluma Aqueduct, through NMWD's system to Lake Stafford storage, and subsequently delivered to the Nicasio or Soulajule. However this capacity will be limited to periods of time of winter water availability and available storage capacity in Stafford, Soulajule, or Nicasio reservoirs.

Figure D-3. Alternative to convey water from Stafford Lake to MMWD reservoirs

D.3.4.2 Yield and Costs

This alternative is anticipated to yield 1,000 AFY of additional dry period water supply. The associated cost construct the connector pipeline is $29 to $37 million with an annual O&M cost of $1.7 million. The unit cost of water for this alternative is estimated at $3,100 – 3,500 per AF.

D.3.5 Maximize Use of Sonoma Water with Dedicated Conveyance from Petaluma Aqueduct to Soulajule/Nicasio Reservoirs (with STS)

D.3.5.1 Description

This alternative incorporates a dedicated MMWD conveyance to transfer water from the North Marin Aqueduct directly to Soulajule or Nicasio reservoirs. Included in the alternative is the new STS conveyance described in the previous alternative. The combination of the STS and the Petaluma-Soulajule/Nicasio connection allows greater imports of Sonoma Water supplies when the Russian River is in surplus conditions. The new conveyance pipelines avoids hydraulic limitations at the Ely Booster Station and within NMWD system; permitting direct conveyance to Soulajule and Nicasio reservoirs. This alternative assumes a dedicated pipeline that will connect the Petaluma Aqueduct downstream from Kastania Pump Station, in the proximity of North Marin's system, to Hicks Valley, Nicasio and Soulajule. This alternative offers potential future partnership with North Marin and extra connection to supply imported water to Stafford Lake without using North Marin's transmission lines (Figure D-4).

Figure D-4. Alternative to convey water from Petaluma aqueduct into MMWD reservoirs

D.3.5.2 Yield and Costs

This alternative is anticipated to provide up to 4,000 AFY of additional dry period water supply. As with the STS alternative, it is assumed that the cost of the STS would be shared with Sonoma Water and its contractors. MMWD share is assumed to be 50% of the total cost. The associated MMWD cost is approximately $99 to $124 million with an annual O&M cost of $5.2 million. The unit cost of water for this alternative is estimated at $2,900 - $3,200 per AF.

D.3.6 Maximize Use of Sonoma Water with Dedicated Conveyance from Cotati to Soulajule/Nicasio Reservoirs

D.3.6.1 Description

This alternative incorporates a new, dedicated conveyance pipeline to convey water from the Cotati tanks on Sonoma Water's transmission system directly to Soulajule and Nicasio reservoirs. The dedicated conveyance would alleviate two major impediments: (1) bypassing hydraulic limitations on the Petaluma Aqueduct that occasionally limit take of larger quantities of Russian River supply during winter and (2) allow supply to be directly connected to MMWD reservoirs. The new conveyance pipeline would connect to aqueduct at the Cotati tanks and follow a route to the west to Hicks Valley where the water could then be delivered to either Soulajule or Nicasio reservoirs (Figure D-5). The alternative assumed 37 mgd capacity in the new pipeline.

Figure D-5. Alternative to convey imported water from Cotati tanks into MMWD reservoirs west of STS

D.3.6.2 Yield and Costs

This alternative is anticipated to yield between 5,000 and 6,000 AFY of additional dry period water by allowing winter water to be delivered directly to MMWD reservoirs. The associated cost is estimated at $158 million with an annual O&M cost of over $6 million. The unit cost of water for this alternative is estimated at $3,000 – $3,300 per AF.

D.3.7 Regional Groundwater Bank

D.3.7.1 Description

Three major groundwater basins underly the Sonoma Water transmission system service areas: Santa Rosa Plain, Sonoma Valley, and Petaluma Valley (Figure D-6). This conceptual alternative includes the development of a regional groundwater bank involving aquifer storage and recovery (ASR) in one or more of these groundwater basins. During high flow conditions on the Russian River, available supply could be diverted through Sonoma Water's existing collectors and transmission system and used to recharge the aquifers. During dry conditions, stored water would be extracted for delivery to water bank participants including MMWD. This alternative includes the development of a regional groundwater bank, combining each of these basins using facilities like ASR wells, connections to aqueducts, and water treatment. Delivery of water could take the form of in-lieu exchanges in which an overlying participant pumps groundwater in-lieu of aqueduct deliveries.

For this assessment, a regional groundwater bank of up to 20,000 AF of storage was characterized. It was assumed that MMWD could participate in the regional bank with up to 5,000 AF of capacity. Further it is assumed that, once filled, the stored water could be extracted over two years. The alternative has only been described as a concept at this point in time. The ability to create storage space in these groundwater basins with generally high groundwater levels may limit the size of such a groundwater bank. Further investigations, technical analysis, and policy discussions are required to better describe the potential for this alternative.

Figure D-6. The three main groundwater basins in the region

D.3.7.2 Yield and Costs

This alternative is anticipated to yield approximately 1,250 AFY of additional dry period water supply (5,000 AF of storage extracted over 4 years) for MMWD. The associated cost is approximately for MMWD's participation is between $6 and $12 million with an annual O&M cost of approximately $5 million. As a whole, this is a cost range estimate of $2,300-2,500 per AF.

D.4 Local Surface Storage

Local Surface Storage alternatives are options related to expansion of current MMWD reservoirs or increase the ability to store inflows in the watershed with infrastructure and operational improvements.

An initial analysis existing MMWD reservoirs was performed to better understand the storage usage under various hydrologic conditions, the frequency of spills, and to determine if sufficient inflow occurs in the watersheds to justify increases of the storage capacity. The analysis relied on measured reservoir inflows available for the MMWD reservoirs from 1992 to 2021 and an extended period of 1910 to 1992 using correlated inflows. The initial analysis considering average annual inflows is presented on Table D-2. On an annual average basis, MMWD reservoirs receive more inflows (96,921 AFY) than the system total storage capacity (78,384 AF). Most reservoirs currently have capacities that are less than the average annual inflows. For example, Soulajule Reservoir currently has a capacity that less than 60% of the annual inflows to the reservoir, indicating that increased capacity could yield additional water supply. Bon Tempe and Kent reservoirs, on the other hand, have more capacity in comparison to the average annual inflows; Bon Tempe Reservoir has a storage capacity of 174% of the annual average inflows and Kent Lake has storage capacity of 164% of the annual average inflows.

Table D-2. MMWD reservoirs capacities and average inflows from 1910 to 2021

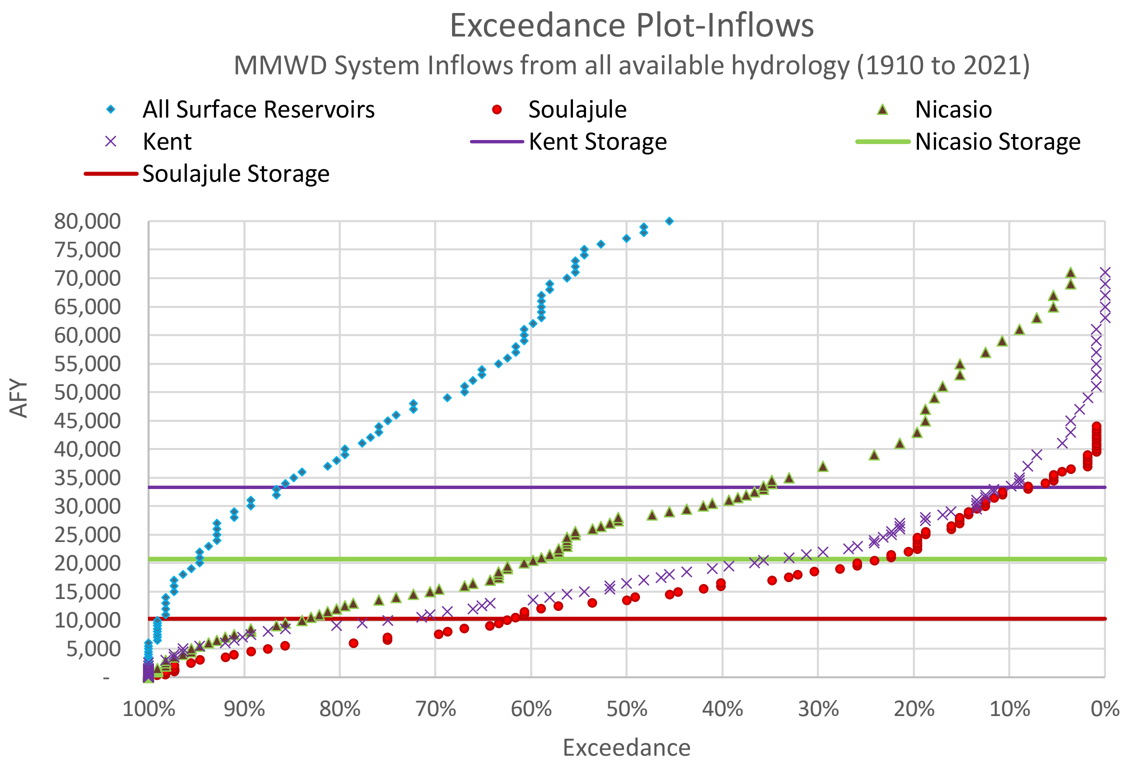
Reservoir	Reservoir Capacity* (AF)	Average Inflow (AFY)	Storage Capacity/Average Inflow (%)
Lake Lagunitas	331	3,582	10%
Phoenix Lake	306	3,665	11%
Bon Tempe Reservoir	4,504	2,305	174%
Alpine Lake	8,953	13,776	65%
Kent Lake	33,310	20,069	164%
Nicasio Reservoir	20,723	35,399	82%
Soulajule Reservoir	10,257	18,125	58%
Total	**78,384**	**96,921**	**81%**

Note: Reservoir capacity derived from 2017 bathymetric survey

An annual analysis of the inflows was also prepared to determine the probability of inflow exceeding storage capacity for the entire available historical inflows to the reservoirs (1910 to 2021). Figure D-7 shows the exceedance of inflows to all MMWD reservoirs, and to Soulajule, Nicasio, and Kent reservoirs which represent the largest reservoirs in the system. Figure D-7 shows that 50th percentile (median) of historical annual inflows to all MMWD reservoirs is greater than 75,500 AFY. Table D-2 indicates that Kent Lake has more available storage than the average inflows. Figure D-8 complements that indication by showing that the inflows to Kent Lake exceed the storage capacity in 10% of the years. Soulajule and Nicasio reservoirs, on the other hand, have inflows that exceed the reservoir storage capacity in more than 50% of the years, presenting a more favorable condition to capture additional supply.

Other aspects that are important to consider in the assessment of storage potential is the timing of the inflows, reservoir operations, release requirements, and bathymetry. These variables are included in the Decision Support Model developed to evaluate the benefit of all the different alternatives.

Figure D-7. Storage inflow exceedance plot



https://jacobsengineering.sharepoint.com/sites/CPW8Y17700/Shared%20Documents/0900_WorkingDocuments/Task3_UpdateDSM/Storage/MMWD%20Dam%20Summary%20-%202022.xlsx?web=1

Following is a description of eight project alternatives considered in the SWSA related to MMWD local surface storage augmentation. The cost of storage projects presented here are concept level costs using reported costs from recent dam expansions in California including the San Vicente Dam in San Diego and Los Vaqueros Dam in Contra Costa.

D.4.1 Soulajule Enlargement

D.4.1.1 Description

Soulajule Reservoir is located in north Marin County and receives inflow from Walker Creek. The upstream drainage area for the reservoir is approximately 12,054 acres. Soulajule Dam was constructed in 1979 to provide additional water supplies during water shortage years in the Lagunitas Creek Basin and to enhance the Walker Creek fishery. The reservoir's current storage is 10,572 AF. Since its construction in 1979, Soulajule Reservoir has not been consistently used as a water supply source due to lack of permanent electricity supply. On average, 2,000 AFY is released from Soulajule Reservoir for downstream environmental requirements, in addition to frequent reservoir spills. The average annual reservoir inflow is in the approximately 18,000 AF, or almost twice the reservoir capacity. Currently the dam does not have permanent electricity and any pumping to Nicasio Reservoir relies on diesel generators.

This alternative consists of raising the Soulajule Dam up to 49 feet to increase the amount of storage available to MMWD by up to 30,000 AF. Current inflows into the Soulajule Reservoir are between 14,000 and 18,000 AFY (based on measured storage records from MMWD and model flows). The project alternative also includes the installation of permanent pumping infrastructure to meet potable water demands. Table D-3 presents the Soulajule Reservoir storage capacity and inundated area associated with differing dam height changes. These height increments correspond to increases in storage capacity of 10,000, 20,000, and 30,000 AF.

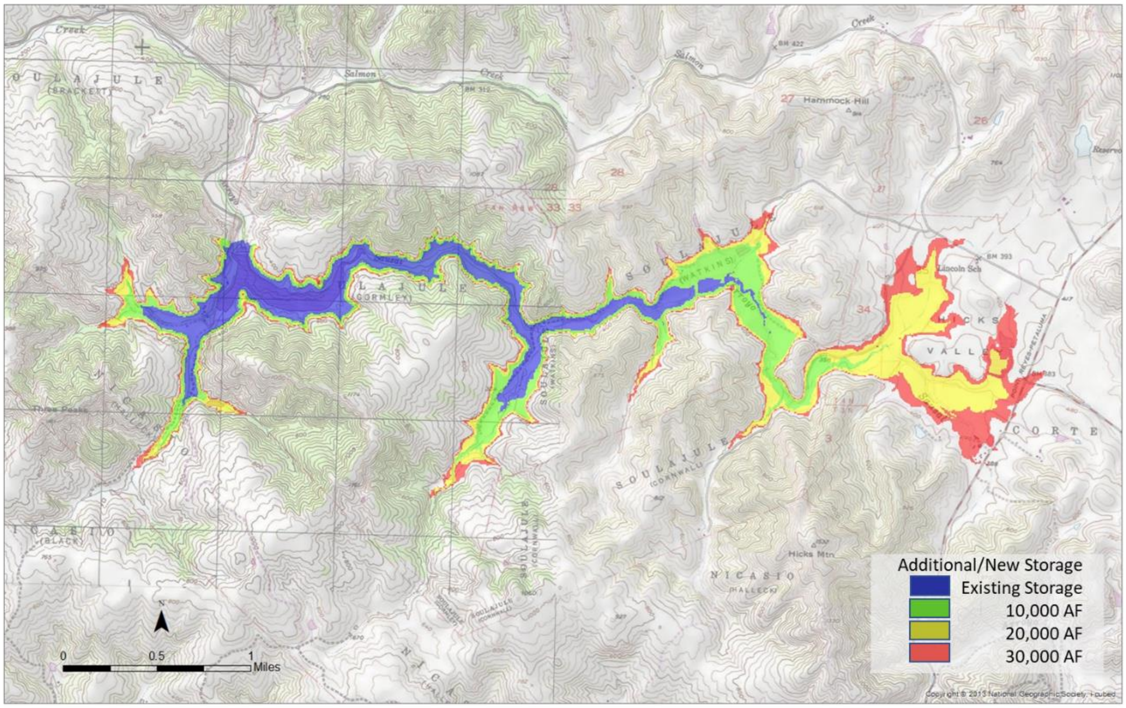
Figure D-8 shows the existing extent of the inundation area for the maximum current storage and the estimated extent of inundated areas for 10,000, 20,000, and 30,000 AF storage expansions. For the purposes of this assessment, the alternative is described as an increase in dam height of 39 feet or 20,000 AF storage capacity increase. Increases in inundated area are based on natural topography. Saddle dams or dikes would likely be implemented to protect certain areas from inundation.

Table D-3. Soulajule additional storage and corresponding extra dam height and inundated area.

Storage (AF)	Spillway Elevation (ft)	Inundated Area (ac)
10,572	Current Elevation = 335.4’	Current Inundation = 321.4 ac
20,572	Current Elevation + 24’	Current Inundation + 236 ac
30,572	Current Elevation + 39’	Current Inundation + 523 ac
40,572	Current Elevation + 49’	Current Inundation + 756 ac

In 1975, two additional studies were conducted to evaluate the feasibility of raising Soulajule Dam. In the 1975 Environmental Assessment of Natural Water Supply Project Report (Madrone Associates, 1975), the Soulajule Project was evaluated to raise the present 53-foot dam by 57 feet. The additional water stored in the Soulajule Reservoir would be pumped south into the Nicasio Reservoir. From the study no major environmental concerns were present.

Figure D-8. Soulajule current maximum inundation area and inundation estimates for additional storage



D.4.1.2 Yield and Costs

This alternative is anticipated to have a nominal yield between 4,000 and 5,000 AFY of additional dry period water supply during four-year drought. The associated cost is approximately $65 to $90 million. Based on the anticipated dry year water supply and cost, this alternative has a unit cost of $1,300 to $2,000 per AF. Currently, the same cost assumptions are used for Soulajule, Nicasio, and Kent enlargement alternatives and will need to be further refined if these options are advanced.

D.4.2 Nicasio Enlargement

D.4.2.1 Description

The Nicasio Reservoir is located in west Marin County and receives water from the Nicasio Creek watershed. The drainage area upstream of the current dam is approximately 23,000 acres. The reservoir capacity is estimated to be 22,430 AF while the average inflow is estimated to be 35,399 AFY. Two options were considered to increase Nicasio Reservoir storage: dredging the lake to recover some of storage and to increase the dam height. Dredging Nicasio Lake was initially evaluated as an option to expand the storage available to MMWD. The dredging alternative involved excavating Nicasio Lake and assumes that 1.6 million cubic yards of sediment must be removed from Nicasio Lake to increase capacity by 100 AF. This alternative was evaluated assuming a 100% yield return for the initial cost. When a cost per AF of storage created was calculated, the dredging option had a significant high cost and was rejected for further analysis. The increase of Nicasio dam height would be possible and at a lower cost per AF of storage created than dredging.

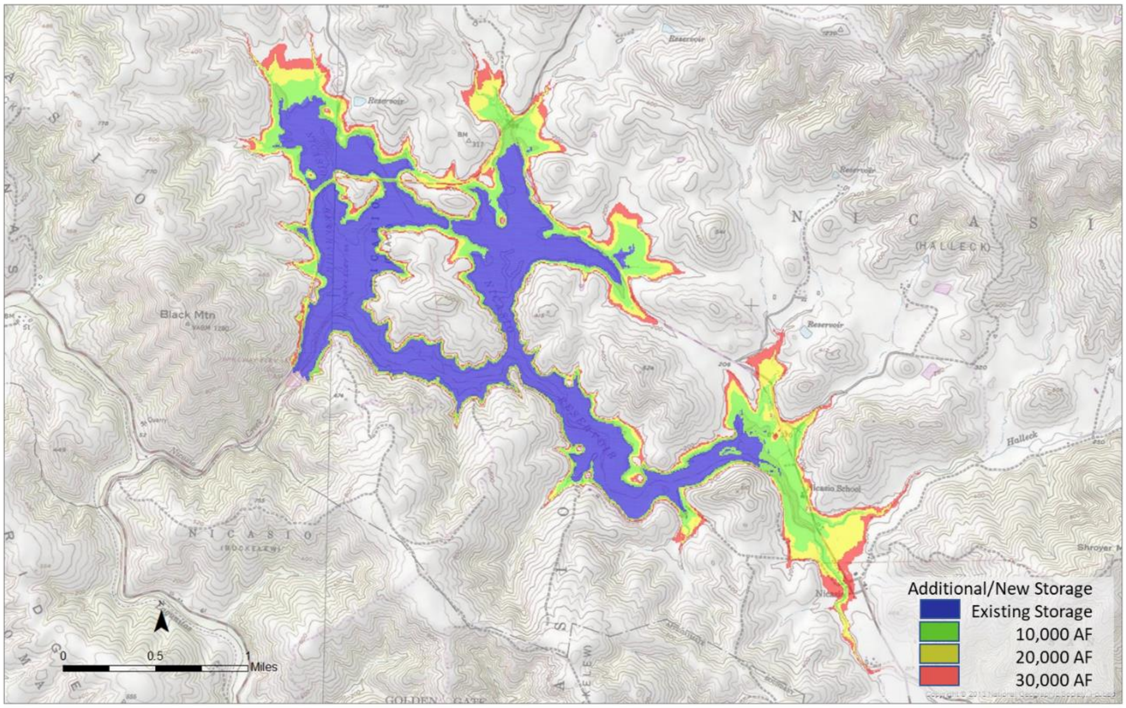
Table D-4 presents the Nicasio Reservoir storage capacity and inundated area associated with differing dam height changes. These height increments correspond to increases in storage capacity of 10,000, 20,000, and 30,000 AF.

Figure D-9 shows the existing extent of the inundation area for the maximum current storage and the estimated extent of inundated areas for 10,000, 20,000, and 30,000 AF storage expansions. For the purposes of this assessment, the alternative is described as an increase in dam height of 19 feet or 20,000 AF storage capacity increase. Increases in inundated area are based on natural topography. Saddle dams or dikes would likely be implemented to protect certain areas from inundation.

Table D-4. Nicasio additional storage and corresponding extra dam height and inundated area

Storage (AF)	Spillway Elevation (ft)	Inundated Area (ac)
22,430	Current Elevation = 168.3’	Current Inundation = 796.8 ac
32,430	Current Elevation +12’	Current Inundation +378 ac
42,430	Current Elevation +19’	Current Inundation +630 ac
52,430	Current Elevation +26’	Current Inundation +837 ac

Figure D-9. Nicasio current maximum inundation area and inundation estimates for additional storage



Previous reports mention that enlarging Nicasio Dam could inundate significant community areas and some prehistoric archeological sites (RMC 2017). Figure D-9 shows a significant area being inundated southeast of the reservoir even at the lowest storage increase of 10,000 AF.

D.4.2.2 Yield and Costs

This alternative is anticipated to yield between 4,000 and 5,000 AFY of additional dry period water supply during four-year drought. The associated cost is approximately $65 to $90 million. Based on the anticipated dry year water supply and cost, this alternative has a unit cost of $1,300 to $2,000 per AF. Currently, the same cost assumptions are used for Soulajule, Nicasio, and Kent enlargement alternatives and will need to be further refined if these options are advanced.

D.4.3 Kent Lake Enlargement

D.4.3.1 Description

Kent Lake is a reservoir formed by the construction of Peters Dam across Lagunitas Creek. Kent Lake's drainage area is approximately 13,847 acres and also includes three others upstream MMWD reservoirs: Alpine, Bon Tempe, and Lagunitas. Kent Lake was originally built in 1953 with a 16,050 AF capacity but it was expanded in 1982 to a total 32,895 AF. Kent Lake is MMWD's largest reservoir and provides significant portion of the MMWD water supply. Kent

Lake also releases approximately 6,000 AFY for downstream environmental requirements in Lagunitas Creek.

Kent Lake is approximately parallel and 2 miles east of the San Andreas fault. The reservoir is located in a steep terrain as compared to the Soulajule and Nicasio reservoirs. Due to the geographic location and steep terrain, increases in the dam height and storage will inundate a much smaller amount of the land as compared to the other reservoir enlargements considered.

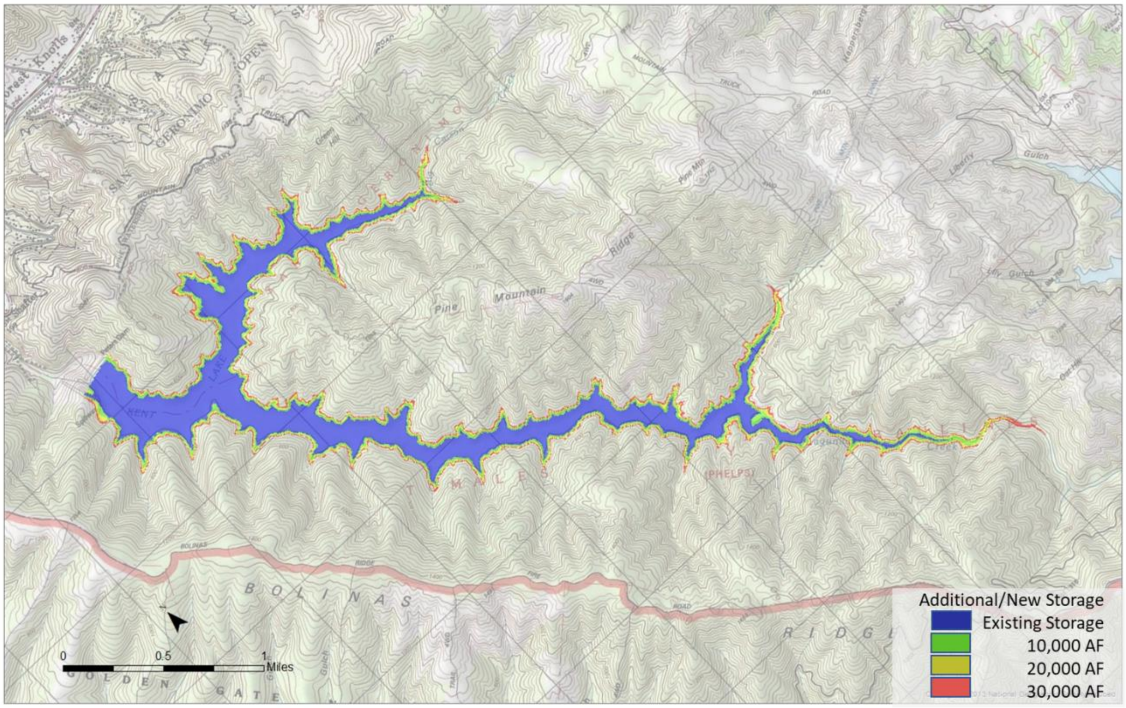
Table D-5 presents the Kent Lake storage capacity and inundated area associated with differing dam height changes. These height increments correspond to increases in storage capacity of 10,000, 20,000, and 30,000 AF.

Figure D-10 shows the existing extent of the inundation area for the maximum current storage and the estimated extent of inundated areas for 10,000, 20,000, and 30,000 AF storage expansions. For the purposes of this assessment, the alternative is described as an increase in dam height of 35 feet or 20,000 AF storage capacity increase.

Table D-5. Kent additional storage and corresponding extra dam height and inundated area.

Storage (AF)	Spillway Elevation (ft)	Inundated Area (ac)
32,895	Current Elevation =403.2’	Current Inundation =451.2 ac
42,895	Current Elevation +19’	Current Inundation + 116 ac
52,895	Current Elevation +35’	Current Inundation + 194 ac
62,895	Current Elevation +50’	Current Inundation + 268 ac

Figure D-10. Kent current maximum inundation area and inundation estimates for additional storage



D.4.3.2 Yield and Costs

This alternative is anticipated to yield between 4,000 and 5,000 AFY of additional dry period water supply during four-year drought. The associated cost is approximately $65 to $90 million. Based on the anticipated dry year water supply and cost, this alternative has a unit cost of $1,300 to $2,000 per AF. Currently, the same cost assumptions are used for Soulajule, Nicasio, and Kent enlargement alternatives and will need to be further refined if these options are advanced.

D.4.4 Halleck Reservoir (Proposed)

D.4.4.1 Description

The Halleck site is a newly proposed location for another reservoir. This location has not been evaluated in previous investigations. The site is located upstream of Nicasio Reservoir and would thus impact inflows to this reservoir. The watershed drainage area upstream of the proposed dam location is approximately 2,895 acres.

Although it is possible to develop new surface storage at this location, the Halleck site presents two major challenges. First, due to the topography in the area, a dam of more 180 feet in height would be required to develop even 10,000 AF of storage. Second, the Halleck site is situated in the upper of the watershed with minimal drainage area.

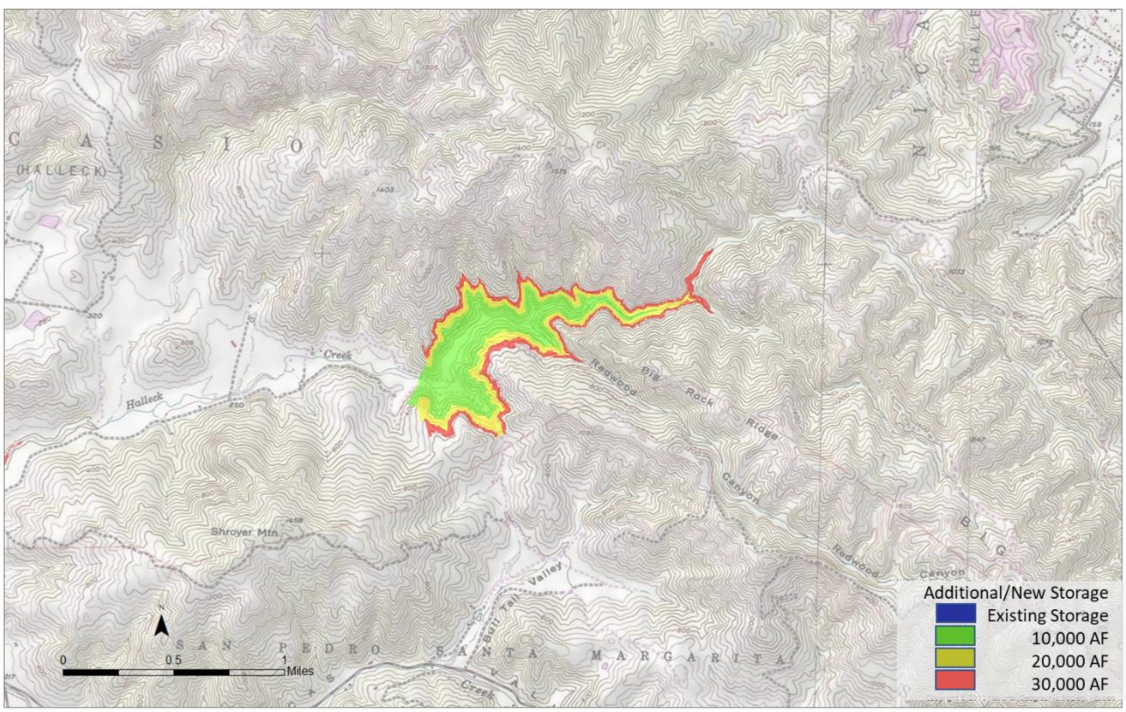
Table D-6 presents the proposed Halleck Reservoir storage capacity and inundated area associated with differing dam height changes. These height increments correspond to increases in storage capacity of 10,000, 20,000, and 30,000 AF.

Figure D-11 shows the extent of the inundation area for 10,000, 20,000, and 30,000 AF storage reservoir capacities. For the purposes of this assessment, the alternative is described as a new dam of height of 186 feet or 10,000 AF storage capacity. Larger dam heights were not considered practical give the hydrological conditions and topography.

Table D-6. Halleck storage and corresponding dam height and inundated area.

Storage (AF)	Dam Height (ft)	Inundated Area (ac)
10,000	186	118
20,000	254	180
30,000	303	229

Figure D-11. Halleck inundation estimates for site storage



D.4.4.2 Yield and Costs

This alternative is anticipated to yield no more than 2,500 AFY of additional dry period water supply. The associated cost is approximately $396 to $630 million. Based on the anticipated dry year water supply and cost, this alternative has a unit cost of $8,100 to $12,800 per AF.

Currently, the same cost assumptions are used for Halleck and Devils Gulch proposed reservoir alterantives and will need to be further refined if these options are advanced.

D.4.5 Devil's Gulch Reservoir (Proposed)

D.4.5.1 Description

The Devil's Gulch Site is located downstream of Kent reservoir in a tributary of the Lagunitas creek. The watershed drainage area upstream of the proposed dam location totals approximately 1,729 acres.

The Devil's Gulch Site was already considered in a previous report (CH2MHill, 1973). At the time of the report, the project was rejected due to significant environmental impacts and the yield was estimated to be 9,000 AFY (CH2MHill, 1973). Besides environmental challenges, the Devil's Gulch site also faces similar challenges of the Halleck site in relation to large required dam height and small contributing upstream watershed.

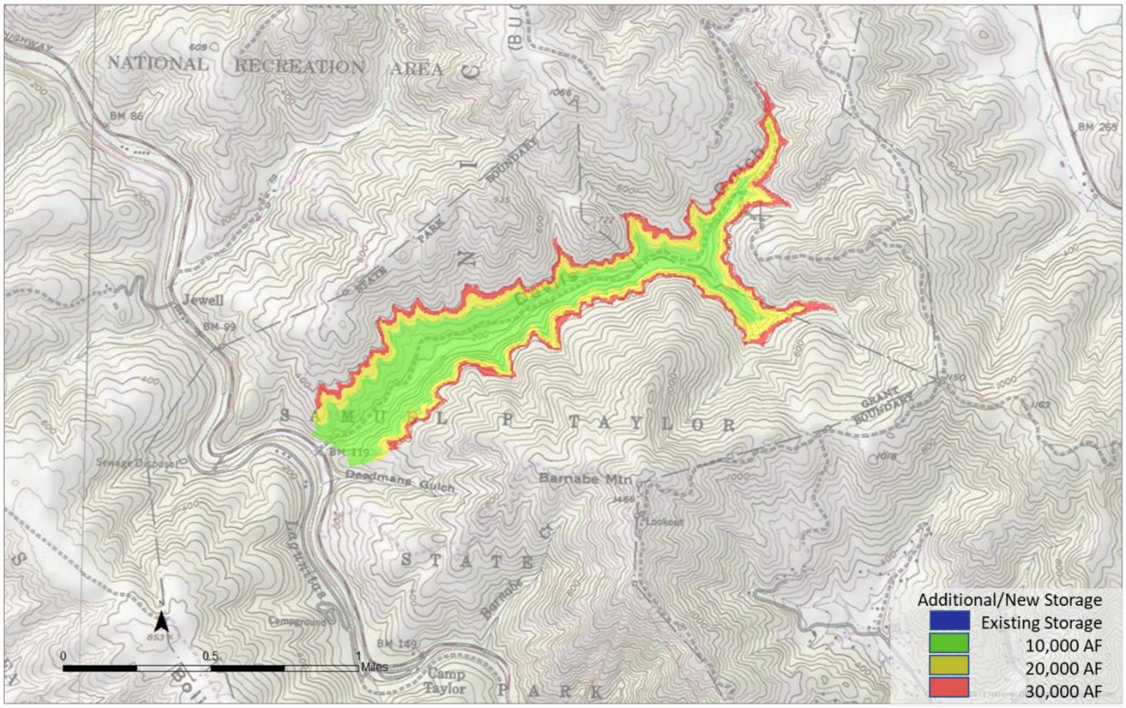
Table D-7 presents the proposed Devil's Gulch Reservoir storage capacity and inundated area associated with differing dam height changes. These height increments correspond to increases in storage capacity of 10,000, 20,000, and 30,000 AF.

Figure D-12 shows the extent of the inundation area for 10,000, 20,000, and 30,000 AF storage reservoir capacities. For the purposes of this assessment, the alternative is described as a new dam of height of 186 feet or 10,000 AF storage capacity. Larger dam heights were not considered practical give the hydrological conditions and topography.

Table D-7. Devil's Gulch storage and corresponding dam height and inundated area.

Storage (AF)	Dam Height(ft)	Inundated Area (ac)
10,000	186	154
20,000	238	232
30,000	277	293

Figure D-12. Devil's Gulch inundation estimates for site storage



D.4.5.2 Yield and Costs

This alternative is anticipated to yield no more than 2,500 AFY of additional dry period water supply. The associated cost is approximately $396 to $630 million. Based on the anticipated dry year water supply and cost, this alternative has a unit cost of $8,100 to $12,800 per AF. Currently, the same cost assumptions are used for Halleck and Devils Gulch proposed reservoir alternatives and will need to be further refined if these options are advanced.

D.4.6 Movable Spillway Gates

D.4.6.1 Description

Adjustable or "movable" spillway gates have been proposed to be installed at some of MMWD's reservoirs to create additional, temporary water storage. These movable spillway gates would be installed as either inflatable bladders or spillway notch slide gates. These gates would be operated only under certain hydrological conditions to gain limited storage for carryover into a potential forthcoming dry season. The operation of the gates would not have an impact on flood operations, downstream required releases, or inundated areas. When non-operational, the gates will have no impact on the current reservoir operations or flood control functions.

Table D-8 shows the potential increase in temporary storage that could be attained at Kent, Nicasio, Soulajule, and Alpine reservoirs with increasing the water surface elevation from one to five feet. Each of the dams and spillways is unique, and movable gates may not be feasible at all of these locations. For this assessment it is assumed that installation of movable gates would permit up to the three feet of increase in water surface elevation at these dams. This could result in a total of 5,270 AF of additional temporary storage capacity. The operation of the movable gates would be designed to capture and store additional water supply in wet years or seasons prior to potential drought conditions.

Table D-8. Increase in temporary storage at Kent, Nicasio, Soulajule, and Alpine reservoirs

Water Surface Elevation Increase (ft)	Kent Lake (acre-feet)	Nicasio (acre-feet)	Soulajule (acre-feet)	Alpine Lake (acre-feet)
1	440	750	300	230
2	880	1520	620	460
3	1330	2310	930	700
4	1780	3110	1250	930
5	2240	3920	1580	1180

D.4.6.2 Yield and Costs

This alternative is anticipated to yield no more than 1,300 AFY of additional dry period water supply. The associated cost is installation of the movable gates at Kent, Nicasio, Soulajule, and Alpine reservoirs is approximately $31 million. Based on the anticipated dry year water supply and cost, this alternative has a unit cost of $2,000 - $2,300 per AF.

D.4.7 Soulajule Electrification

D.4.7.1 Description

The use of water stored in Soulajule Reservoir is currently limited by the ability to pump water into Nicasio Reservoir, from where the water can be sent into MMWD system. The Soulajule Reservoir does not have a permanent electricity supply and the pumps rely on diesel generators. This alternative assumes that a permanent electricity supply would be added to the site resulting in a more consistent operation that permits water from Soulajule to be transferred to Nicasio Reservoir and eventually into MMWD's system. The regular movement of water out of Soulajule can also reduce the risk spill of stored supply at both reservoirs. For this alternative it is assumed that Soulajule stored water would be pumped to Nicasio only after Nicasio storage falls below 50% of its capacity.

The alternative includes full electrification of the Soulajule pumping facilities and assumes that water will be pumped from Soulajule to Nicasio every year starting in April and extending through June. Pumping may extend through October only if the pumping is not interrupted, there is available capacity at Nicasio, the pumping does not impact environmental releases from Soulajule, and Soulajule storage is near maximum capacity.

D.4.7.2 Yield and Costs

This alternative is anticipated to yield 420 AFY of additional water supply when compared with the current District operation that relies on diesel generators that are only mobilized when Nicasio is at less than 50% of its capacity. The anticipated yield is due to the increased flexibility to optimize storage operations between Soulajule and Nicasio reservoirs. The associated cost is approximately $6 million with an annual O&M cost of under $0.5 million. The estimated annual unit water cost is approximately $1,000 per AF for this alternative.

D.4.8 Phoenix-Bon Tempe Connection

D.4.8.1 Description

Phoenix Lake is one of the smallest reservoirs in the MMWD system (411 AF). However, it is estimated that inflows average 3,665 AFY. The lake is the only one of all MMWD storage facilities that lies on the east of the main watershed divide. Phoenix Lake water is pumped to Bon Tempe WTP only in dry conditions.

This alternative would establish a permanent connection between Lake Phoenix and Bon-Tempe Reservoir to capture excess inflows to Lake Phoenix that would be otherwise spilled. This alternative has two main challenges. First, when there is excess water in Lake Phoenix, there is a high chance that other reservoirs in the system are nearing spill conditions, reducing the ability to store excess water from Phoenix. Second, large pumps would be needed to capture excess inflows into Phoenix and deliver water to Bon Tempe. This alternative currently assumes a 3 mgd pump to move water from Phoenix to Bon Tempe.

D.4.8.2 Yield and Costs

This alternative is anticipated to yield approximately 260 AFY of additional dry period water supply. The associated cost is approximately $5 million with an annual O&M cost of $0.1 million. The estimated annual unit water cost is approximately $1,400 per AF for this alternative.

D.5 Water Purchases with Conveyance through Bay Interties

Four different alternatives were developed for supplementing MMWD's water supply using water purchases from the Central Valley with conveyance through interties with existing Bay partners. In each of these alternatives, it is assumed that the MMWD enters into a temporary transfer agreement with one or more willing sellers in the Sacramento River or San Joaquin River watersheds and the purchased supplied is conveyed through existing partner agency systems and new interties to deliver water to MMWD. These alternatives are described in the following subsections.

D.5.1 East Bay Municipal Utility District (EBMUD) Intertie

D.5.1.1 Description

This supply option includes the purchase of water from the Sacramento Valley (Yuba Water), diversion and conveyance through EBMUD's Freeport intake on the Sacramento River, treatment of supplies through EBMUD's facilities, and construction of a new pipeline across the San Rafael Bridge to allow MMWD to accept treated water through EBMUD's facilities. This option includes the cost of purchasing water Yuba Water, wheeling and treatment costs through EBMUD's facilities, construction and operation of the new San Rafael Bridge pipeline and a pump station at Richmond, including a regulatory storage at Pelican Way and interim pump station and pipeline to tie-in located near the Central Marin Sanitation Agency (CMSA) plan (Figure D-13 and D-14).

EBMUD has developed a set of wheeling principles that would need to be adhered to when conveying water through EBMUD facilities. These principles would make successful operation of such an intertie to prevent drought emergencies virtually impossible and are presented below:

- No financial impact to EBMUD, full cost recovery (e.g., staff time, O&M costs, construction
- costs, recovery of capital investments)
- No water quality impacts to EBMUD customers
- No reduced level of service to EBMUD customers
- No EBMUD water supplies (Mokelumne, local, CVP) will be sold to Marin Water
- No impact to EBMUD's ability to prioritize purchase of transfer water for EBMUD
- customers. Marin Water will not compete with EBMUD for water transfers.
- EBMUD has the right to terminate wheeling agreement for any reasonable cause as determined by
- EBMUD (operational, staff resources, etc.)
- No opposition to project from the City of Richmond
- Marin Water performs substantial engagement in Richmond and West Contra Costa County and
- includes EBMUD in meetings
- Mitigation for community impacts in Richmond and EBMUD's service area considered through
- an equity lens with follow-through on commitments
- Marin Water should support EBMUD customers as a community partner. Examples include a potential contribution to EBMUD Customer Assistance Program or Water Lifeline Program, full street paving for construction activities, and/or other partnerships

- If EBMUD is asking for customer demand reductions, Marin Water must achieve water efficiency levels equivalent to EBMUD for EBMUD to support Marin Water in meeting public health and safety needs
- EBMUD will make its own determination on CEQA compliance
- No significant unmitigated impacts to native fish species
- If constructed, operation of emergency intertie may only occur when Marin Water has declared drought emergency and EBMUD principles for wheeling are met

Figure D-13. Sacramento Valley Purchases and Conveyance through EBMUD Intertie

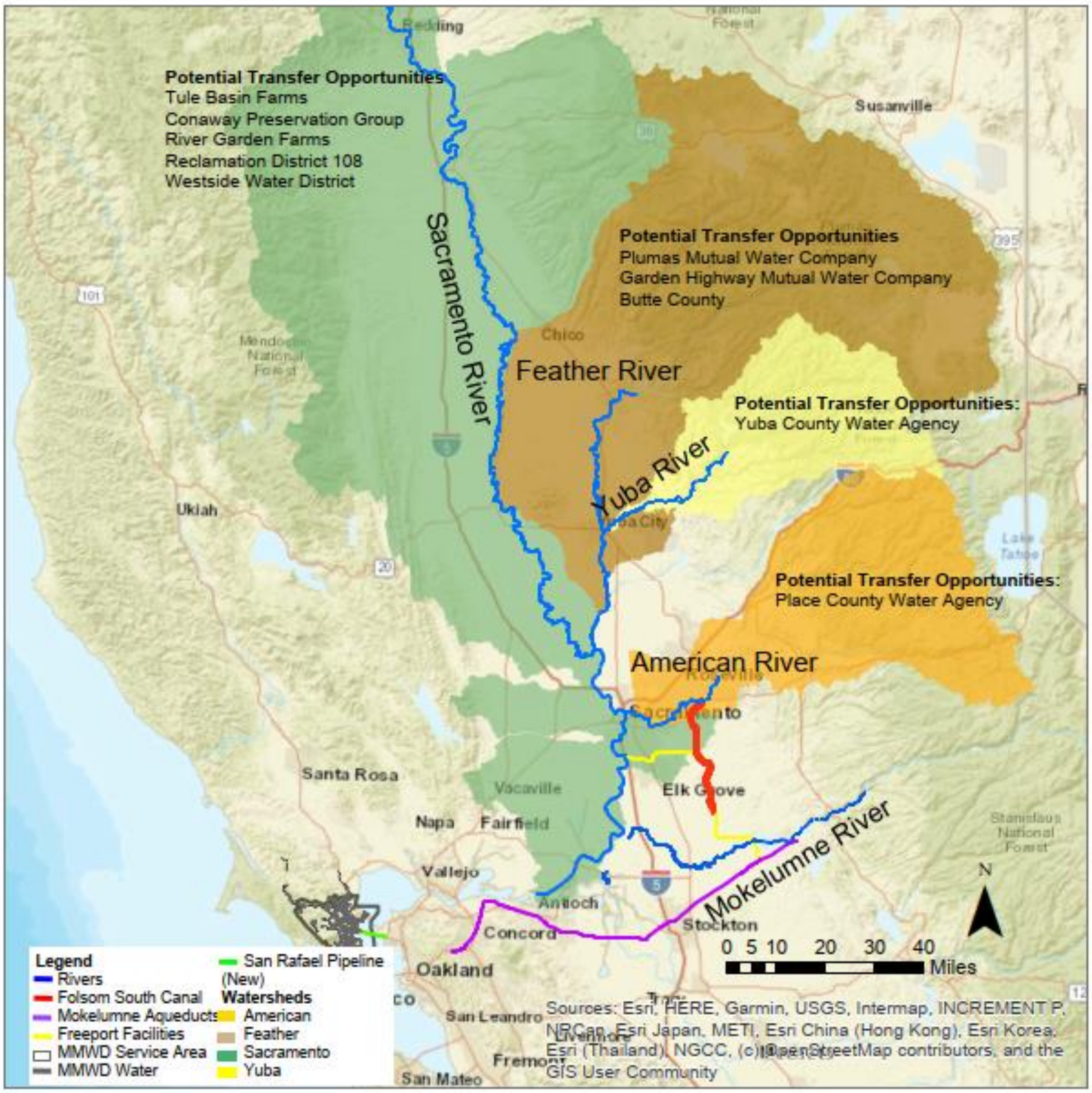


Figure D-14. San Rafael Bridge Pipeline to Complete Intertie with EBMUD System

In addition to the purchase and wheeling operations and agreements with EBMUD, MMWD would construct a new 6 mile San Rafael Bridge Pipeline, new Richmond pump station, and storage of approximately 2 MG and interim pump station at Pelican Way site and a 3-mile pipeline to connect into MMWD distribution system. Facilities have been sized to provide capacity for up to 15 mgd maximum flows.

D.5.1.2 Yield and Costs

A summary of the cost associated with the EBMUD Intertie option is included in Table D-9. O&M costs include the water purchase, wheeling, treatment, and pumping costs. The “low” and “high” ranges are associated with uncertainty in the purchase price of water.

It is assumed that MMWD could purchase up to 20,000 AF during a drought period and may take that supply over 4 years. The resulting annual dry year yield is assumed to be 5,000 AF.

Table D-9. Planning-level cost estimate for EBMUD Intertie

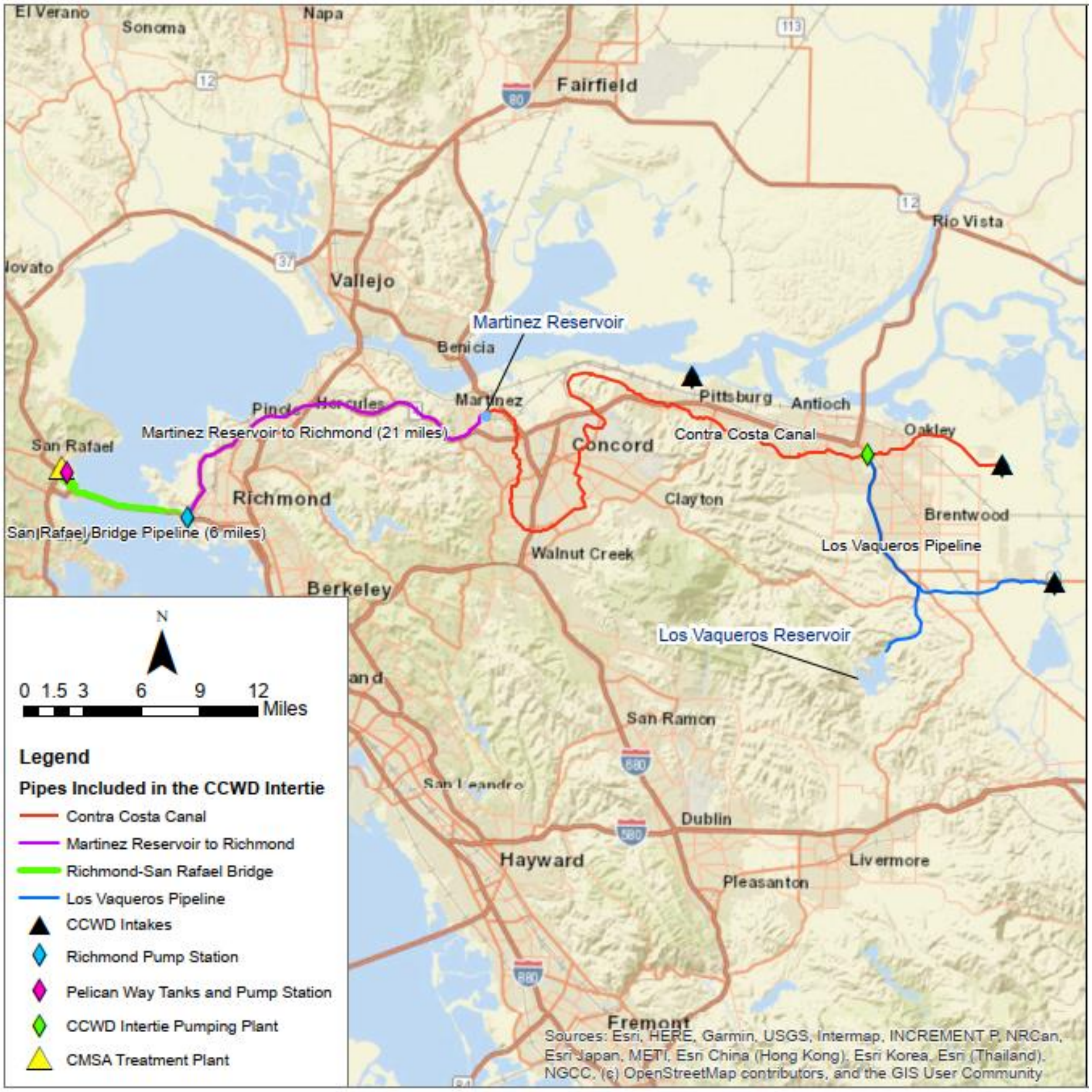
Cost Estimate Components	Low	High
Capital Cost	$111,350,000	$111,350,000
Annual O&M Total, $/year	$7,355,000	$8,894,000
Total Annualized Cost	$13,036,000	$14,575,000
Yield	5000	5000
Total Cost per AF	$2,600	$2,900

D.5.2 Contra Costa Water District (CCWD) Intertie

D.5.2.1 Description

Similar to the EBMUD Intertie option, this supply option includes the purchase of water from the Sacramento Valley (Yuba Water). Diversion would occur at CCWD’s delta pumping plants and water would be conveyed through CCWD’s system. Potential temporary storage of supply could be achieved in Los Vaqueros Reservoir. Delivery of supplies to MMWD requires an advanced connection of the CCWD’s system and construction of a new pipeline across the San Rafael Bridge to allow MMWD to accept treated water through CCWD’s facilities. This option includes the cost of purchasing Yuba water, wheeling and treatment costs through CCWD’s facilities, construction and operation of new pump station and pipeline connecting CCWD system to the new San Rafael Bridge pipeline and pump station at Richmond, including regulatory storage and a tie-in located near the Central Marin Sanitation Agency (CMSA) plant.

Figure D-15. Extended Pipeline to Complete Intertie with CCWD System



In addition to the purchase and wheeling operations and agreements with CCWD, MMWD would construct a new 21 Mile pipeline to convey water from Martinez Reservoir to Richmond, a 6-mile San Rafael Bridge Pipeline, new Richmond pump station, and regulatory storage of approximately 2 MG at the Pelican Way site, an interim pump station at Pelican Way and pipeline connecting to MMWD near CMSA. Facilities have been sized to provide capacity for up to 15 mgd maximum flows.

D.5.2.2 Yield and Costs

A summary of the cost associated with the CCWD Intertie option is included in Table D-10. O&M costs include the water purchase, wheeling, treatment, and pumping costs. The “low” and “high” ranges are associated with uncertainty in the purchase price of water.

It is assumed that MMWD could purchase up to 20,000 AF during a drought period and may take that supply over 4 years. The resulting annual dry year yield is assumed to be 5,000 AF.

Table D-10. Planning-level cost estimate for CCWD Intertie

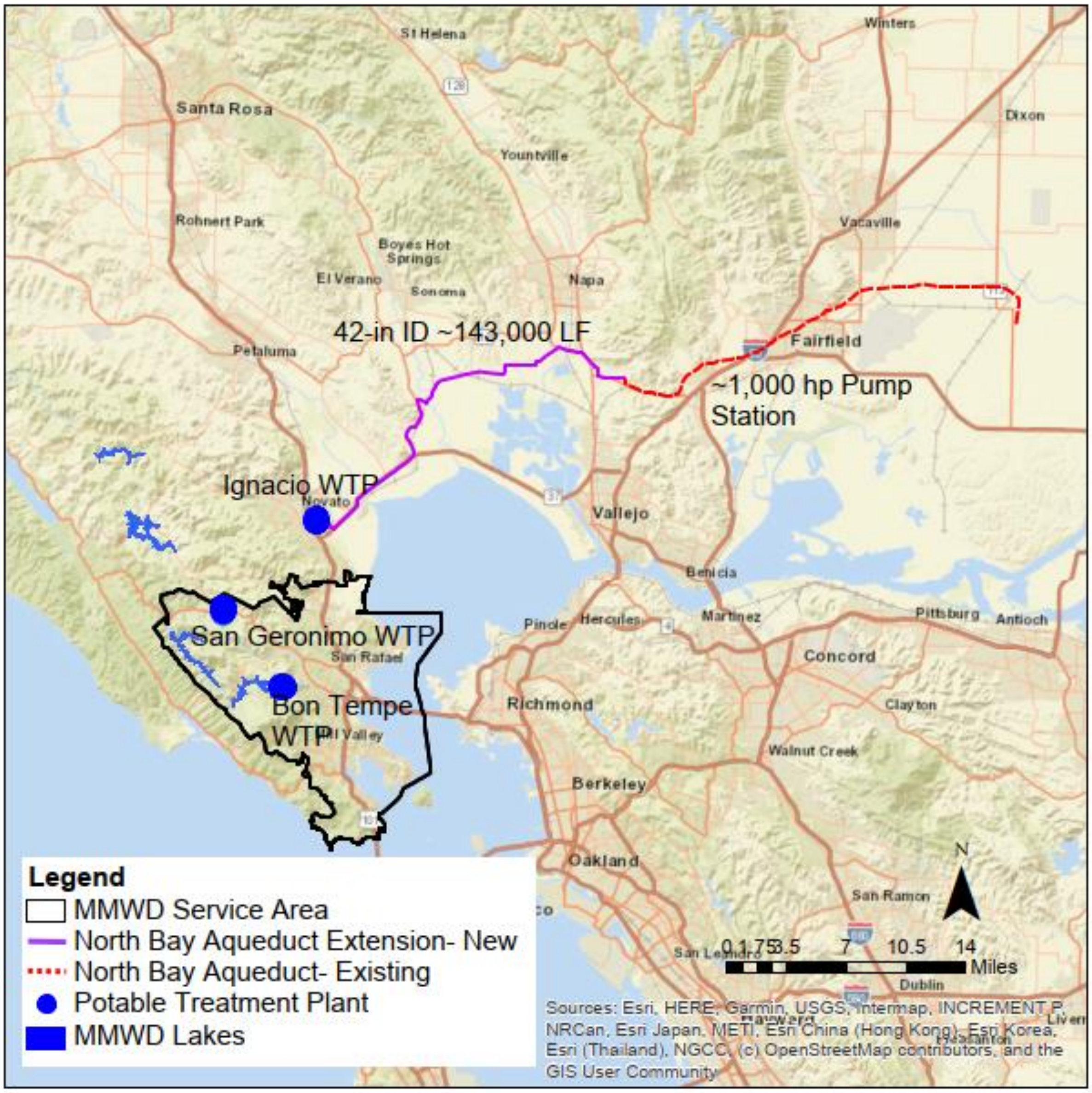
Cost Estimate Components	Low	High
Capital Cost	$280,434,000	$280,434,000
Annual O&M Total, $/year	$7,355,000	$8.894,000
Total Annualized Cost	$21,663,000	$23,202,000
Yield	5000	5000
Total Cost per AF	$4,300	$4,600

D.5.3 North Bay Aqueduct (NBA) Intertie

D.5.3.1 Description

This intertie option considers developing an connection to the existing North Bay Aqueduct. Similar to the other intertie options, this supply option includes the purchase of water from the Sacramento Valley (Yuba Water). Diversion would occur at the NBA delta pumping plants and water would be conveyed through the existing NBA to Napa. Treatment would occur at Napa’s Jameison Water Treatment Plant (if capacity is available) or additional treatment capacity would be added at this location. Delivery of supplies to MMWD requires a 34 mile pipeline from Jameison Plant to MMWD’s system. This option includes the cost of purchasing water Yuba Water, wheeling costs through NBA facilities, treatment costs, and construction and operation of the new pipeline and pump station, including a tie-in to MMWD’s treated water system.

Figure D-16. North Bay Aqueduct Intertie Concept



In addition to the purchase and wheeling operations and agreements with NBA users and Napa, MMWD would construct a new 34 mile pipeline and build/operate (or pay for) treatment for approximately 5 mgd capacity.

D.5.3.2 Yield and Costs

A summary of the cost associated with the NBA Intertie option is included in Table D-11. O&M costs include the water purchase, wheeling, treatment, and pumping costs. The “low” and “high” ranges are associated with uncertainty in the purchase price of water.

It is assumed that MMWD could purchase up to 20,000 AF during a drought period and may take that supply over 4 years. The resulting annual dry year yield is assumed to be 5,000 AF.

Table D-11. Planning-level cost estimate for NBA Intertie

Cost Estimate Components	Low	High
Capital Cost	$346,163,000	$410,136,000
Annual O&M Total, $/year	$6,365,000	$7,903,000
Total Annualized Cost	$24,026,000	$28,829,000
Yield	5000	5000
Total Cost per AF	$4,800	$5,800

D.5.4 San Francisco Public Utilities Commission (SFPUC) Intertie

D.5.4.1 Description

This intertie option considers developing a connection to the SFPUC's system with a pipeline across the Golden Gate Bridge. Water would be purchased directly from SFPUC or purchased and exchanged in the Tuolumne River watershed, wheeled through SFPUC's existing system, connected to the new Bridge pipeline, and delivered to MMWD's southern service area. Treatment is assumed to occur through SFPUC's existing treatment plants. Delivery of supplies to MMWD requires a 5 mile pipeline from SPFUC's system to MMWD's treated water distribution system. Since the connection would occur at the end of both SFPUC's and MMWD's systems with small diameter pipelines, the area that could be served will be limited. This option includes the cost of purchasing water, wheeling costs through SFPUC facilities, and construction and operation of the new pipeline and pump station, including a tie-in to MMWD's treated water system.

D.5.4.2 Yield and Costs

A summary of the cost associated with the SFPUC Intertie option is included in Table D-12. O&M costs include the water purchase, wheeling, and pumping costs. The "low" and "high" ranges are associated with uncertainty in the purchase price of water.

Due to restricted service area, it is expected that the ability to deliver would be limited to approximately 1,000 AFY. Discussions with SFPUC have not yet occurred and further analysis would be required if this alternative is advanced.

Table D-12. Planning-level cost estimate for SFPUC Intertie

	Low	High
Capital Cost	$31,215,000	$31,215,000
Annual O&M Total, $/year	$1,273,000	$1,580,000
Total Annualized Cost	$2,866,000	$3,174,000
Yield	1000	1000
Total Cost per AF	$2,900	$3,200

D.6 Desalination

Four different options were developed for supplementing MMWD's water supply using desalination of either brackish or seawater (Bay Water) supplies. These options are described in the following subsections. Note that capital costs listed for each option do not include costs for installation of new electrical facilities (overhead power lines, substations) that may be required to supply power to the desalination systems.

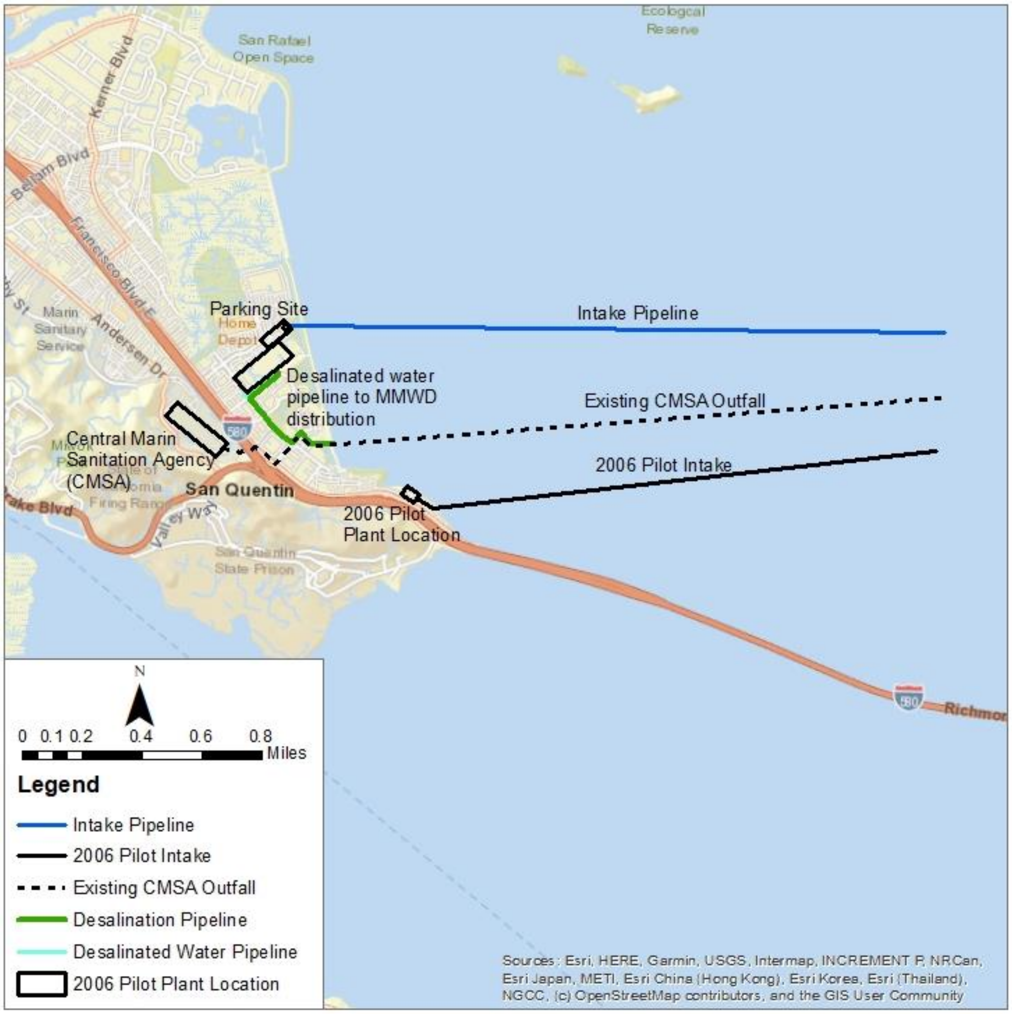
D.6.1 Marin Permanent Regional Desalination Plant (MPRDP)

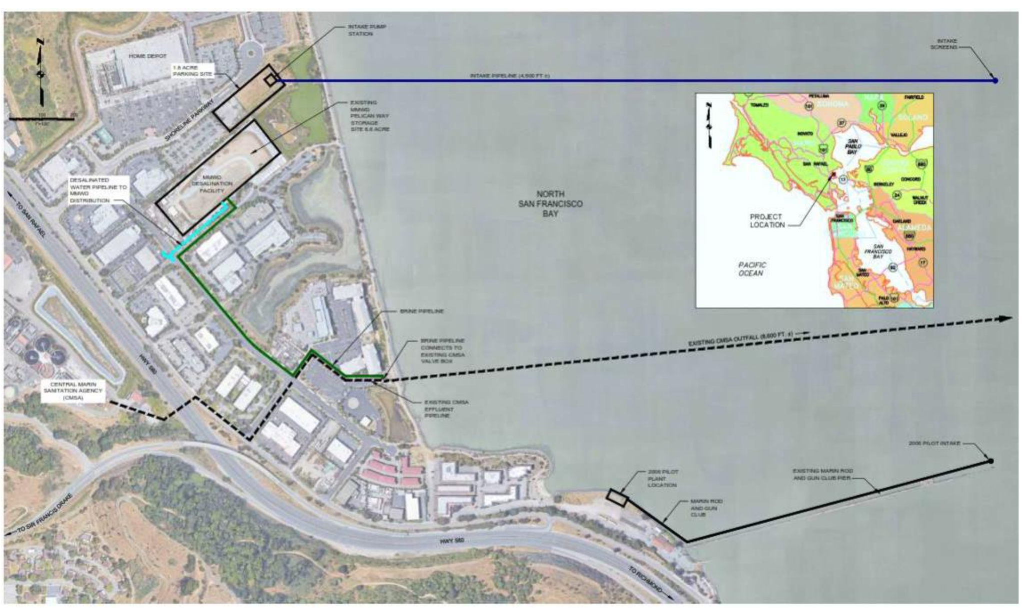
D.6.1.1 Description

In 2005/2006, MMWD, assisted by Kennedy Jenks (KJ) and Jacobs (then CH2M Hill), conducted a year-long pilot program that demonstrated Bay water can be desalinated to provide a drought-proof, supplemental drinking water supply for the residents of Marin (Kennedy Jenks &CH2M HILL, 2007). The pilot program included a successful public outreach component and provided information to support an Environmental Impact Report (EIR) that was certified by MMWD in 2007. Information from the pilot program was used to develop a conceptual design and Class V costs for a permanent 5-mgd desalination facility that could be expanded to either 10 or 15 mgd. Capital costs (only) for these facilities were updated in 2021 (Kennedy Jenks &Jacobs, 2021), however these costs did not fully account for the impacts on Covid on materials costs and supply chain impacts resulting therefrom.

The proposed site for the 5-, expandable to 10- or 15-mgd, facility is the 6.6-acre MMWD Pelican Way Storage Site in San Rafael. Although originally proposed to be located on a reconstructed pier at the Marin Rod and Gun Club, the onshore intake pump station was relocated in the 2021 study northeast of the storage site on an un-developed parking lot with the intake pipeline located directly east into the Bay (see Figure D-17). Brine from the desalination facility would be conveyed to, and blended, with secondary effluent, for discharge into the Bay through the Central Marin Sanitation Agency (CMSA) existing outfall.

Figure D-17. Location of Permanent Marin Regional Desalination Plant





Water from the North San Francisco Bay will supply the desalination plant. Bay water salinity ranges from 29,000 to 32,000 mg/L total dissolved solids (TDS), slightly lower than Pacific Ocean water (34,000 mg/L). Because of this high salinity level, a seawater-based desalination system is required to provide sufficient salt removal to meet MMWD's treated water quality objectives.

Based on the results of the 2006 pilot study, the desalination plant would comprise the following:

- Intake system, consisting of passive, 1-mm screens located approximately 4,500 feet from shore, connected to an on-shore pump station via a 48-inch HDPE pipeline. The intake would be located in twelve feet of water and screens sit six feet above the seabed. Bay water would flow into the pump station, be pressurized and conveyed to the pretreatment system.
- Pretreatment system consisting of 80-100 micron fine screens followed by a pressurized membrane filtration system (MFS) (either micro- or ultra-filtration) to remove particulate matter and selected pathogens; antiscalant dosing to prevent mineral precipitation within the RO membranes; and cartridge filtration to prevent any particulate matter passing through membrane filtration from reaching the membranes. The MFS would include backwash and chemical cleaning systems as well as backwash water storage and pumping to the CMSA outfall.
- Reverse osmosis desalination system, comprising 1st-pass high pressure pumps, (seawater) RO trains and energy recovery systems; 1st-pass permeate storage. Although not anticipated, accommodations will be made to add a partial 2nd pass system, comprising feed pumps and (brackish water) RO trains. A chemical cleaning system will be provided for 1st and/or 1st & 2nd pass RO trains.
- Desalinated water post-treatment stabilization and disinfection systems, comprising lime and CO2 addition, chlorination (with contact basin) for primary disinfection; ammonia (for secondary disinfection), fluoride and phosphate addition.
- Finished water storage, pumping and pipeline conveyance to connect to multiple locations within the existing distribution system.

The treatment processes outlined above would produce a finished water whose quality would be similar in key characteristics to that of MMWD's current potable water supply. This would include a TDS of less than 200 mg/L.

The seawater desalination process will generate a brine volume that is slightly greater than the finished water volume with a TDS approximately two times higher than the Bay water. The brine will be stored and then pumped through a dedicated pipeline to a blending station located on the CMSA outfall pipeline where it will be blended with effluent from the CMSA wastewater treatment plant.

D.6.1.2 Yield and Costs

Water production (yield) and costs associated with this option are presented in Tables D-13 and D-14. Costs have been developed for the following alternative capacities:

- 5-mgd, fixed-capacity facility
- 5-mgd, expandable to 15-mgd, facility
- 10-mgd, expandable to 15-mgd, facility
- 15-mgd facility

Low and high costs for the 5-mgd, fixed-capacity option utilize granular media filtration and ultrafiltration pretreatment, respectively. All other options utilize ultrafiltration pretreatment. Costs are Class V as defined by the American Association of Cost Engineers and have a range of -50% to +100%.

Capital costs for each option do not include costs associated with any new facilities that may be required to supply power to desalination plant (e.g., substation, power lines).

Table D-13. Yield and Costs for Option 1 – Marin Regional Desalination Facility: Low Costs

Option	5-mgd Fixed Capacity	5-mgd Expandable	10-mgd Expandable	15-mgd
Capital Cost	$224,980,000	$246,473,000	$319,796,000	$373,393,000
Annual O&M Cost	$11,049,000	$12,434,000	$20,474,000	$28,383,000
Total Annualized Cost	$22,432,000	$24,903,000	$36,654,000	$47,274,000
Yield, AFY	5,045	5,045	10,089	15,134
Plant Cost, AFY	$4,400	$4,900	$3,600	$3,100

Total annualized cost based on 30 years

Table D-14. Yield and Costs for Option 1 – Marin Regional Desalination Facility: High Costs

Option	5-mgd Fixed Capacity	5-mgd Expandable	10-mgd Expandable	15-mgd
Capital Cost,	$249,912,000	$273,887,000	$331,200,000	$401,069,000
Annual O&M Cost	$11,877,000	$13,417,000	$21,756,000	$29,144,000
Total Annualized Cost	$24,520,000	$27,273,000	$38,512,000	$49,435,000
Yield, AFY	5,045	5,045	10,089	15,134
Plant Cost, AFY	$4,900	$5,400	$3,800	$3,300

Total annualized cost based on 30 years

Costs in Tables D-13 and D-14 assume year-round operation of the desalination plant at a high on-line factor (90% or greater). Given the significant operating costs associated with this facility (particularly for energy which represents ~50% of operating costs), the facility could be (1) operated year round at some reduced capacity, (2) operated intermittently or (3) placed in some form of standby to minimize these costs. Seawater desalination plants in Australia have been operated in one or more of these modes given that most were constructed in response to a drought that ended shortly after their start-up.

Considerations for Reduced Capacity Operations

Advantages:

- Reduced operating costs (energy, chemicals, labor); potentially reduced membrane filtration module and RO element replacement costs
- Reduced equipment maintenance costs

Disadvantages:

- Reduced payback on capital investment (or another way of saying this is much higher cost per AF)
- Ability to maintain proper level of training of operating staff
- Need to prevent biological fouling in pretreatment and RO membrane systems (periodic renewal of preservation solutions; requirement to operate at plant at minimal capacity to generate desalinated water for preservation)
- Risk of plant not performing as required when required, primarily around membrane system performance (capacity and/or quality)

D.6.2 Marin Containerized Regional Desalination Plant (CRDP)

D.6.2.1 Description

In response to drought and declining reservoir levels, in April 2021 MMWD requested that Kennedy Jenks (KJ) and Jacobs investigate desalination options to augment drinking water supplies on an emergency basis. The investigation evaluated two options: (1) a barge-mounted desalination system that would be anchored off of San Rafael, desalinate Bay water and convey treated water to shore via a pipeline; and (2) a pre-fabricated, skid-mounted or containerized desalination units that would be installed at the District's Pelican Way Storage Site in San Rafael, receiving Bay water from an intake and pump station located on or adjacent to the storage site similar to the location of the permanent desalination and intake facilities described in Desalination Option 1 and as shown in Figure D-17 of this option. As with Option 1, treated water from the emergency system would be pumped into the MMWD potable water distribution system via a pipeline running along east Francisco Boulevard and the brine would be discharged into the CMSA outfall pipeline after mixing with secondary effluent.

Of the four entities identified who might supply a barged-mounted system, one was no longer in business, the assets of two were already on lease (or otherwise unavailable), while the fourth had not yet fabricated a system. Due to these availability constraints and with anticipated permitting challenges associated with mooring and operating a ship-based desalination in the Bay, this option was eliminated from further consideration.

A request for Information (RFI) was developed and sent to ten vendors requesting ability to supply ≥2 mgd of desalinated water using skid-mounted or containerized system(s) provided on a lease basis for a minimum of 12 months. Three vendors indicated they could meet these requirements, two using skid-mounted systems of 2-mgd capacity and one using a containerized system of 3.6-mgd capacity. Based on further evaluation, KJ/Jacobs selected the 3.6-mgd system (supplied as two 1.8-mgd systems) from Osmoflo to be incorporated into a fully-functioning desalination system and for development of conceptual-level system costing. The Osmoflo system was selected based on its greater capacity, the fewest number of units to mobilize, install and operate; and a system that is ‘plug and play’. A picture of the 1.8-mgd system is shown in Figure D-18.

For purposes of this alternative, a 5.4-mgd Osmoflo system, comprising three 1.8-mgd containerized systems, is used as the basis for estimating costs and for populating the evaluation criteria listed below. Similar to Option 1, the containerized Osmoflo system would be constructed overseas, shipped and then installed at the Pelican Way Storage Site, along with other required equipment.

Figure D-18*. Osmoflo Containerized 1.8-mgd Desalination System*

Similar to Option 1, water from the North San Francisco Bay will supply the desalination plant. Bay water salinity ranges from 29,000 to 32,000 mg/L total dissolved solids (TDS), slightly lower than Pacific Ocean water (34,000 mg/L). Because of this high salinity level, a seawater-based desalination system is required to provide sufficient salt removal to meet MMWD’s treated water quality objectives.

Based on the results of the 2006 pilot study, the desalination plant would comprise the following:

- Intake system, consisting of passive, 1-mm screens located approximately 4,500 feet from shore, connected to an on-shore pump station via a 48-inch HDPE pipeline. The intake would be located in twelve feet of water and screens sit six feet above the seabed. Bay water would flow into the pump station, be pressurized and conveyed to the pretreatment system.
- A Bay water receiving tank and pump station would accept water from the intake pump station and supply it to the pretreatment portion of the Osmoflo system.

Each of the three 1.8-mgd containers will contain the following:

- Pretreatment system consisting of 80-100 micron fine screens followed by a pressurized membrane filtration system (MFS) (either micro- or ultra-filtration) to remove particulate matter and selected pathogens; antiscalant dosing to prevent mineral precipitation within the RO membranes; and cartridge filtration to prevent any particulate matter passing through membrane filtration from reaching the membranes. The MFS would include backwash and chemical cleaning systems as well as backwash water storage and pumping to the CMSA outfall.
- Reverse osmosis desalination system, comprising high pressure pump, seawater RO train and energy recovery system
- A chemical cleaning system to service all RO trains.
- Desalinated water post-treatment comprising CO2 dosing and calcite contactors for stabilization and chlorination (with contact basin) for primary disinfection; ammonia (for secondary disinfection), and fluoride and phosphate addition.
- Finished water storage, pumping and pipeline conveyance to connect to multiple locations within the existing distribution system.

The treatment processes outlined above would produce a finished water whose quality would be similar in key characteristics to that of MMWD's current potable water supply. This would include a TDS of less than 200 mg/L.

The seawater desalination process will generate a brine volume that is slightly greater than the finished water volume with a TDS approximately two times higher than the Bay water. The brine will be stored in a tank adjacent to the containerized system and then pumped through a dedicated pipeline to a blending station located on the CMSA outfall pipeline where it will be blended with effluent from the CMSA wastewater treatment plant.

D.6.2.2 Yield and Costs

Water production (yield) and costs associated with this option are presented in Table D-15. Costs are Class V as defined by the American Association of Cost Engineers and have a range of -50% to+100%. For the purposes of costing this desalination alternative, the life of the containerized system was assumed at 20 years while that of the remaining infrastructure (intake, post-treatment system, storage tanks and desalinated water and brine pumps stations) was assumed at 30 years.

Capital costs do not include costs associated with any new facilities that may be required to supply power to the desalination plant (e.g., substation, power lines).

Table D-15. Yield and Costs for Option 2 – Containerized, Leased Marin Desalination Facility

	Low	High
Capital Cost	$131,654,000	$143,434,000
Annual O&M Cost	$12,105,000	$12,928,000
Total Annualized Cost	$15,252,000	$16,334,000
Yield, AFY	5,145	5,145
Plant Cost, AFY	$3,000	$3,200

Total annualized cost based on 20 years for containerized equipment and 30 years for remaining facilities.

As described in Option 1, the above costs assume year-round operation of the containerized desalination plant. Operating costs could be reduced through either intermittent operation or operation at reduced capacity during non-drought periods when desalinated water is not required to meet MMWD's potable water requirements.

D.6.3 Bay Area Regional Desalination Project (BARDP)

D.6.3.1 Description

BARDP is a regional partnership between CCWD, EBMUD, SFPUC, Valley Water and Zone 7 Water Agency. The project, as currently envisioned, would provide a new, supplemental drinking water supply to these agencies. Although a number of locations for a desalination plant have been considered since the project's inception in 2003, the currently preferred location, based on minimizing new conveyance infrastructure, is the East Contra Costa Site where brackish water would be abstracted from CCWD's existing Mallard Slough intake location and treated. In addition to the option for direct delivery to CCWD and EBMUD, the desalinated water could be conveyed to Los Vaqueros Reservoir (LVR) for storage and used during dry (drought years) providing the ability to meet partners water supply needs through wet weather storage.

Based on a memorandum of agreement (MOU) between the agencies (ACFC&WCD, 2011), a maximum of 25 mgd of brackish water would be pumped from the Slough eleven months of the year. The amount of water each agency would receive is yet to be determined. According to a 2011 BADRP funded study (BARDP, 2011), potential water demands were listed as shown in the

Table D-16 below. More recently SFPUC listed a supply benefit from BARDP of between 5 and 15 mgd with a steady supply of 9 mgd when combined with water storage in the LVR (3) consistent with the 2011 table (SFPUC, 2021).

Table D-16. Projected Desalination Water Demand for Water Agencies, taken from 2011 BADRP funded study (BADRP, 2011)

	Potential Water Demand from BARDP (mgd)	Demand Frequency (years)
EBUMD	9	1 in 5
CCWD	13	1 in 10 (2030+)
SFPUC	9	Every year
SCVWD	10	1 in5
XZone 7*	5	Wet and normal year or every year if water is available
Total	14 (every year) – 46 (max)	

For this desalination option, based on the results of a desalination pilot study conducted in 2008 and 2009, up to 25 mgd of brackish water would be pumped at the Mallard Slough intake to produce a maximum 20 mgd of desalinated water over eleven months of the calendar year, of which MMWD would have access to 5 mgd of the desalinated water. The desalinated water would be pumped from the treatment plant into the EBMUD Mokelumne Aqueduct for conveyance to a new pump station located on the Richmond side of the Richmond-San Rafael Bridge, where it would be pumped over the bridge into a tank located at Pelican Way and from there pumped into the MMWD potable water distribution system. The actual amount of water that MMWD would have access to during drought years would need to be determined based on an agreement between MMWD and the BARDP members.

Salinity in the Mallard Slough can range from <1,000 mg/L to as high as 12,000 mg/L as total dissolved solids (TDS). For the purpose of developing a RO system design and associated costs, a median TDS of 7,400 mg/L was used. The process used to treat the slough water provided by the existing CCWD intake include: fine screening; coagulant addition and rapid mix; ultrafiltration; scale inhibitor dosing, two-stage RO using a hybrid seawater-brackish water configuration; chemical addition to the RO permeate for stabilization and disinfection including carbon dioxide, lime and chlorine. The finished water would be stored in a two-million-gallon tank and pumped to the Molekumne Aqueduct for conveyance to MMWD through the EBMUD system[1]. Concentrate (brine) generated by the RO process is stored and conveyed to the Delta Diablo Sanitation District's WWTP for blending with effluent prior to discharge to Broad Slough via an existing outfall.

TDS of the finished water would be between 65 and 175 mg/L depending on raw water salinity, temperature and age of the RO membranes. The finished water would be stabilized to a Langelier Saturation Index of +0.1 to +0.3.

D.6.3.2 Yield and Costs

Water production (yield) and costs associated with this option are presented in Table D-17. Costs are Class V as defined by the American Association of Cost Engineers and have a range of -50% to+100%. Costs are based on (1) 25 percent of the capital and operating costs for the 20-mgd desalination plant (MMWD's share) combined with capital and operating costs to pump and store 5 mgd of desalinated water into the MMWD potable water distribution system. Operating costs also include $30/AF for the use of the Mallard Slough pump station and a wheeling cost of $300/AF (to convey water in the Mokelumne Aqueduct).

Capital costs do not include costs associated with any new facilities that may be required to supply power to the desalination plant (e.g., substation, power lines).

Table D-17. Yield and Costs for Option 3 - Bay Area Regional Desalination Facility

	Low	High
Capital Cost	$252,730,000	$268,004,000
Annual O&M Cost	$5,890,000	$6,236,000
Total Annualized Cost	$19,795,000	$29,795,000
Yield, AFY	5044	5044
Plant Cost, AFY	$3,370	$3,900
Wheeling Cost*	$330	$330
Total Cost per AFY	$3,700	$4,230

Total annualized cost based on 30 years

*Includes wheeling cost of $300 + $30 for use of Mallard Slough Pump Station

D.6.4 Petaluma Brackish Groundwater Desalination Project (PBGDP)

D.6.4.1 Description

This desalination option utilizes a reverse osmosis (RO) desalination plant designed to produce 5 mgd of potable water by treating shallow brackish groundwater from a series of wells to be installed near the Petaluma River south of the City of Petaluma. The desalinated water would be pumped into the Petaluma Aqueduct and mixed with water from Sonoma County Water District (SCWD) that is currently used to supplement MMWD's local water supply.

Based on information from a 2012 U.S. Geological Survey (USGS) study (USGS, 2012) that characterized the quality of 71 wells in the north San Francisco Bay shallow aquifers, brackish water with a total dissolved solids (TDS) as high as 1000 mg/L is present in the shallow groundwater beneath the City of Petaluma and surrounding area near the Petaluma River. Based on this information, it was assumed that brackish water of this salinity could be utilized as source water to a new desalination plant and associated infrastructure, referred to as the

Petaluma Brackish Groundwater Desalination Project (PBGDP). To supply the brackish water, six new wells would be installed within a one-to-two-mile radius, with the water from these wells conveyed to the RO plant via a below-ground pipeline.

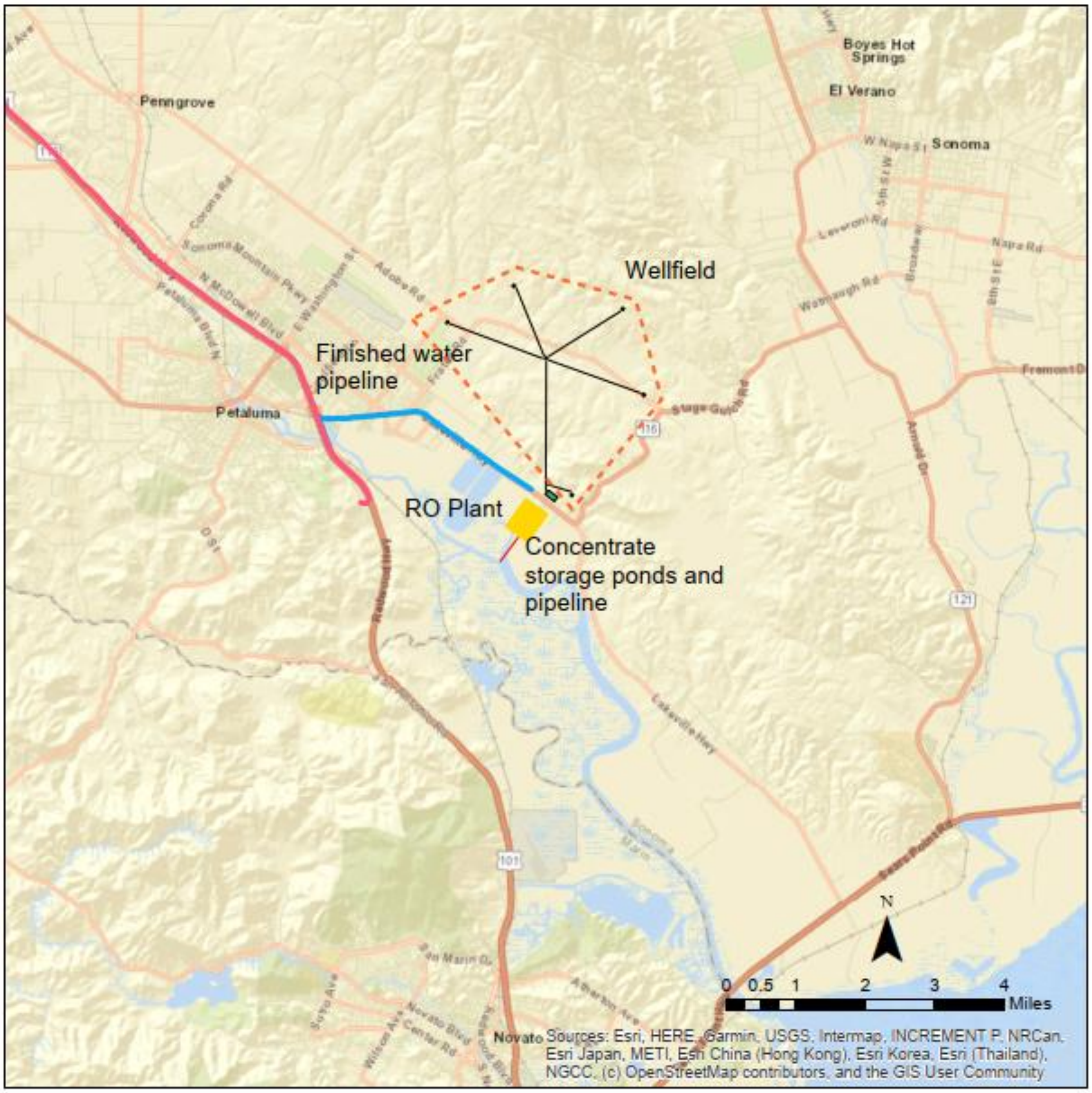
The brackish groundwater would be treated using the following processes: scale inhibitor dosing, cartridge filtration, RO feed pumps and two-stage brackish water RO system. The RO permeate would be chemically conditioned using carbon dioxide and limestone (using a calcite contactor) to increase hardness, alkalinity and pH and then disinfected with free chlorine, providing a finished water of similar quality to that of SCWD water (TDS of <200 mg/L). The finished water would be stored in a 500,000-gal tank and then pumped through a transmission line to the Petaluma Aqueduct.

For purposes of this option, it is assumed that the concentrate generated as a waste stream from the RO process (brine) would be disposed to the Petaluma River. The ability to discharge concentrate to the river will require applying for and obtaining a NPDES permit. Under their existing NPDES permit (CA RWCB, 2021), the City of Petaluma is currently permitted to discharge secondary effluent from their Ellis Creek WWTP, but only during the period October 21st through April 31st. This restriction may be in place based the presence and concentration of specific constituents in the effluent, which would be significantly different from that of the RO concentrate. Given the uncertainty of a year-round discharge, two disposal options were included in the estimation of project costs. Option 1 assumes a year-round discharge. Option 2 assumes the same restriction in place for the Ellis Creek WWTP, requiring that concentrate be stored during the period May 1st through October 20th. Concentrate storage would be via a series of five ponds (4 duty and 1 spare) having a total area of 53 acres of ponds, each having a depth of 15 feet. Additional acreage will be required for access roads around the ponds. During the allowed discharge period, stored concentrate would be pumped into a pipeline, mixed with concentrate produced from the RO plant (during operation), and discharged to the river. Property for the ponds need to be acquired (along with that for the wells and RO plant) and associated costs included in the Project.

Proposed locations for the brackish wellfield, RO plant and concentrate storage ponds are shown in Figures D-19. The storage ponds are located to the south and east of the existing Ellis Creek WWTP effluent storage ponds while the RO plant is located across Route 116 from the storge ponds to the west of the wellfield. Storage pond location was chosen to minimize distance for discharge to the river. As shown in Figure D-19, the finished (desalinated) water pipeline would run northwest along Route 116 to the junction with Route 101, then south along the 101 prior to connecting to the Petaluma Aqueduct on the west side of the 101.

Wells were spaced at one-half mile apart to minimize drawdown between wells with wellfield location chosen to utilize undeveloped land. A detailed hydrogeological study would be required to confirm whether groundwater of the desired salinity (1,000 mg/L or higher) is present in area.

Figure D-19. Proposed location of RO plant, concentrate storage ponds and associated pipelines.



D.6.4.2 Yield and Costs

Water production (yield) and costs associated with this option are presented in Table D-18. Costs are Class V as defined by the American Association of Cost Engineers and have a range of -50% to+100%. 'Low' costs shown in Table D-18 are without seasonal brine storage and pumping; 'high' costs are with seasonal brine storage and pumping.

Capital costs do not include costs associated with any new facilities that may be required to supply power to the desalination plant (e.g., substation, power lines).

Table D-18. Yield and Costs for Option 4 – Petaluma Brackish Groundwater Desalination Facility

	Low	High*
Capital Cost	$122,070,000	$193,855,000
Annual O&M Cost	$3,636,000	$4,395,000
Total Annualized Cost	$9,812,000	$14,202,000
Yield, AFY	5325	5325
Plant Cost, AFY	$1,600	$2,700
Wheeling Cost*	$200	$200
Total Cost per AFY	$1,800	$2,900

Total annualized cost based on 30 years

*Includes costs for concentrate storage ponds and pump station

Considerations

Given the late development of this option a number of assumptions were made in order to develop the treatment concept and associated costs. The following are key considerations that would need to be addressed to better confirm project feasibility, implementation schedule and costs:

- Well location, yield and quality. A hydrogeological investigation will be required to (1) determine the appropriate locations for siting of the shallow wells to access groundwater of the desired quality and yield, (2) confirm the assumed yield of each well and the number of wells required to sustainably supply 6 mgd to the RO plant and (3) to characterize the quality of the groundwater that would be pumped, both as it pertains to RO plant design and to determine whether undesirable constituents are present in the groundwater than might adversely impact finished water quality. The latter is necessary given that the USGS study identified a number of synthetic organic compounds and radionuclides in wells located in the proposed project area.
- Concentrate disposal. As discussed above, a NPDES permit will be required for river disposal of the RO concentrate. This will require discussions with the applicable regulatory agency (State or EPA) to determine feasibility of discharge (either year-round or seasonal) and what water quality and toxicity testing will be required. Such testing could require that a pilot plant be installed and operated in order to generate representative concentrate for water quality testing.
- Land availability and ROW access. Land will need to be acquired for siting the wells, RO plant and, if required, concentrate storage ponds. Rights-of-way will also be required for installation of pipelines from wells to RO plant, from RO plant to Petaluma Aqueduct, and from RO plant to the river (concentrate).

- Feasibility and cost of finished water pipeline under Petaluma River. A permit will need to be obtained from Sonoma County, and cost determined, for installing the finished water line under the Petaluma River adjacent to Route 101.
- Alternative would likely only be advanced in partnership with City of Petaluma due to the location of the infrastructure and potential to generate multiple benefits.

D.7 Water Reuse

D.7.1 Non-Potable Recycled Water Expansion

D.7.1.1 Description

Non-potable use of recycled water has been practiced for the effluent flows from CMSA, SASM, and LGVSD. Based on the recent flow data (2019-2021), approximately 10 percent of the treated effluent was reused for beneficial purposes. The usage relative to the available treated effluent flow is limited by the extent of recycled water distribution system and recycled water users, and seasonality of the demand. From potential future uses identified in the previous studies, two largest reuse opportunities are included in this option:

1. Extension of existing LGVSD RW distribution system to Peacock Gap golf course,
2. A new RW production and delivery from CSMA to San Quentin Prison.

Option 1a: LGVSD Recycled Water to Peacock Gap

The evaluation for the extension of RW distribution system for LGVSD is ongoing as of 2022 (Peacock Gap Recycled Water Transmission Pipeline Project). It is assumed that the route used for the extension will be the South Route shown in Figure D-20. The project includes the conveyance pipeline extension and a recycled water storage tank. The project is expected to deliver approximately up to 285 AF of recycled water to the new customers.

Figure D-20. Non-potable recycled water system conceptual map: LGVSD to Peacock Gap

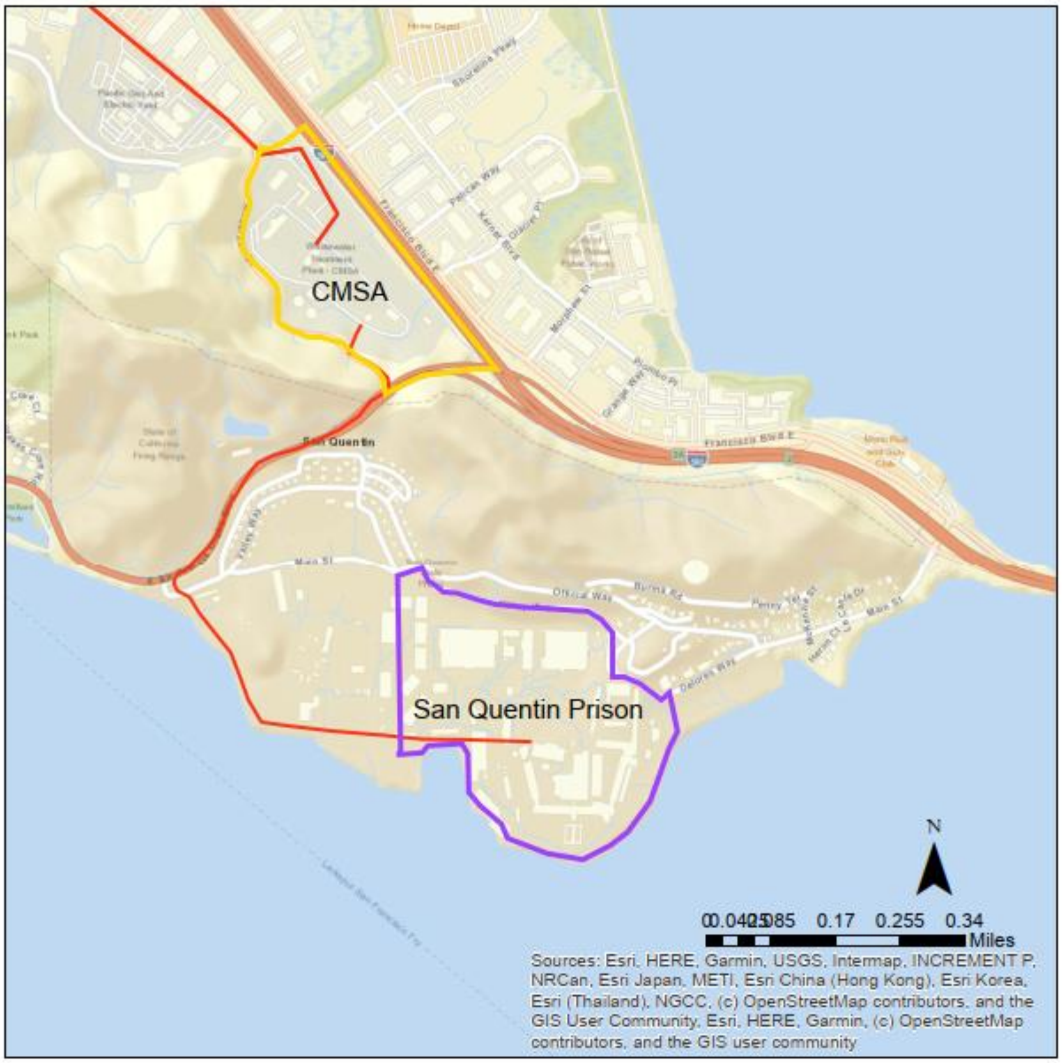
(from 09-17-2021 Agenda Packet Operations Committee – RFP PEACOCK GAP RECYCLED WATER TRANSMISSION PIPELINE PROJECT – PHASE I). The total length of recycled water conveyance is indic

As this project is ongoing as of August 2022, the design basis for the distribution system expansion project is based on the RFP posted in November 2021 with supplemental information provided by MMWD. Capital cost for the treatment system is zero, as the recycled water treatment plant already exists at LGVSD and recently completed the expansion of capacity from 1.4 mgd to 5.4 mgd. O&M cost were estimated based on the available information of current recycled water production which includes ultrafiltration and chlorine disinfection. O&M cost for the secondary treatment of wastewater was assumed to be $500/AF.

Option 1b: CMSA Recycled Water to San Quentin

CSMA RW is a concept level, identified in the CMSA 2016 Recycled Water Feasibility Study as a preferred option and carried forward in the Water Resources Plan 2040 (RMC, 2017). Disinfected tertiary recycled water will be sent to the San Quentin prison as shown in Figure D-21

Figure D-21. Non-potable recycled water system conceptual map: CSMA to San Quentin prison (from Water Resources Plan 2040, 2017).



This project will send recycled water from CMSA to the San Quentin Prison for unrestricted non-potable applications. Treatment upgrade at CMSA will include microfiltration and enhanced disinfection to meet Title 22 disinfected tertiary standards. A recycled water storage tank will be placed within CMSA, and a recycled water pump station will convey recycled water at a maximum day demand of 0.20 mgd. Total annual demand is expected to be 154 AFY.

D.7.1.2 Yield and Costs

The planning-level cost estimate for the Peacock Gap non-potable reuse project (Option 1a) was developed based on the inputs from MMWD, with a range estimated using the ratios developed for other reuse alternatives. The planning-level cost estimate presented in the Water Resources Plan 2040 (RMC, 2017) was used for the CMSA Non-Potable Reuse (Option 1b) cost, which was adjusted with ENR Construction Cost Index (CCI) for the estimate year and the cost range developed based on the other reuse options' cost range. Summaries of cost estimate are provided in Tables D-19 and D-20.

Table D-19. Planning-level cost estimate for LGVSD-Peacock Gap Non-Potable Reuse Project

	Low	High
Capital Total	$13,387,000	$14,955,000
Annual O&M Total, $/year	$296,000	$331,000
Total Annualized Cost	$979,000	$1,094,000
Yield	288	288
Total Cost per AF	$3,400	$3,800

Table D-20. Planning-level cost estimate for CMSA San Quentin Reuse Project

	Low	High
Capital Total	$9,389,000	$10,663,000
Annual O&M Total, $/year	$199,000	$226,000
Total Annualized Cost	$678,000	$770,000
Yield	154	154
Total Cost per AF	$4,400	$5,000

D.7.2 Regional Indirect Potable Reuse

D.7.2.1 Description

The regional indirect potable reuse (IPR) concept, identified in the Water Resources Plan 2040 (RMC, 2017) as Regional IPR, conveys secondary effluent from SASM and LGVSD via 12-inch pipelines to CMSA, where Advanced Water Purification Facility (AWPF) will be constructed and treat a total of 8.8 mgd secondary effluent to the quality suitable for IPR. The AWPF will produce 7.0 mgd of purified water, and a 30-inch pipeline will be constructed deliver purified water to Kent Lake. Assumed system recovery is 80%. In this alternative analysis, the system recovery of 85% is assumed to produce 7.0 mgd of purified water, which translates to the AWPF intake of 8.2 mgd. The AWPF will receive secondary effluent from the three wastewater treatment plants (WWTPs), and treat with ultrafiltration (UF), reverse osmosis (RO), and advanced oxidation (AOP). Backwash and cleaning waste from UF will be sent back to the head of CMSA influent. Concentrate from the RO process will be discharged to the existing ocean outfall for CMSA. The concept of regional IPR from Water Resources Plan 2040 is shown in Figure D-22.

Figure D-22. Regional IPR concept (from Water Resources Plan 2040, 2017)

D.7.2.2 Yield and Costs

The treatment plant sizing is based on the 7 mgd purified water production capacity, or 7,840 AFY. Based on the currently available effluent flows shown in Table D-21 and seasonal non-potable recycled water demand, however, there is a risk that continuing water conservation may result in insufficient effluent flows available to produce 7 mgd purified water during summer. For the preliminary evaluation, the annual potable water yield was assumed to be 90 percent of the production capacity, or 7,056 AFY.

Table D-21. Wastewater discharge and recycled flows 2019-2021 (mgd)

Plant	Permitted capacity (ADWF)	Annual Average discharge	Annual Average Recycled	Effluent = discharge + recycle
CMSA	10	10.0	1.08	11.11
SASM	3.6	2.41	0.02	2.43
LGVSD	2.92	1.98	0.502	2.49

Data Source: State of California Volumetric Annual Report of Wastewater and Recycled water (https://data.ca.gov/dataset/volumetric-annual-report-of-wastewater-and-recycled-water)

The cost estimate developed in the Water Resources Plan 2040 (2017) was used for the planning-level cost estimate, adjusting the estimate year from October 2016 to May 2022 using the ENR construction cost index (CCI). The conveyance route was updated to avoid passing through a high elevation before discharging the purified water to Kent Lake.

The cost range was developed using the same high to low ratio as the DPR cost estimate which was developed with greater detail, with the cost from the Water Resources Plan assumed as the average of the two estimates. A summary of cost estimate is shown in Table D-22.

Table D-22. Planning-level cost estimate for Regional IPR Project

	Low	High
Capital Total	$412,410,000	$461,063,000
Annual O&M Total, $/year	$5,949,000	$6,998,000
Total Annualized Cost	$26,990,000	$30,521,000
Yield, AFY	7060	7060
Total Cost per AF	$3,800	$4,300

D.7.3 Central Marin Sanitation Agency Direct Potable Reuse

D.7.3.1 Description

There are two types of direct potable reuse (DPR). Raw water augmentation DPR will provide purified water from wastewater treatment facility (WWTF) to immediately upstream of the water treatment facility (WTF) (raw water augmentation). Treated water augmentation DPR will provide purified water to existing water distribution system. The raw water augmentation DPR concepts to purify recycled water at three individual WWTFs and deliver purified water to the lakes immediately upstream of the WTF was considered previously in Water Resources Plan 2040 (RMC, 2017). Treated water augmentation is being investigated for CMSA, where purified water will be delivered to an existing water main near the CMSA plant (Carollo, 2022).

For this analysis, two options are considered:

- CMSA DPR Raw Water Augmentation, in which the treated water augmentation DPR concept being investigated for CMSA is modified slightly to deliver purified water to Bon Tempe Lake instead of the water distribution system;
- CMSA DPR Treated Water Augmentation, in which an AWPF will be constructed at CMSA to meet the DPR requirements and send purified water to the potable water distribution system as described in the Carollo 2022 TM.

The conceptual map for the transmission of purified water from CMSA to Bon Tempe Lake is shown in Figure D-23.

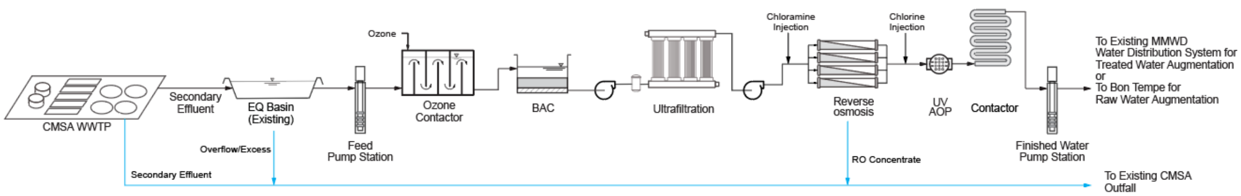
Figure D-23. DPR purified water conveyance concept map

Option 3A: CMSA DPR Raw Water Augmentation (modified from Carollo, 2022)

Source water for the CMSA DPR project will be 5.7 mgd of secondary effluent from CMSA. CMSA is rated for 10 mgd average dry weather flow, and an average monthly discharged flow rate between 2019 and 2021 was 10.1 mgd. The lowest discharge flow recorded during the 3-year period was 5.5 mgd in September 2021.

Purified water treatment system assumed for the CMSA DPR project is shown in Figure D-24, including ozone/biological activated carbon (BAC), ultrafiltration (UF), reverse osmosis (RO), ultraviolet advanced oxidation (UV/AOP), water stabilization, and chlorine contactor. The expected feed water flow rate is 5.7 mgd to produce 4 mgd purified water. The treatment train is developed to meet the microbial and chemical contaminant removal levels suggested in the draft DPR regulations as of March 2022.

Figure D-24. DPR treatment train



Concentrate from the RO process is assumed to be discharged from the existing CMSA effluent outfall. No additional infrastructure other than tie-in to the existing outfall was assumed. Purified and disinfected water will be dechlorinated and pumped to Bon Tempe Lake through a 43,000 LF, 18-inch pipeline. The pump station will be located at CMSA.

Option 3B: CMSA DPR Treated Water Augmentation (adapted from Carollo, 2022)

Source water for the CMSA DPR project will be 5.7 mgd of secondary effluent from CMSA. CMSA is rated for 10 mgd average dry weather flow, and an average monthly discharged flow rate between 2019 and 2021 was 10.1 mgd. The lowest discharge flow recorded during the 3-year period was 5.5 mgd in September 2021.

Purified water treatment system assumed for the CMSA DPR project is shown in Figure D-24, including ozone/biological activated carbon (BAC), ultrafiltration (UF), reverse osmosis (RO), ultraviolet advanced oxidation (UV/AOP), water stabilization, and chlorine contactor. The expected feed water flow rate is 5.7 mgd to produce 4 mgd purified water. The treatment train is developed to meet the microbial and chemical contaminant removal levels suggested in the draft DPR regulations as of March 2022.

Concentrate from the RO process is assumed to be discharged from the existing CMSA effluent outfall. No additional infrastructure other than tie-in to the existing outfall was assumed. Convey purified water to the existing water distribution pipeline near CMSA through a 1759 LF, 12-inch pipeline.

D.7.3.2 Yield and Costs

Increased conservation may result in insufficient secondary effluent supply to reliably produce 4 mgd year-round (4481 AFY). To count for the potential deficiency in available secondary effluent and reduced production due to maintenance and repair, 90 percent of the 4 mgd production at 3.6 mgd average (4030 AFY) was assumed for the annual yield.

The planning-level cost estimate from the CMSA DPR study (Carollo, 2022) was used for the CMSA DPR cost which included the cost for the intake pump station, treatment, RO concentrate disposal pipeline, and connection to the existing water supply system. The cost was supplemented by the additional conveyance cost for the raw water augmentation configuration and the estimate year adjusted with ENR Construction Cost Index (CCI). The pipeline cost included in the treated water augmentation system cost estimate was not subtracted in estimating the raw water augmentation option developed for this study, as it was deemed within the error in estimating the total pipe length. O&M cost presented in the CMSA DPR study (Carollo, 2022) was supplemented by additional O&M cost derived from the Regional DPR project (Water Reuse Alternative 4) estimate and scaling back proportionally for the yield. The conveyance energy requirements for the raw water augmentation (3A) were estimated based on the flows, conveyance distance and elevation change. Summaries of cost estimate for Alternatives 3A and 3B are provided in Tables D-23 and D-24, respectively.

Table D-23. Planning-level cost estimate for CMSA DPR Raw Water Augmentation Project

	Low	High
Capital Total	$164,056,000	$183,412,000
Annual O&M Total, $/year	$9,177,000	$10,787,000
Total Annualized Cost	$17,547,000	$20,145,000
Yield	4030	4030
Total Cost per AF	$5,000	$4,400

Table D-24. Planning-level cost estimate for CMSA DPR Treated Water Augmentation Project

	Low	High
Capital Total	$117,467,000	$131,323,000
Annual O&M Total, $/year	$8,318,000	$9,644,000
Total Annualized Cost	$14,311,000	$16,344,000
Yield, AFY	4030	4030
Total Cost per AF	$3,500	$4,100

D.7.4 Regional Direct Potable Reuse

D.7.4.1 Description

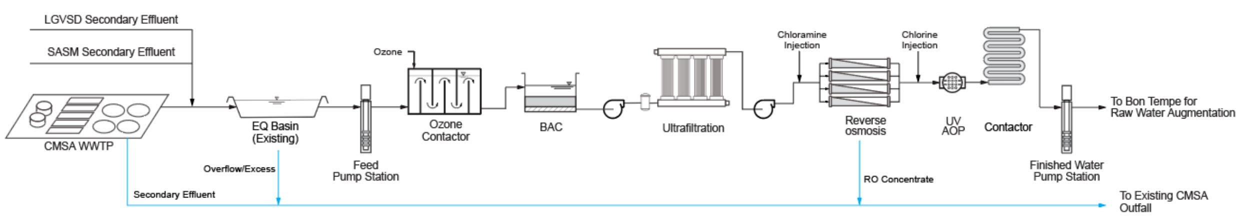
The concept to purify recycled water at three individual WWTFs and deliver purified water to the lakes immediately upstream of the WTF was considered previously in Water Resources Plan 2040 (RMC, 2017) and included in Alternative 3A, Raw Water Augmentation DPR for CMSA. This alternative will take secondary effluent from Las Gallinas Valley Sanitary District (LGVSD) and Sewerage Authority of South Marin (SASM) to CMSA, similar to the Regional IPR Alternative (Alternative 2) and provide water purification meeting the DPR criteria for the combined flow from the three treatment plants and send the purified water to Bon Tempe Lake.

The conceptual map for the transmission of purified water from CMSA to Bon Tempe Lake is shown in Figure D-23.

Source water for the Regional DPR project will be 8.2 mgd of secondary effluent from CMSA, SASM and LGVSD, targeting to produce 7.0 mgd (7841 AFY) of purified water. The total rated treatment capacity of these three treatment plants is 16.5 mgd average dry weather flow, and the total average monthly discharged flow rate between 2019 and 2021 was 14.5 mgd. The lowest discharge flow recorded during the 3-year period was 7.2 mgd in September 2021. It should be noted, however, the LGVSD currently does not discharge its effluent during dry weather season and store the effluent in the effluent storage ponds. By utilizing the effluent that is otherwise stored in the ponds, the total available effluent is expected to be near or above the required 8.2 mgd most of the year. The service areas for these three treatment facilities are expected to increase in the coming years. However, the total available flow may not increase proportionally with the population growth due to ongoing and future water conservation efforts. To count for the potential deficit in secondary effluent flows, the annual yield for the regional DPR project was lowered to 90 percent of the 7 mgd (7841 AFY) production capacity, or 6.3 mgd (7060 AFY). It was assumed all available secondary effluent from LGVSD and SASM will be conveyed to CMSA, and any excess secondary effluent at CMSA will be discharged from the existing CMSA outfall.

Purified water treatment trains assumed for the Regional DPR project is the same as the process assumed for the CMSA DPR project, as shown in Figure D-25. The treatment train includes ozone/biological activated carbon (BAC), ultrafiltration (UF), reverse osmosis (RO), ultraviolet advanced oxidation (UV/AOP), water stabilization, and chlorine contactor. The expected feed water flow rate is 8.2 mgd to produce 7 mgd purified water and assumed 90 percent of the treatment capacity will be the estimated annual yield. The treatment train is developed to meet the microbial and chemical contaminant removal levels suggested in the draft DPR regulations as of March 2022.

Figure D-25. DPR purified water treatment train



Concentrate from the RO process is assumed to be discharged from the existing CMSA effluent outfall. No additional infrastructure other than tie-in to the existing outfall was assumed.

Convey purified water to Bon Tempe Lake (or directly upstream of the Bon Tempe Water Treatment Plant) via a pump station at CMSA and a 30-inch 43,000 LF pipeline. Purified water will be blended with the Bon Tempe Lake water and will supplement source water for the Bon Tempe Water Treatment Plant.

D.7.4.2 Yield and Costs

The Regional DPR project will be designed for the 7 mgd purified water production, and 6.3 mgd (7060 AFY) annual yield for the potable water source augmentation. The total rated treatment capacity of three wastewater treatment facilities producing secondary effluent is 16.5 mgd average dry weather flow, and the total average monthly discharged flow rate between 2019 and 2021 was 14.5 mgd. However, the lowest discharge flow recorded during the 3 year period was 7.2 mgd in September 2021. As the LGVSD currently does not discharge its effluent during dry weather season and store the effluent in the effluent storage ponds, it is anticipated the total available secondary effluent flows will be sufficient for the 7 mgd production year-round. However, the projected yield was lowered to 90 percent of the treatment capacity to count for potential source water deficit and reduction in the production capacity due to maintenance and repair.

The planning-level cost estimate for the Regional DPR project was developed for 7 mgd (7840 AFY) production. Cost per AF was calculated based on the assumed 7060 AFY annual yield. A summary of Regional DPR cost estimate is provided in Table D-25.

Table D-25. Planning-level cost estimate for Regional DPR Project

	Low	High
Capital Total	$392,498,000	$438,803,000
Annual O&M Total, $/year	$15,832,000	$18,523,000
Total Annualized Cost	$35,857,000	$40,910,000
Yield	7030	7030
Total Cost per AF	$5,100	$5,800

D.8 References

Alameda County Flood Control and Water Conservation District (ACFC&WCD) & City and County of San Francisco Public Utilities Commission Contra Costa Water District East Bay Municipal Utility District & Santa Clara Valley Water District. (2011). Memorandum of Agreement To Conduct Site-Specific Analysis of the Bay Area Regional Desalination Plant.

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