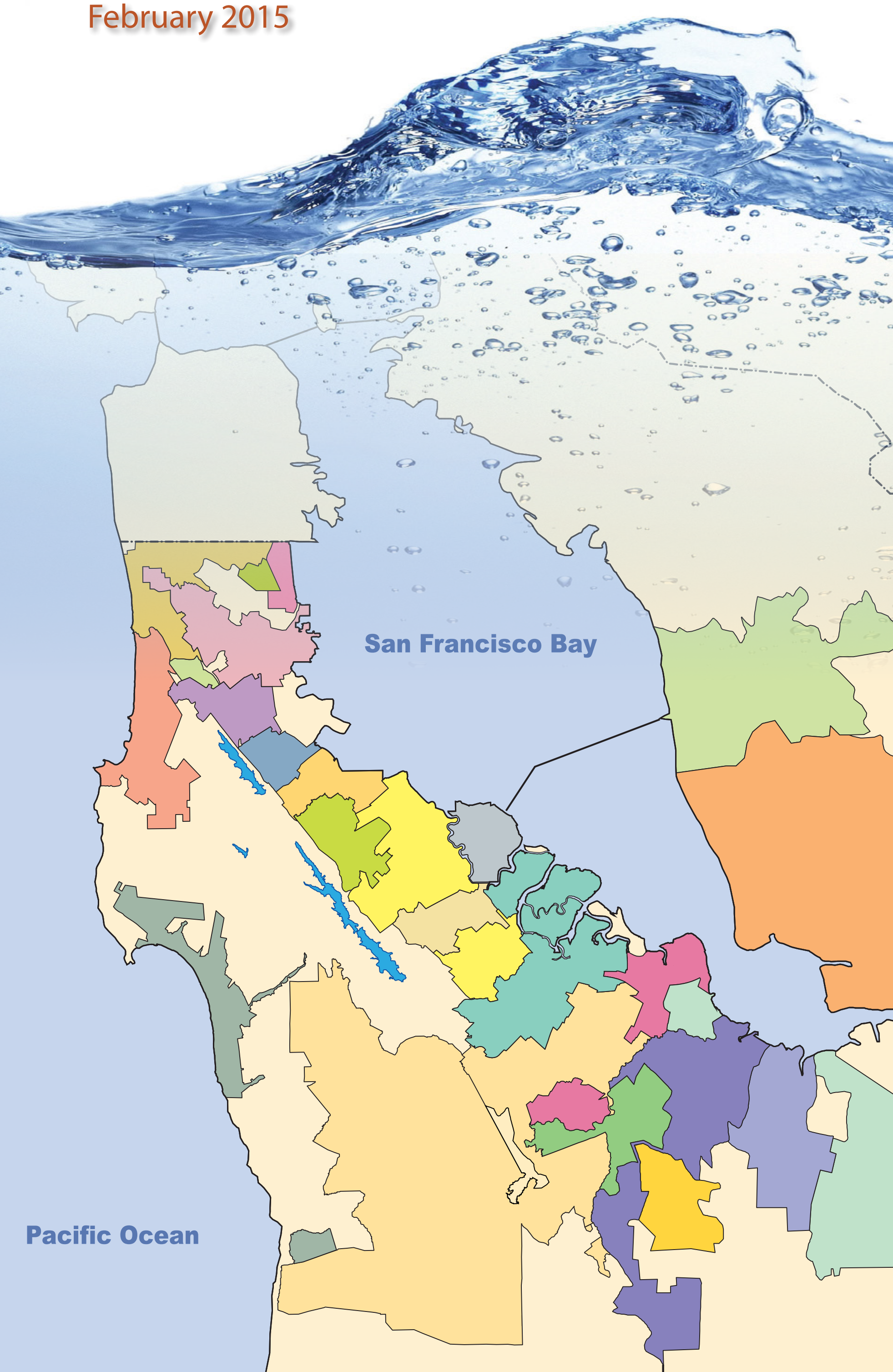
BAWSCA

Bay Area Water Supply & Conservation Agency

Long-Term Reliable Water Supply Strategy

Strategy Phase II Final Report

February 2015



CDM Smith

Bay Area Water Supply and Conservation Agency

Goals

BAWSCA's goals are to ensure:

- A reliable water supply
- High-quality water
- A fair price

Authorities

BAWSCA has the authority to coordinate water conservation, supply and recycling activities for its agencies; acquire water and make it available to other agencies on a wholesale basis; finance projects, including improvements to the regional water system; and build facilities jointly with other local public agencies or on its own to carry out the agency's purposes.

PROJECT TEAM

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Acronyms

$/AF	dollars per acre-foot
B	billion dollars
M	million dollars
ACWD	Alameda County Water District
AF	acre-feet, acre-foot
AFY	acre-feet per year
BARDP	Bay Area Regional Desalination Project
BARR	Bay Area Regional Reliability
BAWSCA	Bay Area Water Supply and Conservation Agency
Bay	San Francisco Bay
BCDC	Bay Conservation and Development Commission
Board	Board of Directors
BWRO	brackish water reverse osmosis
Cal Water	California Water Service Company
CCC	California Coastal Commission
CCI	Construction Cost Index
CEQA	California Environmental Quality Act
CFA	Central Focus Area
CVP	Central Valley Project
DDW	Division of Drinking Water
Delta	Sacramento-San Joaquin Delta
DRIP	Drought Implementation Plan
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
EBP	East Bay Plain
EIR	Environmental Impact Report
EMID	Estero Municipal Improvement District
ENR	Engineering News-Record
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
fps	feet per second
FRWP	Freeport Regional Water Project
FY	fiscal year
g/L	grams per liter
gpd	gallons per day
gpm	gallons per minute
GW	groundwater
HDD	horizontally directionally drilled
HH/LSM	Hetch Hetchy/Local Simulation Model
HP	horsepower
IRWM	Integrated Regional Water Management
IRWMP	Integrated Regional Water Management Plan
ISG	Individual Supply Guarantee
ISL	Interim Supply Limitation
LID	Low-impact development
LOS	level of service
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MAP	Management Action Plan
MCL	maximum contaminant level
MG	million gallons
mgd	million gallons per day
mg/L	milligrams per liter

MMWD	Marin Municipal Water District
MOU	memorandum of understanding
MTC	Metropolitan Transportation Commission
MWDOC	Municipal Water District of Orange County
NASA	National Aeronautics and Space Administration
NC	Niles Cone
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
O&M	operations and maintenance
ppm	parts per million
project	water supply management project
PW	present worth
Reclamation	Bureau of Reclamation
RW	recycled water
RWQCP	Regional Water Quality Control Plant
SCVWD	Santa Clara Valley Water District
SF RWS	San Francisco Regional Water System
SFA	Southern Focus Area
SFPUC	San Francisco Public Utilities Commission
SGM	Strategy Groundwater Model
State Board	State Water Resources Control Board
Strategy	Long-Term Reliable Water Supply Strategy
SVCW	Silicon Valley Clean Water
SWP	State Water Project
SWRO	surface water reverse osmosis
TDS	total dissolved solids
USEPA	United States Environmental Protection Agency
UWMP	Urban Water Management Plan
WRR	Wholesale Revenue Requirement
WSIP	Water System Improvement Program
WSA	Water Supply Agreement
WSB	Westside Basin
WSS	watershed sanitary survey
WWTP	wastewater treatment plant
YCWA	Yuba County Water Agency

Long-Term Reliable Water Supply Strategy Phase II Final Report: Executive Summary

The Bay Area Water Supply and Conservation Agency's (BAWSCA's) water management objective is to ensure that a reliable, high-quality supply of water is available where and when people within the BAWSCA member agency service area need it. The purpose of the Long-Term Reliable Water Supply Strategy (Strategy) is to quantify the water supply reliability needs of the BAWSCA member agencies through 2040, identify the water supply management projects and/or programs (projects) that could be developed to meet those regional water reliability needs, and develop an implementation plan for the Strategy. Successful implementation of the Strategy is essential to ensuring that there will be reliable water supplies for the BAWSCA member agencies and their customers in the future. The Strategy findings and five recommended actions are presented in this Executive Summary and the report.

In this Executive Summary:

ES.1 Strategy Initiated to Address Key Water Reliability Issues

BAWSCA initiated work on the Strategy in 2009 in response to the following:

1. Demand forecasts by the BAWSCA member agencies, as part of their 2005 Urban Water Management Plans (UWMPs) and other planning documents, suggested that additional water management actions (i.e., increased supplies and/or reduced demands) would be needed to meet then-projected normal and drought year demands.

2. In October 2008, the San Francisco Public Utilities Commission (SFPUC) made the unilateral decision to establish a 184 million gallon per day (mgd) limitation on what the BAWSCA member agencies could purchase collectively from the San Francisco Regional Water System (SF RWS) through at least 2018.

3. In October 2008, SFPUC adopted an 80 percent level of service (LOS) goal for the SF RWS. Based on the rules for drought allocation between SFPUC and the Wholesale Customers, this results in up to a 26 percent cutback, in aggregate, to the BAWSCA member agencies during droughts. This could reduce annual business sales in the BAWSCA and SFPUC service areas by $2.0 billion (B) per year of drought.

4. The reliability of the SFPUC supply could also be adversely affected by climate change and future regulatory actions or policy changes. As such, the BAWSCA member agencies expressed an interest in developing a source of supply that was independent of the SFPUC.

Throughout development of the Strategy, the BAWSCA Board of Directors (Board) has provided direction on scope and policy issues as shown in Figure ES-1.

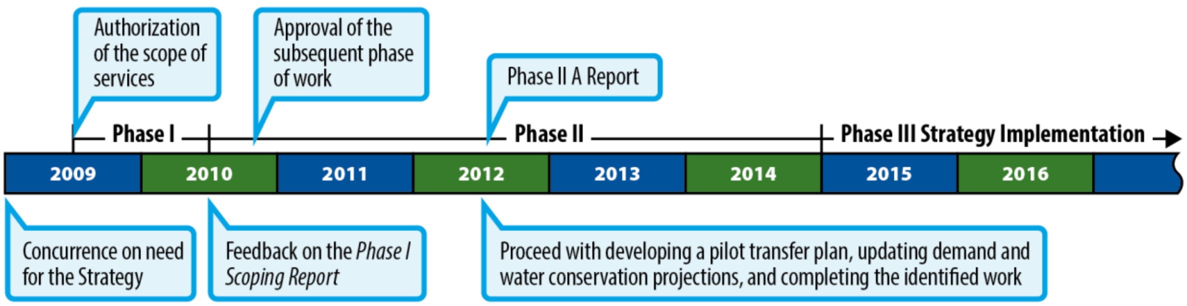

Figure ES-1
Strategy Development Informed by Board Direction

ES.2 While Normal Year Supply is Adequate to 2040, Drought Year Shortfalls are Significant

The demand analysis resulted in the following key findings:

- There is no longer a normal year supply shortfall.
- There is a drought year supply shortfall of up to 43 mgd.

The 2014 *Regional Demand and Conservation Projections Project*, undertaken based on recommendations in the *Phase II A Report*, identified changed water demands and has shaped the Strategy analysis. The analysis showed that the projected reliability need of the BAWSCA member agencies through 2040 will be negligible after accounting for passive and active conservation (as shown in Figure ES-2). In addition, with projected purchases from the SFPUC of 153 mgd in 2018 and 168 mgd in 2040, the short-term adverse impacts of the SFPUC-imposed Interim Supply Limitation of 184 mgd are no longer an immediate concern in normal years due to decreases in demand and increased development of other available supplies.

However, during the same planning period, reliability shortfalls on the SF RWS of up to 43 mgd (approximately 48,000 acre-feet per year [AFY]) are forecast in dry years, resulting in system-wide SFPUC cutbacks of to 20 percent (as shown in Figure ES-3). The reliability need is spread throughout the BAWSCA service area, with individual member agency shortfalls ranging from 0.1 to 10.7 mgd. Any reliability shortfall would need to be met by some combination of additional supplies and/or additional conservation. The Strategy does not assume that the BAWSCA member agencies will commit to filling the entire supply shortfall, but focuses on identifying (1) options for filling all or portions of the shortfall and (2) additional actions to further investigate or implement the projects identified.

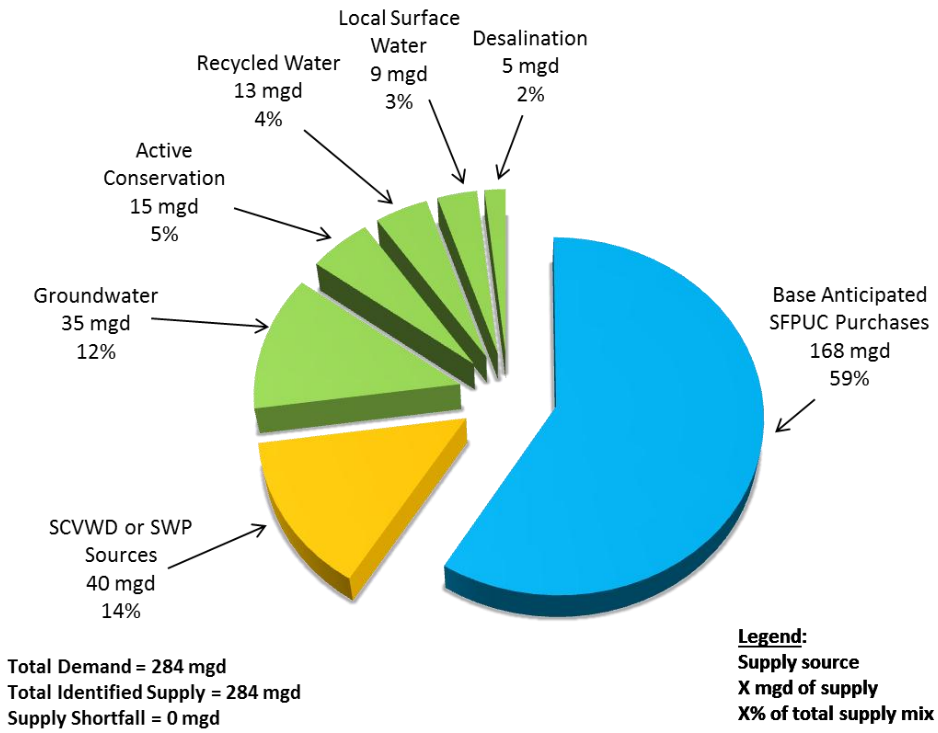

Figure ES-2
Normal Year Water Supply is Sufficient through 2040

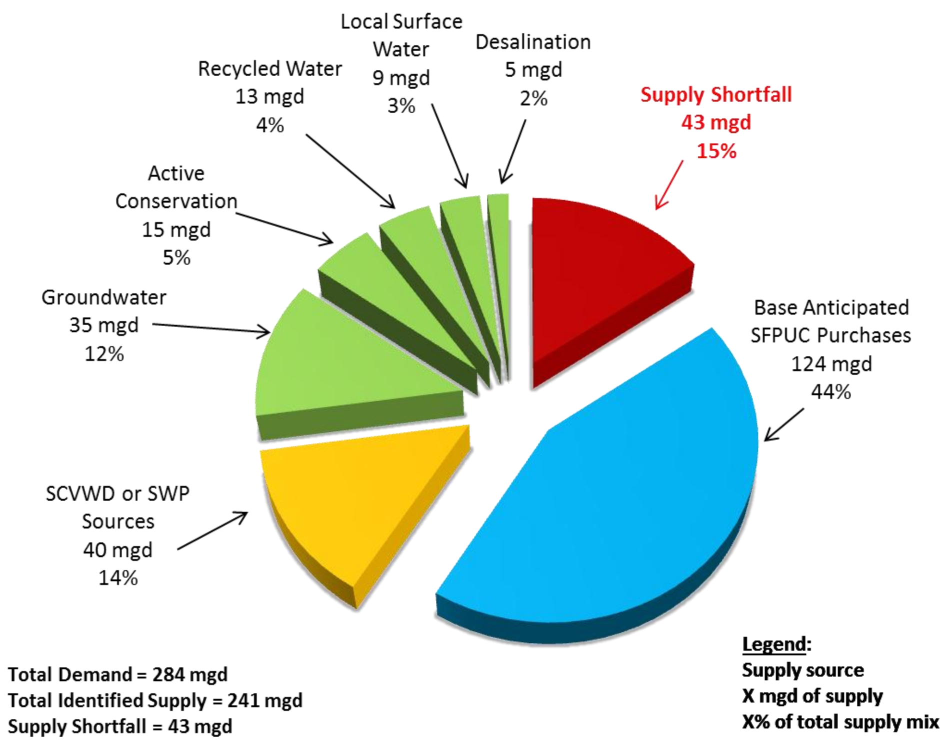

Figure ES-3
Reliability Need Identified for Drought Years (2040)

Based on the 2040 demand assumptions and using 91 years of historical hydrologic data and the SFPUC's Hetch Hetchy/Local Simulation Model, drought year shortages of 10 percent to 20 percent on the SF RWS are estimated to occur up to 8 times during the 91-year historical hydrologic sequence (i.e., 1920 through 2011) that the SFPUC uses for water supply planning purposes. This is the equivalent of a shortage event on t20849he SF RWS approximately every 11 years. The estimated frequency of shortage is conceptually illustrated in Figure ES-4.

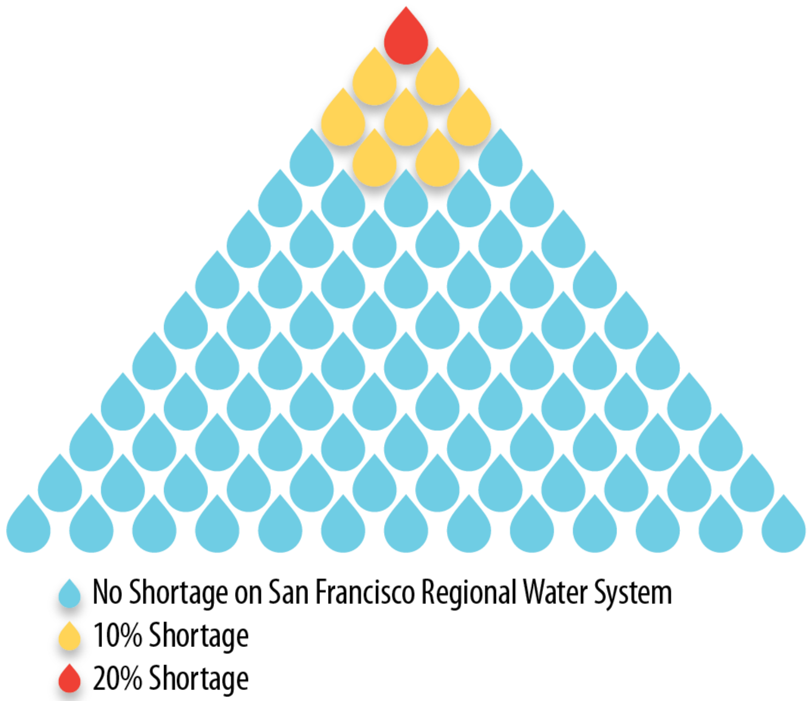

Figure ES-4
Projected Frequency of Shortage on San Francisco RWS in 2040 Based on the 91-Year Historical Hydrologic Record and Estimated Demands

Based on the existing agreements that allocate drought year water supplies between San Francisco and the Wholesale Customers (i.e., the Tier 1 Plan), a drought event that creates a 10 percent system-wide shortfall corresponds to an average 15 percent cutback to the Wholesale Customers, while a 20 percent system-wide shortfall corresponds to an average 26 percent cutback to the Wholesale Customers. In addition, the allocation varies for each BAWSCA member agency (i.e., under a 20 percent system-wide shortfall scenario, some agencies could receive a cutback of up to 40 percent to their SFPUC supply, while some receive less than a 26 percent cutback).

The drought year need may be somewhat greater than estimated above for the following reasons:

- Drought frequency over the historical record may increase when including hydrology through 2014;
- Climate change could impact SFPUC supply reliability; and
- Shortfalls to other imported and local supplies during drought years were not considered when determining drought year need. The shortfalls identified in this report were based solely on the SF RWS historical reliability.

- There could be shortfalls to other imported and local supplies during drought years that were not accounted for when determining drought year need based solely on the SF RWS historical reliability.

Further study of all these areas is suggested as part of the recommended actions.

ES.3 SFPUC Supply Shortfalls Can Have Significant Economic Impacts to the BAWSCA Member Agencies and Region

> **Drought Impacts:**
>
> - Droughts occur 1 in every 11 years on the SF RWS.
> - Some BAWSCA agencies could receive cutbacks of up to 40%.
> - Regional business sales impacts up to $2.0B annually.

SFPUC commissioned an economic impact analysis to estimate the economic effect to the region from potential future droughts through 2035. In the SFPUC study it was estimated that a 10 percent system-wide supply shortfall would reduce annual business sales in the BAWSCA and City and County of San Francisco service areas by as much $0.4B in Fiscal Year 2010-11, and by as much as $2.0B for a 20 percent supply shortfall, based on the 91-year historical record. These impacts could be compounded in the case of multi-year droughts and because per capita demand in the BAWSCA member agency service area is already low compared to other portions of the Bay Area and the State of California.

The potential impacts to the BAWSCA member agencies are regional and not just limited to the individual cities or water districts. For example, the severity of the potential drought's impact to commercial and industrial sectors could cause relocation of businesses for which a reliable water supply is critical. The loss of this commercial and industrial base would undoubtedly weaken the regional economy. Furthermore, the residents and voters in one community often work or own businesses in another community within the BAWSCA member agency service area or neighboring communities. Therefore, a drought year reliability shortfall in one BAWSCA member agency that results in loss of jobs or other impacts could have a detrimental effect on the customers of another BAWSCA member agency, even if that agency itself is not facing a supply shortfall.

ES.4 Several Viable Projects Have Been Identified That Together Can Reduce the Drought Year Shortfall

Over 65 individual water supply management projects were evaluated that could be developed by BAWSCA and the BAWSCA member agencies to meet identified drought year reliability needs through 2040. Projects were not retained as part of the Strategy for any of the following reasons:

1. An agency chose to independently implement a project;
2. An agency was not interested in being a proponent of the project as a part of the Strategy;
3. The project did not provide additional supply;
4. Regulatory restrictions impeded implementation;
5. No regional benefit was found;

6. The project implementation schedule did not fit within the timeline of the Strategy; and
7. The project was deemed infeasible due to water quality issues.

Eleven specific projects were evaluated in greater detail encompassing five project types (i.e., recycled water, groundwater, local capture and reuse, desalination, and water transfer projects), and nine are evaluated and scored in this report. Two projects were not scored given limited data on key criteria.

The projects offer a wide range of potential dry year yield, from small projects that can be implemented individually by member agencies, to large yield projects that would require direct involvement by BAWSCA. These projects, and a summary of their characteristics, are presented below in Table ES-1. Two items are particularly important to note:

1. If all these projects were implemented, and achieved the average anticipated project yield, they would almost meet the 43 mgd (48,000 AFY) dry year supply need.
2. The combined average anticipated yields of two projects - water transfers and desalination - account for meeting over 80 percent of the average projected dry year need.

Even though all projects may be needed to meet BAWSCA's dry year needs, an evaluation of projects was conducted to gain insights on how the projects perform against the Strategy objectives, highlight key tradeoffs between the projects, and identify where more information is needed. This information can then be used to prioritize recommended actions and inform their sequencing.

Table ES-1. Summary of Strategy Projects

Strategy Project Type	Strategy Project	Yield (AFY)	Range of Unit Cost ($/AF)	Schedule
Agency Identified Projects – Recycled Water (RW)	City of Daly City- Colma Expansion Project	1,060	$3,310	3-4 years
	City of Mountain View- Increase Recycled Water Supply from Palo Alto Regional Water Quality Control Plant	429	$1,950-$2,450	3-4 years
	City of Palo Alto- Recycled Water Project to Serve Stanford Research Park	900	$2,830	3-4 years
	City of Redwood City- Regional Recycled Water Supply[1]	Up to 3,200	Not determined	3-4 years
Agency Identified Projects – Groundwater (GW)	City of Sunnyvale Groundwater Project	1,880-2,350	$1,230-$1,350	4 years
Regional Projects – Local Capture and Reuse	Rainwater Harvesting	210-680	$2,900- $4,700	On-going
	Greywater Reuse	1,240-3,000	$550-$4,530	On-going
	Stormwater Capture[1]	Not determined	Not determined	Not determined
Regional Projects – Desalination	Open Bay Intake Desalination	16,800	$2,100-$4,950	5-12 years
	Brackish Well Desalination	780-7,280	$1,400-$7,090	5-12 years
Regional Projects – Transfers	Water Transfers	10,000-31,800	$950-$1,750	2-5 years

[1] The Redwood City Regional Recycled Water Supply project and stormwater capture were dropped from further consideration due to limited information currently available on key criteria of cost and potential demand.

ES.5 Analysis of Individual Projects and Portfolios Converge on Identical Priorities

An analysis was performed to identify those projects and combination of projects, or portfolios, which emphasized significant objectives of the Strategy.

For the project analysis, detailed scoring for each project was created on a normalized scale where the highest possible score was 100 points. The evaluation criteria and metrics were developed with input from the Board and the BAWSCA member agencies. The project scores and weightings were developed using the Strategy objectives and findings.

To reflect that not all objectives and criterion are of equal importance, a sensitivity analysis was conducted with different sets of weighting factors on the various objectives and criteria to evaluate project performance. Figure ES-4 presents the results of the project analysis when emphasizing drought supply, cost, regulatory vulnerability, local control, and institutional complexity evaluation criteria. The bar representing each project combines the individual criterion scores for that project to provide a comparison of the relative contribution of each criterion score across the Strategy projects. The total length of the bar represents the overall performance of the project.

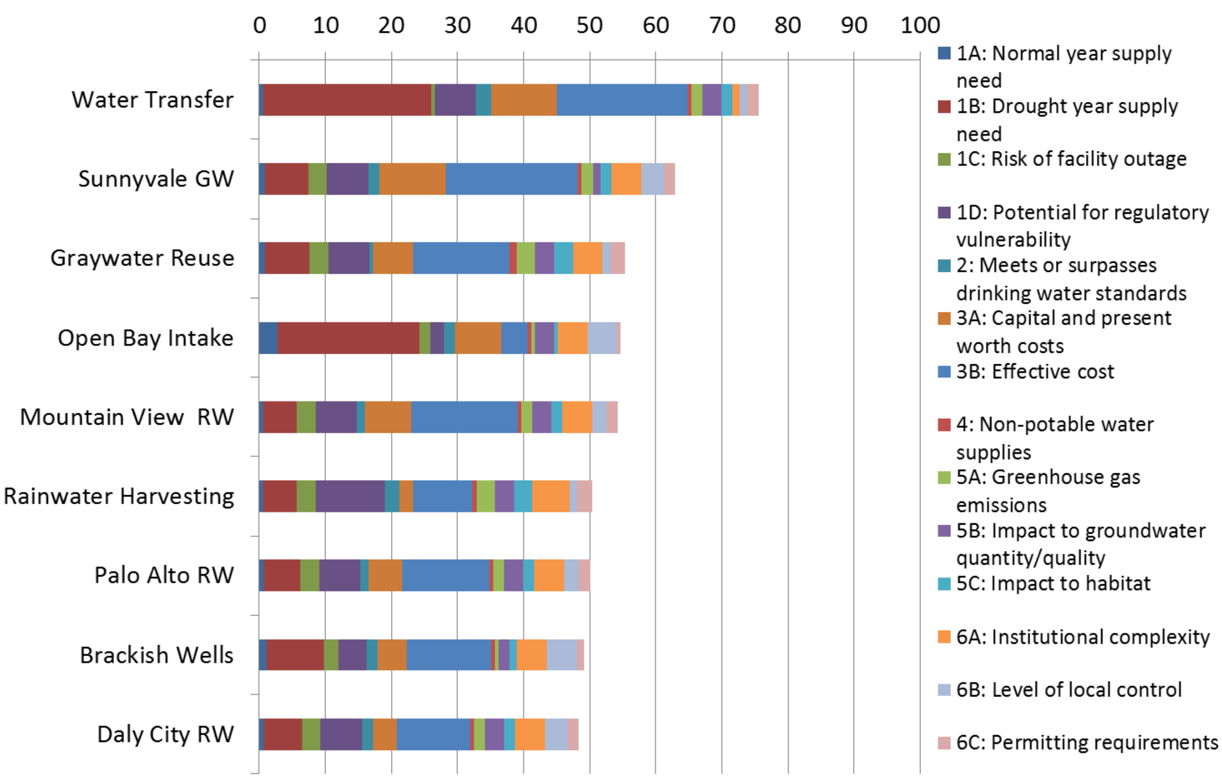

Figure ES-4
Cumulative Score for the Strategy Projects under Sensitivity Emphasizing Drought Supply, Costs, Regulatory Vulnerability, Local Control, and Institutional Complexity

The key findings of the project evaluation analysis were:

1. Water transfers score consistently high across the various performance measures and within various portfolio constructs and thus represent a high priority element of the Strategy.

2. Desalination also potentially provides substantial yield, but its high effective costs and intensive permitting requirements make it a less attractive drought year supply alternative. However, given the limited options for generating significant yield for the region, desalination warrants further investment in information as a hedge against the loss of local or other imported supplies.

3. The other potential regional projects provide tangible, though limited benefit in reducing dry year shortfalls given the small average yields in drought years.

For the portfolio analysis, the individual projects were combined into several different portfolios reflecting different priorities and also analyzed using the same sensitivity weightings. The performance of projects through the sensitivity analysis described above was used to help determine which projects comprised each portfolio. The following observations can be made based on the portfolios analysis:

- Water transfers are a component of all top scoring portfolios.
- The greatest certainty for dry year yield would be the Local Control portfolio, which contains desalination. It represents the highest cost and previous desalination projects have encountered delays in their implementation.
- The Least Stranded Costs portfolio was the highest scoring portfolio. This portfolio consists only of water transfers, which provide a very high dry year yield for no capital costs and a low cost per acre-foot.
- The Local Control and Least Environmental Impact portfolios have the highest number of projects, but are the lowest scoring portfolios on average and do not score as well on yield and cost criteria.
- The Least Cost and Fastest Implementation portfolios contain the same projects.
- Each portfolio provides an average dry year yield of over 20,000 AFY, which is almost half of the 2040 dry year need of 48,000 AFY (assuming a 100 percent LOS). Or, put another way, each of the portfolios would reduce rationing significantly. While no formal decision was made by BAWSCA regarding a preferred LOS, it is recognized that achieving 100 percent LOS was not required.

ES.6 Evaluation Results Identify the Need to Balance Risks and Invest in Further Information

As discussed above, the demand analysis done during Phase II of the Strategy resulted in the following key findings:

- There is no longer a normal year supply shortfall.
- There is a drought year supply shortfall of up to 43 mgd.

In addition, the project evaluation analysis done during Phase II of the Strategy resulted in the following key findings:

- Water transfers score consistently high across the various performance measures and within various portfolio constructs and thus represent a high priority element of the Strategy.
- Desalination also potentially provides substantial yield, but its high effective costs and intensive permitting requirements make it a less attractive drought year supply alternative. However, given the limited options for generating significant yield for the region, desalination warrants further investment in information as a hedge against the loss of local or other imported supplies.
- The other potential regional projects provide tangible, though limited, benefit in reducing dry year shortfalls given the small average yields in drought years[1].

Given that the total average water supply yield of the identified Strategy water management projects is approximately equivalent to the dry year need and the uncertainty around the potential yield and ability to implement the Strategy projects, actions should be taken to implement each of the identified projects. The evaluation of the Strategy projects against the water management objectives has provided information that will be used to prioritize and define sequencing of implementation actions. As evidenced above, water transfers consistently perform higher on most of the objectives than any other project.

The evaluation has also indicated the need to further examine potential risks and tolerance to risk. There are still unknowns surrounding the projects. For example, water transfers may not be able to be secured due to a number of factors, and the brackish desalination project yield could vary up to an order of magnitude due to uncertain geological conditions.

The Strategy, therefore, must proceed on all fronts, pursuing actions on each project, to balance different risks so as to maximize the likelihood that BAWSCA can provide the water when and where it is needed.

The recommended actions have been broadly classified into two categories, depending on the stage of development of the project, degree of risk, level of uncertainty, and level of financial investment required for the action. Figure ES-5 provides a conceptual overview of these two types of actions. These actions are conceptually defined as:

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[1] While specific projects were not developed or evaluated for the Strategy, regional discussions on indirect/direct potable reuse have accelerated dramatically in the last year, making this a water supply management project BAWSCA will be tracking closely.

- *Core Actions*: Low-cost, low-risk actions pursued in an early phase of project development that can provide critical information, identify partnerships, and reduce uncertainty for pursuing full-scale investments in water supply projects.
- *Implementation Actions*: Higher-cost and higher-risk actions pursued in later phases of water supply projects that more directly lead to development of new supplies.

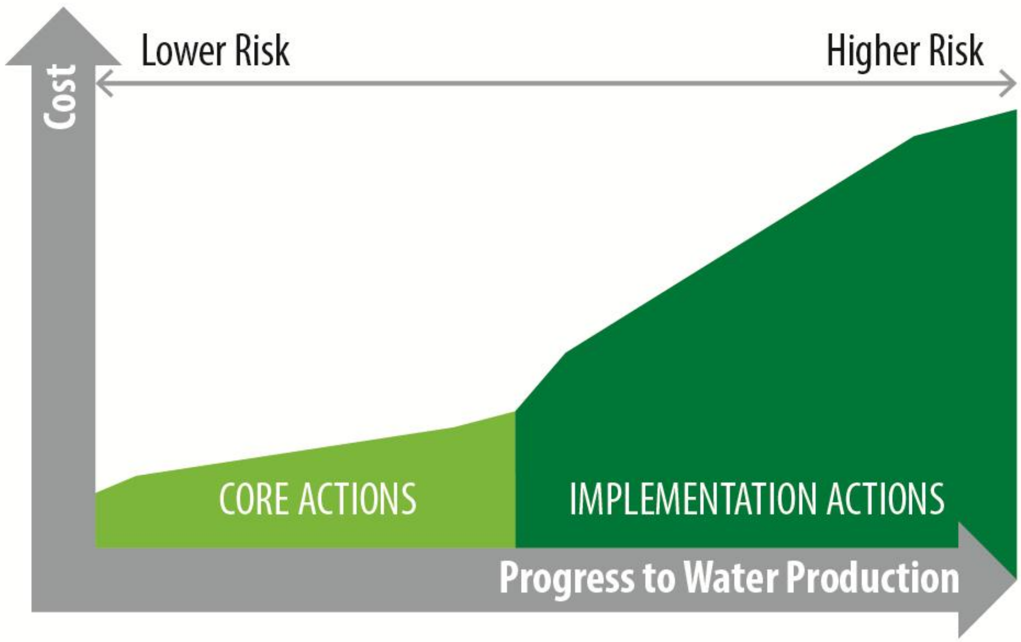

Figure ES-5
Defining Core and Implementation Actions

Figure ES-5 illustrates that Core Actions occur when there is much progress needed before water supply is produced, and Implementation Actions occur closer to the realization of a new water supply. Also, as illustrated in Figure ES-5, Core Actions have lower costs and risks, while Implementation Actions have higher costs and risks, comparatively.

ES.7 Recommendations

Details on the recommended Core Actions and Implementation Actions are presented in Table ES-2 and can be summarized as the following five recommended actions:

1. Lead water transfer development and implementation including identifying and evaluating water storage options;
2. Facilitate desalination partnerships and pursue outside funding for related studies;
3. Support agency-identified projects (i.e., recycled water and groundwater) and local capture and reuse;

4. Participate in regional planning studies in cooperation with others; and

5. Continue monitoring regional water supply investments and policies.

The actions arise from on-going work by BAWSCA and also represent new work for BAWSCA. Of these recommended actions, executing the East Bay Municipal Utility District (EBMUD) Pilot Transfer will have the most immediate financial impact. In addition, some new work has been identified as a priority. For example, identification of potential water storage options could reduce the risks of the water transfers, the highest performing project. Acquiring and storing these surplus supplies during non-drought periods for withdrawal and delivery during drought years would strengthen water transfers as a viable water management action.

Table ES-2. Range of Recommended Actions

Action	Core	Implementation
On-going	**Santa Clara Valley Water District (SCVWD)** Pilot Transfer Plan: complete plan to evaluate potential transfer options	**EBMUD Pilot Transfer**: execute a pilot water transfer
	Recycled Water: facilitate partnerships and grant funding	**Local Capture and Reuse:** implement rain barrel program; pursue funding
	Groundwater: facilitate partnerships and grant funding	
	Planning Studies: examine impacts of non-SFPUC shortfalls; evaluate hydrology under the current drought and climate change; participate in the Bay Area Regional Reliability process	
New	**Water Storage Options:** identify and evaluate storage options	**SCVWD Pilot Transfer**: execute a pilot water transfer[1]
	Recycled Water: monitor indirect/direct potable reuse policy development; facilitate discussions; pursue funding	**Water Storage:** develop agreements[1]
	Local Capture and Reuse: evaluate new programs; pursue funding	**Brackish Desalination:** conduct aquifer testing[1]
	Desalination Projects: facilitate partnerships; pursue funding	
	Planning Studies: review lessons learned from prior droughts; consider development pattern impacts on water demands	

[1] Contingent on findings from earlier activities

Some of the recommended actions reflect that the Strategy is not static and needs to be informed by changes in planning assumptions, impacts, and actions of others. This includes refining estimates of supply need that reflect updated hydrology, shifts in demands associated with development and climate change, and mining insights from other agencies that have made significant investments against future extended droughts. Other recommended actions will either be addressed under proposed work plan activities or will be contingent on findings from proposed work plan activities.

For example, desalination project development actions will be contingent on both identifying partners and obtaining funding through existing and new outside funding channels (e.g., California Proposition 84, the California Water Bond, and Federal funding).

Finally, continued monitoring of other agencies' policy decisions and supply investments is important for the Strategy as changing policy or supply conditions could alter activities related to Strategy implementation and its fundamental objective of assuring reliability for BAWSCA. A summary of the major policy decisions and supply investments that should be monitored as part of the Strategy is presented in Table ES-3.

Table ES-3. Policy Decisions and Supply Investment Activities to Monitor

Element	Entity	Activities to Monitor
Policy	State and Federal	Federal and State decisions that may (1) further limit supply availability from the exiting supplies (e.g., Tuolumne River) and (2) facilitate the development of new supplies (e.g., direct/indirect potable reuse).
	SFPUC	Decision on 2018 interim supply limitation which will impact supply availability from the SF RWS. Determination on role as regional provider.
Supply Investments	BAWSCA Member Agencies	Progress on implementing planned projects will impact supply need. 2015 UWMPs will reflect changes in near-term projections.
	SFPUC	Performance of projects in construction and projects under consideration may impact the magnitude of the supply need.
	SCVWD and Regional Wastewater Agencies	Development of various potable reuse projects, which may indirectly or directly create additional water supply.

Section 1

Introduction

1.1 Strategy Overview

The Bay Area Water Supply and Conservation Agency's (BAWSCA's) water management objective is to ensure that a reliable, high-quality supply of water is available where and when people within the BAWSCA service area need it. The purpose of BAWSCA's Long-Term Reliable Water Supply Strategy (Strategy) is to quantify the water supply reliability needs of the BAWSCA member agencies through 2040, identify the water supply management projects and/or programs (projects) that could be developed to meet those needs, and prepare the implementation plan for the Strategy. Successful implementation of the Strategy is critical to ensuring that there will be sufficient and reliable water supplies for the BAWSCA member agencies and their customers in the future. Figure 1-1 depicts the service areas for the 26 BAWSCA member agencies.

1.2 Strategy Driven by Key Water Supply Issues

At the request of the BAWSCA Board of Directors (Board) and its member agencies, BAWSCA initiated work on the Strategy in 2009 in response to the following circumstances:

1. Demand forecasts by the BAWSCA member agencies as part of their 2005 Urban Water Management Plans (UWMPs) and other planning documents suggested that additional water management actions (i.e., increased supplies and/or reduced demands) would be needed to meet then-projected normal and drought year demands.
2. In October 2008, the San Francisco Public Utilities Commission (SFPUC) made the unilateral decision to establish a 184 million gallons per day (mgd) limitation on what the BAWSCA member agencies could purchase collectively from the San Francisco Regional Water System (SF RWS) through at least 2018.
3. In October 2008, SFPUC adopted an 80 percent level of service (LOS) goal for the SF RWS. Based on the rules for drought allocation between SFPUC and the Wholesale Customers that are documented in the 2009 Water Supply Agreement (WSA), this results in an aggregate cutback of 26 percent to the BAWSCA member agencies during droughts. This could reduce annual business sales in the BAWSCA and SFPUC service areas by up to $2.02 billion (B) during each year of drought (The Brattle Group 2013).
4. The reliability of the SFPUC supply could also be adversely affected by climate change and future regulatory actions or policy changes. As such, the BAWSCA member agencies expressed an interest in developing a source of supply that was independent of the SFPUC.

Sources: BAWSCA, San Mateo County General Plan

Legend

1	Alameda County Water District	**13**	Mid-Peninsula Water District
2	City of Brisbane	**14**	City of Millbrae
3	City of Burlingame	**15**	City of Milpitas
4a	California Water Service Company – Bear Gulch	**16**	City of Mountain View
4b	California Water Service Company – Mid-Peninsula	**17**	North Coast County Water District
4c	California Water Service Company – South San Francisco	**18**	City of Palo Alto
5	Coastside County Water District	**19**	Purissima Hills Water District
6	City of Daly City	**20**	City of Redwood City
7	City of East Palo Alto	**21**	City of San Bruno
8	Estero Municipal Improvement District	**22**	San Jose Municipal Water System
9	Guadalupe Valley Municipal Improvement District	**23**	City of Santa Clara
10	City of Hayward	**24**	Stanford University
11	Town of Hillsborough	**25**	City of Sunnyvale
12	City of Menlo Park	**26**	Westborough Water District

Figure 1-1
BAWSCA Member Agency Service Area Map

1.3 Strategy Developed Based on Guiding Principles

Based on discussions with the BAWSCA Board and the member agency representatives, five principles were identified that inform the development of the Strategy:

1. The Strategy must add value to BAWSCA member agency customers.
2. The Strategy must provide certainty for future planning and development.
3. The Strategy must not result in the uncompensated or involuntary reallocation of BAWSCA member agency assets.
4. The Strategy must be consistent with the water transfer provisions of the 2009 WSA between the City and County of San Francisco and the Wholesale Customers.
5. The projects that are developed as part of the Strategy will be paid for based upon cost allocation methods that will be agreed upon by the BAWSCA Board.

At each stage of the Strategy's development and as part of each decision-making process, the efforts and results are tested against the above principles to ensure that the Strategy is developed and implemented in a manner that is consistent with these principles.

1.4 Strategy Developed in Phases

The Strategy has been developed in phases to provide BAWSCA and the BAWSCA Board the opportunity to confirm the direction of the Strategy at key decision points and redirect efforts as appropriate to ensure that the goals of the Strategy are met. Figure 1-2 presents the general phasing of the Strategy development and implementation.

Figure 1-2
The Strategy Development is Phased to Ensure that the Desired Results will be Achieved

Phase I of the Strategy was completed in May 2010. The *Phase I Scoping Report* (BAWSCA 2010) identified the range of anticipated demands and supply needs for the BAWSCA member agencies, described over 65 different projects that could potentially be developed in some combination to meet the identified needs, and provided the framework to evaluate those projects in Phase II of the Strategy.

Phase II of the Strategy was initiated in summer 2010 and is now complete with the preparation of the *Strategy Phase II Final Report*. In July 2012, the *Phase II A Report* (BAWSCA 2012) provided an interim update to water demands and supply needs, detailed information on a refined list of water supply management projects that could potentially be developed to address those needs, and near-term recommendations for efforts to guide the rest of Phase II.

Since 2012, further refinements have been made to projects considered in the Strategy, and BAWSCA implemented the recommendations from the *Phase II A Report*. The results of these efforts and a short- and long-term Strategy implementation plan are now documented in this *Strategy Phase II Final Report*.

Phase III will encompass implementation of recommendations resulting from the *Strategy Phase II Final Report.*

1.5 Development Managed to Adapt to Changed Conditions and Use Resources Efficiently

The Strategy is not being developed in a vacuum, but rather in the context of changing circumstances, many of which have impacts on the Strategy's results and recommendations. For example, as the Phase II work progressed, significant changes in the projected demand, normal and drought year supply need, and the number and types of projects were identified. It became apparent that several near-term actions needed to be taken. To incorporate these changed conditions and provide solutions that remain relevant and cost effective, the schedule, scope, and focus of the Strategy was modified to efficiently use the available resources to the maximum benefit of the BAWSCA member agencies.

The *Phase II A Report* documented the results of two years of work further defining both the supply need and identifying potential projects to fill the supply need for the BAWSCA member agencies. As a result of the work completed during that time, the *Phase II A Report* presented the following recommendations, which were presented to the BAWSCA Board in September 2012:

1. Complete the reprogrammed Phase II A work by December 2014.
2. Develop a plan for a pilot water transfer.
3. Update the water demand and conservation projections for BAWSCA member agencies using a common methodology.

BAWSCA's work in response to the Phase II A recommendations has been integral to the development of this *Strategy Phase II Final Report*. The results of the updated demand and conservation projections and the pilot water transfer plan are discussed in Sections 2 and 3, respectively.

These Strategy modifications were communicated to the BAWSCA Board and the member agencies over the course of Phase II of the Strategy. The scope and content of the Strategy Report reflects the adaptive nature of the Strategy, as do the resultant implementation recommendations.

1.6 Report Structure

This report presents a summary of the technical information that was developed during Phase II of the Strategy, as well as specific recommendations for short- and long-term BAWSCA actions. The information contained in this report relies on the work performed as part of Phase II and documented in Phase II technical memoranda.

The remainder of this *Strategy Phase II Final Report* consists of the following:

- *Section 2 – Magnitude of the Need: Water Supply and Demand Projections* presents the updated demands and the magnitude of the projected water supply needs within the BAWSCA member agency service area.

- *Section 3 – Consequence of the Status Quo: Estimated Impacts of Supply Shortfalls* summarizes the frequency and magnitude of the projected shortfalls and the information available on economic impacts of supply shortfalls within the BAWSCA service area.
- *Section 4 – Viable Options: Water Supply Management Projects s*ummarizes the projects remaining in the Strategy and the information developed for the evaluation of these projects.
- *Section 5 – Project and Portfolio Performance* addresses the evaluation criteria, scoring and comparison of projects, and development and scoring of portfolios.
- *Section 6 – Strategy Recommendations* summarizes the 2040 water supply need and presents the recommended immediate and potential future actions to be taken by BAWSCA, an implementation schedule to sequence Strategy projects over time, and implementation mechanisms associated with the recommended actions.
- *Section 7 – References* presents documents referenced in this report.
- *Appendix A – Estimated Pumping Yields and Potential Effects from the Production of Brackish Groundwater for Desalination*
- *Appendix B – Detailed Desalination Feasibility Analysis*
- *Appendix C – Developing Costs for Drought-Dependent Desalination Supplies*
- *Appendix D – Overview of Project Evaluation Criteria*
- *Appendix E – Strategy Project Scoring*
- *Appendix F – Detailed Project Scoring Information*
- *Appendix G – Project and Portfolio Performance Evaluation*

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Section 2

Magnitude of the Need: Water Supply and Demand Projections

A key objective of the Strategy is to update the water supply need of the BAWSCA member agencies through 2040 for both normal and drought years. The supply need estimates are based on the differences between the projected water demands of the BAWSCA member agencies and their anticipated use of available water supplies. The information presented in this section is based on new data developed in 2014 for the BAWSCA member agencies in the *Regional Demand and Conservation Projections Project* (BAWSCA 2014).

Total water demands are projected to be 19 percent lower in 2035 than previously projected in 2009 in the *BAWSCA Water Conservation Implementation Plan* (BAWSCA 2009). Total water demand is defined as demand after plumbing code savings but before additional active conservation efforts. While the exact reasons for these reductions are not fully understood, this decline is generally assumed to be associated with a combination of a poor economy, cool weather, and increased conservation as a result of recent drought conditions. Key results presented in this section are:

- Total water demand with active conservation in 2040 is estimated to be 269 mgd;
- Anticipated purchases from SFPUC in 2040 are approximately 168 mgd including projected purchases of 9 mgd from the Cities of San Jose and Santa Clara;
- Since the BAWSCA member agencies are only projecting to purchase 148 and 157 mgd from the SF RWS in 2015 and 2020, respectively, the issue of the SFPUC-imposed Interim Supply Limitation (ISL) on the BAWSCA member agencies of 184 mgd is no longer an immediate concern;
- The need for additional normal year water supplies through 2040 is small with only a few agencies identifying a combined need of less than 1 mgd, an amount which can be purchased from the SFPUC under the WSA due to overall BAWSCA demand on SFPUC supplies being below the 184 mgd ISL.
- The need for additional dry year water supplies remains significant with a shortfall of up to 24 mgd and 43 mgd during 10 percent and 20 percent system-wide shortages on the SF RWS, respectively (assuming 100 percent LOS at this time).

2.1 Population and Water Demands are Increasing

The total population of the BAWSCA member agency service areas increased by 24 percent (from 1.4 million people to 1.7 million people) between 1985 and 2010. This equates to an average increase of 1 percent (13,000 people) per year. As shown in Figure 2-1, based on the information compiled for the *Regional Demand and Conservation Projections Project*, the total population of the BAWSCA member agency service areas is projected to increase to 1.8 million people by 2015 and 2.2 million people by 2040, an increase of 25 percent over 25 years, or also about 1 percent per year. As the population increases, the associated employment and water demands are expected to increase as well.

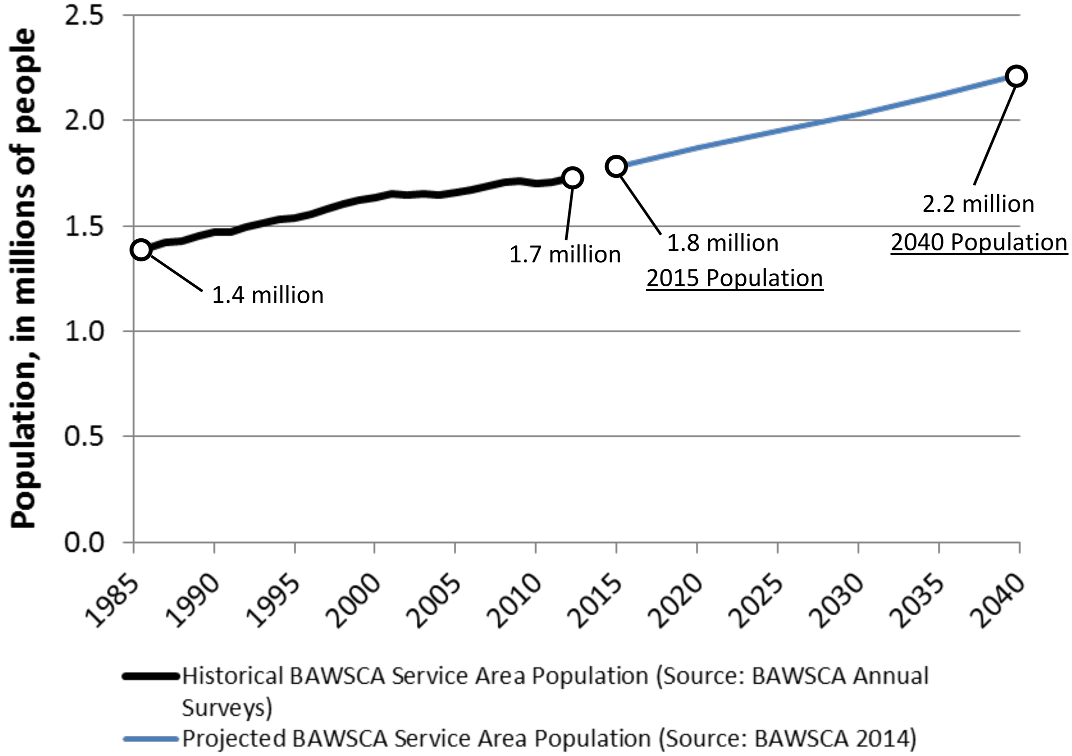

Figure 2-1
Population in the BAWSCA Service Area is Projected to Increase by an Average of 1% per Year From 2015 to 2040

As can be seen in Table 2-1 and Figure 2-2, after accounting for plumbing code savings, the BAWSCA agencies are projecting a total water demand of 233 mgd in 2015 and 284 mgd in 2040, an increase of 22 percent over the next 25 years. This projected future demand is significantly lower than the demands that were projected in the agencies' 2010 UWMPs and in the *Phase II A Report*. The updated demand reflects historic low water use throughout the service area in the last several years, the most recent forecasts for population growth and economic recovery in the Bay Area, and the impact of current and future water conservation efforts.

Table 2-1. Total BAWSCA Demand Projections

Demand Forecast	2015	2020	2025	2030	2035	2040
Total Water Demand with No Plumbing Code Savings (mgd)	234	259	270	281	292	304
Total Water Demand with Plumbing Code Savings (mgd)	233	254	261	267	275	284
Total Water Demand with Plumbing Code Savings and Active Conservation Measure Savings (mgd)	228	246	250	255	260	269

Source: BAWSCA 2014.

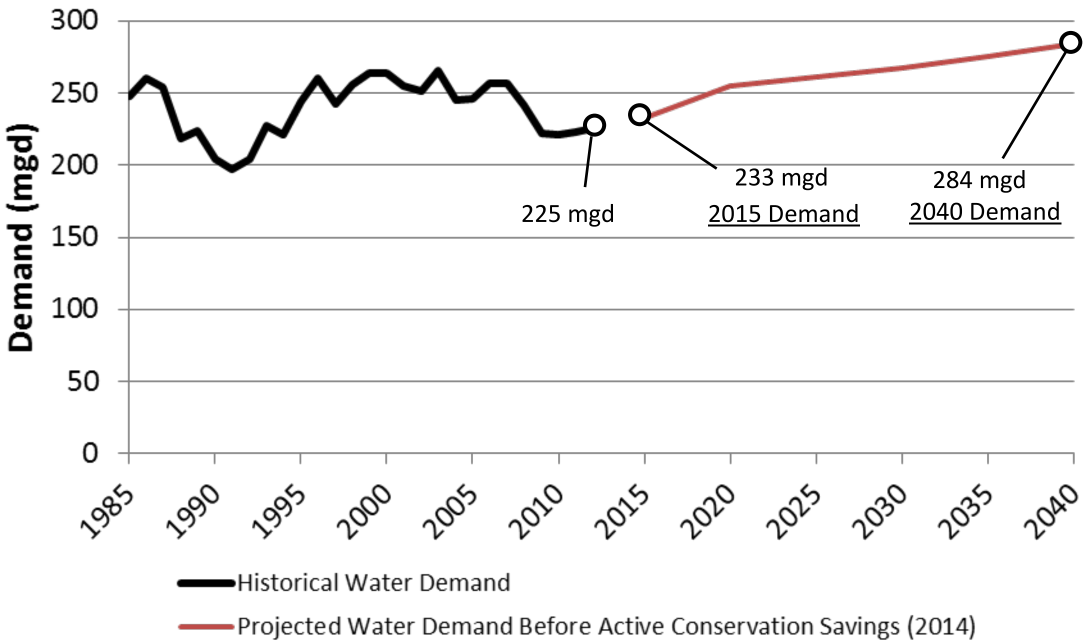

Figure 2-2
Planned Population and Economic Growth Results in Water Demand Increases in the BAWSCA Service Area[1]

2.2 Numerous Factors Influence Future Supply Reliability

The water supplies currently available to the BAWSCA member agencies are limited and their reliability is affected by several factors including: treatment and delivery mechanisms; policy decisions; hydrologic conditions; regulatory actions; system capacity constraints; and climate change.

The ability to predict the impact of these factors on supply reliability varies according to the level of information available for each factor. For example, historical hydrologic conditions have been used to predict the recurrence of drought years, but climate change could affect how accurate the historical record will be in predicting future hydrology. Even the 2014 drought may change the calculated recurrence frequency. Changing environmental requirements and water rights restrictions also add uncertainty into how water supplies will be affected by politics and other factors unrelated to hydrological and climate changes.

Figure 2-3 groups factors that require consideration in assessing the reliability of supply sources:

1. “Known” factors are factors that impact reliability and are readily quantifiable. These factors include: hydrology (through historical hydrology and drought occurrence data); source water quality; current and known future regulatory requirements; and physical system constraints (conveyance capacity, seismic reliability of infrastructure, etc.).

2. “Known unknowns” are inherently less readily quantifiable factors that can still be assessed in a planning-level analysis. These factors include: potential changes in future supply from SFPUC; the impact of climate change on hydrology (how changes in rainfall and

[1] Active conservation not shown since such measures are accounted for under supply sources.

temperatures may change future water availability in the SF RWS); further State Water Resources Control Board (State Board) flow restrictions in the Sacramento-San Joaquin River Delta (Delta); and potential Federal Energy Regulatory Commission (FERC) actions in the relicensing of Don Pedro Project.

3. "Unknown unknowns" are factors that are not easily quantifiable but could create a large shift in supply reliability. These include political climate, natural disasters, and economic disruptions. Some aspects of climate change, including magnitude of temperature increases and frequency of droughts, especially on a local scale, are still considered unknown unknowns.

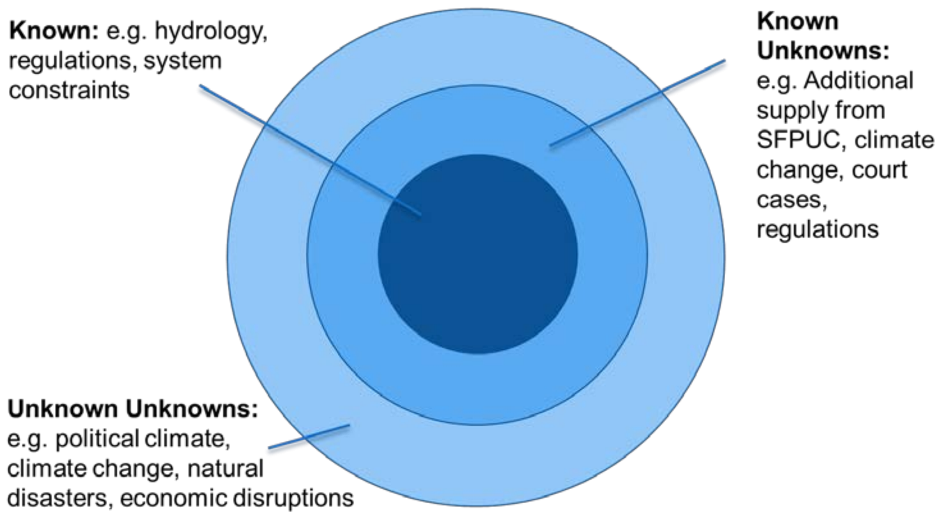

Figure 2-3
Types of Factors Affecting the Reliability of Water Supplies

Although the above factors may affect many of the BAWSCA member agencies' current supply sources, and may increase the total regional supply need during future normal and drought years, the Strategy focuses only on the impacts of these factors on SFPUC supply reliability. At this time, based on conversations with member agencies and Santa Clara Valley Water District (SCVWD), it is assumed that any reductions in non-SFPUC supplies will be addressed by the individual BAWSCA member agencies or the other regional water suppliers (e.g., SCVWD).

Factors that may affect the quantity and reliability of SFPUC supplies include, but are not limited to, the following:

- **SFPUC Policy Decisions -** As part of the Phased Water System Improvement Program (WSIP) Variant, SFPUC made the unilateral decision to limit the water supply available from the SF RWS to the BAWSCA member agencies to 184 mgd until at least 2018. By 2018, the SFPUC will re-evaluate water demands in the service area through 2030 and assess whether or not to increase deliveries from the SF RWS after 2018. The SFPUC may also make a decision at that time regarding the status of the Santa Clara and San Jose contracts. For the purposes of the Strategy, BAWSCA has assumed that deliveries from the SF RWS to the BAWSCA member agencies will continue to be limited to the 184 mgd Supply Assurance in the future and that the SFPUC may decide to not make San Jose and Santa Clara permanent customers (i.e., to not meet their 9 mgd purchase projections).[2]

- **Hydrologic Conditions -** The 2009 WSA commits the SFPUC to meeting a LOS goal for drought reliability of no more than a 20 percent system-wide reduction in any given year and presents the Wholesale Customer share of the SFPUC supply under different drought conditions. Future climate changes may further impact the available SF RWS water supply, and the supply available to the BAWSCA member agencies, by increasing the frequency and/or magnitude of droughts. For the purposes of the Strategy, the values presented in the 2009 WSA continue to be used through 2040.

- **Regulatory Actions -** FERC is in the process of relicensing the Don Pedro Project. The result of this process could include additional instream flow requirements for fishery restoration purposes, and a potential reduction to SFPUC supplies, particularly during droughts. For example, based on SFPUC's current drought supply forecasting protocols, the 2009 proposed instream flow requirements could require a reduction in SF RWS drought year deliveries by as much as 53 percent (FERC 2009).

  In addition, increased flow releases below Calaveras Dam and Crystal Springs Dam to benefit downstream fishery resources are being required by the resource agencies as part of the approval or construction of critical WSIP projects in those areas.

  Changes to the State Board plan for the Delta, which increases unimpaired flows from the Tuolumne watershed, and the State Board development of flow criteria for the Delta ecosystem as part of the Sacramento-San Joaquin Delta Reform Act of 2009 could also affect the yield of the SF RWS.

  Within the Strategy, the potential effects of these impending regulatory actions have not been explicitly included. These pending regulatory issues are identified in Section 6 as issues BAWSCA should continue to monitor.

Potential impacts of the factors described above on SFPUC supply reliability are difficult to assess because studies are ongoing and there is still much uncertainty. For example, scientists researching climate change are nearing a general consensus on long-term forecasts of global temperature rise and rainfall changes, but more research is needed to estimate regional and local impacts on water supplies. It remains essential to continue to track these issues and to include consideration of this uncertainty in long-term water supply planning. In Section 6, it is proposed that BAWSCA should monitor how SFPUC address impacts of climate change on their supply reliability as a core action of the Strategy implementation,

[2] The SFPUC is currently evaluating their upcoming 2018 decisions and ability to meet regional demands through their 2030 Water Management Action Plan (MAP).

2.3 Although Supply Need Has Decreased Since 2012 Study, Service Area is Subject to Water Supply Shortfalls During Droughts

The water supply need for the BAWSCA member agencies is based on the projections of demand and the assumptions regarding the availability of existing supplies under different hydrologic conditions. The member agencies' projections of demand and their anticipated use of supplies have changed since these elements were last assessed in 2012 (see Figure 2-4). Specifically, the current projection of the BAWSCA member agencies' 2035 water demand is 13 percent lower than the demand projection presented in 2012. Much of this change is based on the decline in water use by the BAWSCA member agencies in recent years. For example, there was an approximately 12 percent decline in total BAWSCA member agency demand between Fiscal Year (FY) 2006-2007 and FY 2012-2013, as shown in Figure 2-4. These changes are attributed to a combination of a poor economy, cool weather, population decreases during FY 2010-2011 and FY 2011-2012, and increased conservation as a result of rate increases and conservation efforts, including agencies' progress towards meeting their 20x2020 conservation goals[3].

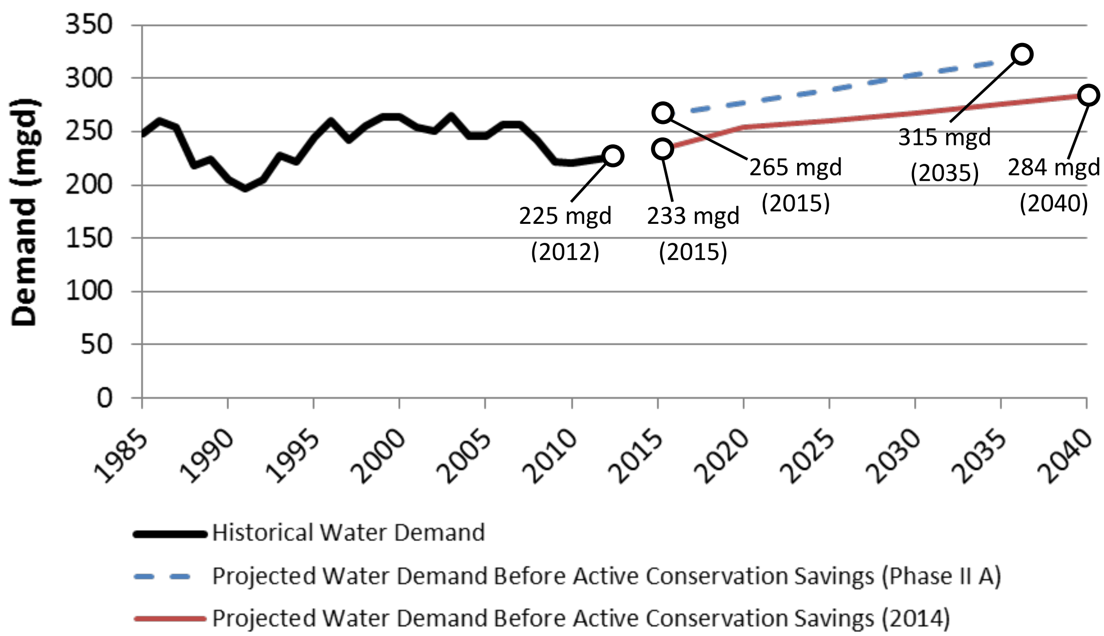

Figure 2-4
Projected Total 2015 BAWSCA Demands Decreased Thirteen Percent Between the 2012 and 2014 Studies

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[3] Pursuant to SB X7 7, the state will have to reduce urban per capita water use by 20 percent no later than December 31, 2020, and by at least 10 percent no later than December 31, 2015. These water use reductions will be compared against a 10- to 15-year baseline period that ends between 2004 and 2010.

The Strategy addresses water supply need related to future normal year conditions and drought conditions when the SFPUC supplies will be curtailed. Figure 2-5 presents the water supply portfolio in 2040 that the BAWSCA member agencies have identified to meet needs in a normal year[4]. As evidenced in Figure 2-5, there is a diverse water supply available to BAWSCA member agencies during normal years. The normal year water supply need in 2040 is minimal, with only a few agencies identifying a combined need of less than 1 mgd. By comparison, the *Phase II A Report* estimated a normal year water supply need of 4 mgd to 13 mgd in 2035.

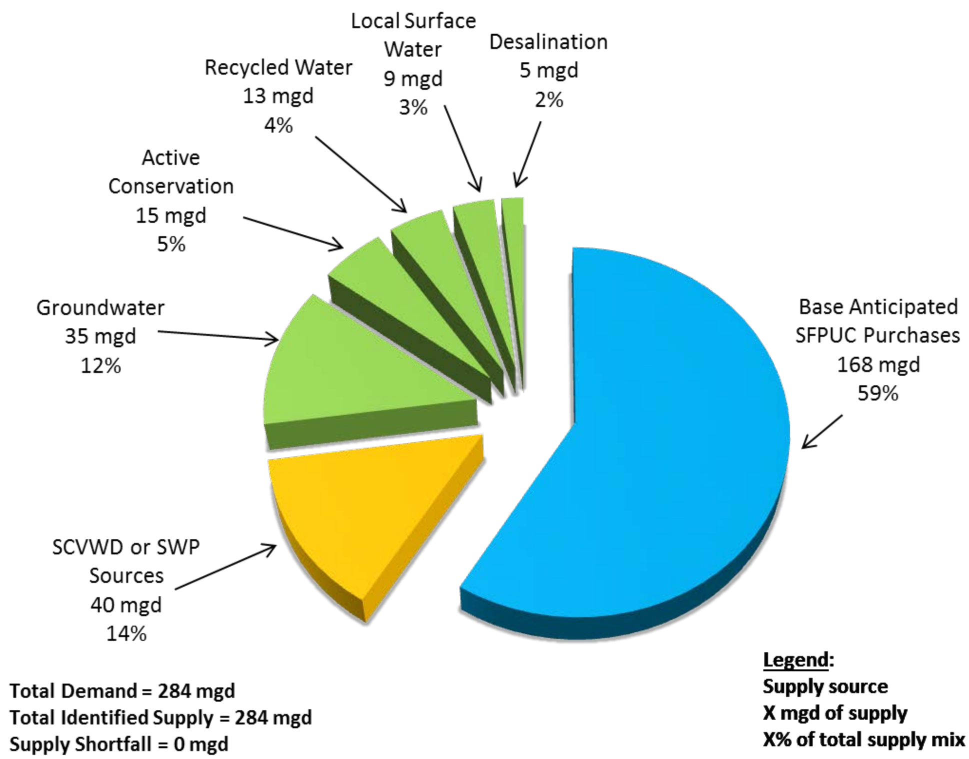

Figure 2-5
BAWSCA Member Agencies Utilize a Diverse Water Supply Portfolio During Normal Years to Meet the Identified Need (2040)

As a result of the reduction in anticipated normal year water supply need in 2040, the focus of the Strategy is now targeted towards meeting the dry year needs of the BAWSCA member agencies. Based on the updated demand projections, the BAWSCA member agencies are projecting to purchase 148 and 157 mgd from the SF RWS in 2015 and 2020, respectively, which would not trigger the 184 mgd ISL. As such, the imposed supply restriction by the SFPUC is no longer an immediate issue.

Consistent with the current SF RWS LOS goals, the SFPUC supply available to the BAWSCA member agencies during a drought was estimated for both a 10 percent and 20 percent system-wide water shortage condition. The Strategy does not address future drought year supply shortfalls for the non-SFPUC supplies on which the member agencies rely, such as groundwater, local sources, or imported surface water. As such, the use of these non-SFPUC supplies is assumed to remain constant regardless of year type. As stated above, it is assumed that any reductions in the non-SFPUC supplies will be

[4] The sum of individual supplies and total demand may not be equal due to rounding of individual supply values.

addressed by the individual BAWSCA member agencies or the other regional supply agencies (e.g., SCVWD).

The 2009 WSA between San Francisco and its Wholesale Customers includes a Water Shortage Allocation Plan to allocate water from the SF RWS to the retail and Wholesale Customers during mandatory system-wide shortages of 20 percent or less (the Tier 1 Plan). Under the rules of the Tier 1 Plan, a 10 percent system-wide reduction in 2040 results in an 15 percent average reduction to the BAWSCA agencies and a 20 percent system-wide reduction results in a 26 percent average reduction to the BAWSCA agencies. The provisions of the Tier 1 Plan allow the Wholesale Customers to "bank" drought allocations and to voluntarily transfer the allocations to each other and San Francisco. The 2009 WSA also presents a schedule for actions preceding and during a drought.

The Tier 2 Drought Implementation Plan (Tier 2 Plan or "DRIP"), which was adopted by all 26 BAWSCA member agencies in March 2011, allocates the collective Wholesale Customer share of SF RWS supplies among each of the 26 BAWSCA member agencies. Under the rules of the Tier 2 Plan, the range of cutback varies for each BAWSCA member agency (i.e., cutbacks in SFPUC supplies during a 20 percent system-wide shortage range from 10 percent to 44 percent for the individual BAWSCA member agencies based on the 2011 DRIP allocation calculation). The current Tier 2 Plan has a sunset date of 2018, but is assumed to extend through 2040 for the purposes of this assessment. The Tier 1 and Tier 2 Plans apply only during times of SFPUC-defined mandatory drought shortages.

The anticipated supplies during a 10 percent and 20 percent system-wide shortage, as applied to the 2040 anticipated SFPUC purchases of 168 mgd, are shown in Figures 2-6 and 2-7, respectively. The updated drought year water supply need in 2040 with 10 percent system-wide shortage conditions is anticipated to be 24 mgd, as compared to the prior Phase II A estimate of 38 mgd to 43 mgd in 2035. The updated drought year water supply need in 2040 with 20 percent system-wide shortage conditions is anticipated to be 43 mgd, as compared to the prior Phase II A estimate of 58 mgd to 62 mgd in 2035. The "Supply Shortfall" category represents the upper bound of the anticipated water supply need, assuming a 100 percent LOS and no execution of drought allocation transfers. It is assumed that a supply shortfall would need to be met by some combination of additional supplies and/or additional conservation.

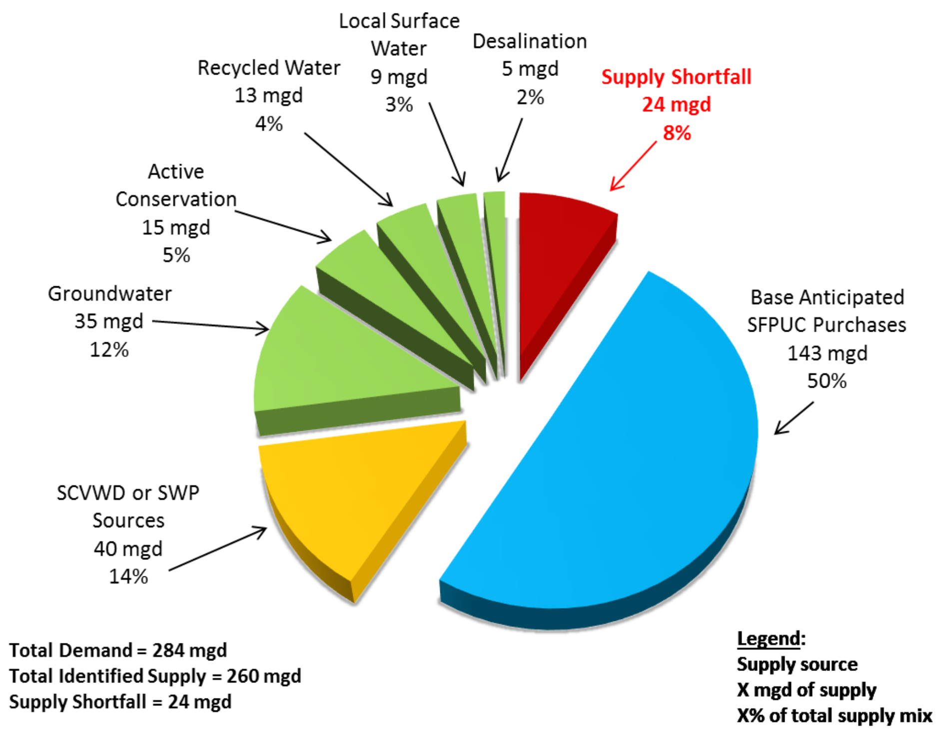

Figure 2-6
During a 10% SF RWS Supply Shortage Additional Supply Will be Needed to Meet the Identified Need (2040)

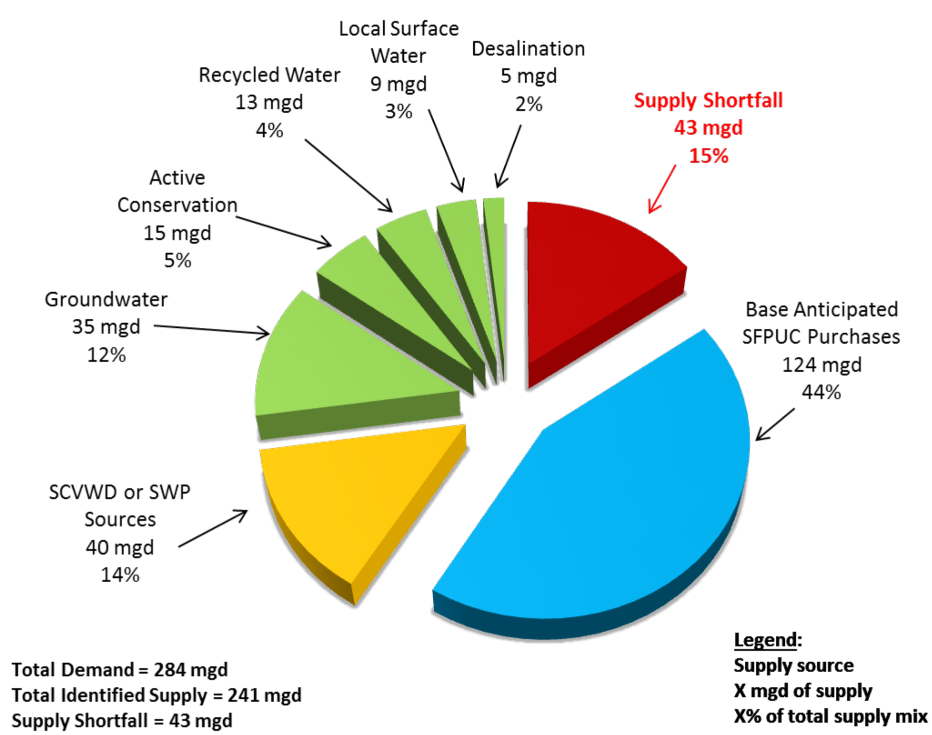

Figure 2-7
During a 20% SF RWS Supply Shortage Additional Supply Will be Needed to Meet the Identified Need (2040)

As stated above, the current projection refines the gaps in dry-year supply reliability. It is important to note, however, that the supply reliability need was calculated on a collective basis for BAWSCA member agencies. Further consideration of the supply need of each member agency is discussed in Section 6.

2.4 Ultimate Supply Need is Based on Target Level of Service

Water supply reliability is generally defined in terms of a LOS goal, which is a measure of the quality and quantity of services provided to meet a community's needs and expectations. BAWSCA member agencies' current supply planning is based on the SFPUC LOS drought goal of no system-wide reduction in supplies greater than 20 percent in which, under the Tier 1 Plan, the BAWSCA member agencies will have an aggregate cutback of 26 percent. The Strategy considers the benefits and costs of developing supplies to supplement the SFPUC LOS.

LOS measures for water supply reliability are most often expressed as a percentage of the total water demand that will be met by the water supply agency. If all demands are met, LOS is 100 percent. LOS may be reduced during a period when demand is increased or supply is reduced, such as during a drought or an emergency outage. An agency's LOS may also be expressed as a frequency of acceptable shortage (e.g., 100 percent reliable 95 percent of the time) or an agency may have a different reliability goal for one customer sector over another.

LOS goals for other agencies and regional providers vary because it is up to an individual agency to make that policy decision. There may also be differences in how wholesalers determine their preferred LOS versus retail agencies. While wholesale agencies may consider factors that influence reliability on an annual or multi-year basis (including hydrology and regional infrastructure issues), retail agencies may be more focused on a day-to-day LOS, based on responding to any catastrophic occurrences, or loss of supply from a wholesaler.

Table 2-2 summarizes LOS goals for a number of water supply agencies in the Bay Area. The drought year LOS goals vary from 80 percent (SFPUC) to 90 percent (SCVWD).

Table 2-2. Level of Service Goals for Water Supply Agencies in the Bay Area

Agency	Normal Year LOS	Drought Year LOS	Notes
Contra Costa Water District	100%	85%	Based on 2010 UWMP
East Bay Municipal Utility District (EBMUD)	100%	85%	EBMUD Policy 9.03 has a goal of limiting customer rationing to a maximum of 15% of district-wide annual demand
SFPUC	100%	80%	Based on WSIP system performance objective to meet 265 mgd during non-drought years and limit rationing to 20% system-wide through 2018
SCVWD	100%	90%	Based on 2012 Water Supply and Infrastructure Master Plan

Some regional water suppliers have replaced quantitative LOS goals with qualitative measures. For example, Metropolitan Water District's 1996 *Integrated Water Resources Plan* established a reliability goal of "full-service demands at the retail level under all foreseeable hydrologic conditions" through 2020. San Diego County Water Authority, which no longer has an adopted LOS policy, utilizes planning documents (their UWMP and Emergency Supply Plan) to provide a statement of reliability. These documents identify a goal of a "highly reliable" supply, but no numeric LOS goal.

LOS goals can be set to meet a target level of reliability to avert economic damages or by assessing the costs to meet varying levels of reliability and setting an achievable goal based on supply availability and cost. The supply shortfall is a critical element in this determination. It is defined as the amount of additional supply needed in both normal and drought years to meet the LOS goal. Table 2-3 summarizes the additional BAWSCA supply needed to provide a range of LOS from 90 percent to 100 percent in both normal and drought years based upon the supply gap analysis described in Section 2.3 and illustrated in Figures 2-6 and 2-7. This additional supply is added to the estimated SFPUC supply available for each demand scenario (Normal, 10% System-wide Shortage, and 20% System-wide Shortage). Table 2-3 demonstrates that a wide range of additional supply may be needed to fill the shortfall of SFPUC supply, based on a selected BAWSCA LOS goal. To meet the 90 percent LOS goal, a portfolio of projects would need to provide approximately 27 mgd of additional supply to the BAWSCA member agencies. This 27 mgd would supplant the shortfall of SFPUC supply in a drought year (20 percent system-wide shortage), and provide the equivalent to a total of 90 percent of the total anticipated purchases during a normal year based on 2040 projections. To meet the 100 percent goal during a drought year, a portfolio would need to provide 43 mgd of supply.

Table 2-3. Additional Supply Needed to Meet LOS Targets

2040 Demand Scenarios	SFPUC Purchases (mgd)	Additional Supply Needed to Meet 90% LOS Goal (mgd)	Additional Supply Needed to Meet 95% LOS Goal (mgd)	Additional Supply Needed to Meet 100% LOS Goal (mgd)
Normal Year Demands	168	not applicable	not applicable	not applicable
Drought Year SFPUC Supply Allocation (During 10% System-wide Shortage on the SF RWS)	143	8	16	24
Drought Year SFPUC Supply Allocation (During 20% System-wide Shortage on the SF RWS)	124	27	35	43

As discussed above, during a 20 percent system-wide shortage on the SF RWS, BAWSCA member agency SFPUC supply allocations will be reduced by 26 percent in aggregate. Based on the DRIP/Tier 2 calculations, updated with 2040 project agency demands, BAWSCA member agencies will experience 10 percent to 40 percent reductions in SFPUC purchases as summarized in Table 2-4. Member agencies' LOS from the SFPUC (percentage of total demand met) will range from 63 percent to 99 percent as a result of this reduction in SFPUC purchases. It is important to note that any supply shortfall would be met by some combination of additional supplies and additional conservation.

Table 2-4. Individual BAWSCA Member Agency SFPUC Allocations During 20% System-wide Shortage on the SF RWS According to the Updated Tier 2/DRIP Calculations

	2040 Total Demand	2040 Anticipated SFPUC Purchases	2040 SFPUC Drought Allocation	2040 SFPUC Drought Cutback	2040 Drought Year Supply Need	2040 Estimated LOS During Drought
ACWD	54.43	7.68	6.912	-10%	0.77	99%
Brisbane/Guadalupe Valley Municipal Improvement District	0.96	0.94	0.661	-30%	0.28	71%
Burlingame	5.42	5.34	3.751	-30%	1.59	71%
Coastside County Water District	2.01	2.03	1.475	-27%	0.55	72%
California Water Service Company (total)	39.38	34.68	23.976	-31%	10.71	73%

Table 2-4. Individual BAWSCA Member Agency SFPUC Allocations During 20% System-wide Shortage on the SF RWS According to the Updated Tier 2/DRIP Calculations

	2040 Total Demand	2040 Anticipated SFPUC Purchases	2040 SFPUC Drought Allocation	2040 SFPUC Drought Cutback	2040 Drought Year Supply Need	2040 Estimated LOS During Drought
Daly City	6.62	2.91	2.582	-11%	0.33	95%
East Palo Alto	2.23	1.96	1.707	-13%	0.25	89%
Estero Municipal Improvement District	4.20	4.01	3.288	-18%	0.73	83%
Hayward	26.83	25.38	18.054	-29%	7.33	73%
Hillsborough	3.19	2.99	2.157	-28%	0.83	74%
Menlo Park	3.37	3.23	2.535	-22%	0.69	79%
Mid-Peninsula Water District	3.40	3.30	2.499	-24%	0.80	76%
Millbrae	3.04	2.93	2.133	-27%	0.80	74%
Milpitas	12.48	8.80	6.491	-26%	2.31	81%
Mountain View	12.84	9.34	7.639	-18%	1.70	87%
North Coast County Water District	3.01	2.93	2.493	-15%	0.44	85%
Palo Alto	15.98	14.52	10.666	-27%	3.86	76%
Purissima Hills	1.88	1.71	1.025	-40%	0.69	63%
Redwood City	11.94	7.98	6.411	-20%	1.57	87%
San Bruno	5.49	3.30	2.417	-27%	0.88	84%
Stanford	4.57	3.00	2.147	-28%	0.85	81%
Sunnyvale	23.14	8.93	7.248	-19%	1.69	93%
Westborough	0.77	0.74	0.666	-10%	0.07	90%
Subtotal	247.17	158.634	118.93	-25%	39.73	84%
San Jose	12.82	4.50	2.695	-40%	1.81	86%
Santa Clara	24.24	4.50	2.695	-40%	1.81	93%
Total	284.23	167.634	124.323	-26%	43.339	85%

2.5 Additional Supply Investments Required for Dry Years

The primary objective of the Strategy is to identify the water supply management projects that could be developed to meet the supply need of the BAWSCA member agencies through 2040 to avoid potential severe economic consequences due to water shortages. Section 4 of this report presents the projects that could provide additional supply for the member agencies to meet the up to 43 mgd dry year supply need. In all instances, and in accordance with a key BAWSCA principle, the water supply management projects that are developed as part of this Strategy will be paid for by those agencies that benefit from their development.

Section 3

Consequences of the Status Quo: Economic Impacts of Supply Shortfalls

A key objective of the Strategy is to quantify the potential impacts of water supply shortages during droughts to the BAWSCA member agencies. This section presents the results of studies completed to date on the economic and social impacts of drought on the BAWSCA member agencies and the current estimates of the frequency and magnitude of drought cutbacks from the SF RWS. As discussed in Section 2, the current LOS goal for the SF RWS is no more than a 20 percent system-wide shortfall during a drought. Based on the current 2040 SFPUC purchase projections and application of the Tier 1 Plan, a 20 percent shortfall on the SF RWS results in an aggregate 26 percent cutback to the Wholesale Customers. This section summarizes the impacts to businesses in the BAWSCA service area associated with that 20 percent system-wide shortfall and presents the following key results:

- Using the 91-year historical hydrologic record to project future conditions, droughts on the SF RWS are estimated to occur roughly once every 6.5 years with droughts projected to cause supply shortfalls occurring once every 11 years;
- A 20 percent system-wide shortfall on the SF RWS is currently estimated to create a $2.02 B impact to business and industry in the BAWSCA service area under FY 2010-2011 conditions (The Brattle Group 2013); and
- Given the interconnected nature of the economy within the BAWSCA service area, drought impacts are a regional issue that will impact all communities.

3.1 Estimates of the Frequency and Magnitude of SFPUC Supply Shortfalls

As part of the development of the Strategy, BAWSCA has been working with SFPUC to assess the probability of supply shortages on the SF RWS. SFPUC has performed, on BAWSCA's behalf, simulations using the Hetch Hetchy/Local Simulation Model (HH/LSM) to study potential shortages using a range of future demands from the BAWSCA member agencies. An August 2013 update to the model was completed to: 1) extend the model's hydrologic record from 2002 to September 2011; and 2) modify operations for consistency with the FERC relicensing modeling effort[1]. HH/LSM results discussed in this section reflect these model updates.

[1] The agricultural water requirements were extended for the modeling period using California Department of Water Resources' consumptive use model, and adjusted to reflect recent (last 10 years) of water use and management practices. Reservoir management during drought has also been changed from previous modeling to reflect a more aggressive use of available storage.

System-wide supply shortages are imposed within the SF RWS operations in a step wise manner. Each step (or "Action Level") is triggered by thresholds based on total system storage on July 1 of each year. Each Action Level is described below:

- **Action Level 1**: Action Level 1 does not impose a reduction in water supply deliveries, but does impose a change in system operation, including the use of SFPUC's Regional Groundwater Storage and Recovery Program to supplement surface water deliveries.
- **Action Level 2**: Action Level 2 results in a 10 percent system-wide supply reduction.
- **Action Level 3**: Action Level 3 results in a 20 percent system-wide supply reduction.

As discussed in Section 2, the 2009 WSA includes a Tier 1 Plan which allocates the available SF RWS water supply during a drought between San Francisco Retail Customers and the Wholesale Customers. With the application of the Tier 1 Plan on projected SF RWS purchases, a 10 percent system-wide shortfall in 2040 corresponds to a 15 percent cutback to the Wholesale Customers, while a 20 percent system-wide shortfall in 2040 corresponds to a 26 percent cutback to the Wholesale Customers. These Action Levels and their corresponding cutbacks (assuming 2040 conditions) are summarized in Table 3-1.

Table 3-1. SFPUC Drought Action Levels and Projected 2040 Supply Cutbacks

Action Level	System-Wide Supply Shortfall	Wholesale Customers Supply Cutback
1	None	None
2	10%	15%
3	20%	26%

The HH/LSM simulates SF RWS operations over a 91-year sequence that represents historical hydrological conditions between 1921 and 2011 and over an 8.5-year Design Drought planning sequence. The Design Drought planning sequence replicates the hydrologic conditions associated with the 1987 through 1992 drought, followed by the hydrologic conditions associated with the 1976 through 1977 drought. The basis for the design of this sequence is that by adding the worst hydrologic years of record to the end of the most severe drought of record, the SFPUC can attempt to mimic a worst case scenario of water availability in the system. It is standard practice to assess water supply by evaluating firm yield, which is the yield that can be met over a particular period with a specified no-failure reliability. At SFPUC, the particular system stress evaluated to anticipate and plan for drought is the Design Drought.

The HH/LSM incorporates information about key aspects of the SF RWS such as reservoir and conveyance attributes, stream runoff, and water demands. By iteratively running the model for the Design Drought and other key periods of the historical record, operating procedures and "rules" have been developed for viable system operation for all tested hydrologic sequences. One of the rules developed from this modeling is the protocol for triggering a reduction to SF RWS deliveries (i.e., the Action Levels) early during a drought period, so the system can continue to provide water supply up to the LOS throughout the duration of a drought.

At BAWSCA's request, the SFPUC analyzed the frequency and magnitude of the potential water supply shortfalls under various demand scenarios using HH/LSM. Three demand scenarios were considered wherein the average purchase levels for the BAWSCA member agencies varied from a minimum of 148.6 mgd, which was the total SFPUC purchases by the BAWSCA member agencies in FY 2009-2010, to a maximum of 186.1 mgd, which represents the 2035 demand as estimated in the *Phase II A Report*. According to the most recent BAWSCA member agency demand and supply information, the anticipated SFPUC purchases in 2040 are projected to be 168 mgd, which is closest to the Intermediate Demand Scenario (176 mgd) HH/LSM simulation from 2013. The SFPUC retail purchases from the SF RWS are projected to range from 75.5 mgd in 2015 to 78.7 mgd in 2035 in these scenarios. In a 2013 SFPUC planning document, the SFPUC estimated that their demand on the SF RWS in 2035 would be 81 mgd (SFPUC 2013). Thus, it is assumed here that the total SF RWS demand in 2040 is equal to the sum of the SF 2035 demand and the BAWSCA 2040 demand, for a total of 249 mgd. This total demand level is very close to the total system demand assumed for the Intermediate Demand Scenario of 252 mgd. The demand scenarios evaluated in this analysis are summarized in Table 3-2.

Table 3-2. Three Different Demand Scenarios Used to Examine Frequency and Magnitude of SFPUC Supply Shortfalls Using SFPUC Hydrologic Model

Scenario Name	Total System Demand (mgd)	Purchases by the BAWSCA Agencies (mgd)	SFPUC Retail Demand (mgd)
Minimum Demand (FY 2009-2010, rounded)	224	149	76
Intermediate Demand (Closest to 2040 Demand for 2014 Updated Demand Information)	252	176	76
Maximum Demand (Projected 2035 Demand from *Phase II A Report*)	265	186	79

All demand scenarios were assessed under hydrologic conditions represented by the hydrologic years 1920 through 2011 (i.e., equivalent to assuming that the historical hydrology will be replicated in the future)[2]. Scenarios were also assessed under the SFPUC's Design Drought conditions. Updates to HH/LSM were made by SFPUC to simulate the impact on the SF RWS from: 1) the increased requirements for instream flows below Calaveras and Crystal Springs Reservoirs; and 2) the increased supply from implemented WSIP projects (e.g., the Regional Groundwater Storage and Recovery Project, the 2 mgd transfer, etc.). However, historical hydrologic conditions were not modified to reflect the potential impacts of climate change.

3.1.1 Shortfalls Assuming Historical Hydrologic Conditions

In the 91 years of model simulation (1920 to 2011), the model triggered water shortage responses on 16 occasions for the Maximum Demand Scenario, 14 occasions for the Intermediate Demand Scenario, and 13 occasions for the Minimum Demand Scenario. Regional Groundwater Storage and Recovery program extractions occur in each year of response. The increase in Action Level 1 events in the Maximum Demand Scenario (one additional event) was the only change from the results presented in 2012. Table 3-3 presents the shortage level frequency results.

[2] The impacts of the current drought, once included in the HH/LSM modeling, will further impact these calculations.

Table 3-3. Frequency of Demand Rationing for the 91-year Hydrology Sequence (1920-2011)

Demand Scenario	Number of Years of Projected Supply Cutbacks to the Wholesale Customers Over 91-year History[1, 2]		
	ACTION LEVEL 1 *No Wholesale Customer Supply Cutback No System-Wide Shortfall*	***ACTION LEVEL 2*** *15% Avg. Wholesale Customer Supply Cutback (10% System-Wide Shortfall)*	***ACTION LEVEL 3*** *26% Avg. Wholesale Customer Supply Cutback (20% System-Wide Shortfall)*
Minimum Demand Scenario (224 mgd)[3]	13	0	0
Intermediate Demand Scenario (252 mgd)[3]	6	7	1
Maximum Demand Scenario (265 mgd)[3]	8	6	2

[1] Reproduced from the HH/LSM update transmittal letter, "Subject: Updated results for Maximum (264.8 MGD), Intermediate (251.8 MGD) and Minimum (224.1 MGD) Demand Scenarios with HH/LSM version 3.1 (updated hydrology to 2011 and Districts canal operations)," dated August 29, 2013.

[2] Action Levels are described above and presented in Table 3-1.

[3] Total demand including San Francisco Retail and Wholesale Customers.

Figure 3-1 shows the projected shortage results from the Intermediate Demand Scenario. An Action Level 1 drought occurrence is shown with a star on Figure 3-1, to indicate years in which there is a shortfall that triggers the use of conjunctive use projects but does not result in a water supply reduction on the SFPUC system. All other modeled responses were identical to model results produced prior to the 2013 model update, as presented in the *Phase II A Report*.

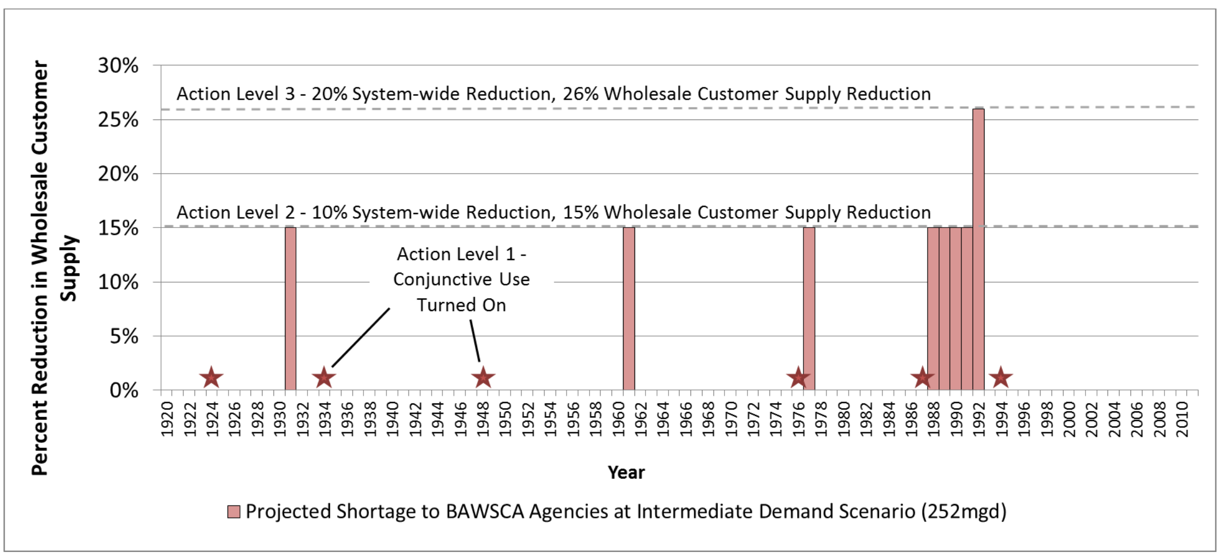

Figure 3-1
SFPUC Supply Cutbacks to Wholesale Customers Estimated from Using Simulated Historical Hydrology and the Intermediate Demand Scenario

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The updated HH/LSM model results from historical hydrologic conditions show 8 years out of 91 in which cutbacks occur under current system operations, with an intermediate or higher water demand from BAWSCA member agencies. This indicates that in intermediate or maximum demand conditions, in any given year there is a 9 percent chance of either a 15 percent or 26 percent cutback of SFPUC supply for the combined BAWSCA service area.

3.1.2 Shortfalls Under the Design Drought Evaluation

Under the Design Drought evaluation, the modeled hydrology for the years leading up to the Design Drought (i.e., 1920 through 1987) is assumed to be the same as those in the historical hydrologic conditions analysis. However, the Design Drought extends the 1987 through 1992 drought period for two additional years (i.e., through 1994). The two additional years of drought produce a shortage of Action Level 3 in the Maximum Demand Scenario.

The results (frequency and magnitude of supply shortages) from the Design Drought simulations, which feature a synthetic drought are centered around the 1987-1992+ drought hydrology, did not change with this latest model update. The Minimum Demand Scenario results in no water supply shortfalls in either historical hydrologic conditions or during the Design Drought. The Intermediate and Maximum Demand Scenarios result in drought shortages in 10 years during the 91-year simulation (including the Design Drought). Table 3-4 summarizes the projected supply reduction to the BAWSCA member agencies and the number of years in which they occur under all demand scenarios for the Design Drought evaluation. Figure 3-2 shows shortages under the Design Drought evaluation for the Intermediate Demand Scenario, with the two additional years of drought identified by cross hatching.

Table 3-4. Projected Frequency of SFPUC Supply Reduction to the Wholesale Customers Assuming Design Drought Hydrologic Conditions

Demand Scenario	Number of Years of Projected Supply Cutbacks to the Wholesale Customers Over 91-year History		
	ACTION LEVEL 1 *No Wholesale Customer Supply Cutback* *No System-Wide Shortfall*	***ACTION LEVEL 2*** *15% Avg. Wholesale Customer Supply Cutback* *(10% System-Wide Shortfall)*	***ACTION LEVEL 3*** *26% Avg. Wholesale Customer Supply Cutback* *(20% System-Wide Shortfall)*
Minimum Demand Scenario (224 mgd)[1]	14	0	0
Intermediate Demand Scenario (252 mgd)[1]	5	7	3
Maximum Demand Scenario (265 mgd)[1]	6	6	4

[1] Total demand including San Francisco Retail and Wholesale Customers.

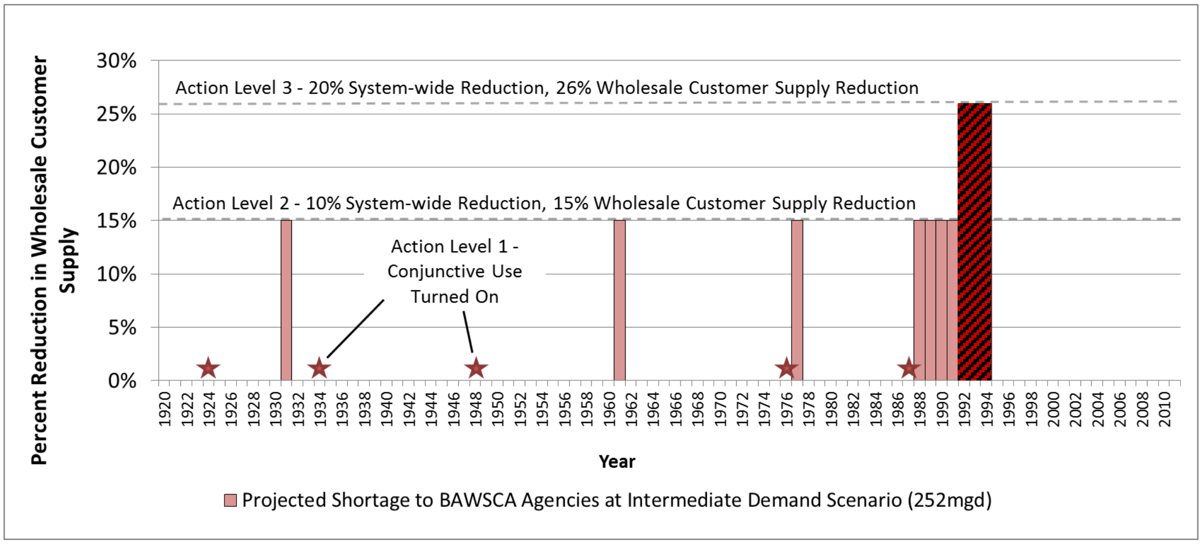

Figure 3-2
Projected SFPUC Supply Cutbacks to the Wholesale Customers
(in the Intermediate Demand Scenario and the Design Drought Sequence)

While any single year of Action Level 2 or 3 shortages would be expected to have some economic impact on the BAWSCA member agencies, the three consecutive years of Action Level 3 shortages that are associated with the Design Drought might have substantial economic impacts, especially for those BAWSCA member agencies that receive cutbacks greater than 26 percent under the Tier 2 Plan.

3.1.3 Factors that May Impact the Drought Estimates

While the SFPUC's HH/LSM provides the best information to date on the frequency and magnitude of the anticipated supply shortfalls on the SF RWS for different projected future demand scenarios, these estimates may not provide the complete picture of the reliability of the SFPUC supply. For example, the SFPUC modeling is based on historical hydrologic conditions. This basis assumes that future hydrologic conditions will be similar to conditions in the past, and does not take climate change into account. The historical 91-year record reflects 8 years of Action Levels 2 and 3 (under Intermediate and Maximum Demand Scenarios), but most of those simulated cutbacks occur in the last 30 years, indicating that the historical record may not be reflective of future conditions.

As discussed in Section 2, there are a number of other issues that may affect the quantity and reliability of SFPUC supplies including SFPUC policy decisions and other agencies' regulatory actions. Because these decisions and actions have not yet occurred, potential impacts of these issues on supply reliability are difficult to assess. For example, potential actions by the State Board may reduce the volume of supply that is available in the SF RWS during normal and drought conditions. BAWSCA's on-going attention is needed to assess the impacts of these issues on the SF RWS long-term reliability.

3.2 Existing Information on Economic Impacts of Drought

It is well documented that water supply shortages during droughts can have significant economic and other impacts to residents and businesses. Several studies have been prepared by the California Department of Water Resources (DWR) and others that have documented these impacts for the 1987 through 1992 drought and for other significant California droughts (DWR 2000; DWR 2008; Moore et. al. 1993; California Natural Resources Agency 2009; United States Climate Change Science Program

2008; PPI 2012). The water supplies that are available to the BAWSCA member agencies are subject to drought shortages, and thus, existing and future customers will be increasingly affected. In a broad sense, without sufficient additional water supplies to meet projected future drought year demands, residential and economic development could be curtailed within the BAWSCA service area and potentially relocated to other parts of the State or elsewhere. This could result in loss of new housing, jobs, manufacturing, community services, and tax revenue.

In 2005, work was done by the resource economist William Wade, Ph.D., to assess the economic impact to the BAWSCA member agencies of a SFPUC supply shortfall during a drought (Wade 2005). SFPUC updated its economic impact analysis of supply reductions to the City and County of San Francisco and the BAWSCA member agencies as part of the FERC relicensing process for the Don Pedro Project (The Brattle Group 2013). Results from this most recent analysis are discussed in this section, along with a comparison of those results with other utilities' studies.

Several different methods have been used to estimate the economic impacts caused by water shortages, with the three main methods being:

- *Direct Economic Costs* – This approach uses economic inputs and outputs to determine the value of water to commercial and industrial customers. The approach has been used by San Diego (2003), Orange County (2004), EBMUD (2012), and SFPUC (The Brattle Group 2013).
- *Welfare Function* – The welfare losses during a shortage are determined by the size of the shortage, the forecasted demand, the price elasticity of demand, the utility's pricing structure, and the source of supply unreliability which dictates the avoided marginal maintenance and delivery costs during a shortage. This approach has been used by Alameda County (1996), and most recently by EBMUD (2012) and SFPUC (The Brattle Group 2013).
- *Contingent Valuation* – Uses advanced survey techniques to illicit consumers' willingness to pay to avoid water shortages. This method has mostly been conducted for residential customers only. It has been used by Metropolitan Water District (1992), by California Urban Water Agencies (1994), and referenced and extrapolated to be used by SCVWD (2002) and Municipal Water District of Orange County (MWDOC) (2004).

The Brattle Group (2013) report took a very comprehensive view of both lost economic sales (economic activity) and welfare due to water shortages using the direct economic costs and welfare function methods described above. This methodology is most similar to the one used for the EBMUD Water Supply Management Program (2012). The economic activity impacts are based on constructing an analysis that converts water as an economic input to a regional economy, then uses economic multipliers to determine the lost sales activity resulting from various water shortages. The welfare impacts are based on an accepted approach of constructing an econometric water demand curve and then using the resulting price elasticity estimates (the change in water demand that is influenced by the price of water) to estimate the value of water and thus the impact of water shortages. The Brattle Group report used both of these methodologies to determine impacts of shortages.

A comparison of the Brattle Group report with similar California-based drought economic impact studies shows that the overall economic impacts estimated in the Brattle Group report are reasonable. Table 3-5 compares the Brattle Group report results with analyses completed by MWDOC and EBMUD.

Table 3-5. Comparison of 2010 Estimation of Economic Impacts Due to 20% Water Shortage

Study	Service Area Population	Economic Impact Method	Present Day Economic Impact ($ B)
SFPUC[1]	2.6 million	Direct Economic Method	$2.0
MWDOC[2]	3.2 million	Contingent Valuation & Direct Economic Method	$2.3
EBMUD[3]	1.3 million	Direct Economic Method	$0.3 to $2.0

Sources:
[1] The Brattle Group 2013.
[2] Orange County Business Council 2004.
[3] EBMUD 2012.

3.2.1 Estimated Impacts to the Commercial and Industrial Sector

The SFPUC released estimates of potential economic impacts to the commercial and industrial sector from varying levels of shortage using both FY 2010-2011 conditions and estimated FY 2035-2036 conditions (The Brattle Group 2013). The results of the Brattle Group study are presented in Table 3-6.

Table 3-6. Brattle Group Report Estimates of Annual Business Sales Losses by Shortage Scenario

Percent Reduction of SF RWS Supply	Lost Sales in FY 2010-2011 ($ B)	Lost Sales in FY 2035-2036 ($ B)
10	$0.44	$1.72
20	$2.02	$8.87

Source: The Brattle Group 2013

As shown in Table 3-6, the Brattle Group found that, for FY 2010-2011 conditions, a 10 percent system-wide supply shortfall on the SF RWS would reduce annual business sales in the BAWSCA and City and County of San Francisco service areas by $0.44B, and a 20 percent system-wide supply shortfall would reduce annual business sales by $2.02B (The Brattle Group 2013). Assuming FY 2035-2036 conditions, a 10 percent system-wide supply shortfall on the SF RWS would reduce annual business sales in the BAWSCA and City and County of San Francisco service areas by $1.72B, and a 20 percent system-wide supply shortfall would reduce annual business sales by $8.87B.

The Brattle Group report assesses the impact of a single year drought, but does not estimate the impact of a multi-year drought. The Brattle Report also considers impacts on the combined SFPUC retail and wholesale customer base, and does not quantify estimated impacts specifically to BAWSCA member agencies. Economic impacts from non-SFPUC-related shortages are also not considered in the Brattle Group report.[3]

The results of the Brattle Group's analysis can be used in combination with the drought frequency analysis described above in Section 3.1 to estimate potential economic impacts during a prolonged drought (e.g., SFPUC's Design Drought) or a standard 30-year planning period.

[3] The subset of industrial sectors that are particularly sensitive to curtailments in water supply (e.g., computer and electronic manufacturers, food and beverage manufacturers, and biotechnology) would be significantly affected by drought and that these issues would be compounded if the drought shortage conditions lasted multiple years (Wade 2005).

3.2.1.1 Estimated Economic Losses During the Design Drought

Table 3-7 presents the potential total business sales losses for the Design Drought scenario. As shown in Figure 3-2, the 1987 to 1994 hydrologic period under the Design Drought sequence modeled with HH/LSM (using the Intermediate Demand Scenario) had 4 instances of a 10 percent shortfall and 3 instances of a 20 percent shortfall (see Figure 3-2). If similar hydrologic conditions were to occur again, each year with a 10 percent shortfall could experience a business sales loss of $0.44B and each year with a 20 percent shortfall could experience a business sales loss of $2.02B, adding up to a total over the extended drought period of losses of $7.8B (for FY 2010-2011 conditions). If FY 2035-2036 conditions are assumed, each year with a 10 percent shortfall could experience a business sales loss of $1.72B and each year with a 20 percent shortfall could experience a business sales loss of $8.87B, adding up to a total losses of $33.49B over the extended drought period.

Table 3-7. Estimates of Total Business Sales Losses by Shortage Scenario for the Design Drought Period Using HH/LSM Drought Frequency Analysis

Percent Reduction of SF RWS Supply	Estimated Occurrences over the Design Drought	Total Lost Sales for FY 2010-2011 Conditions ($ B)	Total Lost Sales for FY 2035-2036 Conditions ($ B)
10	4	$1.76	$6.88
20	3	$6.06	$26.61

3.2.1.2 Estimated Economic Losses During a Thirty-Year Planning Period Based on Historical Drought Recurrence

Table 3-8 presents the potential total business sales losses for different shortage scenarios during a 30-year planning period using the historical hydrologic sequence. The HH/LSM model results estimate that a 10 percent system-wide supply reduction (i.e., Action Level 2) has a 13-year return period for the Intermediate Demand Scenario in the BAWSCA service areas for the historical hydrologic sequence. If three such dry years occur in a 30-year planning period, the economic impact of a 10 percent SFPUC water supply shortage could result in approximately $1.32B in losses for FY 2010-2011 conditions and $5.16B in losses for FY 2035-2036 conditions. The 20 percent system-wide SFPUC supply shortage is estimated to occur just once in 91 years for the historical hydrologic sequence under the Intermediate Demand Scenario, which could result in $2.02B in losses for FY 2010-2011 conditions and $8.87B in losses for FY 2035-2036 conditions in a 30-year planning period.

Table 3-8. Estimates of Total Business Sales Losses by Shortage Scenario for an Average 30-year Planning Period Using HH/LSM Drought Frequency Analysis

% Reduction of SF RWS Supply	Estimated Occurrences over a 30-year Planning Period	Total Lost Sales for FY 2010-2011 Conditions ($ B)	Total Lost Sales for FY 2035-2036 Conditions ($ B)
10	3	$1.32	$5.16
20	1	$2.02	$8.87

3.2.2 Estimated Impacts to the Residential Sector

Drought impacts on the residential sector can include: voluntary or mandatory restrictions for water lawns, washing cars, washing driveways and sidewalks, or filling swimming pools; mandatory water use cutbacks; and increasing water rates and excess use charges. Under extreme drought conditions, all outside water use may be prohibited in the residential sector.

Drought impacts for the residential sector are expected to be compounded in the future as a result of demand hardening (i.e., as conservation measures are increasingly implemented and per capita water use declines, it becomes more difficult to save the next increment of water without applying more drastic measures, such as eliminating landscape irrigation). This is particularly an issue in the BAWSCA service area where residential per capita demand is already low as compared to other portions of the Bay Area and the State.

The SFPUC released estimates of potential annual welfare losses in the region due to shortages on the SF RWS from varying levels of shortage using both FY 2010-2011 conditions and estimated FY 2035-2036 conditions (The Brattle Group 2013). The estimated annual welfare losses are presented in Table 3-9.

Table 3-9. Brattle Group Report Estimates of Annual Welfare Losses by Shortage Scenario

Percent Reduction of SF RWS Supply	Annual Welfare Losses in FY 2010-2011 ($ B)	Annual Welfare Losses in FY 2035-2036 ($ B)
10	$0.07	$0.53
20	$0.23	$1.89

Source: The Brattle Group 2013

The majority of the annual losses presented in Table 3-8 would be experienced by single family residential customers, however, the total value of welfare losses presented here includes impacts to all sectors. It is important to note that the welfare losses should not be added to the economic losses presented in Section 3.2.1, as the welfare losses are calculated using a different methodology and are not readily comparable to the calculation of lost business sales.

3.2.3 Regional Nature of Drought Impacts

It is important to recognize that the potential impacts of drought to the BAWSCA member agencies are regional and not just limited to individual cities or water districts. For example, the severity of the potential drought impact to the commercial and industrial sectors could cause relocation of businesses for which a reliable water supply is critical. The loss of this commercial and industrial base would undoubtedly weaken the regional economy.

A drought-year water supply shortfall in one BAWSCA agency that results in loss of jobs or other impacts can have a detrimental effect on customers of another BAWSCA agency, even if that agency is not facing a supply shortfall. As such, it is important to consider the impacts of drought regionally when weighing the costs and benefits of investing in additional drought reliability.

The residents and voters in one community often work or own businesses in another community within the BAWSCA service area or neighboring communities. Using socioeconomic development data provided by the Association of Bay Area Governments and a transportation model of the Bay Area, the Metropolitan Transportation Commission (MTC) estimated residential commutes between Bay Area Counties from 2010 to 2035 (MTC 2008). In 2010, a large portion of jobs within the Alameda, San

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Mateo, and Santa Clara counties were staffed by employees who reside within the same county (68 percent, 53 percent, and 83 percent, respectively). However, 14 percent to 19 percent of jobs were staffed by employees who reside in the other BAWSCA member agency counties (e.g., reside in Alameda County but work in San Mateo County). Roughly the same percentage on inter-county employment is expected out to 2035, 12 percent to 18 percent across the three BAWSCA counties (MTC 2008). This employment and commute information is indicative of the dependence of the employment base on the region.

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Section 4

Viable Options: Water Supply Management Projects

4.1 A Wide Range of Options were Considered from 2009 to Present

A key objective of the Strategy is to identify and evaluate water supply management projects that could be developed to meet the future drought year water needs of the BAWSCA member agencies through 2040. A wide range of potential projects have been evaluated as part of the Strategy. These projects fit into three general categories:

1. Agency-identified water supply management projects – local projects identified by the BAWSCA member agencies in addition to agencies' already planned investments (e.g., recycled water, groundwater, and coastal desalination);

2. Local capture and reuse projects (e.g., rainwater harvesting, stormwater capture, and graywater reuse); and

3. Regional projects identified by BAWSCA staff and the consultant team, including groundwater, brackish or Bay water desalination, and water transfers.

4.2 Options were Reduced to a Subset that Best Meet Criteria

At each stage of the Strategy, potential projects were developed, reviewed, and refined to identify the projects most feasible to move forward into the next phase of analysis. Local capture and reuse projects have been retained throughout the Strategy, while the agency-identified projects and regional projects have been narrowed.

The *Phase I Scoping Report* classified 65 agency-identified projects as existing, planned, or potential opportunities that could be included in the Strategy. These agency-identified Strategy projects would be implemented in addition to the non-SFPUC supply investments already planned and being made by the BAWSCA member agencies, which are shown in Section 2. Early in Phase II, a project refinement and screening process included extensive coordination with the BAWSCA member agencies. In 2012, the *Phase II A Report* presented 10 agency-identified projects retained for further evaluation.

Consistent with planning objectives reviewed with the BAWSCA Board, BAWSCA chose to respect individual agency efforts and not take over planning and/or implementation of any agency-identified projects, but rather assist the planning process from the outside by potentially providing support to these projects. After additional discussions with member agencies about project priorities, timing, and information development, this *Strategy Phase II Final Report* presents five agency-identified projects. The remaining agency-identified projects are not being evaluated further as part of the Strategy based on the screening criteria agreed upon by the BAWSCA member agencies. Projects were not retained to be a part of the Strategy for any of the following reasons: 1) an agency chose to independently implement a project; 2) an agency was not interested in being a proponent of the project as a part of the Strategy; 3) the project did not provide any additional supply; 4) regulatory restrictions impeded implementation; 5) no regional benefit was found to come from the project; 6) the project implementation schedule did not fit within the timeline of the Strategy; and 7) the project was deemed infeasible due to water quality issues. The agency-identified project refinement process is summarized in Figure 4-1.

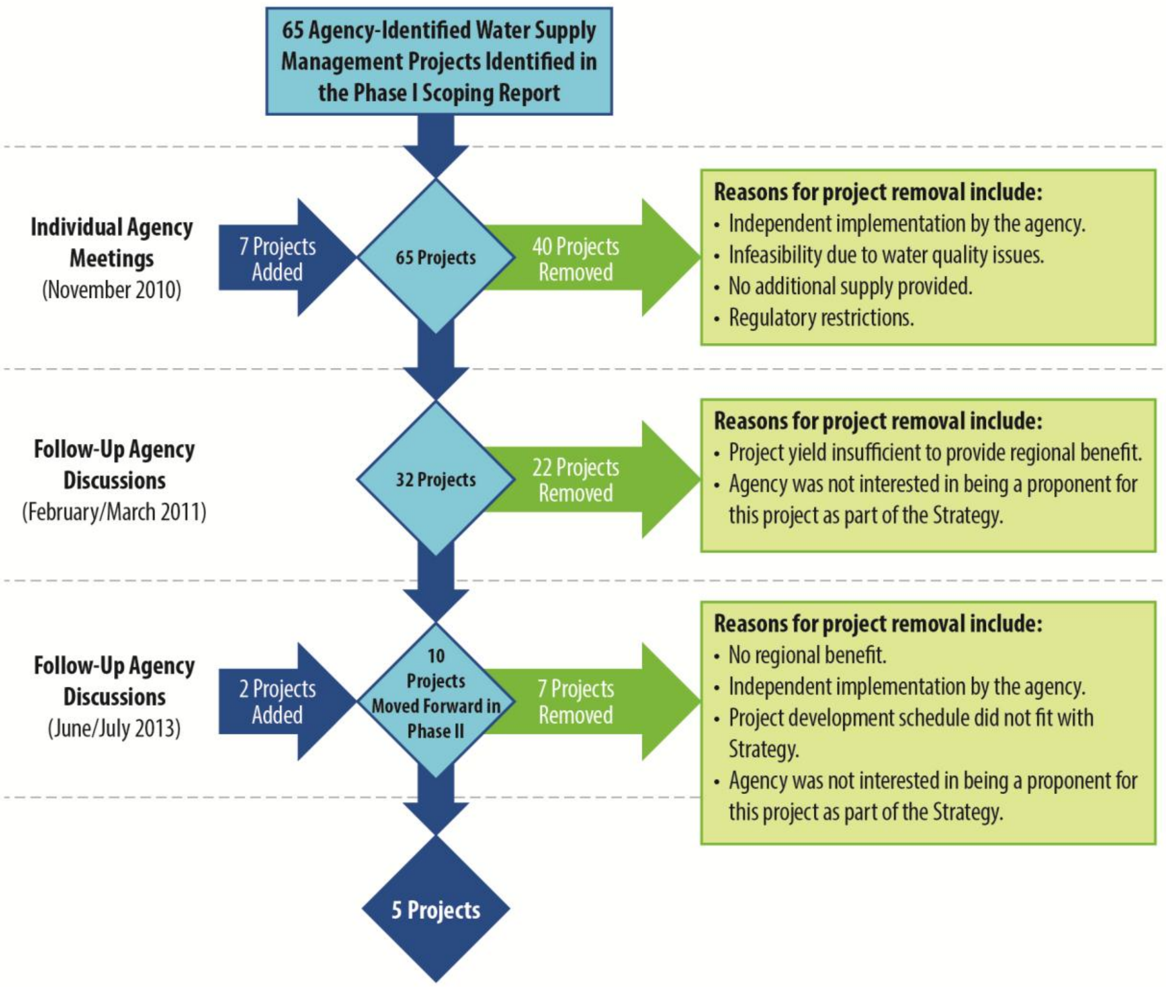

Figure 4-1
Number of Agency-Identified Projects Refined From 65 to 5 During Phase II

The Strategy was developed to investigate the reliability of SFPUC supplies and identify projects that will assist in meeting the supply need created by drought cutbacks on deliveries from the SF RWS. BAWSCA member agency non-SFPUC supplies may also face changes in reliability in the future. The agency-identified Strategy projects will increase the reliability of member agency supplies on the local level.

The *Phase I Scoping Report* also identified potential regional projects. After the number and type of regional projects were narrowed based on review of existing data, discussions with potential partners, and interest by the BAWSCA member agencies, the *Phase II A Report* identified 18 regional projects for further consideration. Since that time, several recommendations from the *Phase II A Report* have been implemented and work has been advanced on several of the regional projects to better assess their feasibility. This *Strategy Phase II Final Report* retains three regional projects: two desalination projects and water transfers. The rest of the regional projects are not being evaluated further as part of the Strategy based on the screening criteria.

The following list presents: 1) the agency-identified projects; 2) the local capture and reuse projects; and 3) the regional projects retained for development and evaluation in this *Strategy Phase II Final Report*:

- Agency-identified projects
  - Recycled water projects:
    - City of Daly City – Recycled Water Expansion Project, Colma Expansion,
    - City of Mountain View – Increase Recycled Water Supply from Palo Alto Regional Water Quality Control Plant (RWQCP),
    - City of Palo Alto – Recycled Water Project to Serve Stanford Research Park,
    - City of Redwood City – Regional Recycled Water Supply,
  - Groundwater project: City of Sunnyvale – Expanding the Use of New or Converted Wells to Normal Year Supply,
- Local capture and reuse projects
  - Rainwater capture
  - Stormwater capture
  - Graywater reuse
- Regional projects:
  - Desalination projects
    - Open Bay intake desalination,
    - Brackish desalination
  - Water transfers project:
    - Water transfer with EBMUD or SCVWD.

In order to allow comparison among the projects retained for further evaluation within the Strategy, key project information was developed in coordination with the BAWSCA member agencies. The following sections summarize the information developed to date for the costs, facilities, supply reliability, and implementation schedule. Figure 4-2 presents the location of the projects and summary information on yield and cost.

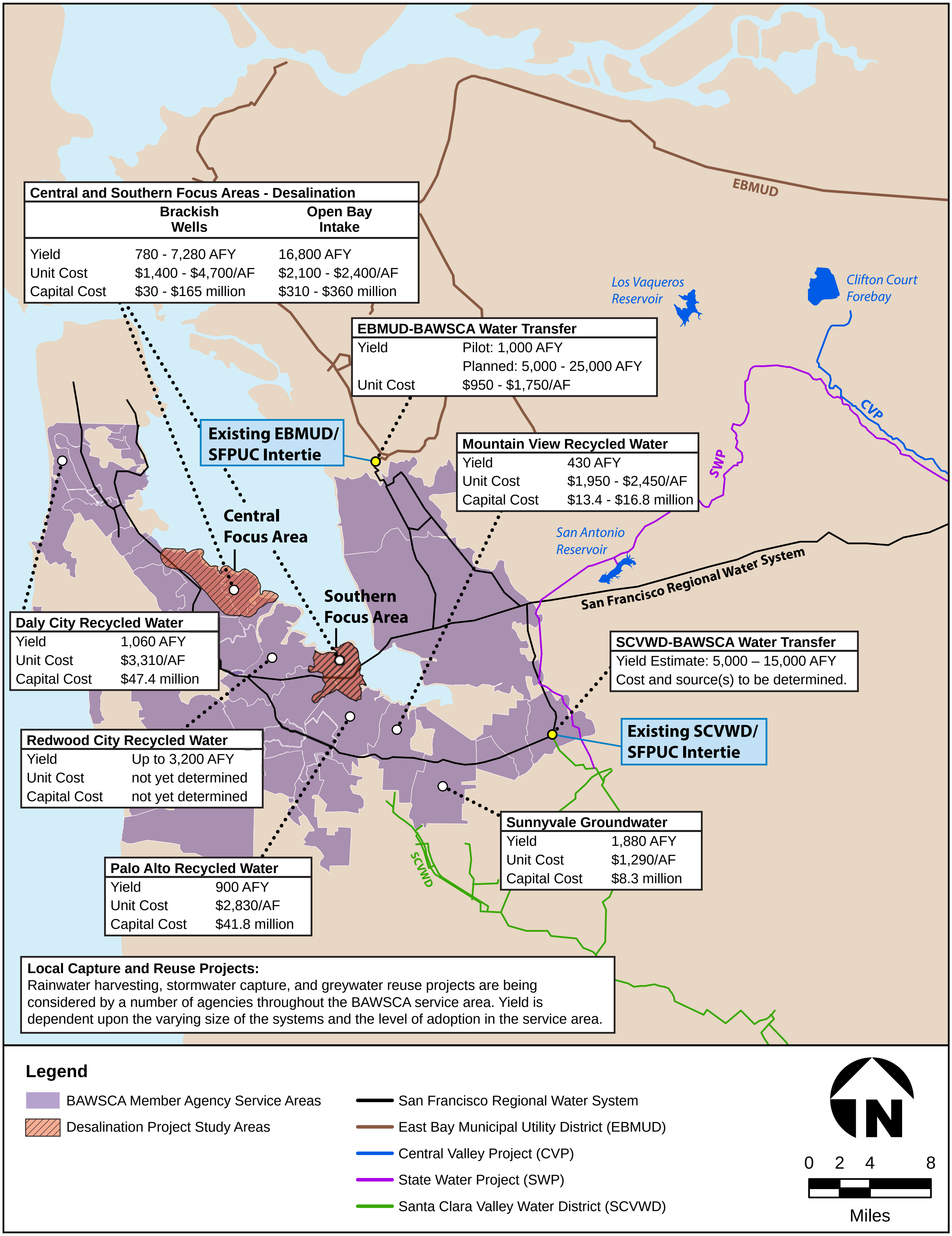

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Figure 4-2
Strategy Water Supply Management Projects

4.2.1 Recycled Water Projects

Several BAWSCA member agencies are producing tertiary treated recycled water for non-potable irrigation and industrial uses. The recycled water projects identified for the Strategy are expansions of existing non-potable systems and would offset the use of potable water in the BAWSCA service area. Other recycled water projects were identified over the course of the Strategy development, but are not included in the Strategy because they are being implemented by individual member agencies or provide no regional supply benefit.

The recycled water projects described in this section include:

- City of Daly City – Colma Expansion Project
- City of Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP
- City of Palo Alto – Recycled Water Project to Serve Stanford Research Park
- City of Redwood City – Regional Recycled Water Supply

Table 4-1 summarizes the project facilities, yield, cost, schedule, and other details.

Potable Reuse Opens Up New Supply Alternatives

The three-year period of drought through 2014 has heightened the review of alternative water supplies, and potable reuse - either indirectly into groundwater basins or directly into a water system - is receiving greater consideration in the Bay Area. If public perception, regulatory considerations, and any remaining technical hurdles can be addressed, potable reuse could provide a large quantity of reliable supply that could have a lower cost and fewer environmental impacts compared to other alternatives. Multiple research efforts are ongoing in the following areas: regulatory concerns; utility concerns; and community concerns (WateReuse Research and WateReuse California 2014).

Currently, there are seven major indirect potable reuse projects in California that supply approximately 190,000 acre-feet per year (AFY). California's most notable indirect potable reuse project is the Groundwater Replenishment System in Orange County which supplies over 100 mgd. SCVWD has also recently commissioned an 8-mgd advanced treatment facility and is considering multiple potable reuse options. In addition, the City of Sunnyvale recently executed an agreement with SCVWD to expand the City's recycled water facilities to produce up to 10 mgd of advanced treated water. SCVWD has convened a National Water Research Institute independent advisory panel on the topic of evaluating potable reuse.

Throughout 2014, BAWSCA participated in discussions with the SFPUC and SCVWD regarding paths to implementation of potable reuse. BAWSCA will continue to monitor development plans for recycled water projects (both new projects and expansions) and, where appropriate, encourage implementation of potable reuse. The following opportunities are under consideration and may have potential to include potable reuse:

- The Cities of San Mateo and Foster City/Estero Municipal Improvement District (EMID) will soon begin work on a recycled water feasibility study to examine potential project alternatives and costs (City of San Mateo 2014). The cities have previously identified combined peak summer demands for non-potable recycled water of up to approximately 3.3 mgd.
- Silicon Valley Clean Water (SVCW) and Palo Alto RWQCP facilities have additional capacity to expand recycled water production.
- West Bay Sanitary District is investigating satellite treatment facilities for irrigation uses or potentially indirect potable reuse.
- City of Hayward is proposing to expand its recycled water capacity by 0.5 mgd.

Table 4-1. Summary of Recycled Water Projects

Project Attribute	City of Daly City – Colma Expansion Project	City of Palo Alto – Recycled Water Project to Serve Stanford Research Park	City of Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP	City of Redwood City – Regional Recycled Water Supply
New Production (mgd)	2.3	0.8	0.52	Up to 2.9
Yield (AFY)	1,060	900	429	Up to 3,200
Capital Costs (million dollars [$M)]	$47.4[1]	$41.8[1]	$13.4 - $16.8[2]	Not determined
Present Worth Unit Cost ($/AF)	$3,310[1]	$2,830[1]	$1,950 - $2,450[2]	Not determined
Estimated Supply Delivery	2018	2017	2017	Not determined
Infrastructure	2.3-mgd recycled water treatment facility; 3-million gallon (MG) storage tank; 1,620-gallons per minute (gpm) pump station; 4,610-gpm pump station; 44,350 feet of pipelines	350-horsepower (HP) booster pump station at the RWQCP; 400-HP booster pump station; 2900 feet of pipelines	1.8-MG storage tank; booster pump station; 23,000 feet of pipelines	Dependent upon regional water supply scenario; some require upgrades to existing facilities; all scenarios require storage, pumping, and pipelines outside of Redwood City. Current limiting factor is lack of demand by potential partners.
Estimated Total Dissolved Solids (TDS) of Supply (milligrams per liter [mg/L])	500	600	600	650-750
Coordination Necessary with Other Entities/Outside Customers	Colma, San Bruno, cemeteries, California Golf Club, schools	Stanford Research Park	Palo Alto RWQCP, National Aeronautics and Space Administration (NASA)	SVCW, potential customers outside of Redwood City

1 Costs in 2014 dollars based on Engineering News-Record (ENR) Construction Cost Index (CCI) for August 2014 of 9846, escalated from data provided by member agencies.
2 City of Mountain View 2014

4.2.1.1 City of Daly City – Colma Expansion Project

The City of Daly City is pursuing an extension of its recycled water system to serve additional irrigation demand within their city, Colma, and San Bruno.

Description

The Daly City recycled water expansion project includes a 2.3-mgd expansion of tertiary treated recycled water production at Daly City by constructing a new recycled water treatment facility. The project would include recycled water treatment, storage, pumping, and a distribution system to serve irrigation customers within Daly City, Colma, and San Bruno, including cemeteries, parks, schools, and a golf course. These irrigation customers currently use private groundwater wells that extract groundwater from the Westside Groundwater Basin or potable water served by California Water Service Company's (Cal Water's) South San Francisco System to irrigate turf and other landscaping. Converting these irrigation customers to recycled water would enable other uses of potable supplies.

Yield

The Daly City recycled water expansion project is designed to meet the estimated combined annual demand of the irrigation customers of about 1,060 AFY with the ability to meet the peak daily demand of 2.3 mgd.

Cost

The present worth cost for the Daly City Colma Expansion Project is about $3,310/AF[1], based on costs provided by Daly City for treatment, storage, pumping, transmission, distribution, conveyance, operations and maintenance (O&M) costs, and other costs.

Project Implementation Schedule

The design phase is expected to begin in 2015 and construction in 2016, lasting 24 months with completion in 2018.

4.2.1.2 City of Palo Alto – Recycled Water Project to Serve Stanford Research Park

The City of Palo Alto is pursuing an extension of its recycled water system to serve the Stanford Research Park and other customers along the pipeline route, primarily for landscaping uses. This project would use existing capacity within the Palo Alto RWQCP, and would require construction of new pipelines and pumping capabilities.

Description

Palo Alto owns and operates the RWQCP, which treats wastewater for six communities and districts including Los Altos, Los Altos Hills, Mountain View, Palo Alto, Stanford University and the East Palo Alto Sanitary District. This project would involve construction of approximately 5.5 miles of 6- to 18-inch pipeline, a 400-HP booster pump station, and a 350-HP pump station at the RWQCP (City of Palo Alto 2011). The project will serve numerous users along the pipeline route, primarily the Stanford Research Park. Other areas that could be served by the project include public spaces and commercial uses in the City of Palo Alto.

Yield

The recycled water system extension would provide average annual and peak demands estimated to be 0.8 mgd and 2.0 mgd, respectively, with an estimated annual yield of 900 AFY (City of Palo Alto 2011). The potential recycled water customers, their demands, projections of delivered water quantity, and annual yield may be updated based on the Environmental Impact Report (EIR) currently being prepared by Palo Alto.

Cost

The present worth cost for the Palo Alto recycled water expansion project is about $2,830/AF[2], based on costs provided by Palo Alto for pipelines, pump stations, treatment, O&M costs, and other costs.

Project Implementation Schedule

The project is undergoing environmental review and Final EIR is expected in June 2015. Engineering design would be completed between mid-2015 and mid-2016. Project construction is estimated to require 12 months with completion in mid-2017.

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[1] Costs in 2014 dollars based on ENR CCI for August 2014 of 9846.

[2] Costs in 2014 dollars based on ENR CCI for August 2014 of 9846.

4.2.1.3 City of Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP

The City of Mountain View provides recycled water produced from the Palo Alto RWQCP and has identified a project to expand recycled water service to maximize the use of their allotted supply from the RWQCP.

Description

Mountain View completed a Recycled Water Feasibility Study in March 2014, which identified a total recycled water demand for existing and potential customers of about 2,130 AFY (Carollo 2014). This estimate includes additional irrigation, indoor use, and industrial use identified within the city limits and in adjacent developed areas. Mountain View staff has recommended pursuing Alternative 1 from the Feasibility Study, based on the estimated cost, the amount of estimated demand, and the potential for a significant portion of the infrastructure to be constructed with, and potentially cost shared with, the Bay View development at the NASA site (City of Mountain View 2014). The project includes 23,000 feet of new pipeline, a 1.8-MG reservoir, and a booster pump station.

Mountain View has been working with Palo Alto on a salinity reduction program, including lining several sewer pipelines. Additional lining projects are planned to extend the life of the sewers and further reduce salinity in the wastewater that enters the Palo Alto RWQCP. These projects will be a prerequisite to extending the term of Mountain View's agreement for recycled water from the RWQCP.

Yield

The additional demand served by the expansion is estimated to be 0.5 mgd, about 430 AFY (City of Mountain View 2014). Alternative 1 would serve 24 customers in the North Bayshore Area and 7 new customers on the NASA site.

Cost

The estimated unit cost for the recommended expansion ranges from $1,950 to $2,450/AF (City of Mountain View 2014). Mountain View continues to work with the Bay View development staff to develop the pipeline alignments necessary within their project site, and will continue to develop Alternative 1 before finalizing the project's necessary infrastructure and costs.

Project Implementation Schedule

Mountain View staff indicated they will return to the City Council in early 2015 with a more clearly defined project proposal, including alignments for the Bay View development, and funding strategies. The design phase is expected to occur in 2015-2016, and construction in 2016-2017 (Carollo 2014).

4.2.1.4 City of Redwood City – Regional Recycled Water Supply

Redwood City completed their "Water Recycling Feasibility Study Update" in 2012 which identified options for expanding recycled water distribution inside and outside the city (Kennedy/Jenks Consultants 2012). Redwood City receives recycled water produced at SVCW. This project considers options for serving recycled water outside of city limits to other BAWSCA agencies.

Description

Redwood City's Feasibility Study Update identified several scenarios for providing a regional water supply, making use of recycled water beyond the amount planned for system build out within the city boundaries.[3] The scenarios assume that all recycled water produced at SVCW beyond what is needed for Redwood City's demands would be available to serve customers outside of Redwood City. The options include: 1) operating the existing facilities as currently permitted and assuming existing flow patterns at SVCW; 2) operating the existing facilities as currently permitted and assuming future flows at SVCW (12 percent higher than current flows); and 3) optimizing existing treatment, storage, and pumping facilities and/or construction of additional storage at SVCW and assuming future flows (Kennedy/Jenks Consultants 2012). In all scenarios, new storage and distribution infrastructure outside of the city would be the responsibility of the outside customers.

Yield

The three scenarios described above could provide 2,574 AFY, 2,792 AFY, and 3,208 AFY, respectively, for export to outside agencies (Kennedy/Jenks Consultants 2012). The yields, however, are significantly greater than identified regional demand adjacent to Redwood City represented by Cal Water and EMID. These two agencies provide supply to San Carlos, San Mateo, and Foster City. The projected demand for recycled water is less than 400 AFY for Cal Water (Cal Water 2011), and zero for EMID (EMID 2011).

Cost

Costs were not developed for these scenarios due to the lack of an identified market at this point among those most proximate to the project. The initial assessment of Cal Water is that the costs are too high based on the need to connect to stub-outs at the city boundary and provide their own distribution lines and storage facilities. Redwood City has no plans to assess market demand further at this point beyond currently their currently identified projects. If the recycled water supply could be treated for potable reuse, there could be potential market opportunities. At this point in time, this project is not carried forward in the rest of the Strategy.

4.2.2 Groundwater Project

Description

The City of Sunnyvale is planning a project in expand its use of new or converted wells for normal year supply. Several wells were completed in 2013, providing 1,800 gpm for the city's supply. Two additional wells can be converted to normal year supply which would reduce the city's reliance on water from the SF RWS[4]. Table 4-2 summarizes the project facilities, yield, cost, schedule, and other details.

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[3] Redwood City has planned and designed their Phase 1 facilities to accommodate up to 273 AFY of recycled water supply to customers outside of the city (Kennedy/Jenks Consultants 2012). No additional treatment, storage, conveyance, or pumping within Redwood City would be necessary to make use of this supply. Outside customers would connect to stub-outs at the city boundary, and provide their own distribution lines and potentially storage facilities. This project is not suitable to include in the Strategy due to its limited supply, approximately 0.25 mgd, and because the identified customers are currently SFPUC retail customers, providing no regional benefit to the BAWSCA service area.

[4] Sunnyvale's Individual Supply Guarantee (ISG) for SFPUC water is 12.58 mgd; however, the city also has a required minimum purchase of 8.93 mgd. While additional groundwater supply would provide additional supply reliability for the city, the minimum purchase of 8.93 mgd of SF RWS supply would still apply.

Table 4-2. Summary of Sunnyvale Groundwater Project

Parameter	Value
New Production (mgd)	2.1
Normal Year Yield (AFY)	2,350
Drought Year Yield (AFY)	1,880
Capital Costs ($M)	$8.31
Present Worth Unit Cost ($/AF)	$1,230 - $1,350[1]
Estimated Supply Delivery	2019
Infrastructure	600-gpm well, 860-gpm well
Estimated TDS of Supply (mg/L)	405
Coordination Necessary with Other Entities/Outside Customers	Potential for partnerships with Santa Clara, Mountain View, Palo Alto, Cal Water, SCVWD

Notes:
[1] Costs in 2014 dollars based on ENR CCI for August 2014 of 9846, escalated from data provided by member agency. Cost range accounts for normal and drought year operation. Cost includes SCVWD's water year 2014-2015 groundwater production charge of $747/AF for municipal and industrial pumping facilities in Zone W-2 (SCVWD 2014).

Yield

Sunnyvale's two wells have a combined capacity of 1,460 gpm. The normal year supply would be 2,350 AFY. In drought years, the estimated supply would be 1,900 AFY[5].

Cost

The present worth cost for the Sunnyvale well conversion project ranges from $480/AF to $600/AF[6] for normal and dry year operation, respectively, based on costs provided by Sunnyvale for well upgrades and conveyance. No additional treatment or storage is necessary. In addition, SCVWD charges a groundwater production fee, established annually, for municipal and industrial groundwater pumping facilities in the Santa Clara Valley Subbasin. For water year 2014-2015, the charge is $747/AF (SCVWD 2014). This brings the total cost of the groundwater project to $1,230/AF to $1,350/AF.

Project Implementation Schedule

Conversion of these two wells is dependent upon upgrading their distribution system pipelines to accommodate the increased capacity. The cost of these infrastructure improvements have not been estimated by Sunnyvale. This has put implementation on hold for several years, with completion anticipated in 2019.

4.2.3 Desalination Projects

A wide range of desalination projects have been considered for the Strategy, ranging in size from 1 mgd to 20 mgd, and ranging in type from brackish groundwater to an ocean water open intake. Options have been eliminated as project preferences have been refined, and two types of projects are carried forward in this *Strategy Phase II Final Report*: 1) a project that produces 15 mgd of water sourced from an open intake in San Francisco Bay; and 2) a project that produces up to 6.5 mgd from brackish water sourced from either shallow vertical brackish groundwater wells or horizontal directionally drilled (HDD) wells extracting higher salinity brackish groundwater from under the Bay. For the Strategy, a project that would use either a vertical or horizontal well is referred to as a

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[5] Based on normal year and drought year yields provided by the City of Sunnyvale.

[6] Costs in 2014 dollars based on ENR CCI for August 2014 of 9846.

"brackish desalination project." Cost estimates were developed for a range of 0.7 mgd to 6.5 mgd for a brackish desalination project.

This section discusses desalination project feasibility in terms of treated water capacity, estimated costs, land availability, brine disposal, and permitting. Figure 4-3 presents these elements and the inputs to determining feasibility. Potential next steps, such as pilot studies and test wells, are also discussed. As shown in this section, brackish water desalination projects compare favorably with open intake desalination projects based on increased regulatory hurdles, costs, and issues with land availability and brine disposal associated with the latter.

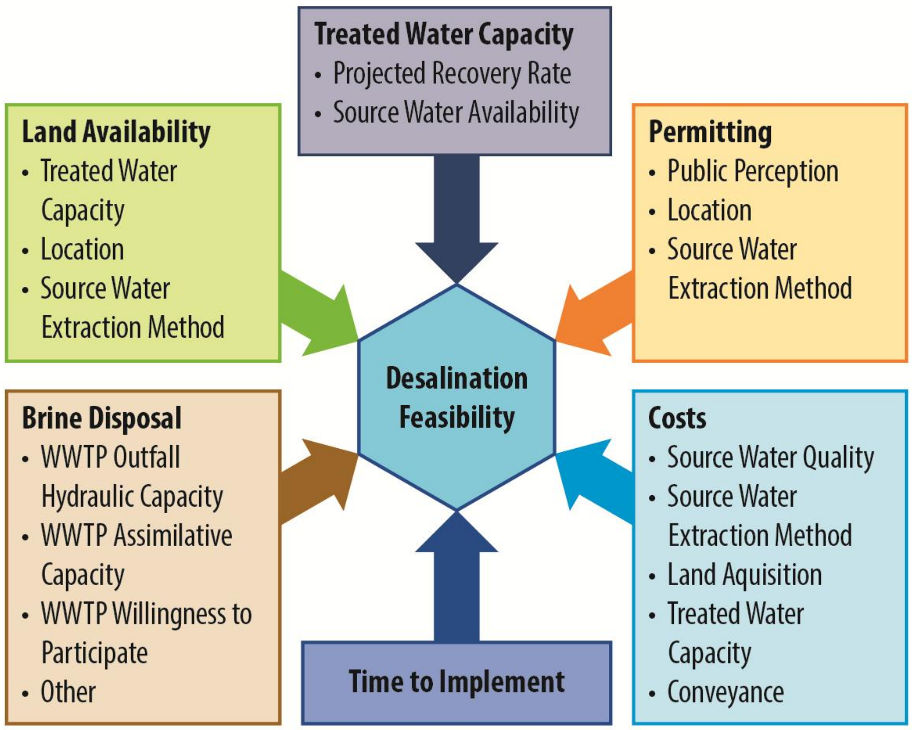

Figure 4-3
Desalination Project Feasibility Considerations

4.2.3.1 Desalination Scenarios

Earlier phases of the Strategy identified three focus areas for potential desalination project sites based on the availability of wastewater treatment plant (WWTP) outfalls that could be utilized to dispose of desalination brine. After further analysis (see Appendix A, *Estimated Pumping Yields and Potential Effects from the Production of Brackish Groundwater for Desalination*) regarding the availability of brackish groundwater and meetings with several WWTP operators, two of the areas remain potentially viable for a desalination project: a Southern Focus Area (SFA) near the Dumbarton Bridge; and a Central Focus Area (CFA) near the San Mateo Bridge. These Focus Areas are shown in Figure 4-4.

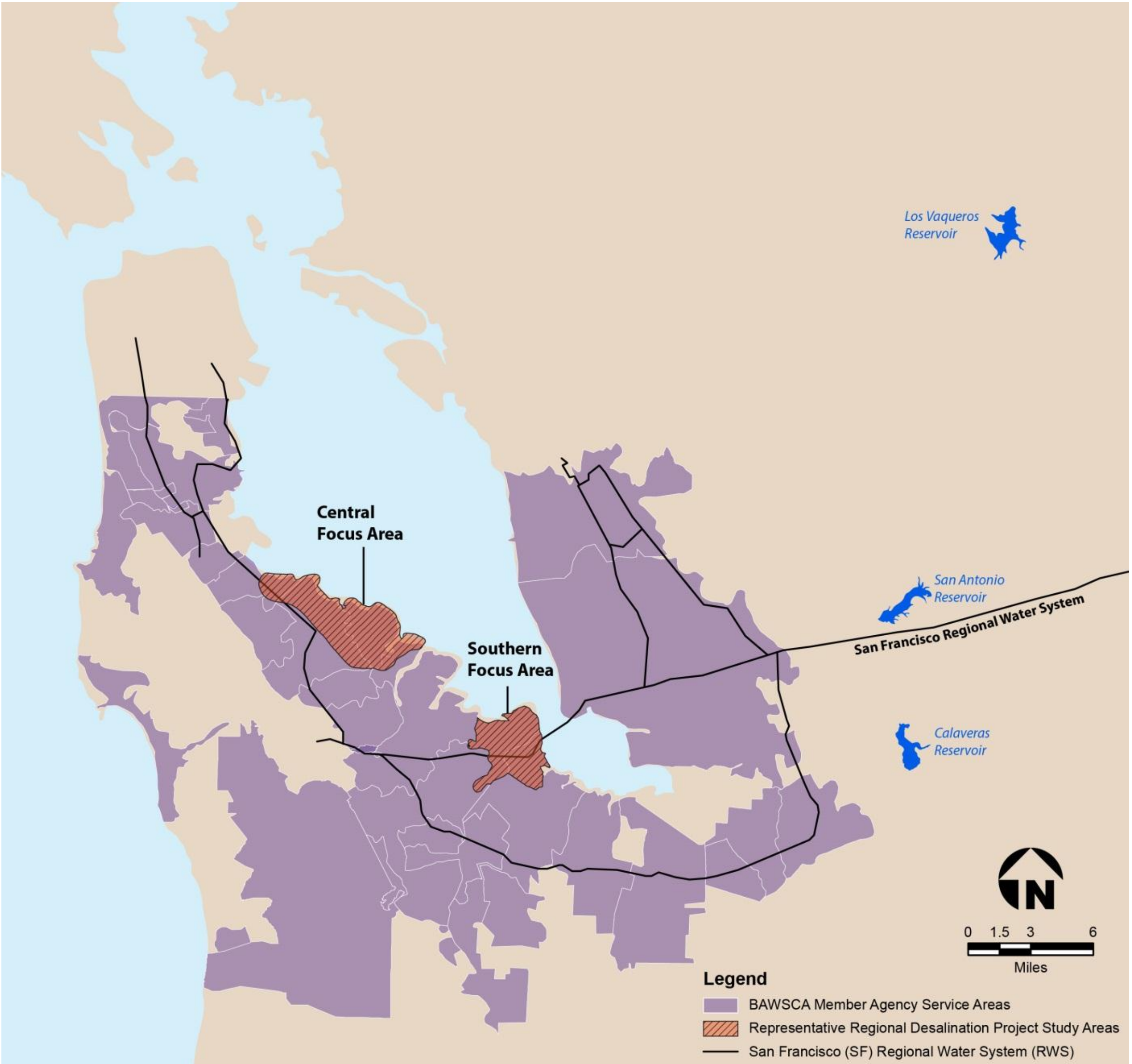

Figure 4-4
Central and Southern Focus Areas

The assumptions used to determine cost estimates and other logistics include the following:

- The desalination projects considered are:
  - Up to 6.5 mgd sourced from brackish groundwater from either:
    - shallow vertical wells (up to 3.5 mgd only), or
    - an HDD well (up to 6.5 mgd), and
  - 15 mgd sourced from an open Bay intake
- A project in the CFA would deliver water into SFPUC Turnout 99 in City of Hillsborough, and a project in the SFA would deliver water to SFPUC Turnout 10 in City of East Palo Alto.

- Open Bay water intake project cost estimates assume that the intake would extend 6,000 feet offshore.
- Brackish groundwater from the shallow aquifer is assumed to have a TDS concentration of 10 grams per liter (g/L). Bay water sources are assumed to have a TDS concentration of 25 g/L. Subsurface horizontal wells would most likely extract a mixture of brackish groundwater and Bay water, with a salinity between 10 and 25 g/L TDS. This analysis assumes 16 g/L TDS to represent water extracted from HDD wells under the Bay.
- Assumed recovery rates (i.e., water produced as a percentage of total raw water processed) are 50 percent for Bay water open intake, 65 percent for subsurface Bay water, and 70 percent for brackish groundwater.
- The projects in the CFA could potentially discharge brine to the outfall of the San Mateo WWTP or SVCW. A plant in the SFA could discharge brine to the outfall of the Palo Alto RWQCP.

Desalination project scenarios evaluated in this document are summarized in Table 4-3. Estimated unit costs of water are also included in the table and are discussed further in the following sections.

Table 4-3. Desalination Project Scenarios

Project Type	Assumed Raw Water TDS (g/L)	Recovery Rate	Brine TDS (g/L)	Treated Water Capacity (mgd)	Raw Water Capacity (mgd)	Brine Production (mgd)	Unit Cost of Water ($/AF)
Brackish Vertical Wells	10	70%	33	0.7	1	0.3	3,600 - 4,700
				1	1.4	0.4	2,600 - 3,600
				1.4	2	0.6	2,100 - 2,900
				3.5	5	1.5	1,400 - 1,900
Brackish HDD Well	16	65%	46	1	1.5	0.5	3,000 - 3,800
				3.3	5	1.75	1,900 - 2,400
				5.0	7.7	2.7	1,800 - 2,200
				6.5	10	3.5	1,600 - 2,000
Open Bay Intake	25	50%	50	15	30	15	2,100 - 2,400

4.2.3.2 Treated Water Capacity

Because desalination technology is not 100 percent efficient, more raw source water is needed than will be produced as potable water (produced water); the treatment process separates raw source water into concentrated brine wastewater and potable drinking water. Potable water demand drives the need for a desalination project in the Bay Area, and as a result the potential produced water capacity is used to evaluate project feasibility.

Groundwater modeling has shown that approximately 3 mgd of brackish vertical well[7] sourced supply may be available in the CFA or SFA (see Appendix A for details on groundwater modeling results). There are a number of factors that contribute to uncertainty in the brackish desalination project yields, including potential future drawdown from planned regional increases in groundwater use. However, well yield is most sensitive to the hydraulic conductivity of both the shallow aquifer and the

[7] Note: this may require multiple wells with adequate hydrogeologic spacing to achieve these yields.

Bay Mud. Further testing is needed to firmly estimate potential yield in the area, as discussed in Appendix A. High Bay Mud conductivity may result in a higher potential yield for an HDD well-sourced supply. For the purposes of a preliminary feasibility discussion, an up to 3.5 mgd brackish desalination project is considered. Cost estimates also include scenarios up to 6.5 mgd for HDD well sources to include the full range of potential yields under the Bay.

An open intake desalination project with a produced water capacity of 15 mgd was selected for inclusion in the Strategy based on available vacant land on which to build a plant, brine disposal constraints, and intake, plant construction, and O&M costs.

4.2.3.3 Project Cost Estimates

Project cost estimates presented in this section include capital costs associated with project construction (including all pipelines conveying raw water, potable water, and brine waste), and also include O&M costs over an assumed 30-year project life. The costs were developed based on continuous operation. The case for intermittent operation is also addressed below. Land acquisition and brine disposal costs are not included in the project cost estimates[8].

Conveyance costs are greatly influenced by pipe routing. To develop cost estimates, a realistic range of potential pipe lengths was identified by developing pipe routes for several of the potentially available parcels identified in the Land Availability section.

The cost estimation methodology used in the *Phase II A Report* was refined based on updated information on chemical costs, recommended treatment practices, recovery rates, and additional examples of recently developed desalination plants. This refined cost estimation methodology (described in Appendix B) was applied to the range of desalination options currently under consideration. As with the costs estimated in the *Phase II A Report*, the refined cost estimates do not include land acquisition costs, which are discussed in the next section.

For each project type and size, a maximum likely cost and a minimum likely cost was developed based on the delivery and disposal pipe length estimates that were made for all parcels in the two focus areas. As discussed in Appendix B, these bracketed cost estimates were developed based on potentially available parcels, potential treated water delivery locations, and potential brine disposal locations.

Table 4-4 summarizes the refined cost estimates associated with the desalination scenarios evaluated. The present worth costs for the BAWSCA representative desalination projects, excluding site acquisition and brine discharge, range from $1,400 to $4,700/AF for inland brackish groundwater projects. The costs for HDD well projects range from $1,600 to $3,800/AF. The open water intake projects have an estimated present worth cost of between $2,100 and $2,400/AF. Inclusion of the site acquisition and brine disposal costs are expected to significantly increase the present worth costs of these representative projects.

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[8] Land acquisition costs were excluded from the cost estimates because there is a large variation depending on the desalination site location and the parcel size needed. Land acquisition costs are discussed in Section 4.2.3.4. Brine disposal costs were excluded from the cost estimates due to large uncertainties associated with regulatory brine disposal requirements and agency coordination. Potential brine disposal options are discussed in Appendix B, Section B.4.

Table 4-4. Refined Cost Estimate Summary[9]

	Open Bay Intake	Subterranean Bay HDD Well Intake				Inland Brackish Vertical Well Intake			
Treated Water Capacity (mgd)	15.0	1.0	3.3	5.0	6.5	0.7	1.0	1.4	3.5
Capital Cost ($M)	$309-362	$36-50	$77-104	$111-141	$128-164	$30-44	$31-45	$31-49	$47-72
Annualized Unit Cost ($/AF)	$2,150-2,370	$2,970-3,800	$1,930-2,420	$1,810-2,190	$1,650-1,990	$3,560-4,740	$2,650-3,570	$2,050-2,850	$1,380-1,870

For all intake types, costs decrease as treated water capacity increases. As can be seen from Table 4-4, higher-capacity brackish desalination is the most cost-effective option per unit produced water, either from shallow vertical wells or HDD wells.

For a project that is used primarily as a drought supply, the unit cost of water is dependent on the frequency of operations and/or how often drought occurs. To refine how unit costs of desalination might change, several drought operating scenarios were assessed. The open water intake desalination was evaluated assuming 20 percent operation during normal years and 100 percent operation during dry years. A Monte Carlo analysis examined 1,000 possible hydrologies, including the probability of drought, in a 30-year planning period. The resulting weighted average cost of total operation over a 30-year period, assuming a range of dry and normal year recurrence probabilities, is $4,950/AF for a 15-mgd open intake desalination project. Using the mixed normal year and dry year operation scenario, over the Design Drought (using the hydrology of 1965 to 1994), the weighted average cost is $3,490/AF. Brackish desalination projects were assumed to operate at 50 percent capacity during normal years and full capacity during dry years. The Monte Carlos analysis resulted in a weighted average long-term cost ranging from $2,950/AF for the 6.5-mgd plant to $7,090/AF for the 0.7-mgd plant. See Appendix C, Developing Costs for Drought-Dependent Desalination Supplies, for more detail on this methodology.

4.2.3.4 Land Costs

A search for property available for purchase across several San Francisco Peninsula municipalities showed general property values ranging from $1 to $3 million per acre. Specific sample properties are shown in Table 4-5. As expected, unit costs decreased as property size increased.

While property values in Table 4-5 average $4 million per acre, the San Mateo County Assessor's Office indicated that industrial properties in the Menlo Park and Redwood City areas tend to range in sales between $2 and $7 million per acre, a range that is consistent with the examples in Table 4-5. In Burlingame and Foster City, sales can be up to $30 million per acre. A similar anecdotal assessment for East Palo Alto was not available.

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[9] Excludes site acquisition and brine disposal costs.

Table 4-5. Properties for Sale in the San Francisco Peninsula

City	Notes	Acres	Price	Cost per Acre
Belmont	On El Camino Real	0.16	$499,000	$3,118,800
East Palo Alto	Residential property	0.18	$412,000	$2,288,900
San Mateo	On East 3rd	0.19	$2,520,000	$13,263,200
Redwood City	Edison Way, building foundation in place	0.56	$1,050,000	$1,875,000
Colma	Across from BART	0.58	$1,150,000	$1,982,800
Milpitas	Industrial property	4.27	$4,092,000	$958,300

Source: San Francisco Business Times Commercial Real Estate 2014. The database was searched for industrial and residential land for sale in the Bay Area. Lots available in the Bayside of the San Francisco Peninsula are listed. Search excluded plots with approved building plans.

Based on a preliminary assessment of data from the County Assessor's office, a desalination plant on 5 acres of land could cost between $10 and $35 million. A plant located on a 15-acre lot could cost between $30 and $105 million. These numbers are speculative and based on a qualitative generalization, but provide a "back of the envelope" cost estimate for planning purposes.[10]

4.2.4 Water Transfer Projects

Water transfers can be a cost-effective alternative for future water supply as they take advantage of existing interconnections with other regional water systems and may not require new infrastructure. As part of the Strategy, BAWSCA has evaluated several options for the source of supply and conveyance to the BAWSCA member agencies. BAWSCA is primarily evaluating options for dry-year transfers.

In addition to identifying a willing seller, two critical components of any transfer are the supply source and the means of conveyance. Initially three options were considered as a supply source for water transfer projects: 1) the Sacramento Valley, north of the Delta; 2) the San Joaquin Valley, in and south of the Delta; and 3) the Tuolumne River or the Stanislaus Watersheds. After further evaluation, only the north and south of Delta transfer options are being pursued for the Strategy[11].

For supplies originating outside of the Bay Area, there are limited existing conveyance facilities that could be used to wheel water to the BAWSCA member agencies. The potential options evaluated include: State Water Project (SWP) and Central Valley Project (CVP) facilities; SCVWD/SFPUC emergency intertie and SCVWD facilities; and EBMUD/SFPUC emergency intertie and EBMUD facilities.

A key recommendation from the *Phase II A Report* was to conduct a pilot water transfer into the BAWSCA member agency service area. To that end, BAWSCA performed further work to better assess the costs and feasibility of such transfers, including questions regarding water quality, system conveyance capacity constraints, and regulatory and permitting requirements. The result of these efforts is the *BAWSCA–EBMUD Short-Term Pilot Water Transfer Plan* (Pilot Plan) described below and further progress towards implementation.

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[10] The additional cost represented by land may range from $60 to $200/AF for brackish and $114 to $400/AF for an open intake. The caveat is that the land cost data is very limited and the extrapolations from small parcels for unit costs to these large parcels may overstate the actual costs.

[11] SFPUC is pursuing options for potential short- and long-term transfers with Oakdale Irrigation District in the Tuolumne and Stanislaus Watersheds.

4.2.4.1 Yield

Yields for water transfer projects vary depending on the supply source and owner. The majority of sellers identified to date by BAWSCA have available supply in the range of 1,000 AFY to 5,000 AFY. However, the amount of transfer water that might be available to BAWSCA and its agencies is currently unknown and will depend on, among other things, the available conveyance capacity. Based on initial discussions with potential conveyance partners, the maximum transfer volume is anticipated to be about 32,000 AFY[12] during specific time windows with a lesser capacity available in other parts of the year.

4.2.4.2 Cost

Water transfer costs are determined from a combination of factors, including supply, treatment, cost structure (i.e., whether the water would need to be paid for in all years regardless of whether it is needed), conveyance, storage[13], and administrative costs. Based on recent water transfers enacted within California, the cost of the water at the point of origin, prior to delivery, may range from $100 to $900/AF. As discussed below, costs for a one-year transfer from a north of the Delta seller have been developed, including conveyance and other costs.

4.2.4.3 Project Implementation Schedule

The implementation schedule for water transfers is dependent on many factors including: water source location and type; need for construction of additional infrastructure for conveyance and/or storage; negotiations and agreements with sellers and potential conveying agencies; and completion of environmental documentation and permitting. Because of the complexity associated with each of these issues, it is estimated that a long-term water transfer project would take a minimum of 3 to 10 years to implement, depending on the yield, complexity, number of partners, and regulatory agencies.

4.2.4.4 Potential Transfer Options for BAWSCA

BAWSCA has been pursuing potential water transfers through facilities operated by EBMUD and SCVWD. A water transfer with EBMUD would involve purchasing a supply that can be accessed north of the Delta through EBMUD's Freeport Regional Water Project (FRWP) and wheeled through EBMUD's existing infrastructure to the SF RWS for delivery to the BAWSCA member agencies. A water transfer with SCVWD could include purchasing supplies from both north and/or south of the Delta given SCVWD's SWP and CVP infrastructure, and options for conveyance to BAWSCA include the SCVWD/SFPUC emergency intertie and storage and delivery through the BAWSCA/SCVWD common customers. The status of BAWSCA's work with both EBMUD and SCVWD on water transfer agreements is discussed below.

EBMUD Pilot Water Transfer

In September 2013, BAWSCA and EBMUD finalized the Pilot Plan. The Pilot Plan studied the potential to conduct a one-year pilot water transfer of 1,000 AF in a future dry year when EBMUD is planning to operate the FRWP. Conducting a one-year pilot water transfer with a willing seller would provide important information needed to evaluate the costs and benefits of a long-term water transfer partnership. The Pilot Plan develops the basics of the pilot water transfer timing, rate, duration, potential costs, necessary agreements and approvals, and next steps. The Pilot Plan also evaluated the

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[12] Estimate assumes combination of the EBMUD and SCVWD transfer options discussed below.

[13] Some projects may require, or be more useful with, storage for banking available normal year water for dry year use. BAWSCA will continue to investigate possibilities for incorporating storage options into a water transfer project.

feasibility of partnering on long-term water transfer projects to improve future water supply reliability for both agencies (EBMUD and BAWSCA 2013).

Figure 4-5 presents the infrastructure that could be used for a BAWSCA-EBMUD water transfer. Such a transfer would involve purchasing water from a willing seller, diverting the water using the FRWP intake, conveying the water through the FRWP facilities and EBMUD's raw water and treated water distribution systems[14], and delivering the transfer water to the BAWSCA service area via the EBMUD/SFPUC/City of Hayward Intertie (Hayward Intertie) and potentially the SF RWS. Transfer water delivered from EBMUD through the Hayward Intertie would be directly used by Hayward in lieu of taking delivery of water from the SF RWS (EBMUD and BAWSCA 2013).

BAWSCA and EBMUD signed a second Memorandum of Understanding (MOU) in January 2014 to implement the second phase of the Pilot Plan ("Memorandum of Understanding between East Bay Municipal Utility District and the Bay Area Water Supply and Conservation Agency for the Development of the Second Phase of a Short-Term Pilot Water Transfer Plan"). BAWSCA staff met with potential sellers north of the Delta in 2013 and 2014 which has led to discussion of a 1,000-AF pilot transfer with Yuba County Water Agency (YCWA), in partnership with SFPUC and Hayward, potentially in 2015. Due to the 2014 and continued 2015 drought conditions, EBMUD may decide to operate its FRWP facilities in 2015 to deliver dry year supply. EBMUD expects to make this decision in April 2015, in which case the pilot transfer, pending BAWSCA Board authorization, could occur in the fall of 2015 depending upon the availability of water from YCWA.

Ongoing work to facilitate this pilot transfer includes BAWSCA, EBMUD, SFPUC, and Hayward finalizing the necessary agreements and completing environmental documentation and YCWA completing the necessary environmental documentation for a change in the place of use of their water supply. BAWSCA is also working closely with Hayward to address operational aspects of the Hayward Intertie, which is owned by EBMUD and SFPUC and operated by Hayward. The pilot transfer between BAWSCA and EBMUD would make use of the Hayward Intertie, which connects EBMUD to the SF RWS. North to south operation of the Hayward Intertie results in a reversal of the normal direction of flow through the Hayward system. During the pilot water transfer, Hayward would be exclusively served by EBMUD water supply that is potentially of a different quality from SFPUC water delivered to the rest of the BAWSCA member agencies. BAWSCA and Hayward are developing an agreement to address these issues to the benefit of all parties.

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[14] EBMUD has indicated they may only have excess capacity in the FRWP through 2040. At that time, EBMUD is estimating they will be using all of the available capacity for their own use.

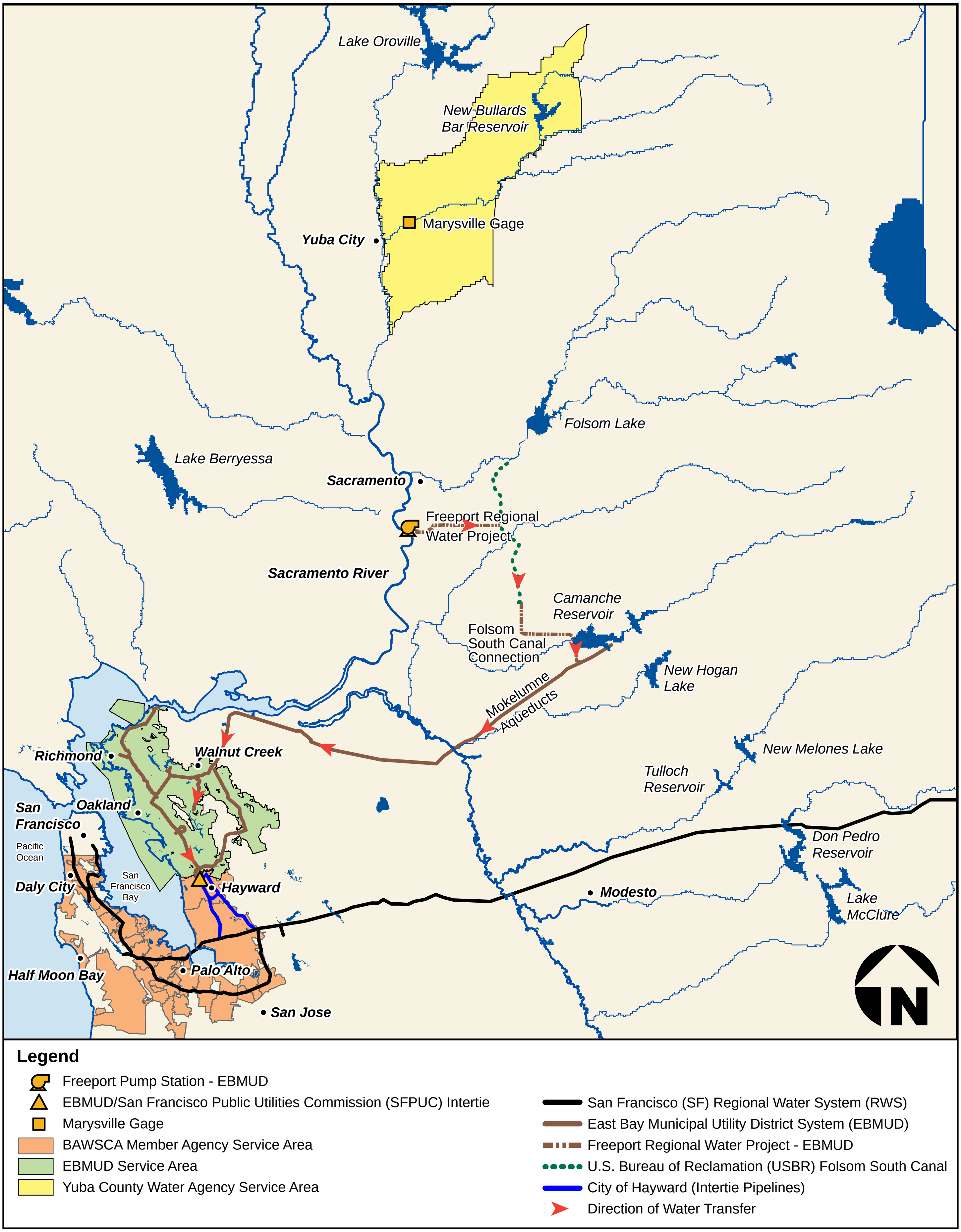

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Figure 4-5
Existing Infrastructure that Would Support Implementation of an EBMUD-BAWSCA Water Transfer

CDM Smith

Table 4-6 presents the costs of the 1,000-AF pilot water transfer being developed between BAWSCA, EBMUD, YCWA, and Hayward. Unit and total costs are comprised of several components: 1) cost of water supply purchase; 2) EBMUD wheeling costs, including administrative, treatment, and operation of EBMUD facilities from the FRWP to the Upper San Leandro Reservoir; 3) Hayward Intertie operation costs, including pump station preparation, staffing, energy, and post-transfer flushing; 4) Hayward's transmission pipeline use fee; and 5) incremental SFPUC Wholesale Revenue Requirement (WRR). The total cost of the 1,000 AF pilot water transfer would range from approximately $0.9 to $1.7 million.

Table 4-6. Anticipated Costs for the 2015 BAWSCA-EBMUD Pilot Water Transfer

	Unit Cost ($/AF)		Total Cost for 1,000-AF Pilot Transfer	
	Low End	High End	Low End	High End
Water Purchase[1]	$50	$350	$50,000	$350,000
EBMUD Wheeling Costs	$360	$550	$350,000	$475,000
Hayward Intertie Facilities	$100	$200	$100,000	$200,000
Hayward Transmission Pipeline Use Fee[2]	TBD	TBD	TBD	TBD
Incremental SFPUC WRR Costs	$425	$625	$425,000	$625,000
	$935	**$1,725**	**$935,000**	**$1,725,000**

Notes:

[1] Costs as presented in the Pilot Plan (EBMUD and BAWSCA 2013). Costs in 2015 will likely be close to the high end due to drought conditions. These costs may change in the future.

[2] Reimbursement to Hayward for proportional use of the transmission pipeline is to be determined (TBD).

Source: BAWSCA 2014

Aside from these transactional costs, BAWSCA would incur additional "soft" costs in the development and implementation of both the pilot transfer and a potential long-term transfer. In the pilot transfer process, costs are incurred for legal support in the development of the institutional agreements between the involved parties and for hydraulic studies being pursued. For a long-term water transfer, legal costs would again occur to draft agreements, and there would also be costs for necessary environmental documentation.

As discussed above, a water transfer through the EBMUD system would use the capacity in the FRWP. It was assumed, based on seasonal availability of transfer water, that BAWSCA would have at most six months of water transfers per year. Since the capacity of the Hayward Intertie is 30 mgd, the maximum water transfer through this system would be 15 mgd, or 16,800 AFY.

SCVWD Transfer

BAWSCA is working with SCVWD to explore opportunities for a one-year water transfer, which would provide vital information on partnering for future long-term and/or dry year transfers. For planning purposes, the approximate range for a SCVWD transfer is assumed to 5,000 to 15,000 AF.

In July 2014, BAWSCA and SCVWD finalized the "Memorandum of Understanding Agreement A3754M between the Santa Clara Valley Water District and the Bay Area Water Supply and Conservation Agency" which lays out the tasks, roles, and responsibilities for the development of a short-term pilot water transfer plan. The scope of work outlines the activities and deliverables for each agency, including tasks for: developing goals and objectives; identifying potential quantities, partners, and sources; evaluating conveyance options; assessing necessary approvals; and developing recommendations for the pilot transfer and future steps.

The project schedule anticipates completion of the Pilot Water Transfer Plan Report in November 2015. The report would identify necessary information for the pilot transfer and additional information, costs, environmental review, approvals, restrictions, permits, and agreements that may be required for a long-term transfer.

Figure 4-6 identifies the existing infrastructure that could be used for an SCVWD-BAWSCA water transfer.

4.2.5 Local Capture and Reuse Projects

The local capture and reuse projects described in this section include:

- Rainwater harvesting;
- Stormwater capture; and
- Graywater reuse.

Detailed information on these projects is available in the *Phase II A Report*, Attachment 2, Exhibit 4.

4.2.5.1 Rainwater Harvesting Projects

Rainwater harvesting includes the collection of rainwater runoff from roof surfaces by gutters and downspouts and storage of that water for use during a subsequent dry day. Using the stored water for landscape irrigation and non-potable indoor uses reduces potable water demands. In the most straightforward single-family residential applications, rainwater is collected from a roof in a rain barrel and used to irrigate a yard or garden. This simple application requires only the purchase of a rain barrel and the appropriate hoses and fittings to convey the stored rainwater to the irrigated area.

For larger scale roof rainwater collection and storage, such as for commercial developments and multi-family housing, greater quantities may be captured, provided that large cisterns are constructed in basements or underground or surface level storage tanks are present at the site. The stored rainwater is then pumped from storage and used for non-potable purposes such as irrigation, car washing, clothes washing machines, toilet flushing, swimming pools, and process water for commercial and industrial uses. These applications would require varying levels of treatment and separate piping systems.

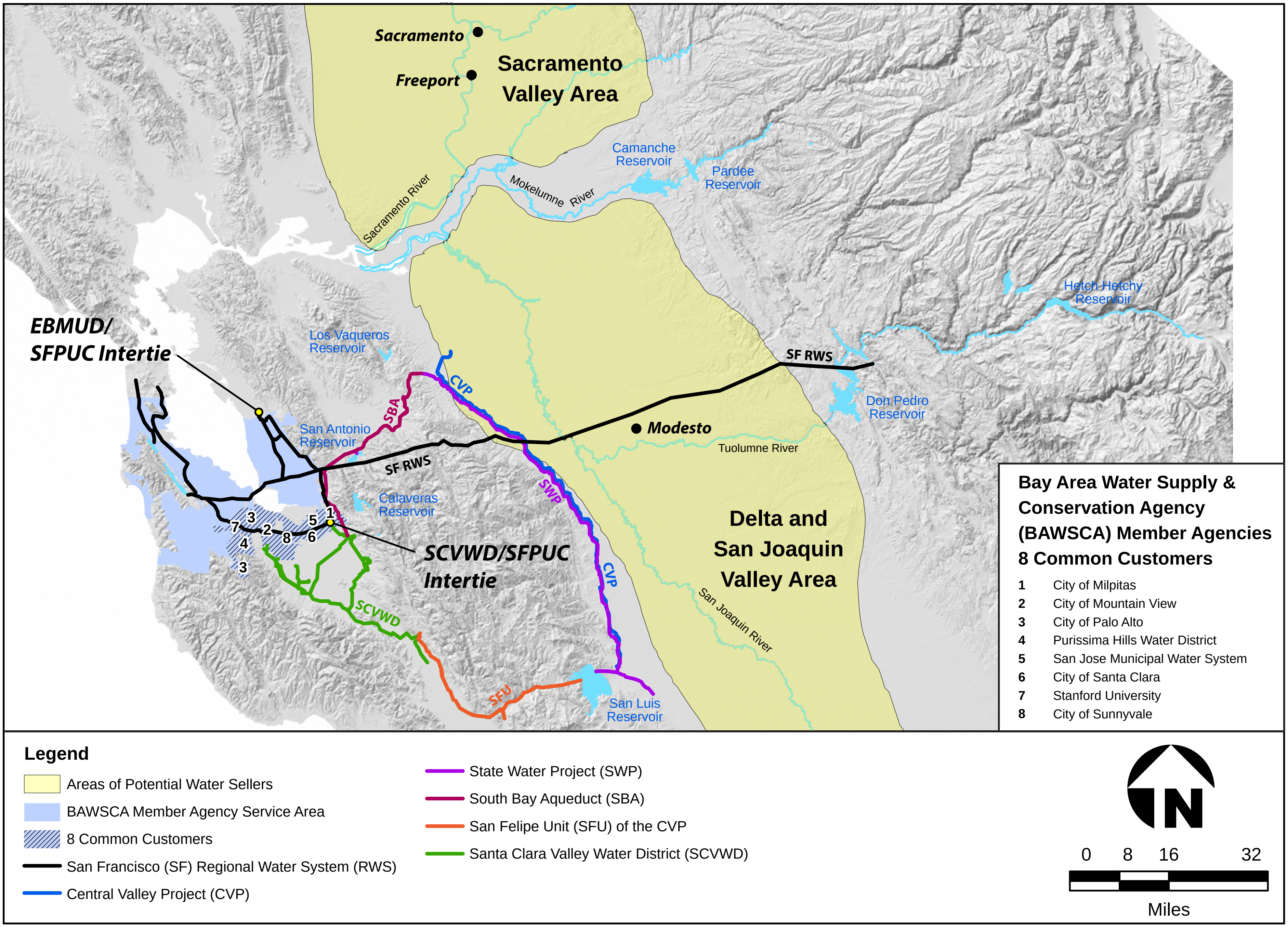

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Figure 4-6
Existing Infrastructure and the Common Customers that Could Facilitate Development of a SCVWD-BAWSCA Water Transfer

Agency Support

Implementation of rainwater harvesting projects throughout the BAWSCA service area requires the support of BAWSCA member agencies and participation from member agency customers. Several BAWSCA agencies' customers have expressed interest in rainwater harvesting. The following BAWSCA agencies currently have rainwater harvesting support and/or implementation plans or projects:

- In partnership with the San Mateo Countywide Water Pollution Prevention Program (a program of the City/County Association of Governments of San Mateo County), BAWSCA and participating member agencies (ACWD, Brisbane/Guadalupe Valley Municipal Improvement District, Hayward, Mid-Peninsula Water District, Millbrae, North Coast County Water District, Redwood City, and Sunnyvale) are offering rebates of $50 to $100 per rain barrel for the purchase and installation of qualifying rain barrels;
- Brisbane has a Rain Barrel Guidance manual;
- Burlingame city leaders hosted a forum in September 2014 on two emerging methods of water conservation titled "The Pros and Cons of Gray Water and Rainwater;
- Millbrae offers a Rainwater Harvesting and Graywater Reuse Workshop annually;
- Palo Alto offers rebates of $50 per rain barrel. Cistern rebates are $0.15 per gallon with a maximum residential rebate of $1,000 and a maximum commercial rebate of $10,000. Palo Alto also hosts rainwater harvesting education events to educate its customers on the benefits and opportunities for rainwater harvesting; and
- Stanford University's Knight Management Center Graduate School of Business installed a 75,000-gallon rainwater harvesting system in which rain runoff from roofs is stored and reused for irrigation onsite.

Yield

A preliminary estimate of the potential yield for rainwater harvesting in 2040 in residential units in the BAWSCA service areas ranges from 210 AFY to 680 AFY. This calculation is based on the projected number of single family residential units within the BAWSCA service area in 2040, average monthly rainfall, average roof size, the percentage of roof area captured by the rainwater harvesting system, and the assumed percentage of total homes that install a rainwater harvesting system. The range in yield was determined by varying the percent of roof runoff that is captured by the rainwater harvesting system (25 and 50 percent) and the BAWSCA customer participation rate (10 and 20 percent). The yield of rainwater harvesting projects is also largely dependent on the magnitude and timing of rainfall and the seasonality of demands that would utilize the stored rainwater (e.g., outdoor irrigation). Implementation of larger scale roof rainwater collection and storage systems were not evaluated as a part of the Strategy.

Cost

The estimated cost of this supply ranges from about $14.8 to $29.6 million based on the following assumptions:

- Household system costs: $300[15];
- Estimated equipment life: 15 years; and
- Number of households participating: 49,300 (10% participation rate) and 98,800 (20% participation rate).

Based on this range of capital costs and potential yields (210 AFY to 680 AFY) the present worth costs are anticipated to range from roughly $2,900/AF to $4,800/AF.

Project Implementation Schedule

Rainwater harvesting projects, depending on ownership and size, will vary in the time required to implement them on an individual basis and within an agency service area. Part of the implementation on the agency level could be the development of the types of rebates or other incentives that an agency may provide to encourage the installation and use of rainwater harvesting systems.

4.2.5.2 Stormwater Capture Projects

The stormwater capture projects addressed in the Strategy are primarily projects that could be developed by property owners on individual parcels of land (i.e., single or multi-family residential, commercial or industrial) that involve the capture and storage of stormwater runoff that can then be used for a variety of purposes, including increasing the groundwater supply through recharge and reducing potable water use for outdoor irrigation. These stormwater capture projects would focus on the potential potable water demand reductions within the BAWSCA service area and area-wide implementation of low-impact development (LID) projects.

Agency Support

Implementation of stormwater capture projects throughout the BAWSCA member service area requires the support of BAWSCA member agencies and participation from member agency customers. Several BAWSCA agencies' customers expressed interest in stormwater capture. ACWD captures rainfall runoff from the Alameda Creek Watershed for use as groundwater recharge. Captured water is diverted to several hundred acres of ponds (former gravel quarries) where water percolates to recharge the underlying Niles Cone Groundwater Basin. Although this project is much larger in scale than the single property-sized stormwater capture projects being the Strategy, it can provide insight into representative potential yields and costs. Additional information is presented in the *Phase II A Report*, Attachment 2, Exhibit 4.

Yield

Reliable information on the potential yield of BAWSCA service area wide implementation of stormwater capture projects is not currently available due to the lack of projects in the region.[16]

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[15] BAWSCA implemented a program starting in October 2014. As of January 2015, the range of costs for installing a single rain barrel and associated fittings was $90 to $150.

[16] A study by the Natural Resources Defense Council (NRDC) found that LID has a substantial potential to save both water and energy in the San Francisco Bay Area. NRDC estimated that LID projects implemented throughout a 3,850-square mile study area including San Francisco, Marin, Contra Costa, Alameda, Santa Clara, and San Mateo Counties could provide 34,500 AFY to

Existing stormwater capture and groundwater recharge projects like those implemented by ACWD could provide some guidance on estimating yields, but are much larger than the single property-sized projects being considered in the Strategy. Yield of individual projects will be determined largely by the magnitude and timing of rainfall runoff as well as the size of land available to capture the stormwater runoff, the method of retention (i.e., capture and storage for reuse or infiltration into the groundwater aquifers), and the amount of demand that could be met through the reuse of the stormwater stored above ground.

Cost

Reliable cost information is not currently available for implementation of stormwater capture and reuse or LID projects on a regional or local scale. As such, neither capital nor present worth costs are included at this time.

Project Implementation Schedule

Implementation of stormwater capture projects is dependent on the individual project developer and the permitting process for planning and approval as part of new developments, or retrofits of existing properties. Financial or other incentives may be necessary to make these projects feasible for developers, and a number of site-specific issues would need to be well understood including the presence or absence of a groundwater basin, whether the local geology is suitable for recharge, and potential water quality impacts.

4.2.5.3 Graywater Reuse Projects

Graywater (also spelled greywater, grey water, and gray water) is the untreated household wastewater from bathtubs, showers, bathroom sinks, and washing machines. Wastewater from toilets, referred to as "black water," is not included. In California, wastewater from kitchen sinks or dishwashers is also not an acceptable source of graywater. Graywater filtration systems such as the Aqua2use, from the Water Wise Group, Inc., and the Flotender from Filtrific, are available to collect, filter, and pump graywater collected from a home's laundry, shower and bath to irrigate plants. These systems are uncommon, and could require special permitting and/or regulatory approval to implement. However, new plumbing codes allow for easier implementation of graywater systems, and no permit is required for washing machine-based systems. These "laundry-to-landscape" systems recycle an average of 25 gallons of water per laundry load.

Unlike rainwater harvesting and stormwater capture, graywater production capacity does not vary seasonally. However, the potential yield from graywater reuse projects is dependent on the timing and magnitude of the demand, especially to the extent that the water is used for irrigation. During the winter months, when irrigation demands are lower, there could be a surplus of graywater supply which would have to be discharged to the sewer or septic system. Graywater can also be used to flush toilets, which provide year-round demands, but this would require the construction of a more complex and permitted system that would provide treatment to California Code of Regulations Title 22 standards.

63,000 AFY by 2030 (or 9.0 AFY to 16.4 AFY of water per square mile) (NRDC 2009). Using this example, the 460-square mile BAWSCA service area would potentially capture 4,100 AFY to 7,500 AFY through service area-wide implementation of LID projects. Because this study includes both roof-top capture stormwater as well as use of stormwater to recharge groundwater, with no breakdown between the two, this potential yield estimate is not used to avoid double-counting with the water savings estimate of the rainwater harvesting projects. In addition, the yield estimate assumes part of the yield is in groundwater recharge which is very limited in many portions of the BAWSCA service area.

Regionally, graywater is gaining traction. SCVWD provides a Graywater Laundry to Landscape rebate of $200 per residential site for properly connecting a clothes washer to a graywater irrigation system. SFPUC's "Laundry-to-Landscape Graywater Program" offers a $112 subsidy towards the cost of a $117 laundry-to-landscape graywater kit. Participants also receive a free workshop on how to properly install the kit, in-home technical assistance from a graywater expert, access to a tool kit for installation, and a copy of the *San Francisco Graywater Design Manual for Outdoor Irrigation* (SFPUC 2014). EBMUD offers a rebate of up to $50 per graywater system 3-way diverter valve.

Elsewhere in California, the San Diego City Council recently voted unanimously to ease municipal code requirements for home-based water recycling systems by not requiring permits for systems that receive water from only a clothes washer or systems that discharge less than 250 gallons per day (gpd).

Agency Support

Implementation of graywater reuse projects throughout the BAWSCA service area requires the support of BAWSCA member agencies and participation from member agency customers. Many BAWSCA agencies are interested in promoting graywater in response to public interest, but some concerns exist regarding sewer system backflow and conflicts with recycled water programs. There is also concern that a reduction in wastewater flows due to the implementation of graywater reuse projects may affect solids movement in wastewater lines. There are currently no documented graywater projects being implemented by BAWSCA member agencies, though there have been educational workshops in the region, and residents living in Santa Clara County can take advantage of the laundry to landscape program being implemented by SCVWD.

Yield

A preliminary estimate of potential graywater yield in 2040 for the BAWSCA member agencies' service areas ranges from about 1,240 AFY to 3,000 AFY for simple systems used for irrigation. This estimate is based on a calculation using the number of single family residential units within the BAWSCA service area, assumed participation rate, and an average volume of graywater generated per household. The yield range is based on assumed graywater production per household (a range of 41 gpd to 108 gpd) and participation rate (10 and 20 percent). The seasonal nature of irrigation demands is also considered in the yield estimate. The estimates for graywater production per household used in the yield calculation are similar to independent assessments like those from Ecology Action, which estimated 68 gpd of graywater production for a typical, four-person household (Ecology Action 2014).

Cost

The estimated cost of this supply ranges from about $12.3 to $169 million based on the following assumptions:

- Household system costs: costs vary depending upon the type of system installed, and if a homeowner self-installs or hires a contractor. The costs are estimated to be $250 for simple owner-installed laundry-to-landscape system, $1,715 for a contractor-installed branch-drained system that would capture water from a shower/sink and the laundry, and $3,790 for a contractor installed pumped system (Ecology Action 2014);
- Estimated equipment life: 15 years; and

- Number of households participating: 49,300 (10% participation rate) and 98,800 (20% participation rate).

Based on this range of capital costs and potential yields (1,240 AFY to 3,000 AFY) the present worth costs are anticipated to range roughly from $550/AF (owner-installed laundry system) to $4,530/AF (contractor-installed branch-drained systems). More extensive household retrofits are possible, with a cost of up to $10,000/AF, with significant in-home pumping.

Ecology Action has performed this preliminary research, but further research could be done to better refine costs, yields, and the potential for household implementation. During the 2014 drought, many more customers than before have expressed interest in graywater systems. BAWSCA may consider following the work of other agencies in the Bay Area, such as Sonoma County Water Agency, on their progress and support of graywater systems.

Project Implementation Schedule

Graywater reuse projects, depending on ownership and size, will vary in the implementation time on an individual basis and within the service areas. Part of the implementation on the agency level could be the development of the types of rebates or other incentives that an agency may provide to encourage the installation and use of graywater reuse systems. In addition, regulations and building codes which currently limit the use of graywater also will affect the implementation

4.2.6 Summary of Projects

The Strategy projects cover a wide range of potential dry year yield, from small projects that can be implemented individually by member agencies, to large yield projects that would require direct involvement by BAWSCA. Figure 4-7 presents the dry year yield for each project[17], including the low, middle, and high end of the yield range.

Figure 4-8 presents the range of long-term expected costs for the Strategy projects, along with the projected cost of water from the SF RWS in FY 2022-2023. For the desalination projects, these values represent the range of expected cost using a mixed normal year and dry year operating scenario.

[17] The Redwood City Regional Recycled Water Supply project and stormwater capture are not presented further in this section because there is limited information currently available on key criteria of cost and potential yield.

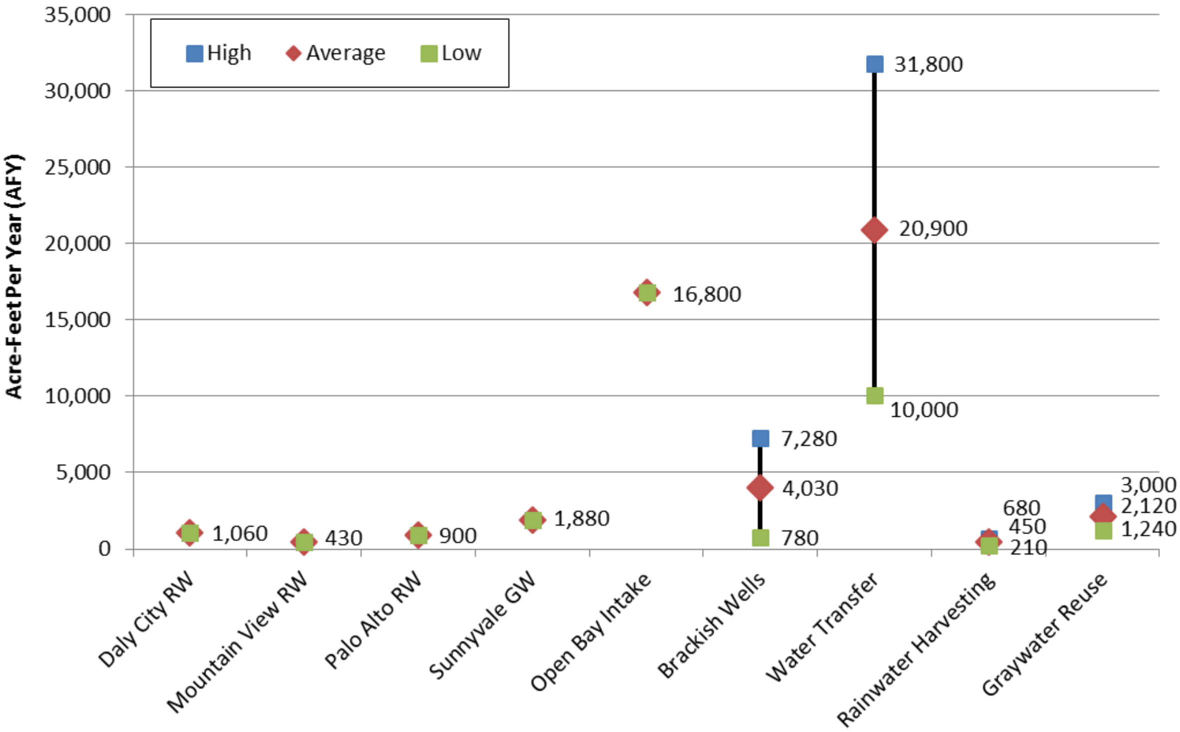

Figure 4-7
Range of Dry Year Yield for the Strategy Projects

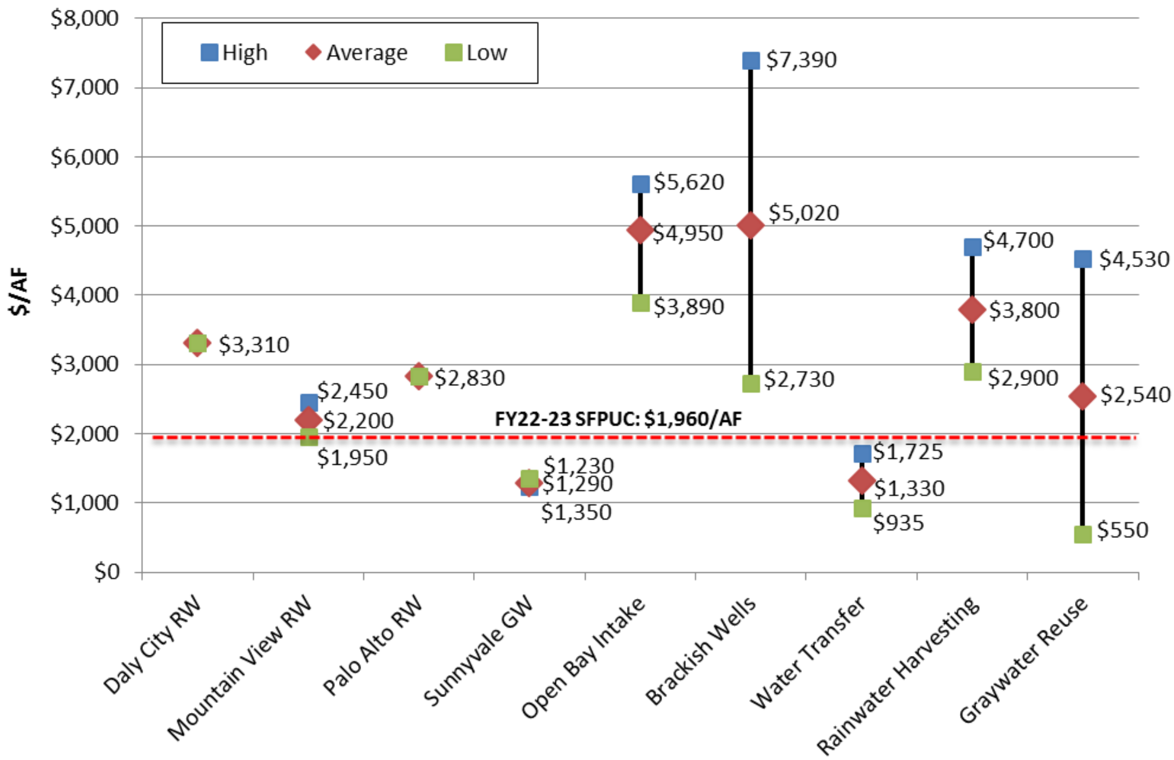

Figure 4-8
Range of Long-Term Expected Cost for the Strategy Projects

Section 5

Project and Portfolio Performance

When the Strategy was initiated in 2009, the most current demand projections developed by the BAWSCA member agencies identified a significant water reliability shortfall in both normal and dry years. The analysis performed as part of the Strategy and presented in Sections 2 through 4 shows that:

- The normal year reliability shortfall through 2040 is virtually absent;
- The number of projects found to provide regional reliability benefits is greatly reduced and the total yield of the viable projects is approximately equivalent to the estimated reliability gap during drought conditions; and
- Consequently, all of the Strategy projects may be needed if BAWSCA member agencies were to seek 100 percent reliability during drought years.

Even though all projects may be needed to achieve 100 percent reliability for BAWSCA member agencies during drought years, the following scoring of projects and portfolios was conducted to gain insights on how the projects perform against the Strategy objectives, highlight key tradeoffs between the projects, and identify where more information is needed. This information can then be used to prioritize implementation actions and inform the sequencing of actions.

The analysis of projects and portfolios, described below, has identified water transfers as the highest rated project, and a component of all top scoring portfolios. Water transfers provide a very high dry year yield for no capital costs and a low cost per acre-foot.

5.1 Evaluation Criteria Included Yield, Cost, Schedule and Environmental Factors

The list of potential regional water management projects was refined throughout the Strategy through multiple steps of data review, analysis, member agency meetings, and discussion. The evaluation process used qualitative and quantitative thresholds to narrow project choices over the course of the Strategy, including volume of supply (initially preferring projects that provided at least 1 mgd of supply), timing of implementation, and regional benefit to the BAWSCA member agencies.

The following Strategy projects, as described in Section 4.2, were selected for further evaluation:

- **Agency-Identified Projects**
  - Recycled water
    - City of Daly City – Recycled Water Expansion Project, Colma Expansion
    - City of Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP

        - City of Palo Alto – Recycled Water Project to Serve Stanford Research Park
        - City of Redwood City – Regional Recycled Water Supply
    - Groundwater
        - City of Sunnyvale
- **Local Capture and Reuse Projects**
    - Rainwater capture
    - Stormwater capture
    - Graywater reuse
- **Regional Projects**
    - Water transfers
    - Desalination
        - Open Bay intake desalination
        - Brackish desalination

Due to lack of available data on criteria for cost and yield, the Redwood City Regional Recycled Water Supply project and stormwater capture were not included in the project or portfolio evaluation process. The available information for these two projects is included in the scoring appendices discussed below.

As presented in Section 2 and shown in Figure 5-1, the anticipated shortfall in SFPUC supplies during a 20 percent system-wide water shortage is 43 mgd, and no tangible shortfall is anticipated during normal years. It is assumed that a supply shortfall would need to be met by some combination of additional supplies and/or additional conservation.

Initially, the Strategy water supply projects were compared based on yield only, as increasing regional reliability is a primary objective of the Strategy. The yield analysis indicated that only water transfers and desalination could likely provide enough yield to significantly address the 43 mgd dry year need as shown in Figure 5-2, which presents the reliability shortfall compared with the total average yield of the Strategy projects (the range of anticipated yields is presented in Figure 4-7).

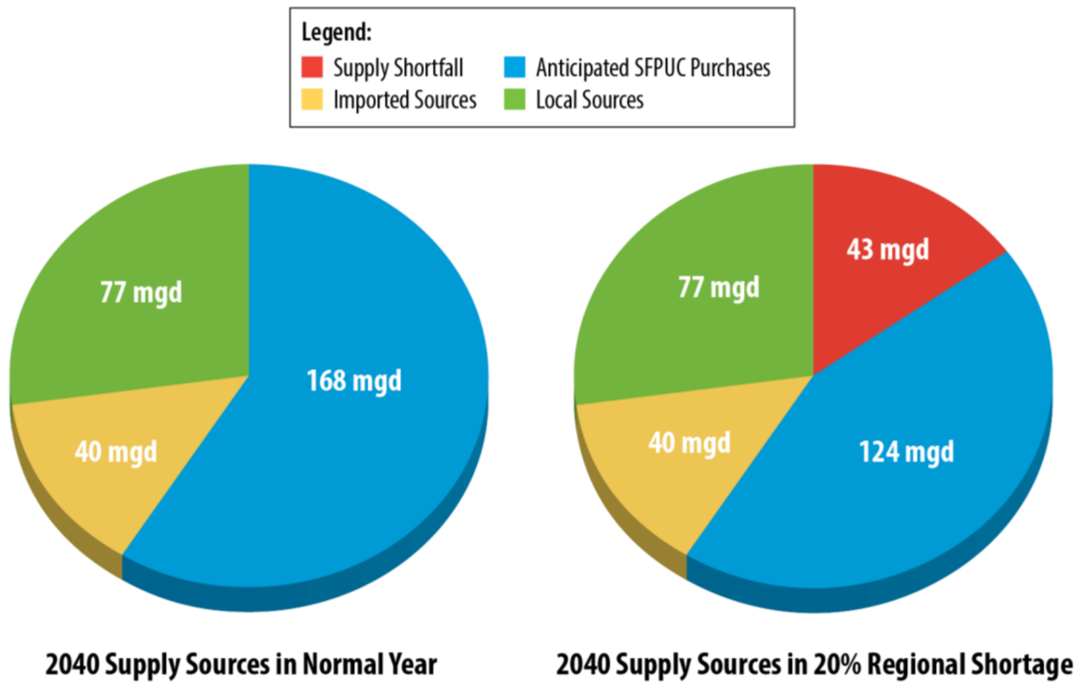

Figure 5-1
Projected Water Supply Sources for BAWSCA Member Agencies in 2040

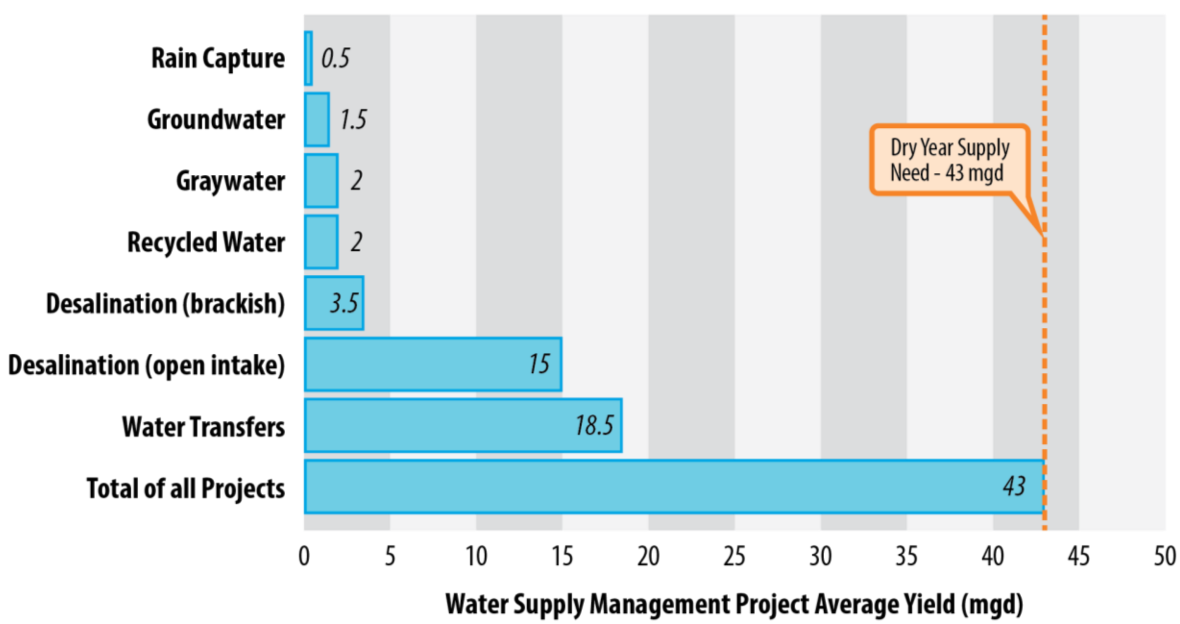

Figure 5-2
Average Yields for Strategy Water Supply Projects Compared with Dry Year Supply Shortfall

The further evaluation of the projects utilized objectives, criteria, and metrics developed and revised with input from the BAWSCA Board and member agencies starting in Phase I and summarized in the *Phase II A Report*. The objectives and criteria are used to differentiate the characteristics of the Strategy projects and portfolios (e.g., increase supply reliability). Objectives define what a project or portfolio is attempting to achieve, in broad terms. Individual criterions more specifically express the objectives (e.g., ability to meet drought year supply need). Several criteria can be associated with an objective. The metrics are measureable terms that are used to differentiate potential projects. The metric is used to indicate to what degree a specific criterion of a given objective is being achieved (e.g., average annual yield under 1987-92 drought). The evaluation metrics for the criteria may be quantitative or qualitative in nature.

Table 5-1 presents the objectives and criteria used to compare the Strategy projects. Details on the criteria are provided in Appendix D, Overview of Project Evaluation Criteria.

Table 5-1. Strategy Project and Portfolio Evaluation Objectives and Criteria, and Metrics

Objective	Criteria
1 - Increase Supply Reliability	Criterion 1A – Ability to Meet Normal Year Supply Need
	Criterion 1B – Ability to Meet Drought Year Supply Need
	Criterion 1C – Risk of Facility Outage
	Criterion 1D – Potential for Regulatory Vulnerability
2 - Provide High Level of Water Quality	Criterion 2 – Meets or Surpasses Drinking Water Quality Standards
3 - Minimize Cost of New Water Supplies	Criterion 3A – Capital and Present Worth Costs
	Criterion 3B – Effective Cost
4 - Reduce Potable Water Demand	Criterion 4 – Augment Non-Potable Water Supplies
5 - Minimize Environmental Impacts of New Water Supplies	Criterion 5A – Greenhouse Gas Emissions
	Criterion 5B – Impact to Groundwater Quantity and Quality
	Criterion 5C – Impact to Habitat
6 - Increase Implementation Potential of New Water Supplies	Criterion 6A – Institutional Complexity
	Criterion 6B – Level of Local Control
	Criterion 6C – Permitting Requirements

5.2 Scoring Analysis of Individual Projects and Portfolios Converge on Identical Priorities

Project scoring and subsequent sensitivity analysis was conducted with different weighting factors on the various objectives and criteria to evaluate individual and grouped project performance. The project scores and weightings were developed using the Strategy objectives and Strategy findings. The individual projects were combined into several different portfolios reflecting different priorities and also analyzed using the same sensitivity weightings. Appendix E, Strategy Project Scoring, presents the project scores for each of the evaluation criteria and Appendix F, Detailed Project Scoring Information, presents the quantitative or qualitative information that is the basis for each score. Detailed project and portfolio cumulative scoring results are presented in Appendix G, Project and Portfolio Performance Evaluation.

The principal insights that emerged were:

1. Water transfers score consistently high across the various performance measures and within various portfolio constructs and thus represent a high priority element of the Strategy.
2. Desalination also potentially provides substantial yield, but its high effective costs and intensive permitting requirements make it a less attractive drought year supply alternative. However, given the limited options for generating significant yield for the region, desalination warrants further investment in information as a hedge against the loss of local or other imported supplies.
3. The other potential regional projects provide tangible but limited benefit in reducing dry year shortfalls given the small average yields in drought years.

5.2.1 Project Scoring

A project scoring analysis was performed to identify those projects that best met the objectives of the Strategy. For this analysis, a scale from 1 to 5 (where 5 is the best score) was developed for each of the 14 criterion above, based on the range of both quantitative and qualitative metrics, and was used to evaluate each project. The scales for each criterion are shown in Appendix E. Each project was scored for each criterion and those scores are also presented in Appendix E. Appendix F presents the quantitative or qualitative information that is the basis for each score.

The total score for a project is the sum of each criterion's score multiplied by its respective weighting factor, as denoted by the following formula:

$$Project\ Score = \sum_{i=1}^{14} Criteria\ Score(i)\ \times Weighting\ Factor(i)$$

For all of the analyses done with the evaluation criteria, the scores were normalized for comparison, where the highest possible project score was scaled to 100 points. This technique allows comparison of scores across different weightings in the sensitivity analysis by transposing each case onto the same scale. Appendix G presents the full results of the project scoring.

As discussed below, weighting factors were selected for each criterion based on the Strategy's objectives (e.g., increase supply reliability, minimize cost of new water supplies) and findings from earlier Strategy analysis (e.g., reduced normal year demands, fewer viable projects). Figure 5-3 presents the results of the project analysis when emphasizing the following criteria: drought supply; costs; regulatory vulnerability; local control; and institutional complexity. The bar representing each project aggregates the individual criterion scores for that project to provide a comparison of the relative contribution of each criterion score across the Strategy projects. The last column in Table 5-2 (Sensitivity Analysis Emphasis #7) presents the weighting used for each criterion to calculate the project scores, and total possible score for each criterion is the same as the percentage listed in the corresponding row of the last column. The total length of the bar represents the overall performance of the project.

The following observations can be made about the projects scores from examination of Figure 5-3:

- Water transfers performed noticeably better than the other projects due to their ability to provide drought year reliability and lower costs, among other factors.
- The Sunnyvale groundwater project also performs well due to its low cost and high level of local control, but the supply is comparatively small.
- Open bay intake provides the second highest dry year yield, but has a high cost so it scores towards the middle of the range of projects.
- Though very small in yield, graywater also scores towards the middle of the range based on ease of implementation and lower costs.
- Brackish desalination had the second lowest score due to both higher effective costs and poorer performance on the drought year supply; however, the yield for brackish desalination is a key area of outstanding uncertainty of the project. If yields are at the higher end of the range, then the supply increases and the effective costs decrease.
- The recycled water projects scored in the mid to low range of project scores mainly due to their lower scores in ability to provide drought year supply need.

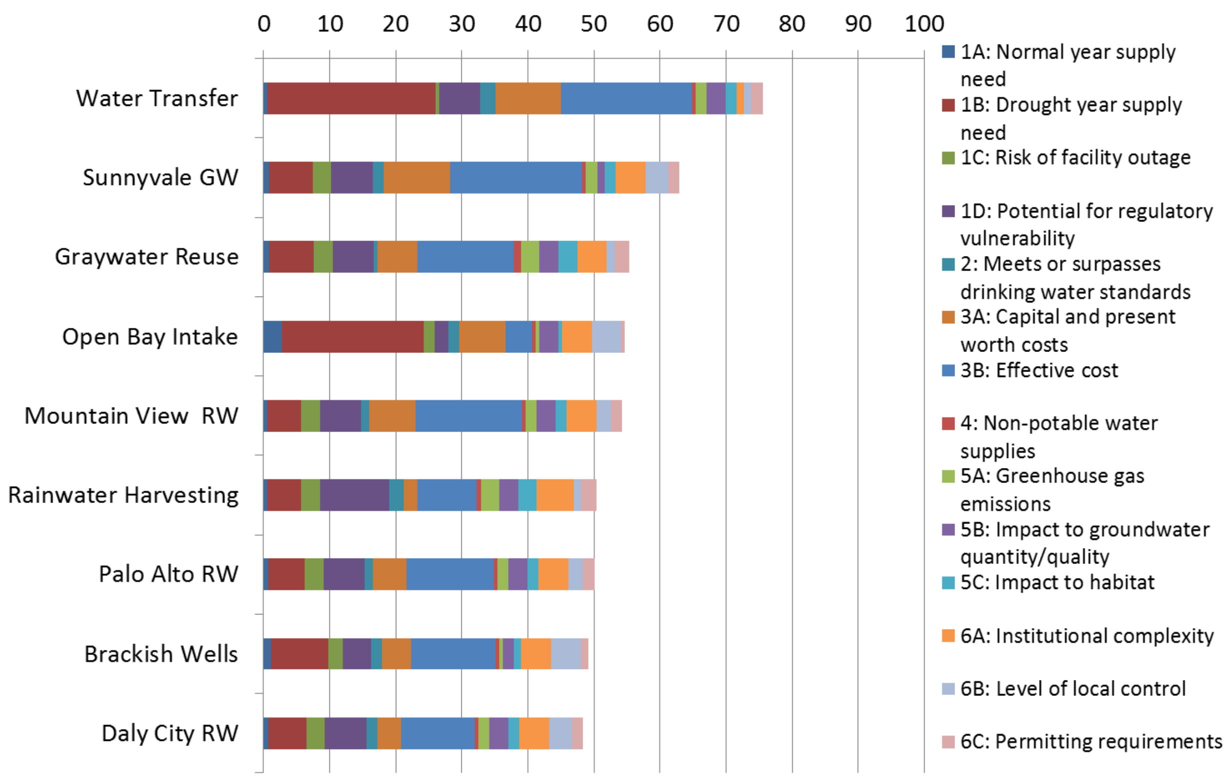

Figure 5-3
Cumulative Score for the Strategy Projects Emphasizing Drought Supply, Costs, Regulatory Vulnerability, Local Control, and Institutional Complexity

CDM Smith

5.2.2 Project Sensitivity Analysis

The sensitivity analyses highlight differences between the projects and the results show which projects score highly across the various priorities. When the sensitivity scenarios are introduced, the range of project scores increased compared to the scoring range found when all the criteria are equally weighted (e.g., project scores varied by 15 points when the evaluation criteria were equally weighted, but under the Environmental Issues analysis, the project scores had a 35-point range).

Table 5-2. Sensitivity Weightings Applied to Evaluation Criteria to Assess Project Performance

Criteria	Sensitivity Analysis Emphasis						
	#1 Drought Supply	#2 Cost	#3 Cost & Drought Supply	#4 Environmental Issues & Drought Supply	#5 Local Control, Drought Supply, Costs, Permitting, & Institutional Complexity	#6 Environmental Issues, Drought Supply, Cost, , & Local Control	#7 Drought Supply, Cost, Regulatory Vulnerability, Local Control & Institutional Complexity
Criterion 1A – Ability to Meet Normal Year Supply Need	6%	4%	4%	2%	3%	2%	3%
Criterion 1B – Ability to Meet Drought Year Supply Need	25%	4%	20%	11%	17%	12%	25%
Criterion 1C – Risk of Facility Outage	6%	4%	4%	2%	3%	2%	3%
Criterion 1D – Potential for Regulatory Vulnerability	6%	4%	4%	2%	3%	2%	10%
Criterion 2 – Meets or Surpasses Drinking Water Quality Standards	6%	4%	4%	4%	3%	2%	3%
Criterion 3A – Capital and Present Worth Costs	6%	25%	20%	4%	7%	12%	10%
Criterion 3B – Effective Cost	6%	25%	20%	4%	7%	12%	20%
Criterion 4 – Augment Non-Potable Water Supplies	6%	4%	4%	2%	3%	2%	3%
Criterion 5A – Greenhouse Gas Emissions	6%	4%	4%	20%	3%	12%	3%
Criterion 5B – Impact to Groundwater Quantity and Quality	6%	4%	4%	20%	3%	12%	3%
Criterion 5C – Impact to Habitat	6%	4%	4%	20%	3%	12%	3%
Criterion 6A – Institutional Complexity	6%	4%	4%	2%	7%	2%	6%
Criterion 6B – Level of Local Control	6%	4%	4%	2%	30%	12%	6%
Criterion 6C – Permitting Requirements	6%	4%	4%	2%	7%	2%	3%
Total	100%	100%	100%	100%	100%	100%	100%

Several observations can be made upon evaluation of the results from the sensitivity analysis:

- Overall, through the sensitivity analysis, water transfers score very well on dry year yield and cost scores due to the potential significant amounts of water that can be obtained and the minimal capital investments required. As a result, water transfers is the top scoring project in sensitivity analyses #1, #3, #6, and #7. The sensitivity analysis results show clearly that water transfers is the top project, or within the top four projects, in all of the sensitivity analyses evaluated.

- Graywater reuse also performs as one of the top three projects under all but one of the sensitivity analysis scenarios. It is an attractive option based on ease of implementation and low environmental impact but scores poorly in dry year yield and level of local control due to the lack of certainty of on-going implementation of the projects to produce the estimated yield.

- The suite of recycled water projects scored mainly in the mid to low range of project scores across the sensitivity analyses. As discussed above, these projects have lower yields compared to the larger projects of open bay intake desalination and water transfers, and, therefore, these projects would not perform as well in sensitivity analyses that emphasizes drought supply.

- Open bay intake provides the second highest dry year yield, so when drought supply is emphasized it tends to score towards the middle of the range of projects. Open bay intake scores low on environmentally-focused criteria and effective cost.

- Brackish desalination scored at the lower end of projects across most scenarios due to poorer performance on the drought year supply; however, the yield for brackish desalination is a key area of outstanding uncertainty of the project. Brackish desalination also scored poorly on environmentally-focused criteria.

- While open intake desalination would be the most reliable supply, it would require multiple approvals and financial commitments prior to construction.

Table 5-3 presents the top scoring project under each sensitivity analysis. Appendix G provides the scores of each project for each sensitivity analysis.

Table 5-3. Sensitivity Analysis Highlights High Scoring Strategy Projects

Sensitivity Emphasis	Highest Scoring Project(s)
1. Drought Supply	Water Transfers
2. Cost	Sunnyvale Groundwater
3. Cost & Drought Supply	Water Transfers
4. Environmental Issues & Drought Supply	Rainwater Harvesting and Graywater Reuse (same score)
5. Local Control, Drought Supply, Costs, Permitting, and Institutional Complexity	Open Bay Intake Desalination
6. Drought Supply, Cost, Environmental Issues, and Local Control	Water Transfers
7. Drought Supply, Cost, Regulatory Vulnerability, Local Control, and Institutional Complexity	Water Transfers

5.2.3 Portfolios Developed to Meet Range of Objectives

The results of the project evaluation and sensitivity analysis were used to develop six portfolios, or groups of projects, to explore combinations of projects based on different objectives or themes that are important to stakeholders in the Strategy: least cost; maximum yield; fastest implementation; local control; least stranded costs; and least environmental impact.

The projects that comprise each portfolio were determined based on which projects best met the needs of each portfolio theme, and performance of projects through the scoring and sensitivity analysis described above. For example, the two projects with the lowest average unit costs and capital costs are included in the Least Cost Portfolio, and the Least Environmental Impact Portfolio includes all projects except the desalination options.

Table 5-4 presents the portfolios, describes the objectives of each portfolio, itemizes the projects included in each, and provides estimates of total average dry-year yield and total capital costs. The portfolios offer a variety of implementation options, ranging from prioritizing local agency control of supply development to a project's ability to be implemented in a short timeframe.

Table 5-4. Strategy Portfolios

Portfolio	Objective	Projects	Total Average Dry Year Yield (AFY)	Capital Costs ($M)[1]	Average Unit Cost Using Long-Term Effective Cost ($/AF)
Least Cost	Minimizes both unit costs and total capital costs	▪ Sunnyvale groundwater ▪ Water transfers	22,800	~$8	$1,330/AF
Maximum Yield	Most yield for fewest projects	▪ Open intake desalination ▪ Water transfers	37,700	$310-$360	$2,940/AF[2]
Fastest Implementation	Brought online rapidly	▪ Sunnyvale groundwater ▪ Water transfers	22,800	~$8	$1,330/AF
Local Control	Maximizes agency control	▪ Daly City recycled water ▪ Mountain View recycled water ▪ Palo Alto recycled water ▪ Sunnyvale groundwater ▪ Open intake desalination ▪ Brackish desalination	25,100	$451-$639	$4,160/AF[2]
Least Stranded Costs	Eliminates projects whose normal year costs are greater than SFPUC costs	▪ Water transfers	20,900	Only "soft" costs	$1,330/AF
Least Environmental Impact	Lowest potential for environmental effects	▪ Daly City recycled water ▪ Mountain View recycled water ▪ Palo Alto recycled water ▪ Sunnyvale groundwater ▪ Water transfers ▪ Rainwater harvesting ▪ Stormwater capture ▪ Graywater reuse	27,700	$138-$313	$1,600/AF

1 No capital costs for transfers

2 The portfolio unit cost decreases to $1,740/AF for the Maximum Yield portfolio and $2,370/AF for the Local Control portfolio when normal year operation is assumed for the desalination projects.

Several observations can be made on the portfolios:

- Water transfers are a component of all top scoring portfolios.
- The Least Stranded Costs portfolio received the highest score of any portfolio and was the highest performing portfolio for five of the eight criteria weightings. This portfolio consists only of water transfers, which provide a very high dry year yield for no capital costs and a low cost per acre-foot.
- The greatest certainty for dry year yield would be the Local Control portfolio, which contains both desalination projects. It represents the highest cost and previous desalination projects have encountered delays in their implementation.
- The Local Control and Least Environmental Impact portfolios have the highest number of projects, but are the lowest scoring portfolios on average and do not score as well on yield and cost criteria.
- The Least Cost and Fastest Implementation portfolios contain the same projects.
- Each portfolio provides an average dry year yield of over 20,000 AFY, which is almost half of the 2040 dry year need of 48,000 AFY (assuming a 100 percent LOS). Or, put another way, each of the portfolios would reduce rationing significantly. While no formal decision was made by BAWSCA regarding a preferred LOS, it is recognized that achieving 100 percent LOS was not required.
- There is uncertainty in the yields for the largest portfolio component: water transfers. While water transfers can be very attractive from a cost perspective, there is a possibility that they may not be available when needed due to timing constraints or lack of available water in an extremely dry year.
- The greatest certainty for dry year yield would be the Local Control portfolio which contains desalination. It represents the highest cost and previous desalination projects have encountered delays in their implementation.

The portfolios were scored using the sum of the scores for the projects that make up the portfolio, and then averaging for the number of projects per portfolio (to not arbitrarily give a higher score to a portfolio with many projects compared to a portfolio with only a few projects). The scores were normalized for comparison, where the highest possible project score was scaled to 100 points. Each portfolio was evaluated based on the sensitivity analysis scenario weightings presented in Table 5-2. On the whole, differences in portfolio scores were small.

Figure 5-4 presents the scoring of the Strategy portfolios based on sensitivity analysis #7, which emphasized drought supply, costs, regulatory vulnerability, local control, and institutional complexity. Table 5-5 presents the top scoring portfolio under each sensitivity analysis. Appendix G presents the full scoring results and charts.

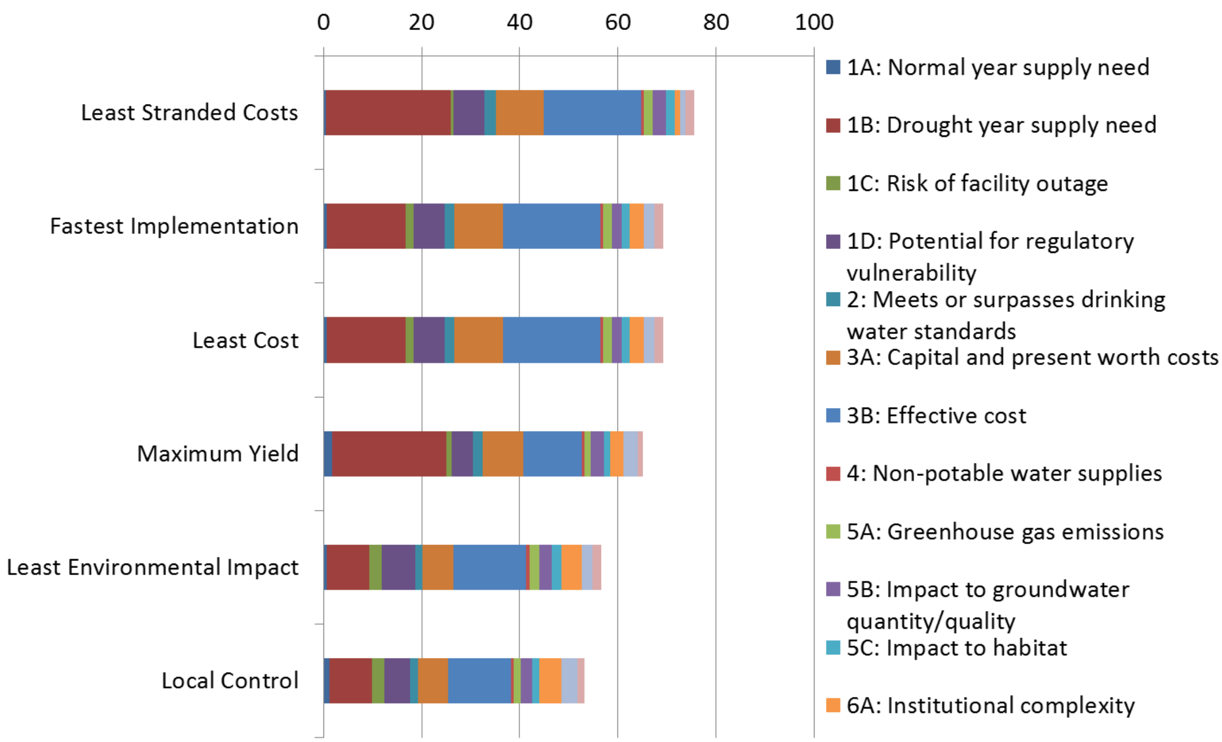

Figure 5-4
Portfolio Scoring Using Sensitivity Emphasizing Drought Supply, Costs, Regulatory Vulnerability, Local Control, and Institutional Complexity

Table 5-5. Sensitivity Analyses Highlight High Scoring Strategy Portfolios

Sensitivity Emphasis	Highest Scoring Portfolio(s)
1. Drought Supply	Least Stranded Costs
2. Cost	Least Cost and Fastest Implementation (same score)
3. Cost & Drought Supply	Least Stranded Costs
4. Environmental Issues & Drought Supply	Least Stranded Costs
5. Local Control & Drought Supply	Maximum Yield
6. Drought Supply, Cost, Environmental Issues, and Local Control	Least Stranded Costs
7. Drought Supply, Cost, Regulatory Vulnerability, Local Control, and Institutional Complexity	Least Stranded Costs

When all the criteria are weighted equally, the portfolio scores only spanned 4 points over the 100-point scale. As with the individual project scores, the range of portfolio scores increased under the sensitivity analyses. The portfolio scoring under the Cost & Drought Supply sensitivity analysis has the greatest range of 23 points, from 55 (Local Control portfolio) to 78 (Least Stranded Costs).

5.3 Evaluation Results Identify Need to Balance Risks and Invest in Further Information

As discussed above, the findings during Phase II of the Strategy indicated that that the total average water supply yield of the identified Strategy water management projects is approximately equivalent to the drought year need. Therefore, given the uncertainty around the potential yield and ability to implement the Strategy projects, some actions should be taken to implement each of the identified projects.

The evaluation of the Strategy projects against the water management objectives has provided information that will be used to prioritize and define sequencing of implementation actions. As evidenced above, water transfers consistently perform higher on most of the objectives than any other project.

The evaluation has also indicated the need to further examine potential risks and tolerance to risk. There are still many unknowns surrounding the projects. For example, water transfers may not be able to be secured due to a large number of factors, and the brackish desalination project yield could vary up to an order of magnitude due to uncertain geological conditions.

The Strategy, therefore, must proceed on all fronts, pursuing actions on each project, to balance different risks so as to maximize the likelihood that BAWSCA and its member agencies can provide the water when and where it is needed.

Section 6

Strategy Implementation

Based on the information and insight developed during Phase II, several actions for Strategy implementation are recommended. The information presented herein is presented to help inform future policy actions of the BAWSCA Board.

In this Section:

6.1 Context for Recommended Actions

As discussed in Section 1, the Strategy consists of three phases (see Figure 6-1):

- *Phase I* – Identified the key objectives of the Strategy, the most central being determining which combination of water management actions that could be developed to address the reliability need of the BAWSCA member agencies through 2040. Principles of participation were identified whereby the interests of each member agency would be respected.

- *Phase II* – Determined and refined the supply need reflecting the best available methods, estimated the economic impacts of reliability shortfalls, narrowed the number of viable projects from 65 to 10, evaluated these 10 projects against performance metrics (e.g., costs, yield, environmental, etc.), ranked them, formulated water supply and demand management portfolios, and developed a list of recommended actions.

- *Phase III* – While further investigations regarding the appropriate regional LOS for BAWSCA continue, a variety of actions to implement the Strategy will proceed as authorized by the Board based on the findings and recommendations of Phase II. The findings and recommended actions are detailed below.

Figure 6-1
The Three Phases of the Strategy

In summary, the demand analysis done during Phase II of the Strategy resulted in the following key findings:

- There is no longer a normal year supply shortfall.
- There is a drought year supply shortfall of up to 43 mgd.

The project evaluation analysis done during Phase II of the Strategy resulted in the following key findings:

- Water transfers score consistently high across the various performance measures and within various portfolio constructs and thus represent a high priority element of the Strategy.
- Desalination also potentially provides substantial yield, but its high effective costs and intensive permitting requirements make it a less attractive drought year supply alternative. However, given the limited options for generating significant yield for the region, desalination warrants further investment in information as a hedge against the loss of local or other imported supplies.
- The other potential regional projects provide tangible, though limited benefit in reducing dry year shortfalls given the small average yields in drought years.

Dry year water supply shortfalls have significant economic impacts with losses that could exceed $8B over the next 30 years in the BAWSCA region (The Brattle Group 2013). Increased regional dry-year reliability should be pursued to avoid significant regional economic impacts of drought.

Figure 6-2 shows the relative yield of the viable water management projects[1]. If all were implemented and achieved the estimated average yields, they could provide sufficient supply to offset a 20 percent system-wide shortfall on the SF RWS. The total capital cost for implementing all these projects ranges from $480 million to $840 million. Alternatively, fewer of these projects might be implemented to only partially off-set dry year shortfalls at a lower capital cost.

[1] While specific projects were not developed or evaluated for the Strategy, regional discussions on indirect/direct potable reuse have accelerated dramatically in the last year, making this a water supply management project BAWSCA will be tracking closely.

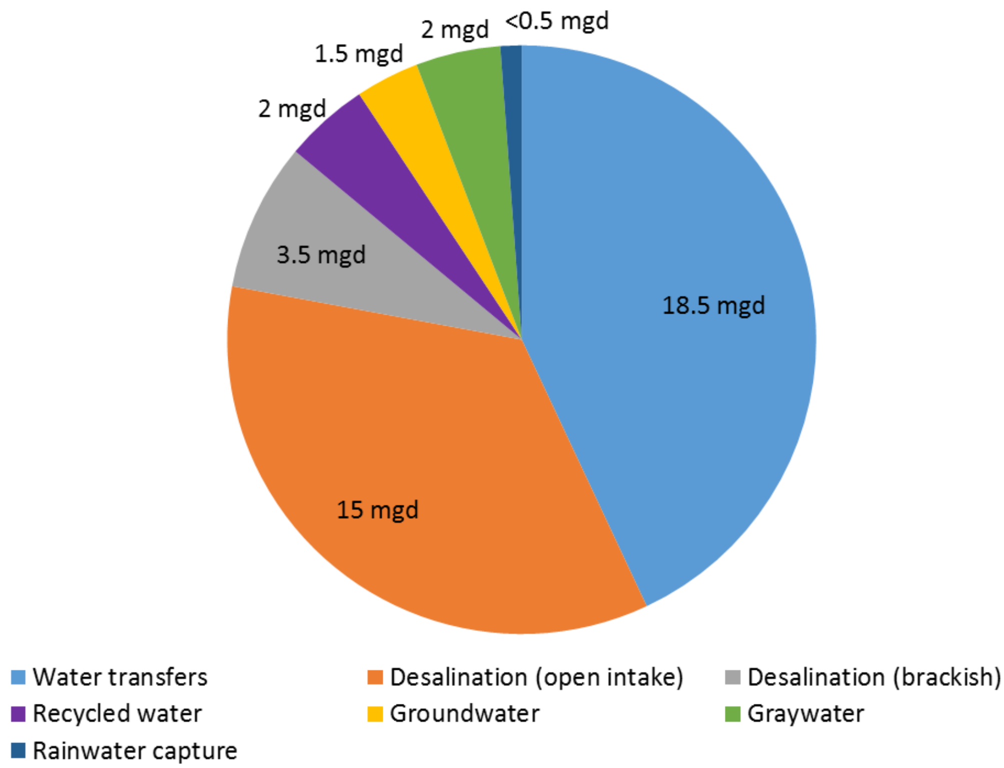

Figure 6-2
Average Yields for Water Management Projects to Meet Dry Year Shortfalls

Given that the total average water supply yield of the identified Strategy water management projects is approximately equivalent to the dry year need, and the uncertainty around the potential yield and ability to implement the Strategy projects, actions should be taken to pursue each of the identified projects. The evaluation of the Strategy projects against the water management objectives has provided information that will be used to prioritize and define sequencing of actions.

The evaluation has also indicated the need to further examine potential risks and tolerance to risk. There are still unknowns surrounding the projects, policy decisions, and planned supply investments. The Strategy, therefore, must proceed on all fronts, pursuing actions on each project, to balance different risks so as to maximize the likelihood that BAWSCA can provide the water when and where it is needed.

6.2 Types of Actions: Core and Implementation

The recommended actions have been broadly classified into two categories, depending on the stage of development of the project, degree of risk, level of uncertainty and level of financial investment required for the action. Figure 6-3 provides a conceptual overview of these two types of actions. These actions are conceptually defined as the following:

- *Core Actions*: Low-cost, low-risk actions pursued in an early phase of project development that can provide critical information, identify partnerships, and reduce uncertainty for pursuing full-scale investments in water supply projects.

- *Implementation Actions*: Higher-cost and higher-risk actions pursued in later phases of water supply projects that more directly lead to development of new supplies.

Figure 6-3 illustrates that Core Actions occur when there is much progress needed before water supply is produced, and Implementation Actions occur closer to the realization of a new water supply. Also, as illustrated in Figure 6-3, Core Actions have lower costs and risks, while Implementation Actions have higher costs and risks, comparatively.

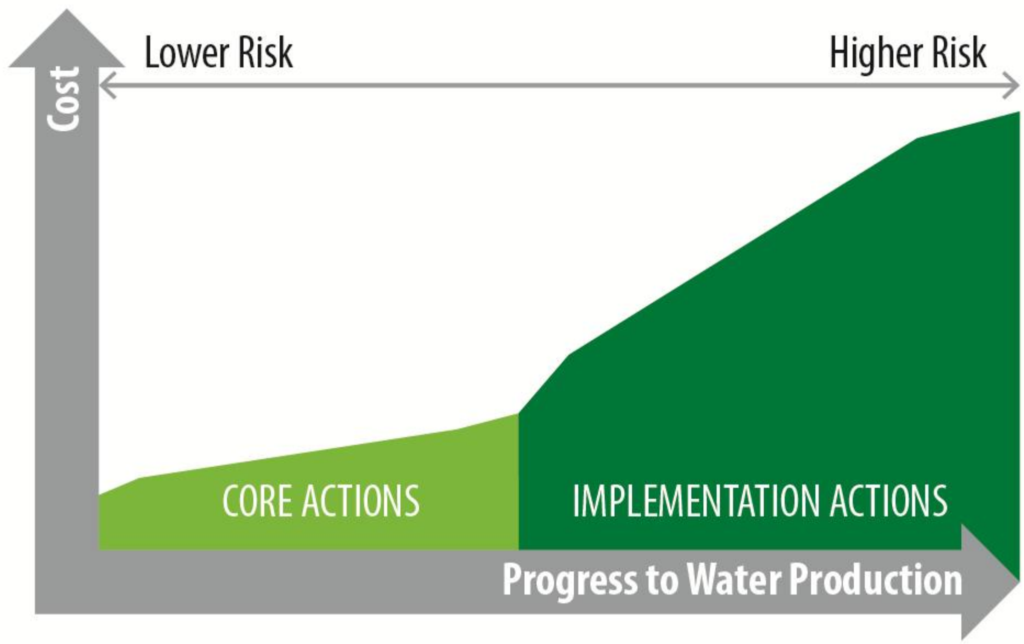

Figure 6-3
Defining Core and Implementation Actions

Examples of Core Actions towards water supply production include: perform master planning; study funding mechanisms; identify collaborations; seek legislative support; and support public outreach for a project. Examples of Implementation Actions include: complete environmental documentation (e.g., California Environmental Quality Act [CEQA] analysis); perform pilot testing; finalize financing; enter design phase; and select a project contractor.

Figure 6-4 provides an illustration of different Core and Implementation Actions using a water transfer project as an example. Since no new construction is required, there are no capital investments needed, so costs are relatively low prior to implementation of a pilot water transfer. Actions such as signing an MOU with transfer partners and working on agreements would qualify as Core Actions towards the development of a new water supply. As shown in Figure 6-4, these actions can be performed with relatively little cost and risk, but are critical steps towards furthering the development of this water management project. To move closer to water supply production will require the higher costs associated with implementation. As shown in Figure 6-4, Implementation Actions of executing a pilot water transfer and then subsequently preparing the environmental documents (i.e., CEQA and/or National Environmental Policy Act compliance) for full-scale water transfers would require progressively greater financial investment. Those investments have a greater associated risk should a long-term transfer agreement not be finalized or if the yields were lower (or the costs higher) than planned.

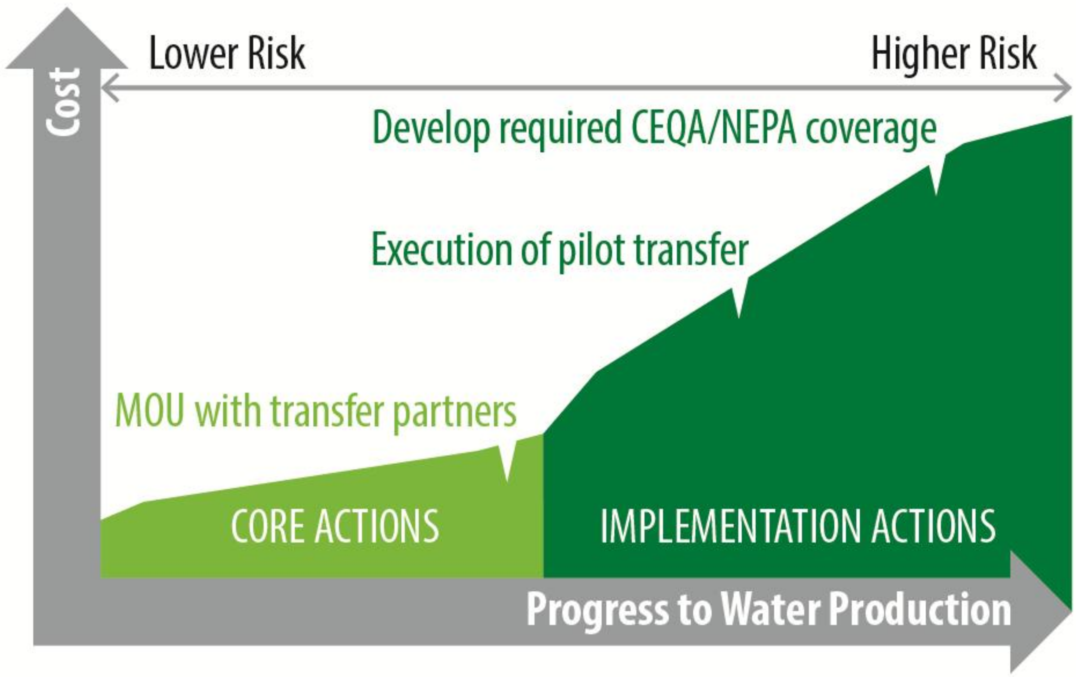

Figure 6-4
Core and Implementation Actions for an Example Water Transfer Project

The Strategy confirms that the borders between member agencies are porous; supply shortfalls have an economic impact throughout the region in addition to the direct impact in the specific location experiencing a shortfall. Given any particular water management project, breaking actions into Core and Implementation may also help define the implementation and cost sharing arrangements among the BAWSCA member agencies. With lower cost and lower risk activities, Core Actions may lend themselves to a broader sharing of costs among the member agencies who all indirectly benefit. The costs related to Implementation Actions, which may have a higher cost, may be more heavily allocated to those BAWSCA agencies that will directly benefit from particular projects.

6.3 A Range of Recommended Actions

The recommended Core Actions and Implementation Actions are compiled in Table 6-1, discussed in detail below, and can be summarized as the following five recommended actions:

1. Lead water transfer development and implementation including identifying and evaluating water storage options;
2. Facilitate desalination partnerships and pursue outside funding for related studies;
3. Support agency-identified projects (i.e., recycled water and groundwater) and local capture and reuse;

4. Participate in regional planning studies in cooperation with others; and

5. Continue monitoring regional water supply investments and policies.

Table 6-1. Range of Recommended Actions

Action	Core	Implementation
On-going	**SCVWD Pilot Transfer Plan:** complete plan to evaluate potential transfer options	**EBMUD Pilot Transfer:** execute a pilot water transfer
	Recycled Water: facilitate partnerships and grant funding	**Local Capture and Reuse:** implement rain barrel program; pursue funding
	Groundwater: facilitate partnerships and grant funding	
	Planning Studies: examine impacts of non-SFPUC shortfalls; evaluate hydrology under the current drought and climate change; participate in the Bay Area Regional Reliability (BARR) process	
New	**Water Storage Options:** identify and evaluate storage options	**SCVWD Pilot Transfer:** execute a pilot water transfer[1]
	Recycled Water: monitor indirect/direct potable reuse policy development; facilitate discussions; pursue funding	**Water Storage:** develop agreements[1]
	Local Capture and Reuse: evaluate new programs; pursue funding	**Brackish Desalination:** conduct aquifer testing[1]
	Desalination Projects: facilitate partnerships; pursue funding	
	Planning Studies: review lessons learned from prior droughts; consider development pattern impacts on water demands	

[1] Contingent on findings from earlier activities

The actions arise from on-going work by BAWSCA and also represent new work for BAWSCA. Of these recommended actions, executing the EBMUD Pilot Transfer will have the most immediate financial impact. In addition, some new work has been identified as a priority. For example, identification of potential water storage options could reduce the risks of the water transfers, the highest performing project. Acquiring and storing these surplus supplies during non-drought periods for withdrawal and delivery during drought years would strengthen water transfers as a viable water management action.

Some of the recommended actions reflect that the Strategy is not static and needs to be informed by changes in planning assumptions, impacts, and actions of others. This includes refining estimates of supply need that reflect updated hydrology, shifts in demands associated with development and climate change, and mining insights from other agencies that have made significant investments against future extended droughts. Other recommended actions will either be addressed under proposed work plan activities or will be contingent on findings from proposed work plan activities.

For example, desalination project development actions will be contingent on both identifying partners and obtaining funding through existing and new outside funding channels (e.g., California Proposition 84, the California Water Bond, and Federal funding).

It is anticipated that BAWSCA will have differing roles for each the Strategy projects. The agency-identified projects and local capture and reuse projects are Strategy projects that will be implemented primarily by individual member agencies, with assistance from BAWSCA. However, implementation of the higher yield regional projects, water transfers and desalination, will require a more active role for BAWSCA.

Facilitating agreements for projects that are highly-developed (e.g., recycling) and facilitating agreements, funding and approvals for projects that are in development (e.g., transfers and desalination) are critical ongoing roles for BAWSCA.

Finally, as described in detail in Section 6.5, continued monitoring of other agencies' policy decisions and supply investments is important for the Strategy as changing policy or supply conditions could alter activities related to Strategy implementation and its fundamental objective of assuring reliability for BAWSCA. A summary of the major policy decisions and supply investments that should be monitored as part of the Strategy is presented in Table 6-4.

6.3.1 On-going: Core Actions

6.3.1.1 Water Transfers

The appeal of water transfers is that they require little to no capital investment and can potentially supply significant portions of projected dry year water reliability needs. The feasibility of transfers, the availability of supply sources, availability of conveyance capacity, and potential for storage of supplies remain questions BAWSCA is working to resolve. The work described below is recommended to reduce the uncertainty around water transfers as a dry-year water supply.

BAWSCA signed an MOU with SCVWD in August 2014 to develop a plan to implement a pilot water transfer. The project would culminate in a report, similar to the effort BAWSCA pursued with EBMUD that concluded in September 2013. The major activities planned for the remainder of FY 2014-2015 and into FY 2015-2016 are summarized in Table 6-2. Following the completion of the SCVWD-BAWSCA Pilot Water Transfer Plan report, BAWSCA may pursue implementation of a pilot water transfer with SCVWD to test institutional mechanisms, and further findings from the plan.

Table 6-2. Tasks for Developing a Potential Pilot Transfer with SCVWD

Task	BAWSCA's Responsibilities
Develop Goals and Objectives	Develop agency-specific set of goals for conducting a pilot transfer.
Identify Pilot Transfer Conditions and Quantity	Identify near-term water supply conditions and/or other criteria related to SFPUC and BAWSCA's member agencies supplies and facilities for a transfer to occur.
Identify Potential Program Partners among BAWSCA Member Agencies	Evaluate potential interest of member agencies, starting with common customers and Cal Water.
Identify Potential Pilot Water Transfer Sources	Confirm that potential pilot transfer sources and other issues developed by SCVWD would be acceptable for the pilot transfer.
Evaluate Ability to Convey Transfer Water to BAWSCA Service Area	Coordinate joint effort to evaluate the ability to convey water through the Milpitas intertie including any water quality and source shifting issues; coordinate; evaluate the ability to deliver water through the SF RWS to member agencies.
Identify Approvals and Institutional Arrangements	Identify environmental review to distribute transfer water to member agencies; provide input to SCVWD's investigation of additional regulatory approvals, permits, or legal/institutional restrictions; identify agreements to distribute transfer water to member agencies.
Develop Recommendations for Pilot Water Transfer	Provide input to total and unit costs developed by SCVWD; identify objectives for the next phase of the pilot transfer; determine trigger points and deadlines for deciding on the timing and approvals to implement the transfer.
Prepare Pilot Water Transfer Plan Study Report	Compile work products into the final report.

6.3.1.2 Recycled Water

As discussed in Section 4, a decision was made early in the Strategy process that BAWSCA would not be directing planning and/or implementation of any agency-identified projects, but rather assisting by potentially providing support to these projects. For the recycled water projects, BAWSCA could facilitate discussion and negotiation among member agencies, and/or between BAWSCA member agencies with excess recycled supplies and non-BAWSCA entities involved in these projects as suppliers and users. The core actions of identifying and facilitating partnerships and funding mechanisms are recommended for furthering progress in implementing these recycled water projects.

Potential purchasers of recycled water supply have been identified for each of the recycled water projects. Many of these are other BAWSCA member agencies, but there are also other entities such as the cemeteries in Colma, the NASA Ames facility in Mountain View, and future developments. Institutional agreements will need to be prepared between the recycled water suppliers and users (whether that is a water supplier or an individual user) to settle issues such as demand, seasonal and diurnal capacity, and costs. The Daly City and Palo Alto projects will require some additional focus on gaining acceptance of recycled water by their users. Previously, the Colma cemeteries have been reluctant to switch from groundwater to recycled water due to concerns about impacts to their extensive landscaping given the close contact with the public. Stanford University is working with the City of Palo Alto to support the recycled water project that will serve Stanford Research Park.

The Palo Alto Recycled Water Project is the only project that is currently in the environmental review phase, with a final EIR expected in mid-2015. The other projects will need to complete the CEQA process before the projects are approved by City Council.

All projects will likely be looking for outside funding to support the projects. The most common options being considered are amendments to existing Bureau of Reclamation (Reclamation) Title XVI funding (which can often be a long process), Clean Water State Revolving Fund loans, and California Proposition 84 Integrated Regional Water Management (IRWM) funding. With the passage of the 2014 Water Bond, there will be additional State funding for recycled water programs.

6.3.1.3 Groundwater

The City of Sunnyvale has identified potential partners for its groundwater project. Coordination would be necessary with SCVWD if Sunnyvale used the groundwater to offset their SFPUC supply and considered transferring their ISG to other BAWSCA member agencies. Similar to the recycled water projects, BAWSCA's core actions could be to facilitate discussion and negotiation between interested parties. BAWSCA recommends these actions be pursued as a part of the near-term work plans.

6.3.1.4 Additional Non-Project Specific Planning and Studies

Determining the water reliability need for the BAWSCA member agencies is based on the projections of demand and the assumptions regarding the availability of existing supplies under different hydrologic conditions. Refining the reliability need is a core action critical for gauging the level of investments required. Several studies are recommended for consideration:

- *Examine Impacts of Non-SFPUC shortages* – Non-SFPUC supply shortfalls can also impact the magnitude of the supply need and require further analysis to understand the potential regional risks. The Strategy is focused on the impacts of SF RWS reliability and did not examine the other water supplies currently used by BAWSCA member agencies (e.g., SWP, CVP, groundwater, local surface water). The reliability of some of these supplies will also be affected under dry year conditions. Consequently, the dry year need may be greater when considering these supply sources. Evaluation and documentation of dry year impacts on other supply sources is important for full understanding of the reliability of the region. Section 6.5.2 discusses the need to monitor the effectiveness of other's supply investments.

- *Evaluate Hydrology Including Recent Dry Period* – The hydrologic dataset (i.e., SFPUC HH/LSM modeling) used for the Strategy does not fully incorporate the impacts of the current drought. Including the impacts of the current drought on the historical dataset may predict more frequent/severe shortfalls. BAWSCA should revisit the HH/LSM modeling conducted by the SFPUC and incorporate the hydrology from the current drought.

- *Evaluate Hydrology Considering Climate Change* – Climate change modeling is on-going and can further influence the estimated supply need. Most drought predictions are made retrospectively (i.e., based on a history of hydrologic data). With climate change, however, questions are being raised as to how accurate that record is for predicting future hydrology and the future water availability in the SF RWS. BAWSCA should be vigilant in ensuring that all the appropriate tools are being used to monitor potential changes in assumptions about future water availability in the SF RWS.

- *Participate in the BARR process* – Along with several other Bay Area water agencies, BAWSCA is working cooperatively to identify means to improve water supply reliability. Certain agency-specific projects, if implemented, are believed to be of benefit to the Bay Area region as a whole. BAWSCA will continue to participate in identifying, evaluating and promoting projects that will be of greatest benefit to member agencies.

6.3.2 On-going: Implementation Actions

6.3.2.1 EBMUD Pilot Water Transfer

BAWSCA has invested significant resources over the last two years in planning for and developing the necessary agreements to implement a pilot transfer with EBMUD. If EBMUD decided to operate its FRWP facilities for dry year supply in 2015 (EBMUD expects to decide in April 2015), a pilot transfer could occur in fall 2015 depending upon the availability of water from YCWA and completion of necessary agreements. If conditions warrant, the BAWSCA staff recommends implementing the pilot water transfer with EBMUD.

If BAWSCA does implement the pilot transfer, it will also collect data to assess the impacts of the operations on the City of Hayward and the SF RWS. This information will be important for assessing the feasibility of future transfers.

Contingent Action: If the evaluation of pilot water transfer with EBMUD is positive, further actions to implement water transfers may be recommended.

6.3.2.2 Local Capture and Reuse

There are two major actions that are recommended to help further implementation of local capture and reuse projects:

- *Implement Regional Programs* (rain barrels) – Rainwater harvesting projects, depending on ownership and size, will vary in the time required to implement them on an individual basis and within an agency service area. BAWSCA should continue providing incentives to encourage the installation and use of rainwater harvesting systems.

- *Seek Funding* – BAWSCA should include implementation of these projects into existing and future grant funding applications (see Section 6.5).

6.3.3 New Projects: Core Actions

6.3.3.1 Water Storage

Since finding water on the market in a very dry year can be more difficult and expensive, one strategy that would strengthen water transfers as a viable water management action is to identify potential storage options. Under this approach, non-dry year supplies could be acquired and stored for later withdrawal and delivery during dry years. Transfer or surplus supplies could be stored in a surface water reservoir (e.g., Contra Costa Water District's Los Vaqueros Reservoir) or via groundwater banking (e.g., Zone 7 Water Agency's Livermore Valley Groundwater Basin). Funding near-term work plan activities to research potential storage options is recommended.

6.3.3.2 Recycled Water

Three core actions are recommended as near-term work plan activities:

- *Monitor Indirect/Direct Potable Reuse Policy Development* – Under the California Water Code Section 13560-13569, the State Board's Division of Drinking Water (DDW) is required to adopt regulations regarding surface water augmentation with recycled water and report to the Legislature on the feasibility of developing uniform water recycling criteria for direct potable reuse by December 31, 2016. This will impact the viability of implementing more extensive potable reuse and its competitiveness compared to other supply options.

- *Facilitate Discussions* – BAWSCA could facilitate discussion and negotiation between member agencies, and non-BAWSCA entities, involved in these potential new projects as suppliers and users.

- *Seek Funding* – BAWSCA should develop costs and program descriptions for potential projects to insert in existing and future grant funding applications (see Section 6.5).

6.3.3.3 Local Capture and Reuse

There are two recommendations for near-term work plan activities:

- *Evaluate New Programs and Projects* – Whether it is stormwater capture or graywater reuse, technology may evolve to improve the cost-effectiveness of these projects. Educational efforts and financial incentives will likely still be needed and BAWSCA should continue to evaluate alternatives for implementation amongst its member agencies.

- *Seek Funding* – BAWSCA should include implementation of projects to insert into existing and future grant funding applications (see Section 6.5).

6.3.3.4 Desalination

The major dry year supply alternative to water transfers is desalination. Implementing a desalination project, whether brackish or open intake, in California can be a long and complex process. Reasons for this include:

- Regulatory requirements are not firmly established;

- Capital and development costs can be high; and
- High potential exists for opposition.

The highest and most reliable yield would be associated with an open intake desalination project, however, implementing a brackish desalination project has proven to be more streamlined and less controversial.

Planning

Identifying/facilitating partnerships and preparing for additional investigations are the main recommended core actions to be implemented in the near term:

- *Partnership Development* – The key priority for both brackish and open bay intake desalination is identifying the potential partners and project developers. This will enable the interested parties to discuss desired supply, risks, cost-sharing and schedule for development. It is recommended that BAWSCA staff further discussions with potential partners on desired normal and dry year yields, costs, and willingness to share in development costs of the project. In addition, potential project developers (e.g., a member agency or a third party that would fund, construct, operate the facility) should be identified. It is also recommended that BAWSCA staff continue to facilitate potential agreements with wastewater agencies for outfall use for brine disposal and with SFPUC on potential conveyance and exchanges.
- *Aquifer Conductivity Testing Scope* – The two most promising brackish desalination plant locations are near the San Mateo Bridge and Dumbarton Bridge. The total shallow-aquifer groundwater yield from both areas range from 1 to 3 mgd but the yields could be as high as 5 to 10 mgd if Bay Mud conductivity is found to be higher than assumed. A shallow aquifer exploration and testing program is recommended to refine project yields and evaluate the hydraulic connection between the shallow aquifer and San Francisco Bay. This is discussed further in Appendix A.

Funding

Sources of funding for executing the aquifer conductivity testing program could include grants. It is recommended that BAWSCA refine the costs and program descriptions in existing and future grant funding applications (see Section 6.5).

6.3.3.5 Additional Non-Project Specific Planning and Studies

There are two groups of studies that are recommended as near-term work plan activities:

- *Review Lessons Learned from Prior Droughts*
  - While refinements have been made to the supply need, the frequency and severity of droughts, and the costs of supply investments, decisions still need to be made without perfect information. In the face of an epic drought in Australia, significant investments were made. Now that the drought is over and the reservoir levels are high, questions have been raised as to the wisdom of the supply investments. BAWSCA should study the Australian experience (and others) to extract relevant lessons to better guide policy decisions.

 - Droughts can have direct financial impacts on water utilities. For example, revenues can be lower due to a decrease in water sales, and costs can be increased due to greater investment in conservation programs and higher supply costs. Impacts of recent dry year shortfalls on utility costs and revenues should be characterized to better guide future actions, whether in alternative revenue structures, additional supply investments or demand management programs.

- *Consider Development Pattern Impacts* – Further development patterns may change the demand projections and hence the projected supply need. If greater levels of densification occur, it may decrease demands. Conversely, if the population growth in certain areas that is predicted is not realized, the demands may be higher. BAWSCA should reanalyze demand projections given different assumptions about population growth.

6.3.4 New Projects: Implementation Actions

Each of the new project Implementation Actions described here are contingent on results of prior work. They would be imlemented only if the analyses demonstrated a high likelihood that a given water management project would produce a reasonable yield at a reasonable cost.

6.3.4.1 Water Transfers

Pending the findings of the 2015 BAWSCA and SCVWD Pilot Water Transfer Plan Report, an opportunity to conduct a pilot transfer akin to the one proposed with EBMUD may be feasible for implementation.

6.3.4.2 Water Storage

Pending the investigations of potential storage alternatives, agreements may be pursued or a pilot may be enacted in concert with a transfer.

6.3.4.3 Desalination

Pending the outcome of (1) the investigation and development of desalination partnerships and (2) researching and securing of funding for brackish desalination, sufficient interest may exist to proceed with the aquifer conductivity testing described in Section 4 that would better define anticipated brackish desalination plant yields.

6.4 Funding Mechanisms

There are several mechanisms available for consideration when examining potential projects:

1. *BAWSCA Assessments*: BAWSCA assessments are the primary mechanism for BAWSCA to raise revenue, and they follow a predefined allocation from each of the member agencies.

2. *Grant Funding*: Through proposal submissions for Proposition 84 and Proposition 1, a cost share may be awarded. Typically grants can range from 25 to 50 percent of the project cost. Currently BAWSCA submits projects as part of the San Francisco Bay Area IRWM Plan (IRWMP).

3. *Water Management Charge*: The 2009 WSA authorizes BAWSCA to direct the SFPUC to collect funds from the Wholesale Customers on their monthly water bills to fund regional water supply development programs and conservation activities. The Water Management Charge is

implemented as approved by the BAWSCA Board and directed by BAWSCA. The Water Management Charge allows for the allocation of costs differently than the assessments.

4. *Partners*: Each water management project envisions multiple partners receiving benefits, and therefore being funding partners. For example, a desalination project may have several member agencies who contribute to the next implementation steps in concert with initial funding from BAWSCA.

6.4.1 BAWSCA Assessments

The assessments are BAWSCA's main funding source. These funds are collected from the member agencies and are based proportionally for each agency on the agency's purchases from SFPUC as defined by Water Code Section 81460. The assessments are used to fund BAWSCA's Work Plan and Operating Budget each fiscal year. Funding Core and Implementation Actions recommended in the Strategy could occur as part of BAWSCA's Operating Budget funded by assessments.

6.4.2 Grant Funding

With respect to grant funding, BAWSCWA should continue to monitor and pursue these opportunities to support development of the Strategy projects. The key activities are summarized in Table 6-3 and detailed below.

Table 6-3. Grant Funding Actions

Grant	Action
Proposition 84 IRWM	Update existing BAWSCA projects in the Bay Area IRWMP. Add projects for open intake desalination and new recycled water projects.
Proposition 1, Water Quality, Supply and Infrastructure Improvement Act of 2014	Monitor mechanism by which funds will be awarded. Prepare to submit projects not funded under the IRWMP.
Water in the 21st Century Act	Monitor the progress of S. 2771/H.R. 5363 through Congress

6.4.2.1 Major Grant Funds

California Proposition 84

The last portion of Proposition 84 IRWM funding allocation will begin in summer 2015. The remaining Prop 84 funding available for the Bay Area is approximately $41 million. Projects eligible for funding include water supply, wastewater, groundwater management, watershed protection, stormwater, and ecosystem restoration. DWR's funding priorities for this final funding round may be highly dependent on hydrologic conditions of this current water year. The 2014 IRWM funding was prioritized for drought-related projects that could begin within the next calendar year. If the 2015 water year continues to be dry, the 2015 funds would also likely focus on drought projects. The Bay Area IRWMP Coordinating Committee is planning to begin soliciting projects for the 2015 funding cycle in March 2015, prior to the finalization of DWR's process and priorities for this funding round.

California Water Bond

California's $7.5 billion Proposition 1, the Water Quality, Supply and Infrastructure Improvement Act of 2014 (Water Bond), will fund water projects and programs state-wide to support investment in increasing water supplies, protecting and restoring watersheds, improving water quality, and increasing flood protection. Funding areas related to Strategy projects include:

- $810 million for regional water reliability, including water conservation and stormwater capture;

- $725 million for recycled water and desalination; and
- $2.7 billion for water storage projects, including groundwater storage.

Funds from the Water Bond would become available from state agencies through a competitive grant process, except for water storage projects which would be chosen by the California Water Commission. The State legislature will most likely not authorize funds until FY 2015-2016 (July 2015).

Future Federal Legislation

A new water infrastructure investment bill is working its way through the Senate and House committees that could provide grants and low-interest loans for a variety of water supply projects. "Water in the 21st Century Act" or "W21" (Senate 2771/House of Representatives 5363) would expand availability of grants and low interest, long-term loans through Reclamation for water storage, conveyance, water recycling, and IRWM projects, and expand rebates and grants for water conservation, wastewater and stormwater management efficiencies, green infrastructure, and water recycling improvements through the United States Environmental Protection Agency's WaterSense Program. The Reclamation financing program would provide loans for up to 100 percent of a project's cost (with a $10 million minimum) with terms up to 35 years and capped at the 30-year Department of Treasury rate. The Senate and House bills have been referred to committee for review.[2]

6.4.2.2 Mechanisms for Obtaining Funding

The Bay Area Coordinating Committee will develop selection criteria for project applicants for the 2015 round of Proposition 84 grant funding. It is assumed the Coordinating Committee will follow the same process as used for the 2014 application and put out a call for proposed projects, review and score projects, develop a list of selected projects, and prepare the grant application.

It remains to be seen which State agencies will receive funds from the Water Bond, but is likely the solicitation process would be similar to the system that DWR has been using for the IRWM program.

6.4.2.3 Immediate Activities

BAWSCA should plan for the following activities (or others as identified later) to support grant funding over the next several years:

- Review, in concert with appropriate member agency proponents, descriptions for Strategy projects that are already included in the 2012 Bay Area IRWMP ("BAWSCA/EBMUD Short-Term Water Transfer Pilot Project," "BAWSCA Brackish Groundwater Field Investigation Project," "Palo Alto Recycled Water Project," "Daly City Expansion Recycled Water Project") and update, as appropriate, so that project details are current for the 2015 Proposition 84 funding solicitation;
- Submit, in concert with appropriate member agency proponents, Strategy projects to the Bay Area IRWMP that are not already in the plan (open intake desalination investigation, Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP, and Sunnyvale – Expanding the

[2] BAWSCA is part of the BARR process involving a consortium of water agencies identifying opportunities for more efficient means of improving reliability. The group will develop projects that will target funding opportunities from the Army Corps of Engineers and Reclamation.

Use of New or Converted Wells to Normal Year Supply) to be eligible for 2015 Proposition 84 funding;

- Encourage project proponents for individual agency recycled water projects to seek funding for planning and construction through other State funding sources, including the Water Recycling Funding Program and the Clean Water State Revolving Fund;
- Monitor funding opportunities that arise from the Water Bond; and
- Monitor progress of Water in the 21st Century Act legislation.[3]

In addition, BAWSCA should periodically review of all funding options and strategies as implementation progresses.

6.4.3 Water Management Charge

The Water Management Charge can be used to fund regional water supply projects. The Water Management Charge is flexible, and money can be collected over a number of months or years if necessary. If a large sum of money is needed initially, BAWSCA could obtain short-term financing to cover the expense with repayment funded by the Wholesale Customers' Water Management Charge payments that get collected by the SFPUC and paid to BAWSCA.

For example, the pilot water transfer could be funded via the Water Management Charge. The Board would need to approve the implementation of the pilot water transfer, and authorize the BAWSCA Chief Executive Officer/General Manager to enter into agreements with project partners. The agreements outline anticipated costs to implement the pilot water transfer, and Board authorization would cover approval of these costs. The Board would also authorize the collection of money to fund the pilot water transfer using the Water Management Charge, and the total amount to fund the pilot water transfer would be collected by all of the member agencies over a one-year period. For the pilot water transfer it is assumed that each member agency would purchase water in proportion to their water use, so the Water Management Charge would be applied in proportion to the agencies purchases. To obtain money quickly to pay costs associated with the implementation of the pilot water transfer, BAWSCA would obtain short-term financing. The money that BAWSCA obtains from the member agencies via the SFPUC through the Water Management Charge would then be used to repay the loan.

Use of the Water Management Charge offers the following benefits when compared with funding the Pilot Water Transfer through the BAWSCA annual budget and agency assessments:

- Provides the Board flexibility in collecting revenue and allocating costs for the transfer, as opposed to the assessment process, which funds BAWSCA's annual operating budget and is set by State law;
- Represents a discrete project budget independent of the BAWSCA annual operating budget that can be tracked and monitored separately;
- Revenue stream is not constrained by the fiscal year, which is beneficial when pursuing activities that extend beyond a single fiscal year;

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[3] http://www.opencongress.org/bill/s2771-113/show and http://www.opencongress.org/bill/hr5363-113/show.

- Enables BAWSCA member agencies to accommodate the cost of the Pilot Water Transfer as part of the cost of water from SFPUC (which is where that cost would occur if SFPUC was undertaking this effort) rather than as an increased cost associated with participation in BAWSCA; and

- Shows as a separate line item on each agency's water bill from the SFPUC.

This is just one example of how the Water Management Charge could be used to fund a water supply project. When used to fund the Strategy, the cost of the Water Management Charge was allocated to all agencies in proportion to their FY 2000-2001 water purchases from the SFPUC. This is the same proportion as the BAWSCA assessments. The result was a fixed monthly amount collected from each BAWSCA agency.

A few additional conditions are imposed on SFPUC and BAWSCA if the Water Management Charge is utilized:

- SFPUC will provide an annual accounting of revenue collected from the member agencies and remitted to BAWSCA; and

- BAWSCA will provide an annual report to the SFPUC describing the projects and programs funded with this revenue and an estimate of water conservation savings and new supply yield associated with this expenditure.

The Water Management Charge is a flexible source of income, easily collected by the SFPUC on the member agencies' monthly bills and remitted to BAWSCA.

6.4.4 Partners

While a cost allocation approach remains to be developed by the Board, the Strategy principles presented in Section 1.3 lay the foundation for an approach. It seems likely that costs and risks will be shared amongst the partners for each water management project according to the benefits. This will include a share of the costs for core and implementation activities (e.g., additional studies, environmental documents, and design). A brackish desalination project, for example, will require some aquifer testing the cost of which may be partially shared the member agencies interested in the project, perhaps also with initial funding from BAWSCA.

6.5 Monitoring Other Agencies' Policy Decisions and Supply Investments

Continued monitoring of other agencies' policy decisions and supply investments is important for the Strategy as changing policy or supply conditions could alter activities related to Strategy implementation and its fundamental objective of assuring reliability for BAWSCA.

The major policy decisions and supply investments that should be monitored as part of the Strategy are summarized in Table 6-4 and presented in detail in the remainder of Section 6.5.

Table 6-4. Policy Decisions and Supply Investment Activities to Monitor

Element	Entity	Activities to Monitor
Policy	State and Federal	Federal and State decisions that may (1) further limit supply availability from the exiting supplies (e.g., Tuolumne River) and (2) facilitate the development of new supplies (e.g., direct/indirect potable reuse).
	SFPUC	Decision on 2018 ISL which will impact supply availability from the SF RWS. Determination on role as regional provider.
Supply Investments	BAWSCA Member Agencies	Progress on implementing planned projects will impact supply need. 2015 UWMPs will reflect changes in near-term projections.
	SFPUC	Performance of projects in construction and projects under consideration may impact the magnitude of the supply need.
	SCVWD	Development of various potable reuse projects which may indirectly or directly create additional water supply.

6.5.1 Policy Decisions

6.5.1.1 State and Federal Agencies

Federal or State regulatory actions may reduce supply reliability of the SFPUC supplies and should be closely monitored:

- FERC is in the process of evaluating the relicensing of the Don Pedro Project. The result of this process could include additional instream flow requirements for fishery restoration purposes, and a potential reduction to SFPUC supplies, particularly during droughts. For example, based on SFPUC's current drought supply forecasting protocols, the 2009 proposed instream flow requirements could require a reduction in SF RWS drought year deliveries by as much as 53 percent (FERC 2009).
- Changes to the State Board plan for the Delta, which increases unimpaired flows from the Tuolumne watershed, and the State Board development of flow criteria for the Delta ecosystem as part of the Sacramento-San Joaquin Delta Reform Act of 2009 could also affect the yield of the SF RWS.
- Other decisions (e.g., potential court rulings).

Federal or State policy decisions that impact the development of new supplies, such as potable reuse and desalination, should also be closely monitored.

6.5.1.2 SFPUC

As stated in SFPUC Resolution 08-200, dated October 30, 2008, approving the Phased WSIP, SFPUC will re-evaluate water demands in the service area through 2030 and assess whether or not to increase deliveries beyond the current contract obligations by 2018. For the purposes of the Strategy, BAWSCA has assumed that deliveries from the SF RWS to the BAWSCA member agencies will continue to be limited to the 184 mgd Supply Assurance in the future and that the SFPUC may decide to not make San Jose and Santa Clara permanent customers (i.e., to not meet their 9 mgd purchase projections). Several items will be important to monitor:

- Whether SFPUC elects to maintain or change its ISL of 184 mgd for the BAWSCA member agencies.

- How successfully SFPUC implements all of the WSIP supply projects (e.g., 2 mgd water transfer).
- The dry year yield impacts on the SF RWS of increased flow release requirements below Calaveras Dam and Crystal Springs Dam to benefit downstream fishery resources.
- Actions emerging from SFPUC's water supply planning process (i.e., 2030 Water MAP), which will determine whether SFPUC will take action to make San Jose and Santa Clara permanent customers and/or provide a supply in excess of its current contraction obligation of 184 mgd. Additional supply development is possible that may reduce the dry year supply need for BAWSCA.

6.5.1.3 Other

Under the California Water Code Section 13560-13569, the DDW is required to adopt regulations regarding surface water augmentation with recycled water and report to the Legislature on the feasibility of developing uniform water recycling criteria for direct potable reuse by December 31, 2016. This will impact the viability of implementing more extensive potable reuse and its competitiveness compared to other supply options. In addition, the State Board will be issuing new desalination policies in late 2014 which could directly impact desalination procedures for BAWSCA.

6.5.2 Supply Investments of Others

Projects implemented by others may either increase or decrease BAWSCA's supply need or others' ability to implement projects under consideration. This includes the Bay Area Regional Desalination Project (BARDP) and its impact on conveyance capacity for transfers, ACWD providing desalinated water to SFPUC and the potential for potable reuse to open up new supply alternatives.

6.5.2.1 BAWSCA Member Agencies

In addition to the demand study recently conducted by BAWSCA, BAWSCA member agencies will be providing their updated UWMPs to DWR by July 1, 2016. These plans describe their long-term resource planning and assumptions about current and future water supplies. BAWSCA staff will monitor these to determine whether the assumptions about individual member agency supply development are consistent with those incorporated into the analysis summarized in the Strategy.

6.5.2.2 SFPUC

SFPUC is looking at supply options to meet their contractual obligations and water supply level of service goals (e.g., instream flow requirements for Alameda Creek and San Mateo Creek) and to meet other regional needs (i.e., a decision to make San Jose and Santa Clara permanent customers, decreasing allowable drought reductions). A number of WSIP projects are in construction (e.g., Calaveras Dam Replacement Project and the Regional Groundwater Storage and Recovery Project) which should be monitored for how the predicted yields compare to the realized yields. The impact of SFPUC's implementation of potential projects (e.g., BARDP, water transfers, and retail system supplies) should also be monitored for how it impacts supply availability for BAWSCA.

6.5.2.3 SCVWD

As SCVWD continues to develop its water resource strategy, BAWSCA should monitor developments that might open new opportunities for addressing their supply need. This includes SCVWD's potable reuse plans and the potential for partnering for supplemental supplies.

6.6 Next Steps for Strategy Implementation

Due to the size of the supply and reliability need, and the uncertainty around yield of some Strategy projects, BAWSCA will need to pursue multiple actions and projects in order to provide some level of increased water supply reliability for its member agencies. On an annual basis, BAWSCA will reevaluate Strategy recommendations and results in conjunction with development of the work plan for the following year. In this way, actions can be modified to accommodate changing conditions and new developments.

The decision, however, on which actions to pursue and their respective timing is a policy decision for the Board. Any actions that the Board elects to pursue can be discussed in conjunction with the regular work plan and operating budget adoption or separately, if necessary.

Specifically, it is recommended that BAWSCA:

1. Pursue a balanced suite of actions for Strategy Implementation as described in Table 6-1. These consist of Core Actions that will provide more refinement to project information with relatively low cost and low risk and Implementation Actions that will further develop the projects. Some of the Implementation Actions are dependent upon information confirming the viability obtained from the Core Actions.

2. Continue to monitor other agencies' policy decisions and supply investments that will inform Strategy Implementation going forward.

3. Report regularly to the Board on progress and new developments.

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Section 7

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Appendix A

Estimated Pumping Yields and Potential Effects from the Production of Brackish Groundwater for Desalination

Estimated Pumping Yields and Potential Effects from the Production of Brackish Groundwater for Desalination

Section 1

Overview

Among the project alternatives identified in the Strategy *Phase II A Report*[1] were desalination projects using either: 1) shallow brackish groundwater wells adjacent to San Francisco Bay (Bay); 2) higher salinity brackish groundwater from horizontal wells under the Bay ([1] and [2] collectively referred to as "brackish desalination"); or 3) seawater through open water intakes.[2] Of these options, brackish groundwater wells (both vertical and horizontal) located in shallow aquifers adjacent to and beneath the Bay where fresh groundwater and Bay seawater comingle were further analyzed in this Task 6-C Memo. This memo documents the use of the Strategy Groundwater Model (SGM) to estimate yield and local and regional drawdown due to both types of brackish desalination projects.

Several factors will influence selection of desalination project options: a) anticipated yield relative to supply need, b) costs, c) schedule, and d) implementation risks. Anticipated yield of brackish desalination projects, as discussed in this memo, is dependent on the hydrogeology and the effects of extraction. Costs are a function of location, yield, staffing and mode of operation (i.e., year-round vs. seasonal). Both schedule and implementation risks are sensitive to the evolving regulatory environment and public support for additional supplies.

Brackish desalination projects are anticipated to have the lowest capital and operational costs compared to other desalination options since (1) particulate levels are lower reducing pretreatment requirements, and (2) the salinity levels are lower requiring less energy than a seawater system.

In this Memo:

1. Overview
2. Results of Strategy Groundwater Model Simulations
3. Conclusions and Next Steps

Attachment A – Detailed Modeling Approach

The impact on groundwater levels of future planned changes in regional groundwater use by Bay area Water Supply and Conservation Agency (BAWSCA) agencies is also examined to provide context to the impact of the potential brackish desalination projects. Section 2 discusses the estimated yield of the brackish desalination projects and Section 3

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[1] BAWSCA 2012.

[2] Open water intakes are possible and are being pursued for the Bay Area Regional Desalination Project and Marin Municipal Water District (MMWD) desalination projects. They have the advantage of larger capacity withdrawals than either brackish groundwater alternatives. These types of intakes, however, present numerous challenges. Open water intakes: 1) involve more extensive permitting; 2) have higher energy consumption; 3) increase capital and operating costs; and 4) are opposed by many environmental special interest groups, including groups which have filed lawsuits against the proposed MMWD and southern California desalination facilities that have undergone the California Environmental Quality Act (CEQA) review process.

discusses conclusions of the analysis and potential next steps in moving forward with these projects. Attachment A provides detailed information on the modeling approach.

Based on the simulated groundwater yields presented here, the efficiency of current desalination technologies, and the anticipated water quality of brackish groundwater (up to 16,000 parts per million [ppm] of total dissolved solids [TDS]), the ultimate treated drinking water yield of a brackish desalination project could range from below 1 million gallons per day (mgd) to over 7 mgd.

Based on a preliminary review of hydrological conditions along the western edge of the Bay, potential wastewater treatment plant (WWTP) outfalls for a co-located brine discharge, and possible locations for connection within the BAWSCA service areas; three potential locations for a future desalination facility using brackish groundwater were identified. As shown on Figure 1-1, focus areas near existing WWTP outfalls selected for possible future consideration include: 1) the Southern Focus Area (SFA), near the Dumbarton Bridge with a nearby existing outfall from the Palo Alto WWTP; 2) the Central Focus Area (CFA), near the San Mateo Bridge with a nearby existing outfall from the WWTP serving Redwood City, San Carlos, and San Mateo; and 3) the Northern Focus Area, in South San Francisco just north of San Francisco International Airport near the existing outfall from the South San Francisco/San Bruno WWTP. The Central and Southern Focus Areas appear to be the most promising potential brackish desalination plant locations. Preliminary simulations using the SGM indicated expected yields from wells located in the Northern Focus Area were less than the CFA and SFA. Accordingly, subsequent SGM simulations summarized in this report focus on possible brackish groundwater projects in the CFA and SFA only.

The ultimate feasibility of a brackish desalination project will be based, in part, on: 1) how much yield is available at the selected locations and 2) whether the anticipated pumping produces any regional impacts to other users of the groundwater basin. This initial analysis of the estimated pumping yields and potential effects used the following two-step approach: Step 1 developed the SGM, a generalized, regional, numerical groundwater-flow model created to provide a planning-level assessment of available brackish groundwater yield and hydraulic effects on both local and regional groundwater levels.[3] Figure 1-1 shows the SGM grid extent and the three focus areas considered for possible brackish desalination projects. In Step 2, the SGM was used to simulate well yield and isolate the incremental simulated hydraulic effects (drawdown) of possible future new extractions from both the BAWSCA brackish desalination projects and planned changes in groundwater use as documented by the BAWSCA agencies in the Phase II A Report. The SGM was also used to assess the impact of varying aquifer parameter assumptions (specifically the hydraulic conductivity of a shallow mud layer beneath and adjacent to the Bay, referred to as the Bay Mud) on well yields.

[3] The development and calibration of the SGM (Step 1) is described in the Task 5-D Memo, Brackish Groundwater Desalination Feasibility Assessment – BAWSCA Strategy Groundwater Model Development, dated March 12, 2013. The Task 5-D Memo documents the SGM data sources, design, calibration, uncertainty, and limitations, and adequately supports its intended use as a project screening tool for simulating potential shallow extraction wells and the associated water level drawdown in areas located adjacent to San Francisco Bay. More detailed documentation for the deeper groundwater systems represented by the model and possibly additional data analysis and processing could be necessary to determine the SGM's suitability for screening projects that extract deep groundwater or projects that extract groundwater from model subareas other than the Bay Plain. This additional documentation was not necessary for this assessment, which has as its focus the extraction of shallow groundwater in bayside areas. However, these additional model refinements and documentation could be necessary should the brackish desalination projects be further investigated and the SGM utilized for project design or to determine potential pumping impacts on groundwater as part of a CEQA analysis.

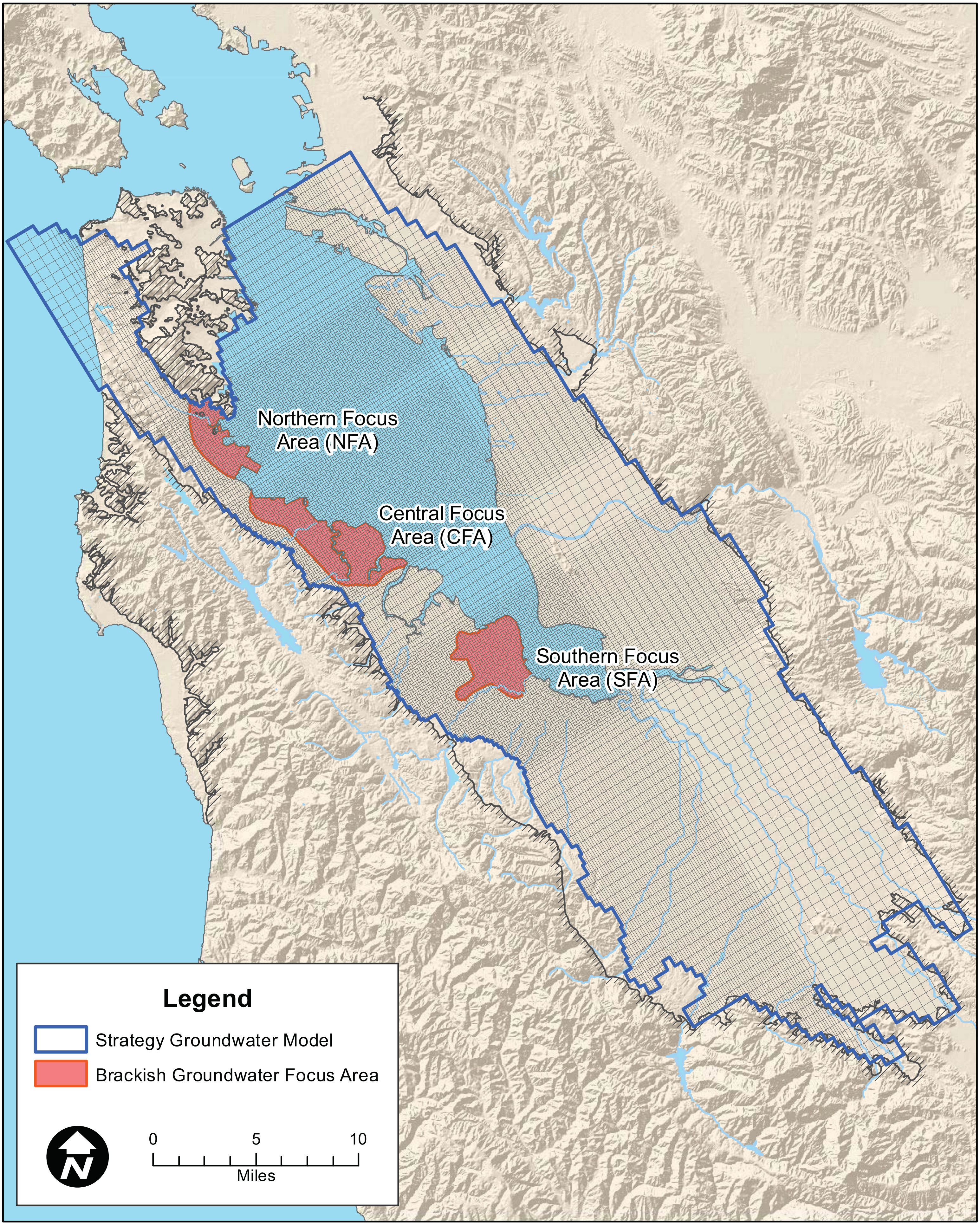

Figure 1-1. Strategy Groundwater Model and Brackish Groundwater Focus Areas

Two conservative assumptions were used for the SGM simulations presented here: 1) relatively low values for hydraulic conductivity of Bay Mud, and 2) a maximum one-foot drawdown at regional compliance wells located in the Westside Basin (WSB), East Bay Plain (EBP), and Niles Cone (NC) subareas. The projected yield using only the low hydraulic conductivity value is almost 3 mgd (producing almost 2 mgd of treated drinking water). The projected yield using the regional compliance wells in addition to the low hydraulic conductivity value is more than 1 mgd (producing more than 0.7 mgd of treated drinking water). The projected yields were found to be highly sensitive to assumed values for the Bay Mud hydraulic conductivity (as described in Attachment A), and it is plausible that yields could reach 10 mgd corresponding to treated water capacity of 7 mgd. While these projects represent relatively small capacities, they could be combined in a larger supply portfolio to address the future supply needs of BAWSCA's member agencies.

Section 2

Results of Strategy Groundwater Model Simulations

2.1 Model Description

The primary tool used to assess the yield and regional impact of brackish desalination projects was the Strategy Groundwater Model. The SGM was employed to:

- Assess the potential yield of possible BAWSCA brackish desalination projects and the relative changes in local and regional groundwater levels due to shallow groundwater extraction by those projects;
- Simulate relative changes in regional groundwater levels based on planned net increases in groundwater extraction by BAWSCA agencies; and
- Conduct a sensitivity analysis of a range of aquifer parameter assumptions on well yields.

As pumping from a brackish well is increased, the drawdown in both local and regional connected aquifers would increase. In the yield analysis, the pumping assigned in the model was iteratively increased until the drawdown was no more than one foot at the regional test well locations in the Westside Basin, East Bay Plain, and Niles Cone Basin. This one-foot regional drawdown threshold[4], however, is not proposed as a significance threshold from the standpoint of an impact analysis, but rather a modeling threshold for regional hydraulic effects as part of the initial project screening analysis only. The one-foot regional drawdown threshold was applied as a constraint at compliance locations in the WSB, the EBP, and the NC model subareas. Figure 2-1 shows these three subareas and the regional drawdown assessment locations.[5]

Two well configurations were simulated: vertical wells pumping from the shallow aquifer adjacent to the bay; and slant/horizontal wells extracting shallow groundwater from beneath the bay. These two well configurations were chosen to maximize yield from the shallow aquifer. Figures 2-2a and 2-2b show the vertical extraction well locations, Figures 2-3a and 2-3b show the horizontal well locations, and Table 2-1 summarizes the simulated yields. Slant (or horizontal directionally-drilled [HDD]) wells could be drilled under the Bay. HDD wells would have potentially higher yields than vertical shallow wells and fewer pretreatment requirements than an open intake system.

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[4] The one-foot regional drawdown threshold is based on SGM simulations that replicated a 1963 California Department of Water Resources (DWR) aquifer pump test in the San Mateo and Alameda County areas. In the simulated pump test, the calibrated SGM indicated about one foot of drawdown at a monitoring well used in the DWR test located across the San Francisco Bay and in the Niles Cone Subarea. However, during the 1963 test no drawdown was observed at this well. The comparison between simulated and observed drawdown may therefore indicate that the SGM is conservative (i.e., it may have overestimated the cross-bay drawdown by approximately one foot). In other words, one foot of drawdown simulated by the SGM may indicate an actual observed drawdown of zero.

[5] The EBP compliance location is an existing well located near East Bay Municipal Utility District's (EBMUD's) aquifer storage and recovery project. The WSB compliance location is a proposed groundwater storage and recovery project well in Millbrae, which is nearest to the CFA. Compliance in the NC subarea is determined by the average of several existing wells located in the Bay Plain portion of Alameda County Water District's (ACWD's) service area.

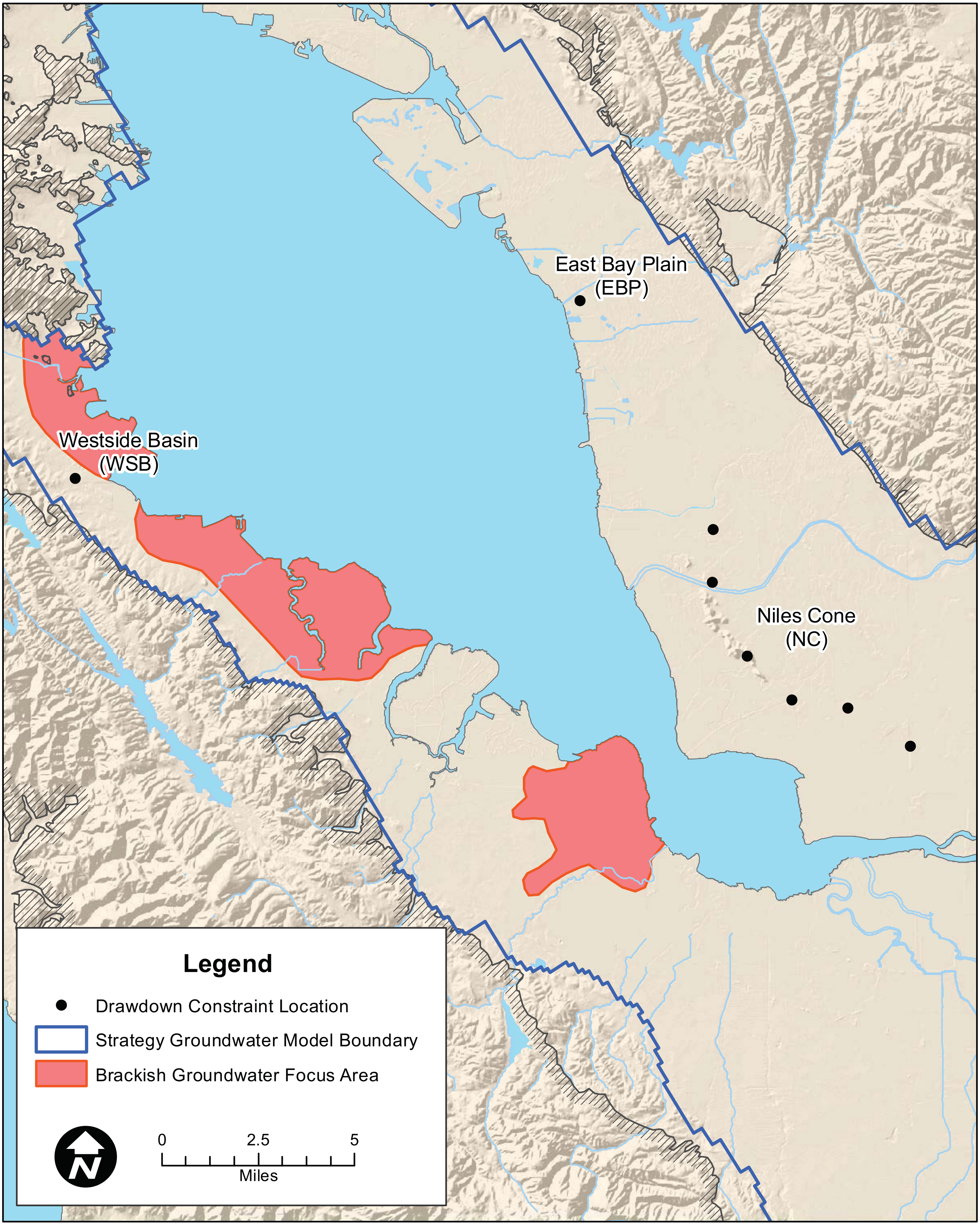

Figure 2-1. Regional Drawdown Compliance Locations

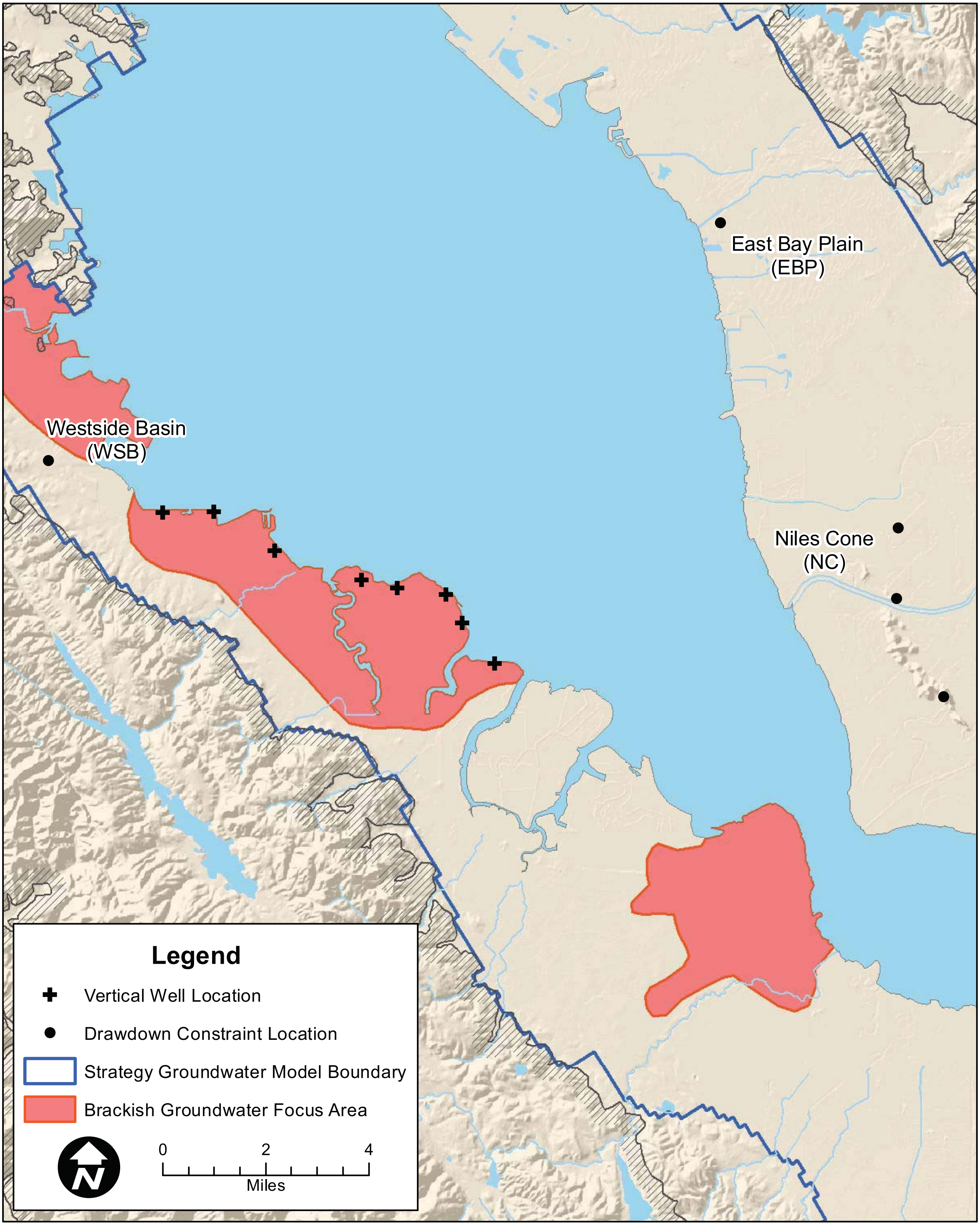

Figure 2-2a. Simulated Shallow Vertical Brackish Groundwater Well Locations, Central Focus Area

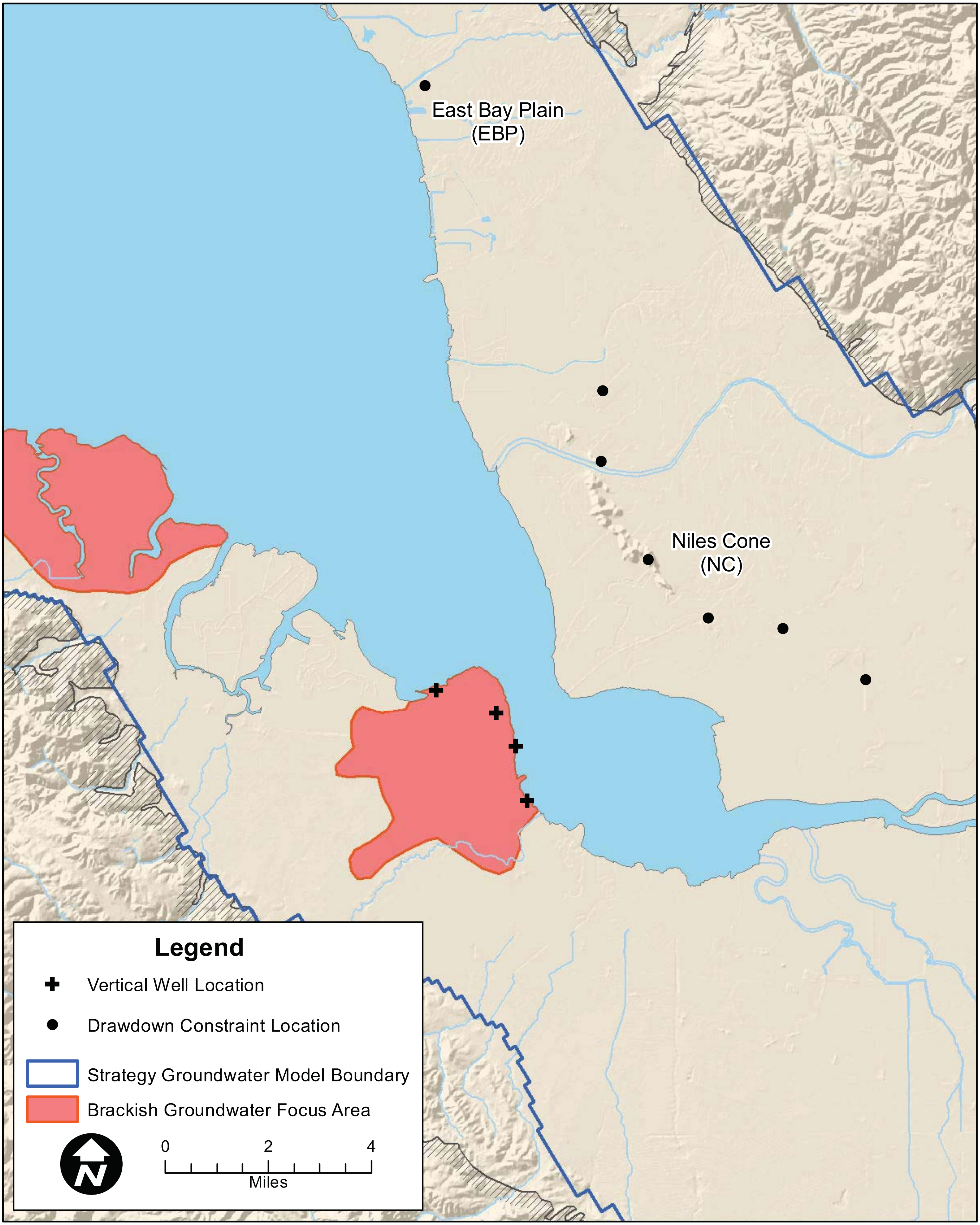

Figure 2-2b. Simulated Shallow Vertical Brackish Groundwater Well Locations, Southern Focus Area

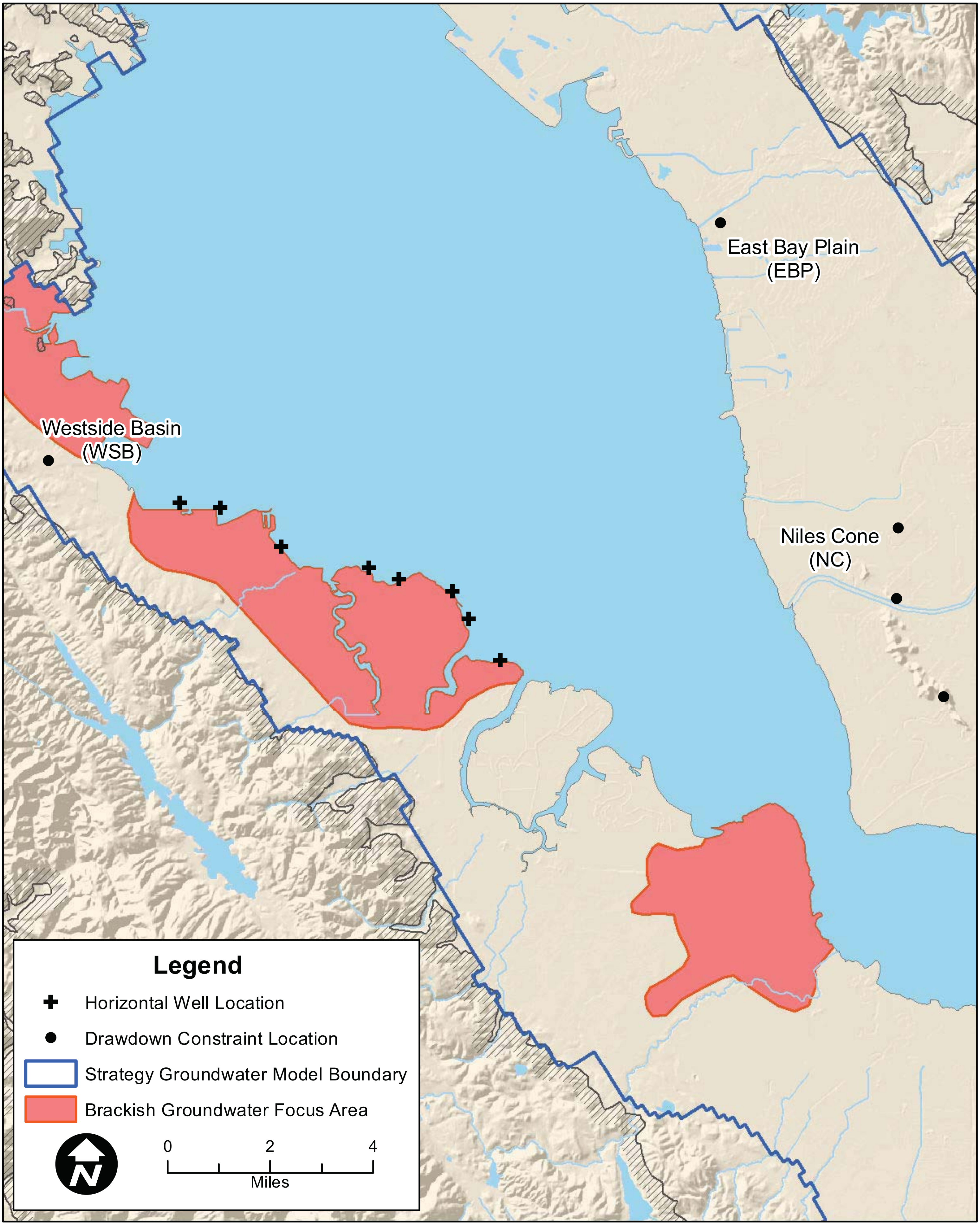

Figure 2-3a. Simulated Shallow Horizontal Brackish Groundwater Well Locations, Central Focus Area

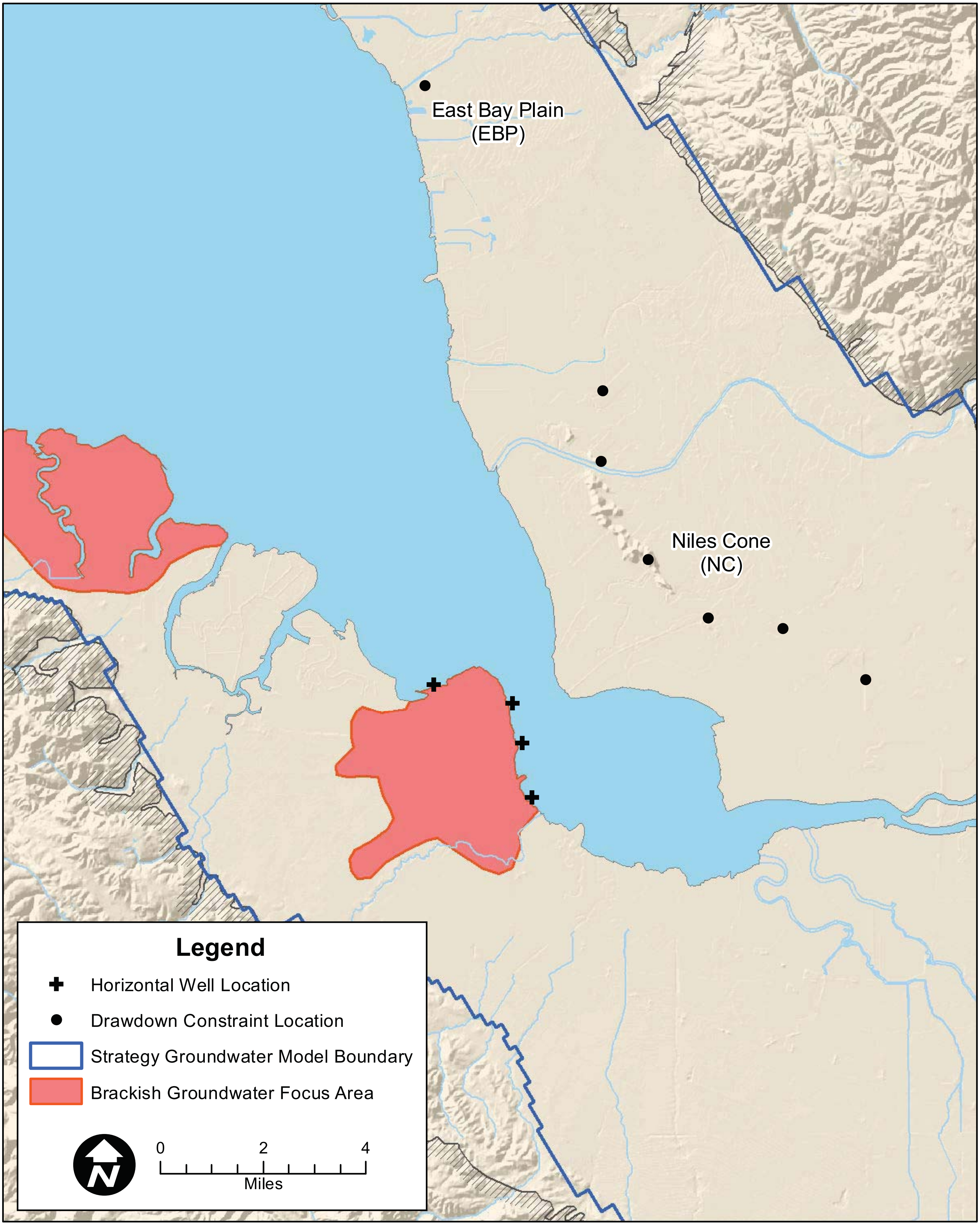

Figure 2-3b. Simulated Shallow Horizontal Brackish Groundwater Well Locations, Southern Focus Area

Table 2-1. Simulated Yield in Central and Southern Focus Areas With and Without Regional Drawdown Constraints

Number of Extraction Wells	Well Configuration	Drawdown Constraint (Location of Limiting Compliance Location)1	Yield in mgd from SGM (maximum yield from sensitivity testing)2
Central Focus Area			
8	Vertical-shallow	Local Only	1.15 (2.14)
8	Vertical-shallow	Local and Regional (EBP)	0.45 (2.14)
8	Horizontal-shallow	Local Only	1.00 (10.2)
8	Horizontal-shallow	Local and Regional (EBP)	0.55 (10.2)
Southern Focus Area			
4	Vertical-shallow	Local Only	1.68 (3.68)
4	Vertical-shallow	Local and Regional (NC)	0.72 (3.68)
4	Horizontal-shallow	Local Only	1.51 (5.27)
4	Horizontal-shallow	Local and Regional (NC)	0.74 (5.27)

[1] Where noted, the simulated yield was constrained by a one-foot drawdown threshold at representative compliance locations in the EBP, WSB, and NC model subareas. See Figure 2-1 for compliance drawdown locations. The entry listed under "Location of Limiting Drawdown Constraint" is the regional compliance location that controls the maximum simulated yield.

[2] Sensitivity analysis by evaluating plausible values for hydraulic conductivity of Bay Mud as 100 times greater than value utilized in analysis as discussed in Attachment A, Section A.3.

2.2 Estimated Project Yields from Individual Focus Areas

In the CFA, the simulated yields for the vertical and horizontal well configurations under only the local drawdown threshold were 1.15 and 1.00 mgd, respectively. The yields for both configurations are limited by the regional drawdown threshold at the EBP compliance location. To comply with the one-foot drawdown threshold in the EBP, the simulated yield from vertical wells was reduced to 0.45 mgd (a 61 percent decrease), and the simulated yield from the horizontal wells was reduced to 0.55 mgd (a 45 percent decrease).

In the SFA, the simulated yields for the vertical and horizontal well configurations under only the local drawdown threshold were 1.68 and 1.51 mgd, respectively. Both well configurations are limited by the regional drawdown threshold at the NC compliance locations. To conform with the one-foot drawdown threshold in the NC, the simulated yield from vertical wells was reduced to 0.72 mgd (a 57 percent decrease), and the simulated yield from the horizontal wells was reduced to 0.74 mgd (a 51 percent decrease).

There are a number of factors that contribute to uncertainty in the SGM-simulated yields, including modeling assumptions (primarily hydraulic conductivity) and potential future drawdown from planned regional increases in groundwater use.

Well yield is most sensitive to the properties of the aquifer adjacent to the well screen, the hydraulic conductivity of the shallow aquifer (represented by model layer 1), and the hydraulic conductivity of the overlying Bay Mud. In contrast, drawdown at the regional compliance locations is more influenced by the deep aquifer vertical hydraulic conductivity (layer 3), the regional confining unit that underlies most of the modeled shallow aquifer area (layer 2), and the conductivity of the Bay Mud. Of these three parameters, yield tests with the SGM indicated that the vertical conductivity of the Bay Mud has the greatest influence on well yield, local drawdown, and regional hydraulic effects. Attachment Section A.3 provides greater detail on model uncertainties.

The simulated yields for all well configurations in both focus areas were most sensitive to uncertainty in the vertical conductivity of the Bay Mud. Available data indicate that the effective conductivity of the Bay Mud could be 100 times greater than the calibrated value utilized in the SGM. Increasing the modeled hydraulic conductivity of the Bay Mud results in leakage of bay water through the Bay Mud that recharges the shallow aquifer and increases the simulated yield of shallow pumping wells. Increasing the leakage of the Bay Mud layer significantly reduces the yield-limiting control of the drawdown constraints. In all configurations and focus areas, increasing the conductivity of the Bay Mud eliminated the yield-limiting control of the regional drawdown thresholds. Simulated yields increased in the CFA to 2.14 and 10.2 mgd for the vertical and horizontal well configurations, respectively. In the SFA the simulated yields increased to 3.68 and 5.27 mgd for the vertical and horizontal well configurations, respectively.

2.3 Regional Effects of Pumping

Based on information provided to BAWSCA as part of the Strategy Phase II A analysis and outreach efforts by BAWSCA with other water management agencies in the region, multiple agencies were identified within the SGM study area that plan to increase groundwater use by the year 2035. The potential drawdown from net increases in groundwater pumping from these planned projects was simulated using the SGM to compare to the maximum one foot of regional drawdown to which the brackish desalination projects were limited. The extraction of brackish groundwater produces a simulated drawdown that would be additive to changes that may occur as a result of other future water supply and use projects.

Projected pumping increases in Cal Water's Mid-Peninsula District, East Palo Alto, Santa Clara, San Jose, and Milpitas were simulated with the SGM and combined with the simulated drawdowns estimated from pumping for the brackish groundwater project. Attachment Section A.4 describes in greater detail the magnitude of potential pumping increases by agencies within the SGM study area, the associated water level impacts, and the assumptions used for the regional analysis.

The results of this analysis show that in the shallow aquifer (model layer 1), the regional net drawdown ranged from a value of 5 feet in the Westside Basin subarea to an average value of 24 feet in the Niles Cone subarea (Niles Cone subarea drawdowns range from 22 to 29 feet), as shown in Figure A-3. The drawdown in the shallow aquifer at these same locations due solely to the brackish groundwater project ranged from about 0.1 foot to almost 1.0 foot, respectively. Hence, the cumulative hydraulic effect at these locations is estimated to be at most 5.1 feet in the Westside Basin subarea and an average of 25 feet in the Niles Cone subarea. The brackish groundwater project therefore could contribute between about 2 to 4 percent of the cumulative hydraulic effect, respectively, and is estimated to have the greatest influence in the Niles Cone subarea (4 percent) and less influence in the Westside Basin subarea (2 percent).

The simulated regional hydraulic effect due to other planned projects is slightly greater in the deep aquifer and main production zone represented by model layer 3. In Figure A-3, these drawdowns in the main production zone range from 6 feet in the WSB subarea to an average value of almost 35 feet in the NC subarea. The drawdown in the main production zone at these same locations due solely to the brackish groundwater project ranged from 0.2 to almost 1.0 foot, respectively. Hence, the cumulative hydraulic effect in the main production zone is estimated to range from 6.2 feet in the WSB subarea to an average value of 36 feet in the NC subarea. The results for the main production zone are reported here for completeness, and to provide a qualitative comparison of the relative drawdown effects between shallow and deeper water-bearing zones. However, the focus of the SGM is the shallow groundwater system, and results for the deeper groundwater system should be interpreted with caution.[6]

The results show that the projected pumping increases from the potential brackish desalination projects are estimated to be significantly smaller than drawdown from planned increases in groundwater use by BAWSCA member agencies. Refer to Attachment A Section A.4 for a full discussion of the regional hydraulic effects from projected groundwater use.

[6] Ibid. [3], pg 1-2.

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Section 3

Conclusions and Next Steps

Using two conservative assumptions: a) relatively low values for hydraulic conductivity of Bay Mud (i.e., leakage), and b) a maximum one-foot drawdown at regional compliance wells located in the WSB, EBP, and NC subareas, the most promising potential desalination plant locations are in the Central Focus Area, near the San Mateo Bridge, and Southern Focus Area, near the Dumbarton Bridge. The projected yield using only the low hydraulic conductivity value is almost 3 mgd (producing almost 2 mgd of treated drinking water). The projected yield using the regional compliance wells in addition to the low hydraulic conductivity value is more than 1 mgd (producing more than 0.7 mgd of treated drinking water). While these represent small capacities, they nevertheless represent contributions to addressing future supply need.

Better characterization of the Bay Mud conductivity (i.e., determining the potential recharge from leakage of bay water induced by shallow pumping near and beneath the bay) is of critical importance to better determining the potential yield and potential regional effects of pumping brackish groundwater for desalination. Sensitivity analyses increasing the Bay Mud conductivity by a factor of 100 (based on ranges found in available geotechnical data) resulted in yields of up to 10.2 and 5.27 mgd from the CFA and SFA, respectively, while still meeting the one-foot regional drawdown threshold at compliance locations.

Testing is recommended to evaluate Bay Mud conductivity and would include:

- *Key objectives*: Measure site specific well yield and the resulting hydraulic interaction between the pumped aquifer and the bay.
- *Approach*: Controlled aquifer tests using either existing wells or a new test well. Test wells are needed to pump groundwater exclusively from the shallow aquifer and measure the resulting water level changes at variable distances from the pumping well and the bay.
- *Duration*: An extended monitoring period (one month or more) may be required to provide the data necessary to estimate the effective hydraulic conductivity of the Bay Mud.
- *Chemical analyses*: Determine groundwater quality of pumped water and estimate changes in the proportional contribution of bay water.

This approach would be used for tests conducted on both vertical and horizontal wells. A number of shallow vertical wells reportedly exist in the focus areas and could provide the opportunity to design one or more controlled aquifer tests. In contrast, no HDD wells are known to exist in the SGM area, and any controlled aquifer test using HDD wells will require construction of a new test well.

With results from testing of the Bay mud, the finalized yield determination would be incorporated into the comparison of alternative projects in the Strategy.

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Attachment A

Detailed Modeling Approach

A.1 Overview of the Superposition Modeling Approach

This analysis uses the superposition modeling approach to isolate the impact of one or more groundwater pumping projects on the local and regional groundwater system. The theory of superposition indicates that solutions to simpler parts of a complex problem can be added to solve the more complex composite problem. For example, in groundwater-flow systems, superposition can be employed to estimate the effects of a specified stress (e.g., pumping) even if the other stresses (e.g., recharge) are unknown, thereby isolating the effect of the analyzed stress from all the other stresses. The principal constraint to using superposition is that the mathematical equation describing the groundwater problem must be linear. The validity and applicability of the superposition approach is predicated on the groundwater system being confined or the saturated thickness effectively does not change (for example, the saturated thickness does not change by more than 10 percent).[7] In the system modeled by the SGM, these conditions were met because: 1) the aquifers beneath the San Francisco Bay and adjacent Bay Plain are confined; and 2) the simulated drawdown in the proposed shallow extraction wells was limited to the top of the water-bearing zone (i.e., the bottom of the upper most confining bed, which in this case is the bottom of the Bay Mud). Therefore the saturated thickness of the pumped aquifer essentially did not change.[8] The SGM and principle of superposition were therefore employed to:

- Assess the potential yield of possible BAWSCA brackish desalination projects and the relative changes in local and regional groundwater levels due to shallow groundwater extraction by those projects;
- Simulate relative changes in regional groundwater levels based on planned increases in groundwater extraction by BAWSCA agencies; and
- Conduct a sensitivity analysis of a range of aquifer parameter assumptions on well yields.

When employing the SGM for the superposition analysis, water levels everywhere in the model are set to zero, and historical pumping and recharge rates are all also set to zero. The new pumping from brackish groundwater wells is the only stress simulated in the model, and the simulated drawdown is the hydraulic effect due solely to the new pumping. The drawdown from these brackish groundwater wells would be generally similar under periods of average, above average, and below average rainfall, and additive to the sum of all other influences on groundwater conditions (e.g., other pumping wells, changes in recharge, etc.).

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[7] *The principle of superposition and its application in ground-water hydraulics*, 1987, Reilly, Thomas E.; Franke, O. Lehn; Bennett, Gordon D. USGS Techniques of Water-Resource Investigation: 03-B6.

[8] As described in the Task 5-D Memo, the SGM is a steady-state model calibrated to average climatic and water use conditions during the period 1987-1996. The 1987-1996 calibration period was chosen because average rainfall was similar in magnitude to the long-term average observed at multiple area weather stations, and the period includes wet, normal, and drought years. When employing the SGM for the superposition analysis, historical pumping and recharge rates are all set to zero and only the net effect from the future planned stresses are analyzed.

As stated above, the water levels everywhere in the superposition model are set to zero. These initial water levels have practical application in the interpretation of modeled water level changes for the brackish groundwater assessment. In the Bay Plain areas, groundwater occurs at shallow depths and is in hydraulic communication with water in the bay. The groundwater levels are reasonably near mean sea level, which in the model has a value of zero. The simulated drawdown is therefore a general approximation of the lowering of absolute water levels in the Bay Plain. In contrast, in the upland areas and away from the bay, groundwater levels can be substantially different from mean sea level. Hence, the simulated drawdown in these upland areas represents the water level change relative to the actual water levels. The distinction between simulated drawdowns in the lowland and upland areas relate to the interpretation of the local and regional drawdown thresholds utilized to constrain simulated yields. These thresholds are discussed in Section A.2, Modeling Operation of the BAWSCA Brackish Desalination Projects.

Based on information provided to BAWSCA as part of the Strategy Phase II A analysis[9], several agencies in the BAWSCA service area are planning to increase their groundwater use by the year 2035. These planned future increases in groundwater use were allocated to existing or new wells represented in the model as appropriate, and their hydraulic effect on regional water levels was also isolated using the superposition model. This regional analysis is discussed in Section 2.3, Regional Effects of Pumping.

A.2 Simulating the Operation of the BAWSCA Brackish Desalination Projects

The SGM simulations considered both shallow vertical wells and shallow HDD wells. Deep vertical wells are not being considered by BAWSCA at this time because initial simulations using deep vertical wells showed very limited well yields when using the regional drawdown constraint. Furthermore, preliminary SGM simulations indicated expected yields from wells located in the Northern Focus Area (NFA) were less than the CFA and SFA. Accordingly, subsequent SGM simulations summarized in this report focus on possible brackish groundwater projects in the CFA and SFA shallow aquifer only.

Shallow vertical wells and HDD wells were both represented in the model as extracting water from a single model cell using MODFLOW'S WEL package. The WEL package is designed to simulate features (wells) that withdraw water from the aquifer at a specified rate, where that rate is independent of both the model cell dimensions and the water level in the cell. The difference between simulated vertical and horizontal wells is therefore due primarily to dry land simulated above the vertical well and an effectively unlimited volume of recharge represented by surface water in the bay above the horizontal well. The remaining variations between simulated well configurations are due to the different geographic locations and variable hydrogeologic conditions (e.g., Bay Mud thickness, aquifer thickness, transmissivity, etc.).

Simulated vertical well yields account for the 50-feet sanitary seal required for water supply wells in San Mateo County. For example, if the overlying Bay Mud at a well location is 40 feet thick and the underlying shallow aquifer tapped by the well is also 40 feet thick, the 40-foot thick Bay Mud is represented by the general-head boundary and the underlying 40 feet of saturated shallow aquifer is represented by model layer 1. A 50-foot deep sanitary seal would extend through the Bay Mud and 10

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[9] BAWSCA 2012.

feet into the upper portion of the aquifer, thereby reducing the saturated interval adjacent to the well screen from 40 to 30 feet. Accordingly, the simulated well yield is reduced 25 percent to approximately account for this 10-foot reduction in screen length. At another well location the Bay Mud may be 60 feet thick, and therefore the 50-foot sanitary seal ends within the Bay Mud 10 feet above the top of the saturated aquifer. Accordingly, the well screen can be open to the entire thickness of saturated aquifer represented by layer 1 and the simulated yield does not need to be adjusted. The simulated HDD wells are reduced similarly to the vertical wells to approximately account for their assumed 350-foot screen length, which is 53 percent less than the total length of the model cells in which the HDD wells are located (666 feet). Specifically, the simulated HDD well yield is reduced by 53 percent.

An iterative approach was employed to assess a range of possible configurations (number of wells, locations, and pumping rates) of vertical and HDD wells in the CFA and SFA. Three brackish groundwater yield scenarios were simulated. The first scenario estimated the maximum yield in either the CFA or the SFA under a single, local constraint – the drawdown in the aquifer adjacent to the pumping wells cannot exceed the bottom of the overlying Bay Mud (referred to as a local drawdown threshold). The second scenario constrained drawdown locally and at select existing well locations in the region that corresponded with other groundwater projects (referred to as the regional drawdown threshold). A value of one foot was utilized for the regional drawdown threshold, and it was applied as a constraint at compliance locations in the WSB, the EBP, and the NC model subareas. Figure 2-1 shows these three subareas and the regional drawdown assessment locations.[10]

The one-foot regional drawdown threshold is based on SGM simulations that replicated a 1963 California DWR aquifer pump test in the San Mateo and Alameda County areas. In the simulated pump test, the SGM indicated about one foot of drawdown at a monitoring well used in the DWR test located across the San Francisco Bay and in the Niles Cone Subarea. However, during the 1963 test no drawdown was observed at this well. The comparison between simulated and observed drawdown may therefore indicate that the SGM is conservative (i.e., it may have overestimated the cross-bay drawdown by approximately one foot). In other words, one foot of drawdown simulated by the SGM may indicate an actual observed drawdown of zero. This one-foot regional drawdown threshold is not proposed as a significance threshold from the standpoint of an impact analysis, but rather a modeling threshold for regional hydraulic effects as part of the initial project screening analysis only.

A.3 Model Uncertainties and Sensitivity Analysis

Two factors that contribute to uncertainty in the SGM simulated yields include: 1) the uncertainty in model parameters that influence the relationship between simulated extraction rates and the simulated drawdown in the water bearing zone adjacent to the well screen; and 2) the uncertainty in model parameters that influence the relationship between simulated extraction rates and the drawdown at the regional compliance locations. When looking at the influence on drawdown using the local and regional thresholds, the following three parameters were the most important: (1) the water transmitting properties of the shallow aquifers the wells extract from (2) the deep aquifer vertical hydraulic conductivity beneath the Bay Plain, the regional confining unit that underlies most

[10] The EBP compliance location is an existing well located near East Bay Municipal Utility District's (EBMUD's) aquifer storage and recovery project. The WSB compliance location is a proposed groundwater storage and recovery project well in Millbrae, which is nearest to the CFA. Compliance in the NC subarea is determined by the average of several existing wells located in the Bay Plain portion of ACWD's service area.

of the model area, and (3) the conductivity of the Bay Mud.[11] Of the three parameters, yield tests with the SGM indicated that the vertical conductivity of the Bay Mud has the greatest influence on well yield, local drawdown, and regional hydraulic effects. The evaluated ranges in modeled parameter values were based on the observed variations in measured conductivity and the variations in conductivity values employed by other models developed previously for subareas in the region.

The simulated yields for all well configurations in both focus areas were most sensitive to uncertainty in the vertical conductivity of the Bay Mud. Available data indicate that the effective conductivity of the Bay Mud could be 100 times greater than the calibrated value utilized in the SGM.[12] When incorporated into the SGM this sensitivity increased simulated yields by factors ranging from 2 to 10 (see Table A-1). The increased yield is the result of increased leakage from the bay into the shallow aquifer.

Perhaps of greater significance is the effect leakage has on reducing the yield-limiting control of the regional drawdown constraint. In all configurations and focus areas where groundwater is extracted solely from the shallow aquifer, increasing the conductivity of the Bay Mud eliminated the yield-limiting control of the regional drawdown thresholds. Instead, yields are limited by the local constraints which are spatially variable owing to local hydrogeological conditions. This resulted in simulated yields that increased by factors ranging from about 2 to almost 20.

The SGM calibration was revisited with the higher conductivity assumption to confirm that the increase in Bay Mud hydraulic conductivity did not affect the model performance of the calibrated SGM (and therefore impact its predictive capabilities). The change had a small impact on model performance, increasing the sum of the square errors (a measure of how well the model simulated heads match observed data) by 5 percent over the entire model. In the region of the modeled Focus Areas, increasing the conductivity of the bay mud improved model performance, and the sum of the square errors in the Bay Plain decreased by almost 40%. The increase in Bay Mud conductivity was determined to be reasonable based on this finding, which points to the uncertainty of this parameter and the need to further examine the actual hydraulic conductivity of the Bay Mud in the Focus Areas. The DWR pump test was not re-evaluated using the higher Bay Mud conductivity because the simulated yields were controlled by the local drawdown constraint, and the regional drawdown constraint was not a factor that affected simulated yields.

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[11] The development and calibration of the SGM (Step 1) is described in the Strategy Task 5-D Memo: Brackish Groundwater Desalination Feasibility Assessment – BAWSCA's Strategy Groundwater Model Development, dated March 12, 2013. As described in the Task 5-D Memo, the SGM is a steady-state model calibrated to average climatic and water use conditions during the period 1987-1996. The 1987-1996 calibration period was chosen because average rainfall was similar in magnitude to the long-term average observed at multiple area weather stations, and the period included wet, normal, and drought years.

[12] The calibrated model value for the recent Bay Mud conductivity is 0.0016 feet per day (ft/d). Geotechnical testing of eight intact Bay Mud cores sampled from two Ravenswood wells located near East Palo Alto indicated hydraulic conductivity values ranging from 0.0002-0.011 ft/d (geometric mean value of 0.001 ft/d). Because the sampled sediments were deposited naturally within the well casings in a low energy, tidal estuary environment, the conductivity results probably represent a lower limit for the recent Bay Mud. Typically breaks in the clay beds and other heterogeneities result in effective conductivity values that are substantially greater than core sample results. DWR reported estimated hydraulic conductivity values for Niles Cone aquitards (old Bay Muds) that range from 0.0003 to 0.003 ft/d. These values probably are also likely representative of the lower end member because these clay beds are older deposits and buried deeper in the profile, and accordingly their conductivity values are likely lower than the recent Bay Mud deposits underlying San Francisco Bay. Lastly, pumping Menlo Park area monitoring wells in the shallow aquifer located near the bay indicated an effective hydraulic conductivity of the shallow confining beds of 0.5 ft/d. Based on these findings, the calibrated Bay Mud conductivity is reasonable but likely represents the lower end of the effective conductivity range, whereas at the upper end it would not be unreasonable to consider values 100 times greater than the calibrated model value.

Table A-1. Sensitivity Analysis of Simulated Yield in Central and Southern Focus Areas With and Without Drawdown Constraints

Number of Extraction Wells	Well Configuration	Location of Limiting Drawdown Constraint1	Yield (MGD)	
			SGM (calibrated model)	Maximum from Sensitivity Testing
Central Focus Area				
8	Vertical-shallow	Local Only	1.15	2.14
8	Vertical-shallow	Local and Regional (EBP)	0.45	2.14
8	Horizontal-shallow	Local Only	1.00	10.2
8	Horizontal-shallow	Local and Regional (EBP)	0.55	10.2
Southern Focus Area				
4	Vertical-shallow	Local Only	1.68	3.68
4	Vertical-shallow	Local and Regional (NC)	0.72	3.68
4	Horizontal-shallow	Local Only	1.51	5.27
4	Horizontal-shallow	Local and Regional (NC)	0.74	5.27

[1] Where noted, the simulated yield was constrained by a one-foot drawdown threshold at representative compliance locations in the ESB, WSB, and NC model subareas. See Figure 2-1 for compliance drawdown locations. The entry listed under "*Location of Limiting Drawdown Constraint*" is the regional compliance location that controls the maximum simulated yield.

A.4 Regional Hydraulic Effects from Projected Groundwater Use by Agencies in Region

The extraction of brackish groundwater for desalination, and associated groundwater drawdown, would be additive to anticipated extraction and related drawdown that may occur as a result of other future water supply and use projects. Based on information provided to BAWSCA as part of the Strategy Phase II A analysis,[13] and outreach efforts by BAWSCA with other water management agencies in the region, multiple agencies were identified within the SGM area that plan to increase groundwater use by the year 2035.[14] When considered collectively, the combined hydraulic effects from BAWSCA agency groundwater use is referred to as the regional hydraulic effect. When the simulated regional hydraulic effect is added to the simulated drawdown due to brackish groundwater extractions, the resulting sum represents the cumulative hydraulic effect of all new projects on the groundwater system. This regional drawdown (measured as a net change in water levels) was also estimated using the SGM and the principle of superposition.

Table A-2 lists the BAWSCA agencies that forecasted an increase in their groundwater use between 2015 and 2035 as reported to BAWSCA as part of the Strategy Phase II A effort. For reference and to document that actual groundwater use varies year by year, the actual groundwater use by these BAWSCA agencies in fiscal year (FY) 2011-2012 is shown in the second column of Table A-2. The projected increase in overall groundwater use is up to about 15 mgd, an increase of up to 60 percent over their 2015 planned use. Not all of this increase represents a net increase in groundwater consumption. For example, ACWD reports a net increase of 5.74 mgd, but their intentional recharge

[13] BAWSCA 2012

[14] EBMUD's Bayside Groundwater Project and SFPUC's Regional Groundwater Storage and Recovery Project provide coordinated management of recharge and pumping operations to maximize the sustainable yield of the aquifer. Because the long-term net pumping drawdown due solely to these projects should therefore be zero (no net change in storage), they are not considered as a future new use that contributes to the regional hydraulic effect.

program actively manages groundwater levels and storage. Although future groundwater extraction rates in ACWD are planned to increase, ACWD plans to compensate for extractions with increased recharge. Hence, no net change in groundwater consumption is assumed to occur. In contrast, the planned increases in groundwater use by the Cities of San Jose, Santa Clara, and Milpitas may or may not be compensated with greater recharge by the Santa Clara Valley Water District (SCVWD). For the purposes of conducting this assessment, two scenarios were evaluated to examine potential regional effects. The first scenario assumed that SCVWD would engage in intentional recharge activities in amounts corresponding to the planned increase in groundwater use for the three cities, thereby reducing or eliminating their contribution to the regional hydraulic effect. The second scenario conservatively assumed that the increases in these three cities represent a net increase in groundwater consumption, and model results therefore represent the maximum regional hydraulic effect.

Table A-2. BAWSCA Agency Groundwater Use: Current (2011/2012) and Planned Future (2015 and 2035) in mgd

Agency	Groundwater Use					
	Actual	Anticipated				
	FY 2011-2012	2015	2035	Net Increase	Modeled Future Increase	See Explanatory Note
ACWD	9.34	4.04	9.78	5.74	0.00	(1)
Cal Water (South San Francisco District)	0.50	1.37	1.37	0.00	0.00	(2)
Cal Water (Mid-Peninsula District)	0.00	0.00	1.00	1.00	1.00	(3)
Coastside County Water District	0.00	0.11	0.11	0.00	0.00	(4)
Daly City, City of	3.18	2.99	3.43	0.44	0.00	(2)
East Palo Alto, City of	0.00	0.00	1.29	1.29	1.29	(5)
Milpitas, City of	0.00	0.00	0.75	0.75	0.00, 0.75	(6),(8)
Mountain View, City of	0.32	0.22	0.25	0.03	0.00	(7)
San Bruno, City of	1.50	2.10	2.10	0.00	0.00	(2)
San Jose, City of (portion of north San Jose)	0.00	1.34	3.04	1.70	0.00, 1.70	(8)
Santa Clara, City of	13.00	11.23	15.31	4.08	0.00, 4.08	(8)
Stanford University	0.21	0.00	0.00	0.00	0.00	---
Sunnyvale, City of	0.21	0.98	0.98	0.00	0.00	---
Totals	**28.26**	**24.38**	**39.41**	**15.03**	**2.29, 8.82**	---

(1) ACWD is assumed to compensate for the net increase in groundwater consumption with a corresponding increase in intentional recharge. The net increase in groundwater pumping therefore is not considered a net increase in groundwater consumption in the region.
(2) Daly City, California Water Service Company (Cal Water), the City of San Bruno, and the SFPUC are Partner Agencies working collectively to manage groundwater resources in the Westside Basin. Part of their collective effort is the SPFUC groundwater storage and recovery project that includes plans for Partner Agencies to voluntarily manage pumping levels to ensure no long-term net depletion of groundwater storage. Accordingly, for the purpose of simulating the cumulative drawdown effect in the Westside Basin, these agencies are assumed to have no net increase in groundwater consumption in the region.
(3) Cal Water plans to purchase land and drill and equip a well located in the San Mateo portion of the Mid-Peninsula District. The well was assumed to be located in the Bay Meadows area of San Mateo. This new well represents a new groundwater use in the region.
(4) Not in model domain and therefore not simulated.
(5) East Palo Alto is planning to develop local groundwater to supplement their current water supply. These efforts represent a new groundwater use in the region.
(6) Milpitas' recently installed Curtis Well will be used to extract as much as 0.75 mgd. The actual use will depend on the quality of the well water and results of their well blending study. This new well represents a new groundwater use in the region.
(7) Planned production is for continued well maintenance purposes only, and therefore does not represent a new groundwater use in the region.
(8) Groundwater recharge in the Santa Clara Valley is managed by SCVWD, where groundwater users pay a pump tax for the water extracted. This net increase in anticipated groundwater use may or may not be compensated by additional future recharge. Accordingly, both conditions were simulated with the model.

The regional hydraulic effect was simulated using the principle of superposition, and only the projected net increase in groundwater extraction from the BAWSCA agencies identified in Table A-2 were modeled. Any other planned increases in groundwater extraction in the modeled area were not considered in this study. The modeled future increases in groundwater extraction by the Cities of San Jose and Santa Clara were simulated using the same active pumping wells employed to calibrate the SGM (Figure A-1), whereas the future extractions by Cal Water's Mid-Peninsula District and the Cities of East Palo Alto and Milpitas are simulated by new wells introduced into the model. Table A-3 summarizes the net increases in modeled agency groundwater extractions, the number of active wells modeled to simulate the regional hydraulic effect, and the allocation of pumping in the model between Layer 1 (the "shallow" aquifer) and Layer 3 (the deeper or "main" production aquifer). The distribution of modeled pumpage between layers represents the actual extraction rates of existing wells and the depths at which these wells are screened (the depth in the aquifer from which the wells draw water).

Table A-3. Summary of Modeled Increases in Groundwater Use by Other BAWSCA Agencies Simulated to Estimate the Regional Hydraulic Effect

Agency	Modeled Pumping Increase (mgd)	SGM Extraction Wells Within Agency Boundary Utilized to Simulate Future Pumping Increase	% Applied to SGM Layer 1	% Applied to SGM Layer 3
Cal Water (Mid-Peninsula District)	1.00	1	20	80
East Palo Alto, City of	1.29	2	0	100
Milpitas, City of	0.75	1	20	80
San Jose, City of (portion of north San Jose)	1.70	32	20	80
Santa Clara, City of	4.08	19	20	80

SGM-simulated drawdowns at regional compliance locations resulting from modeled maximum pumping increases in San Mateo County were examined (the pumping increase is simulated in Cal Water's Mid-Peninsula District and East Palo Alto). This scenario assumes that the extractions by other agencies located in Santa Clara County are compensated for using intentional recharge. In the shallow aquifer (model layer 1), the regional hydraulic effect was modeled to be 4 feet in the WSB subarea and an average value of about 4 feet in the NC subarea (NC subarea drawdowns range from 4 to 5 feet) (Figure A-2). The drawdowns in layer 1 at these same locations due solely to the brackish groundwater project ranged from about 0.1 foot to almost 1.0 foot, respectively (results not shown in Figure A-2). Hence, the cumulative hydraulic effect at these locations is at most 4.1 feet in the WSB subarea (4 feet from the regional effect plus a maximum of 0.1 foot from the brackish groundwater project) and an average of 5 feet in the NC subarea (4 feet from the regional effect plus a maximum of 1.0 foot from the brackish groundwater project). The brackish groundwater project therefore contributes about 2 percent of the cumulative hydraulic effect in the shallow aquifer of WSB subarea, and on average 20 percent of the cumulative hydraulic effect in the shallow aquifer of the NC subarea.

SGM-simulated drawdowns at regional compliance locations resulting from modeled maximum pumping increases in Cal Water's Mid-Peninsula District, East Palo Alto, Santa Clara, San Jose, and Milpitas are posted in Figure A-3. This scenario assumes that projected pumping increases by the Cities of Santa Clara, San Jose, and Milpitas are not compensated for by increased intentional recharge in the Santa Clara Valley. In the shallow aquifer (model layer 1), the regional hydraulic effect was modeled to be 5 feet in the WSB subarea and an average value of 24 feet in the NC subarea (NC subarea drawdowns range from 22 to 29 feet). The drawdown in the shallow aquifer at these same locations due solely to the brackish groundwater project ranged from about 0.1 foot to almost 1.0 foot, respectively. Hence, the cumulative hydraulic effect at these locations is estimated to be at most 5.1 feet in the WSB subarea and an average of 25 feet in the NC subarea. The brackish groundwater project therefore could contribute between about 2 to 4 percent of the cumulative hydraulic effect, respectively, and is estimated to have the greatest influence in the NC subarea (4 percent) and less influence in the WSB subarea (2 percent).

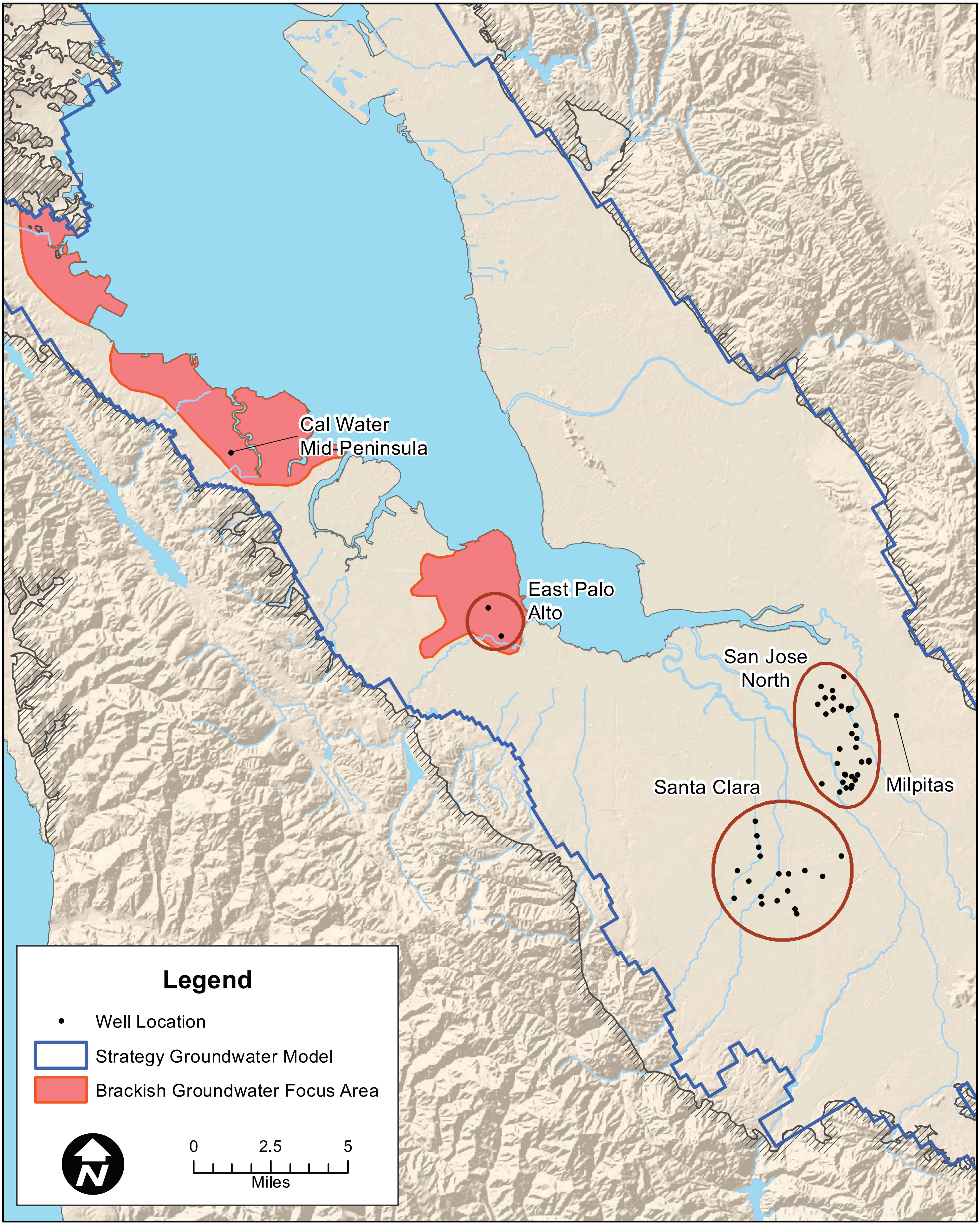

Figure A-1. Well Locations for Future Increases in BAWSCA Agency Groundwater Use

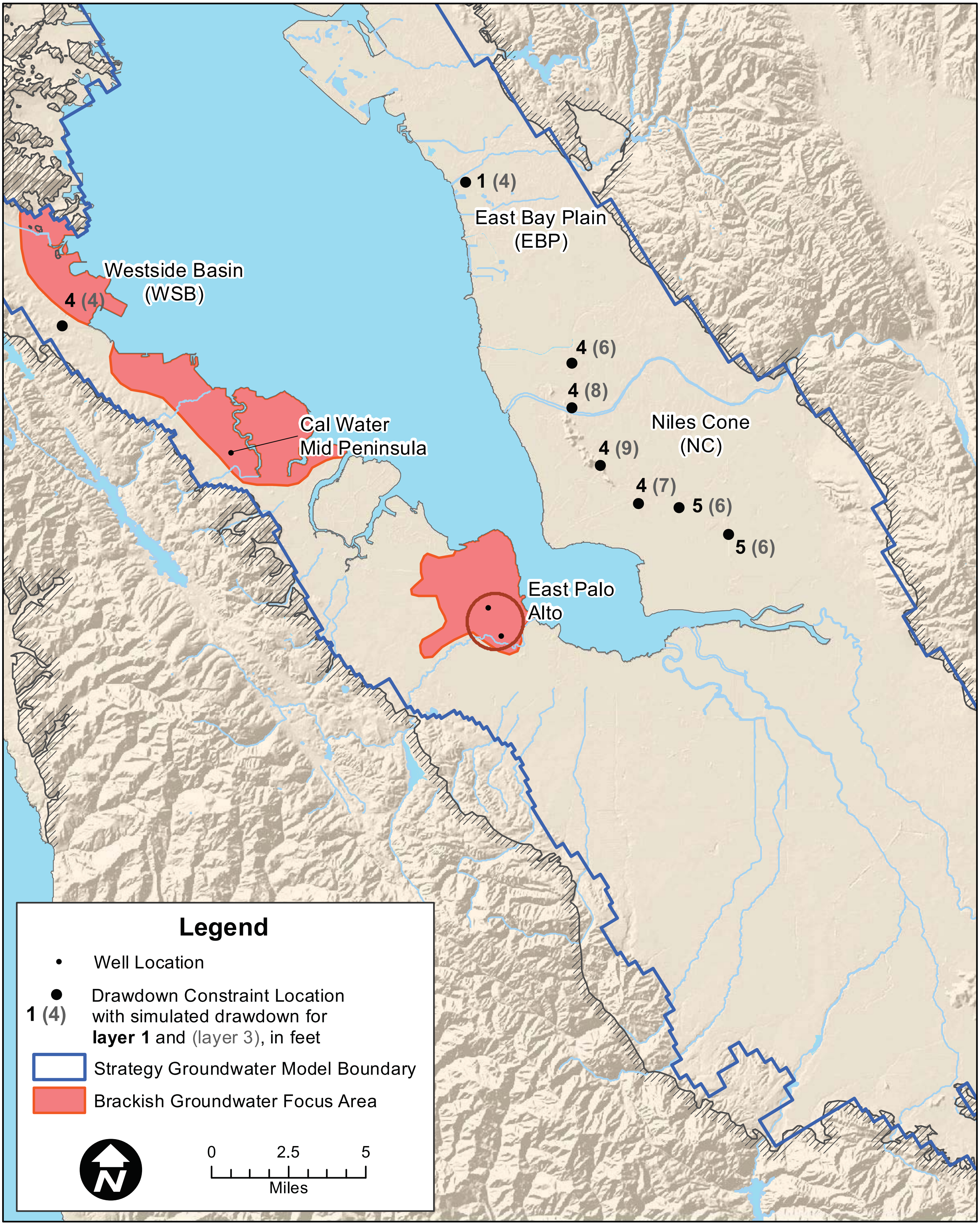

Figure A-2. Simulated Regional Drawdown Effect for Future Increases in Groundwater Use, San Mateo County Agencies Only

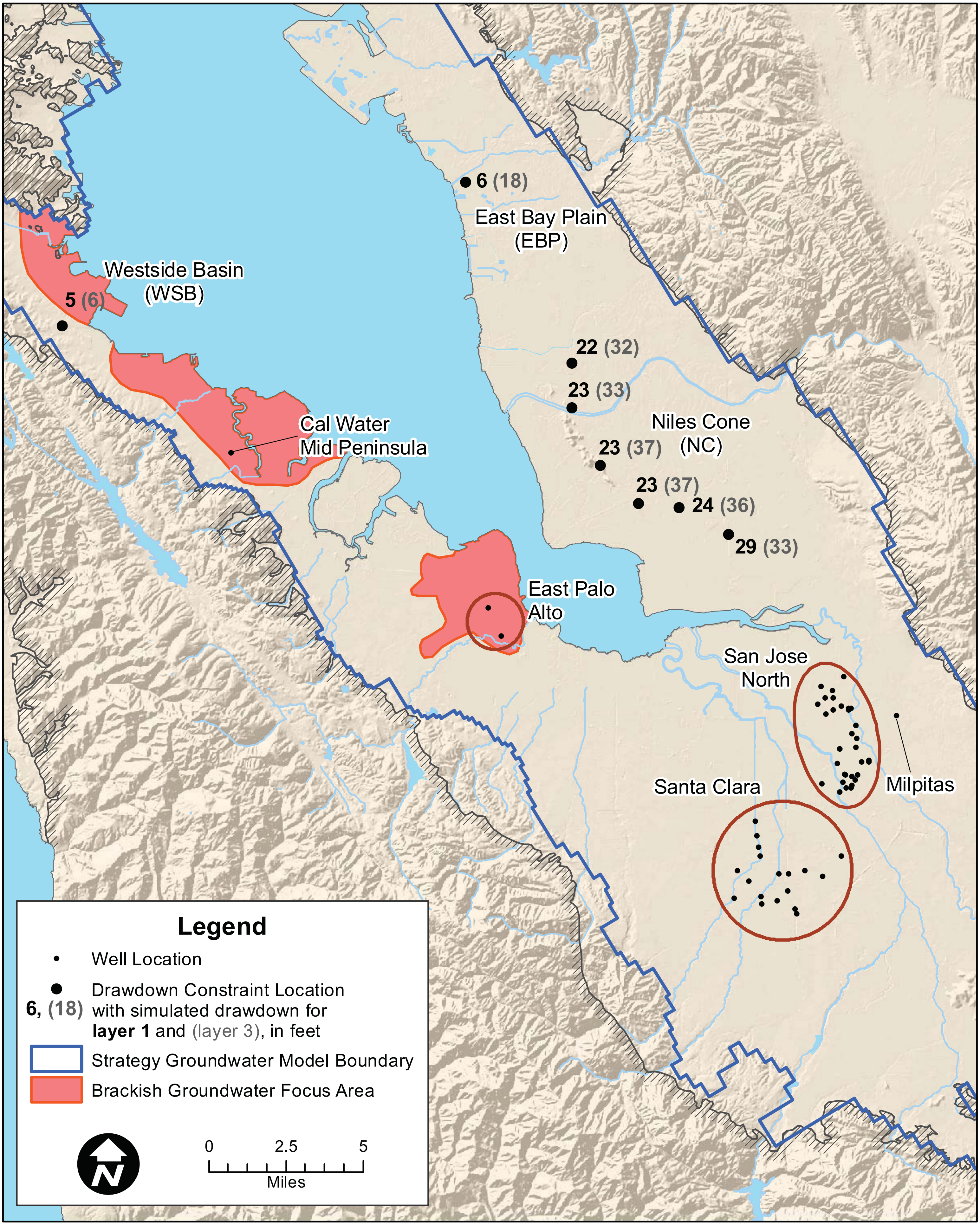

Figure A-3. Simulated Regional Drawdown Effect for Future Increases in BAWSCA Agency Groundwater Use

The results for main production zone (model layer 3) are reported Figures A-2 and A-3 for completeness, and to provide a qualitative comparison of the relative drawdown effects between shallow and deeper water-bearing zones. However, the focus of the SGM is the shallow groundwater system, and results for the deeper groundwater system should be interpreted with caution.[15] The regional hydraulic effect is slightly greater in the main production zone. In Figure A-3, these drawdowns range from 6 feet in the WSB subarea to an average value of almost 35 feet in the NC subarea (NC subarea drawdowns range from 32 to 37 feet). The drawdown in the main production zone at these same locations due solely to the brackish groundwater project ranged from 0.2 to almost 1.0 foot, respectively. Hence, the cumulative hydraulic effect in the main production zone is at most 6.2 feet in the WSB subarea to an average value of almost 36 feet in the NC subarea.

A.5 Projected Water Quality of Desalination Projects

Groundwater extracted from the shallow aquifer would contain a mix of brackish groundwater and saltwater from the bay, and the water quality would be determined by the ratio of these two sources produced from the extraction wells. The TDS concentrations of shallow groundwater adjacent to the bay are spatially variable: the TDS levels can range from about 3,000 milligrams per liter (mg/L) to 18,000 mg/L or more.[16,17] The greatest TDS concentrations have been measured in shallow wells located near the saltwater evaporators in the SFA. In these areas, shallow groundwater TDS concentrations beneath the evaporator ponds can exceed that of bay water, with measured concentrations as great as 50,000 mg/L or more.[18]

Sources of uncertainty in the estimated quality of the water produced include the spatial variability in shallow groundwater quality and the uncertainty in the potential contribution of bay leakage to the groundwater extracted over time. For example, increasing the modeled hydraulic conductivity of the Bay Mud results in leakage of bay water through the Bay Mud that recharges the shallow aquifer and increases the simulated yield of shallow pumping wells. In Table A-1, results show that increasing the conductivity of the Bay Mud by a factor of 100 increases the simulated yield from vertical wells located in the CFA from 0.45 to 2.14 mgd, a five-fold increase in yield. Simulated water budgets indicate that approximately 50 percent of the additional yield is existing groundwater discharge to the bay that is captured by the extraction wells, and the remaining 50 percent is increased recharge from bay leakage. Assuming the TDS concentrations in near-shore brackish groundwater are approximately 10,000 mg/L, and the TDS concentration of bay water is 25,000 mg/L, the TDS concentration of the produced water (that is, the TDS concentration of the brackish groundwater produced by the project that would need to be treated) would be up to approximately 16,000 mg/L on average, assuming a mix of 60 percent brackish groundwater and 40 percent Bay water. These results indicate a possible 60 percent increase in TDS concentrations relative to the existing brackish groundwater; however, TDS concentrations both initially and after extended pumping periods will depend on actual site specific conditions.

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[15] *Ibid.* [3] pg. 1-2.

[16] *Database of Wells and Areal Data, South San Francisco Bay and Peninsula Area, California*, Leighton, David A., John L. Fio, and Loren F. Metzger, U.S. Geological Survey Water-Resources Investigations Report 94-4151, 47 pp., 1995.

[17] *2012 Annual Groundwater Monitoring Report Westside Basin San Francisco and San Mateo Counties, California*, Prepared by: San Francisco Public Utilities Commission (SFPUC) in cooperation with The City Of Daly City, The City Of San Bruno, and The California Water Service Company (South San Francisco District), April 2013.

[18] *Groundwater-flow System Description and Simulated Constituent Transport, Raychem/Tyco Electronics Site, 300-314 Constitution Drive, Menlo Park, California*, HydroFocus Inc., November 2003.

Appendix B

Detailed Desalination Feasibility Analysis

Appendix B

Detailed Desalination Feasibility Analysis

B.1 Summary

This appendix contains detailed information on desalination project option evaluation. Two options are evaluated in detail: an open intake option with a capacity of 15 mgd and a subsurface well intake of up to 6.5 mgd. This appendix evaluates the source water, intake and treatment associated with both desalination projects, discusses land requirements associated with them and land availability, discusses brine discharge, and evaluates planning level costs associated with each project. Next steps associated with each project are also discussed. Sections of this appendix include:

Several hypothetical desalination projects were developed for planning purposes in the *Phase II A Report*. The evaluations discussed in this appendix refine the Phase II A evaluation by:

- Updating several assumptions per added information on likely yields and source water quality;
- Including a discussion on land availability;
- Tailoring the cost evaluation to a range of potential costs for each project, rather than selecting individual scenarios. This strategy provides a bracketed potential cost;
- Including additional information available on current desalination technology; and
- Including a discussion regarding pilot testing and aquifer testing.

B.2 Source Water, Intake, and Treatment Options

This section presents general logistics of the desalination projects. The processes provide a basis for assumptions that are made in cost estimates and other feasibility analyses.

B.2.1 Source Water Options

Earlier phases of the Strategy identified several alternatives associated with desalination, including brackish groundwater, subsurface Bay water, Bay water via an open intake, and ocean water via an open intake or subsurface well. As options have been evaluated and refined, the universe of options has been narrowed down to two potential desalination options: and open Bay intake and brackish groundwater via vertical or HDD wells.

Vertical groundwater wells (see Figure B-1) are typically used for brackish groundwater supplies. This type of water supply is practical when used for small facilities (less than five mgd), such as the existing facility in Sand City, California.

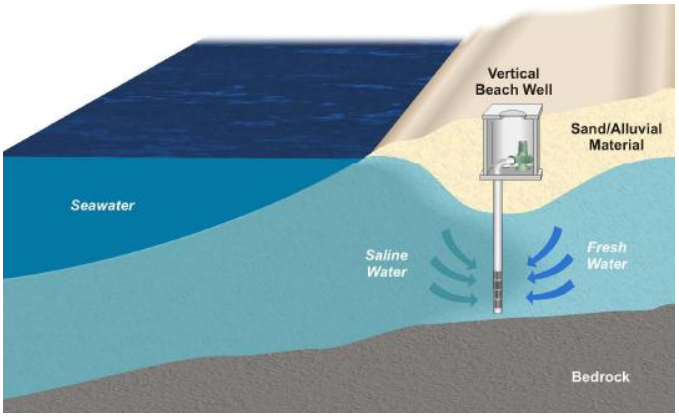


Figure B-1
Vertical Wells

Slant wells and/or HDD wells (see Figure B-2) use relatively new pipe drilling methods to drill at an angle beneath the Bay floor. Well shafts, screens, and a gravel pack slurry are inserted into the pipe to create the well prior to the pipe being removed. The slant well approach was recently piloted for a proposed facility in Orange County, California and the horizontal approach is being considered for proposed facilities in Monterey and San Diego counties. Because there is potential for Bay water to influence a horizontally drilled, subsurface groundwater well, slightly higher yields may be anticipated with an HDD well than with a more traditional vertical well. However, source water obtained from an HDD well would likely originate from a combination of groundwater aquifers and Bay water, rather than solely from the Bay.

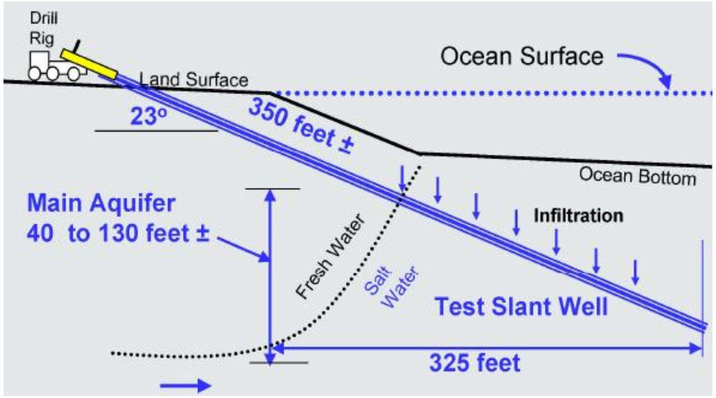


Figure B-2
Horizontally Directionally Drilled Well - Illustration

Appendix A discusses the groundwater yield evaluation. A Southern Focus Area (SFA) near the Dumbarton Bridge and a Central Focus Area (CFA) near the San Mateo Bridge have both been identified as potentially providing adequate groundwater supplies to support an up to 6.5 mgd desalination project.

For planning purposes, an open Bay intake is assumed to provide 25 g/L TDS source water; an HDD well intake is assumed to provide 16 g/L water, and a vertical well is assumed to provide a slightly lower salinity of 10 g/L.

B.2.2 Open Intake Options

Open water intakes are used most frequently for desalination facilities greater than five mgd and in locations where subsurface options are not feasible due to cost and/or local geology. Conventional screens such as bar screens, traveling screens, and drum screens with large slot widths and high input velocities are not expected to be permitted here because low velocity and fine screen open water intakes are preferred by permitting agencies to limit impingement of marine life to the surface of the screen and entrainment of marine life through the screen and into the intake pipeline and pumps.

The low velocity intake options currently being considered for proposed seawater reverse osmosis (SWRO) desalination facilities in California include:

- *Velocity cap structures* (see Figure B-3) – Structures designed to reduce the velocity of the incoming water to less than 0.5 foot per second (fps). Most structures provide coarse screening to reduce entrainment of debris which may damage the intake pumps. These are considered more viable in "low biologically productive" areas (equivalent to undersea deserts). Recently, multiple large capacity (>50 mgd) velocity cap intakes have been constructed for seawater desalination facilities in Australia and Europe and have demonstrated very low levels of entrainment and impingement.

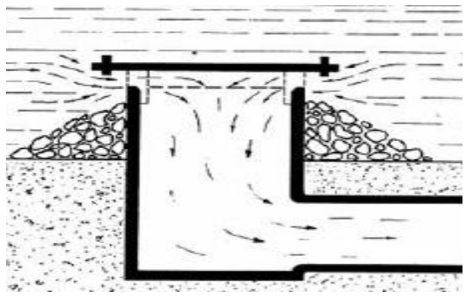


Figure B-3
Velocity Cap Illustration

- *Passive screen intake structures* (see Figure B-4) – These structures are considered the preferred open water intake technology in California because passive screens are expected to have the least impact on marine life. Passive screens use a combination of fine screening and low water velocities (<0.5 fps) to minimize impingement and entrainment. The California Coastal Commission has recommended one and two millimeter screens which were recently piloted for the proposed facilities in Santa Cruz and El Segundo, California and have been in use for six years at a facility near Taunton, Massachusetts. The Department of Fish and Wildlife recommended 3/32-inch screens for the proposed Bay water facility in Marin County. The reliability of passive screens is a concern in locations which require frequent cleaning. Passive screens are designed to use both local currents and air sparging to clean the screens; however, divers are occasionally required to perform more thorough cleanings. Copper-nickel alloys or super-duplex stainless steels with special coatings are typically used to minimize corrosion and biological growth on the screen surface.

Figure B-4
Passive Screen Illustration and a Picture of a Large-Diameter Passive Wedgewire Screen (Courtesy of Johnson Screens)

Before an open water intake can be permitted, the State Water Resource Control Board will likely require hydrogeologic investigations to determine the feasibility of a subsurface intake. If a subsurface option is determined to not be feasible, it is likely that a passive screen intake structure will be preferred by permitting agencies unless a location can be found suitable for a velocity cap type intake.

A 316(b) type impingement and entrainment study will also be required to assess the impact on marine life by different open water intake options. The United States Environmental Protection Agency (USEPA) 316(b) regulations assume that any organism entrained into the intake pipeline will not survive. Smaller screen slot sizes reduce entrainment, but also increase cleaning frequency and reliability concerns.

It is also anticipated that development of coastal wetlands or other types of habitat restoration may be required to offset the estimated entrainment of an open water intake, as was required for the Carlsbad Desalination Facility. These and other aspects of permitting, and overall implementation, are discussed in Section B.7.1.

B.2.3 Desalination Treatment

The components for a potential desalination facility can be divided into the following categories: 1) the intake and raw water supply system; 2) the pre-treatment system; 3) the reverse osmosis (RO) desalination and energy recovery system; 4) the post-treatment and stabilization system; 5) treated water disinfection, storage, and high service pump station; 6) solids handling system; 7) brine disposal system; and 8) ancillary facilities. Figure B-5 presents a schematic of the treatment process for a Bay water or seawater desalination facility assuming an open Bay intake and a robust pre-treatment system. The pre-treatment clarification and filtration processes would not be required for subsurface intakes, unless high iron or manganese levels are found to be present.

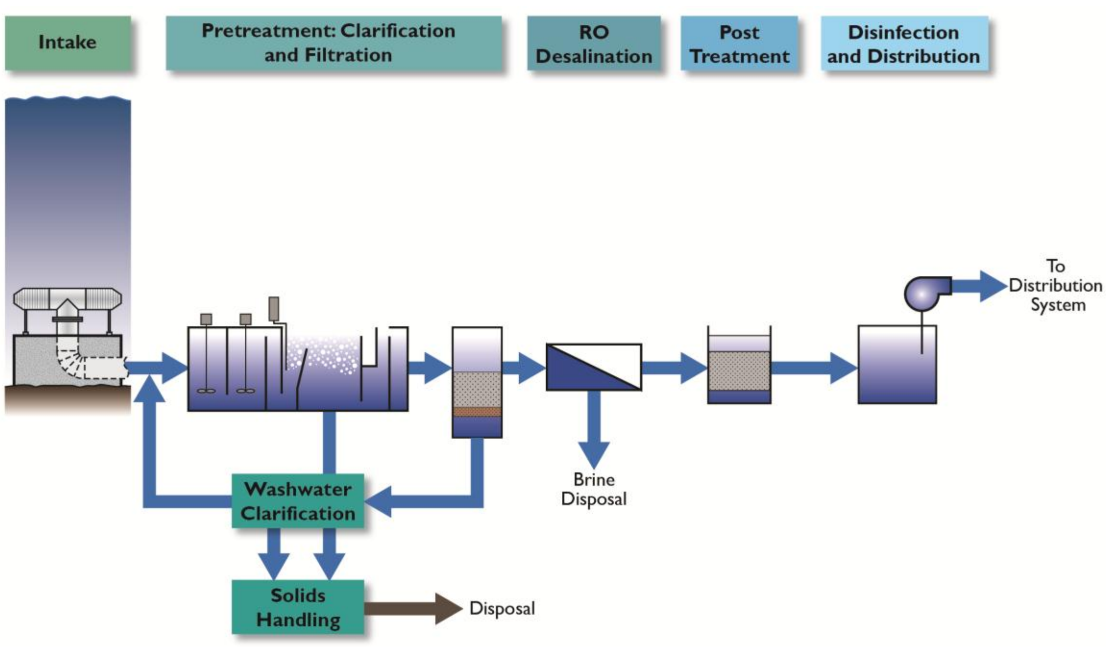


Figure B-5
Bay Water Intake RO Desalination Plant Process Schematic

The selection and complexity of the process components vary for different sources of supply and site-specific considerations such as source water quality and intake type.

B.2.3.1 Pre-treatment

Pre-treatment is required to protect the RO membranes used for desalination and to limit downtime due to maintenance and cleaning of the desalination system. The level of pre-treatment required is determined by source water quality and State Board Division of Drinking Water (DDW) requirements are based on source water monitoring results. Below is a discussion of pre-treatment for well sources and for open water intake sources.

Pre-treatment for Well Sources

Well water sources typically require only the addition of chemicals (e.g., antiscalant and possibly sulfuric acid) and cartridge filtration to maximize the useful life of the RO membranes in the desalination system. However, additional pre-treatment may be required if iron or manganese is present or if the test wells are determined to be "under the direct influence of surface water" according to DDW guidelines during pump tests.

If iron or manganese is present, additional pre-treatment such as chlorination, filtration, and dechlorination may be required to protect against particulate iron or manganese which can clog and physically damage the cartridge filters and RO membrane surface. If the wells are determined to be "under the influence of surface water," a Watershed Sanitary Survey (WSS), Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) monitoring, and potentially pilot-scale testing may be required to determine the amount of filtration and disinfection to comply with DDW pathogen removal requirements. Alternatively, monitoring and pilot-scale testing can be bypassed if the maximum pathogen removal/inactivation requirements are achieved within the treatment process. This approach is typically more cost-effective for small facilities, and was used to "fast-track" the permitting process for the beach well source desalination facility (less than one mgd) in Sand City, California, which began operation in 2009.

Pre-treatment for Open Water Intake Sources

Most seawater desalination facilities with open water intakes require a robust and reliable pre-treatment system (e.g., coagulation, flocculation, clarification, filtration, 5-micron cartridge filters and multiple chemicals) especially during storm and algal bloom events (e.g., red tides). One year of pilot-scale testing, a one-year WSS, and two years of LT2ESWTR monitoring are typically required by DDW to determine the pre-treatment and pathogen removal requirements for facilities with new open water intakes.

B.2.3.2 RO System Options

RO membranes and process configurations for brackish water and Bay water facilities are discussed below.

RO Membranes

Brackish water desalination facilities often typically utilize brackish water reverse osmosis (BWRO) membranes which are designed to achieve desired water quality with minimal energy use at pressures less than 300 pounds per square inch (psi).

Bay water facilities would require SWRO membranes to achieve desired water quality at pressures that exceed 300 psi. If the salinity of the source water varies significantly, a combination of BWRO and

SWRO elements may be used to achieve the lowest energy use over a range of source water quality conditions.

RO Process Configurations

BWRO systems operate at higher production efficiencies, or recovery rate, than ocean or Bay water RO systems due primarily to the lower salinity of the source water. Brackish water desalination facilities typically utilize a single-pass, two-stage configuration to maximize water production from a facility (e.g., 65 to 85 percent of source water is converted to drinking water; the remaining flow is discharged as high-saline brine). A third stage is required to exceed 85 percent recovery; however, fouling concerns typically limit recovery to 80 percent or less for most brackish water sources. For the purposes of these analyses, it is assumed that water sourced from a vertical brackish groundwater well would have a recovery rate of 70 percent. Because of the potentially higher salinity associate with HDD well source water, it is assumed that HDD well-sourced water would have a recovery rate of 65 percent.

A Bay water facility is assumed to utilize a single-pass, single-stage configuration and achieve recoveries of 40 to 60 percent depending on source water salinity. A second pass RO system may be required for the desalinated water to match chloride bromide, and boron concentrations in existing sources. Bromide is of particular concern because it impacts the stability of chloramine formation at the facility the stability of the residual in the distribution system, and the formation of brominated disinfection by products. Boron and chloride are of concern because these salts may impact plant health/growth at concentrations exceeding those in typical surface water sources. A second pass RO system uses additional RO membranes to re-treat a portion of the water produced by the first RO pass to further reduce salts in the final product water. In some cases, a second stage or RO membranes may also be desired to increase total recovery during periods of lower source water salinity. For planning purposes, it is assumed that Bay water sourced from an open intake structure would have an overall recovery rate of 50 percent. This assumption includes a pretreatment recovery rate of 91 percent and an RO recovery of 55 percent.

B.3 Land Availability

Land requirements for desalination plants are determined by water source/intake type and treated water capacity. As documented in the *Phase II A Report*, a brackish desalination plant would require approximately one-half acre per mgd of treated water capacity. Open intake Bay water sources would require approximately one acre per mgd of treated water capacity. For the range of treated water capacities being considered, a land parcel of 10 acres or greater (for open intake-sourced) or 1 to 5 acres (for well-sourced) would be needed.

A preliminary search for vacant parcels was conducted in the *Phase II A Report*. As potential treated water capacities were refined for the *Strategy Report*, parcels from the Phase II A land search were examined further for availability in the SFA and CFA. In addition to potential groundwater yields, these areas were selected for further evaluation for several reasons:

- Proximity to potential discharge facilities. As discussed in the next section, BAWSCA is considering disposing of desalination brine via existing wastewater treatment facilities. The CFA is near SVCW and San Mateo WWTP. The SFA is located near Palo Alto RWQCP;

- Proximity to SFPUC main distribution lines. There are several turnouts along the main SF RWS distribution pipeline that runs through the SFA and CFA. These turnouts could potentially be used to distribute treated water; and
- Proximity to raw water sources. Both the SFA and CFA are near either an open intake source (the Bay) or a well source (an aquifer with a potentially sufficient yield).

Land use categories in the San Mateo County Assessor's office were evaluated, and some additional internet searches were conducted to identify potential future uses of apparently vacant parcels. Additional parcels were also identified.

The parcels identified in Figure B-6 appear vacant from a search of aerial photographs of the area (Google Earth 2014; San Mateo County 2014). Contiguous parcels large enough to accommodate an open intake desalination plant are less abundant than smaller parcels that could accommodate a brackish desalination plant. Most are identified as vacant parcels in San Mateo County Assessor maps (San Mateo County 2014), with the exception of two parcels that are not assessed by the County. These parcels are instead assessed by the State Board of Equalization, but their vacancy status was not verified. These unconfirmed parcels are indicated in Figure B-6. For all properties, property owners have not been contacted to discuss willingness to sell and/or lease.

Most of the parcels identified from the assessment discussed above were large enough to accommodate a well-sourced desalination plant, but not an open intake plant. This search was not exhaustive, but may be indicative of general land availability in the SFA and CFA.

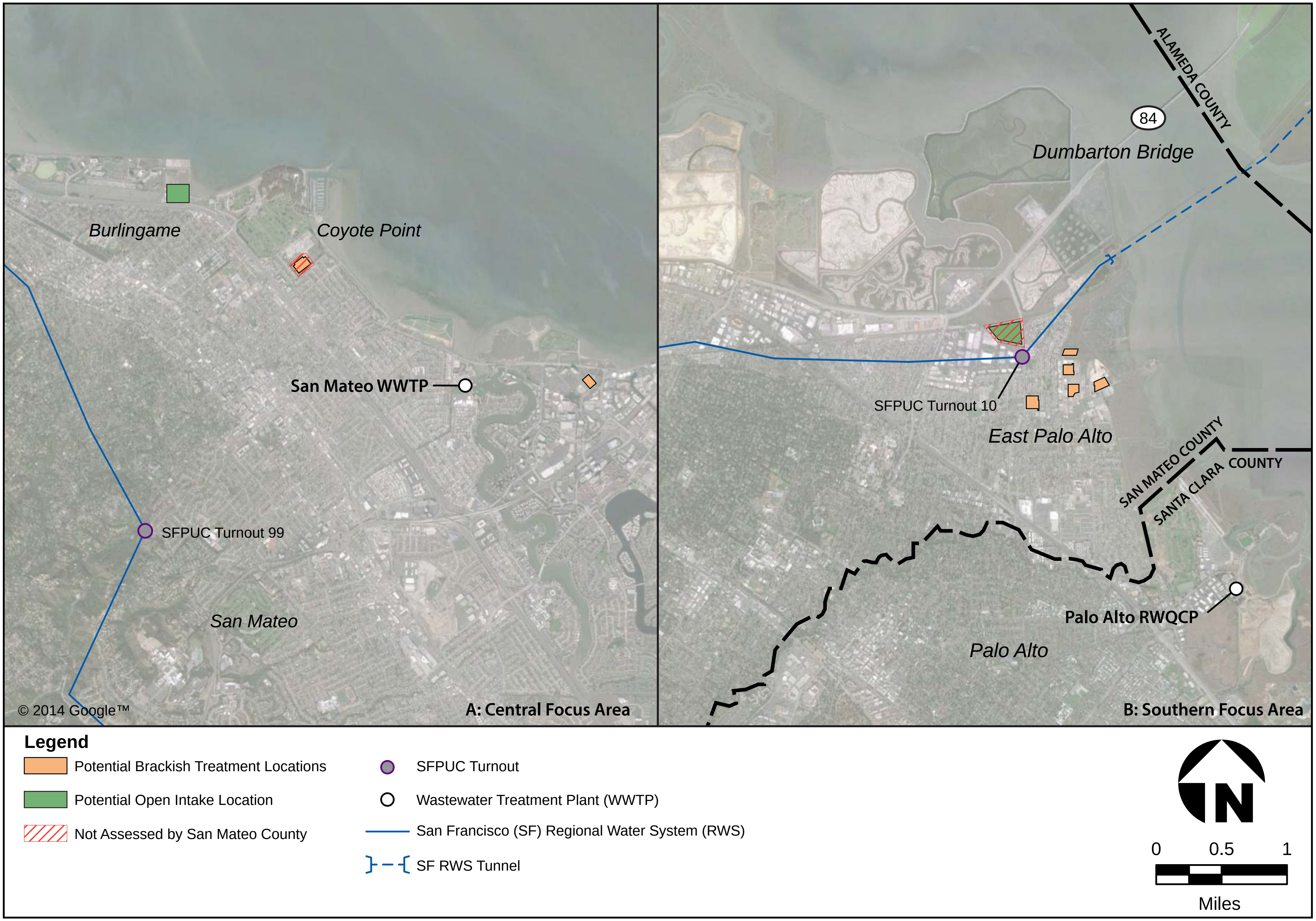
The actual land area needed for a well (or wells) and associated piping and pumping stations is relatively small, and could likely be integrated into other land uses. It may be possible to form a partnership between two or more entities to create a multi-benefit project that would provide access to a well field site. For example, BAWSCA could conceivably help purchase land and fund marshland habitat restoration, and in return be allowed to design and configure a project in a way that gives them access to operate a secure well field. This option would be particularly useful if land availability requires the desalination plant to be located on a different property than the well field for a groundwater desalination project.

B.4 Brine Discharge Options

Desalination of either Bay water or brackish well water would create between 0.4 and 1 mgd of brine per mgd of produced water. This brine would have a TDS concentration between 33 and 50 g/L. The brine would likely be discharged into the San Francisco Bay. For planning purposes, it is assumed that Bay water salt content represents a receiving water concentration of 25 g/L TDS.

B.4.1 Options in the Central and Southern Focus Areas

Most desalination plants either discharge brine directly into a receiving water body or discharge into a WWTP or power plant discharge outfall. Using an existing outfall provides TDS dilution (due to blending brine with a lower TDS discharge), and can reduce costs associated with outfall construction and maintenance (provided that excess hydraulic capacity exists in the current outfall). The State Board encourages brine disposal with a WWTP (State Board 2014). Table B-1 summarizes brine disposal practices for other desalination plants, both operational and planned.



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CDM Smith

Figure B-6
Potentially Available Parcels in the Central and Southern Focus Area

Table B-1. Brine Disposal Practices for Operational and Planned Desalination Plants

Location	Plant Production Capacity (mgd)	Description
Operational		
Newark, CA (Alameda County Water District)	15	Direct discharge to slough leading to San Francisco Bay
Sand City, CA	0.3	Seawater intake (from horizontal beach wells), discharge through subsurface outfall
Orange County Water District, CA	70	Discharge blended with Orange County Sanitation District discharge
Tampa, FL	25	Blended with power plant discharge into Tampa Bay estuary
Barcelona, Spain	52	Seawater intake, discharge blended with WWTP discharge
Australia	Varies	Six individual plants, direct discharge to ocean
Israel	Varies	Direct discharge to ocean
Planned		
Carlsbad, CA	50	Discharge blended with power plant discharge
Santa Cruz, CA	3	Discharge blended with WWTP discharge
Monterey area, CA (California American Water)	10	Discharge blended with WWTP discharge

Note: Information contained in this table reflects CDM Smith industry experience and personal communication with various experts in the desalination community.

BAWSCA is investigating the possibility of disposing of brine discharge through existing WWTP outfalls. In February through May 2014, BAWSCA met with representatives from San Mateo WWTP, SVCW, and Palo Alto RWQCP to discuss interest in potentially partnering with BAWSCA. All three agencies expressed a willingness to continue discussing sharing of up to 10 mgd of dry weather hydraulic capacity in their outfalls. A desalination project in the CFA may be able to dispose of brine in the existing outfall for either San Mateo WWTP or SVCW. A potential desalination project in the SFA may be able to utilize the existing outfall for Palo Alto RWQCP.

Brine production and disposal information is summarized in Tables 4-3 (see Section 4) and B-2, respectively. For the brackish desalination alternatives (shallow vertical well or HDD well), the amount of brine could be up to 3.5 mgd in either focus area, corresponding to a treated water capacity of up to 6.5 mgd. These flows are well within the capacity of the existing agency outfalls. For an open intake project with a 15 mgd treated water capacity, the assumed 50 percent recovery rate would result in 15 mgd of brine from the 30 mgd of raw water withdrawn from the Bay[1]. While San Mateo WWTP, SVCW, and Palo Alto RWQCP have expressed a willingness to potentially accept up to 10 mgd of brine, it is possible that they could accept a higher quantity, though this has not been confirmed. In addition, water quality constraints could limit the amount of brine allowed to be discharged. In summer, the most limiting season, the estimated maximum treated water capacity without exceeding the ambient TDS in the receiving water by over 10 percent is between 13.5 mgd and 17 mgd at the San Mateo WWTP and SVCW, respectively. A desalination plant with a capacity of 15 mgd would not likely result in a greater than 10 percent exceedance in the SFA.

[1] Differences in brine production for each of the treated water capacities examined for this study are presented in Table 4-3.

Table B-2. Summary of Brine Disposal Needs

Parameter		Value
Brine Volume	Brackish Vertical Wells	Up to 1.5 mgd
	Brackish HDD Wells	Up to 3.5 mgd
	Bay water	15 mgd
Brine Quality (TDS, assuming 25 g/L in bay water, 10 g/L in brackish water)	Brackish Vertical Wells	33 g/L

B.4.2 Potential Water Quality Constraints on Brine Outfall Capacity

Permitting agencies will often impose water quality constraints on desalination brine discharges. If the discharge TDS can be kept below, or within a few percent of, the ambient receiving water, less analysis for permitting is required. As the discharge salinity increases significantly over ambient salinity, additional field investigations and discharge modeling may be required. For example, the Carlsbad seawater desalination project is permitted to have a maximum hourly average discharge concentration of 44 g/L, which exceeds ocean salinity by 30 percent. However, extensive mixing studies and toxicity tests were conducted to demonstrate the environmental impacts of the high TDS discharge (San Diego Regional Water Quality Control Board 2007). While regulations on brine disposal are not firmly established in California, the State Board is releasing an amendment to the State Board Ocean Plan that may also clarify regulatory requirements on desalination brine discharge in the near future (State Board 2014).

Regulatory requirements could potentially limit the maximum capacity of desalination brine discharge via discharge water quality requirements. If treated wastewater discharges were too low, there could be limits on the amount of brine allowed to be discharged, and thus the capacity of the desalination plant would be limited. For planning purposes, a preliminary analysis was conducted to estimate potential water quality-related capacity limitations. This preliminary analysis uses flow data provided by WWTPs to examine two cases:

- Maximum desalination plant treated water capacity if discharge TDS is required to not exceed the receiving water salinity by more than 10 percent, and
- Maximum percent exceedance of ambient TDS if desalination plant is an open intake plant at 15 mgd treated water capacity.

Table B-3 summarizes potential water quality constraints on brine capacity from the preliminary analysis. Under all of the scenarios shown in the table, there are no constraints on the potential 1 to 6.5 mgd brackish desalination capacities (vertical well or HDD well) at any of the potential outfalls. However, Table B-3 shows that at all outfall locations, a 15 mgd open Bay intake desalination plant is more likely to have capacity restrictions due to brine discharge water quality limitations in the CFA. While the limitation of 10 percent TDS exceedance of receiving water salinity is purely hypothetical and this table should not be used to estimate likely brine disposal limitations, it can be used to evaluate *relative potential risk* associated with groundwater and open intake desalination projects.

Table B-3. Desalination Plant Treated Water Capacity Limits Imposed by Potential Water Quality Constraints in Brine Disposal

Facility	Intake Type	Desalination Plant Recovery Rate (%)	Average Desalination Plant Treated Water Capacity[1] (mgd)			
			Summer[2]		Winter[2]	
			Maximum Treated Water Capacity without 10% TDS Exceedence[3]	Maximum % TDS Exceedance at 15 mgd[3]	Maximum Treated Water Capacity without 10% TDS Exceedence[3]	Maximum % TDS Exceedance at 15 mgd[3]
San Mateo WWTP[4]	Open bay intake	50%	13.5	16%	16.8	15%
	HDD well	65%	> 20	< 0	> 20	< 0
	Brackish vertical well	70%	> 20	< 0	> 20	< 0
SVCW[4]	Open bay intake	50%	17.0	5%	18.8	2%
	HDD well	65%	> 20	< 0	> 20	< 0
	Brackish vertical well	70%	> 20	< 0	> 20	< 0
Palo Alto RWQCP[5]	Open bay intake	50%	> 20	< 0	> 20	< 0
	HDD well	65%	> 20	< 0	> 20	< 0
	Brackish vertical well	70%	> 20	< 0	> 20	< 0

[1] Hydraulic capacity is based on outfall pipeline hydraulic capacity and monthly average WWTP flows.
[2] Summer flows are considered flows from May through October. Winter flows include flows from November through April.
[3] Percentage exceedance is the percentage salinity of the outfall (brine blended with WWTP flows) that is in exceedance of the receiving water salinity (Assumed to be 25 g/L).
[4] The San Mateo WWTP and SVCW provided BAWSCA with flow data from 2010 and 2008, respectively.
[5] Palo Alto RWQCP data was unavailable. Because San Mateo WWTP and South San Francisco WWTP had similar monthly flow patterns, the normalized monthly peaking patterns of San Mateo and South San Francisco WWTPs were averaged and applied to Palo Alto RWQCP's mean flows for this analysis.

B.5 Basis for Planning Level Costs

B.5.1 Overview

This section presents the planning level cost information used as the basis of costs for the desalination projects. Estimates include:

- Construction Costs ($M);
- Capital Costs ($M);
- Annual O&M Costs ($M);
- Present Worth Costs ($M);
- Estimated Annual Production ($M);
- Unit Cost of Total Present Worth ($M/AF); and
- Unit Annualized Costs ($/AF).

In addition to the capital costs (construction costs plus adjustments) and O&M costs, two different approaches are included for comparing alternative projects. These include the development of present worth analysis (or life-cycle costs) and annualized costs. The present worth analysis includes the conversion of all cash flows to a common point in time, February 2014. As such, it requires the consideration of the time value of money and all future cash flows discounted back to the present. The present worth analysis converts all annual O&M costs (i.e., chemicals, power, labor, RO membrane replacement, etc.) to a present worth value and adds this to the present worth of the capital cost.

An annualized cost estimates the yearly cost of owning and operating an asset and is also expressed in present dollars. The annualized cost analysis computes the annual debt service on the capital (i.e., one year of payments of interest and principal required on the bond or loan used for financing the project) and adds it to one year's worth of O&M costs. To compute the unit cost of water this sum can be divided by the total amount of water produced by the project in one year.

Neither method calculates the actual unit cost of water as this requires a more detailed analysis that is tailored to the specific conditions of how the project is financed and how this financing is paid back through water rates. The simplified approach for both methods (and often the more conservative) is to assume that the annual escalation rate for expendables is the same as the discount rate (i.e., bond or loan rate).

B.5.2 Unit Construction Cost Curves

B.5.2.1 Desalination Treatment Construction Costs

Unit construction cost curves were developed for brackish water and Bay water RO desalination facilities based on other recent desalination projects. This cost information was developed based on existing and proposed facilities in the United States (U.S.), Australia, the Bahamas, and Oman. U.S. costs were escalated using the San Francisco ENR CCI factor to February 2014 dollars; international projects were escalated at three percent annually from project bid cost numbers published in the Global Water Intelligence World Desalination Report. Table B-4 summarizes the information that was used in developing the cost curves, categorized as brackish well, slant well, beach well and bay/brackish river intake. Figure B-7 presents these construction cost data points. On evaluating cost curves and the data used to develop them, it was determined that there was significant pretreatment associated with mode of the examples used to develop a cost curve for slant wells. Because of this, it was determined that the beach wells curve may more accurately estimate costs associated with HDD wells. The brackish well curve is used to estimate desalination plant costs for vertical groundwater sources, and the bay/river intake curve is used to estimate Bay open intake costs.

Table B-4. Desalination Plant Construction Cost Data Table

	Capacity (mgd)	Plant Construction Cost As Bid ($M)	Bid Date	ENR Factor (if available)	ENR Reference City	Escalation Factor	Costs Escalated to February 2014	
							Plant Construction Cost ($M)	Unit Construction Cost ($M/mgd)
Brackish Well BWRO								
Alameda County Water District [ACWD] NDF1, Fremont, CA	5.0	$13,000,000	2002	7722	San Francisco	1.41	$18	$3.67
ACWD NDF2, Fremont, CA	10.0	$20,000,000	2009	9725	San Francisco	1.12	$22	$2.24
EL Paso, TX	28.0	$30,000,000	2005	7298	General	1.49	$45	$1.60
Deerfield Beach, FL	13.0	$13,900,000	2006	6538	General	1.67	$23	$1.78
Clewiston	3.0	$13,295,000	2005	7647	General	1.42	$19	$6.31
Lake Region WTP	10.0	$19,727,000	2005	7479	General	1.46	$29	$2.87

Table B-4. Desalination Plant Construction Cost Data Table

	Capacity (mgd)	Plant Construction Cost As Bid ($M)	Bid Date	ENR Factor (if available)	ENR Reference City	Escalation Factor	Costs Escalated to February 2014	
							Plant Construction Cost ($M)	Unit Construction Cost ($M/mgd)
Slant Well SWRO								
Municipal Water District of Orange County, CA	15.0	$136	2007	8873	Los Angeles	1.23	$167	$11.1
Monterey County, CA	7.5	$58	2003	7789	San Francisco	1.00	$89	$9.27
Monterey County, CA	10.0	$72	2003	7789	San Francisco	1.40	$81	$10.8
Cambria, CA	1.1	$15	2011	10192	Los Angeles	1.40	$101	$10.1
Bay/Brackish Open Intake BWRO/SWRO								
Taunton, Massachusetts (open River intake under influence of seawater)	5.0	$65	2008	9071	General	1.20	$78	$15.6
Haverstraw, NY	2.5	$35	2011	9080	General	1.20	$42	$16.8
Bay Area Regional Desalination Project (BARDP) at East Contra Costa Site, CA	25.0	$113	2007	9063	San Francisco	1.20	$136	$5.43
BARDP at East Contra Costa Site, CA	65.0	$234	2007	9063	San Francisco	1.20	$281	$4.33
Beach Well SWRO								
Sand City	0.6	$5.7	2008	9134	San Francisco	1.19	$7	$11.3
Blue Hills, Bahamas	7.2	$29	2006		3% Escalation	1.16	$34	$4.75
Sur, Oman	21.2	$65	2007		3% Escalation	1.13	$73	$3.45

The cost information used for Figure B-7 includes reported construction bid amounts and engineer's estimates from feasibility or preliminary design reports, and in general do not include costs for offsite pipeline installation, soft costs (permitting, legal fees, other studies), environmental mitigation, land purchase, obtaining right of ways/easements, or utility staff time.

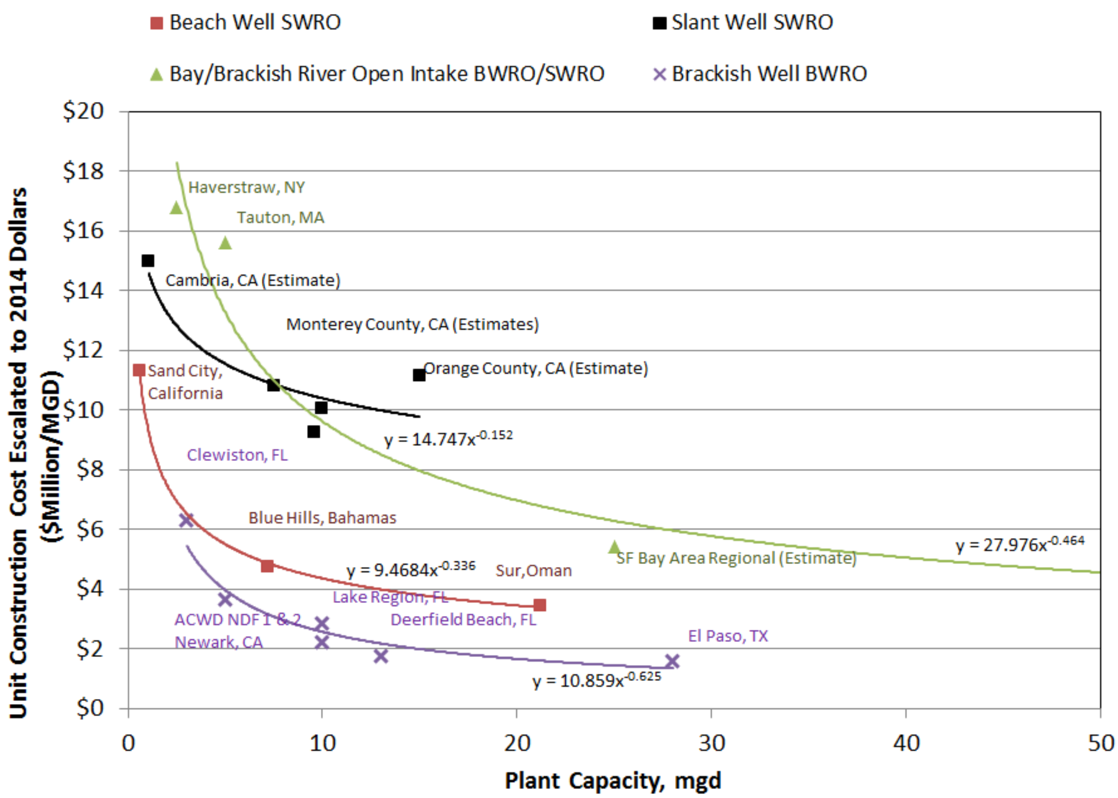

Figure B-7
Desalination Plant Unit Construction Costs and Curves – Historical Data

Table B-5 indicates the information and assumptions used in developing construction cost estimates for the different types of intakes for the desalination projects. Figure B-8 presents the construction costs used for costing the intake facilities. All costs are adjusted to February 2014.

Table B-5. Basis of Construction Costs for Intake Structures

Intake Type	Source	Formula
Vertical Well	Assumes values from meeting with Ranney/Layne	Brackish vertical well field (assumes up to 1500 gpm wells at $1.0M per well)
HDD well	Assumes values from August meeting with Geoscience	HDD well - subsurface intake (assumes up to 2000 gpm wells up to 3000 feet in length)
Open Ocean or Open Bay Intake	Assumes equation using cost curve for Santa Cruz, Marin, and SF Bay Regional projects	Regression Curve

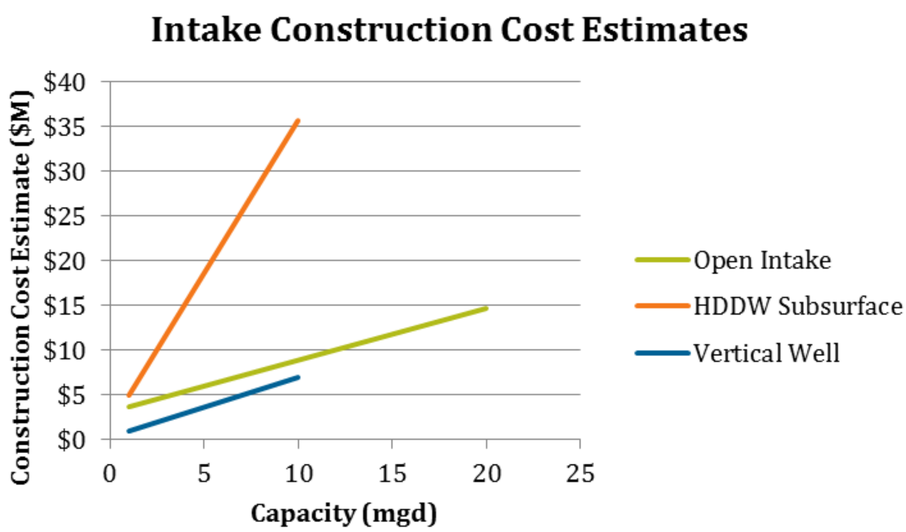

Figure B-8
Intake Construction Cost Curves

B.5.2.2 Pipeline and Treated Water Storage Construction Cost Assumptions

The unit cost assumptions for the pipelines, pump stations and reservoir storage are based on review of projects constructed within the Bay Area over the last ten years. All unit costs indicated in Table B-6 are presented in February 2014 dollars.

Table B-6. Pipeline and Storage Construction Cost Assumptions

Description	Unit Cost Assumption
Pipelines installed in an urban area	$15/in-ft
Pipelines requiring jack and bore	$39/in-ft
Offshore pipelines	$20/in-ft
Pump stations[1]	$2,400/HP
Steel above ground treated water storage tank	$800,000 per MG

[1] It is assumed that the intake and treatment plant construction cost curves include construction costs for a pump station worth a nominal power of 50 HP. Costs are included for any HP requirements above 50 HP.

B.5.3 Capital Costs

Capital costs are developed for the proposed facilities based on the construction costs presented in Section B.5.1 adjusted by the factors noted in Table B-7.

Table B-7. Cost Adjustment Factors

Cost Element	Portion of Construction Cost
Engineering feasibility studies, preliminary and final design, services during construction and construction management	25 percent
Contractor markup: including overhead, profit and prorates	15 percent
"Soft costs" including legal fees, permitting, and other miscellaneous costs	15 percent
Contingency	40 percent

The 15 percent allowance for "soft costs" is a higher percentage than typically included in planning level cost estimates; however, a higher than typical estimate is appropriate given the costs incurred for permitting other desalination facilities in California. For example, the costs incurred for permitting the facility in Carlsbad have been greater than 6 percent (over $20 million) of the estimated construction cost (approximately $300 million) information provided by Poseidon Resources.

Some key costs have not been included the current analysis, including:

- Land purchase cost;
- Purchase of easements or rights-of-way;
- Wheeling or “Transfer” costs for conveyance of water through other agencies facilities; and
- Purchase price of water if required.

B.5.4 Operations and Maintenance Costs

O&M costs are a key part of the overall costs for desalination facilities. These costs include:

- Cost of power (electrical);
- Chemicals;
- Labor;
- Solids disposal to landfills;
- Microfiltration/ultrafiltration membrane replacement costs;
- Cartridge filter replacement; and
- RO membrane replacement.

The O&M costs are adjusted for General Maintenance (non-labor costs) at 10 percent of the total for the components listed above, and also include 10 percent contingency for those same items.

The present worth (PW) calculations for the assumed 30-year life of these projects includes the onetime cost for all capital facilities assumed to occur in the future as well as the stream of operational costs escalated each year over 30 years and then brought back to a PW value in February 2014. The present worth calculations use the following assumptions:

- 2014 costs are current as of February 2014;
- 2018 project start date (O&M costs starting 2019);
- Assumed project life of 30 years;
- PW estimates include a 3 percent escalation and a 3 percent discount rate. The same escalation rate is used for electricity, materials, labor and capital costs;
- Annual and total production assumes a base load of 80 percent; and
- Annualized costs are calculated over project life in 2014 dollars.

B.5.5 Cost Bracketing

Estimated plant costs vary among potential locations due to estimated pipe length and boring requirements. For each plant type and size, a maximum likely cost and a minimum likely cost was developed based on the delivery and disposal pipe length estimates that were made for all parcels in the two focus areas. These bracketed cost estimates were developed based on potentially available parcels, potential treated water delivery locations, and potential brine disposal locations. To develop this range, a plant in the CFA is assumed to discharge brine to the San Mateo WWTP, and a plant in the SFA would discharge brine to the Palo Alto RWQCP. A plant in the CFA is assumed to deliver treated water into the water system at SFPUC Turnout 99, and a plant in the SFA would deliver water into the system at SFPUC Turnout 10. Pipe length ranges used to develop bracketed costs are shown in Table B-8.

Table B-8. Pipe Lengths Used to Develop Maximum and Minimum Likely Costs

Likely Cost	Plant Type	Plant to Distribution System (ft)		Plant to Discharge (ft)		Intake to plant (ft)	
		Normal	Tunnel	Normal	Tunnel	Normal	Tunnel
maximum	Brackish	16,000	4,800	14,000	4,200	4,500	1,350
minimum		900	270	2,000	600	0	0
maximum	Open Bay Intake	16,000	4,800	14,000	4,200	10,000	0
minimum		900	270	2,000	600	6,000	0

Notes:
For all estimates, it is assumed that 25% of total pipe lengths require tunneling.
Maximum “intake to plant” length of 0 ft for Brackish/HDD well plants assumes that wells are co-located with the desalination plant.

B.5.6 Refinements for Final Strategy

Cost estimates were developed in the *Phase II A Report*. The costs developed for the *Final Strategy Report* differ from those developed in the *Phase II A Report* in the following ways:

- Different scenarios are costed. Expected source water TDS and capacity were refined based on findings from groundwater modeling studies, and ranges of potential piping requirements were developed for each potential intake type;
- Costs were updated to 2014-appropriate estimates;
- Refinements were made to O&M cost estimation relevant to:
  - electric power usage,
  - filter replacement,
  - sludge chemicals,
  - pretreatment,
  - RO pressures,
  - Post treatment for brackish groundwater,
- Recovery calculations based on updated expected source water TDS; and
- Additional examples for cost curves.

B.6 Planning Level Cost Estimates

For the open intake desalination project, a single scenario of a 15-mgd facility was costed with a range of potential piping requirements as discussed above. For the brackish groundwater desalination project, several scenarios were developed for cost estimation purposes. These include a capacity range from 0.7 mgd of treated water up to 6.5 mgd. Vertical well scenarios were developed for a range of low capacity groundwater yields (0.7 to 3.5 mgd). Higher yields were included in HDD well cost scenarios (1 to 6.5 mgd). The costed scenarios are summarized in Table B-9.

Table B-9. Desalination Project Scenarios

Project Type	Assumed Raw Water TDS (g/L)	Recovery Rate	Brine TDS (g/L)	Treated Water Capacity (mgd)
Brackish Vertical Wells	10	70%	33	0.7
				1
				1.4
				3.5
Brackish HDD well	16	65%	46	1
				3.3
				5.0
				6.5
Open Bay Intake	25	50%	50	15

Table B-10 provides cost estimates for:

- Capital costs (in $2014)
- O&M costs (in $ 2014),
- PW total project cost (in $2014), and
- The annualized cost per AF.

Table B-10. Cost Estimates for Desalination Project Options

	Open Bay Intake	Subterranean Bay HDD well Intake				Inland Brackish Vertical Well Intake			
Treated Water Capacity (mgd)	15.0	1.0	3.3	5.0	6.5	0.7	1.0	1.4	3.5
Capital Cost ($M)	$309-362	$36-50	$77-104	$111-141	$128-164	$30-44	$31-45	$31-49	$47-72
Annual O&M ($M)	$13.1-13.4	$0.8-0.9	$1.8-1.9	$2.5-2.6	$3.1-3.2	$0.7	$0.8-0.9	$1.0-1.1	$1.9-2.2
Total PW ($M)	$702-764	$61-76	$130-160	$185-220	$220-261	$51-66	$55-72	$61-81	$105-138
Annualized Unit Cost ($/AF)	$2,150-2,370	$2,970-3,800	$1,930-2,420	$1,810-2,190	$1,650-1,990	$3,560-4,740	$2,650-3,570	$2,050-2,850	$1,380-1,870

B.7 Next Steps: Implementation and Groundwater Aquifer Testing

Whether groundwater or Bay water is used as a water source, developing a desalination project involves several processes that should be started as soon as practicable. In this way, desalination lends itself to planning strategies that incorporate elements of adaptive management; initial planning steps can be taken at an early stage when actual need is less clear, without significant financial investment. This section discusses overall steps, both near-term and longer-term, that should be considered in desalination project development. Coordination with regulating agencies is discussed as an initial activity that will expedite permitting significantly. This section also discusses aquifer testing that should be conducted early in the desalination development process.

B.7.1 Desalination Implementation

Desalination is a major dry year supply alternative in the Strategy. While it is more expensive than other options such as transfers, it has much greater certainty on yield and cost. Despite these benefits, implementing a desalination project in California can be a long and complex process. Reasons for this include:

- Regulatory requirements are not firmly established;
- Capital and development costs can be high; and
- High potential exists for opposition.

Two desalination project types were evaluated: a) 15-mgd open bay intake; and b) 0.7- to 6.5-mgd brackish groundwater. Brackish groundwater desalination may be less expensive, easier to permit, and may result in simpler brine disposal and land acquisition. A brackish desalination project may have a higher yield with a horizontal well under the Bay versus a vertical well due to the potential for Bay water to infiltrate the well's capture zone. Accurate estimates of yield for a groundwater desalination project should be verified with aquifer testing. The highest and most reliable yield would be associated with an open intake desalination project.

Brine disposal could potentially be provided through existing WWTP facilities. This option would simplify disposal permitting and potentially simplify logistics and costs associated with disposal. However, it is possible that the large volume of brine associated with an open intake plant could complicate negotiations with either permitting agencies or with the WWTP facilities.

The higher yield brackish groundwater desalination projects would likely be more cost effective in terms of unit cost than open intake projects; larger capacity HDD wells and vertical well projects would likely have an annualized lifecycle cost of $2,000/AF or less. However, lower yield groundwater and open intake projects may be closer to $3,000/AF.

B.7.1.1 Open Intake Desalination

Open water intake desalination plants can be especially vulnerable to opposition, as several key interest groups have expressed opposition to open intakes because of risks to marine life. The California Coastal Commission (CCC) has expressed a goal of avoiding open ocean intakes *wherever feasible*, creating potential delays in Coastal Development Permit approval for facilities utilizing such intakes. While the CCC would likely not have jurisdiction over a project within the Bay, this position sets a precedent within California of discouraging open intake desalination plants. The location of the desalination plants under consideration for BAWSCA fall under the jurisdiction of the Bay Conservation and Development Commission (BCDC) as the permitting authority. The BCDC has not yet permitted an intake, though the Marin Municipal Water District had begun the process. The State Board is developing an Ocean Plan Amendment specific to desalination facilities. In support of that work, the State Board has released a "Proposed Desalination Amendment and Draft Staff Report" (State Board 2014) that recommends limiting open intakes to locations where subsurface intakes have been demonstrated to be infeasible, or where the open intake is projected to be no more damaging to the environment than a subsurface intake. While a pathway does exist for regulatory approval of open intake desalination in California, many projects have been delayed indefinitely or cancelled outright due to uncertainty or delays in the development process. The State Board expects to finalize the desalination amendment by the end of 2014, and the permitting process may need to be revisited at that time. If the groundwater investigations completed as part of the Strategy are not considered sufficient, it could be necessary to perform an aquifer test to confirm that groundwater yield would not meet the needs of BAWSCA in order to justify an open intake desalination facility from a permitting perspective.

For an open Bay intake desalination project, it is recommended that dialog begin with key permitting and coordinating agencies as soon as practicable, including state permitting agencies and also other stakeholders, such as developing agreements with wastewater agencies for outfall use for brine disposal. Table B-11 provides a summary of implementation steps in project development, anticipated duration and level of effort for developing the information needed, regulatory agencies involved, and decisions required to proceed. Some of the permits and implementation steps may not be required depending on the selected site and approach for the intake, treatment facility, and brine disposal. Key elements of the project implementation are also presented graphically in Figure B-9. Table B-11 and Figure B-9 show that implementation could take over 10 years.

Table B-11. Implementation Steps for an Open Intake Desalination Facility

Implementation Step/Information to be Developed	Relevant Regulatory Agency	Decision Required for Proceeding	Duration
Feasibility Study and Master Plan	None	▪ Capacity ▪ Treatment approach ▪ Conceptual cost ▪ Funding approach	1 year
Offshore geophysical study and intake feasibility study	United States Fish & Wildlife Service, National Marine Fisheries Service, California Department of Fish and Wildlife	▪ Intake approach	2-3 years
Energy minimization and greenhouse gas reduction study	Various	▪ Use of renewable energy ▪ Other mitigation	0.5 years
EIR and/or Environmental Impact Statement (EIS)	Various	▪ Site selection ▪ Environmental impact reduction measures	2-3 years
Watershed Sanitary Survey	State Board DDW	• Source water treatment requirements	3 years

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Table B-11. Implementation Steps for an Open Intake Desalination Facility

Implementation Step/Information to be Developed	Relevant Regulatory Agency	Decision Required for Proceeding	Duration
Preliminary design	DDW	▪ Design criteria ▪ Site layout ▪ Piping and instrumentation diagrams ▪ Standard operating procedures	0.5 years
San Francisco Bay Development Permitting	BCDC	▪ Additional measures required for bay area protection and public access	2-3 years
Waste discharge permitting	Regional Water Quality Control Board (RWQCB), United States Environmental Protection Agency (USEPA)	▪ Brine disposal method	1-2 years
Final design	Various	▪ Complete bid documents ▪ Permitting documents	1.5 years
Construction	Various	▪ Project completion	3 years

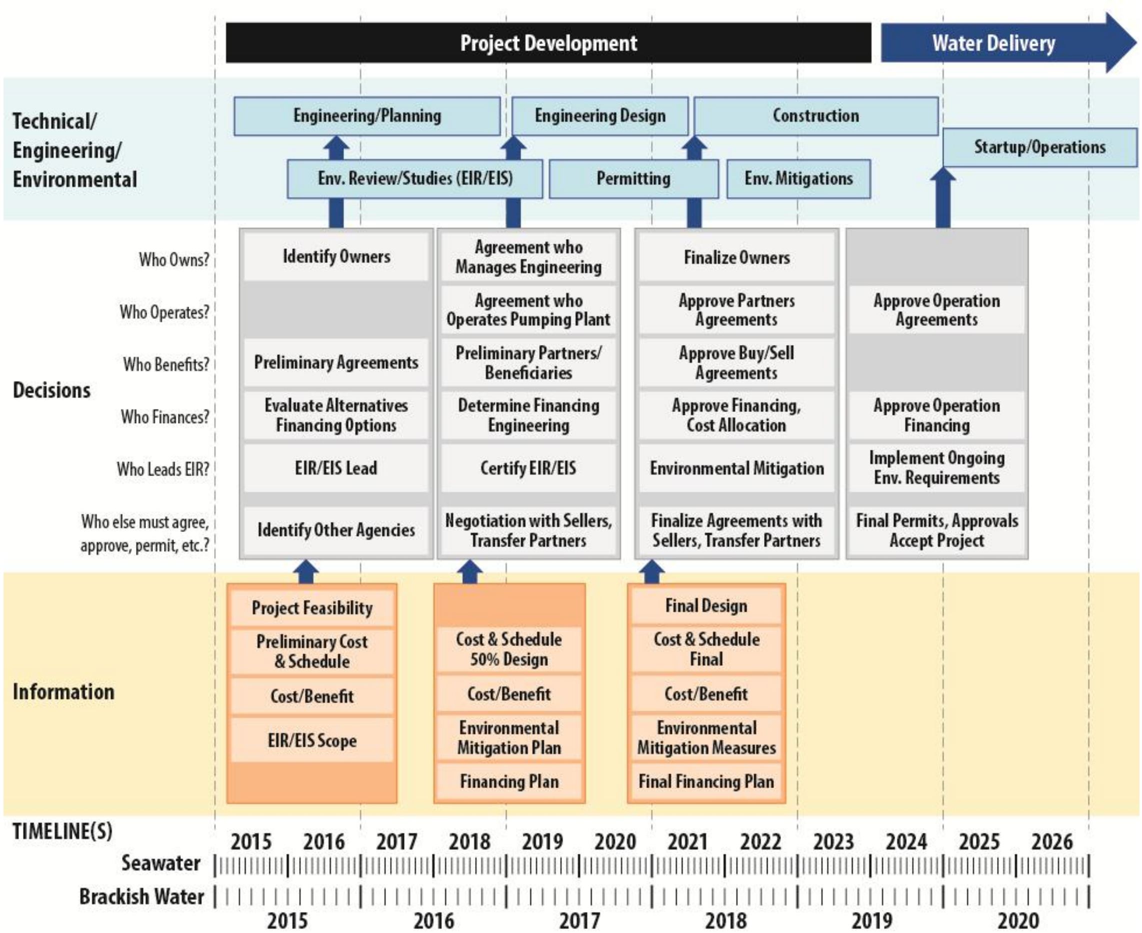


Figure B-9
Key Elements for Project Implementation

B.7.1.2 Brackish Desalination

Because many of the permitting steps are necessary for either an open intake project or a groundwater project, Figure B-9 also includes a separate timeline for a groundwater project. It is clear from the timeline that a groundwater projects would have a much faster implementation time, potentially six years.

Although implementing a brackish groundwater desalination project is less complex than seawater desalination, it is also recommended that a dialogue with the State Board and other permitting agencies begin as soon as practicable. For groundwater desalination projects, energy requirements are lower, treatment requirements are lower, and potential environmental impacts are smaller than for open intake facilities. The approval process still requires early coordination with regulatory agencies; however, many of the regulatory requirements applying to open intake desalination facilities are not required for groundwater treatment. Brine disposal will need to be addressed via agreements with local wastewater agencies. BCDC permitting can potentially be avoided if no work is required along the San Francisco Bay shoreline. DDW will not require the two years of water quality monitoring associated with a Watershed Sanitary Survey, unless the well is determined to be under the direct influence of surface water.

The most promising groundwater and subsurface Bay water desalination plant locations are near the San Mateo Bridge (CFA) and Dumbarton Bridge (SFA). The total shallow-aquifer groundwater yield from both areas, as estimated by the computer modeling effort discussed in Appendix A, range from 1 to 3 mgd but the yields could be as high as 5 to 10 mgd if Bay Mud conductivity is found to be higher than assumed.

As part of the implementation steps for brackish desalination (see Table B-12), a shallow aquifer exploration and testing program is recommended to refine project yields and evaluate the hydraulic connection between the shallow aquifer and San Francisco Bay. This is discussed further in Section B.7.2.

Table B-12. Implementation Steps for a Brackish Groundwater Desalination Facility

Implementation Step/Information to be Developed	Relevant Regulatory Agency	Decision Required for Proceeding	Duration
Feasibility Study and Master Plan	None	▪ Capacity and yield determination ▪ Treatment approach ▪ Conceptual cost ▪ Funding approach	1 year
EIR/EIS	Various	▪ Site selection ▪ Environmental impact reduction measures	2 years
Preliminary design	DDW	▪ Design criteria ▪ Site layout ▪ Processing and Instrumentation Drawings ▪ Standard operating procedures	0.5 years
Waste discharge permitting	RWQCB, USEPA	▪ Brine disposal	0.5 years
Final design	Various	▪ Complete bid documents ▪ Permitting documents	1 year
Construction	Various	▪ Project completion	2 years

B.7.2 Aquifer Testing

For a groundwater desalination project, an aquifer test will be necessary. The groundwater modeling study included in Appendix A evaluates potential yields in the Focus Areas based on available data. In order to accurately estimate project yields, a formal aquifer test needs to be performed. An aquifer test will also provide a more accurate estimate of expected source water salinity as a given intake site.

For an open intake desalination project, an aquifer test may also be necessary to confirm that expected yields are below the higher yields that could be obtained from an open intake project. Regardless of the project option being pursued, this section discusses considerations for detailed aquifer testing.

B.7.2.1 Aquifer Test Components

The total shallow-aquifer groundwater yield from both the SFA and CFA range from one to three mgd, and the yields are sensitive to assumed values for Bay Mud conductivity (higher yield groundwater scenarios are costed for HDD well configurations rather than vertical well configurations for this reason). A shallow aquifer exploration and testing program is recommended to refine estimated yields and evaluate the hydraulic connection between the shallow aquifer and San Francisco Bay. The testing program would include the following:

1. *Approach*: After site selection, implement a step-wise, systematic well-drilling and data collection program with three pre-defined intermediate decision points. The three decision points coincide with the following tasks: 1) drill test boring for extraction well; 2) install and test dual-purpose monitoring- and extraction-well; and 3) install supplementary monitoring wells (one shallow and one deep) and conduct long-term controlled aquifer test. At each point the data is evaluated to determine whether the program is feasible or not. If determined feasible, the effort continues to the next step, whereas if determined infeasible the investigation is discontinued or modified as appropriate.

2. *Key objectives*: Measure site-specific well yield and hydraulic connection between the shallow aquifer and bay.

3. *Duration*: Of sufficient length to appropriately measure and evaluate the hydraulic interaction between the shallow aquifer and bay. This may require one month or more of pumping to induce a sufficient response and acquire adequate data to estimate the effective hydraulic conductivity of the Bay Mud.

4. *Chemical analyses*: Determine potential changes in groundwater quality and estimate changes in the proportional contribution of bay water to the well yield.

The estimated cost to install and conduct this program using either vertical or horizontal wells are summarized below in Table B-13. Costs in the table include analyzing and interpreting the data and reporting of results.

Table B-13. Estimated Shallow Aquifer Well-Drilling and Data Collection Program Costs.

Monitoring/Extraction Well Installation and Testing	Vertical	Horizontal
Test Boring and Install Monitoring/Extraction Well	$96,000	$970,000
Tidal Response and Short-Term Yield Test	$93,000	$93,000
Install Vertical Monitoring Well (shallow)	$55,000	$55,000
Install Vertical Monitoring Well (deep)	$76,000	$76,000
30-45 day Aquifer Test	$235,000	$235,000
Grand Total	$555,000	$1,429,000

B.7.2.2 Potential Test Site Locations

Based on regional modeling with the Strategy Groundwater Model (SGM) discussed in Appendix A, for groundwater desalination a series of wells distributed across a fair length of shoreline would be recommended to maximize yield and minimize drawdown in existing wells. The closer the well is located to the bay (or, in the case of a horizontal well, located beneath the bay), the less of an impact shallow pumping will have on inland groundwater levels and the greater is the potential for well recharge from the bay.

Specific sites were selected, based on the preliminary land parcel availability analysis discussed in Section B.3, to focus the data collection planning discussion. These sites were analyzed in detail to determine expected pumping rates, water level responses, and required test durations to guide the data collection program design and cost estimating effort. Figure B-10 shows the selected Central Focus Ares test site including recommended extraction and monitoring well locations, and Figure B-11 shows two potential SFA test sites. Extraction and monitoring well locations are recommended for site OW-1S in Figure B-11 because it is likely more accessible, however the site is located near a USEPA site (the Romic site) where soil and shallow groundwater is contaminated by volatile organic compounds. For this reason, a second site (OW-2S in Figure B-11) is also considered located at the outer edge of salt restoration ponds near Menlo Park. The only significant entities that own lands in the bayside areas represented by this second site are Cargill Salt, Pacific Gas and Electric (at least one substation is located in the mudflats), the Salt Pond Restoration Project (Redwood City), and perhaps local or regional parks.

B.7.2.3 Drill Test Boring and Install Vertical Monitoring/Extraction Well

The test boring can provide several sequential pieces of information. The geologic samples and geophysical survey from the test boring will confirm or refute the expected aquifer characteristics beneath the site (the cumulative thickness of fine-grained clay and coarse-grained sand and gravel). Because the well will be in close proximity to San Francisco Bay, measured water levels in the well should also show an influence from the magnitude and frequency of sea level changes. The predominant tidal fluctuations are the semi-diurnal (every 12 hours and 25 minutes) and diurnal cycles (every 24 hours and 50 minutes). Groundwater that is hydraulically connected to the bay is also affected by these tides, and the magnitude of the tidal influence measured in the well is determined by the water transmitting and storage properties of the shallow aquifer. These water level changes can be measured and analyzed to determine the water transmitting and storage properties of the aquifer.

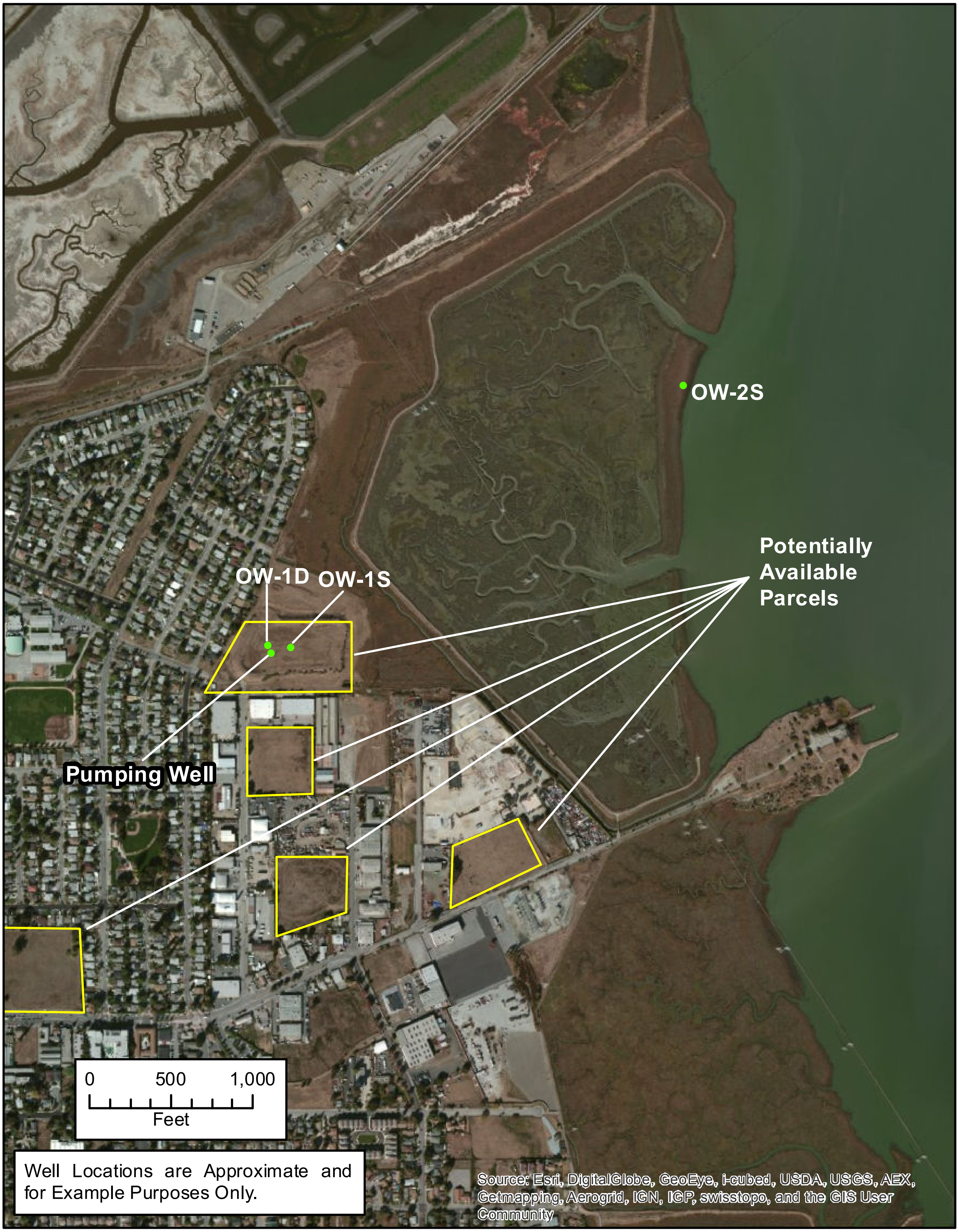
HYDROFOCUS INC. Solutions for Land and Water Resources

Wells Used in Pump Test Simulation, Central Focus Area.

Figure B-10

PROJECT: 5052

DATE: 6/20/2014



HYDROFOCUS INC. Solutions for Land and Water Resources	Wells Used in Pump Test Simulation, South Focus Area.	Figure B-11
PROJECT: 5052	DATE: 6/20/2014	

Continuous water level data collected the vertical test well over a three-month period should be analyzed to determine the water storage and transmitting properties of the aquifer. The well can then be used to conduct a short-term pumping test (24 hours or less) to verify these results and determine actual well yield. The pumping test results would then be used to design a longer-term test (1 to 1.5 months) necessary to confirm yields and quantify the hydraulic condition between the aquifer and bay. Additional monitoring wells would be needed to prepare for this long-term test.

B.7.2.4 Install Shallow and Deep Monitoring Wells and Conduct Aquifer Test

Monitoring wells should be installed on-site to measure drawdown in both the shallow (100 feet or less) and deep aquifers (200 feet deep). Uncertainty in aquifer conditions, specifically the degree of shallow aquifer confinement and the hydraulic conductivity of the bay mud, produce a fairly large range in the possible groundwater level response to extractions from the shallow aquifer. This range in responses influences the volumes of water extracted and the required pump test duration. The SGM was used to estimate potential pumping rates, pumping duration, and monitoring well locations that are required for conceptual pumping tests located in the SFA and CFA. The estimated pumping rate is 0.2 million gallons per day (about 140 gpm), and the simulated drawdowns range from about 30 feet in the pumping well to 2.5 feet in the shallow observation well; the pumping duration required to evaluate the bay-aquifer hydraulic connection could range from about one week to more than one month. For planning purposes, we assumed the pumping test would be conducted for 45 days or less.

B.7.2.5 Characterize Groundwater Quality and Mixing of Between Groundwater and Baywater

After well installation and development, samples of the pumped well water should be collected and analyzed to characterize the quality of water produced by the well and identify potential bay water indicators (for example, chloride, boron, and stable isotopes of oxygen and deuterium). During the extended pumping test, samples of the extracted water shall also be periodically collected and analyzed to determine relative changes over time in the proportional mixture of shallow groundwater and baywater produced by the well. Observed changes in water quality and the water level data can be used to quantify the hydraulic conductivity of the bay mud.

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Appendix C

Developing Costs for Drought-Dependent Desalination Supplies

Appendix C

Developing Costs for Drought-Dependent Desalination Supplies

The unit cost of water produced from a water supply project that is used primarily during drought is dependent on the assumptions of how the project is operated during normal years and drought years, and how often drought occurs. To better understand how unit costs of water supply projects change based on expected hydrology, a Monte Carlo analysis was developed to look at a large number of possible hydrological sequences, including both normal years and drought years, in a 30-year planning period. The analysis was then used to estimate the effective cost of a project over the same 30-year planning period, assuming that capital costs were distributed over the planning period and that O&M costs were dependent on the level of project operation.

The hydrology, or the determination of which years during the 30-year planning period were identified as drought years, was based on the historic record of shortages as predicted by SFPUC's HH/LSM modeling (see Section 3 for more information). The HH/LSM model results include a sequence of years identified as either normal or drought (10 percent or 20 percent system-wide shortfall) for the period 1925 to 2011. The Monte Carlo analysis utilized 1,000 simulations to capture a range of drought probability, where a start year was randomly selected for each of the 1,000 simulations and data from the HH/LSM results were used to populate the selected start year and the remaining 29 years, in sequence, in the planning period. During the 30-year planning period, based on the HH/LSM modeling results, one can expect between 1 and 6 drought years to occur. The probability of the drought recurrence is summarized in Table C-1.

Table C-1. Probability of Drought Recurrence for the 30-year Planning Period

Number of Drought Years During 30-year Planning Period	Probability of Occurrence (1,000 simulations)
1	47.6%
2	14.0%
3	2.3%
4	2.5%
5	16.1%
6	17.5%
Total	**100.0%**

The Monte Carlo analysis was used to develop effective costs for two potential desalination projects: a brackish desalination project that ranged in yield from 0.7 mgd to 6.5 mgd, and a 15 mgd-open intake desalination project. Tables C-2 through C-4 summarize the effective unit costs for these projects. A weighted average of the costs, equal to the sum of each of the possible unit costs multiplied by the probability of occurrence, was calculated for each project and is included in each table.

The 0.7 mgd brackish desalination project was assumed to operate at 50 percent production during normal years to ensure the plant remained operational, and 100 percent production during drought years. The annual O&M costs were assumed to be $2.5 million at full production and linearly related to production. Capital costs for this project were assumed to be $44 million. Section 4.2.3 contains more detailed project information.

The resulting possible unit costs under these assumptions are shown in Table C-4. The unit costs range from $6,553/AF to $7,390/AF. The weighted average effective cost is $7,086/AF.

Table C-2. Probability of Drought Recurrence for the 30-year Planning Period and Costs for the 0.7 mgd Brackish Desalination Project

Probability of Occurrence (1,000 simulations)	Unit Cost Assuming the Drought Recurrence (per AF)
47.6%	$7,390
14.0%	$7,210
2.3%	$7,030
2.5%	$6,850
16.1%	$6,700
17.5%	$6,550
Weighted Average Effective Cost	**$7,090**

The 6.5 mgd brackish desalination project was assumed to operate at 50 percent production during normal years to ensure the plant remained operational, and 100 percent production during drought years. The annual O&M costs were assumed to be $9.4 million at full production and linearly related to production. Capital costs for this project were assumed to be $164 million. Section 4.2.3 contains more detailed project information.

The resulting possible unit costs under these assumptions are shown in Table C-3. The unit costs range from $2,740/AF to $3,070/AF. Out of the 1,000 potential outcomes, the unit cost of the project is expected to be approximately $3,000/AF around half the time. The weighted average effective cost is $2,950/AF.

Table C-3. Probability of Drought Recurrence for the 30-year Planning Period and Costs for the 6.5 mgd Brackish Desalination Project

Probability of Occurrence (1,000 simulations)	Unit Cost Assuming the Drought Recurrence (per AF)
47.6%	$3,070
14.0%	$3,000
2.3%	$2,930
2.5%	$2,850
16.1%	$2,800
17.5%	$2,740
Weighted Average Effective Cost	**$2,950**

The 15-mgd open-intake desalination project was assumed to operate at 20 percent production during normal years to ensure the plant remained operational, and 100 percent production during drought years. The annual O&M costs were assumed to be $11 million at full production and linearly related to production. Capital costs for this project were assumed to be $362 million. Section 4.2.3 contains more detailed project information.

The resulting possible unit costs under these assumptions are shown in Table C-4. The unit costs range from $3,890/AF to $5,620/AF. Out of the 1,000 potential outcomes, the unit cost of the project is expected to be greater than $5,000/AF more than half the time. The weighted average effective cost is $4,950/AF.

Table C-4. Probability of Drought Recurrence for the 30-year Planning Period and Costs for the 15 mgd Open Intake Desalination Project

Probability of Occurrence (1,000 simulations)	Unit Cost Assuming the Drought Recurrence (per AF)
47.6%	$5,620
14.0%	$5,130
2.3%	$4,750
2.5%	$4,380
16.1%	$4,070
17.5%	$3,890
Weighted Average Effective Cost	**$4,950**

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Appendix D

Overview of Project Evaluation Criteria

Appendix D

Overview of Project Evaluation Criteria

The objectives, evaluation criteria, and metrics used as part of the Strategy water supply management project evaluation process are summarized below. Section 5 includes the scoring and evaluation of Strategy projects.

D.1 Objective 1 – Increase Supply Reliability

Criteria 1A and 1B evaluate the reliability of potential projects during a normal year and drought year, respectively. The criteria and the associated metrics that further define this objective are shown below.

- *Criterion 1A – Ability to Meet Normal Year Supply Need* – An estimate of the ability of a project to meet the normal hydrologic year supply needs of the BAWSCA member agencies will be measured by the annual yield of the project during normal hydrologic conditions by the 2040 planning horizon. This will be a quantitative value, measured in AFY.

- *Criterion 1B – Ability to Meet Drought Year Supply Need* – An estimate of the ability of a project to meet the supply needs of the BAWSCA member agencies during a drought is measured by the annual yield of the project during drought (e.g., hydrology similar to the 1987-1992 drought). The criterion of drought reliability captures whether a project is resistant to drought impacts. This will be a quantitative value, measured in AFY.

- *Criterion 1C – Risk of Facility Outage* – The supply vulnerability is measured by the probability and duration of potential outages to a particular project due to a major conveyance failure. This criterion captures the vulnerability of projects to emergency outages. This metric will be a qualitative measure ranging from 1 through 5, with a score of "5" identifying the projects that are least susceptible to emergency outages and a score of "1" indicating high susceptibility to emergency outages.

- *Criterion 1D – Potential for Regulatory Vulnerability* – This criterion estimates the susceptibility of a project to interruption as a result of regulatory issues including legal, political, or environmental constraints. This metric will be a qualitative measure ranging from 1 through 5, with a score of "1" identifying the projects with a high susceptibility to regulatory risk and a score of "5" indicating low susceptibility to regulatory risk.

D.2 Objective 2 – Provide a High Level of Water Quality

These criteria address the ability of member agencies to meet the water quality needs of their customers, both for potable and non-potable water. Thus, the criteria further refine whether a given project meets potable water quality objectives or other water quality objectives.

- *Criterion 2A – Meets or Surpasses Drinking Water Quality Standards* – The criterion representing potable supply will be addressed by the quantitative metric of the aggregate water quality, measured by TDS levels. TDS is a surrogate for other water quality parameters representing water quality.

D.3 Objective 3 – Minimize the Cost of New Water Supplies

This criterion will evaluate the present worth costs for each project.

- *Criterion 3A – Capital and Life-Cycle Costs* – The present worth costs, including capital, operations, and maintenance costs, for each project will be estimated. The performance metric is the normalized cost presented in $/AF for each project.

- *Criterion 3B – Effective Cost* – The long-term cost, a sum of annual use cost based on expected frequency of use over a 30-year period, will be estimated for each project. The performance metric is the normalized cost presented in $/AF for each project.

D.4 Objective 4 – Reduce Potable Water Demand

This criterion will evaluate the impact that each project will have on reducing the demand for potable water supplies. This criterion addresses the augmentation of non-potable supplies.

- *Criterion 4 – Augment Non-Potable Water Supplies* – The use of non-potable water sources will help reduce the overall potable water supply need. Projects that include non-potable water supplies, commensurate with a demand for the additional non-potable water, will score well within this criterion. The quantitative metric for this criterion will be the annual yield of additional non-potable supply produced and utilized to offset potable demand. This will be a quantitative value, measured in AF/year.

D.5 Objective 5 – Minimize Environmental Impacts of New Water Supplies

With these criteria, projects that provide environmental benefits, or have no or limited negative environmental impacts, will score better than those that provide no benefits or result in greater environmental impacts. Environmental benefits and impacts are evaluated within the BAWSCA service area. Potential environmental impacts are measured with three criteria, designed to be proxies for a wide range of environmental issues.

- *Criterion 5A – Greenhouse Gas Emissions* – Adequate data was not available to quantitatively estimate potential greenhouse gas emissions; therefore, this criterion was scored on a qualitative basis using a relative comparison of projects.

- *Criterion 5B – Impact to Groundwater Quantity and Quality* – Projects that do not negatively affect groundwater supplies will be measured favorably in this criterion. A combined qualitative estimate of potential groundwater impacts will be evaluated in terms of potential reductions in groundwater levels, impacts to groundwater quality, and the risk of increase in land subsidence. This metric will be a qualitative measure ranging from 1 through 5, with a score of "1" identifying the projects with the highest potential for adversely affecting groundwater quantity and quality and a score of "5" indicating low probability of adverse impacts.

- *Criterion 5C – Impact to Habitat* – This criterion addresses long-term impacts to the ecosystems, not short-term effects related to temporary construction activities. Projects that do not adversely affect sensitive habitat areas such as wetlands, riparian zones, and potential special-status species habitat, or have significant inundation areas will be measured favorably in this criterion. A combined qualitative estimate of potential habitat impacts will be evaluated in terms of potential site acreage, proximity to sensitive habitat zones, and flood potential. This metric will be a qualitative measure ranging from 1 through 5, with a score of "1" identifying the projects with the highest potential for adverse impacts to habitat and a score of "5" indicating low probability of adverse effects to terrestrial, aquatic, and riparian species.

D.6 Objective 6 – Increase Implementation Potential of New Water Supplies

Developing water supply solutions that can be implemented within the 2040 planning horizon is a primary objective of the Strategy. These criteria assess the implementation potential of projects. All of these criteria will be assessed qualitatively. Metrics for these criteria will be a qualitative assessment ranging from 1 through 5, with a score of "1" being the least favorable and a score of "5" indicating the most favorable.

- *Criterion 6A – Institutional Complexity* – This criterion addresses the level of institutional coordination required for implementation of a project. A qualitative metric will be used to estimate the coordination required if multiple local or regional agencies or agreements are necessary. The projects that are assumed to require less coordination, and to receive less opposition, will score better than those that are more complex or potentially controversial.

- *Criterion 6B – Level of Local Control of Water Supply* – Local management of a project will minimize dependency on imported water supplies and the drought impacts associated with those supplies. A rating scale will be developed to evaluate the amount of BAWSCA-owned or BAWSCA member-owned supply for each project. Projects that are fully owned by BAWSCA or the member agencies will score higher than projects owned fully or partially by other entities that might be affected by regulatory risk, multiple party agreements, and supplies that may have a higher risk of not being available further into the future, or under drought conditions.

- *Criterion 6C – Permitting Requirements* – This criterion addresses the objective of minimizing the regulatory and environmental permitting obstacles associated with projects. Projects with other similar metrics (including cost) may have differing permitting requirements, which can affect their overall implementation. The performance metric is a qualitative measure of the permitting requirements of each project. Projects that have less regulatory and environmental permitting obstacles will receive a better score than those projects with more complex permitting requirements.

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Appendix E

Strategy Project Scoring

Criteria	Metrics (For Project/For Portfolio)	Scale	Recycled Water Projects			Groundwater Project	Desalination Projects			Local Capture and Reuse Projects	
			Daly City – Recycled Water Expansion Project, Colma Expansion	Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP	Palo Alto – Recycled Water Project to Serve Stanford Research Park	Sunnyvale – Expanding the Use of New or Converted Wells to Normal Year Supply	Open Bay Intake [1]	Brackish Vertical Wells [2]	Water Transfer	Rainwater harvesting	Graywater Reuse
Criterion 1A – Ability to Meet Normal Year Supply Need [3]	Quantitative (AFY): Average annual yield in normal years in 2035	5 - Highest yield 4 ↑ 3 2 ↓ 1 - Lowest yield	1.3	1.1	1.2	1.6	5.0	2.0	1.0	1.1	1.5
Criterion 1B – Ability to Meet Drought Supply Need [3, 4]	Quantitative (AFY): Average annual yield with drought hydrology of 1987 – 1992	5 - Highest yield 4 ↑ 3 2 ↓ 1 - Lowest yield	1.1	1.0	1.1	1.3	4.2	1.7	5.0	1.0	1.3
Criterion 1C – Risk of Facility Outage	Qualitative (1-5): Estimated probability and duration of major conveyance failure	5 - Low Risk (e.g., Utilizes only SFRWS [or a single] conveyance infrastructure exclusively) 4 3 - Average risk (e.g., Utilizes SF RWS and local conveyance infrastructure) 2 1 - High risk (e.g., Utilizes inter-agency conveyance infrastructure [beyond Bay Area, multi-systems, the Delta])	5	5	5	5	3	4	1	5	5
Criterion 1D – Potential for Regulatory Vulnerability	Qualitative (1-5): Potential for regulatory decisions to impact supply reliability	5 - No Regulatory Vulnerability 4 3 - Medium Regulatory Vulnerability (e.g., Subject to Title 22 and or NPDES permit) 2 1 - High Regulatory Vulnerability (e.g., Subject to supply or use vulnerability due to Endangered Species Act [ESA], habitat impacts or other regulatory hurdles, etc.)	3	3	3	3	1	2	3	5	3
Criterion 2A – Meets or Surpasses Drinking Water Quality Standards	Quantitative (mg/L): TDS level as an indicator of water quality.	5 - TDS <50 mg/L (Hetch Hetchy system) 4 - TDS < 250 mg/L (Local Surface Water) 3 - TDS < 500 mg/L (secondary maximum contaminant level [MCL] for drinking water) 2 - TDS < 700 mg/L 1 - TDS >700 mg/L (some recycled water)	3	2	2	3	3	3	4	4	1
Criterion 3A – Capital and Life-Cycle Costs [3, 5]	Quantitative ($/AF): Life-cycle costs including capital and operating costs	5 - Highest cost 4 ↑ 3 2 ↓ 1 - Lowest cost	1.8	3.5	2.5	5.0	3.5	2.2	4.9	1.0	3.0
Criterion 3B – Effective Cost [3, 6]	Qualitative ($/AF): Median effective cost - long-term cost, sum of annual use cost based on expected frequency of use over 30-year period.	5 - Highest cost 4 ↑ 3 2 ↓ 1 - Lowest cost	2.8	4.0	3.3	5.0	1.0	3.2	5.0	2.3	3.6

Criteria	Metrics (For Project/For Portfolio)	Scale	Recycled Water Projects			Groundwater Project	Desalination Projects			Local Capture and Reuse Projects	
			Daly City – Recycled Water Expansion Project, Colma Expansion	Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP	Palo Alto – Recycled Water Project to Serve Stanford Research Park	Sunnyvale – Expanding the Use of New or Converted Wells to Normal Year Supply	Open Bay Intake [1]	Brackish Vertical Wells [2]	Water Transfer	Rainwater harvesting	Graywater Reuse
Criterion 4 – Augment Non-Potable Water Supplies	Qualitative (AFY): Reduction of potable water demand by use of non-potable supply.	5 - >5,000 AFY 4 ↑ 3 2 ↓ 1 - <1,000 AFY	1	1	1	1	1	1	1	1	2
Criterion 5A – Greenhouse Gas Emissions	Qualitative (1-5): Relative comparison of potential greenhouse gas emissions across projects.	5 - Lowest 4 ↑ 3 2 ↓ 1 - Highest	3	3	3	3	1	1	3	5	5
Criterion 5B – Effect on Groundwater Quantity and Quality	Qualitative (1-5): Potential impacts to groundwater levels, groundwater quality, or potential for subsidence	5 - No effect (e.g., Recycled water projects, some transfers) 4 3 - Some effect (e.g., Brackish groundwater projects) 2 1 - Potential unavoidable effects (e.g., New groundwater projects)	5	5	5	2	5	3	5	5	5
Criterion 5C – Impact to Habitat	Qualitative (1-5): Potential impacts to habitat, such as wetlands, riparian zones, fisheries, and inundation areas.	5 - No effects (e.g., No new construction or access of water from potentially vulnerable sources) 4 3 - Some effects (e.g., New construction in built environment and no access of water from potentially vulnerable sources) 2 1 - Potential unavoidable effects (e.g., New construction in undisturbed habitat and/or access of water from potentially vulnerable sources)	3	3	3	3	1	2	3	5	5
Criterion 6A – Institutional Complexity	Qualitative (1-5): Number and type of agencies and agreements involved	5 - Low complexity (e.g., environmental documents exist, or single agency) 4 3 - Some complexity (e.g., 3 agencies involved in institutional agreements) 2 1 - High complexity (e.g., Multiple environmental docs would need to be pursued, or multiple agencies involved in institutional agreements)	4	4	4	4	4	4	1	5	4
Criterion 6B – Level of Local Control	Qualitative (1-5): BAWSCA and Member Agency ownership of supply projects	5 - BAWSCA and Agency co-owned 4 3 - Agency owned 2 1 - Multiple owners with BAWSCA as partner	3	2	2	3	4	4	1	1	1
Criterion 6C – Permitting Requirements	Qualitative (1-5): Permitting or regulatory issues for supply projects	5 - Standard level of permitting 4 3 - Moderate level of permitting complexity 2 1 - High level of permitting complexity (e.g., open bay intake desal)	3	3	3	3	1	2	3	4	4

Notes:
NA = not available
[1] Assumes 15 mgd open intake desalination project.
[2] Assumes mid-range yield and unit cost for brackish well desalination, unless otherwise noted.
[3] Score was normalized across the range of values.
[4] Yield score based on average of yield range.
[5] Cost score based on average of unit cost range.
[6] Brackish desalination score based on 6.5-mgd capacity.

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Appendix F

Detailed Project Scoring Information

			Recycled Water Projects			Groundwater Project	Desalination Projects			Local Capture and Reuse Projects	
Criteria	Metrics (For Project/For Portfolio)	Scale	Daly City – Recycled Water Expansion Project, Colma Expansion	Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP	Palo Alto – Recycled Water Project to Serve Stanford Research Park	Sunnyvale – Expanding the Use of New or Converted Wells to Normal Year Supply	Open Bay Intake [1]	Brackish Vertical Wells [2]	Water Transfer	Rainwater Harvesting	Graywater Reuse
Criterion 1A – Ability to Meet Normal Year Supply Need	Quantitative (AFY): Average annual yield in normal years in 2035	5 - Highest yield 4 3 2 1 - Lowest yield	1,060	430	900	2,350	16,800	4,030	0	210-680	1,240-3,000
Criterion 1B – Ability to Meet Drought Supply Need [3]	Quantitative (AFY): Average annual yield with drought hydrology of 1987 – 1992	5 - Highest yield 4 3 2 1 - Lowest yield	1,060	430	900	1,880	16,800	4,030	20,900	450	2,120
Criterion 1C – Risk of Facility Outage	Qualitative (1-5): Estimated probability and duration of major conveyance failure	5 - Low Risk (e.g., Utilizes only SF RWS [or a single] conveyance infrastructure exclusively) 4 3 - Average risk (e.g., Utilizes SF RWS and local conveyance infrastructure) 2 1 - High risk (e.g., Utilizes inter-agency conveyance infrastructure [beyond Bay Area, multi-systems, the Delta])	Low risk - infrastructure only within Daly City	Low risk - infrastructure only within Mountain View	Low risk - infrastructure only within Palo Alto	Low risk - infrastructure only within Sunnyvale	Average risk - utilizes SF RWS and new intake which is so far unstudied	Average to low risk - utilizes SF RWS but no crossing of major seismic faults	High risk - crosses Delta, and utilizes many transmission systems, including reversing flow in the City of Hayward	Low risk - no conveyance	Low risk - no conveyance
Criterion 1D – Potential for Regulatory Vulnerability	Qualitative (1-5): Potential for regulatory decisions to impact supply reliability	5 - No Regulatory Vulnerability 4 3 - Medium Regulatory Vulnerability (e.g., Subject to Title 22 and or NPDES permit) 2 1 - High Regulatory Vulnerability (e.g., Subject to supply or use vulnerability due to Endangered Species Act [ESA], habitat impacts or other regulatory hurdles, etc.)	Medium vulnerability - subject to Title 22 but recycled water is commonplace in the Bay Area	Medium vulnerability - subject to Title 22 but recycled water is commonplace in the Bay Area	Medium vulnerability - subject to Title 22 but recycled water is commonplace in the Bay Area	Medium vulnerability - groundwater source, but Department of Public Health involvement due to moving from emergency supply to normal supply	High regulatory vulnerability - NPDES discharge and intake concerns	Medium to high regulatory vulnerability - NPDES discharge	Medium vulnerability - could have effects from pumping subject to ESA issues (other habitat vulnerabilities assessed elsewhere)	No regulatory vulnerability as only city permits are necessary	Medium regulatory vulnerability, due to potential for cross connection
Criterion 2A – Meets or Surpasses Drinking Water Quality Standards	Quantitative (mg/L): TDS level as an indicator of water quality.	5 - TDS <50 mg/L (Hetch Hetchy system) 4 - TDS < 250 mg/L (Local Surface Water) 3 - TDS < 500 mg/L (secondary maximum contaminant level [MCL] for drinking water) 2 - TDS < 700 mg/L 1 - TDS >700 mg/L (some recycled water)	500	600	600	405	Assuming <500 mg/L as the secondary MCL for drinking water	Assuming <500 mg/L as the secondary MCL for drinking water	Freeport water quality, closer to local surface water	Assumed low TDS level due to capture straight from rainfall	Assumed high level due to source
Criterion 3A – Capital and Life-Cycle Costs [4]	Quantitative ($/AF): Life-cycle costs including capital and operating costs	5 - Highest cost 4 3 2 1 - Lowest cost	$3,310	$2,200	$2,830	$1,290	$2,250	$3,050	$1,330	$3,800	$2,540
Criterion 3B – Effective Cost [5]	Qualitative ($/AF): Median effective cost - long-term cost, sum of annual use cost based on expected frequency of use over 30-year period.	5 - Highest cost 4 3 2 1 - Lowest cost	$3,310	$2,200	$2,830	$1,290	$4,950	$2,950	$1,330	$3,800	$2,540

			Recycled Water Projects			Groundwater Project	Desalination Projects			Local Capture and Reuse Projects	
Criteria	Metrics (For Project/For Portfolio)	Scale	Daly City – Recycled Water Expansion Project, Colma Expansion	Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP	Palo Alto – Recycled Water Project to Serve Stanford Research Park	Sunnyvale – Expanding the Use of New or Converted Wells to Normal Year Supply	Open Bay Intake [1]	Brackish Vertical Wells [2]	Water Transfer	Rainwater Harvesting	Graywater Reuse
Criterion 4 – Augment Non-Potable Water Supplies	Qualitative (AFY): Reduction of potable water demand by use of non-potable supply.	5 - >5,000 AFY 4 3 2 1 - <1,000 AFY	1,060	429	900	0 - new supply is potable water	0 - new supply is potable water	0 - new supply is potable water	0 - new supply is potable water	210-680	1,240-3,000
Criterion 5A – Greenhouse Gas Emissions	Qualitative (1-5): Relative comparison of potential greenhouse gas emissions across projects.	5 - Lowest 4 3 2 1 - Highest	Mid-range - compared across potential projects.	Mid-range - compared across potential projects.	Mid-range - compared across potential projects.	Mid-range - compared across potential projects.	Highest - Desal projects use greatest amount of energy.	Highest - Desal projects use greatest amount of energy.	Mid-range - transfers require some pumping for lift into Mokelumne Aqueduct, Upper San Leandro Reservoir, and into Skywest Pump Station; considered lower energy usage than desalination.	Lowest - marginal energy usage.	Lowest - marginal energy usage.
Criterion 5B – Effect on Groundwater Quantity and Quality	Qualitative (1-5): Potential impacts to groundwater levels, groundwater quality, or potential for subsidence	5 - No effect (e.g., Recycled water projects, some transfers) 4 3 - Some effect (e.g., Brackish groundwater projects) 2 1 - Potential unavoidable effects (e.g., New groundwater projects)	No effect - recycled water project	No effect - recycled water project	No effect - recycled water project	Low to mid effect - new groundwater project	No effect to groundwater	Some effect - new brackish groundwater project	No local groundwater impacts	No effect to beneficial effect - recharge to groundwater	Beneficial effect - recharge to groundwater
Criterion 5C – Impact to Habitat	Qualitative (1-5): Potential impacts to habitat, such as wetlands, riparian zones, fisheries, and inundation areas.	5 - No effects (e.g., No new construction or access of water from potentially vulnerable sources) 4 3 - Some effects (e.g., New construction in built environment and no access of water from potentially vulnerable sources) 2 1 - Potential unavoidable effects (e.g., New construction in undisturbed habitat and/or access of water from potentially vulnerable sources)	Some effects - new construction in existing roadways	Some effects - new construction in existing roadways	Some effects - new construction in existing roadways	Some effects - new construction in built environment	Potential impacts to risks to marine life; BCDC has not approved open intake in Bay Area yet	Moderate level of potential effects	Some effect - water transfers have potential for habitat impacts for some endangered species, but there is no new construction	No construction	No construction
Criterion 6A – Institutional Complexity	Qualitative (1-5): Number and type of agencies and agreements involved	5 - Low complexity (e.g., environmental documents exist, or single agency) 4 3 - Some complexity (e.g., 3 agencies involved in institutional agreements) 2 1 - High complexity (e.g., Multiple environmental docs would need to be pursued, or multiple agencies involved in institutional agreements)	Moderate complexity - potential parties include Daly City, Colma, San Bruno, cemeteries, California Golf Club, schools, BAWSCA	Moderate complexity - potential parties include Mountain View, Palo Alto RWQCP, NASA, BAWSCA	Some complexity - potential parties include Palo Alto, Stanford Research Park, BAWSCA	Moderate complexity - potential parties include Sunnyvale, Potential for partnerships with Santa Clara, Mountain View, Palo Alto, Cal Water, SCVWD, BAWSCA	Some complexity - potential parties include BAWSCA and project lead	Some complexity - potential parties include BAWSCA and WWTP discharger	High complexity - potential parties include BAWSCA, EBMUD or SCVWD, SFPUC, DWR or Bureau of Reclamation, seller agency	Low complexity - residential users only	Moderate complexity - residential users plus water agency participation, and uncertainty in change of home ownership
Criterion 6B – Level of Local Control	Qualitative (1-5): BAWSCA and Member Agency ownership of supply projects	5 - BAWSCA and Agency co-owned 4 3 - Agency owned 2 1 - Multiple owners with BAWSCA as partner	Daly City owned	Palo Alto RWQCP owns plant, Mountain View owns distribution	Palo Alto RWQCP owns plant, Palo Alto Utilities owns distribution	Sunnyvale owned	BAWSCA, potentially Cal Water as partner	BAWSCA, potentially Cal Water as partner	BAWSCA is not owner of any facilities	Residential user owned	Residential user owned

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			Recycled Water Projects			Groundwater Project	Desalination Projects			Local Capture and Reuse Projects	
Criteria	Metrics (For Project/For Portfolio)	Scale	Daly City – Recycled Water Expansion Project, Colma Expansion	Mountain View – Increase Recycled Water Supply from Palo Alto RWQCP	Palo Alto – Recycled Water Project to Serve Stanford Research Park	Sunnyvale – Expanding the Use of New or Converted Wells to Normal Year Supply	Open Bay Intake [1]	Brackish Vertical Wells [2]	Water Transfer	Rainwater Harvesting	Graywater Reuse
Criterion 6C – Permitting Requirements	Qualitative (1-5): Permitting or regulatory issues for supply projects	5 - Standard level of permitting 4 3 - Moderate level of permitting complexity 2 1 - High level of permitting complexity (e.g., open bay intake desal)	Moderate level of permitting	Moderate level of permitting	Moderate level of permitting	Moderate level of permitting (change from emergency to normal year supply)	High level of permitting complexity - BCDC has not approved an open intake in Bay Area yet	Moderate to high level of permitting complexity	Moderate level of permitting complexity	Low to moderate level of permitting - city or water district, and county	Low to moderate level of permitting - city or water district, and county

Notes:
NA = not available
[1] Assumes 15 mgd open intake desalination project.
[2] Assumes mid-range yield and unit cost for brackish well desalination, unless otherwise noted.
[3] Average of yield range.
[4] Average of unit cost range.
[5] Brackish desalination cost based on 6.5-mgd capacity.

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Appendix G

Project and Portfolio Performance Evaluation

Appendix G

Project and Portfolio Performance Evaluation

G.1 Project Evaluation

Project evaluation criteria were developed to evaluate the Strategy water supply management projects described in Section 4.2. Project evaluation objectives, criteria, and metrics were developed and revised with input from the BAWSCA member agencies and the BAWSCA Board starting in Phase I and were presented in the *Phase II A Report*. The objectives and criteria are used to differentiate the characteristics of the Strategy projects and portfolios. The objectives define what a project or portfolio is attempting to achieve, in broad terms. Individual criterion help define the objectives in more specific terms and address the major issues that may affect the feasibility of potential projects. For each criterion, an evaluation measure, or metric, is specified. The metric is used to indicate to what degree a specific objective of a criterion is being achieved. The evaluation metrics for the criteria may be quantitative or qualitative in nature. For qualitative performance measures, the rating score for each water supply management project or portfolio is relative to the scores of other projects and portfolios.

Appendix D describes the objectives, criteria, and metrics used for project and portfolio evaluation. A scale from 1 to 5 (where 5 is the best score) was developed for each criterion, based on the range of both quantitative and qualitative metrics, and was used to evaluate each project. The scales for each criterion are shown in Appendix E, Strategy Project Scoring. Appendix E also presents the evaluation criteria scores for the Strategy projects described in Section 4.2[1]. Appendix F, Detailed Project Scoring Information, presents the quantitative or qualitative information that is the basis for each score.

Each project was scored for each criterion. As discussed below, a weighting factor was selected for each criterion. The total score for a project is the sum of each criterion's score multiplied by its respective weighting factor, as denoted by the following formula:

$$Project\ Score = \sum_{i=1}^{14} Criteria\ Score\ i\ \times Weighting\ Factor\ i$$

For all of the analyses done with the evaluation criteria, the scores were normalized for comparison, where the highest possible project score was scaled to 100 points. This technique allows comparison of scores across different weightings in the sensitivity analysis by transposing each case onto the same scale.

Using the unweighted suite of metrics to score the projects did not provide the type of detailed information needed to differentiate between the performances of the projects with respect to the objectives of the Strategy. When all the criteria are weighted equally, the project scores are clustered in a 15-point range (total scores from 50 to 65) on the 100-point scale. In addition, some of the

[1] Due to lack of available data on key criteria for cost and potential yield, the Redwood City Regional Recycled Water Supply project and stormwater capture were not included in the project or portfolio evaluation process. The available information for these two projects is in included in Appendices E and F.

projects that would provide a very small quantity of water supply on an annual basis scored better than other projects overall because the small projects scored very well on some of the other criteria, distorting total unweighted scores. To provide more information on the performance of each project in relation to different objectives, a sensitivity analysis was performed on project scoring.

Seven sets of sensitivity weighting factors were developed to be applied to the evaluation criteria to assess the projects based on different priorities. Each sensitivity analysis weighted a single criterion or group of criteria, and the emphasis of each sensitivity is as follows:

1. Drought supply;
2. Cost;
3. Drought supply and cost;
4. Environmental issues and drought supply;
5. Local control, drought supply, costs, permitting, and institutional complexity;
6. Environmental issues, drought supply, costs, and local control; and
7. Drought supply, costs, regulatory vulnerability, local control, and institutional complexity.

Table G-1 presents the various weighting factors used in the sensitivity analysis. As can be seen in Table G-1, each sensitivity analysis consisted of a division of a total of 100 percentage points among the criteria, with the largest percentages allocated to the emphasized criteria.

Table G-1. Sensitivity Weightings Applied to Evaluation Criteria

	Sensitivity Analysis Emphasis							
Criteria	None (Equal Weights)	#1 Drought Supply	#2 Cost	#3 Drought Supply & Cost	#4 Environmental Issues & Drought Supply	#5 Local Control, Drought Supply, Costs, Permitting, & Institutional Complexity	#6 Environmental Issues, Drought Supply, Cost, & Local Control	#7 Drought Supply, Cost, Regulatory Vulnerability, & Institutional Control
Criterion 1A – Ability to Meet Normal Year Supply Need	7%	6%	4%	4%	2%	3%	2%	3%
Criterion 1B – Ability to Meet Drought Year Supply Need	7%	25%	4%	20%	11%	17%	12%	25%
Criterion 1C – Risk of Facility Outage	7%	6%	4%	4%	2%	3%	2%	3%
Criterion 1D – Potential for Regulatory Vulnerability	7%	6%	4%	4%	2%	3%	2%	10%
Criterion 2 – Meets or Surpasses Drinking Water Quality Standards	7%	6%	4%	4%	4%	3%	2%	3%

Table G-1. Sensitivity Weightings Applied to Evaluation Criteria

	Sensitivity Analysis Emphasis							
Criteria	None (Equal Weights)	#1 Drought Supply	#2 Cost	#3 Drought Supply & Cost	#4 Environmental Issues & Drought Supply	#5 Local Control, Drought Supply, Costs, Permitting, & Institutional Complexity	#6 Environmental Issues, Drought Supply, Cost, & Local Control	#7 Drought Supply, Cost, Regulatory Vulnerability, & Institutional Control
Criterion 3A – Capital and Present Worth Costs	7%	6%	25%	20%	4%	7%	12%	10%
Criterion 3B – Effective Cost	7%	6%	25%	20%	4%	7%	12%	20%
Criterion 4 – Augment Non-Potable Water Supplies	7%	6%	4%	4%	2%	3%	2%	3%
Criterion 5A – Greenhouse Gas Emissions	7%	6%	4%	4%	20%	3%	12%	3%
Criterion 5B – Impact to Groundwater Quantity and Quality	7%	6%	4%	4%	20%	3%	12%	3%
Criterion 5C – Impact to Habitat	7%	6%	4%	4%	20%	3%	12%	3%
Criterion 6A – Institutional Complexity	7%	6%	4%	4%	2%	7%	2%	6%
Criterion 6B – Level of Local Control	7%	6%	4%	4%	2%	30%	12%	6%
Criterion 6C – Permitting Requirements	7%	6%	4%	4%	2%	7%	2%	3%
Total	100%	100%	100%	100%	100%	100%	100%	100%

The scores for each project under each sensitivity are shown in Table G-2.

Table G-2. Project Scoring and Sensitivity Analysis (highest scoring project in bold)

	Sensitivity Scenario Emphasis							
Criteria	None (Equal Weights)	#1 Drought Supply	#2 Cost	#3 Drought Supply & Cost	#4 Environmental Issues & Drought Supply	#5 Local Control, Drought Supply, Costs, Permitting, & Institutional Complexity	#6 Environmental Issues, Drought Supply, Cost, & Local Control	#7 Drought Supply, Cost, Regulatory Vulnerability, & Institutional Control
Daly City Recycled Water	57	50	52	48	62	53	56	48
Mountain View Recycled Water	58	51	65	58	63	50	61	54
Palo Alto Recycled Water	56	49	57	51	62	48	57	50
Sunnyvale Groundwater	61	54	**77**	68	56	59	63	63
Open Bay Intake Desalination	54	60	50	56	52	**64**	56	55
Brackish Vertical Wells Desalination	50	48	52	49	44	57	49	49
Water Transfers	58	**67**	75	**78**	72	55	**72**	**76**
Rainwater Harvesting	**65**	56	51	47	**79**	46	60	50
Graywater Reuse	64	56	65	58	**79**	48	67	55

The sensitivity analyses highlight differences between the projects and the results show which projects score highly across the various priorities. When the sensitivity scenarios are introduced, the range of project scores can increase compared to the scoring range found when all the criteria are equally weighted (e.g., project scores varied by 15 points when the evaluation criteria were equally weighted, but under the environmental issues and drought supply analysis, the project scores had a 35-point range).

Water transfers score very well on dry year yield and cost scores due to the potential significant amounts of water that can be obtained and the minimal capital investments required. As a result, water transfers is the top scoring project in sensitivity analyses #1, #3, #6, and #7. The sensitivity analysis results show clearly that water transfers is the top project, or within the top four projects, in all the sensitivity analyses evaluated. Graywater reuse also performs as one of the top three projects under all but one of the sensitivity analysis scenarios. It is an attractive option based on ease of implementation and low environmental impact.

The suite of recycled water projects scored mainly in the mid to low range of project scores across the sensitivity analyses. These projects have lower yields compared to the larger projects of open bay intake desalination and water transfers, and, therefore, these projects would not perform as well in sensitivity analysis that emphasizes drought supply. Brackish well desalination also scored at the lower end of projects across most scenarios due to poorer performance on the drought year supply (brackish desalination dry year yield used for scoring was the average of the 0.7-mgd and 6.5-mgd capacity options) and environmentally-focused criteria.

Figures G-1 through G-8 present a comparison of the project scores for each sensitivity analysis scenario listed in Table G-2, respectively. In each chart, the bar representing each project aggregates the individual criterion scores for that project to provide a comparison of the relative contribution of each criterion score across the Strategy projects.

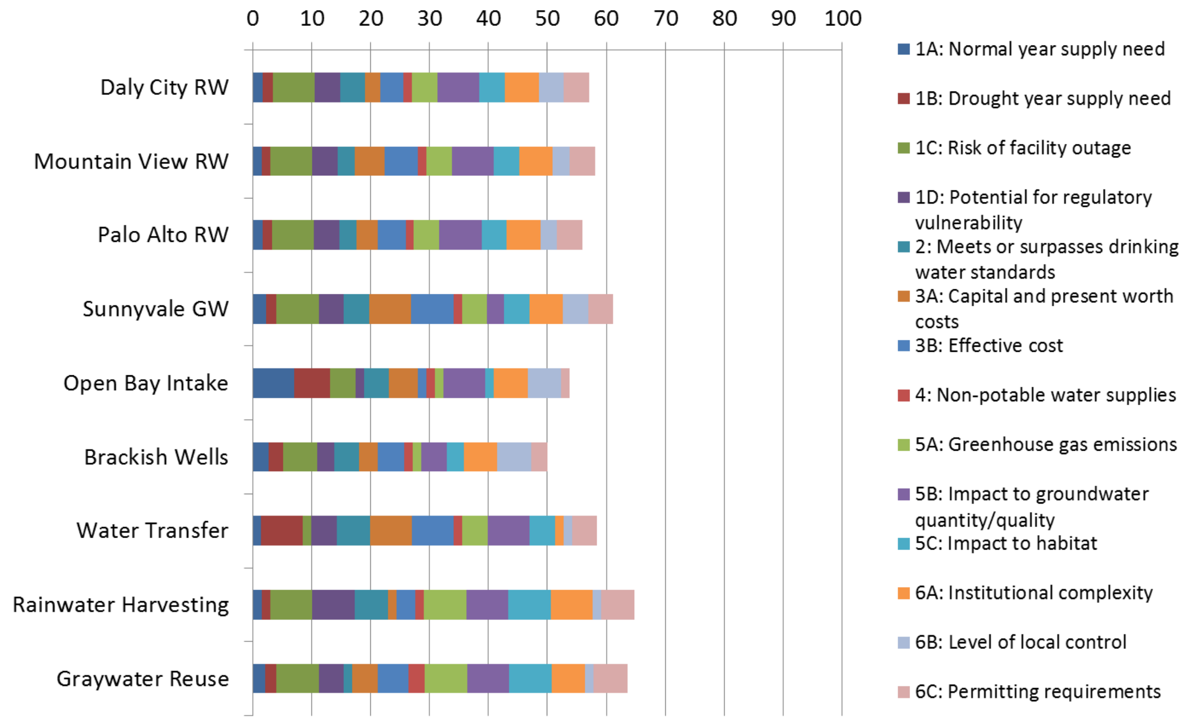

Figure G-1
Project Scoring Using Equal Weight Sensitivity Analysis

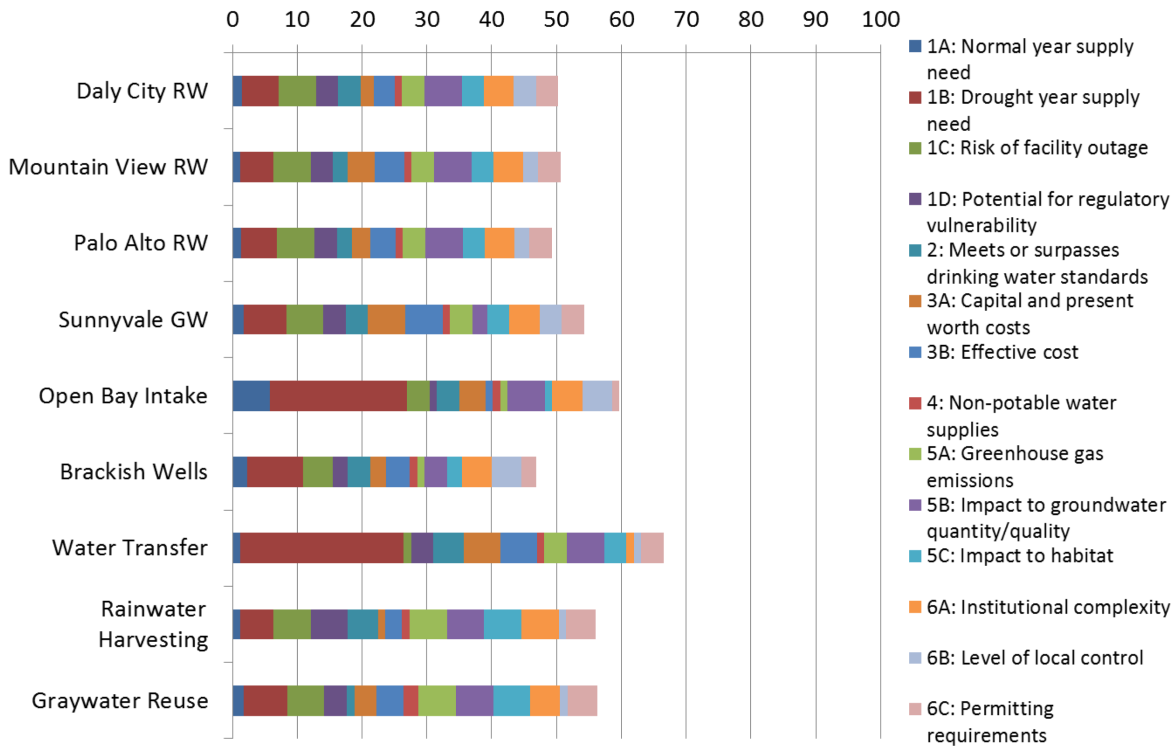

Figure G-2
Project Scoring Using Drought Supply Sensitivity Analysis

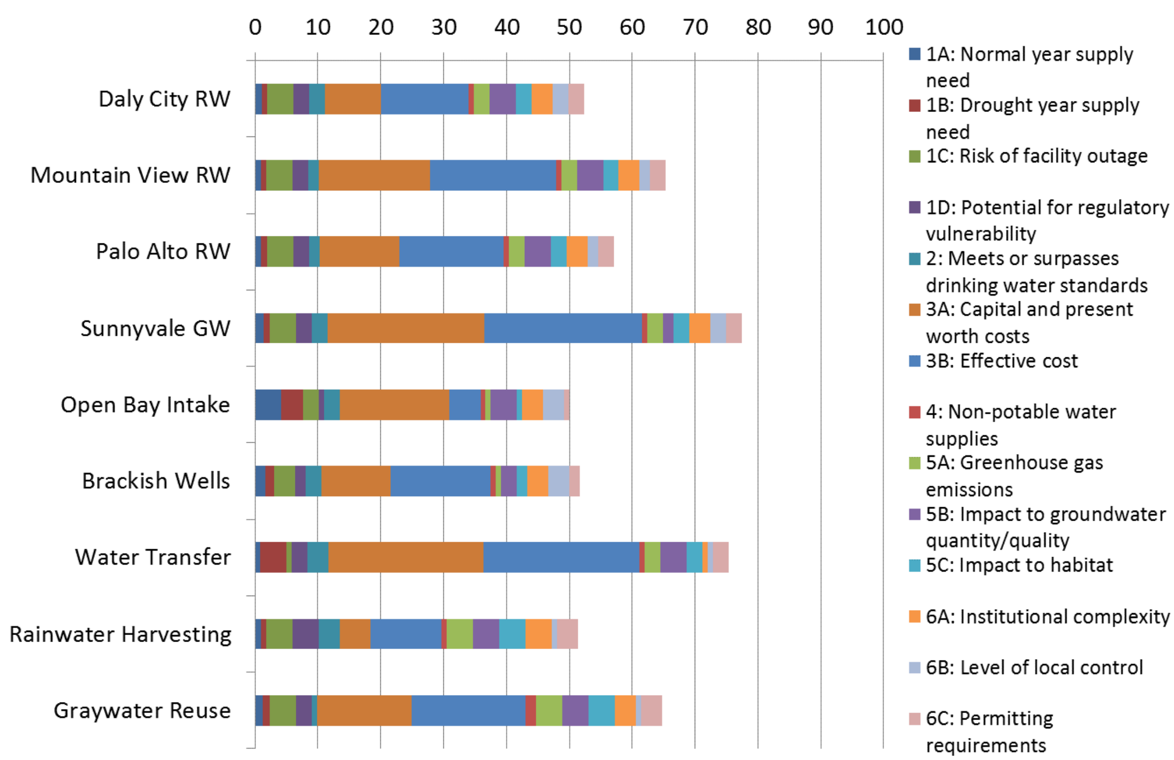

Figure G-3
Project Scoring Using Cost Sensitivity Analysis

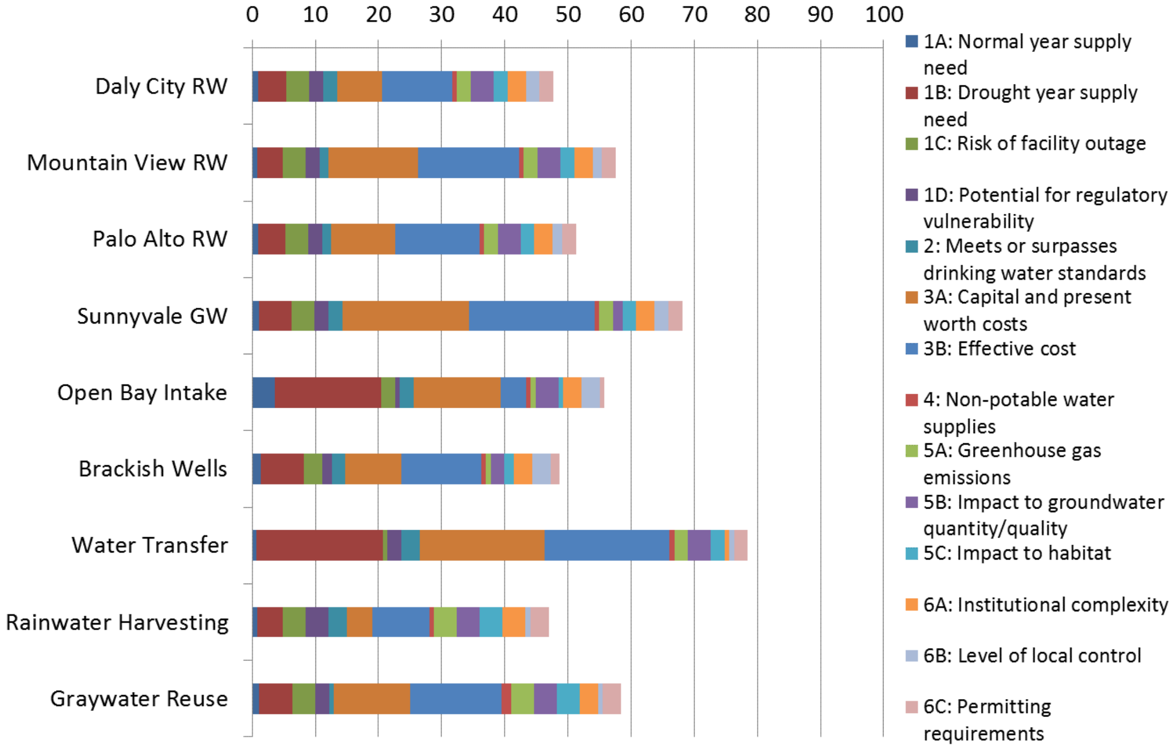

Figure G-4
Project Scoring Using Drought Supply & Cost Sensitivity Analysis

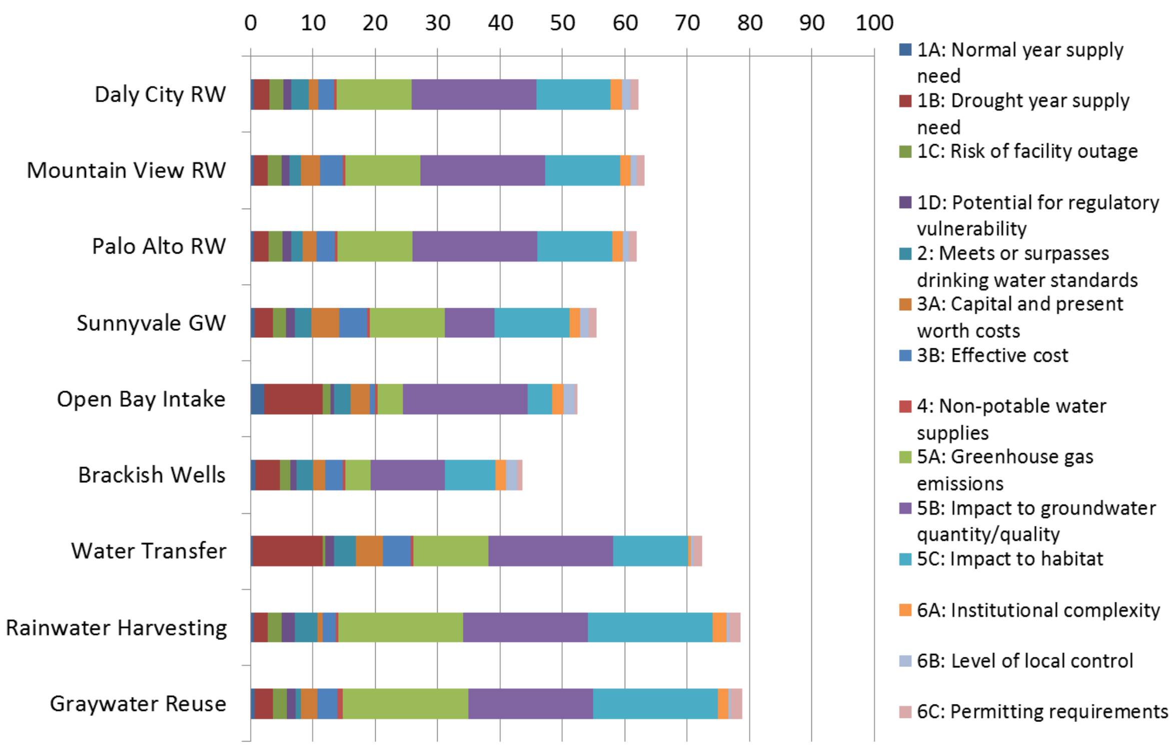

Figure G-5
Project Scoring Using Environmental Issues & Drought Supply Sensitivity Analysis

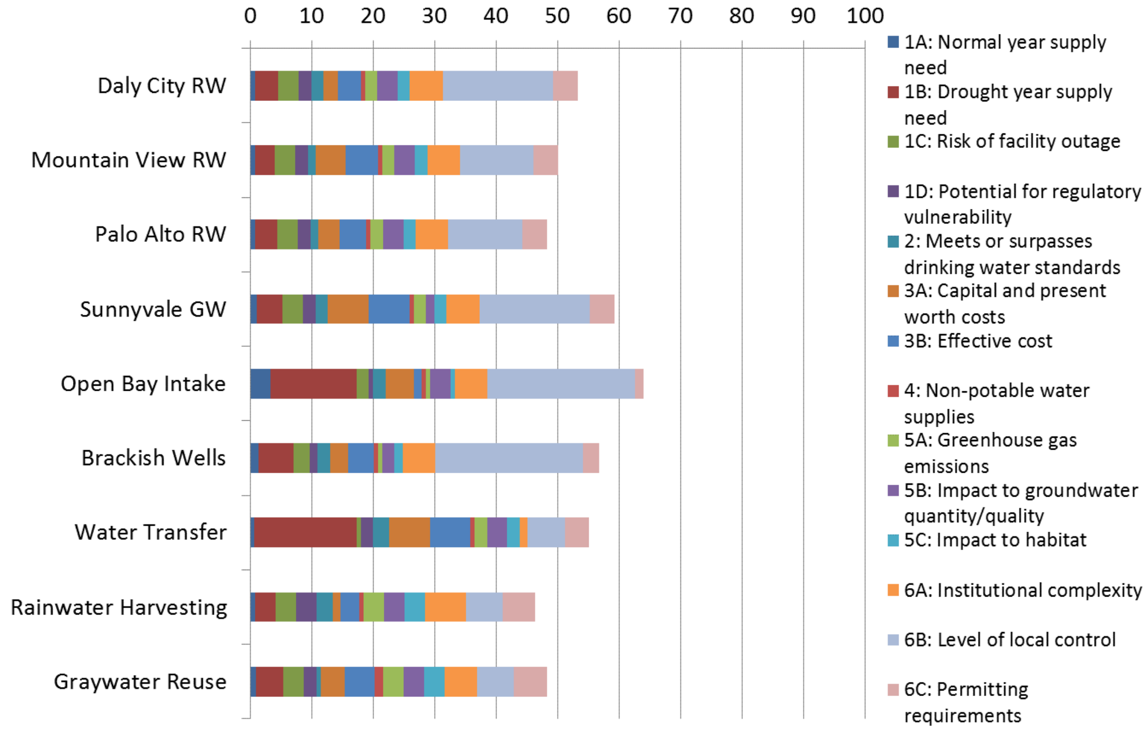

Figure G-6
Project Scoring Using Local Control, Drought Supply, Costs, Permitting, & Institutional Complexity Sensitivity Analysis

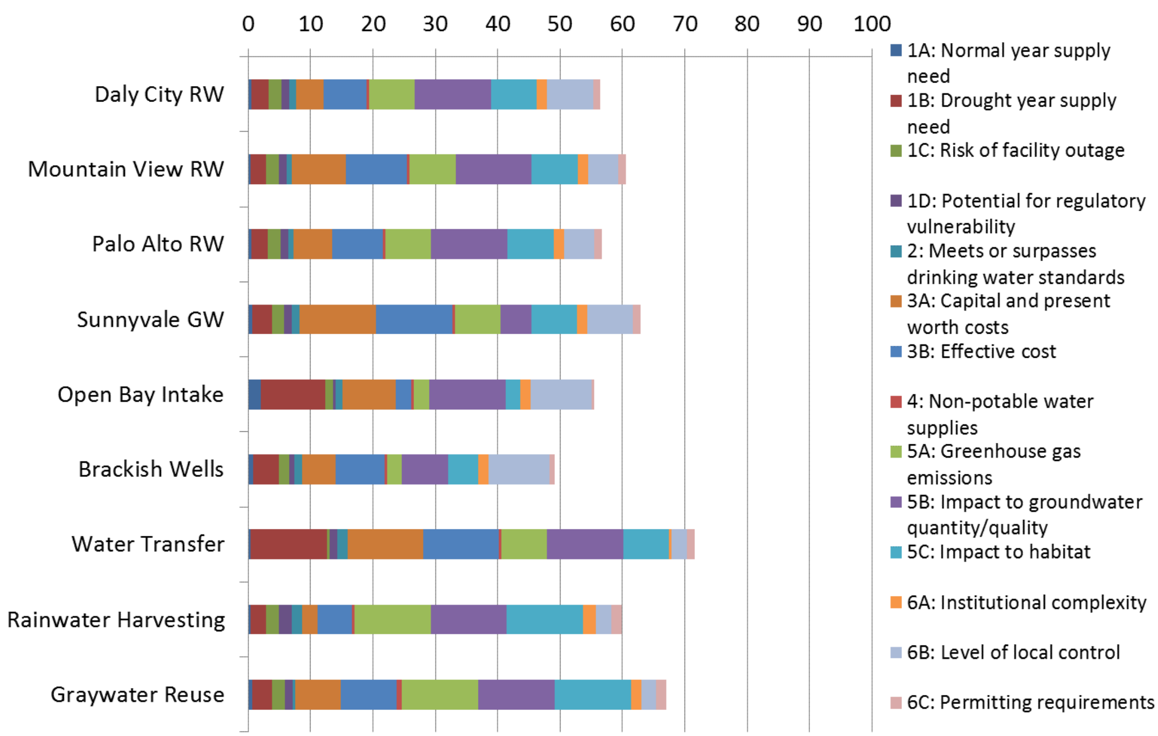

Figure G-7
Project Scoring Using Environmental Issues, Drought Supply, Cost, & Local Control Sensitivity Analysis

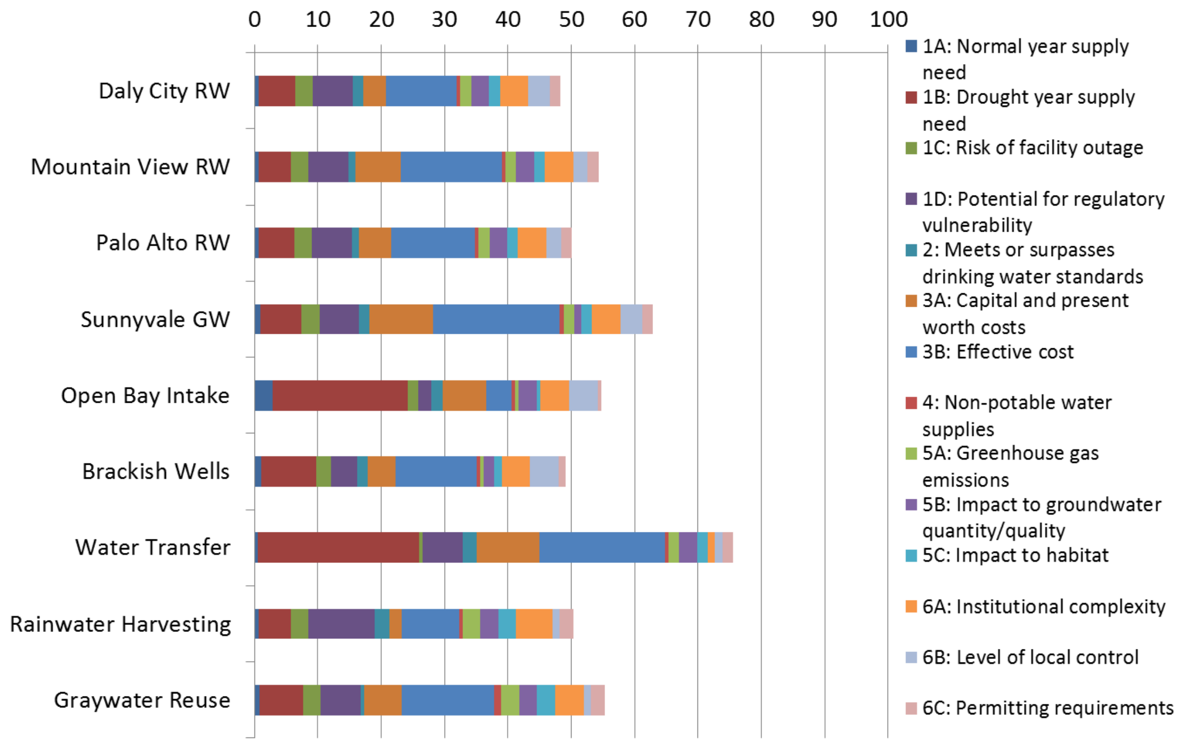

Figure G-8
Project Scoring Using Drought Supply, Cost, Regulatory Vulnerability, & Institutional Control Sensitivity Analysis

G.2 Portfolio Evaluation

A number of portfolios were developed to explore combinations of projects based on different objectives or themes that are important to stakeholders in the Strategy: least cost; maximum yield; fastest implementation; local control; least stranded costs; and least environmental impact. The projects that comprise each portfolio were determined based on which projects best met the needs of each portfolio theme, and performance of projects through the scoring and sensitivity analysis described above. For example, the two projects with the lowest average unit costs and capital costs are included in the Least Cost Portfolio, and the Least Environmental Impact Portfolio includes all projects except the desalination options. Table G-3 presents the portfolios, describes the objectives of each portfolio, and itemizes the projects included in each.

Table G-3. Strategy Portfolios

Portfolio	Objective	Projects
Least Cost	Minimizes both unit costs and total capital costs	Sunnyvale groundwater Water transfers
Maximum Yield	Most yield for fewest projects	Open intake desalination Water transfers
Fastest Implementation	Brought online rapidly	Sunnyvale groundwater Water transfers
Local Control	Maximizes agency control	Daly City recycled water Mountain View recycled water Palo Alto recycled water Sunnyvale groundwater Open intake desalination Brackish desalination
Least Stranded Costs	Eliminates projects whose normal year costs are greater than SFPUC costs	Water transfers
Least Environmental Impact	Lowest potential for environmental effects	Daly City recycled water Mountain View recycled water Palo Alto recycled water Sunnyvale groundwater Water transfers Rainwater harvesting Stormwater capture Graywater reuse

The portfolios were scored using the sum of the scores for the projects that make up the portfolio, and then averaging for the number of projects per portfolio (to not arbitrarily give a higher score to a portfolio with many projects compared to a portfolio with only a few projects). The scores were normalized for comparison, where the highest possible project score was scaled to 100 points. Each portfolio was evaluated based on (1) the equal criteria weighting and (2) the seven sensitivity analysis weightings presented in Table G-1.

Table G-4 presents each portfolio's score for each sensitivity analysis.

Table G-4. Portfolio Scoring and Sensitivity Analysis (highest scoring portfolio in bold)

	Sensitivity Analysis Emphasis							
Criteria	None (Equal Weights)	#1 Drought Supply	#2 Cost	#3 Drought Supply & Cost	#4 Environmental Issues & Drought Supply	#5 Local Control, Drought Supply, Costs, Permitting, & Institutional Complexity	#6 Environmental Issues, Drought Supply, Cost, & Local Control	#7 Drought Supply, Cost, Regulatory Vulnerability, & Institutional Control
Least Cost	60	60	**76**	73	64	57	67	69
Maximum Yield	56	63	63	67	62	**60**	64	65
Fastest Implementation	60	60	**76**	73	64	57	67	69
Local Control	56	52	59	55	57	55	57	53
Least Stranded Costs	58	**67**	75	**78**	**72**	55	**72**	**76**
Least Environmental Impact	**60**	55	63	58	68	52	62	57

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Several observations can be made on the portfolios:

- Each portfolio provides an average dry year yield of over 20,000 AFY, which is almost half of the 2040 dry year need of 48,000 AFY (assuming a 100 percent LOS). Or, put another way, each of the portfolios would reduce rationing significantly. While no formal decision was made by BAWSCA regarding a preferred LOS, it is recognized that achieving 100 percent LOS was not required.

- There is significant uncertainty in the yields for the largest portfolio component: water transfers. While water transfers can be very attractive from a cost perspective, there is a possibility that they may not be available when needed due to timing constraints or lack of available water in an extremely dry year.

- While open intake desalination would be the most reliable supply, it would require multiple approvals and financial commitments prior to construction.

- The Least Cost and Fastest Implementation portfolios contain the same projects.

- The greatest certainty for dry year yield would be the Local Control portfolio which contains desalination. It represents the highest cost and previous desalination projects have encountered delays in their implementation.

When all the criteria are weighted equally, the portfolio scores only spanned 4 points over the 100-point scale. As with the individual project scores, the range of portfolio scores increased under the sensitivity analyses. The portfolio scoring under the Drought Supply & Cost sensitivity analysis has the greatest range, of a range of 23 points, from 55 (Local Control portfolio) to 78 (Least Stranded Costs). The highest scoring portfolio overall using equal weights was Least Environmental Impact. The Least Stranded Costs portfolio received the highest score of any portfolio (78) and was the highest performing portfolio for 5 of the 8 criteria weightings. This portfolio consists only of water transfers, which provide a very high dry year yield for no capital costs and a low cost per acre-foot. Water transfers, the second highest rated individual project, are a component of all top scoring portfolios. The Local Control and Least Environmental Impact portfolios have the highest number of projects, but are the lowest scoring portfolios on average and do not score as well on yield and cost criteria.

Figures G-9 through G-16 present a comparison of the portfolio scores for each sensitivity analysis listed in Table G-4, respectively. In each chart, the bar representing each portfolio aggregates the individual criterion scores for the portfolio's projects to provide a comparison of the relative contribution of each criterion score across the portfolios.

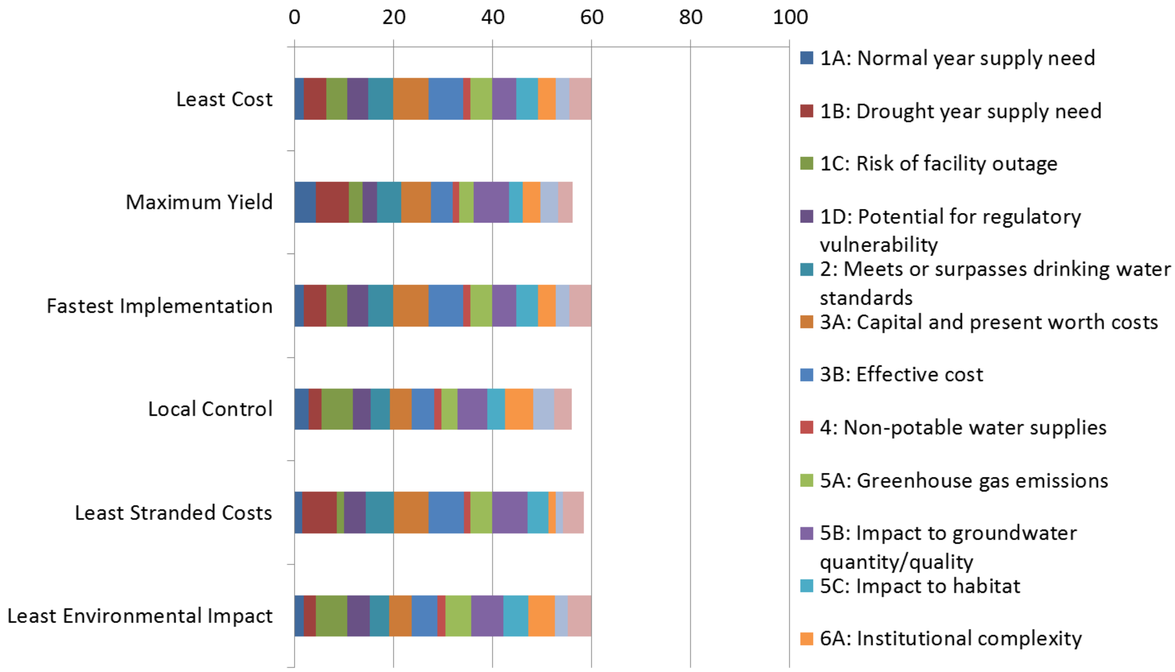

Figure G-9
Portfolio Scoring Using Equal Weight Sensitivity Analysis

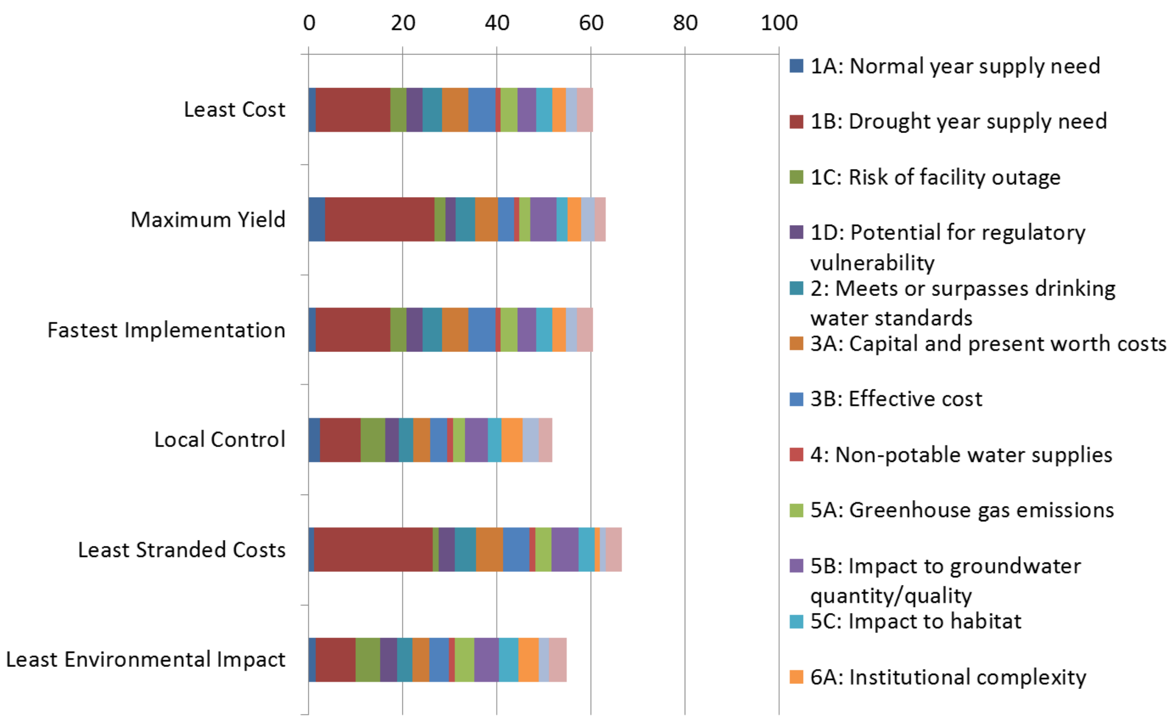

Figure G-10
Portfolio Scoring Using Drought Supply Sensitivity Analysis

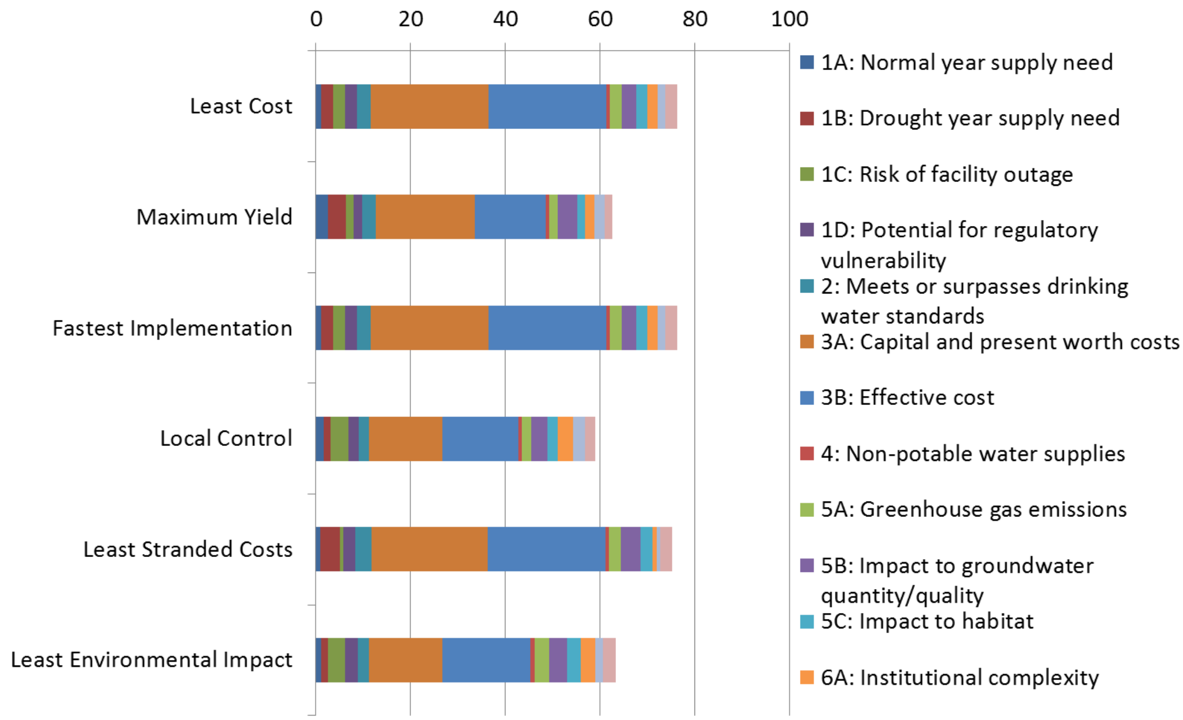

Figure G-11
Portfolio Scoring Using Cost Sensitivity Analysis

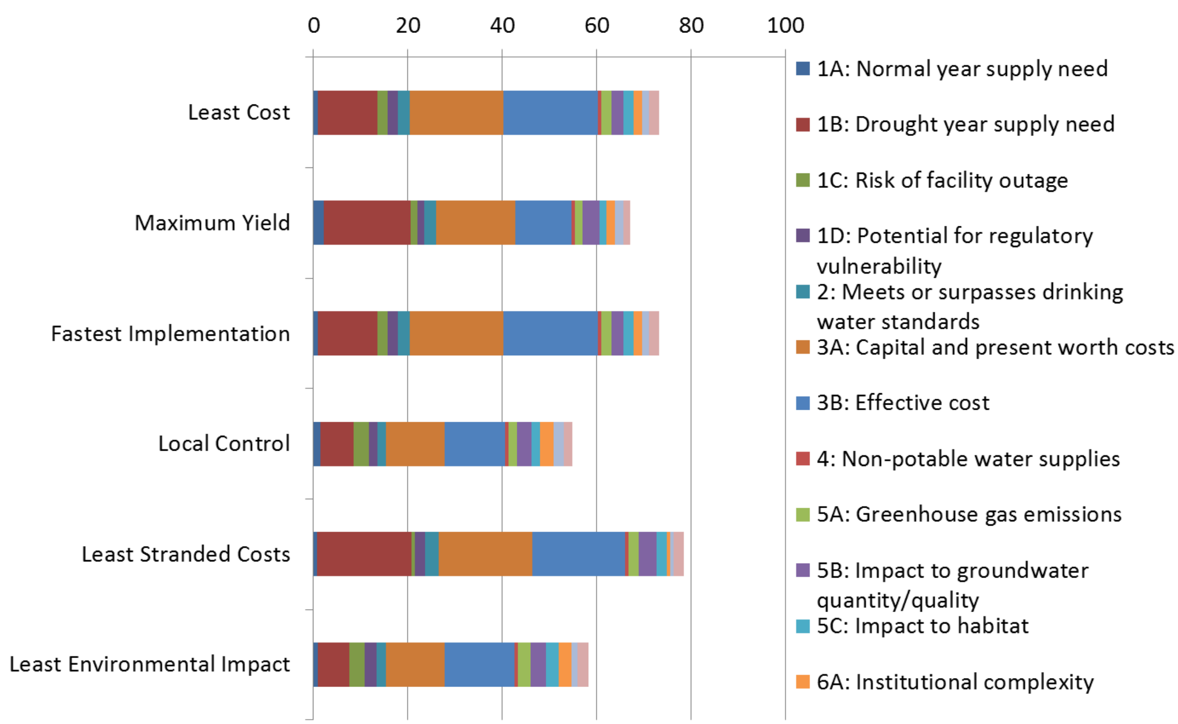

Figure G-12
Portfolio Scoring Using Drought Supply & Cost Sensitivity Analysis

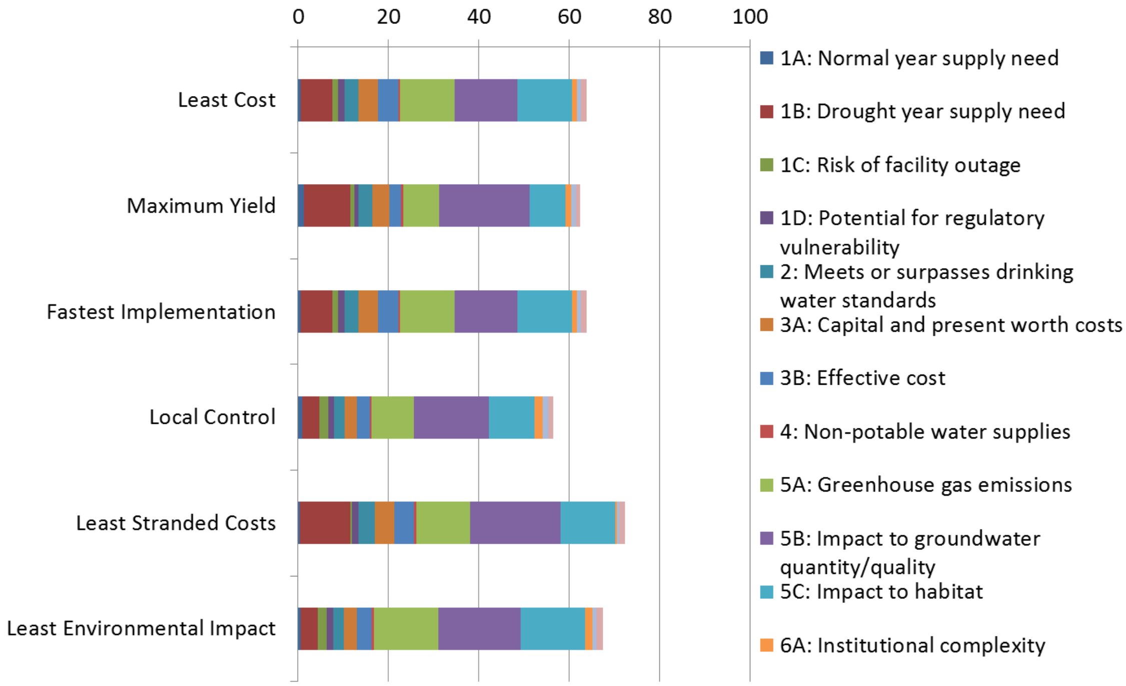

Figure G-13
Portfolio Scoring Using Environmental Issues & Drought Supply Sensitivity Analysis

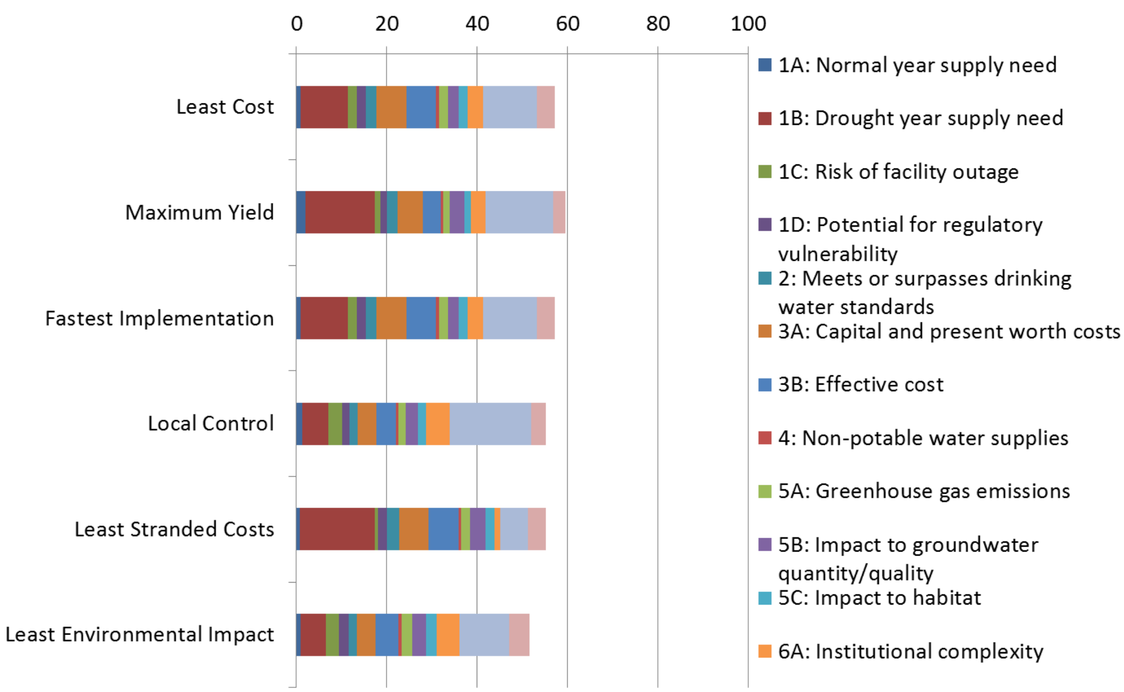

Figure G-14
Portfolio Scoring Using Local Control, Drought Supply, Costs, Permitting, & Institutional Complexity Sensitivity Analysis

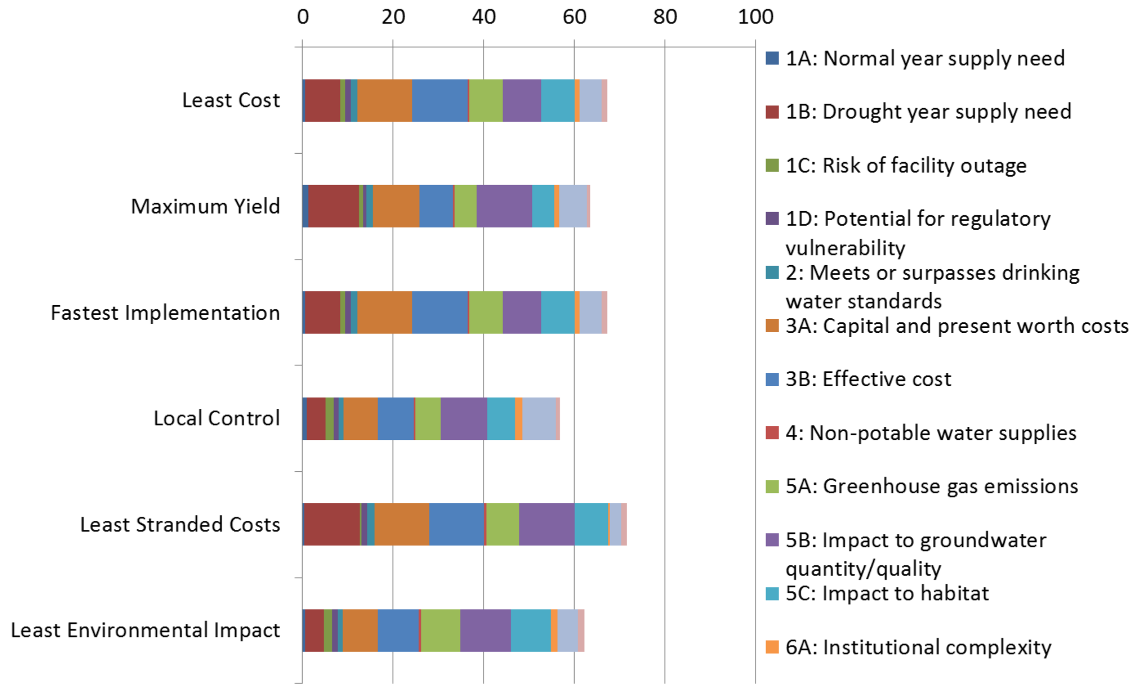

Figure G-15
Portfolio Scoring Using Environmental Issues, Drought Supply, Cost, & Local Control Sensitivity Analysis

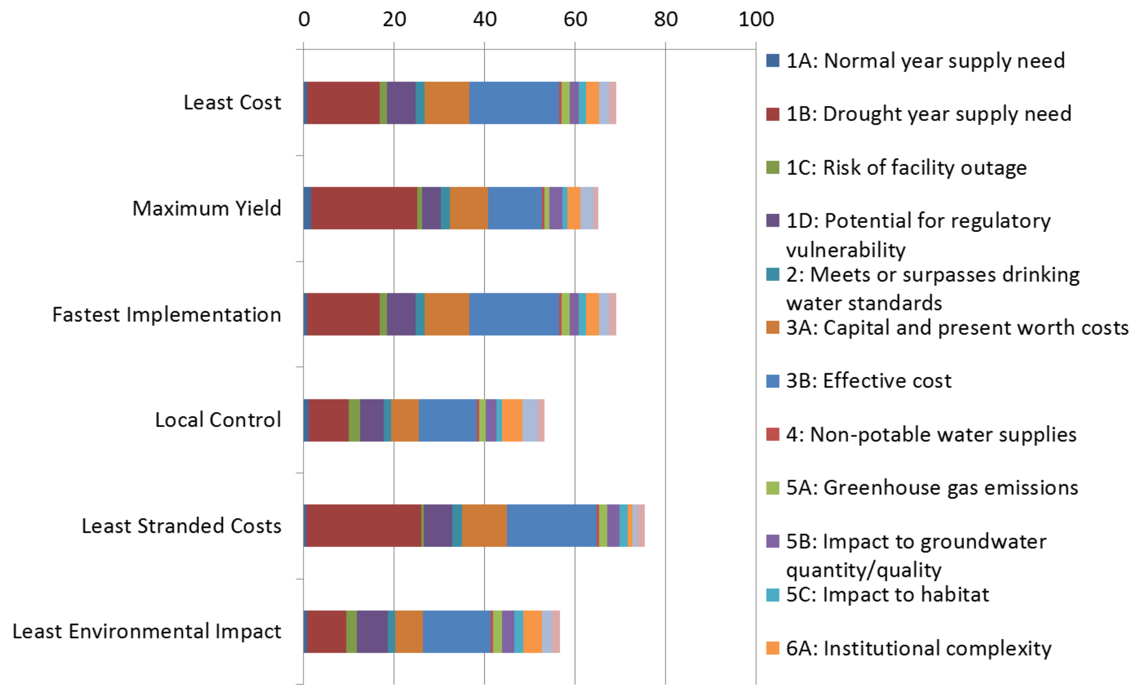

Figure G-16
Portfolio Scoring Using Drought Supply, Cost, Regulatory Vulnerability, & Institutional Control Sensitivity Analysis

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