EAST BAY MUNICIPAL UTILITY DISTRICT

CONTRA COSTA WATER DISTRICT

Santa Clara Valley Water District

SAN FRANCISCO Public Utilities Commission

BAY AREA REGIONAL DESALINATION PROJECT PRE-FEASIBILITY STUDY FINAL REPORT

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Acronyms and Abbreviations

ACWD	Alameda County Water District
AFB	Aquatic Filter Barrier
BAAQMD	Bay Area Air Quality Management District
BCDC	Bay Conservation Development Commission
BDPL	Bay Division Pipelines
Cal/EPA	California Environmental Protection Agency
Caltrans	California Department of Transportation
CCWD	Contra Costa Water District
CDFG	California Department of Fish and Game
CDPs	Coastal Development Permits
CEC	California Energy Commission
CEQA	California Environmental Quality Act
dB	decibels
Delta	Sacramento–San Joaquin River Delta
DHS	California Department of Health Services
DPR	California Department of Parks and Recreation
DWR	California Department of Water Resources
EA	Environmental Assessment
EBMUD	East Bay Municipal Utility District
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
gpd	gallons per day

gpd/ft^2	gallons per day per square foot
HTWTP	Harry Tracy Water Treatment Plant
JARPA	Joint Aquatic Resource Permit Application
JPA	joint powers authority
KCl	potassium chloride
KwHr	kilowatt hour
LCP	Local Coastal Program
MCLs	Maximum Contaminant Levels
Met	Metropolitan Water District of Southern California
MF	microfiltration
MG	million gallons
mg/L	milligrams per liter
MGD	million gallons per day
MSF	multistage flash distillation
MW	megawatts
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Services
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
PARWQC	Palo Alto Regional Water Quality Control Plant Site
PCBs	polychlorinated biphenyls
psi	pounds per square inch
psu	practical salinity unit
RDP	Bay Area Regional Desalination Project
Reclamation Board	California State Reclamation Board
RMP	San Francisco Estuary Regional Monitoring Program
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board
SCVWD	Santa Clara Valley Water District
SFPUC	San Francisco Public Utilities Commission
SFRWQCB	San Francisco Regional Water Quality Control Board

SLC	State Lands Commission
SMCL	Secondary Maximum Contaminant Levels
SWRCB	State Water Resources Control Board
TBSDP	Tampa Bay Seawater Desalination Project
TDS	Total dissolved solids
TMDL	Total Maximum Daily Load
UF	ultrafiltration
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USEPA	U.S. Environment Protection Agency
USFWS	U.S. Fish and Wildlife Service
WDRs	Waste Discharge Requirements
WPCP	Water Pollution Control Plant
WQOs	Water Quality Objectives
WWTP	Waste Water Treatment Plant

INTRODUCTION

Four of the Bay Area's regional water supply agencies, East Bay Municipal Utility District (EBMUD), San Francisco Public Utilities Commission (SFPUC), Santa Clara Valley Water District (SCVWD), and Contra Costa Water District (CCWD) (hereafter referred to collectively as the "agencies"), are jointly exploring desalination as a means of meeting the water needs of their constituencies The proposed Regional Desalination Project (RDP) may consist of one or more desalination facilities, likely built in increments of 20 million gallons per day (MGD) or less, with an ultimate total capacity of up to 120 MGD. The objective of the RDP would be to improve water supply reliability for the approximately 5.04 million residents and businesses served by the four agencies.

EBMUD, SFPUC, SCVWD, and CCWD have somewhat different needs or proposed uses for the RDP. These uses could include the following:

- Providing additional sources of water during emergencies such as earthquakes
- Providing a supplemental supply source during extended drought periods
- Allowing other major facilities such as treatment plants, transmission mains, and pump stations to be taken out of service for an extended period of time for maintenance or repairs
- Providing a full-time supplemental water supply to increase the diversity of the agencies' water supply portfolio, which would increase reliability

SITING

Site selection for a desalination plant is one of the most important decisions in the development process as it may have a substantial impact on cost, schedule, and potential environmental effects. Site selection for a desalination facility must take into account a multitude of non-technical factors in addition to engineering and economic factors. A systematic approach to making siting decisions, properly documented and presented, helps avoid some of the potential impediments to the development of a successful project.

The 13 sites reviewed for the RDP are shown below.

Potential Sites for the Bay Area Desalination Project

Identified Sites	Within Service Area of Agency
C&H Sugar, Crockett	EBMUD
Mirant Contra Costa Plant, Antioch	CCWD
Mirant Pittsburg Plant, Pittsburg	CCWD
Palo Alto	SCVWD
Pico Power Plant Site, Santa Clara	SCVWD
Los Esteros Power Plant Site, San Jose	SCVWD
Treasure Island Site, San Francisco	SFPUC
Oceanside, San Francisco	SFPUC

Potential Sites for the Bay Area Desalination Project (continued)

BDLP 1&2 at Dumbarton Point, San Francisco	SFPUC
San Francisco Airport	SFPUC
Mallard Slough, CCWD	CCWD
Barge-Mounted Plant	All
Near Bay Bridge	EBMUD

Evaluation criteria were developed to rank the 13 sites for suitability for a regional desalination project. The criteria were developed based upon needs identified by the agencies and a review of information from the California Desalination Task Force. The criteria are listed as follows:

- Feedwater quality
- Cost of product water (based on input, operation, and distribution costs)
- Permitting/water rights requirements
- Public acceptance/socioeconomic effects (including environmental justice, growth inducement, and land use impacts)
- Potential to receive grant funding
- Capability to supply product water to multiple agencies during droughts
- Environmental effects

For each site, each of the criteria were rated on a scale of -1 to 5, 5 being ideal or best conceivable. A score of 0 indicated that the site ranked as "conditionally acceptable" or neutral on the given criterion; a score of -1 indicated that the site was absolutely unacceptable for that criterion. The results of the ranking procedure are shown in the table below.

Ranking Results for the Bay Area Desalination Project Sites

Identified Sites	Total Score
Mirant Contra Costa Plant, Antioch	21
Mirant Pittsburg Plant, Pittsburg	21
Oceanside, San Francisco	20
Near Bay Bridge	20
Palo Alto	19
Pico Power Plant Site, Santa Clara	19
Los Esteros Power Plant Site, San Jose	19
Treasure Island Site, San Francisco	19

Ranking Results for the Bay Area Desalination Project Sites (continued)

Mallard Slough, CCWD	19
San Francisco Airport	18
Barge-Mounted Plant	18
BDLP 1&2 at Dumbarton Point, San Francisco	17
C&H Sugar, Crockett	16

The two Mirant Power Plant sites ranked No. 1, the Oceanside site ranked No. 2, and the Near Bay Bridge site ranked No. 3. Since there was a tie for No. 1, it was agreed that the Mirant Pittsburg Plant site would be selected as No. 1 and the other Mirant Power Plant site would be eliminated. Coincidentally, the three sites seemed to represent a mix of Bay/Delta water (Mirant Pittsburg), Bay seawater (Near Bay Bridge), and ocean seawater (Oceanside).

While the ranking described above indicated a first, second, and third place, the pros and cons of each site may be viewed differently by the agencies. As such, the sites are not ranked in any preferential order. The benefits and challenges of each of the top-ranking sites are summarized below.

Mirant Pittsburg Plant Site

The Mirant Pittsburg Plant site has the following advantages for collocating a desalination plant:

- Existing intake and outfall structures
- High-quality source water
- Economical energy source
- Proximity to CCWD and EBMUD transmission facilities

Given these advantages, construction and operation of a desalination plant at this location would be the most cost effective. It could also directly serve two of the water agencies.

Since the Mirant Pittsburg Plant is located on the Delta, permitting the desalination plant may present greater challenges than at the Near Bay Bridge or Oceanside sites. Water rights for consumptive use of the source water would be required. Obtaining these waters rights in the Delta could be a lengthy and difficult process. In addition, discharge standards into the Delta are more stringent than for the Bay or ocean. Therefore, obtaining a National Pollutant Discharge Elimination System permit for discharging the concentrate through the existing power plant outfall into the Delta could be difficult. There could be additional water take restrictions during drought conditions.

Near Bay Bridge

The Near Bay Bridge site offers the following advantages:

- Existing outfall structure
- Proximity to EBMUD transmission facilities

Constructing and operating a desalination plant at this site would be more costly than at the Mirant Pittsburg Plant site because an intake structure would need to be built, the water quality is not as good, and energy would be more costly. A desalination plant at this site would only be able to connect directly to EBMUD's transmission system. Benefits to other agencies could be achieved through transfers. However, none of the permitting issues associated with the Delta would be as difficult at this site.

Oceanside

The Oceanside site is the only site in this study that is on the ocean rather than the Bay or Delta. An existing outfall structure at the site has ample capacity to accommodate a desalination plant. Because the outfall is in the ocean, concentrate discharged through the outfall would have greater dispersion than concentrate discharged into the Bay. As such, concentrate disposal in the ocean may be easier to permit than concentrate disposal in the Bay or Delta.

The Oceanside site is not very close to SFPUC's transmission lines, therefore construction of a connection to existing transmission lines would be more costly than at the other two sites. In addition, the source water at this location would have the highest salinity of the three sites. Therefore, construction and operation of a desalination plant at this site would be the most costly of the three sites. As with the Near Bay Bridge site, a desalination plant at the Oceanside site would be able to directly connect to only one of the participating agencies' transmission system. Other agencies would realize benefits through transfers.

CONCLUSION

Siting a regional desalination plant in the Bay Area can present several challenges. Based upon the limited review conducted in this study, it appears that siting a desalination plant at the Oceanside site would be the most costly of the three sites, while the Mirant Pittsburg Plant site may be the most cost effective. However, permitting a desalination plant at the Mirant Pittsburg Plant site may be the most difficult, while permitting at the Oceanside site may be the simplest. In any case, pooling the resources of all four partner agencies in this effort would enhance the project's success.

The siting of the desalination plant must consider the planned uses of the product water by each of the agencies, who would directly benefit (i.e., direct connection to transmission system) and who would indirectly benefit (i.e., water transfers). It must also consider the construction and operation costs and the timeframe required for permitting and constructing the facility or facilities.

In order to develop a shared RDP, the partner agencies would need to set up and execute an institutional arrangement among them. While there are various ways in which an arrangement can be formalized, it could require up to an estimated one-third full-time equivalent personnel effort on behalf of each participating agency to establish and carry forward such an arrangement.

Given the size and complexity of the proposed RDP project, a number of studies would have to be undertaken before the project can be implemented. The following studies of a selected site or sites could be conducted in the near term (6 to 12 months):

- Further Refinement of Project Definition
- Geotechnical Investigations
- Hazardous Waste Investigations
- Initial Environmental Screening

The following studies of the selected site could be conducted in the long term (12 to 36 months):

- Preliminary Engineering Design
- Fisheries Studies
- Intake/Outfall Modeling
- Full Environmental Impact Report
- Desalination Pilot Project
- Education Workshops
- Public Outreach Program

In addition to the technical studies, the agencies should also revisit their shared needs and objectives to determine the most appropriate project structure early in the process. Ultimately, the viability of the RDP project will depend on the commitment of each of the agency's stakeholders, including board members, management, and staff.

1.1 INTRODUCTION

Four of the Bay Area's regional water supply agencies, East Bay Municipal Utility District (EBMUD), San Francisco Public Utilities Commission (SFPUC), Santa Clara Valley Water District (SCVWD), and Contra Costa Water District (CCWD) (hereafter referred to collectively as the "agencies"), are jointly exploring developing a regional desalination facility or multiple facilities. Developing Bay Area desalination facilities would improve water supply reliability for the approximately 5.04 million residents and businesses served by the four agencies. To help meet the water supply needs of their customers, EBMUD, SFPUC, SCVWD, and CCWD may jointly develop the Bay Area Regional Desalination Project (RDP). The RDP may consist of one or more desalination facilities, probably built in increments of 20 million gallons per day (MGD) or less, with an ultimate total capacity of up to 120 MGD. The four agencies have somewhat different needs or proposed uses for the RDP. These uses could include the following:

- Providing additional sources of water during emergencies such as an earthquake
- Providing a supplemental supply during extended drought periods
- Allowing other major facilities such as treatment plants, transmission mains, and pump stations to be taken out of service for an extended period of time for maintenance or repairs
- Providing a full-time supplemental water supply to increase the diversity of the agencies' water supply portfolio, which would increase reliability

This section presents a review of recent Bay Area desalination studies, describes each of the agencies' need and proposed use for desalination, and identifies opportunities for the agencies to benefit from a regional desalination plant(s).

1.2 RECENT BAY AREA DESALINATION STUDIES

Several recent investigations have been conducted regarding desalination facilities in the Bay Area. A review of these studies is presented below.

1.2.1 San Francisco Public Utilities Commission

As part of the SFPUC Bay Division Pipelines (BDPL) *Hydraulic Upgrade Optioneering Phase I* (SFPUC 2002), desalination was analyzed as a possible alternative to reinforcement of certain facilities in the system. The following information is summarized from that report.

The plant size analyzed was a 120 MGD facility because a plant of that size would cover all eventualities except for provide peak day demand with the Irvington Tunnel out of service. The plant would operate under the following conditions:

- The Irvington Tunnel (which transmits water through the East Bay Hills) is out of service for inspection, maintenance, or repair
- The Harry Tracy Water Treatment Plant (HTWTP) is out of service because of water quality issues or for repair (such as following an earthquake)
- Additional water supply is needed due to a drought

The analysis assumed the plant would operate at a minimum of 10 percent capacity on a continuous basis.

Three sites were considered for the plant location:

- Adjacent to the Dumbarton Bridge BDPL 1 & 2 and the Bay
- Adjacent to the Oceanside Waste Water Treatment Plant (WWTP) (the Oceanside site)
- Treasure Island

The study found that locating a plant near BDPL 1 & 2 would provide a short delivery into the transmission system. However, discharging the brine into the South Bay could cause significant environmental impacts. A plant adjacent to the Oceanside site would have fewer issues associated with brine disposal but connecting to the transmission system would be more difficult. The Treasure Island site would potentially have fewer issues associated with brine disposal but again would be difficult to connect to the transmission system.

The report recommended further investigation of desalination as part of providing benefits to the entire SFPUC water system. The BDPL 1 & 2 site, the Oceanside site and the Treasure Island site were recommended by the SFPUC as three of the nine sites that the agencies are considering for a regional desalination facility.

1.2.2 East Bay Municipal Water District

EBMUD, with participation by CCWD, recently conducted a fatal flaw analysis of operating a co-located desalination facility at three sites east of the Carquinez Straits (EBMUD 2003). The following information is summarized from that report.

The report examined the potential for constructing and operating a 20 MGD desalination plant at C&H Sugar Refinery, the Mirant Pittsburg Power Plant, and the Mirant Contra Costa Power Plant in Antioch. These sites were selected because power plants already exist at each site and have intake and outfall structures that could also be used by a desalination plant. Additionally, there are advantages for using water that has been warmed by passing through the process occurring at these sites. Obtaining consumptive water rights would be required for each of the sites. All three sites are relatively close to connections to the EBMUD distribution system.

Feedwater obtained at the C&H Sugar Refinery site would be the most brackish of the three sites. Also, during the ebb flow of the tidal cycle, the intake structure is downstream of C&H Sugar’s Waste 002 outfall. Public perception issues could arise from obtaining feedwater at this location, although the outfall discharge is expected to be diluted immediately due to the depth of the channels and the strong current in that section of the Carquinez Straits.

The report concluded that in concept, locating a desalination plant at any of these three sites is feasible, although constraints and/or issues are associated with each. All three of these sites were recommended by EBMUD as three of the nine sites considered by the agencies for a regional desalination facility.

1.2.3 Contra Costa Water District

In 1996, CCWD conducted a future water supply study (CCWD 1996). The following information is summarized from that study.

Resource alternatives were developed and screened in two separate rounds. Desalination from Mallard Slough was examined as part of the first round of alternatives. CCWD has consumptive water rights of 25 MGD from Mallard Slough. A desalination plant at this location would produce 20 MGD. In reality, CCWD only uses water from Mallard Slough during the wet season (approximately 4 months of the year), when the water quality from the slough is at its best. Use of desalination at Mallard Slough may not result in a net increase in water supply during drought years (if used in a normal year) due to a possible offsetting deduction from CCWD’s Central Valley Project historical use. Desalination of Mallard Slough feedwater should be beneficial to CCWD if it were used for water quality improvement.

The desalination at Mallard Slough alternative did not advance to the Round Two screening in the CCWD study for a variety of reasons. High energy costs, brine disposal issues, reliability concerns, and high construction costs eliminated this alternative from further consideration. However, it was recommended that desalination at Mallard Slough be revisited in future updates of the future water supply study (every 5 years or so) to review how technology may have progressed to reduce construction and operating costs.

The Mallard Slough site was later suggested by CCWD as one site to add to the original nine sites considered by the agencies for a regional desalination facility.

1.2.4 Marin Municipal Water District

Although not part of this study, Marin Municipal Water District (MMWD) also is considering desalination. In 1989, the MMWD Water Supply Master Plan recommended that an additional 10,000 acre-feet of water per year be secured to meet supply shortfalls during drought and to meet additional growth projected to occur within its service area. In 1990, MMWD embarked on a series of studies to develop plans and designs for various water supply facilities. That information was used as the basis for an Environmental Impact Report (EIR) that addressed environmental associated with two water supply options:

- A 10,000 acre-feet per year (approximately 9 MGD) desalination plant to be located on MMWD property at Pelican Way in San Rafael
- Establishment of an 8-mile pipeline from near Petaluma to Novato (the Sonoma-Marin Transmission Line) to convey Russian River water to be purchased from the Sonoma County Water Agency to MMWD’s conveyance and distribution system

The EIR was certified, but the Board of Directors voted in July 1991 not to build a permanent plant. The Board instead selected the Sonoma-Marin Transmission Line project and placed an $80 million bond measure on the November 1991 ballot to fund the project. The bond measure was defeated. In November 1992, a subsequent bond measure for $37.5 million was passed to fund expansion of water recycling, conservation, and water imports.

In 2001, MMWD commissioned a new study of desalination as a water supply alternative (MMWD 2001). This report compared capital and operating costs of various desalination alternatives and reviewed and evaluated six different sites for desalination plants.

In 2003, MMWD hired URS Corporation to update the desalination project description, conduct a regulatory reconnaissance, perform an environmental screening of alternatives, and conduct an alternative energy study for the project (MMWD 2003).

MMWD now intends to move forward through the permitting process with the most feasible alternatives. The district issued a Notice of Preparation of an environmental impact report on the project in August 2003. The hope is to have a 10 MGD desalination facility in operation sometime in 2005.

1.3 AGENCY-SPECIFIC PROJECT INFORMATION

Individual interviews were conducted on June 11, 12, and 19, 2003, with each of the four agencies to get a better understanding of their need, intended use, and concerns regarding the RDP. Each agency was asked the same set of questions, and their responses are summarized below.

1.3.1 San Francisco Public Utilities Commission

SFPUC views desalination primarily as a supplementary water source to be used for emergencies (i.e., following an earthquake or during a drought) and while existing water facilities are closed for maintenance and repairs. According to SFPUC, a 120 MGD facility would best suit its emergency supply needs because it would cover all eventualities, except for peak day demand when Irvington Tunnel is out of service.

SFPUC’s primary concerns with locating a desalination facility within its service area relate to environmental justice. The public may be concerned with aspects of the project such as plant size, off-gas emissions, noise levels, brine discharge, construction impacts, and growth inducement. However, based on its experience with existing power plants in the Potrero Hill and Hunters Point areas, SFPUC expects environmental justice to be the main public concern.

During the interview, SFPUC also raised some technical concerns regarding water quality and plant operation. SFPUC indicated that the product water must meet the Maximum Contaminant Levels (MCLs). The reverse osmosis (RO) process would have to be further examined to determine the elements that would be removed. The taste and odor would also have to be acceptable to the SFPUC. While blending the existing water supply with the product water from the desalination plant may be acceptable, SFPUC would have to ensure that the blending ratio meets appropriate standards. On water distribution, SFPUC noted that a 120 MGD plant would need to tie into a 72-inch line. SFPUC’s transmission maps would have to be reviewed to identify the location of those lines.

Although the 2002 SFPUC report considered a 120 MGD facility (see Section 1.2.1), SFPUC is willing to consider a number of smaller-sized plants located within its service area.

1.3.2 East Bay Municipal Water District

EBMUD seeks to limit its water rationing to no more than 25 percent by supplementing its current water supply. The agency is currently pursuing several supplemental supply projects (ranging from 5 MGD to 100 MGD facilities) for its service area. Together, these projects would help satisfy EBMUD’s long-term supply needs and provide drought relief. EBMUD would use the proposed RDP project to provide some of the needed drought relief. The desalination facility could provide other benefits such as emergency supply (in cases such as earthquakes, facility breakdowns, or terrorist attacks) and planned or unplanned facility outages. These benefits, although valuable, would not justify the project without the supplemental supply element of the project.

EBMUD wants to investigate various issues that may be of public concern including growth inducement, environmental effects of brine discharge, source water quality concerns, water rights issues, fish intake issues, the effectiveness of treatment and lack of long-term operational history of desalination, and high electricity consumption. EBMUD suggested implementing a well-planned public outreach campaign through which other possible concerns (such as taste and odor) could be effectively addressed.

Assuming that the selected treatment (combination of pre-treatment and RO) would produce finished water quality that satisfies all state and federal drinking water standards and provides a high-quality water source comparable to other EBMUD water sources, EBMUD discussed other concerns associated with the RDP project. As was the case with CCWD, the primary concern cited by EMBUD was the public perception of producing potable water through desalination from bay or ocean water. Source water quality and treatment effectiveness are the key issues that would have to be addressed. EBMUD noted that its treatment plants cannot treat raw Sacramento–San Joaquin River Delta (Delta) quality water. While blending is generally an acceptable method according to the California Department of Health Services (DHS) and other agencies, EBMUD would prefer to blend the desalination product water with EBMUD's other source water prior to treatment/filtration. However, each scenario (i.e., water quality, distribution system) would have to be evaluated by the staff individually.

With respect to siting, EBMUD's main concerns are the potential (or the appearance of) negative environmental impacts, equivalent water quality to customers, environmental justice, and public perception. EBMUD is concerned about the public perception of RDP resulting in unmitigable environmental impacts (e.g., brine discharge, intake structure, facilities construction). If the RDP sites are at or near the Delta, appearance of negatively impacting the salinity of the Delta may be a concern to EBMUD and other state, local, and other water agencies.

With respect to distribution, EBMUD commented that if the RDP facility location is near the aqueducts (e.g., Mirant Plants), a 120 MGD supply tie-in to the aqueducts would be conceivable in dry years. Limited capacity may be available in wet years. Water placed in aqueducts would be treated again at EBMUD treatment plants. However, to tie in 120 MGD at other locations, hydraulic/distribution system modeling would have to be completed. The system may not be able to accept 120 MGD at one single point. Smaller capacity tie-ins could be done at many different points in the system. Additional information can be provided as the project proceeds and a better definition of the capacity and location become available.

1.3.3 Contra Costa Water District

CCWD views desalination as a secondary water source that could be used to relieve shortages during drought periods and possibly to serve future growth. Desalination may also have the benefit of improving overall water quality or may be used to meet future supply shortfalls, according to CCWD.

Given its intended use, CCWD is not aware of any major public concerns that would impede the development of the proposed project. CCWD foresees supplying the desalination product water directly through their distribution system as a public perception issue. To avoid this issue, CCWD expressed a preference for treating the product water from the desalination plant along with CCWD's existing raw water supply before distribution. A second concern that CCWD expressed was the siting of the brine disposal outfall. The agency would be concerned about locating a brine disposal outfall upstream of CCWD water supply intakes or near Water Quality Control Plan compliance locations (Chipps Island and Collinsville) that affect Central Valley Project, State Water Project, and CCWD's Los Vaqueros Reservoir operations.

CCWD has the water rights for 25 MGD from Mallard Slough. The agency is currently using only approximately 25 percent (about 5 MGD) of its supply. CCWD would like to maximize its water use from Mallard Slough. Information on the Mallard Slough site, along with information on the C&H Sugar site and two power plant sites, can be found in the EBMUD 2003 study (see Section 1.2.3).

1.3.4 Santa Clara Valley Water District

SCVWD is trying to look beyond local and state-based options to meet its long-term water supply needs. It sees regional-based desalination as a viable way to diversify its water supply portfolio. In its Integrated Water Resources Plan, SCVWD has identified two preliminary alternatives for desalination. Desalination would help augment the agency's current water resources and provide greater reliability by serving as a consistent, long-term water supply source.

In the interview, SCVWD staff discussed their concerns with regard to siting, public opinion, and technical specifications of the proposed plant. On siting, SCVWD expects environmental justice to be the primary concern, particularly if Alviso is considered as a possible location for the RDP. Other issues of public concern include growth inducement and the public perception associated with drinking Bay water. On the technical front, SCVWD raised the issue of the filters' ability to remove endocrine disruptors. Three of the potential sites identified to date are located within SCVWD's service area. Each of these sites has shallow brackish water, and SCVWD is not aware of any aquifer contamination concerns for those sites.

1.4 RECENT DESALINATION PROJECTS

1.4.1 Alameda County Water District Desalination Plant

The Alameda County Water District (ACWD) has built a 5 MGD brackish water desalination facility in Newark, California, to provide a new local source of water supply for the district. The desalination facility is currently in start-up mode and will produce drinkable water by removing salts and other minerals from brackish groundwater in the local aquifer system.

The ACWD currently operates a series of wells that remove brackish water from the groundwater basin. This program, called the Aquifer Reclamation Program, was developed to stop the spread of saltwater already in the groundwater basin and to reclaim the aquifers of the basin for future potable use. Brackish water from some of these wells will be treated at the desalination facility rather than being allowed to flow to San Francisco Bay, as was previously the case.

The desalination facility uses RO technology to convert brackish water to potable water. The soft water produced by the desalination facility can be blended with the hard water pumped from other parts of the groundwater basin to maintain a more uniform water hardness throughout the year and throughout the ACWD's service area.

The ACWD completed a reconnaissance-level feasibility study in 1993 before planning and designing the desalination facility. The feasibility study included: (1) a survey of current desalination technology and practices; (2) an investigation of the RO process for three different applications (brackish water, municipal wastewater, and seawater); and (3) cost analysis of alternatives. A small-scale pilot project was also implemented to test the project design features before the required permits were obtained.

1.4.2 Tampa Bay Seawater Desalination Project

The Tampa Bay Seawater Desalination Project (TBSDP) is a 25 MGD two-stage RO plant located at Tampa Electric Company's Big Bend Power Station site, in Southern Hillsborough County, Florida. The site was chosen for four reasons: (1) abundant supply to meet its intake requirement of 44 million gallons (the power plant already has 14,000 million gallons of seawater moving through it daily); (2) the existing outfall structure provides an environmentally sound mechanism to discharge the concentrated reject water; (3) due to its location, the facility would not have any adverse effects on the community; and (4) the site provides reasonable access to existing water supply pipelines for distribution to the community. The RO desalination plant uses the cooling water from the power plant as its raw material. Sand filtration technology is used for pre-treatment before the water passes through the racks of reverse osmosis membrane cartridges. The product water will then move to a storage system until it is sent to the Tampa Bay Water distribution system, while the discharge is blended with the power plant's outfall. This blending results in an overall increase in discharge salinity of only 0.5 percent. During the post-treatment phase, calcium carbonate is added to the treated water to make it more suitable for distribution.

Six environmental studies were performed for the project:

- *Cumulative Impact Analysis for Master Water Plan Projects,* April 1998
- *Potential Effects of Tampa Bay Surface Water Project on Salinity and Circulation in Tampa Bay*
- *Assessment of Potential Impacts on Biological Communities of McKay Bay from Proposed Reductions in Freshwater Inflow from the Tampa Bypass Canal*
- *Assessment of the Effects of Reductions in Freshwater Inflow on the Biological Communities of the Lower Alafia River*
- *Numerical Modeling Investigation of Proposed Desalination Facility at Big Bend, Tampa, Florida, Phases 1 and II, Model Calibration and Individual Effects*
- *Numerical Modeling Investigation of Proposed Desalination Facility at Big Bend, Tampa Florida, Phase III, Cumulative Effects* (of all water projects)

The first four studies listed above included all Master Plan water projects, while the latter two were specific to the desalination plant. No significant effects were found for the project.

TBSDP is a key component of Tampa Bay Water's Master Water Plan. To meet the region's water needs, Tampa Bay Water must tap into new sources of water other than groundwater. By

2003, the plan calls for the creation of 53 MGD of new water sources and a total of 111 MGD by 2008. Tampa Bay Water is a regional water utility that was created in 1998 to supercede the West Coast Regional Water Supply Authority. TBSDP's output is 25 MGD, which could increase to 35 MGD in the future. The seawater desalination project is one piece of the water supply solution and will provide 10 percent of the region's overall water supply, reducing ground water production by 68 MGD by 2008.

Covanta Energy Corporation will operate TBSDP for the first 30 years. The estimated cost for the TBSDP is $100 million.

1.4.3 Metropolitan Water District Desalination Program

The Metropolitan Water District of Southern California (MWD) is a 26-member regional agency with an annual budget of $1.39 billion. It was created and authorized by the State Legislature in 1928 with the passage of the Metropolitan Water District Act. MWD is responsible for managing imported water supplied to the six southern California counties (Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura). The agency owns and operates the 242-mile Colorado River Aqueduct and contracts with the State of California to provide up to 1 million acre-feet of water annually through the State Water Project.

MWD is also responsible for ensuring that reliable water supply is available for the entire region. As such, Met institutes programs and offers some financing for recycling, groundwater development/cleanup, conservation, and desalination to protect against future water shortages and lessen the need for imported water.

For desalination, MWD offers financial assistance of up to $250 per acre-foot for terms of up to 25 years. The project must be built and the water delivered to receive MWD's incentives ("Pay for Performance"), and performance provisions must continue throughout agreement term. Five member agencies have submitted proposals to MWD for desalination projects. The agencies are at different stages of the project planning process. MWD member agencies considering desalination are the Long Beach Water Department, Los Angeles Department of Water and Power, Municipal Water District of Orange County, San Diego County Water Authority, and the West Basin Municipal Water District. None of these projects have advanced to the stage of permitting. However, the Long Beach Water Department is presently operating a desalination pilot plant.

1.5 PROJECT GOAL STATEMENT

The goal of the Bay Area Regional Desalination Project is to develop a desalination plant, or plants, at a site, or sites, that will provide benefit, either directly or indirectly, to each of the agencies that choose to participate. The plant(s) can be constructed as a single facility capable of producing up to 120 MGD of product water or can consist of multiple facilities with a minimum capacity of 20 MGD each. The agencies can benefit either by directly receiving desalination product water into their water systems or by receiving other water from an agency that directly receives desalination product water. Agreement must be reached among the participating agencies to share the water to fit their particular needs. The desalination plant(s) could benefit the region by providing a supply either as a continuous addition to water supply or as an emergency supply.

2.1 INTRODUCTION

Construction and operation of the proposed project would require obtaining permits or approvals from a variety of resource agencies. This chapter describes the permits and environmental reviews that are likely to be required.

The key environmental reviews, permits, and approvals that are likely to be needed are listed below and summarized in Appendix A. Based on the selected location of the desalination plant(s), other permits and approvals may also be required. This document provides an overview of the various resource agencies that may be involved in the regulatory oversight of this project as well as a discussion of the potentially required permits.

Environmental reviews and major permits or approvals that will likely be required for the proposed project include the following:

- Compliance with the California Environmental Quality Act (CEQA).
- Compliance with the National Environmental Policy Act (NEPA), if federal funds are used to finance any portion of the project, or if the project takes place on federal land, or if a federal permit is required.
- A National Pollutant Discharge Elimination System (NPDES) permit from the California Environmental Protection Agency (Cal/EPA), through the Regional Water Quality Control Board (RWQCB) (either San Francisco or Sacramento, depending on the site selected). The U.S. Environment Protection Agency (USEPA) Region IX oversees the implementation of the program.
- Section 404 Permit (Clean Water Act) and Section 10 Permit (Rivers and Harbors Act) from the U.S. Army Corps of Engineers (USACE).
- Permit from the Bay Conservation Development Commission (BCDC).
- An amendment of Drinking Water Permits from the DHS will be required to include the new water supply source.
- A California Coastal Commission permit will be required if development is proposed within the coastal zone.
- A lease permit may be required from the State Lands Commission (SLC) if there are any offshore components of the proposed project on any ungranted tidelands.
- Consultation with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Services (NMFS) in accordance with Section 7 of the Federal Endangered Species Act.
- Consultation with California Department of Fish and Game (CDFG) through the Federal Endangered Species Act Section 7 process for state-listed threatened or endangered species.
- Consultation with the State Historic Preservation Office.
- A Water Rights Permit from the State Water Resources Control Board (SWRCB).

2.2 CALIFORNIA ENVIRONMENTAL QUALITY ACT AND NATIONAL ENVIRONMENTAL POLICY ACT

Regardless of the site selected for the RDP, the project will be subject to the provisions of CEQA. As such, the designated Lead Agency would determine what type of environmental document would be required (Initial Study/Negative Declaration or EIR) for CEQA compliance. Given the nature of the potential impacts, it is likely that the document would be an EIR.

NEPA would be invoked if any federal action is required for the RDP. Actions that may trigger NEPA include spending federal funds, using federal lands, or needing a federal permit. Under NEPA, the designated Lead Federal Agency would determine whether the project may significantly affect the quality of the human environment. Based on the anticipated level of impacts, the Lead Agency may prepare an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). As the proposed action may have significant effects on the quality of the human environment, it is likely that the appropriate document would be an EIS. A joint EIR-EIS can be prepared to satisfy the requirements of both CEQA and NEPA.

Following completion of the Draft and Final EIR/EIS, the Lead Agencies must certify or approve that the environmental document was prepared in accordance with CEQA and NEPA requirements. The certified/approved EIR/EIS may also be used by other federal, state and local agencies during their permitting and approval processes. No permits or approvals will be issued before the EIR/EIS is certified/approved.

2.3 PERMITTING AGENCIES

A number of the major permits described in this section can be applied for under the San Francisco Bay Area Joint Aquatic Resource Permit Application (JARPA). While the permit applications and appropriate fees would have to be submitted individually to each authorizing agency, the process is streamlined through the uniform JARPA application (see Appendix B). Agencies accepting the JARPA application include the Bay Conservation Development Commission (BCDC), the San Francisco Bay Regional Water Quality Control Board (SFRWQCB), the State Lands Commission (SLC), the U.S. Army Corps of Engineers (USACE), the U.S. Environmental Protection Agency (USEPA), the U.S. Fish and Wildlife Service (USFWS), the National Oceanic Atmospheric Association Fisheries (NOAA Fisheries), and the U.S. Coast Guard (USCG) (for a Section 9 Bridge Permit).

2.3.1 San Francisco Regional Water Quality Control Board

The State Water Resources Control Board (SWRCB) is responsible for determining whether discharges would pose a threat to state waters. The SFRWQCB regulates discharges to protect ground and surface water quality in the Bay Area through National Pollutant Discharge Elimination System (NPDES) permits and Waste Discharge Requirements (WDRs). The SFRWQCB also regulates ocean discharges through NPDES permits via the California Ocean Plan. The SWRCB and the RWQCB are part of California Environmental Protection Agency (Cal/EPA).

Waste discharged into surface waters is subject to NPDES permitting. Other types of discharges, such as those that affect groundwater or are diffused in nature (e.g., erosion from soil disturbance or waste discharge to land) are subject to WDRs. All permits issued to control pollution must implement Basin Plan requirements (i.e., water quality standards). The location selected for the proposed project would dictate the appropriate Basin Plan (San Francisco Bay Region Basin Plan, Bay-Delta Plan, or California Ocean Plan).

2.3.1.1 National Pollutant Discharge Elimination System Permit

Construction of a desalination plant will require obtaining an NPDES permit to discharge desalination reject water. The options for discharge of desalination reject water are essentially direct discharge or discharge through an existing power plant or sewage treatment plant outfall. Direct discharge allows a discharge outfall to be designed for maximum dilution but also requires additional cost for design/construction as well as the permitting of the new outfall. Discharge through an existing outfall structure has the benefit of providing initial dilution via the existing wastewater stream; it may also reduce design and construction costs.

Water Quality Issues

To assess the environmental issues and subsequent permitting issues associated with the discharge, the potential concentration in the desalination reject water will have to be compared to the Bay Water Quality Objectives (WQOs) contained in the relevant Basin Plan (or Bay-Delta Plan/Ocean Plan, as applicable) and the California Toxics Rule.

<u>Water Quality Objectives</u>

Under the provisions of the Porter-Cologne Act and the Clean Water Act, the SFRWQCB regulates water quality in the San Francisco Bay watershed through its Basin Plan. The Basin Plan identifies beneficial uses and WQOs for waters of the state, including surface waters and groundwaters, as well as effluent limitations and discharge prohibitions intended to protect beneficial uses. Similarly, sites located within the Delta (as defined in California Water Code Section 12220) would be would be subject to Bay-Delta Plan requirements. The Oceanside site would be regulated by the Ocean Plan.

<u>California Toxics Rule</u>

The Clean Water Act requires states to adopt numeric water quality criteria for priority toxic pollutants for which the USEPA has issued criteria guidelines, the presence or discharge of which could reasonably be expected to interfere with maintaining beneficial uses. In California, litigation over the process the State used to develop the criteria prevented their adoption. As a result, USEPA developed the criteria for the state and on May 18, 2000, adopted the California Toxics Rule in 40 CFR Part 131. These criteria are to be considered by the Regional Water Quality Control Boards during the tri-annual update to the Basin Plans. However, the Basin Plan is currently undergoing review and has not been updated since 1995. As a result, California Toxics Rule criteria are compared for waters where the beneficial use they are designed to protect exists or potentially exists.

<u>Types of Likely NPDES Limits</u>

NPDES permits often contain both concentration and mass based limits. Concentration limits are designed to prevent exceedances of the water quality criteria in the receiving water in the vicinity of the discharge. Exceedance of the criteria for aquatic life could result in toxicity to sensitive aquatic species. The SFRWQCB can provide a dilution allowance for the immediate dilution that occurs when water is discharged from a properly engineered deepwater diffuser outfall. The allowance is calculated as ten times the water quality criteria less the amount of chemical already present in the receiving water.

Mass-based permit limits are generally set for pollutants that are persistent or may bioaccumulate and cause impacts as a result of accumulating in the system. Mass based limits may be set as a result of a Total Maximum Daily Load (TMDL) process. Currently, TMDLs are being developed for copper, nickel, mercury, 4-4'DDE, polychlorinated biphenyls (PCBs), dieldrin, and dioxin.

Desalination Reject Water Concentrate

The reject water from the desalination process is a concentrate that is likely to have a salt content of approximately twice that of the Bay or ocean. Furthermore, the concentrate could potentially have higher concentrations of metals and other constituents in the Bay or ocean, depending on the selected plant location. For the purpose of this regulatory review, we have estimated that the concentration would be approximately two times the dissolved concentration of those constituents found in the Bay or ocean. Only dissolved constituents were used due to removal of sediment during the pretreatment prior to desalting.

Mass Discharges

It is important to note that the total mass discharged to the Bay or ocean of any particular constituent would not be any higher than what is taken from the Bay or ocean. In fact, for constituents that are associated with suspended sediment, the mass discharged would be lower due to the removal of those sediments in the pretreatment process.

Water Quality Analysis

It should be noted that the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (State Implementation Plan) sets minimum levels for reporting pollutants based on the approved USEPA analysis methods. Minimum levels are used to determine compliance with effluent limits. The site-specific water quality objective would have to be reviewed.

Hydraulic and Dilution Issues

Based on the selected outfall location, the hydraulics of the structure would need to be considered in order to ensure appropriate mixing in the outfall and to address any seawater infiltration that may be occurring in the diffuser.

Outfall Hydraulics

The discharge of desalination reject water could be done either by a purpose-built outfall or an existing outfall. A purpose-built outfall (i.e., one designed and built for the project) could be designed to reach maximum dilution but could require significantly more permits. The use of an existing outfall may have other concerns such as capacity and mixing. For an existing wastewater treatment plant outfall, peak wet weather flows may exceed the capacity of the selected outfall structure, making hydraulics an issue during the peak wet weather flows. The connection point could create a localized headloss (pressure), which could raise the level in the outfall sump resulting in passive bypass. A standard procedure for throttling desalination facility flow when effluent flows approach capacity would need to be developed.

Also of concern is the fluctuation in flow during the day. To determine the fluctuation, dilution of the proposed outfall discharge would have to be considered to include both peak flows and non-peak hour flows. A model can then be developed to determine the dilution ratio that can be met at the extreme flows. If the dilution required by the SFRWQCB cannot be met at the low flows, the agencies may need to consider storage of desalination reject water concentrate until the outfall discharge increases to meet dilution requirements.

Dilution

A purpose-built outfall can be designed to meet dilution requirements. A consideration when discharging the desalination reject water concentrate into an existing outfall is the density of the effluent. The desalination reject water discharge may be negatively buoyant. Generally speaking, as buoyancy is decreased so is mixing and hence dilution unless the reduction in buoyant mixing can be compensated by increased momentum mixing (i.e., increased velocity from the ports on the outfall). Dilution modeling using the USEPA's Visual Plumes model can be performed to indicate the amount of mixing that may be required to meet the required dilution criteria. This model will help determine the size of the facility that may be acceptable to maintain the appropriate dilution levels under different environmental conditions.

2.3.1.2 Potential Issues Involved

The two main issues associated with the NPDES permit will be the concentration limits (despite the fact that desalination reject water will not increase the total mass of constituents in the Bay/ocean) and the dilution from the outfall diffuser.

Modeling of a range of environmental conditions based on the selected outfall location would be needed to fully evaluate the potential for achieving the required dilution for the discharge.

2.3.2 U.S. Army Corps of Engineers

Pursuant to the Clean Water Act and the Rivers and Harbors Act, the USACE has jurisdiction over all navigable waterways (including non-navigable streams, marshes, and diked lands) and requires a permit for any work with the waters of the United States that involves a discharge.

2.3.2.1 Section 404 Permit

Under Section 404 of the Clean Water Act, the USACE has jurisdiction over any activity involving the discharge of dredge or fill material into waters of the United States. Activities for the proposed project that would be regulated under Section 404 may include construction and placement of intake and outfall structures. USACE jurisdiction will be limited to work conducted in or affecting waters of the United States, including "special aquatic sites" such as wetlands, mudflats, and eelgrass beds.

2.3.2.2 Section 10 Permit

Section 10 of the Rivers and Harbors Act of 1899 requires approval from the USACE prior to completing any work in or over "navigable waters" of the United States or work that may affect the course, location, condition or capacity of such waters. Any dredging, excavation, or construction of intake/outfall structures within the Bay associated with the RDP is likely to require a Section 10 permit.

2.3.2.3 Types of Permits

Authorization of a jurisdictional activity under Section 404 or Section 10 can be granted by the USACE in two ways, based on the type of activity involved. The permit required would depend on the types of facilities and location of the proposed project.

General Permit

A general permit is issued if the activity complies with a specific category of activity. The two types of general permits are:

- Nationwide Permits, which are used for defined activities that fall within specific parameters
- Regional or programmatic approvals, which are not likely to apply to a proposed project in the San Francisco Bay Area

Individual Permit

An Individual Permit is required for activities that do not meet the definitions and conditions specified under the General Permit. This permit undergoes greater review and processing by the USACE and involves careful consideration of alternatives.

2.3.2.4 Potential Issues Involved

The proposed project may involve construction of intake and/or outfall structures in the Bay or ocean. These structures would constitute fill, and the construction would involve dredging or excavation. Therefore, a Section 404 and a Section 10 permit would be required. The USACE can process these two permits simultaneously.

2.3.3 Bay Conservation and Development Commission

The San Francisco BCDC is a California state agency that was established to accomplish two primary goals: to prevent the unnecessary filling of San Francisco Bay, and to increase public access to and along the Bay shoreline. The Commission is responsible for carrying out two state laws (the McAteer-Petris Act and the Suisun Marsh Preservation Act) and two plans (the San Francisco Bay Plan and the Suisun Marsh Protection Plan). These laws and plans were adopted to protect the Bay and the Suisun Marsh as great natural resources for the benefit of the public and to encourage development compatible with this protection.

2.3.3.1 BCDC Permit

It is necessary to obtain BCDC approval prior to undertaking any of the following activities:

- Filling: Placing solid material, building pile-supported or cantilevered structures, disposing of material or permanently mooring vessels in the Bay or in certain tributaries of the Bay
- Dredging: Extracting material from the Bay bottom

- Shoreline projects: Nearly all work, including grading, on the land within 100 feet of the Bay shoreline
- Other projects: Any filling, new construction, major remodeling, substantial change in use, and many land subdivisions in the Bay, along the shoreline, in salt ponds, duck hunting preserves or other managed wetlands adjacent to the Bay

To obtain the required approval, it is necessary to complete an application form (the uniform JARPA form can be used, as noted earlier), provide the necessary additional information and exhibits, and pay a processing fee. BCDC cannot deem an application complete until the agencies have received all discretionary local permits (i.e., variances, zoning changes, excavation or fill permits).

After a complete application is filed, the Commission has a maximum of 90 days to act on the application. Most applications are processed within 5 to 8 weeks. A public hearing will be held on an application for a major project. Thereafter, if the Commission votes to approve the project, a permit with relevant conditions will be issued.

2.3.3.2 Potential Issues Involved

The proposed desalination project may involve building a new intake or outfall structure in the Bay. Placing a new intake and or outfall structure in the Bay would be considered placement of fill. BCDC would require mitigation for such activities. Typically, mitigation for BCDC would satisfy the mitigation requirements for other agencies, such as the USACE. However, agencies may have specific interests that would drive some mitigation requirements. For example, BCDC is interested in maintaining and enhancing public access to the Bay and may look to the project to help enhance public access to the Bay as part of the mitigation.

2.3.4 California Department of Health Services

The DHS is responsible for adoption of implementing regulations under the California Health and Safety Code and the enforcement of state drinking water laws. Chapter 7 of the California Health and Safety Code contains the Safe Drinking Water Act, a key feature of which is the requirement that no person may operate a public water system without having secured a Domestic Water Supply Permit from DHS. Although each of the agencies already has this permit, an amendment would be required for the new water supply from the proposed RDP.

2.3.4.1 Domestic Water Supply Permit (Amendment)

Any project that distributes domestic water must comply with the Safe Drinking Water Act, regulated by the DHS. An important element of the Safe Drinking Water Act is the Surface Water Treatment Rule, which prescribes a multibarrier treatment for surface water used in a public water system to protect users from microbial contaminants. Source approval and desalination treatment requirements would therefore be subject to the Surface Water Treatment Rule.

To satisfy DHS requirements for an Amendment to the Domestic Water Supply Permits, the quality of the delivered water would have to meet the DHS standards. Information regarding the proposed treatment facilities and technology would also have to be reviewed by DHS.

2.3.4.2 Potential Issues Involved

Issues that DHS would be most concerned with for the RDP include the following:

- Source water characteristics
- Watershed conditions
- Contaminant removal capabilities
- Reliability features – technical, financial, and managerial

2.3.5 California Department of Fish and Game

The CDFG is responsible for conserving, protecting, and managing California's fish, wildlife, and native plant resources. If any pipelines or other structures associated with the proposed RDP cross a stream (or otherwise alter the streambed, channel, lake or river bank) and the CDFG determines that the project may adversely affect existing fish and wildlife resources, a Lake or Streambed Alteration Agreement would be required.

Under Section 1601 of the California Fish and Game Code, before the agencies begin construction of the RDP, they must determine whether the project would:

- Divert, obstruct, or change the natural flow or the bed, channel, or bank of any river, stream, or lake
- Use materials from a streambed
- Result in the disposal or deposition of debris, waste, or other material containing crumbled, flaked, or ground pavement where it can pass into any river, stream, or lake

If the project falls in any of the above categories, the agencies would have to submit a Notification of Lake or Streambed Alteration form and a Project Questionnaire form to the CDFG. These forms, along with any other required documents and applicable fees, would constitute a complete application. The JARPA form can be used to provide much of the required information.

Notification is generally required for any project that will take place in or in the vicinity of a river, stream, lake, or their tributaries. This includes rivers or streams that flow at least periodically or permanently through a bed or channel with banks that support fish or other aquatic life and watercourses having a surface or subsurface flow that support or have supported riparian vegetation.

The CDFG will evaluate the completed application to determine if a Lake or Streambed Alteration Agreement is required for the project. Typically, field staff that will evaluate the proposed project and its impacts will be assigned to the project. On-site inspections may be also occur at this time. This review would take approximately 30 days, according to the CDFG.

If the CDFG determines that a Lake or Streambed Alteration Agreement is not required, the agencies may immediately begin work on the project. If a Lake or Streambed Alteration Agreement is needed, however, work on the project cannot begin until the CDFG develops a draft Lake or Streambed Alteration Agreement and the project described in that agreement is reviewed as required by CEQA. This Agreement would likely include measures that would have to be taken to minimize potential impacts.

2.3.6 California Coastal Commission

The California Coastal Commission serves as the lead agency for California's coastal management program under the California Coastal Act. If the proposed desalination plant is located in the coastal zone, it would fall under the jurisdiction of the Commission.

2.3.6.1 Coastal Development Permit

If it is located within the coastal zone, the RDP must satisfy the requirements of the California Coastal Act and the federal Coastal Zone Management Act. Coastal Development Permits (CDPs) are authorized by the presiding local jurisdiction where the Commission has a certified Local Coastal Program (LCP). If the proposed project includes development in an area of the coastal zone where there is no fully certified LCP, a CDP from the Commission will be required under Section 30600(c) of the Coastal Act.

The Commission retains permit jurisdiction over any portion of a project that is in state waters, on land up to the mean high tide line, on the immediate shoreline, or on lands subject to the public trust. If the RDP is proposed within these areas, a Commission permit will be required. In addition to issuing CDPs, the Commission will also review LCP amendments that provide for desalination plants.

Along with a CDP application, the following items must be sent to the Commission for the application to be filed. These items include:

- An adequate description including maps, plans, photographs, etc., of the proposed development, project site, and vicinity sufficient to determine whether the project complies with all relevant policies of the California Coastal Act of 1976, including sufficient information concerning land and water areas in the vicinity of the site of the proposed project. The description of the development shall also include any feasible alternatives or any feasible mitigation measures available that would substantially lessen any significant adverse impact that the development may have on the environment.
- The applicant must also demonstrate a legal right, interest or other entitlement to use a property for the proposed development (Public Resources Code Section 30601.5; 14 California Code of Regulations 13053[b]). This may include a lease or permit from the SLC for use of state lands if the project will be located in the SLC's jurisdiction area. In addition, the applicant should submit with the coastal development permit application evidence that an NPDES permit authorizes the proposed discharges. If a permit for disposal of solid waste is required, this permit should also be submitted to the Commission with the coastal development permit application. All permits required for a proposed project must be obtained prior to plant operation.

2.3.6.2 Potential Issues Involved

The Commission will need to determine whether the RDP will qualify as a "coastal-dependent development" and/or a "coastal-dependent industrial development." The Coastal Act defines a coastal-dependent development or use as "any development or use which requires a site on, or adjacent to, the sea to be able to function at all" (Section 30101). Because desalination plants that use seawater as feedwater will need to be located fairly near the coast, but not necessarily in the coastal zone, this determination will be site-specific. If the project site is determined by the Commission to be a coastal-dependent development, it is likely to have priority over other development on or near the shoreline, provided that it would not adversely affect public welfare or have environmental effects that cannot be mitigated.

The Commission is concerned about induced growth in the coastal zone, impacts to marine organisms, and seawater cooled power plants. The Commission may review the RDP proposal under consistency authority when it will have impacts on the coastal zone and have federal involvement. Coastal Act conformity determination comes after all other permits are complete and does not take into consideration benefits outside the coastal zone.

2.3.7 State Lands Commission

The SLC manages approximately 4.5 million acres of land held in trust for the people of California. The jurisdiction of the SLC includes a 3-mile-wide section of tidal and submerged land adjacent to the coast and offshore islands, including bays, estuaries, and lagoons. It also includes the waters and underlying beds of more than 120 rivers, lakes, streams, and sloughs. The State holds these lands for the public trust purposes of water-related commerce, navigation, fisheries, recreation, and open space.

The SLC is responsible for granting a Dredging Permit, if the RDP proposal requires any dredging of lands under the jurisdiction of the SLC. In addition, the SLC is responsible for issuing Land Use Leases and otherwise regulating the use of tidelands and submerged lands under its jurisdiction to ensure that proposed uses of these lands are consistent with a public purpose. A land use lease may be required for any RDP proposal to use navigable waterways for any purpose other than dredging; for example, a floating barge platform desalination facility would require this type of lease.

2.3.8 California Department of Transportation

The California Department of Transportation (Caltrans) has authority over all state highway and freeway right-of-ways, including easements and undeveloped rights-of-way which have been acquired in anticipation of future construction. Any project that proposes to perform earthwork within the right-of-way of the state highway or freeway must obtain an Encroachment Permit from Caltrans.

If any development associated with the RDP is within the Caltrans' right-of-way, an Encroachment Permit would have to be obtained from Caltrans' Engineering Division. The permit application would include an illustrative site plan, payment of an encroachment fee, demonstration of insurance, a cash deposit equal to the value of the work being done within the right-of-way, and the contractor's license number.

2.3.9 U.S. Coast Guard

The USCG is the nation's leading maritime law enforcement agency and has broad, multi-faceted jurisdictional authority. The Operational Law Enforcement Mission is directed primarily in the areas of boating safety, drug interdiction, living marine resources, alien migrant interdiction, and responding to vessel incidents involving violent acts or other criminal activity. The USCG also has jurisdiction over bridges which cross the navigable waters of the United States. Its authority relates to the location, clearances of bridges, bridge permits, construction activities, navigation lights and signals at bridges, and the regulations that govern the operation of drawbridges.

A 1973 Memorandum of Agreement between the USCG and the USACE clarifies the USACE responsibility under Section 10 of the Rivers and Harbors Act of 1899 and the Coast Guard responsibilities under the Department of Transportation Act of 1966, with respect to bridges and causeways.

If the RDP intake or outfall structure(s) falls within the jurisdiction of the Coast Guard, or the selected site is a barge-mounted plant, the USCG may be involved as a regulating or permitting authority. The USCG may approve activities involving the movement of vessels, traffic safety, and navigational hazards potentially associated with the RDP. If required, the USCG would review the Section 10 Permit issued by the USACE. It may also consult with the USACE during the Section 10/404 process.

2.3.10 California Department of Parks and Recreation

The Department of Parks and Recreation (DPR) has a role in the protection, restoration, and interpretation of the state's wetlands. A primary goal for DPR is the preservation of the state's biological diversity and the protection of its valued natural resources including wetlands. DPR manages over 265 park units, including over 280 miles of coastline and 250 miles of rivers. Many of the coastal units contain river mouths with coastal lagoons and estuaries.

A permit from the DPR would only be required if the proposed RDP plant site is located within the jurisdiction of the DPR.

2.3.11 California State Reclamation Board

The California State Reclamation Board (Reclamation Board) is charged with the following responsibilities:

- To control flooding along the Sacramento and San Joaquin Rivers and their tributaries in cooperation with the USACE
- To cooperate with various agencies of the federal, state, and local governments in establishing, planning, constructing, operating, and maintaining flood control works
- To maintain the integrity of the existing flood control system and designated floodways through the Board's regulatory authority by issuing permits for encroachments

A permit from the Reclamation Board may be required if the RDP involves the placement, construction, or removal of any landscaping, culvert, conduit, fill, encroachment, or structure within an area under the jurisdiction of the Reclamation Board. A permit may also be required for any work done in an area for which there is an adopted flood-control plan.

2.3.12 Bay Area Air Quality Management District

If a new power generation source for the RDP desalination plant is not required, its operation would not directly result in significant air quality impacts. The only air pollution, resulting from fugitive emissions during construction and transportation equipment, would be temporary and restricted to the vicinity of the site. According to the Bay Area Air Quality Management District (BAAQMD), while temporary impacts may require that the agencies take mitigation measures such as water sprinkling, no permit would be required.

If electrical power is generated on-site for the desalination plant, it may result in the emission of particulates and sulfur oxides from combustion. Such activity would require an Air Quality Permit. Also, if substances extracted from the product water are stockpiled on-site, a permit may be required from the BAAQMD. While the determination will depend on the final plant configuration, it is unlikely that any permits would be required through the BAAQMD.

2.3.13 Port Authorities and Port Districts

Coordination and regulatory guidance from port authorities may be required depending on the location of the RDP site. Port authorities located in the area include the Ports of San Francisco, Richmond, Oakland, and Redwood City.

2.3.14 State Water Resources Control Board

The SWRCB, in conjunction with nine semiautonomous regional boards, regulates water quality in the state. The regional boards—which are funded by the state board and are under the SWRBD's oversight—implement water quality programs in accordance with policies, plans, and standards developed by the SWRCB.

The SWRCB carries out its water quality responsibilities by (1) establishing wastewater discharge policies and standards; (2) implementing programs to ensure that the waters of the state are not contaminated by underground or aboveground tanks; and (3) administering state and federal loans and grants to local governments for the construction of wastewater treatment, water reclamation, and storm drainage facilities. Waste discharge permits are issued and enforced mainly by the regional boards, although the SWRCB issues some permits and initiates enforcement actions when deemed necessary.

The SWRCB also administers water rights in the state. It does this by issuing and reviewing permits and licenses to applicants who wish to take water from the state's streams, rivers, and lakes.

2.3.14.1 Appropriative Water Right Permit

Diverting water from surface waters or subterranean streams flowing in known and definite channels, either (1) directly to use on land which is not riparian to the source, (2) to storage in a reservoir for later use on either riparian or nonriparian land, or (3) for direct use of water which would not naturally be in the source, requires an appropriative water right permit from the SWRCB. A Delta location for the proposed project would require a water right permit. Some Bay locations may also require a water right permit from the SWRCB. An ocean site would not fall under the jurisdiction of the SWRCB.

2.3.14.2 Potential Issues Involved

A number of applications for Delta water rights permits have been submitted for review by the SWRCB. According to the Division of Water Rights, given the limited availability of Delta water due to prior rights issued and the large number of applications in queue, obtaining a water right permit for a proposed desalination project in the Delta would likely face challenges. However, if the applicant's appropriation is demonstrated to be in the public interest, and unappropriated water is available to supply the project, other considerations may be overridden by the SWRCB. Once permitted, the project would still have to meet stringent outflow standards, preserving instream uses such as recreation and fish and wildlife habitat.

Seawater does not generally fall within the Department of Water Rights' jurisdiction. Therefore, a Bay site may not (depending on the location) and an ocean site would not require a water right permit issued by the SWRCB.

2.4 NONPERMITTING AGENCIES

2.4.1 U.S. Fish and Wildlife Service

The USFWS would be involved with the project for any consultation requirements in accordance with Section 7 of the Federal Endangered Species Act. In the absence of a "may affect" or "adverse effect" determination, the USFWS's role would be limited to providing comments, expert advise or information to the agencies. If listed species could be adversely affected (i.e., a "take" as defined under Section 7), then the opinions and findings of USFWS must be addressed, and formal Section 7 consultation and review would need to be conducted.

2.4.1.1 Potential Issues Involved

USFWS would be formally requested (through a letter) to provide a list to the agencies of the potential species of concern within the project region. For each species that is potentially present within the region (based on known occurrences or potential habitat present), documentation will be needed to describe and analyze the potential for adverse effects and whether any adverse effects can be minimized or avoided. Federally listed species that would be of concern would be winter and spring run chinook salmon, steelhead, and coho salmon. Delta smelt and Sacramento splittail would also be of concern, particularly at the North Bay and Delta locations. Other terrestrial species may be of concern, depending on project alternatives. The following steps would be required to comply with the Federal Endangered Species Act:

- **Special Studies.** Special studies may be required to document the presence or absence of listed species, address potential impacts to those species present, and determine mitigation options necessary. These studies would be summarized in a Biological Assessment.
- **Consultation.** Informal or formal consultation would be initiated depending on the nature and extent of the anticipated impacts and species present.
- **Mitigation Plan.** A mitigation plan would be developed if it is determined that listed species could be affected.

- **Review Period.** The USFWS has a 135-day review period specified in the Endangered Species Act in which the USFWS will either concur and issue a Biological Opinion, or require additional studies. Issuance of the Biological Opinion will require concurrence from the National Oceanic and Atmospheric Administration's Fisheries (NOAA Fisheries) and the CDFG.

2.4.2 National Oceanic Atmospheric Association Fisheries

NOAA Fisheries regulates activities that have the potential to impact habitat conditions for listed threatened or endangered fish species. To that end, NOAA Fisheries reviews the Biological Assessment to determine if the impacts' assessment and mitigation are adequate for the protection of listed fish species. In addition, in accordance with the Magnuson-Stevens Fisheries Act, NOAA Fisheries will review the Essential Fish Habitat report that must be prepared for the project.

NOAA Fisheries will not necessarily prescribe studies that may need to be done. However, adequate information must be provided to show that listed species can be protected from potential project adverse effects. It is likely that some fisheries sampling for both adult and larval fish should be conducted.

NOAA Fisheries will also look very closely at project alternatives and at the purpose and need for the project to determine if there is strong need for a project that could potentially affect listed or managed fish species.

2.4.2.1 Potential Issues Involved

NOAA Fisheries will review fisheries information but would not issue a specific permit. NOAA Fisheries will issue a letter of concurrence to USFWS if proposed mitigation measures are satisfactory. This concurrence is required if USFWS needs to issue a Biological Opinion. Essential Fish Habitat recommendations are advisory only.

The primary issues that NOAA Fisheries will be concerned with for the proposed project are anadromous fish species including steelhead, winter and spring-run chinook salmon, and coho salmon. For the North Bay locations under consideration, Delta smelt and Sacramento splittail would be of particular concern. NOAA Fisheries will also be interested in species groups managed under the Magnuson-Stevens Fisheries Act, including the Pacific Coast Salmon, Coastal Pelagic Species and West Coast Groundfish groups. In addition, NOAA Fisheries has suggested that they would look carefully at potential impacts to Pacific herring. Though Pacific herring is not a listed species, it is a species of commercial importance in San Francisco Bay.

If piles are to be driven for construction of Bay/ocean water intake and/or outfall structures, noise generated during this construction activity could potentially temporarily affect marine mammals, harbor seals in particular. Under the Marine Mammal Protection Act of 1972 (and amended in 1994), it is forbidden to intentionally harass marine mammals. Harassment is defined under the Act as "any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment) or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption to migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment)." Pile driving activities would be considered Level B harassment.

NOAA Fisheries considers, as a guideline, underwater sound pressure levels at or above 160 decibels (dB) referenced to 1 micropascal (160 dB re μPa) as constituting harassment to marine mammals. Studies have suggested that sound pressure levels above 180 dB re 1 μPa can cause temporary hearing impairment in marine mammals. It is possible that NOAA Fisheries would require an Incidental Harassment Authorization before construction pile driving could begin.

2.4.3 California Department of Fish and Game

The proposed project may have the potential to affect state-listed threatened or endangered species. The CDFG would therefore participate in the project informally through the Federal Endangered Species Act Section 7 consultation process. Under Section 2090 of the Fish and Game Code, the CDFG is required to provide consultation to the USFWS for state-listed species. The USFWS would seek concurrence with CDFG. To facilitate efficiency in the consultation process, CDFG should be notified of potential impacts and mitigation to avoid impacts to special status species under its jurisdiction as soon as such details are identified and known.

2.4.3.1 Potential Issues Involved

The primary species of concern will be anadromous fish including the state-listed winter and spring-run chinook salmon. CDFG will also be concerned with potential impacts to Pacific herring because of their commercial importance in San Francisco Bay. Pacific herring spawn on hard substrates and eelgrass primarily in the central and northern portions of the Bay. Juvenile herring and eggs could be susceptible to entrainment within the intake system and to the effects of desalination reject water discharge.

2.5 OTHER REGULATIONS WITH WHICH COMPLIANCE MAY BE REQUIRED

2.5.1 Farmland Protection Policy Act

Compliance with the Farmland Protection Policy Act would be required if the project is located on federal land, permitted by a federal agency, or funded using federal money and involves prime or unique farmland as identified by the Natural Resources Conservation Service.

2.5.2 Executive Order 11990 (Protection of Wetlands)

If the project is located on federal land or supported by federal funds and may affect wetlands, compliance with Executive Order 11990 would be required.

2.5.3 Executive Order 11988 (Floodplain Management)

If the project is supported using federal funds and may affect a floodplain, compliance with Executive Order 11988 would be required.

2.6 RECENTLY PERMITTED DESALINATION PLANTS

2.6.1 Alameda County Water District Desalination

Alameda County Water District is beginning operation of a 5 MGD desalination facility in Newark, California. Brackish water from wells currently operated by the County is used as feedwater for the RO desalination plant. The product water is blended with harder water pumped from other parts of the groundwater basin to maintain a uniform water hardness throughout the year and throughout ACWD's service area.

According to ACWD, the issue of releasing reject concentrate into the local flood control system was the key environmental concern. To facilitate the NPDES permit process, ACWD tested a pilot project and obtained actual water quality data. Since the wells provided the source water for the desalination project, the NPDES permit was issued under the rubric of an existing permit the County had for well discharges. However, when the permit is scheduled for renewal in 2005, the County anticipates that a new and separate may be required by the RWQCB. Having the NPDES permit also facilitated the process of obtaining other permits from agencies including USACE and CDFG.

2.6.2 Tampa Bay Seawater Desalination Plant

The Tampa Bay Seawater Desalination Plant is co-located with the Tampa Electric Company's Big Bend electrical plant in Florida. The plant is designed to treat 44 MGD of seawater to produce 25 MGD of potable water, discharging 19 MGD of concentrated reject water that is mixed with up to 1.4 billion gallons of cooling water from the Big Bend Power Station before being returned to the bay.

Numerous environmental studies were undertaken by the developer, demonstrating that effects to the marine ecology or biology were the key concerns. The following conditions affected the project costs and permitting time:

- Mandatory environmental feasibility studies (before decision that seawater desalination project was viable and could be permitted, conducted extensive scientific impact analyses)
- Source and product water qualities (lower salinity equals lower costs)
- Intake/discharge design (shorter distance equals lower costs)
- Delivery/transmission distances (shorter distance equals lower costs)
- Land/facility (co-locating with conventional power plant site equals lower costs and favorable permitting)
- Citizen acceptance (longer time delays if organized activist groups oppose the facility and appeal associated permits)

The permitting process started in December of 1999, and the final permit was issued in November of 2001. Twenty-three permits were obtained. Given the environmental issues, the NPDES permit was the most challenging to obtain. After a thorough review and a number of conditions set, Florida's Department of Environmental Protection issued an NPDES permit. This permit was later contested in court, but the judge found on behalf of the project proponents, stating the developer evidenced "that its discharge would not adversely affect the propagation of fish, wildlife or other aquatic species."

3.1 INTRODUCTION

Nine sites were identified for desalination plants around the Bay in the RFP, and another four sites were added to this list after considering thirteen additional potential sites. Table 3-1 shows the names and locations of these sites.

Table 3-1
Site Identification and Selection for the Bay Area Desalination Project

Identified Sites	Within Service Area of Agency
C&H Sugar, Crockett	EBMUD
Mirant Contra Costa Plant, Antioch	CCWD
Mirant Pittsburg Plant, Pittsburg	CCWD
Palo Alto	SCVWD
Pico Power Plant site, Santa Clara	SCVWD
Los Esteros Power Plant Site, San Jose	SCVWD
Treasure Island Site, San Francisco	SFPUC
Oceanside, San Francisco	SFPUC
BDLP 1&2 at Dumbarton Point, San Francisco	SFPUC
San Francisco Airport	SFPUC
Mallard Slough, CCWD	CCWD
Barge Mounted Plant	All
Near Bay Bridge	EBMUD

3.2 DESALINATION PROCESS

In designing an RO treatment system, a number of unit operations are placed in series with the RO system to adjust the water chemistry for optimal performance. The most important considerations are the feedwater entering the system and the quality of the product water leaving the treatment process.

Desalination involves the removal of salts from saline water. This is achievable by various processes. The worldwide largest amount of installed desalination capacity for seawater and highly saline water desalination is the use of multistage flash distillation (MSF). This process is commonly used in the Middle East where seawater desalination is a common means of water production. However, this process is most advantageous if it is combined with a power plant, as the process requires both thermal energy and electrical energy. Reverse osmosis (RO) is increasingly being used for seawater desalination in the Middle East and throughout the world because of its economic improvement and energy efficiency. Significant RO performance and economic improvements have been made in the last 30 years. For this study, RO is the desalination process to be considered.

The RO process is illustrated on Figure 3-1. The treatment steps are:

- Feedwater enters a pretreatment process
- The treated feedwater is pressurized prior to entering the RO process. The process produces two streams: a brine and a low salinity product water
- Some of the first pass RO product water is sent to a second pass RO for additional desalting
- The first and second pass RO product water receives post treatment
- Energy recovery from the first pass brine
- Brine disposal
- Reject form the second pass is fed to the first pass. This is done because the second pass is fed with low salinity water from the first pass, and therefore the reject from the second pass is less saline and dilutes feedwater.

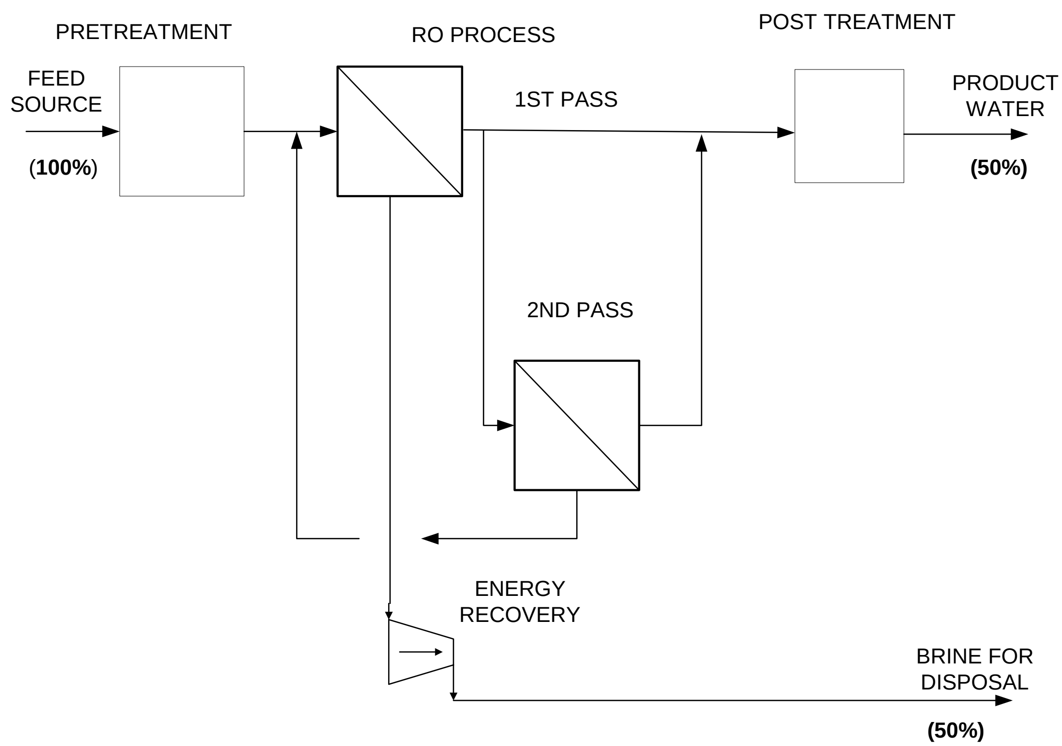

Figure 3-1 Reverse Osmosis Process

Pretreatment is required to remove foulant and scale producing constituents that can harm the RO membranes. For seawater, the pretreated water is pressurized to approximately 800 to 1200 pounds per square inch so that it can be forced through the RO membrane (lower salinity waters require less pressure). The RO membrane allows low salinity product water to pass through the membrane while the remaining water exits the process with the concentrated salt solution. In the event the product water does not meet the water quality standard, then some of the product water can be further treated with another RO membrane, a “second pass.” This RO process operates at much lower pressure (typically 200 to 400 psi). Treated water is then combined with the higher salinity first pass product water, prior to post treatment that adjusts the water quality to meet system scale and corrosion requirements.

The concentrated salt solution from the first pass, “brine,” contains the salts in the feedwater that were rejected by the RO membranes. This “brine” solution remains at nearly the same as the feed pressure, and, as a result, this stream can be used in an energy recovery device to recover energy. Very high efficient energy recovery devices have been developed that have enhanced the economics of RO desalination by lowering the energy requirements.

Recovery ratio is defined as the amount of product produced from feedwater. A 50 percent recovery ratio is common for seawater systems. For every 2 gallons of feedwater, one gallon of product water is produced. Brackish water RO desalination plants can achieve much higher recoveries. Typically a 75 percent recovery ratio can be achieved. In this case, 3 gallons of product water can be produced from 4 gallons of feedwater.

High recovery ratios are achieved through multiple stages in the membrane array configuration. A membrane array is a series of membrane elements arranged in stages with a decreasing number of membrane elements in each succeeding stage. The greater the number of stages, the higher the recovery rate.

The boxes that represent the RO process in Figure 3-1 are units of membrane arrays, which can consist of several stages. An example is a three-stage system with the number of elements in a ratio 4:2:1 going from stage 1 to stage 2 to stage 3. This example is presented in Figure 3-2. An arrangement like the one in the figure would typically be used for groundwater or brackish water desalination.

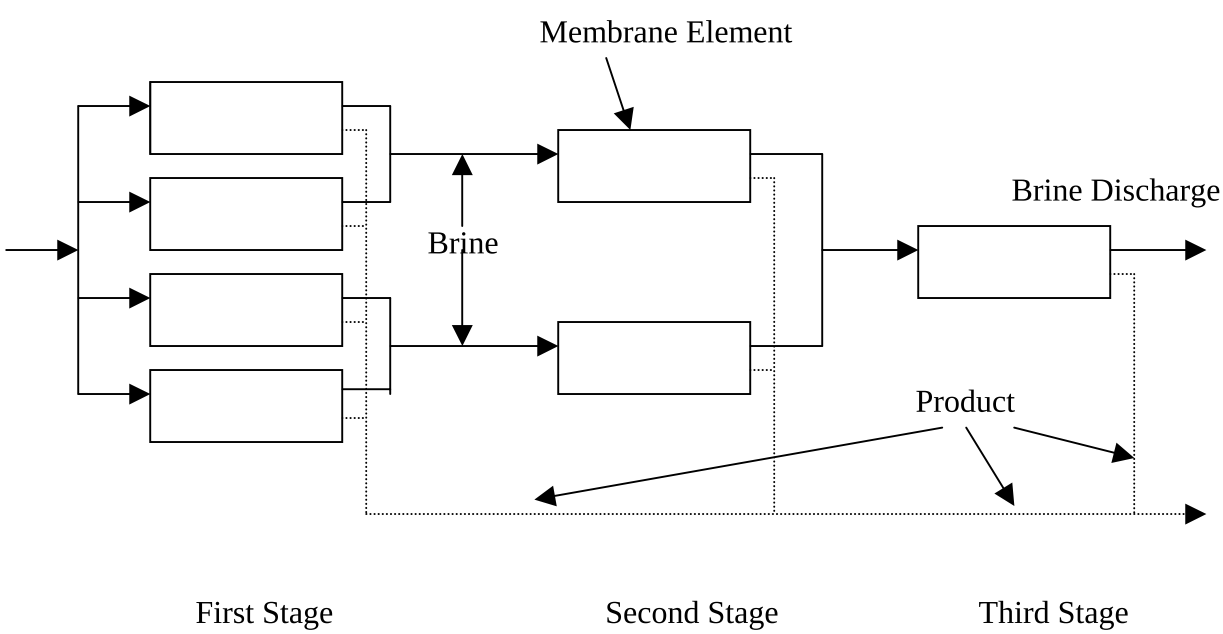

Figure 3-2 Example of a Membrane Array with Three Stages

In Figure 3-2, feedwater enters the system on the left and goes through 4 elements in the first stage. Product water from the first stage is collected and brine goes to the second stage. The second stage has only 2 elements because approximately 50 percent of the feedwater has already been retrieved as product from the first stage. Product water leaving the second stage is collected, and the increasingly saline brine is sent to the third stage, where the last product water is produced. Brine is discharged after the third stage.

Assuming a 50 percent recovery rate per membrane element, the theoretic maximum recovery rate for this arrangement would be 87.5 percent. However, due to pressure losses, a membrane array with three stages usually achieves recovery rates between 75 and 85 percent.

The study guidelines stated that a 120 MGD plant be considered. A listing of seawater RO plants is shown in Table 3-2. It can be seen that 120 MGD plant would be the largest seawater RO plant in the world. Typical performance values for a 120 MGD RO process are shown in the Table 3-3.

Table 3-2
Seawater RO Plants

Location	Plant Size (MGD)	Comments
Medina/Yanbu, Saudi Arabia	33	Largest operating plant
Jeddah, Saudi Arabia	15	Operating since 1988
Tampa, Florida	25	Recently began operation
Point Lisas, Trinidad	29	Largest operating plant in western world
Ashkelon, Israel	72	Not yet operating
Singapore	36	Not yet operating
Abu Dhabi	60	Not yet operating

Table 3-3
Typical Performance Parameters for a 120 MGD Seawater Desalination Facility

Parameter	Units	Value	Comments
Energy	MW	<90	Based upon 18 KwHr/1000 gallons. Better energy efficiency is expected which lowers the power requirement.
Feed flow	MGD	240	Assumes 50% recovery ratio
Brine flow	MGD	120	One half the feedflow at 50% recovery ratio. For brackish water a 75% recovery ratio will be used.
Brine concentration	TDS	2X	Approximately 2 times the feed concentration
Recovery ratio	%	50	Ratio of product to feed flow
Area	Acres	20	Extrapolation of Figure 10-51[1], less space could be required with multistory construction

(1) Desalination Handbook for Planner, U.S. Bureau of Reclamation, to be published.

3.3 FEEDWATER CHARACTERISTICS

Feedwater composition varies substantially from site to site, ranging from seawater with 35 (practical salinity units) (psu) at the Oceanside site to brackish water with 0 to 1.8 psu at the mouth of the San Joaquin River (Mirant Contra Costa Plant site in Antioch). In addition to the surface water intake sites, three sites in the South Bay have groundwater with low salinity that could be used as feedwater.

Practical salinity units were adopted in the United Nations Educational, Scientific and Cultural Organization Practical Salinity Scale of 1978 when techniques to determine salinity from measurements of conductivity, temperature and pressure were developed. The practical salinity is defined in terms of the ratio K of the electrical conductivity at 15° Celsius and one atmosphere, to that of a potassium chloride (KCl) solution, in which the mass fraction of KCl is 0.0324356, at the same temperature and pressure. The K value exactly equal to one corresponds, by definition, to a practical salinity of 35 psu.

Bay water composition analyzed from water samples taken at different locations were compiled from the San Francisco Estuary Regional Monitoring Program (RMP). The monitoring program collects samples 1 meter below the water surface. Six stations were chosen for their proximity to the sites in consideration for this project. The RMP data are summarized in Table 3-4. It must be noted that several important parameters in the design of a RO system, such as calcium, chloride, barium, strontium, turbidity, and silica were not available in the RMP. The location of the RMP stations selected to characterize feedwater are presented on Figure 3-3.

The sites that will be using groundwater are all in the Santa Clara Valley, and groundwater quality data were retrieved from the SCVWD 2001 Groundwater Conditions report. A summary of groundwater quality data is presented in Table 3-5. It is important to understand the aquifer's behavior in order to predict changes in feedwater quality and to assess the capacity of the aquifer to prevent saltwater intrusion.

Raw water quality summary data for Mallard Slough were provided by the CCWD to URS. The data are summarized in Table 3-6.

The water quality tables show that the Bay has a much higher variability than groundwater for every parameter, which can potentially create problems in the design of the RO system. These problems might be overcome by designing for worst-case conditions, which would lead to higher costs and could potentially determine the feasibility of a desalination plant in a particular site.

Ocean water quality data for a limited number of parameters were provided by the Oceanside site. The data were collected below surface level at approximately 4 miles offshore. Default ocean water composition was used to estimate values for the rest of the parameters in order to assess the sites that would be using ocean water. Ocean water quality data are presented in Table 3-7.

Water quality data for Mallard Slough were provided by CCWD in the form of five annual tables corresponding to years 1996 through 2000. The tables present monthly data and annual averages for each parameter, not specifying the number of samples that were taken each month. Table 3-6 presents the maximum and minimum values found over the 5-year period as well as the 5-year average for each parameter.

INSERT FIGURE 3-1

Figure 3-3 RMP Sampling Stations

Table 3-4
Feedwater Quality Data from the RMP

		Conductivity (µmho)	Salinity (psu)	DO (mg/L)	DOC (µg/L)	Hardness (mg/L)	pH	Phosphate (mg/L)	Silicates (mg/L)	TSS (mg/L)	Temperature (°Celsius)
San Joaquin River	Avg	620	ND	9.02	3,042	119	7.58	0.07	5.68	30.14	16.85
	Max	3,610	1.80	11.20	6,534	530	8.10	0.17	14.50	70.00	23.70
	Min	110	0.00	7.30	1,671	43	6.30	0.01	0.10	11.10	9.50
Davis Point	Avg	59,261	13.01	8.86	2,204	1,878	7.76	0.08	4.19	70.99	15.46
	Max	922,400*	22.20	11.90	3,856	4,200	8.00	0.14	10.80	443.00	20.30
	Min	110	3.80	5.60	1,405	48	6.90	0.03	0.10	10.30	9.60
Yerba Buena Island	Avg	34,682	23.62	8.77	1,741	NA	7.93	0.08	2.40	9.53	15.18
	Max	47,030	30.40	13.10	2,835	NA	8.30	0.18	5.00	36.00	19.00
	Min	16,500	13.20	6.20	1,095	NA	7.60	0.01	0.10	2.30	10.80
Alameda	Avg	34,822	24.26	8.40	1,911	NA	7.98	0.11	2.50	11.07	15.61
	Max	48,600	31.10	11.10	3,795	NA	8.30	0.22	6.20	55.70	21.00
	Min	17,000	13.50	5.80	1,165	NA	7.70	0.02	0.10	0.30	10.70
Oyster Point	Avg	34,280	24.12	8.43	1,868	NA	7.84	0.11	2.35	9.77	15.52
	Max	47,080	31.00	11.70	3,195	NA	8.40	0.26	5.60	39.40	21.00
	Min	17,000	15.30	6.00	1,291	NA	7.30	0.04	0.00	1.00	10.00
South Bay	Avg	30,935	20.78	7.67	2,957	4,230	7.94	0.32	3.63	39.10	17.54
	Max	43,200	28.10	10.00	4,024	5,190	9.90	0.61	9.60	147.90	24.00
	Min	12,380	12.30	5.50	1,634	2,960	7.60	0.07	0.40	6.00	10.60

* This extremely high value is likely a mistake on the RMP web site. The value was probably 92,240 µmho, which would make an average of 23,167 umho for the Davis Point station.

µmho = micromhos, psu = practical salinity units, mg/L = milligrams per liter, µg/L = micrograms per liter

Table 3-5
Groundwater Quality from the SCVWD

Constituent	Units	Santa Clara Valley Subbasin Upper Aquifer Zone
Aluminum	µg/L	<50
Arsenic	µg/L	<2
Barium	µg/L	<240
Beryllium	µg/L	<1
Boron	µg/L	144–264
Bromide	µg/L	0.17–0.46
Cadmium	µg/L	<1
Calcium	mg/L	67–109
Chloride	mg/L	56–107
Chromium	µg/L	<10
Copper	µg/L	<50
Fluoride	mg/L	<0.18
Hardness	mg/L	373–555
Iron	µg/L	<67
Lead	µg/L	<5
Magnesium	mg/L	34–70
Manganese	µg/L	<538
Mercury	µg/L	<1
Nickel	µg/L	<10
Nitrate as NO3	mg/L	<9
Selenium	µg/L	<5
Silver	µg/L	<10
Sodium	mg/L	43–154
Conductivity	µS/cm	721–1360
Sulfate	mg/L	35–231
TDS	mg/L	520-860
Zinc	µg/L	<50

Table 3-6
Summary of Water Quality for Mallard Slough (1996–2000)

Contaminant	Units	Max	Min	Avg
Turbidity	NTU	146	4.09	24.1
Calcium	mg/L	276	3.9	35.2
Magnesium	mg/L	190	5.6	78.7
Sodium	mg/L	1600	10	595.2
Chloride	mg/L	**3100**	13	776
Potassium	mg/L	200	1.2	20.2
Sulfate	mg/L	420	10	151.5
Nitrate	mg/L	3.7	0.23	1.56
Phosphate	mg/L	3.4	<0.2	0.31
Silica	mg/L	23	13	17
Hardness	mg/L	**960**	36	**295**
PH	–	8.4	6.22	7.67
Alkalinity	mg/L	82	22	61.61
Conductivity	µmhos/cm	9550	130	2792.2
TDS	mg/L	**5737**	70	2137.8
Ammonia	mg/L	0.25	<0.1	0.1
TOC	mg/L	5.7	0.5	2.7

Table 3-7
Seawater Composition to Be Used at the Oceanside Site

Parameter	Unit	Concentration in Sea Water
Sodium	mg/L	10,765
Potassium	mg/L	398
Calcium	mg/L	412
Magnesium	mg/L	1,275
Strontium	mg/L	7.9
Barium	mg/L	0.014
Lithium	mg/L	0.17
Silicon	mg/L	2.8
Aluminum	mg/L	$5.4x10^{-4}$
Iron	mg/L	$6x10^{-5}$
Manganese	mg/L	$3x10^{-5}$
Boron	mg/L	4.6
Chloride	mg/L	19,385
Sulfate	mg/L	900*
Bromide	mg/L	67
Ammonia**	mg/L	<0.05
Total Suspended Solids**	g/L	8.8
Oil and grease**	mg/L	<5
DOX	mg/L	7.95
Temperature**	C	11.6
pH**	pH units	8.03
Salinity**	psu	35.95

Notes: Typical seawater concentration estimated from Bruland (1983).

* Value is for sulfur

** Data provided by the Oceanside Site, sampled right below surface level at about 4 miles offshore, from their last sampling event in December 1996.

Water quality data in Mallard Slough present very high variability because of the wide range of Delta outflows and seawater intrusion during low Delta outflows. When outflows are high, brackish water is pushed back into San Pablo Bay, causing the water quality at Mallard Slough to be close to that of the Sacramento River.

High seasonal variability exists, and water in the Delta usually presents low salinity during the winter and higher salinity in the fall. An example of this variability is for year 1997, when the concentration of total dissolved solids (TDS) in February was 110 milligrams per liter (mg/L). In October, it reached 5,737 mg/L.

Variability also exists among years, with water in the Delta having a higher salinity during dry years than during wet years. For example, in 1998 (an El Niño year), the TDS concentration in October was only 224 mg/L, while October TDS concentrations usually exceed 4,000 mg/L.

3.4 PRETREATMENT

Source waters need to be pretreated to preserve membrane integrity. The most commonly used pretreatments in desalination processes are scale control and prefiltration.

3.4.1 Scale Control

As product water that is relatively low in solutes passes through the membranes, the remaining feedwater becomes increasingly concentrated in dissolved solids. This can result in precipitation of salts for which the solubility limit is exceeded. Scaling can reduce the flow of permeate and irreversibly damage the membranes.

Common salts that can precipitate and foul the membranes are calcium carbonate ($CaCO_{3)}$, calcium sulfate ($CaSO_{4)}$, barium sulfate ($BaSO_{4)}$, strontium sulfate ($SrSO_{4)}$, and silica ($SiO_{2)}$. Bay water and ocean water have very high concentrations of cations and ions that can form the salts of concern. RMP data show very high water hardness around the Bay (4,230 mg/L average at the South Bay station) especially when compared to default ocean water hardness (around 1,700 mg/L). The San Joaquin River station, however, shows low hardness (average of 119 mg/L).

Adding an acid to source water can prevent the formation of calcium carbonate and magnesium scales by converting carbonate ions to bicarbonate ions, which can subsequently be converted to carbonic acid and carbon dioxide during acidification. Acidification would probably be necessary to some extent for every site that is being considered, however potentially to a less extent for the two Mirant sites in the Delta.

Antiscalants inhibit the rate of formation of crystals by interacting with the compounds as they start to form crystals. Feedwater then flushes the particles from the membrane surface. This method is the most widely used to prevent crystalline scales. A more detailed study would be needed to determine if sites such as the Mirant sites in the San Joaquin River and the three sites that use groundwater in the South Bay could control scaling by adding antiscalants, thereby reducing the need for acidification.

There are other methods for scale control, such as cation exchange softening, lime softening, aeration and filtration and oxidation filtration, but these methods are either not applicable for ocean or Bay water or very expensive. For sites that will potentially use high salinity water, designing a plant with a low recovery rate (ratio between permeate and concentrate volumes) can limit scale formation, since the brine will present lower salts concentrations than for a high recovery rate plant. The recovery rate could be set so that solubility for the different salts is not exceeded in the concentrate. However, this does lower the total product water produced relative to the volume of intake water.

3.4.2 Silt and Colloidal Fouling Control

Deposition of silt or other suspended solids on the membranes can cause fouling. For some types of feedwater, particulate matter can be so small that filtration alone is not sufficient to protect the membranes. In these cases, adding chemicals to coagulate the colloidal particles is necessary. Coagulants destabilize colloidal particles, neutralizing them. Once neutralized, the particles agglomerate and are removed by filtration.

There is no particulate size distribution in the compiled feedwater compositions. However, it can be assumed that most stations in the Bay have fine particles and would use coagulants. Most plants that use groundwater do not need the use of coagulants, and some large seawater plants have been able to avoid the use of coagulants by drawing their water from beach wells. For the identified sites that are expected to use already existing surface water intake structures, the use of coagulants should be taken into account.

An alternative to using coagulants could be microfiltration (MF) or ultrafiltration (UF) upstream of the RO membranes. The technical and cost evaluation to choose between the use of coagulants or MF/UF should be done on a site-specific basis.

The Marin Desalination Pilot Plant studied several pretreatment systems and identified two systems that could control membrane fouling (MMWD 1991). The two successful pretreatments were ultrafiltration and flocculation followed by a gravity settler and two stage filtration. Pretreatments such as antiscalants or acidification were not considered in the Pilot Plant Study.

3.4.3 Prefiltration

Particulate matter can include sand, rust particles and other corrosion by-products. The identified sites would need to use micron-sized prefilters to protect the downstream membrane from fouling and mechanical damage caused by particulate matter. Prefiltration is usually done by using cartridge filters in pressure vessels.

3.4.4 Biological Fouling Prevention

The interior of the membranes is an ideal place for microorganisms to grow. Membranes that sit out of service for more than a day should be flushed with pretreated water daily. Identified sites that use surface water are more likely to present problems related to biological fouling.

Continuous chlorination might be necessary for waters with high levels of microorganisms, and this can determine the type of membrane to use since not all membranes are resistant to chlorine. Chlorination can increase the amount of disinfection by-products that are later rejected by the RO membranes. For waters with lower levels of microorganisms, periodic shock treatments with high chlorine doses may protect the membranes.

An alternative to chlorination is UV disinfection. UV disinfection is an effective treatment against most waterborne diseases. This technology uses UV lamps, and disinfection is achieved when the UV light output is sufficient to modify nuclei of microorganism's cells so they cannot reproduce.

3.5 REVERSE OSMOSIS

In RO processes, water is forced through a membrane by a pressure differential, and dissolved salts pass through the membrane because of a concentration differential. The membrane is semipermeable, meaning that water and salts are transported to differing degrees through the molecular structure of the active surface layer of the membrane.

The RO process can remove more than 99 percent of all dissolved minerals and organic compounds, as well as biological and colloidal suspended matter, from water.

Flow characteristics are a function of the membrane polymer. A bigger membrane area will result in higher water flows, and a thicker membrane will give less water flow than a thinner membrane of the same polymer. The pressure applied to the system and the concentration differential across the membrane are parameters that can be adjusted by the end user.

3.5.1 Membranes

Reverse osmosis membranes are classified according to type, material used, and configuration or packaging. The two basic types currently used are asymmetric homogenous and composite. The two basic materials are cellulose acetate and aromatic polyamides. The two most prominent configurations are sheet membrane in a spiral-wound device and hollow fiber in a U-tube device.

Cellulosic membranes have major limitations, mainly because the material hydrolizes over a period of time, resulting in a loss of efficiency. Optimal feedwater pH is approximately 5, and pH should be maintained between 4.5 and 6.5. High volumes of acid would need to be used to bring the feedwater pH to these levels since feedwater in the Bay Area tends to be well buffered, thus adding to the overall cost of the process. Warmer water temperatures also accelerate hydrolysis.

Aromatic polyamide membranes can operate in a much wider range of pH (from 4 to 11). Polyamide membranes have limited resistance to chlorine. There is a potential for biological fouling for all surface water intake sites and chlorination can be required to control biological fouling. Continuously chlorinated feedwater would need to be dechlorinated if polyamide membranes are to be used. An alternative to chlorination would be the use of UV disinfection devices instead of chlorination, which would eliminate the problem of membranes not being resistant to chlorine.

Asymmetrical membranes are subject to compaction and the resulting loss in productivity. Compaction happens when the porous spongy substrate of the membrane gradually compresses, mainly as a result of the applied pressure, thus compaction effects (lower water flux) tend to be more pronounced in high-pressure seawater RO. Composite membranes have an ultrathin layer that acts as the salt barrier and is supported by a microporous layer that does not compact. The barrier layer is usually made of polyamides, thus presenting limited tolerance to chlorine.

3.5.2 Membrane Array Configuration

The recovery rate is the ratio between the permeate and the feed volumes, and it is usually expressed as a percentage. The recovery rate is a design parameter and should be identified for each of the sites depending on the concentrate disposal options and feedwater characteristics. For sites with feedwater high in TDS, a high recovery rate will result in very concentrated brine reject that can exceed the solubility limits for several salts, thus fouling the membranes. A very concentrated brine can also pose important environmental concerns. Sites using ocean or Bay water will have low recovery rates (50 percent or less), while sites using groundwater or brackish water can achieve much higher recovery rates. High recovery rates are important to achieve when using a finite water source like a groundwater aquifer.

In the design process, an assumed maximum flux is usually set so that undue fouling rates are prevented. A flux greater than the maximum flux would result in higher concentration of salts by the membrane, potentially causing scaling. This flux ranges up to 16 gallons per day per square foot (gpd/ft^2) for spiral-wound membrane elements for fresh and brackish sources, and up to less than 1 gpd/ft^2 for hollow fiber membranes. Membrane trains are limited to approximately 2.5 MGD for seawater systems.

The membrane array configuration for the sites where groundwater is expected to be the source water will probably need to have three stages, in order to maximize the recovery rate and not to overpump the aquifers. As illustrated on Figure 3-2, a membrane array configuration with three stages can achieve recovery rates greater than 75 percent.

In the other sites around the Bay, a single-stage configuration will result in less concentrated brine discharges and less potential membrane fouling through scaling. These sites may require a second pass (i.e., water passes through the membrane array twice before becoming permeate, as shown in Figure 3-1) to meet product water quality objectives.

3.6 POST-TREATMENT

Reverse osmosis processes produce corrosive finished waters because they lower the pH and remove too much calcium and alkalinity. Produced water is thus not buffered or stabilized and needs post-treatment before distribution. The following describes the primary post-treatment operations.

3.6.1 Alkalinity Recovery

Alkalinity concentration provides an indication of a water’s resistance to pH changes when an acid is added. Alkalinity in natural waters is mostly composed by hydroxide, carbonates, and bicarbonates. It is generally recommended to have an alkalinity greater than 40 mg/L to provide pH stability.

The feedwater pH is lowered to a level between 5.5 and 7 during the RO process to prevent calcium carbonate from precipitating in the membrane. A substantial amount of the alkalinity has been converted to carbon dioxide as a result of the acidification pretreatment. Carbon dioxide passes through the membrane and then becomes the source of inorganic carbon for the desired finished alkalinity.

Carbon dioxide is converted into alkalinity by raising the pH of the permeate. This should be done before gas stripping, because gas stripping emits carbon dioxide to the atmosphere, thereby losing the source of inorganic carbon needed for the alkalinity recovery. If gas stripping is done before the alkalinity recovery, caustic should be used to stabilize the permeate, and this results in poorly buffered finished waters. However, the optimal arrangement can be site-specific, and conducting gas stripping before alkalinity recovery can sometimes be the best option. Sources of alkalinity include sodium hydroxide, calcium hydroxide, or filtration through calcium carbonate.

3.6.2 Gas Stripping

Degasification or gas stripping is sometimes required to remove gases such as carbon dioxide and hydrogen sulfide. Using groundwater sources can result in the presence of hydrogen sulfide in the permeate (which is responsible for bad tastes and odors).

There are several types of equipment for gas stripping, including aeration or gas transfer equipment. The most commonly used being tray aereators, air strippers and packed towers. Most modern RO facilities use packed towers for gas stripping, since they are the most efficient for hydrogen sulfide removal and pH recovery. Packed towers consist of a cylindrical shell containing a plate that supports the packing material (plastic materials in various shapes can be used as packing material), with water and gas flowing in a countercurrent pattern.

Seawater sources usually do not contain carbon dioxide or hydrogen sulfide. Air stripping might not be needed for all the proposed sites, if another post-treatment is chosen for pH recovery.

3.6.3 Disinfection

Chlorine is added to the product water for disinfection to destroy pathogenic microorganisms, providing an adequate residual within the distribution system. RO permeate waters do not need a lot of chlorine due to a low chlorine demand. The reduced chlorine demand is a result of the process having already rejected disinfection by-products and other oxidizable materials that if present would require higher chlorine doses to maintain the adequate residual levels in the distribution system.

3.6.4 Stabilization and Corrosion Control

A finished water is considered stable when it is neither undersaturated nor supersaturated with respect to calcium carbonate. Methods to stabilize a corrosive permeate include degasification to remove gases and raise the pH and adding chemicals such as lime to increase alkalinity and hardness.

3.7 EXAMPLES OF DESALINATION PRODUCT WATER QUALITY

Tables 3-8, 3-9, and 3-10 present typical water quality for RO membrane processes that use seawater, brackish water, and groundwater, respectively. The third column in the tables is the RO permeate quality before post-treatment, and the fourth column presents the RO rejection rate for each parameter, and the last column presents finished water quality (i.e., after post-treatment and ready for distribution). These examples have been taken from the AWWA Reverse Osmosis and Nanofiltration Manual (AWWA 1999).

Table 3-8
Water Quality for Seawater RO

Parameter	Source (Florida) (mg/L)	Permeate (mg/L)	Rejection (%)	Finished (mg/L)
Calcium	400	1.4	99.65	1.4
Magnesium	1292	4.6	99.64	4.6
Sodium	10734	105	99.02	109.7*
Potassium	385	3.4	99.38	3.4
Strontium	14	0	100	0
Bicarbonate	144	4	97.2	16.6
Sulfate	2688	9.6	99.64	9.6
Chloride	19336	171.6	99.1	171.6*
Fluoride	1	0	100	0
Carbon dioxide	2.4	8.9	Not Applicable	0.14
TDS	35000	299.6	99.14	316.9
pH	8	5.9	Not Applicable	8.2

Results obtained for 50 percent recovery, 1,000 pounds per square inch gauge, 20°C.
* Anything above 100 mg/L can be tasted by the average person

Table 3-8 presents results for a plant in Florida, designed for 50 percent recovery (i.e., one single stage in the membrane array configuration), 1,000 pounds per square inch gauge and 20°C. By comparing the quality of the RO permeate and the finished water it can be inferred that some post-treatment was also applied. In particular, the table shows an increase in pH, a decrease in carbon dioxide, and an increase in bicarbonate, which can be the result of post-treatments such as gas stripping and stabilization. Gas stripping is usually not necessary for seawater desalination since hydrogen sulfide is normally not present in seawater. However, hydrogen sulfide is found off the Florida coast. Levels of chloride and sodium are higher than what is currently being distributed in the Bay Area, and a second pass (see Figure 3-1) would make those levels acceptably low.

Table 3-9 shows an example for RO technology applied to brackish water in southwest Florida. Comparing the pH values in the source and the permeate columns shows how the RO process results in acidic waters (lower pH value).

Table 3-9
Water Quality for Brackish Water RO

Parameter	Source (mg/L)	Permeate (mg/L)	Rejection (%)	Finished (mg/L)
Calcium	131	2	98.5	2
Sodium	1725	125	92.8	129*
Chloride	2978	193	93.5	193*
Bicarbonate	197	14.3	92.7	20.1
Carbonate	0.2	0	100	0
TDS	5736	351	93.9	360
pH	7.4	5.6	Not Applicable	8.3

Post-treatment includes degasification, caustic, orthophosphate, and chlorine addition.
* Anything above 100 mg/L can be tasted by the average person.

Table 3-10 presents data for a brackish water aquifer RO plant in coastal Florida. In this case, post-treatment included lime addition and gas stripping. The effects of post-treatment are a decrease in carbon dioxide and an increase in calcium, TDS, carbonate, and pH. Groundwater desalination usually involves several RO stages to achieve a high recovery rate, and in this example it can be seen how low TDS levels can be achieved in the RO permeate.

Table 3-10
Water Quality for Groundwater RO

Parameter	Source (mg/L)	Permeate (mg/L)	Rejection (%)	Finished* (mg/L)
Calcium	102	3.5	96.6	32
Sodium	235	39	83.4	42
Chloride	400	44	89	50
Bicarbonate	215	7	96.7	8.3
Carbonate	0	0	Not Applicable	5.2
Carbon dioxide	6	57	Not Applicable	0
TDS	983	65	93.4	255
pH	7.8	5.5	Not Applicable	8.3

*Permeate is mixed with lime-softened water after gas stripping.

Table 3-11 shows the results from the MMWD desalination pilot plant. The pilot plant operated for three months in 1990, and pretreatment consisted of gravity settler followed by two-stage filtration. It was found that single-pass RO would not meet water quality targets established by MMWD, but two-pass RO was shown to be sufficient. Limestone treatment was used as post-treatment, and carbon dioxide or acid injection prior to limestone treatment was recommended for a full-scale plant. Table 3-11 shows how a second RO pass can reduce chloride and sodium levels to meet current drinking water quality.

Table 3-11
Water Quality for Marin Pilot Plant

Parameter	Source (mg/L)	First RO pass (mg/L)	Rejection (%)	Finished water* (mg/L)
Hardness	120	9	92.5	22
Alkalinity	Not Monitored	4.4	Not Applicable	22
Chloride	16,947	109	99.4	23
Sodium	8,202	71	99.1	14
TDS	30,000	225	99.3	138
pH	7.9	5.8	Not Applicable	7.7

* Finished water includes a second RO pass and limestone post treatment.

3.8 PRODUCT WATER REQUIREMENTS

The goal for the desalination plants is to produce drinking water with similar quality to the water that is currently being provided by the municipal utilities. If RO water does not meet the quality of distributed water, it could be used as a raw water source to water treatment plants, but this would be an expensive solution. Four water agencies serve the areas where the sites have been identified: SFPUC, EBMUD, CCWD, and SCVWD. Each agency has water quality standards for their product water.

The USEPA and the Department of Health and Safety (DHS) also set water quality standards, called Maximum Contaminant Levels (MCL) and Secondary Maximum Contaminant Levels (SMCL). Table 3-12 presents data gathered from the four municipalities regarding their water quality standards as well as the USEPA and DHS drinking water standards.

When comparing the drinking water quality provided below to the product quality in the examples above, the only parameter that seems to be consistently higher is TDS. This means that the examples of typical RO-produced water provided in the AWWA Reverse Osmosis and Nanofiltration Manual present slightly higher levels of TDS compared to water currently distributed in the Bay Area.

TDS in the example RO product water is in the range of TDS values found in some of the drinking water that is currently distributed in the Bay Area, and it is well below the MCL standard of 1,000 mg/L. It is also important to realize that the desalination process can be tailored to site-specific conditions and requirements. For example, applying a second RO pass (i.e., sending the product water through the RO process a second time) or designing the process for higher TDS removal would achieve lower levels of TDS in the RO product water. The results from the Marin Pilot Plant show how a second RO pass can reduce TDS to levels that are similar to those of currently distributed water in the Bay Area.

For the rest of the parameters identified in the three examples, values are generally within the range found in drinking water quality data from the water districts. Table 3-13 compares typical RO water quality from the examples above and Bay Area drinking water quality. It appears that RO finished water values for sodium and chloride can be slightly higher than the existing drinking water quality in the Bay Area. Tailoring the process to reduce TDS in the product water would reduce the concentration of sodium and chloride in the finished water, as the Marin Pilot Plant results show.

Future drinking water regulations are expected to focus on total organic carbon (TOC), bromide, and Cryptosporidium. Bromide can become an issue when it transforms into bromate, which can happen when water is disinfected with ozone. A study on water quality implications of large-scale seawater desalination is being conducted by the AWWA Research Foundation and the West Basin Municipal Water District. The study has not identified water quality issues regarding TOC and bromide, and preliminary results show that chlorine boost is necessary to prevent bromamine formation. UV disinfection systems can inactivate Cryptosporidium. The USEPA is working on a guidance manual to provide states with direction on the proper installation and operation of UV systems to meet future regulations.

Table 3-12
Drinking Water Quality in the Bay Area and Quality Standards

Contaminants	Units	MCL or SMCL[(1)]	SFPUC Water Quality		EBMUD Water Quality [(14)]		CCWD Water Quality		SCVWD Water Quality [(17)]	
			Range	Avg	Range	Avg	Range	Avg	Range	Avg
Turbidity (Filtered)	NTU	0.3 [(2)]	0.06 - 0.29 [(2)]	0.08	0.05 - 0.24	0.05	0.05 - 0.08	0.07	0.03 - 0.25	0.0567
Total Trihalomethanes (TTHMs) [(3)]	ppb	80	29 - 104	58	20 - 62	41	18 - 53	36	NA	NA
Total Haloacetic Acid (HAAs) [(3)]	ppb	60	5 - 33	15	1.4 - 54.3	24.4	3 - 27	12	NA	NA
Total Haloacetonitriles (HANs) [(4)]	ppb	NS	1 - 2	2	<0.5 - 6.1	1	ND - 9.9	5.3	NA	NA
Total Coliform	%	5 [(7)]	0 - 0.7	0.2	NA	<0.3	0 - 0.61	0.1	Absent	Absent
Arsenic	ppb	50	<2 - 2 [(8)]	<2	<2 - 3.4	<2	ND	ND	2 - 3	3
Chlorate [(4)]	ppb	NS	23 - 340	150	71 - 1400	335	31 - 290	90	0 - 300	133.33
Natural Fluoride	ppm	2	<0.1 - 0.3 [(8)]	0.2	NA	NA	NA	NA	NA	NA
Nitrate (as NO3)	ppm	45	<2 - 2 [(8)]	<2	NA	NA	ND - 2.6	ND	ND - 5	3.67
Chlorine	ppm	4 [(5)]	0.01 - 2.2	0.6	NA	NA	ND - 4	2.2	NA	NA
Copper	ppb	1300 [(6)]	11 - 350 [(11)]	120 [(12)]	NA	74 [(12)]	ND	ND	<50	<50
Lead	ppb	15 [(6)]	<2 - 59 [(11)]	7 [(12)]	NA	<5 [(12)]	ND	ND	<5	<5
Iron	ppb	300	<100 - 160 [(8)]	<100	NA	NA	ND	ND	<100	<100
Chloride	ppm	500	<3 - 23 [(8)]	11	4.5 - 15	9.3	34 - 80	60	14 - 122	82.33
Specific Conductance	μS/cm	1600	8 - 340 [(8)]	195	65 - 467	205	240 - 570	480	290 - 743	532.33
Sulfate	ppm	500	0.6 - 25 [(8)]	12	1.3 - 37	17	47 - 55	52	36.6 - 71.7	54.8
Total Dissolved Solids (TDS)	ppm	1000	<5 - 190 [(8)]	104	37 - 170	102	NA	NA	160 – 341	289
Color	unit	15	<5 - 24 [(9)]	<5	NA	NA	ND - 10	ND	<2.5 - 3	<2.5
Odor Threshold	TON	3	<1 - 2 [(9)]	<1	0 - 2.8	1.2	NA	NA	NA	NA
Alkalinity (as CaCO3)	ppm	NS	13 - 120 [(9)]	63	20 - 104	51.5	56 - 117	89	57 - 156	75
Boron	ppb	NS	<100 - 180 [(10)]	<100	<100	<100	100 - 170	150	110 - 210	156.67
Calcium	ppm	NS	4 - 31 [(9)]	16	4.4 - 29.6	NA	15-26	21	15 - 24	20.33

Table 3-12
Drinking Water Quality in the Bay Area and Quality Standards

Contaminants	Units	MCL or SMCL[1]	SFPUC Water Quality Range	SFPUC Water Quality Avg	EBMUD Water Quality[14] Range	EBMUD Water Quality[14] Avg	CCWD Water Quality Range	CCWD Water Quality Avg	SCVWD Water Quality[17] Range	SCVWD Water Quality[17] Avg
Fluoride	ppm	NS	0.1 - 1.3 [9]	1	<0.1 - 0.15 [13]	<0.1	0.78 - 0.94	0.84	<0.1 - 0.1	0.1
Hardness (as CaCO3)	ppm	NS	10 - 142 [9]	64	15 - 130	NA	72 - 120	102	67 - 168	102.33
Magnesium	ppm	NS	<0.5 - 11 [9]	6	0.8 - 14.6	NA	9 - 14	12	8 - 18	14
pH	unit	NS	7.4 - 9.8 [9]	9	8.5 - 9.5	NA	8.8-9.0	8.9	6.7 - 8.2	7.6
Potassium	ppm	NS	<0.5 - 1.0 [9]	0.5	0.5 - 3.5	NA	1.9 - 3.3	2.7	1.6 - 4.4	2.9
Silica	ppm	NS	5 - 6 [9]	5	2.8 - 13	NA	NA	NA	6 - 19	12
Sodium	ppm	NS	3 - 22 [9]	13	4.3 - 28.6	NA	35 - 76	61	24 - 82	61.67

Data from the SFPUC 2002 Annual Water Quality Report, the EBMUD 2001 Annual Water Quality Report, CCWD 2002 data, and SCVWD water quality summary.
NA: Not Available. ND: Non-detect. NS: Not sampled.

(1) MCL: Maximum Contaminant Level, SMCL: Secondary Maximum Contaminant Level, both set by USEPA and DHS.
(2) Turbidity standard for unfiltered supplies is 5 NTU (from Hetch Hetchy). Filtered water turbidity must be less than 0.3 NTU 95% of the time.
(3) Compliance is based on 4-quarter running annual average of San Francisco treated water.
(4) Based on Information Collection Rule data collected in 1998 in San Francisco. CCWD 1999 data.
(5) MRDL: Maximum Residual Disinfectant Level.
(6) This number is the Action Level (AL), the 90th percentile level of copper or lead must be less than the action level.
(7) Monthly positive samples in City of San Francisco treated water.
(8) Data for untreated water from Hetch Hetchy, Calaveras, San Antonio, Lower Crystal Springs, San Andreas, Stone Dam, and Pilarcitos Reservoir.
(9) Data obtained from Alameda East, Sunol Valley, and Harry Tracy Water Treatment Plants.
(10) Data obtained from quarterly State UCMR monitoring.
(11) Data collected from 53 San Francisco residences in 2001.
(12) This number is the 90th percentile, not the average. The number should be compared to the AL, see note (6).
(13) Fluoride in the source waters. Fluoride was added in the range of 0.9 to 1 mg/l to prevent dental caries in consumers.
(14) EBMUD data is for treated water from Lafayette, Orinda, Sobrante, San Pablo, USL, and Walnut Creek plants.
(15) Public Health Goal (PHG) adopted by the State Office of Environmental Hazard Assessment (OEHHA) of the Cal/EPA.
(16) Maximum Contaminant Level Goal (MCLG) set by the USEPA.
(17) SCVWD data from Penitencia, Rinconada, and Santa Teresa Water Treatment Plant.

Table 3-13
Comparison Between Typical RO Water and Bay Area Drinking Water

Parameter	Seawater RO Finished Water (mg/L)	Brackish Water RO Finished Water (mg/L)	Groundwater RO Finished Water (mg/L)	Marin Pilot Plant Product Water (mg/L)	SFPUC Water Quality (mg/L)	EBMUD Water Quality (mg/L)	CCWD Water Quality (mg/L)	SCVWD Water Quality (mg/L)
Calcium	1.4	2	32	NA	16	NA	21	20.3
Magnesium	4.6	NA	NA	NA	6	NA	12	14
Sodium	109.7	129	42	14	13	NA	61	62
Potassium	3.4	NA	NA	NA	0.5	NA	2.7	2.9
Sulfate	9.6	NA	NA	NA	12	17	52	55
Chloride	171.6	193	50	23	11	9.3	60	82.3
Fluoride	0	NA	NA	NA	1	<0.1	0.84**	0.1
TDS	316.9	360	255	138	104	102	300*	289
pH	8.2	8.3	8.3	7.7	9	NA	8.9	7.6

RO Water compositions taken from examples provided by the AWWA RO and NF manual (AWWA M46, 1999)
NA: Not Available
* Data from CCWD 2001 Annual Water Quality Report.
** Fluoride added at the end of the process for dental health.

This section identifies potential desalination plant sites, ranks the sites by selected criteria, and identifies three sites to be carried forward for cost estimating. Detailed assessments of the sites have not been carried out. A considerably more detailed analysis will be required to define specific technical, economic, and environmental issues required to construct a desalination plant at any of these locations. A conceptual cost estimate for each of the facilities is presented in Section 5.

4.1 OBJECTIVE AND APPROACH

The objective of this section is to identify up to three sites to be carried forward for cost analysis in Section 5. Nine sites were identified in the study guidelines. The study is required to identify at least four additional sites for consideration.

Site selection for a desalination plant can be one of the most important decisions in the development process as it may have a substantial impact on cost and schedule. Site selection for a desalination facility must take into account a multitude of nontechnical factors in addition to engineering and economic factors. A systematic approach to making siting decisions, properly documented and presented, will help to avoid some of the potential impediments to the development of a successful project.

The approach is to consider cost, permitting, and other environmental/socioeconomic project considerations. These considerations are summarized numerically for each site in a common, standard format. The objective is to place the alternatives on an equal basis and to rate them for comparison. The study requirements list several relevant criteria and others have been added as a result of this study. The essential ingredients of site selection are data and subjective judgment of experienced personnel within a multidisciplinary team.

4.2 SITE IDENTIFICATION

Additional potential sites were identified as a result of meetings with the agencies during the Project Understanding phase, previous Bay Area studies, review of related material, and knowledge of local conditions.

Nine of the sites were identified in the study guidelines. The site selection process identified a total of 22 sites, which are listed in Table 4-1. These sites represent a wide range of potential locations.

Some of the sites are "generic sites" as a specific site has not yet been identified. For example, "refineries" represents any one of the refineries along the Bay. If a "refineries" site were selected, further analysis would be required to identify the specific refinery. Three of the sites were identified in an earlier study of desalination for the Bay.

Table 4-1
Potential Desalination Sites

NO.	SITE	FEEDWATER	COMMENTS

IDENTIFIED IN STUDY GUIDELINES			
1	C&H Sugar Refinery, Crockett	Bay Seawater	
2	Mirant Contra Costa Plant, Antioch	Brackish water	
3	Mirant Pittsburg Plant, Pittsburg	Brackish water	
4	Palo Alto Water Pollution Control Plant Site, Palo Alto	Brackish water	
5	Pico Power Plant Site, Santa Clara	Brackish water	
6	Los Esteros Power Plant Site, San Jose	Brackish water	
7	Treasure Island Site, San Francisco	Bay Seawater	
8	Oceanside, San Francisco	Seawater	
9	BDPL 1&2 at Dumbarton Point	Bay Seawater	
POTENTIAL ADDITIONAL SITES			
10	Near Bay Bridge	Bay Seawater	
11	Mallard Slough	Brackish water	
12	San Francisco Airport	Bay Seawater	
13	Barge-Mounted Plant	Bay Seawater	
14	Alameda Point, Alameda	Bay Seawater	
15	Russell City Power Plant, Hayward	Bay Seawater	
16	Oakland Airport	Bay Seawater	
17	“Refineries”	Bay Seawater	Any of the Bay Area refineries
18	Southeast WWTP	Bay Seawater	Located near Hunters Point
19	Richmond-Sunset WPCP	Seawater	Identified in Boyle Study. Outfall still exists. However, the WPCP has been replaced by a soccer field.
20	Hunters Point Power Plant	Bay Seawater	Identified in Boyle Study
21	Embarcadero Location	Bay Seawater	Identified in Boyle Study
22	“Power Plant Site”	Bay Seawater	Located in San Francisco

Note: “Seawater” is from the ocean and is typically about 35,000 TDS, “Bay seawater” is within the Bay and can vary considerably in salinity because of tidal action, and “Brackish water” is low salinity ground water.

4.3 INITIAL SITE SCREENING AND SELECTION

An initial site screening was completed to identify 13 sites for further evaluation. The following sites were eliminated for reasons of public acceptance, environmental concerns, or site availability:

- “Refineries”
- Southeast WWTP
- Richmond-Sunset Water Pollution Control Plant (WPCP)
- Hunters Point Power Plant
- Embarcadero Location
- “Power Plant Site”
- Alameda Point
- Oakland Airport
- Russell City Power Plant

This narrowed the list to 13 potential sites. In addition to the original sites identified in the study, four additional sites were included in site screening:

- Near Bay Bridge
- Mallard Slough
- San Francisco Airport
- Barge-Mounted Plant

Evaluation criteria were developed to rank the 13 sites for suitability for a regional desalination project. The following criteria were developed based upon needs identified in the study guidelines, review of the Project Understanding requirements, and a review of information from the California Desalination Task Force.

- **Feedwater Quality:** Source of water quality concerns such as wastewater discharges or seabed contamination in close proximity to the feedwater intake location that would cause concern with the product water quality.
- **Water Cost:** Cost factors that will lead to the lowest water cost, including
  - Low-cost power
  - Low-salinity feedwater
  - Existing infrastructure (distribution pipeline, power supply, etc.)
  - Operation with a high demand factor
  - Co-location with a power plant (existing intake/discharge infrastructure)
- **Permitting/Water Rights:** Permit requirements to license a plant including
  - Water rights issues
  - Construction permits
  - Intake/brine discharge permits
- **Public Acceptance**: Public acceptance based upon such factors as
  - Environmental justice
  - Land use
  - Growth inducement issues
  - Demonstrated need
- **Grant Potential:** The best potential to receive a grant. Important factors include
  - Innovative design features
  - Regional benefits
  - California Proposition 50
- **Regional Capability**: Production capacity to supply several agencies during droughts through either

  - Interties (several of the agencies have interties to the other agencies so they can directly transfer water)
  - Water transfer (water that the agency will normally receive is transferred to another agency)
- **Environmental:** Environmental permitting requirements including
  - Land use
  - Ecological impacts of brine disposal
  - Waste stream characterization
  - Intake/outfall ecological impacts
  - Hydrogeology
  - Public health
  - Energy usage

The initial criteria list did not consider water rights. Water rights were added to the permitting potential criteria and a separate criterion was created for environmental permitting. Some other wording changes were suggested by the agencies for other criteria.

Additional changes to the list came from a DWR Desalination Task Force document. In their initial meeting, the Task Force presented a "Summary of Key Issues" that identified important issues associated with seawater desalination plants. This summary was reviewed and items were added to the Criteria List.

4.4 SITE EVALUATION

The 13 selected sites are listed in Table 4-2, and their locations are shown on Figure 4-1. Background information on the sites is discussed in the following paragraphs. This information is used in the rating for each site.

Table 4-2
Sites Selected for Further Consideration

NO.	SITE	FEEDWATER	DESAL SIZE (MGD)	COMMENTS
IDENTIFIED IN STUDY GUIDELINES				
1	C&H Sugar Refinery, Crockett	Bay Seawater	12	Limited area and outfall capacity
2	Mirant Contra Costa Plant, Antioch	Brackish water	100	
3	Mirant Pittsburg Plant, Pittsburg	Brackish water	100	
4	Palo Alto Water Regional Pollution Control Plant Site, Palo Alto	Brackish water	<5	
5	Pico Power Plant Site, Santa Clara	Brackish water	<5	
6	Los Esteros Power Plant Site, San Jose	Brackish water	<5	
7	Treasure Island Site, San Francisco	Bay Seawater	120	Power supply is limited to 20 MVA.
8	Oceanside, San Francisco	Seawater	120	
9	BDPL 1&2 at Dumbarton Point	Bay Seawater	120	Brine disposal to South Bay Issue
SELECTED 4 ADDITIONAL SITES				
10	Near Bay Bridge	Bay Seawater	~100	
11	Mallard Slough	Brackish water	~20	
12	San Francisco Airport	Bay Seawater	~100	Some power generated on site.
13	Barge Mounted Plant	Bay Seawater	~20	

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NO.	SITE	NO.	SITE
1	C&H Sugar Refinery, Crocket	8	Oceanside, San Francisco
2	Mirant Contra Costa Plant, Antioch	9	BDPL 1&2 at Dumbarton Point
3	Mirant Pittsburg Plant, Pittsburg	10	Near Bay Bridge
4	Palo Alto Water Pollution Control Plant Site	11	Mallard Slough
5	Pico Power Plant Site, Santa Clara	12	San Francisco Airport
6	Los Esteros Power Plant Site, San Jose	13	Barge-Mounted Plant
7	Treasure Island Site, San Francisco		

Figure 4-1 Site Location Map

4.4.1 Santa Clara County

Two aquifer zones exist within the Santa Clara Basin. The division is formed by an extensive regional aquitard that occurs at depths ranging from about 100 feet near the forebay to about 150 to 250 feet in the interior portion of the basin and beneath San Francisco Bay. Several aquifer systems occur in the upper aquifer zone separated by aquitards which may be leaky or very tight. The lower aquifer zone occurs beneath the practically impermeable regional aquitard. From a basin utility standpoint, at present most of the groundwater pumped is from the lower aquifer zone, followed by that pumped from the forebay. The upper zone aquifers are little used now, only serving for local domestic or agricultural purposes and extraction for chemical contamination remediation projects. Little information exists on the production capacity for this aquifer but it is estimated to be less than 5 MGD at each of the following three sites. This aquifer would be used as the source for desalinated water. Brackish groundwater is available on the sites. Desalination would be possible with likely brine discharge to the Bay. The three potential sites in Santa Clara County are the Pico Power Plant site in Santa Clara, the Los Esteros Power Plant site in San Jose, and the Palo Alto Water Regional Water Pollution Control Plant site in Palo Alto.

4.4.1.1 Pico Power Plant Site

The Pico Power Project (Location 5, Figure 4-1) would be located at an existing Silicon Valley Power substation in an industrial area of Santa Clara. The power plant will produce approximately 147 megawatts (MW) of power using two high-efficiency combustion turbines with added heat recovery steam generators (the latest combined-cycle generation technology). The California Energy Commission (CEC) has granted the Pico Power Project a six-month, fast-track approval process. Santa Clara expects CEC approval in mid-2003 and construction completed by December 2004.

The new power plant will use recycled water for its cooling tower and groundwater for other applications. The blow-down water will be discharged to the existing sanitary sewer.

4.4.1.2 Los Esteros Power Plant Site

This power plant (Location 6, Figure 4-1) is owned by Calpine and began commercial operation in 2003. The plant was built on 15 acres of a 55-acre site owned by Calpine near Milpitas. The power plant is fired by natural gas. Under a three-year DWR contract, Calpine will operate as many as 4,000 hours annually and will receive fixed annual capacity payments averaging $38.8 million. The power plant is surrounded by a large area of buffer land that is owned by the San Jose/Santa Clara Water Pollution Control Plant. Therefore, land could be available for a desalination plant.

The power plant uses recycled water for its cooling tower and discharges blow-down water to an existing sanitary sewer. This same sewer is potentially a possible discharge method as well, but this usage would require further study.

4.4.1.3 Palo Alto Regional Water Quality Control Plant Site

PARWQCP (Location 4, Figure 4-1) is a regional wastewater treatment facility operated by the City of Palo Alto for the communities of East Palo Alto, Los Altos, Los Altos Hills, Mountain

View, Palo Alto, and Stanford University. The PARWQCP is an advanced biological treatment facility that uses biological processes to remove unwanted organic material and toxins from wastewater. The plant's treated effluent is discharged to the southern end of San Francisco Bay. The final treatment provides fine polishing filtration prior to discharge to the Bay.

4.4.2 Contra Costa County

Several potential plant sites have been identified in Contra Costa County. Three of these locations were previously analyzed as potential locations for a desalination plant (EBMUD 2003). This study was a "fatal flaw" analysis for locating a desalination plant at any of these locations. All sites were reviewed for their potential to accommodate a 20 MGD desalination plant. In addition, there were indications that a 100 MGD facility could be located at the two power plant sites. The sites were selected because of the potential for co-locating a desalination plant along with an industrial facility in order to minimize permitting and environmental issues. The study reviewed the permitting and licensing issues and found that there appears to be no fatal flaw regarding the co-location a desalination plant at any of the locations. However, the reference identified the unresolved issue of obtaining consumptive water rights. Further investigation will be required before proceeding with a desalination plant in these locations.

The three sites are:

- C&H Sugar Refinery site
- Mirant Pittsburg Plant site
- Mirant Power Plant at Antioch

In addition, a fourth site has been identified at Mallard Slough. CCWD currently has limited water rights at this location.

4.4.2.1 C&H Sugar Refinery

The C&H Sugar Refinery (Location 1, Figure 4-1) is located on the Carquinez Straits in the San Francisco Bay-Delta region. It has an intake located near the shoreline that has a maximum capacity of approximately 20 MGD, although it is probable that the capacity could be increased to 30 or 40 MGD by installing a larger pump. The refinery site is within EBMUD boundaries, and distribution piping is already in place. Further study is required to identify if the existing piping can accommodate the increased flow. It may be necessary to increase pipe sizes in this northern portion of EBMUD territory.

The referenced report (EBMUD 2003) showed that several environmental requirements need to be studied further. These include:

- The necessity for an aquatic filter barrier at the intake structure
- The existing NPDES permit does not describe sensitive species in the vicinity of this site
- There are thermal discharge issues to be addressed

Although there is a California Energy Commission permit for the C&H Cogeneration facility, no permit is in place for the refinery. During the anticipated CEQA process, the CEC may choose to comment on the proposed project, but no permit should be required.

Limited land area is a consideration at the refinery. The SLC owns the property nearby below the existing Carquinez Bridge. The SLC would need to be contacted to determine if a lease or purchase agreement can be reached to obtain sufficient land for a desalination plant.

4.4.2.2 Mirant Pittsburg Plant Site

The Mirant Pittsburg Plant site (Location 3, Figure 4-1) is within CCWD boundaries. The plant is a 2,060 MW power plant located near Pittsburg with a permitted annual flow of 658 MGD. The site is relatively close to the EBMUD raw water aqueduct, and the desalinated water could be mixed into that system where it would blend with other EBMUD water and then be conveyed to EBMUD facilities for treatment before being pumped into the distribution system. Approximately 2 miles of transmission pipe and a pumping plant would need to be constructed. The power plant has two shoreline intakes located approximately 2,000 feet west of New York Point. The water is used to cool the power plant condensers.

The power plant site is approximately 1,080 acres in size. It is thought that the desalination facility can be located outside the jurisdictional boundaries of the BCDC on the power plant site. All of the power generating units at the Mirant Pittsburg Plant site predate the California Energy Commission and are therefore out of its jurisdiction.

4.4.2.3 Mirant Contra Costa Power Plant

This 1,210 MW power plant (Location 2, Figure 4-1) is located near Antioch with a permitted average annual flow of 340 MGD. The power plant is within the CCWD boundaries. The Contra Cost Power Plant site is relatively close to the EBMUD aqueduct and the desalinated water could be injected into that system where it would mix with other EBMUD water and then be conveyed to EBMUD facilities for treatment before being pumped into the distribution system. Approximately 5 miles of transmission pipe and a pumping plant would need to be constructed. The power plant has one shoreline intake as well as an intake located in the river approximately 250 feet from the shoreline. Some water is drawn from the system for use within the plant. This water is treated with a clarifier followed by various modes of filtration (dual media, sand, and cartridge) and then is subject to RO and de-ionization prior to use.

The power plant site is approximately 160 acres in size. It is thought that with the available land at the site, it is probable that the 20 MGD desalination facility can be located outside the boundaries of the BCDC. A larger facility would require further analysis to determine if sufficient area is available. The existing facility predates the California Energy Commission and is therefore out of its jurisdiction. However, operator Mirant obtained a certification from the Commission in May 2001 to construct a new 530 MW unit at the site. Conditions of Certification were issued and the CEC has jurisdiction over the construction and operation of the new unit as well as any ancillary systems that need to be installed for that unit.

4.4.2.4 Mallard Slough

Mallard Slough (Location 11, Figure 4-1) is located on the Delta near Bay Point between the C&H Sugar Refinery and the nearby Mirant Pittsburg Plant site. It is the furthest west of any domestic water supply intake in the Delta area. Due to its close proximity to San Francisco Bay, the salinity of the intake water varies widely and changes often depending on the tidal fluctuations and the quantity of fresh water flow through the Delta. TDS levels measured at the intake from 1997 to 2000 ranged from 70 mg/L to 5,700 mg/L, with levels in June through December typically greater than 1,000 mg/L. Note that similar salinity variations exist at the Mirant power plant sites and the C&H Sugar Refinery. CCWD has some consumptive water rights and this water, when of acceptable salinity (lower chlorides), is used as part of their supply. The salinity levels are significantly higher than the CCWD's goal of approximately 200 mg/L TDS. Due to the variably high TDS levels, CCWD uses the intake only seasonally when TDS levels are consistently low. Unfortunately, this is usually during winter and spring months when water demands within the service area are typically low.

4.4.3 San Francisco County

The San Francisco Public Utilities Commission identified three sites for 120 MGD desalination facilities (SFPUC 2002). The sites are:

- Oceanside
- Treasure Island location
- BDPL 1 & 2 at the Bay (discussed below under Alameda County)

4.4.3.1 Oceanside

This location (Location 8, Figure 4-1) is "adjacent to the existing Oceanside wastewater treatment plant," but could be any location on the western shore of the Peninsula within San Francisco. A location near but not necessarily at the Oceanside plant has advantages. Seawater would be available as a feedwater source while the brine discharge may be blended with the existing wastewater discharge. This site would have the highest salinity due to its ocean intake.

Modeling studies would be required to determine the impact of brine disposal into the ocean environment (as well as for the other sites). At this location, strong ocean currents and tidal flushing will aid in the disposal of the brine. Constructing the plant close to the Oceanside plant would have the additional advantage of allowing the strongly saline treatment plant waste product to mix with the low salinity treated wastewater from the wastewater plant. This will reduce the impact of both flows, as there are some potential advantages for mixing the denser brine with the low salinity, less dense wastewater.

Product water distribution pipelines would need to be provided specifically for this water supply source and hydraulic analyses would be needed to ascertain which customers could be provided with the desalinated water. Potentially the water could be delivered to the two San Francisco Sunset area storage tanks (89 and 87 million gallons). Internal water transfers would allow this water to be distributed within San Francisco while exchanging water with other agencies.

4.4.3.2 Treasure Island Site

This location (Location 7, Figure 4-1) would place the plant in the Bay but in a location with strong currents and tidal flushing. As with the other locations, the true impact of a plant on this site could only be assessed after proper modeling. Limited power is available at the site, which would be a major limitation on the desalination plant size unless more power is provided.

As in the previous example, a transmission line will be required to feed water into the Peninsula transmission system and/or to Alameda County. This pipeline would be required to lie in the Bay until it reaches the shore.

4.4.4 Alameda County

Two potential plant sites have been identified in Alameda County.

4.4.4.1 Adjacent to BDPL 1 & 2 at the Bay

A location has been identified adjacent to the San Francisco South Bay near the Dumbarton Bridge (Location 9, Figure 4-1) that would have a short intake pipeline to the desalination plant and would provide a short delivery into the transmission system. Water from the plant would be boosted into the BDPL and from there could be delivered to any of the customers in the South Bay and the Peninsula. Intake pipelines could be located on the Bay shoreline, and saline feedwater would be obtained from the Bay.

Brine could be returned directly to the Bay, disposed of into available salt ponds, or transported elsewhere for disposal. Discharge of the brine from the plant into the South Bay may cause significant environmental impact. Disposal to some other location is potentially expensive and would require long pipelines that in turn would impact the environment.

4.4.4.2 Near Bay Bridge

EBMUD provides wastewater treatment for parts of Alameda and Contra Costa Counties (Location 10, Figure 4-1). The wastewater system serves approximately 640,000 people along the east shore of San Francisco Bay. A desalination plant could potentially use the discharge line currently in place if an intake structure could be located to minimize any recirculation. As with the Treasure Island site, the intake could be located where there are strong currents and tidal flushing.

Wastewater flows to EBMUD’s wastewater treatment plant in Oakland near the entrance of the San Francisco-Oakland Bay Bridge. The treatment process includes primary treatment and secondary biological treatment. The wastewater treatment steps are pre-chlorination, screening, grit removal, primary sedimentation, secondary treatment using high-purity, oxygen-activated sludge, and final clarification. The treated effluent is then disinfected, dechlorinated and discharged one mile off the East Bay shore through a deep-water outfall into San Francisco Bay. EBMUD provides secondary treatment for a maximum flow of 168 MGD. Primary treatment can be provided for up to 320 MGD. Storage basins provide plant capacity for a short-term hydraulic peak of 415 MGD. The average annual flow is currently 80 MGD allowing capacity for seawater concentrate discharge.

4.4.5 Other Locations

Two other locations were selected as potential sites.

4.4.5.1 Barge-Mounted Plant

Another approach to providing a regional facility is the use of a barge-mounted desalination plant that would be mobile within the Bay (Location 13, Figure 4-1). The barge could be quickly relocated to an agency requiring water. The desalination plant would be built on a large barge and would be approximately 20 MGD capacity. Barge-mounted plants have been used in several locations in the Middle East. The first desalination plant at the Jubail Industrial Facility in Saudi Arabia was a 5 MGD barge-mounted plant. This plant contained both the desalination plant and a power plant so that it was completely self contained. This concept offers several potential advantages:

- Quickly movable to a location for emergency or maintenance usage.
- An innovative concept is more likely to attract funding (e.g., an innovative desalination concept by Long Beach has attracted federal research and development funds).
- Cost could be shared with other communities that might also want to use the emergency water supply. For example, Southern California could have an earthquake while the Bay Area would remain unaffected.
- Maximum flexibility to meet the various agencies objectives. Several barges could be combined at one location to provide maximum production for a major facilities outage.

4.4.5.2 San Francisco Airport

San Francisco Airport is administered by San Francisco but is located in Burlingame south of San Francisco (Location 12, Figure 4-1). This site offers several potential advantages. A prime advantage is that it is located near a source of low-cost power. In addition, the site offers a potential for access to an existing outfall from the airport's wastewater treatment plant.

4.5 SITE SELECTION

The ranking procedure was as follows:

- Rating scores (shown below) were provided for each of the criteria
- Sites were reviewed and rated by specialists knowledgeable for the specific criteria
- The specialists conducted independent ratings
- The independent ratings were reviewed and compared
- Consensus was then reached for a final rating

The sites were then ranked based on their rating scores as shown below.

Criteria	Rating
Ideal or best conceivable	5
Excellent	4
Good or above average	3
Fair or below average	2
Poor	1

Conditionally acceptable	0
Absolutely unacceptable	-1

The results of the ranking procedure are shown in Table 4-3. The results are listed in descending order by the final evaluated score. Appendix C provides the ranking for each location.

The two Mirant Power Plant sites are ranked No. 1 (Locations 2 and 3, Figure 4-1), the Oceanside site ranked No. 2 (Location 8), and the Near Bay Bridge site ranked No. 3 (Location 10). Since there was a tie for No. 1, it was agreed that the Mirant Pittsburg Plant site would be selected as No. 1 and the other Mirant Power Plant site would be eliminated. Serendipitously, the three sites represent a mix of Bay/Delta water (Mirant Pittsburg), Bay seawater (Near Bay Bridge), and ocean seawater (Oceanside).

4.6 CONCLUSIONS

The sites to be carried forward for cost estimating are:

- Mirant Pittsburg Plant
- Near Bay Bridge
- Oceanside

Sites will be eliminated from further consideration where the desalination plant capacity would be less than 20 MGD, as this size plant would limit the regional capability for sharing water.

The cost estimates will include costs of connecting to the transmission system based on distance to a trunk line or storage facility.

Table 4-3
Ranking Results

CRITERIA	Mirant Contra Costa Plant	Mirant Pittsburg Plant	Oceanside	Near Bay Bridge	Palo Alto Water Pollution Control Plant Site	Pico Power Plant Site	Los Esteros Power Plant Site	Treasure Island Site	Mallard Slough	San Francisco Airport	Barge Mounted Plant	BDPL 1&2 at Dumbarton Point	C&H Sugar
FEEDWATER WATER QUALITY	3	3	3	3	4	4	4	4	3	3	3	3	3
WATER COST	4	4	2	2	5	5	5	1	4	2	3	2	2
WATER RIGHTS/ PERMITTING POTENTIAL	3	3	2	2	3	3	3	3	3	2	1	2	1
PUBLIC ACCEPTANCE	2	2	3	3	1	1	1	4	2	2	4	1	3
GRANT POTENTIAL	3	3	4	3	3	3	3	2	3	3	4	3	2
REGIONAL CAPABILITY	4	4	3	4	1	1	1	4	1	3	2	4	2
ENVIRONMENTAL	2	2	3	3	2	2	2	1	3	3	1	2	3
TOTAL	21	21	20	20	19	19	19	19	19	18	18	17	16

4.7 OPPORTUNITIES FOR SHARED BENEFITS FROM THE RDP

All four participating agencies, or any subset of the four, could benefit either directly or indirectly from a regional desalination plant. This could be done by sharing the water from the desalination plant or arranging interdistrict transfers of other water. However, additional information is required regarding each of the agencies' water conveyance systems to more precisely determine how each agency would benefit.

There are either existing or proposed locations among the agencies transmission systems where water can be transferred from one agency to another (Figure 4-2). SFPUC and SCVWD have an existing intertie in the South Bay that allows up to 45 MGD to be transferred from one agency to the other. CCWD and EBMUD could share water through an intertie between the Mokelumne Aqueduct and the Contra Costa Canal in the vicinity of Walnut Creek. CCWD and SCVWD could share water if the Los Vaqueros Reservoir expansion project is implemented that would allow CCWD access to the South Bay Aqueduct. EBMUD and SFPUC have signed a Memorandum of Understanding to pursue an intertie through the City of Hayward. Therefore, there are multiple opportunities to share water between the agencies resulting in mutual benefits from a regional desalination plant. The potential interties are summarized as follows:

- CCWD/EBMUD
- CCWD/SCVWD
- SCVWD/SFPUC
- SFPUC/EBMUD

4.7.1 Operational Scenarios

Operational scenarios for sharing water from a desalination plant constructed at each of the three selected sites are discussed below. Desalination water may be used as part of a full-time water portfolio or reserved only for emergency or drought relief. Therefore, there could be an infinite number of operational scenarios for a regional desalination plant. The discussion presented here is limited to the physical constraints associated with transmitting product water from a desalination plant at each of the proposed sites. This discussion also assumes that the aforementioned interties are constructed.

4.7.1.1 Mirant Pittsburg Plant Site

If a desalination plant is constructed at the Mirant Pittsburg Plant site it could be connected to either CCWD or EBMUD, or both. If it is connected to CCWD, then CCWD could share water directly with EBMUD or SCVWD. This could free up EBMUD water from the Mokelumne Aqueduct which could then be shared with SCVWD and SFPUC. If it is connected to EBMUD, then EBMUD could share water directly with CCWD or SFPUC. This could free up EBMUD water from the Mokelumne Aqueduct which could then be shared with SCVWD.

INSERT FIGURE 4-2

Figure 4-2 Transmission Pipelines and Existing/Potential Interties

4.7.1.2 Near Bay Bridge Site

If a desalination plant is constructed at the Bay Bridge site it would be connected directly to EBMUD. This could free up EBMUD water from the Mokelumne Aqueduct which could then be shared directly with CCWD and SFPUC. SCVWD could get water indirectly through either of these two agencies.

4.7.1.3 Oceanside Site

If a desalination plant is constructed at the Oceanside site it would be connected directly to SFPUC. This could free up SFPUC water from the Hetch Hetchy Aqueduct which could then be shared directly with SCVWD and EBMUD. CCWD could get water indirectly through either of these two agencies.

4.7.2 Institutional Arrangements

There are basically three options for entering into an institutional arrangement for the development, construction and operation of a regional desalination facility. These options are:

- Contracting among participating agencies with one being the lead agency
- Creation of a joint powers authority among the participating agencies
- Each participating agency contracting with DWR or the USBR

The easiest of these options would likely be a contract among the participating agencies. A good example of this is the project between the SFPUC and the SCVWD for the Milpitas Intertie. This intertie connects the two systems for emergency operations. It was constructed with the SFPUC as the lead agency. A Memorandum of Understanding between the agencies provides the basis for its operation.

A joint powers authority (JPA) among two or more agencies can also be implemented. Since it involves the creation of a new entity with a new board of directors, it may be more complex than a contract. Good examples of recent JPAs are the Freeport Regional Water Authority and Dublin San Ramon Services District–EBMUD Recycled Water Authority. Each of these has unique characteristics that have made a JPA desirable.

The last option is for the participating agencies to contract with DWR, USBR or other third party provider of service. This may make sense if the facility were to be a State Water Project or Central Valley Project facility and if the water were managed as a State or Federal project asset. However, it is more likely to be a local or regional facility that is not a part of either project. Of course, this discussion is not intended to preclude contracting out the construction or operation of any facility to a public or private entity where operating efficiencies may provide a lower cost product.

The Bay Area Water Quality and Supply Reliability Program is an effort being carried out under the auspices of the CALFED Bay-Delta Authority to evaluate the potential for cooperative projects and/or operating systems among the major Bay Area water agencies. The goal of this effort is to identify and develop mutually beneficial projects among the Bay Area water agencies that help to achieve the goals of the CALFED Bay-Delta Program regarding water supply reliability, water quality, ecosystem restoration, and levee system integrity.

This section covers the development of capital and O&M cost estimates for water desalting plants at the three sites selected in Section 4:

- Mirant Pittsburg Plant site in Pittsburg (Location 3, Figure 4-1)
- Oceanside site (Location 8, Figure 4-1) in San Francisco
- Near Bay Bridge site (Location 10, Figure 4-1) in Oakland

The cost estimates are based on two scenarios:

- 40 MGD plants at the Mirant Pittsburg Plant site, the Near Bay Bridge site, and San Francisco's Oceanside site
- 120 MGD plant at the Mirant Pittsburg Plant site

5.1 RAW AND PRODUCT WATER QUALITIES

Raw water qualities for the three plant sites vary considerably from each other. Table 5-1 shows the assumed TDS concentrations for each site.

Table 5-1
Assumed Raw Water TDS Qualities (mg/L)

Mirant Pittsburg Plant	Near Bay Bridge	Oceanside
5,737	30,400	35,000

The assumed desalting plant product water quality goals are shown in Table 5-2. TDS values in the table are based on information presented in Section 3.

Table 5-2
Product Water Quality Goals

Constituents (mg/L)	Mirant Pittsburg	Near Bay Bridge	Oceanside
TDS	200	300	300
Hardness	100	150	150

It was also assumed that the raw water supply at each site would be surface water containing suspended solids. Therefore, the raw water would need to be filtered to provide quality suitable for RO desalting. It was assumed that membrane filtration would be used rather than conventional filtration for feedwater treatment.

5.2 REVERSE OSMOSIS

RO is the proposed desalting process (see Section 3). Osmosis is a natural phenomenon that occurs when a semi-permeable membrane is placed between two waters with differing salt concentrations. The water with the lower salt concentration will naturally flow through the membrane into the water with the higher salt concentration, thus equalizing the salt concentrations on both sides of the membrane. The "driving pressure" forcing the water through the membrane is termed "osmotic pressure."

If pressure greater than the osmotic pressure is applied to the water with higher salt concentration, water will flow across the membrane to the less salty water. The majority of the TDS remains on the salty waterside of the membrane. The TDS concentration of the water on the salty side of the membrane increases because most of the TDS is contained in a smaller volume of water. Thus, the name "reverse osmosis" or simply RO.

The following terms will be used in the discussion below.

- Raw water: the desalting plant influent such as ocean water, San Francisco Bay water, river water, etc.
- Filtered water: effluent from the filtration process
- (RO) feedwater: water supply to the RO desalting process
- (RO) permeate: desalted water emanating from the RO process
- Recovery: the percentage of water that enters a water treatment process or plant that is recovered as usable water
- (RO) concentrate: wastewater from the RO process containing the substances (TDS, for example) rejected by the RO membranes
- (RO) bypass: (filtered) water that bypasses the RO process and is blended with RO permeate
- Product water: water conveyed to water consumers (may be permeate only or a blend of permeate plus filtered but undesalted water)

Two streams emanate from a RO process:

- Permeate—desalted water
- Concentrate (brine)—a portion of the RO feedwater that contains the majority of the mass (pounds) of dissolved salts that were in the feedwater. The dissolved salt concentration in the concentrate is much higher than in the feedwater.

Recovery, in general, was defined above. There can be two different recoveries associated with a desalting plant. *Desalting process recovery* is the percentage of desalted water *recovered* from the desalting process feedwater. *Overall plant recovery* is the percentage of raw water entering the desalting plant that is recovered as potable water. The difference in recoveries can occur if some water bypasses the RO desalting process. In this case, the overall plant recovery would be greater than the RO process recovery.

RO process recovery depends primarily on the raw water TDS. For seawater RO plants, RO (and overall) recovery is typically about 50 percent. For a brackish water desalting plant, RO recovery is usually about 60 percent to 85 percent although higher recovery ratios can be achieved. Overall recovery for a brackish water desalting plant is usually higher than the RO recovery because some of the raw water may be able to bypass the RO process and be blended with RO permeate to meet the product water quality goals. In addition, seawater RO process recovery can be limited by the maximum allowable membrane operating pressure.

The RO process feedwater pressure required depends primarily on the TDS of the raw water. The higher the TDS, the higher the RO feedwater pressure needed to obtain a given RO process recovery.

Table 5-3 shows approximate RO feedwater pressures and commonly observed RO recoveries based on feedwater TDS.

Table 5-3
RO Recoveries

Feedwater TDS (mg/l)	Operating Pressure (psi)	Recovery (%)
15,000 - 45,000	800 - 1,200	40-60
3,500 - 15,000	600 - 800	60-85
500 - 3,500	100 - 600	60-85

5.3 CONCEPTUAL PROCESS FLOW DIAGRAMS

Figure 5-1 is a conceptual process flow diagram for a desalting plant at the Mirant Pittsburg Plant site. The process shown on the figure is based on a raw water TDS = 5,737 mg/L and product water TDS = 200 mg/L and hardness (as calcium carbonate) = 100 mg/L. Flow rates (MGD) and TDS values are shown for two product water capacities, 40 MGD and 120 MGD.

In addition, the assumed treatment process recoveries are shown on Figure 5-1. For example, the filtration process recovery, Y, is shown as “Y = 92%.”

While detailed raw water quality data were not available for this conceptual level study, it is likely that the TDS of the combined permeate streams (Stream 11 on Figure 5-1) would consist primarily of sodium and chloride with very little hardness or alkalinity. Therefore, as noted on Figure 5-1, the TDS of the combined permeate flows would be about 150 mg/L—50 mg/L less than the TDS = 200 mg/L product water goal. The 50 mg/L was provided as an “allowance” for adding hardness and alkalinity in the post-treatment process.

The process shown on the figure is described as follows:

- Raw water is filtered to remove suspended solids prior to RO desalting.
- All of the filtered water is desalted by RO (first-pass RO).
- In order to meet the Mirant Pittsburg Plant site TDS goal (200 mg/L), it would be necessary to desalt a portion of the first-pass RO permeate in a second RO pass.
- The first-pass RO and second-pass RO streams are combined and post-treated.
- The second-pass RO concentrate is returned to the first-pass RO feedwater stream because the TDS of the second-pass RO concentrate is less than the filtered raw water. This reduces the TDS of the first-pass RO feedwater and conserves filtered water, thus reducing the required capacity of the filtration process as compared to disposing of the second-pass RO concentrate.
- The filter backwash water and first-pass RO concentrate streams are combined and disposed of to the Bay.
- The post-treated combined permeate flows are delivered to customers.

INSERT FIGURE HERE

Figure 5-1 PFD for Pittsburg Desalter, 40 MGD and 120 MGD Product Water

INSERT FIGURE HERE

Figure 5-2 PFD for EBMUD and Oceanside Desalters, 40 MGD Product Water (Each)

Figure 5-2 is similar to Figure 5-1 except that it shows conceptual process flow diagrams for 40 MGD Oceanside and EBMUD desalters. Similar to the Mirant Pittsburg Plant site process flow diagram, the combined first- and second- pass RO streams are shown with a projected TDS of 200 mg/L, 100 mg/L less than the TDS goal of 300 mg/L. Post-treatment to add hardness and alkalinity to the primarily sodium chloride water would increase the TDS to the 300 mg/L goal.

Table 5-4 shows the raw water and product flow rates based on Figures 5-1 and 5-2.

Table 5-4
Desalting Plant Raw Water and Product Water Flow Rates

Plant	Raw Water (MGD)	Product Water (MGD)
Mirant Pittsburg	187.5	120
Mirant Pittsburg	62.5	40
Near Bay Bridge	87.8	40
Oceanside	87.9	40

5.4 CONCEPTUAL OPINION OF CAPITAL COST

The opinions of capital costs given here should be considered as conceptual in nature. The cost opinions are based on experience with previous desalting projects including numerous brackish water desalting projects in which Boyle Engineering was involved during planning, design, and construction. The seawater desalting cost opinions are based in particular on recent work by Boyle Engineering on the 25 MGD and 50 MGD seawater desalting plants proposed at Dana Point and Carlsbad in Southern California.

There are “off-site” facilities associated with desalting plants. These include raw water supply facilities, concentrate disposal improvements and product water delivery pipelines and pump stations. Assumptions made for the three sites relative to these concerns include:

- Mirant Pittsburg Plant site
  - Raw water will be obtained from the power plant’s cooling water system
  - Concentrate disposal will be via the power plant’s cooling water return line
  - Product water delivery to EBMUD’s Mokelumne Aqueduct will require a pump station (a 500 foot lift) and a 3-mile-long, 6-foot-diameter pipeline for the 120 MGD alternative and 3-mile-long, 4-foot-diameter pipeline for the 40 MGD alternative[1]
- Near Bay Bridge site
  - Raw water intake will be 3 miles long. The 6-foot-diameter intake would obtain feedwater from the Bay at a depth of over 20 feet

[1] Also, an alternative case could be considered with an intake and outfall west of Chips Island and outside the Delta. It is assumed these pipelines would be about 3 miles in length. However, lower energy costs would be associated with delivery into the Contra Costa Canal.

  - Concentrate disposal will be via the existing treated wastewater outfall
  - Product water delivery to the EBMUD distribution system will require a pump station to lift the water about 100 feet through a pipeline 4 feet in diameter and about 2 miles long
- Oceanside site
  - A 6-foot-diameter ocean water intake 2 miles long will be constructed
  - Concentrate disposal will be via the treated wastewater ocean outfall
  - Product water delivery to the Sunset reservoir will require a pump station (400 foot lift) and a 4-foot-diameter pipeline 3 miles long delivering water

Estimated capital costs of major desalting plant components include:

- Raw water intake allowances
  - Mirant Pittsburg Plant site—$2 million for 40 MGD plant; $5 million for 120 MGD plant
  - Near Bay Bridge site—$10 million
  - Oceanside site—$20 million
- Raw water filtration = $0.50/gpd of filtrate flow
- First pass brackish water RO equipment = $0.75/gpd of permeate capacity (Mirant Pittsburg Plant site)
- Seawater RO equipment = $1.50/gpd of permeate capacity (Near Bay Bridge site and Oceanside site)
- Second pass brackish water RO equipment = $0.75/gpd of permeate capacity
- Site development (civil works) = 5 percent of construction cost
- Chemical feed systems = 3 percent of construction costs
- Electrical and instrumentation/control systems = 10 percent of construction costs
- Buildings = 5 percent of construction cost
- Allowances for product water clearwells, pump stations, and transmission pipelines
  - Mirant Pittsburg Plant site—$20 million (40 MGD plant); $40 million (120 MGD plant)
  - Near Bay Bridge site—$20 million
  - Oceanside site—$20 million
- Allowances for concentrate disposal
  - Mirant Pittsburg Plant site—Via existing power plant cooling water system, $2 million (40 MGD plant); $5 million (120 MGD plant)
  - Near Bay Bridge site—Via existing treated wastewater outfall—$2 million
  - Oceanside site—Via existing treated wastewater outfall—$2 million
- Engineering, legal, financial, and administrative = 12 percent of construction costs

- Contingencies = 25 percent of construction, legal, financial, and administrative costs

Other costs should be expected in implementing a desalting plant. For example, land and right-of-way costs can be significant. Environmental/permitting costs could also be substantial. In addition, it was assumed that sufficient electrical power was available at the sites. These, and other potential costs, cannot be identified until additional detailed studies on particular sites are prepared. Table 5-5 summarizes the capital cost opinions.

Table 5-5
Capital Cost Opinions

		40 MGD			Sum of 3	120 MGD
		Mirant Pittsburg	Near Bay Bridge	Oceanside	Plants	Mirant Pittsburg
Filter Feedwater	MGD	62.5	87.8	87.9	238.2	187.5
Filtrate	MGD	57.5	80.9	80.9	219.3	172.5
First Pass BW RO Permeate	MGD	40.8	0	0	40.8	122.4
Second Pass BW RO Permeate	MGD	15	16	22	53	45
Sea Water RO	MGD	0	40.9	40.9	81.8	0
Overall Plant Recovery		64%	46%	46%		64%
Million (M$)						
Raw Water Intake		2.0	10.0	20.0	32.0	5.0
Filtration		28.8	40.5	40.5	109.7	86.2
First Pass Brackish Water RO		30.6	0.0	0.0	30.6	91.8
Second Pass Brackish Water RO		11.3	12.0	16.5	39.8	33.8
Sea Water RO		0.0	61.4	61.4	122.7	0.0
Electrical & Instruments/Control Systems		12.3	18.9	20.8	52.0	34.0
Chemical Feeds		3.7	5.6	6.2	15.6	10.2
Buildings		6.1	9.5	10.4	26.0	17.0
Site Civil		6.1	9.5	10.4	26.0	17.0
Product Water Facilities		20.0	20.0	20.0	60.0	40.0
Concentrate Disposal		2.0	2.0	2.0	6.0	5.0
CONSTRUCTION		**122.9**	**189.4**	**208.2**	**520.4**	**340.0**
Engineering & Administrative Fees		14.7	22.7	25.0	62.4	40.8
Contingency		30.7	47.3	52.0	130.1	85.0
CAPITAL COST		**168.3**	**259.4**	**285.2**	**712.9**	**465.8**

5.5 CONCEPTUAL O&M COST OPINIONS

As noted with the conceptual capital cost opinions, the opinions of O&M costs given here should be considered as conceptual in nature. The cost opinions are based on experience with previous desalting projects including brackish water and seawater desalting projects in which Boyle Engineering was involved.

The operating and maintenance or O&M cost opinions are based on the following assumptions:

- Membrane replacement costs
  - Membrane filtration = $15/million gallons (MG) of filtrate

- Brackish RO membranes = $50/MG of permeate
- Seawater RO membranes = $200/MG of permeate

- Labor costs (assumed)
  - 40 MGD plant staff = 10-12 personnel @ $1 million/year total cost
  - 120 MGD plant staff = 20-24 personnel @ $2 million/year.
- Chemical Costs—A number of chemicals would be involved in the membrane filtration, RO desalting, and post-treatment (including disinfection) processes. Therefore, for this conceptual level report, opinions of chemical costs were based on experience with previous filtration and RO plants. For purposes of this report, the following chemical costs were used
  - Membrane filtration—$25/MG of filtrate
  - Reverse osmosis desalting—$100/MG of RO permeate
  - Post-treatment—$75/MG of product water (Mirant Pittsburg Plant site) $125/MG of product water (Near Bay Bridge and Oceanside)
- Power costs were estimated using $0.08/KwHr and the following power consumptions
  - Mirant Pittsburg Plant site—7,500 KwHr/MG of product water
  - Near Bay Bridge site—19,000 KwHr/MG of product water
  - Oceanside site—22,000 KwHr/MG of product water

  These power consumption figures include pumping the raw water to the filtration process, filtration process power, RO process power, and product water pumping. Energy recovery from the RO concentrate is also accounted for in the above figures.
- Miscellaneous maintenance, repairs, and replacement—An allowance of 2 percent of construction cost was included for O&M costs not covered above

Table 5-6 summarizes the O&M cost opinion.

Table 5-6
O&M Cost Opinion

		40 MGD			**Sum of 3 Plants**	**120 MGD Pittsburg**
		Mirant Pittsburg	**Near Bay Bridge**	**Oceanside**		
Plant Production	MGY	13,870	13,870	13,870	46,160	46,160
M$/Yr						
Labor		1.0	1.0	1.0	3.0	2.0
Electrical		8.3	21.1	24.4	53.8	27.7
Membrane Replacement		0.9	3.7	3.7	8.3	2.7
Chemical Feed System		2.8	3.5	3.5	9.8	8.4
Miscellaneous Maintenance		3.7	5.1	5.6	14.4	10.4
TOTAL		**16.7**	**34.4**	**38.2**	**89.3**	**51.2**

5.6 PRODUCT WATER COST

"Product water cost" is the sum of the annual (amortized) capital cost plus annual O&M costs divided by the volume (acre-feet per year) of product water. Capital cost is annualized by a factor to account for the interest rate and plant life (5.5 percent for 30 years which is equivalent to an annual amortization factor of 0.0688). Water cost assumes the on-stream factor (percent operating time in a year) is 95 percent. Table 5-7 shows the product water costs for the desalting plant alternatives considered.

Table 5-7
Water Costs

	Mirant Pittsburg	Near Bay Bridge	Oceanside	Sum of 3 Plants	120 MGD at Pittsburg
Capital Cost (M$)	168	259	285	713	466
Annual Capital Cost (M$/Year)	12	18	20	49	32
TOTAL O&M (M$/Year)	17	34	38	89	51
TOTAL ANNUAL COST (M$/Year)	29	52	58	138	83
Annual Production (1000AF)	43	43	43	128	128
Water Cost ($/AF)	674	1,209	1,349	1,078	648

If water is obtained outside of the defined Delta area, an intake and discharge west of Chipps Island could be constructed to serve Mirant Pittsburg Plant site, which would remain at 40 MGD. The intake would be 5 feet in diameter, and the outfall would be 3 feet in diameter. Both pipelines would be about 3 miles long. If this were done, the capital cost for Mirant Pittsburg Plant site would increase by about $50 million to about $220 million. Operating costs for pumping would increase by about $2 million per year. The water cost would increase by about $250 per acre-foot.

5.7 RESULTS AND CONCLUSIONS

Based on the costs presented in Table 5-7, the most cost effective solution is to build one (1) 120 MGD plant at Mirant Pittsburg Plant site.

Analysis of the water cost for the Oceanside site (seawater) and Mirant Pittsburg Plant site (brackish water) is shown in Table 5-8. It can be seen that the capital cost and electricity constitutes the majority of the water cost. Thus these factors are most important in determining the water cost.

Table 5-8
Water Cost Factors

Factor	Mirant Pittsburg	Oceanside
	% of Total	% of Total
Capital	41%	34%
Electricity	30%	42%
Other O&M	29%	24%
Total	100%	100%

It was assumed that all locations would have the same power cost, interest rate, and on-stream factor. However, it is likely different cost factors will be experienced at different sites. The effect of variability in these factors is shown in Table 5-9. The two plants at the extremes in TDS were analyzed for varying economic factors. It can be seen that power cost, interest rate, and especially on-stream factor can have a significant impact on the water cost.

Table 5-9
Influence of Economic Factors on Water Cost

Location TDS (mg/L)	**Mirant Pittsburg 5,737**		**Oceanside 35,000**	
POWER COST ($/KwHr)	WATER COST ($/AF)	% OF BASE	WATER COST ($/AF)	% OF BASE
0.04	578	86%	1,065	79%
0.06	626	93%	1,207	89%
0.08	674	BASE	1,349	BASE
0.10	723	107%	1,491	111%
0.12	771	114%	1,633	121%
INTEREST RATE				
5.5%	674	BASE	1,349	BASE
6%	690	102%	1,375	102%
8%	756	112%	1,484	110%
ON-STREAM FACTOR				
95%	674	BASE	1,349	BASE
90%	719	107%	1,439	107%
75%	863	128%	1,727	128%
50%	1,295	192%	2,590	192%
25%	2,590	384%	5,180	384%
10%	6,475	960%	12,951	960%

A comparison of the economic results of this study with other current seawater desalination costs is shown in Table 5-10. Seawater is selected as brackish water desalination costs are especially sensitive to feedwater salinity and operational economic factors. The projects selected include:

- A 25 MGD seawater desalination plant recently in operation in Tampa Bay, Florida. The plant is not a true seawater plant as the feedwater varies from about 18,000 to 31,000 parts per million TDS. The plant is co-located with a power plant so that very inexpensive electrical power can be obtained. In addition, the seawater intake and outfall system are provided by the power plant. The reported costs vary over the life of the plant.
- The Metropolitan Water District of Southern California issued a Request for Proposals for new water supply from seawater. The district received five proposals. Three of those proposal costs are shown in Table 5-10. The location or agencies are shown in the table.

Table 5-10
Comparison of Seawater Desalination Costs

Location or Agency	Oceanside	Tampa Bay 1st Yr	Tampa Bay 30 Yr	West Basin*	Carlsbad*	Orange County*
Plant Size (MGD)	40	25		18	50	25
Feedwater	Seawater	31,000		Seawater	Seawater	Seawater
Capital Cost M$	285	105		130	301	115
$/GPD	$7.13	$4.20		$7.22	$6.02	$4.60
Annual Capital Cost M$/Yr						
Total Water Cost						
$/Af	1349	659	812	904	909	860-1007

Notes:
* Reported in Water Desalination Report, September 19, 2002

Differences in water cost per acre foot (AF) are partially explained by factors such as project scope (what is included in the facility), project financing, and electrical energy cost.

Several conclusions can be draw from this analysis.

- The factors most affecting the water cost are:
  - The feedwater TDS
  - The interest rate for financing the project
  - The electrical energy cost
- There is little economy of scale for a 120 MGD plant as compared to a 40 MGD plant for the Mirant Pittsburg Plant site.
- Because electrical energy cost is a bigger part of the water cost for a seawater desalination plant, the seawater plant's water cost will be more influenced by electric power cost than for a brackish water plant.
- The most desirable location for a regional plant will be a location with the lowest salinity feedwater, electrical energy cost, and interest rate. Additionally, it obviously necessary that the plant be permittable and environmentally acceptable.
- The Mirant Pittsburg location may offer the lowest-cost option for a regional plant based upon the assumptions in this study.
- Inter-agency cooperation can be very beneficial to achieve the least costly desalination plant, i.e., low financing and electrical energy costs.

As stated in the previous section, a more detailed analysis is necessary to determine the requirement for siting a desalination plant at any of these locations.

AWWA. 1999. *Manual of Water Supply Practices, Reverse Osmosis and Nanofiltration*. American Water Works Association. M46.

CCWD. 1996. *Future Water Supply Report*. Prepared by Contra Costa Water District with assistance from EDAW, Inc., Montgomery Watson, Bookman Edmonston, and RMI. Final Report. August.

EBMUD. 2003. *Fatal Flaw Analysis of Proposed Desalination Facility*. RW Beck. Final Report. June.

MMWD. 1991. *Seawater Desalination Project, Desalination Pilot Plant Report*. Prepared by Boyle Engineering Corporation. April.

2001. *Seawater Desalination as Possible Alternative Component of Integrated Water Resources for MMWD*. Prepared by Bahman Sheikh, Ph.D., P.E., in association with Parsons. June.

2003. *Initial Project Review and Environmental Screening Marin Municipal Water District Desalination Project*. URS Corporation. May.

SFPUC. 2002. *BDPL Hydraulic Capacity Upgrade Phase I Final Report, Appendix 6 – Desalination Technology*. March.

USACE. 1993. *Desalination Alternative for the San Francisco Regional Water Supply Reconnaissance Study*. Prepared by Boyle Engineering Corporation. February.

Appendix A

Regulatory Agencies and Permitting Responsibilities
(With Estimated Timeframe)

Potential Major Permits and Approvals Required
Ocean Desalination Project

Responsible Agency	Permit, Approval, or Review	Potentially Applicable To	Estimated Time Frame [a]	Public Hearing Requirements
FEDERAL				
U.S. Army Corps of Engineers **(USACE)**	Section 10 (Rivers and Harbors Act)	Seawater intake; offshore pipeline to shore; outfall line in "navigable waters" of the U.S., would be processed in conjunction with the Section 404 permit	12 months	None
	404 Permit (Clean Water Act)	Seawater intake; offshore pipeline to shore; outfall line in "navigable waters" of the U.S., would be processed in conjunction with the Section 10 permit. The USACE has indicated that an individual permit would be required.	12 months	Optional, at discretion of District Engineer
Designated Federal Lead Agency	NEPA Compliance	Required because of the federal action involved in issuing the Section 404/10 permit. The USACE would be the lead agency and has indicated it would require an EIS	12 months – 18 months concurrent w/ Section 10/404 Process	Required if substantial environmental controversy, substantial interest or requested by another agency with jurisdiction
U.S. Fish and Wildlife Services	Commenting agency to the USACE, Responsible for compliance with federal Endangered Species Act	All project components that involve federal land and/or require federal permits and/or approvals. It is anticipated that this project does not have the potential to affect any federal listed species. Therefore, a formal consultation under Section 7 of the Endangered Species Act probably would not be required	12 months	None

Potential Major Permits and Approvals Required
Ocean Desalination Project

Responsible Agency	Permit, Approval, or Review	Potentially Applicable To	Estimated Time Frame [a]	Public Hearing Requirements
U.S. Coast Guard	Review of Section 10 permit and Approval of Operations	Vessels, traffic safety and navigation hazards potentially associated with offshore intake structure. Will consult with the USACE during Section 10/404 process.	12 months	None
National Oceanic Atmospheric Association Fisheries (NOAA Fisheries)	Commenting agency to the USACE; must determine if project has potential to impact Essential Fish Habitat; responsible for marine fishes and marine mammals covered under federal Endangered Species Act	Offshore components with potential to impact marine fisheries or marine mammals. If it is anticipated that this project would not have the potential to affect any federal listed species, a formal consultation under Section 7 of the Endangered Species Act probably would not be required	12 months	None
State Historic Preservation Office (SHPO)	Section 106 Compliance, National Historic Preservation Act	Construction, operation, and/or abandonment of facilities on lands under federal jurisdiction	6 months	None
STATE				
Designated CEQA Lead Agency	Compliance with CEQA	All project components.	12 to 18 months	Not required but encouraged
California Coastal Commission	Coastal Development Permit	All project components within areas of "original jurisdiction" as shown on official Local Coastal Plan Post-Certification map	12 months	Required as part of the regular Coastal Development Permit process
	Consistency Determination	Offshore components requiring federal approval. The coastal Commission has indicated it would process a joint Coastal Development Permit/Consistency Determination for this project	12 months	Required

Potential Major Permits and Approvals Required
Ocean Desalination Project

Responsible Agency	Permit, Approval, or Review	Potentially Applicable To	Estimated Time Frame [a]	Public Hearing Requirements
Department of Health Services, Office of Drinking Water	Amended Domestic Water Permit Source Water Assessment and Protection Plan	Required to assess quality of delivered water, proposed treatment facilities, etc. Offshore intake structure.	2-3 months 6 months	None None
Regional Water Quality Control Board, San Francisco Region (SFRWQCB)	NPDES Permit or Waste Discharge Permit 401 – Water Quality Certification	Desalination brine discharge via outfall Certify that discharge into the USACE jurisdiction will not have adverse water quality impacts	6 months 2 months	Hearing required before Regional Water Quality Control Board; decision appealable to State Water Resources Control Board
State Lands Commission	Possible lease permit for area below mean high tide line (1)	Offshore components on any un-granted tidelands	6 months	Yes
California Department of Fish and Game	CEQA review, review of draft NPDES permit, consulting agency to USFWS, USACE and Coastal Commission	CDFG will review EIR/EIS and will consult with USFWS, USACE and Coastal Commission regarding impacts to biological resources	12 months	None
Bay Area Air Quality Management District	Air Quality Permit	Waste stockpile on site; power generation at project location	6 Months	None
State Water Resources Control Board	Water Rights Permit	Use of Delta or possibly Bay water	?	Likely

(1) The State Lands Commission typically consults with the State Historic Preservation Officer regarding potential impacts to cultural resources (e.g., shipwrecks) in State waters. This review/consultation would occur as part of the CEQA compliance process as well.

Potential Major Permits and Approvals Required
Ocean Desalination Project

Responsible Agency	Permit, Approval, or Review	Potentially Applicable To	Estimated Time Frame [a]	Public Hearing Requirements
LOCAL				
County Property Permits	Encroachment on State Tidelands Granted to County.	Offshore or Beach Structures.	2 Months	No
City Permit	Discretionary land use/zoning permits (i.e. Use Permit, Flood Plain Overlay Zone Permit, etc.) [b]	Construction and operation of project depending on location	3-6 Months	Planning Commission decision; appealable to City Council

a. The listed time frames for permit approval are estimated typical agency processing and review time frames. These time frames typically begin after the appropriate environmental review document has been certified. These estimated time frames could vary widely depending on length of staff review, degree of public involvement in the environmental review and permitting process, and the number and duration of potential appeals.

b. Section 53091 of the government code states that “zoning ordinances of a county or city shall not apply to the location or construction of facilities for the production, generation, storage, or transmission of water…” such an exemption may apply to all or portions of the proposed project(s).

Appendix B
Joint Aquatic Resource Permit Application

Appendix C

Potential Desalination Plant Location Rankings

LOCATION/ CRITERIA	C&H Sugar Refinery		Mirant Contra Costa Plant, Antioch	
	RATING	COMMENT	RATING	COMMENT
Feedwater Quality	3	Near Delta but fax enough down. May not be an issue but freshwater is available.	3	Good because of low salinity in the Delta
Water Cost	2	Near seawater salinity so will be near highest cost for desalination.	4	Near best achievable because of low salinity. Desalination plant will be low in cost. Available power supply is a benefit.
Water Rights/Permits	1	Proximity to Delta may make it difficult	3	There is a "take permit" but will need a "use" permit.
Public Acceptance	3	Proximity to Delta and industry.	2	Fish intake, power plant is detraction.
Grant Potential	2	Nothing particularly advantageous about this site.	3	Average, no particular advantage.
Regional Capability	2	Small site will limit the plant size.	4	Could provide very high volume which is beneficial as a regional supply.
Environmental	3	In high mixing zone but still close to the Delta.	2	Good disposal but salinity discharge will be an issue as well as intake.

LOCATION/ CRITERIA	Pico Power Plant, Santa Clara		Los Esteros Power Plant, San Jose	
	RATING	**COMMENT**	**RATING**	**COMMENT**
Feedwater Quality	4	Brackish ground water.	4	Brackish ground water.
Water Cost	5	Lowest potential cost because of brackish ground water.	5	Lowest potential cost because of brackish ground water.
Water Rights/Permits	3	Above average ability to get groundwater rights.	3	Above average as it is groundwater.
Public Acceptance	1	Perception that ground water is polluted and proximity to power plant. .	1	Perception that ground water is polluted.
Grant Potential	3	Not big but groundwater is listed as a grant potential.	3	Nothing very advantageous but groundwater is listed as a grant potential.
Regional Capability	1	Very limited capacity for a regional supply.	1	Very limited capacity for a regional supply.
Environmental	2	Brine discharge in south Bay, hydrogeology	2	Brine discharge in south Bay, hydrogeology

LOCATION/ CRITERIA	Mirant Pittsburg Plant		Palo Alto Water Pollution Control Plant	
	RATING	**COMMENT**	**RATING**	**COMMENT**
Feedwater Quality	3	Good because of low salinity in the Delta	4	Brackish ground water.
Water Cost	4	Near best achievable because of low salinity. Desalination plant will be low in cost. Available power supply is a benefit.	5	Lowest potential cost because of brackish ground water.
Water Rights/Permits	3	There is a “take permit” but will need a “use” permit.	3	Above average as it is groundwater.
Public Acceptance	2	Fish intake, power plant is detraction.	1	Perception that ground water is polluted.
Grant Potential	3	Average, no particular advantage.	3	Nothing very advantageous but groundwater is listed as a grant potential.
Regional Capability	4	Could provide very high volume which is beneficial as a regional supply.	1	Very limited capacity for a regional supply.
Environmental	2	Good disposal but salinity discharge will be an issue as well as intake.	2	Brine discharge concerns and hydrogeology

LOCATION/ CRITERIA	BDPL 1&2 AT Dumbarton Point		Near Bay Bridge Site	
	RATING	COMMENT	RATING	COMMENT
Feedwater Quality	3	Average salinity but lower in summer as result of WWTP discharge.	3	Good flow and mixing as near the Golden Gate Bridge but close to WWTP.
Water Cost	2	Quite good because of low salinity.	2	Will be high because water is near seawater salinity.
Water Rights/Permits	2	Fair capability	2	Fair capability.
Public Acceptance	1	South Bay has several WWTP and is considered polluted by many.	3	Close to WWTP.
Grant Potential	3	Average with high capacity for regional capability.	3	High regional capability.
Regional Capability	4	Access to major multi-agency distribution.	4	High volume and good location for distribution system.
Environmental	2	Concerns regarding new south Bay discharges.	3	Location is industrial area, some concern with ell grass.

LOCATION/ CRITERIA	Treasure Island Site		Oceanside Site, San Francisco	
	RATING	COMMENT	RATING	COMMENT
Feedwater Quality	4	Close to the Golden Gate bridge but will be near seawater salinity in quality.	3	Ocean water is good but needs to address proximity to wastewater treatment plant. Site is described as "near Oceanside WPCP" so that the site represents an area along the shore.
Water Cost	1	Highest cost because near seawater salinity and high cost of distribution system from Treasure Island.	2	Will be high cost for desalination system.
Water Rights/Permits	3	Should not be difficult	2	Should not be difficult for water rights but proximity to National Park is an issue.
Public Acceptance	4	Perception is probably good but proximity to former military base may be problematic.	3	If plant is designed to avoid perception of location near WWTP could be OK bust still will be a concern.
Grant Potential	2	Poor for grant potential.	4	Has high regional concept related to peninsula and brine discharge
Regional Capability	4	Good as with an adequate distribution system, could serve agencies on both sides of the Bay.	3	Large size potential and location near distribution system.
Environmental	1	New development area but still in bay. Pipeline across bay would be a major issue.	3	Ability to take advantage of high mixing zone.

LOCATION/ CRITERIA	Barge Mounted Plant	
	RATING	COMMENT
Feedwater Quality	3	Average as can be located anywhere within the bay.
Water Cost	3	Average as could be less expensive than a fixed location plant
Water Rights/Permits	1	Movable "take rights" will be difficult to obtain.
Public Acceptance	4	Will be viewed as temporary and movable.
Grant Potential	4	Innovative design.
Regional Capability	2	Limited in flow.
Environmental	1	Very difficult to permit.

LOCATION/ CRITERIA	Mallard Slough		San Francisco Airport	
	RATING	COMMENT	RATING	COMMENT
Feedwater Quality	3	Low salinity and close to Delta.	3	Average bay seawater salinity but high total suspended solids.
Water Cost	4	Will be low water cost because of the low salinity.	2	Will be high cost because of salinity and water treatment requirements.
Water Rights/Permits	3	Some existing water rights.	2	Fair permit potential.
Public Acceptance	2	Already have some acceptance but may cause perception issue regarding fish.	2	Already high profile area making acceptance an issue.
Grant Potential	3	Average. Plant would improve water quality in system.	3	Average, nothing particularly advantageous about location.
Regional Capability	1	Limited distribution requirements and currently limited flow.	3	Average.
Environmental	3	Several studies already exist for this site.	3	Many environmental studies have been completed.