Appendix G- Economic Analysis

Associated with the Draft Final Staff Report Including the Draft Final Substitute Environmental Documentation for the ~~Proposed~~ Draft Final Desalination Amendment

Economic Analysis of the Proposed Desalination Amendment to the Water Quality Control Plan for Ocean Waters of California

June 2014

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Contract GS-10F-0146L
BPA-10-03

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List of Exhibits

Abbreviations

APF	Area production foregone
CCC	California Coastal Commission
CDP	Coastal Development Permit
CEQA	California Environmental Quality Act
CWA	Clean Water Act
EIR	Environmental Impact Report
ETM	Empirical transport model
ENR CCI	Engineering News Record Construction Cost Index
gpm	Gallons per minute
MG	Million gallons
mgd	Million gallons per day
MMA	Marine Managed Area
NAICS	North American Industrial Classification System
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and maintenance
Ocean Plan	Water Quality Control Plan for Ocean Waters of California
Porter-Cologne	Porter-Cologne Water Quality Control Act
ppt	Parts per thousand
psu	Practical salinity units
RO	Reverse Osmosis
SIC	Standard Industrial Classification
$scwd^2$	Santa Cruz Water Department and Soquel Creek Water District
State Water Board	State Water Resources Control Board
SWQPA-GP	State Water Quality Protection Areas – General Protection
TDS	Total dissolved solids
ZID	Zone of initial dilution

Executive Summary

The State Water Resources Control Board (State Water Board) is proposing an amendment to the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) addressing sea water intakes and brine disposal from desalination plants. Specifically, the amendment would: (1) define the how the regional water boards will determine the best site, design, technology, and mitigation measures for intakes and discharge outfalls for new or expanded desalination facilities as specified under Porter-Cologne Section 13142.5(b); and (2) establish receiving water limitations for salinity as well as monitoring and reporting requirements for all desalination facilities.

This report presents economic considerations related to the proposed amendment to address provisions under the Porter-Cologne Water Quality Control Act (Porter-Cologne), and the California Environmental Quality Act (CEQA). These considerations include compliance with the requirements, methods to achieve compliance, and the costs of those methods. Compliance actions and costs attributable to the proposed amendment are those that would not likely be incurred under the existing regulatory framework. There are a number of existing regulations addressing the potential impacts associated with intakes and brine discharges from desalination plants, including the Ocean Plan, Porter-Cologne, the CEQA, and the California Coastal Act.

Existing Facilities

Under the proposed amendment, desalination brine discharges may only increase ambient salinity by 2 ppt. The proposed amendment also identifies primary options available for brine discharges from desalination plants to comply with the receiving water limits. These options include discharging raw brine through a multiport diffuser or commingling the brine with treated wastewater for dilution credits. Dischargers must implement the method that is most protective of marine resources based on a comparison of the magnitude of marine life mortality between dilution and discharging raw brine using multiport diffusers, or another proposed discharge technology.

Under existing regulations, dischargers must prevent degradation of marine communities. Most of the current National Pollutant Discharge Elimination System (NPDES) permit requirements for desalination brine are based on facilities providing a minimum dilution ratio or measuring salinity effects based on acute toxicity. There is no numeric-based limit applicable to all brine dischargers. Consequently, under the proposed amendment, dischargers that do not currently have dilution or mixing zone studies indicating less than a 2 ppt increase above ambient salinity or are not currently operating multiport diffusers may incur incremental costs.

Based on conceptual and preliminary estimates from proposed facilities, Abt Associates estimated that capital unit costs for multiport diffusers could range from $0.02 per gallon per day (gpd) to $0.15 per gpd. For operation and maintenance (O&M) costs, Abt Associates estimated average costs of $1.46 per million gallon (MG) treated for activities such as periodic cleaning and inspection of the system.

To estimate incremental statewide costs to existing brine discharges from desalination plants, Abt Associates used information in current NPDES permits on existing discharge controls and conditions and unit costs for multiport diffusers. Thus, estimated incremental annual costs for the 14 existing desalination plants could range from between approximately $1.1 million to $6.6 million.

New and Expanding Plants

The proposed amendment, once adopted, represents the baseline regulatory framework for the development of new desalination facilities. Thus, the timing for adoption will affect the incremental nature of the requirements. However, existing regulations and policies also provide for similar considerations in constructing new desalination capacity. Thus, there may be little change under the proposed amendment.

For example, the Porter-Cologne Section 13142.5(b) requires the regional water board to determine the best site, design, technology, and mitigation measures feasible to minimize the intake and mortality of all forms of marine life at new desalination facilities in California. However, Porter-Cologne does not define or describe best site, design, technology, or mitigation measures. In addition, the California Coastal Commission (CCC) has the authority to delay or reject permits if applicants do not conduct adequate environmental impact assessments for the effects on marine life due to entrainment and impingement. The CCC exercised this authority in November 2013 in voting to delay permitting for Poseidon Resource's proposed Huntington Beach desalination facility until the company performed a feasibility study for subsurface seawater intake structures. The current plan for the facility uses open ocean intakes, which opponents argue are harmful to marine life (Joyce, 2013).

For mitigation, all entities constructing new or expanded facilities must fully mitigate impacts to marine life, through either in-lieu funding or mitigation under the proposed amendment. Whether this change imposes incremental discharge and intake control costs is uncertain. For example, the CEQA requires entities to mitigate identified significant impacts that cannot be avoided.

Nonetheless, this report provides information on costs associated with subsurface intakes, surface intake screens, multiport diffusers, and mitigation measures. For example, when compared to the cost of surface water intakes, subsurface intakes could decrease total project capital costs by 2% to 9% due primarily to reduced pretreatment costs. Subsurface intakes produce a higher quality feed water that is low in suspended solids and other pollutants, whereas the feed water from surface water intakes must be pretreated to remove foulants prior to the reverse osmosis process.

Surface intake screens could account for up to 1.2% of total project capital and 0.3% of annual total O&M costs. Multiport diffusers could account for up to 0.8% of total project capital and 0.1% of annual total O&M costs.

For mitigation, Foster et al. (2013; Appendix 4) indicates that compensation can be attained for between approximately $36,000 and $154,000 per acre, depending on the water body type.

• Introduction

The State Water Resources Control Board (State Water Board) is proposing an amendment to the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) addressing seawater intakes and brine disposal from desalination facilities. This report presents analysis of economic factors related to the amendment.

○ Need for the Proposed Rule

Desalination processes salt water for human use, but can have negative effects on the marine environment. Brine discharged from desalination plants is highly concentrated, and can be toxic to aquatic life within a certain distance of the discharge location. In addition, water intake systems for these facilities can trap and kill fish and other aquatic organisms.

High salt concentrations make desalination brine denser than ocean water, allowing the discharge to settle on the ocean floor and adversely affect the health of benthic ecosystems. Several studies investigating the effects of elevated salinity levels have shown reduced survival rates for sea grasses and other bottom dwelling species, such as sea urchins and sea cucumbers (Gacia et al., 2007; Latorre, 2005; Sánchez-Lizaso et al., 2008).

The reverse osmosis (RO) process used in the majority of desalination plants leaves a variety of chemicals in plant discharges. Chemical additives such as antiscalants and antifoulants are used on intake water to protect membranes utilized in the RO process. Additionally, plants commonly blend the desalination brine with wastewater from plant cooling processes, which has a higher temperature than seawater and can contain a number of other dissolved chemicals. Concentrated doses of these chemicals within plant discharge can have potentially toxic effects on the growth and survival of marine organisms.

Seawater intake structures for desalination plants can be hazardous to aquatic life. Small fish and crustaceans can die from entrainment when they pass through the mesh screens of intake structures and cannot escape. Larger organisms can become impinged to the screens by the suction of the intake.

To address these issues, the State Water Board is proposing limitations on salinity in discharges, and requirements to limit the adverse impacts associated with intake for desalination.

○ Scope of the Analysis

The Porter-Cologne Water Quality Act (Porter-Cologne) requires the regional water boards to take “economic considerations,” among other factors, into account when they establish water quality objectives. The other factors include the past, present, and probable future beneficial uses of water; environmental characteristics of the hydrographic unit under consideration; water quality conditions that could reasonably be achieved through the coordinated control of all factors affecting water quality in the area; the need for housing; and the need to develop and use recycled water. The objectives must ensure the reasonable protection of beneficial uses, and the prevention of nuisance.

To meet the economic considerations requirement, the State Water Board (1999; 1994) concluded that, at a minimum, the regional water boards must analyze:

Whether the proposed objective is currently being attained;
If not, what methods are available to achieve compliance; and
The cost of those methods.

If the economic consequences of adoption are potentially significant, the regional water boards must explain why adoption is necessary to ensure reasonable protection of beneficial uses or prevent nuisance. The Boards can adopt objectives despite significant economic consequences; there is no requirement for a formal cost-benefit analysis.[1]

The amendment to the Ocean Plan that the State Water Board is proposing does not include water quality objectives, but rather limitations on water discharges (receiving water limitations) for a particular sector. Nonetheless, to inform policy development, the State Water Board is considering economic factors similar to developing water quality objectives. As such, under a contract with the United States Environmental Protection Agency, Abt Associates provided the State Water Board with an analysis of economic considerations. Specifically, Abt Associates identified potentially affected facilities, likely incremental compliance actions and costs for these facilities under the proposed amendment, and economic factors related to the requirements for the design and construction of future desalination facilities, including mitigation.

o Organization of this Report

This report is organized as follows:

Section 2 – describes the current applicable objectives and requirements that provide the baseline for the analysis of the incremental impact of the amendment.
Section 3 – describes the proposed amendment limitations and implementation.
Section 4 – describes the data we used to identify existing conditions and compliance methods and costs.
Section 5 – describes the method we used to evaluate compliance under the current regulatory framework and the amendment for existing dischargers, and the potential incremental costs of compliance.
Section 6 – discusses the potential for incremental compliance controls under the proposed amendment and presents estimates of unit costs for such controls.
Section 7 – provides the references for the analysis.

Appendices provide detailed information on unit cost estimates () and baseline conditions for existing desalination plants ().

[1] Water quality objectives establish concentrations protective of beneficial uses and the fishable/swimmable goals of the Clean Water Act (CWA), and thus are based on science and not economics. Under the CWA, economics can play a role in establishing water quality standards through the analysis of use attainability [removal of a beneficial use which is not an existing use under 40 CFR 131.10(g)]. However, the applicable economic criterion in such an analysis is not efficiency (i.e., maximizing net benefits, based on cost-benefit analysis) but distributional impacts (a determination of whether there will be substantial and widespread economic and social impacts from implementing controls more stringent than those required by sections 301(b) and 306 of the Act). This criterion may also be employed at the local level in the evaluation of temporary variances.

• Baseline for the Analysis

This Section identifies the current framework for regulating the quality of ocean waters in California. The current regulatory framework is the baseline against which the cost changes associated with the Amendment should be assessed. Thus, only costs that are greater or less than the costs associated with the baseline (i.e., incremental costs) would be attributable to the proposed amendment.

Several existing regulations address the potential impacts associated with desalination plants, including the Ocean Plan, Porter-Cologne, the Coastal Act discussed below. The CEQA requires environmental review of projects subject to government approvals, including desalination plant operation, construction, and expansion.

○ Ocean Plan

The Ocean Plan does not currently contain objectives or receiving water limitations specific to salinity. However, it does require dischargers of desalination brine to monitor salinity as part of their core monitoring programs.

The Ocean Plan has provisions applicable to new and existing seawater intakes within a state water quality protection area for general protection (SWQPA-GP). For example, for existing permitted seawater intakes with capacity greater than one million gallons per day (mgd), the Ocean Plan requires controls to minimize entrainment and impingement by using best technology available. For new seawater intakes, the Ocean Plan prohibits open ocean intakes within SWQPA-GP; the plan allows new sub-seafloor intakes in these areas where studies indicate that there is no predictable entrainment or impingement of marine life. The Ocean Plan does not currently prohibit or regulate new or existing seawater intakes outside of SWQPA-GPs.

○ Porter-Cologne Water Quality Control Act

For new or expanded coastal power plant or other industrial installation using seawater for cooling, heating, or industrial processing, Porter-Cologne Section 13142.5(b) requires use of the best available site, design, technology, and mitigation measures feasible to minimize the intake and mortality of all forms of marine life. However, Porter-Cologne does not define feasible.

○ California Coastal Act

The Coastal Act contains narrative requirements related to protection of marine organisms and the marine environment. For example, Section 30230 requires marine resources to be maintained, enhanced, and where feasible, restored with special protection given to areas and species of special biological or economic significance. Uses of the marine environment must be carried out in a manner that will sustain the biological productivity of coastal waters, and that maintains healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

In addition, Section 30231 requires the biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health to be maintained and, where feasible, restored. This may be accomplished through the following, among other means:

Minimizing adverse effects of waste water discharges and entrainment;
Controlling runoff;
Preventing depletion of ground water supplies and substantial interference with surface water flow;
Encouraging waste water reclamation;
Maintaining natural vegetation buffer areas that protect riparian habitats; and
Minimizing alteration of natural streams.

The Coastal Act also permanently established the California Coastal Commission (CCC), which has the mission to protect, conserve, restore, and enhance environmental and human-based resources of the California coast and ocean for environmentally sustainable and prudent use by current and future generations. In cooperation with local governments, the CCC regulates development (including construction, land division, and other activities that change the intensity of land use) in the coastal zone. In most cases, any new development project requires a Coastal Development Permit, which is issued by either the CCC or an authorized local government. As part of the permit application, entities must submit an Environmental Impact Report (see Section 2.4) for review if one is prepared.

o California Environmental Quality Act

The state legislature enacted the CEQA in 1970 as a system of checks and balances for land-use development and management decisions. The CEQA applies to entities undertaking projects defined in the act as an activity that:

is undertaken by a public agency, or a private activity which must receive some discretionary approval from a government agency (meaning that the agency has the authority to deny the requested permit or approval) and
may cause either a direct physical change in the environment or a reasonably foreseeable indirect change in the environment.

For example, the CEQA requires at least some environmental review of every development project subject to governmental approval, unless an exemption applies.

The CEQA requires the responsible entity to identify, avoid, and mitigate adverse environmental effects of the proposed Desalination Amendment. For all projects, the entity must determine whether the potential impacts of a project may be significant (defined as a substantial adverse change in the physical conditions which exist in the area affected by the proposed Desalination Amendment). Depending on this determination, the entity prepares one of the following documents:

A Negative Declaration if no significant impacts will occur,
A Mitigated Negative Declaration if the original project would have significant effects, but the agency revises it to avoid or mitigate the effects, or
An Environmental Impact Report (EIR), if it finds significant impacts.

When an EIR shows that a project will have significant effects, the entity must demonstrate how these effects have been avoided, minimized, or mitigated through project design changes, selection of alternatives, or disproval of project.

The CEQA Guidelines define “mitigation” as including, in order of preference (CEQA Section 15370): 1) avoiding the impact altogether by not taking a certain action or parts of an action, 2) minimizing the impact by limiting the degree or magnitude of the action and its implementation, 3) rectifying the impact by repairing, rehabilitating, or restoring the impacted environment, 4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action, or 5) compensating for the impact by replacing or providing substitute resources or environments. If the significant effects are unavoidable, the agency must demonstrate that it is acceptable through a Statement of Overriding Considerations in balancing the economic, legal, social, technological, and other factors.

o Summary

As described above, there are existing regulations applicable to the discharge of wastes and intake structures for both existing and new desalination plants. However, the provisions are generally narrative, and may result in inconsistencies in permitting or controls across the state. For example, none of the regulations establish numeric objectives for salinity in ocean waters. The regulations only require that marine life be sustained and protected where feasible, but do not specify design considerations or control measures that must be considered.

• Description of the Proposed Amendment

This Section describes the implementation requirements of the proposed amendment which defines the how the regional water boards will determine the best site, design, technology, and mitigation measures for each new or expanded desalination facility as specified under Porter-Cologne Section 13142.5(b). The amendment also establishes receiving water limitations for salinity as well as monitoring and reporting requirements for all desalination facilities.

o Applicability

The proposed amendment applies to seawater desalination plants in California, and defines these facilities in terms of existing, new, or expanded.

Existing facilities are those that have permits and have at least commenced construction of the facility beyond site grading.

Expanded facilities are existing facilities for which the owner or operator does either of the following in a manner that could increase intake or mortality of marine life: 1) increases the amount of seawater used either exclusively by the facility or used by the facility in conjunction with other facilities or uses, or 2) changes the design or operation of the facility after the effective date of the amendment.

New facilities are facilities that do not meet the definition of existing or expanding facilities.

o Site, Design, Technology, and Mitigation Measures Feasibility Considerations

For each new or expanded facility, the regional water board shall analyze a range of feasible alternatives for the best site, design, technology, and mitigation measures, and determine the best combination to minimize intake and mortality of marine life. The Board's analysis for expanded facilities will be limited to those expansions or other changes that result in the increased intake or mortality of marine life, unless the regional water board determines that additional measures that minimize intake and mortality of marine life are feasible for the existing portions of the facility.

▪ Site

Site is the general onshore and offshore location of a new or expanded facility. The regional water board requires the owner or operator of a new or expanded facility to:

Analyze the feasibility of subsurface intakes, including whether proposed design capacity is consistent with regional water needs;

Analyze the feasibility of placing intake, discharge, and other facility infrastructure in a location that avoids impacts to sensitive habitats and sensitive species;

Analyze the direct and indirect effects on marine life resulting from facility construction;

Analyze operation, oceanographic, bathymetric, geologic, hydrogeologic, and seafloor topographic conditions;

Analyze the presence of existing infrastructure and the availability of wastewater to dilute the facility's brine discharge;

Ensure that the facility is sited a sufficient distance from any Marine Protected Areas (MPA) or State Water Quality Protection Areas (SWQPA).

- **Design**

Design is the layout, form, and function of a facility, including the configuration and type of infrastructure, including intake and outfall structures. The regional water board requires the owner or operator of each facility to:

Analyze the potential design configurations of the intake, discharge, and other facility infrastructure to avoid impacts to sensitive habitats and sensitive species;

If a surface intake is proposed, the regional board requires an analysis of potential designs in order to minimize entrainment and the Area Production Forgone (APF);

Ensure that intake and discharges are located a sufficient distance from a MPA or SWQPA so that the salinity within the boundaries of a MPA or SWQPA does not exceed natural background salinity;

Design the outfall so that the brine mixing zone does not encompass or otherwise adversely affect existing sensitive habitat;

Perform plume modeling and/or field studies to show that discharges do not result in dense, negatively-buoyant plumes that result in adverse effects due to elevated salinity or anoxic conditions occurring outside the brine mixing zone;

Design outfall structures to minimize the suspension of benthic sediments.

- **Technology**

Technology is the type of equipment, materials, and methods that are used to construct and operate the design components of the desalination facility. The regional water board shall apply the following considerations in determining whether a proposed technology best minimizes intake and mortality of marine life:

- **Intake technology:**
  - The regional water board shall require subsurface intakes unless it determines that subsurface intakes are infeasible based on an analysis of approved criteria;
  - Installation and maintenance of subsurface intakes shall avoid, to the maximum extent feasible, the disturbance of sensitive habitats and sensitive species;
  - Surface water intakes must be screened with a 0.5 mm (0.02 in) or smaller slot size screen. An alternate method of preventing entrainment can be used if the facility demonstrates that it provides an equivalent level of protection using a study with Empirical Transport Model (ETM)/ Area of Production Forgone (APF) approach;
  - In order to minimize impingement, through-screen velocity at the surface water intake shall not exceed 0.15 meters per second (0.5 feet per second).
- **Discharge technology:**
  - The preferred technology for minimizing intake and mortality of marine life resulting from brine disposal is to commingle brine with wastewater that would otherwise be discharged to the ocean, unless the wastewater is of suitable quality and quantity to support domestic or irrigation uses. Multiport diffusers are the

next best method for disposing of brine when the brine cannot be diluted by wastewater and when there are no live organisms in the discharge;
- The regional water board shall require the owner or operator to analyze the brine disposal technology or combination of brine disposal technologies that best reduce the effects of the discharge of brine on marine life;
- Other brine disposal technologies may be used if an owner or operator can demonstrate to the regional water board that the technology provides a comparable level of protection;
- An owner or operator proposing to use flow augmentation as an alternative brine discharge technology must use low turbulence intakes and conveyance pipes and convey and mix dilution water in a manner that limits thermal stress, osmotic stress, turbulent shear stress, and other factors that could cause marine life mortality. Within three years of beginning operation the facility must submit to the regional water board an empirical study showing that the intake and mortality of marine life associated with flow augmentation is equal to or more protective than a facility using wastewater dilution or multiport diffusers. If the report shows it is less protective, the facility must either cease flow augmentation or re-design the flow-augmentation system. Facilities proposing to using flow augmentation through surface intakes are prohibited from discharging through multiport diffusers.

Mitigation

Mitigation is the replacement of marine life or habitat that is lost due to the activity of a desalination facility after minimizing marine life mortality through site, design, and technology measures. The regional water board requires the following mitigation measures:

- A Marine Life Mortality Report that projects the marine life mortality resulting from operation and construction of the facility after implementation of the facility's required site, design, and technology measures;
- The owner or operator shall mitigate for the marine life mortality determined in the report above by choosing to either complete a mitigation project or provide in-lieu funding.
    - **Mitigation Project:** The project must accomplish mitigation through the expansion, restoration, or creation of kelp beds, estuaries, coastal wetlands, natural reefs, MPAs, or other projects approved by the regional water board. The owner or operator must demonstrate that the project fully mitigates for intake-, discharge-, and construction-related marine life mortality. Intake-related marine life mortality must be mitigated using acreage that is at least equivalent in size to the APF calculated in the Marine Life Mortality Report. For every acre of discharge and construction-related disturbance, the owner or operator must restore one acre of habitat unless the regional water board determines that a greater than 1:1 ratio is needed.
    - **In-lieu Funding:** Instead of a project, the owner or operator may choose to provide funding to a mitigation program run by an approved public agency. The

amount of the fee associated with this option will depend on the cost of the mitigation project, or on the particular desalination facility's share of the cost. The mitigation program must result in the creation and ongoing implementation of a mitigation project that meets the requirements described for the first mitigation option and best compensates for intake and mortality of marine life caused by the facility.

o Receiving Water Limitations

The proposed amendment states that existing discharges of brine from desalination plants shall not exceed 2 parts per thousand (ppt) above natural background salinity, to be measured as total dissolved solids (TDS) no more than 100 meters (328 ft) horizontally from the discharge.

An owner or operator may submit a proposal to the regional water board for approval of an alternative salinity receiving water limitation. The facility-specific alternative receiving water limitation shall be based on the no observed effect level (NOEL) for the most sensitive species and toxicity endpoint as determined by chronic toxicity studies. The regional water board may require additional toxicity tests, information, or studies if needed. The regional water board may eliminate or revise a facility-specific alternative receiving water limitation for salinity based on a facility's monitoring data, the results from their Before-After Control-Impact (BACI) study, or other relevant information.

Existing facilities that do not meet the receiving water limitation at the edge of the brine mixing zone and throughout the water column must come into compliance by establishing a facility-specific alternative receiving water limitation for salinity as described above, or updating their brine discharge method to meet the 2 ppt limit.

o Monitoring and Reporting Programs

Owners and operators of desalination plants must submit a Monitoring and Reporting Plan to the regional water board for approval. The Monitoring and Reporting Plan shall, at a minimum, include monitoring for benthic community health, aquatic life toxicity, and receiving water characteristics. Receiving water monitoring for salinity shall be conducted at times when the monitoring locations are most likely affected by the discharge. New and expanded facilities must perform facility-specific monitoring to demonstrate compliance with the receiving water limitation for salinity, and evaluate the potential effects of the discharge within the water column, bottom sediments, and the benthic communities until the regional water board determines that the program is adequate to ensure compliance with the receiving water limitation. These facilities must also establish baseline biological conditions prior to discharge by conducting Before-After Control-Impact (BACI) biological surveys prior to commencement of construction.

• Data for the Analysis

To estimate the potential costs of implementing the proposed amendment, Abt Associates identified existing discharge conditions for National Pollutant Discharge Elimination System (NPDES)-permitted brine dischargers, the types of controls facilities may implement under the proposed amendment for compliance with the discharge and intake provisions, and the cost of those controls. Abt Associates relied on publicly available data sources for these analyses, as described below.

o Existing Facility Discharge Conditions

The State Water Board provided Abt Associates a list of potentially affected existing facilities discharging brine wastes to surface waters. Abt Associates used information in NPDES permits/fact sheets, State Water Board meeting minutes, and municipal websites to determine the facility type (e.g., desalination facility discharging to ocean waters), discharge flow, current effluent or receiving water limitations, the basis for limitations (e.g., results of mixing zone studies), monitoring requirements related to salinity, and outfall configuration (e.g., discharging through a multiport diffuser or commingled with another waste stream for dilution).

o Compliance Methods and Costs

Abt Associates relied primarily on feasibility studies and conceptual design reports for proposed desalination facilities in California to identify the types of controls that would enable compliance with the proposed amendment and the cost of those controls. The cost estimates generally represent conceptual level estimates, with reported accuracies ranging from -30% to +50%. The cost estimates also include varying contingency, installation, and other add-ons costs. Thus, there may be a significant range in unit costs for certain controls.

For mitigation costs, Abt Associates relied on the final report from the expert review panel (Foster, et al., 2013) submitted to the State Water Board in October 2013. The report estimates mitigation costs based on the cost of replacing the marine life or habitat lost by producing new, equivalent habitat, restoration that replaces the lost production, or other projects deemed equivalent.

• Potential Compliance and Costs: Existing Facility Requirements

This Section describes the method for evaluating current compliance with the amendment, identifies available compliance methods, and provides estimates of potential incremental compliance costs to existing dischargers.

o Overview of Method

The estimated compliance costs represent the cost of the incremental level of control above and beyond those activities already required under the existing regulatory framework. The method for evaluating potential impacts involves determining whether existing controls are sufficient for compliance with the proposed amendment, identifying the incremental compliance activities or controls needed to meet the provisions in the proposed amendment, and estimating the associated costs of those activities and controls.

o Affected Dischargers

Based on information provided by the State Water Board, Abt Associates has identified 13 existing seawater desalination facilities to which the proposed amendment would apply (**Exhibit Error**! No text of specified style in document.**-1**). This list does not include plants with NPDES permits that are not currently under construction (e.g., Huntington Beach Desalination Plant) or pilot/demonstration plants for full scale operations yet to be constructed.

Exhibit Error! No text of specified style in document.**-1: Existing Seawater Desalination Plants in California**

NPDES ID	Desalination Facility Name[1]	SIC Code	Brine Discharge (mgd)	Total Discharge (mgd)
CA0003751	PG&E, Diablo Canyon	4911	1.44	2540
CA0050016	Ocean View Plaza	4941	0.116	0.116
CA0061191	Pebble Beach Desalination Plant	4941	NS	0.72
CA0061794	US Navy, San Nicholas	4941	NS	0.067
CA0064564	Naval Base Ventura County	4941	NS	0.95
CA0109223	Carlsbad Desalination Project[2]	4941	54	540.5
CAG993001	City of Morro Bay	4941	0.9	0.9
CAG993001	Chevron, Gaviota	4941	0.14	1.2
CA0048143	Santa Barbara	4952	12.5	23.5
CA0107417	South Orange County Wastewater Authority - San Juan Creek Ocean Outfall	4952	2.8	38.78
CA0107433	City of Oceanside	4952	2	21
CA0107611	South Orange County Wastewater Authority - Aliso Creek Ocean Outfall	4952	1	34
CAG993003	Monterey Bay Aquarium	8422	0.04	>0.04

mgd = million gallons per day
NPDES ID = National Pollutant Discharge Elimination System Identification
NS = not specified
SIC = Standard Industrial Classification
1. Does not include NPDES-permitted plants that have not yet been constructed (e.g., Huntington Beach Desalination Facility).
2. Currently under construction.

○ Compliance Methods and Costs

Under the proposed amendment, desalination brine discharges may only increase ambient salinity by 2 ppt. The proposed amendment identifies the primary options available for brine discharges from desalination plants to comply with the receiving water limits, including discharging raw brine through a multiport diffuser or commingling the brine with treated wastewater for dilution credits. Dischargers must implement the method that is most protective of marine resources based on a comparison of the magnitude of marine life mortality between dilution and discharging raw brine using multiport diffusers, or other proposed discharge technology.

Under existing regulations, dischargers must prevent degradation of marine life. Most of the current NPDES permits requirements for desalination brine are based on facilities providing a minimum dilution ratio or measuring salinity effects based on acute toxicity. There is no numeric-based limit applicable to all brine dischargers. Thus, under the proposed amendment, facilities that do not currently have dilution or mixing zone studies indicating less than a 2 ppt increase above ambient salinity or are not currently operating multiport diffusers may incur incremental costs.

Abt Associates based estimates of potential incremental costs to existing desalination brine dischargers on costs associated with multiport diffusers because the availability and necessary quantities of dilution water is site-specific. **Exhibit Error**! No text of specified style in document.**-2** provides a summary of unit cost estimates from planned desalination plants in California.

Exhibit Error! No text of specified style in document.**-2: Unit Cost Estimates for Multiport Diffusers**

Location	Source	Project Costs (2013$)		Flow (mgd)[1]	Unit Costs (2013$)	
		Capital	Annual O&M		Capital ($/gpd)[2]	O&M ($/MG)[3]
Camp Pendleton	Malcolm Pirnie (2008)	$21,943,658	$73,230	150.0	$0.15	$1.34
Monterey Peninsula Water Supply Project	Leeper and Naranjo (2013)	$516,684		13.4	$0.04	-
West Basin, 20 mgd[4]	WBMWD (2013)	$952,676	$16,655	20.0	$0.05	$2.28
West Basin, 60 mgd[4]	WBMWD (2013)	$1,103,802	$16,655	60.0	$0.02	$0.76

gpd = gallon per day
MG = million gallons
mgd = million gallons per day
O&M = operation and maintenance
1. Represents the total flow of the waste discharge.
2. Calculated by dividing project capital costs by flow in gpd (mgd × 1,000,000).
3. Calculated by dividing annual project O&M costs by flow and 365 days per year.
4. Costs represent average for El Segundo and Redondo Beach sites.

A number of site-specific factors can affect the design of a diffuser. For example, the Camp Pendleton desalination plant design is broken up into three phases with the first for 50 mgd, and each subsequent phase adding an additional 50 mgd, up to 150 mgd. To accommodate this variability in flow, the facility proposal includes a specially designed Y-shaped diffuser. The facility will be able to close one branch of the “Y” during periods of low flow and open it when the facility is operating at full capacity (Malcolm Pirnie, 2008). Conversely, feasibility studies for the 2 potential 60 mgd desalination plants to service the West Basin Municipal Water District indicate that a conventional single multiport diffuser design would provide sufficient dilution and capacity.

Characteristics of receiving waters can also influence diffuser design. An analysis of the expected brine salinity and ocean currents at the West Basin facilities showed that 5-port diffusers would meet ambient salinity requirements, whereas Camp Pendleton’s diffuser is designed to have 130 ports even though the flows differ by only a factor of 3 (WBMWD, 2013).

Lastly, the cost estimate in **Exhibit** Error! No text of specified style in document.**-2** are conceptual and preliminary, and include varying add-on factors such as installation/mobilization, contingencies, legal and administrative fees, professional or engineering fees, contractor overhead and profit, etc. Details for the individual unit cost calculations are in . Given the numerous site-specific factors affecting costs and the significant range in capital unit costs (i.e., an order of magnitude between the high and low estimates), Abt Associates used the range of capital unit costs to estimate the potential incremental impacts to existing desalination brine dischargers, $0.02 per gallon per day (gpd) to $0.15 per gpd.

For operations and maintenance (O&M) costs, Abt Associates used an average of $1.46 per MG treated because the maintenance activities for multiport diffusers are typically similar regardless of diffuser design (e.g., periodic cleaning and inspection of the system).

o Statewide Costs

Abt Associates used information in current NPDES permits on existing discharge controls and conditions to determine which existing desalination plants in California may incur incremental costs to comply with the brine discharge provisions in the proposed amendment. Appendix B provides detailed baseline information for each facility for this evaluation.

Abt Associates estimated annual costs based on the unit cost estimates presented in Section o, and the facility-specific flows shown in **Exhibit Error**! No text of specified style in document.**-3**. Annual costs include capital costs annualized at 5% over 20 years plus annual O&M costs. The annualization rate is based on interest rates for the Carlsbad desalination facility currently under construction. WBMWD (2013) indicates that the useful life of a diffuser is approximately 20 years. As shown in the exhibit, incremental annual costs could range between approximately $1.2 million and $6.8 million.

Exhibit Error! No text of specified style in document.**-3: Potential Incremental Compliance Costs for Existing Desalination Plants**

NPDES ID	Facility Name	Flow (mgd)		Incremental Controls Needed	Rationale	Multiport Diffuser Costs		
		Brine	Total			Capital[1]	Annual O&M[2]	Annualized Costs[3]
CA0003751	PG&E, Diablo Canyon	1.44	2540	No	Commingled (brine 0.06% of effluent)	$0	$0	$0
CA0050016	Ocean View Plaza	0.116	0.116	No	Diffuser; dilution study indicates ambient salinity increase < 2ppt	$0	$0	$0
CA0061191	Pebble Beach Desalination Plant	NS	0.72	Possibly	Rip rap slope	$14,400 to $108,000	$400	$1,600 to $9,100
CA0061794	US Navy, San Nicholas	NS	0.067	No	Low volume discharged via dispersion through sand	$0	$0	$0
CA0064564	Naval Base Ventura County	NS	0.95	No	Commingled with permeate (pass-through water)	$0	$0	$0
CA0109223	Carlsbad Desalination Plant	54	540.5	Possibly	No diffuser; dilution study indicate increase in ambient salinity > 2ppt	$10,810,000 to $81,075,000	$288,000	$1,155,400 to $6,793,700
CAG993001	City of Morro Bay	0.9	0.9	No	Diffuser system; general permit justification indicates discharge at or below seawater salinity	$0	$0	$0
CAG993001	Chevron, Gaviota	0.14	1.2	No	Commingled with diffuser	$0	$0	$0
CA0048143	Santa Barbara	12.5	23.5	No	Commingled with diffuser; intermittent	$0	$0	$0

Exhibit Error! No text of specified style in document.**-3: Potential Incremental Compliance Costs for Existing Desalination Plants**

NPDES ID	Facility Name	Flow (mgd)		Incremental Controls Needed	Rationale	Multiport Diffuser Costs		
		Brine	Total			Capital[1]	Annual O&M[2]	Annualized Costs[3]
CA0107417	South Orange County Wastewater Authority - San Juan Creek Ocean Outfall	2.8	38.78	No	Commingled with diffuser	$0	$0	$0
CA0107433	City of Oceanside	2	21	No	Commingled with diffuser	$0	$0	$0
CA0107611	South Orange County Wastewater Authority - Aliso Creek Ocean Outfall	1	34	No	Commingled with diffuser	$0	$0	$0
CAG993003	Monterey Bay Aquarium	0.04	>0.04	No	Commingled; permit indicates effect of brine on salinity negligible	$0	$0	$0
Total	NA	A	A	NA	NA	$10,824,400 to $81,183,000	$288,400	$1,157,000 to $6,802,800

mgd = million gallons per day
NA = not applicable
NPDES ID = National Pollutant Discharge Elimination System Identification
NS = not specified
O&M = operations & maintenance
1. Total flow in gpd multiplied by $0.02 per gpd to $0.15 per gpd.
2. Total flow multiplied by $1.46 per MG and 365 days per year.
3. Capital costs annualized at 5% over 20 years plus annual O&M costs.

o Limitations and Uncertainties

Limited facility-specific information is available from current NPDES permits (e.g., not enough detail on the outfall structure, limited data on available dilution/mixing zone). Thus, the estimates of the potential incremental costs may over- or underestimate actual compliance costs. For example, relatively low cost dilution options such as combining brine discharge with a nearby wastewater treatment plant effluent could reduce compliance costs. Site-specific factors could result in higher or lower unit costs for installation of multiport diffusers than those presented in **Exhibit** Error! No text of specified style in document.**-3**.

• Potential Compliance and Costs: New and Expanded Plant Requirements

The proposed amendment, once adopted, represents the baseline regulatory framework for the development of new desalination facilities. Thus, the timing of adopting the proposed amendment will determine whether the requirements are baseline or incremental for any particular entity. This Section discusses current plans for additional desalination capacity, methods of compliance with the proposed amendment, and costs of the required activities and controls.

o New and Expanding Plants

The State Water Board has identified plans for a number of desalination plants that may meet the definition of new or expanded, depending on the effective date of the amendment. For example, Poseidon Resources has obtained local land use permits for the Huntington Beach facility but has not yet received a Coastal Development Permit (CDP) from the CCC. Thus, construction of the plant has been delayed until Poseidon Resources can conduct additional studies on environmental impacts. The West Basin Water District is also working towards compliance requirements for a CDP and NPDES permit for a desalination plant for which it has yet to receive approval. Since there are numerous efforts underway to conceptualize, plan, and design new and expanded plants, it is not feasible to identify all such activity.

o Potential Compliance with the Proposed Amendment

Under the proposed amendment, entities constructing new and expanded desalination plants need to utilize subsurface intake structures where feasible. If an applicant demonstrates to the satisfaction of the Regional Board that a subsurface intake is not feasible, the applicant may utilize a surface water intake after demonstrating a level of biological protection equivalent to or better than a subsurface intake and after taking mitigation measures into account. At minimum, surface water intakes would need to include intake screens.

Currently Porter-Cologne Section 13142.5(b) requires the regional water board to determine the best site, design, technology, and mitigation measures feasible to minimize the intake and mortality of all forms of marine life at new desalination facilities in California. However, Porter-Cologne does not define or describe best site, design, technology, or mitigation measures.

In addition, the CCC has the authority to delay or reject permits if applicants do not conduct adequate environmental impact assessments for the effects on marine life due to entrainment and impingement. For example, in November 2013, the CCC voted to delay permitting for the Huntington Beach desalination facility until the company performed a feasibility study for subsurface seawater intake structures. The current plan for the plant uses open ocean intakes, which opponents argue are harmful to marine life (Joyce, 2013).

Thus, there is uncertainty regarding whether the proposed amendment would result in incremental intake controls and configurations compared to the current regulatory framework.

Nonetheless, the Sections below provide information on various types of subsurface intakes and surface intake screens.

Once constructed, facilities would need to meet the receiving water limits for salinity. As shown in Section □o, there are several ways existing facilities are complying with this provision. The fact that there are dischargers that may need to make changes to their existing discharge structure indicates that there could be changes to the construction of new outfalls associated with the proposed amendment.

For mitigation, all entities developing new or expanded plants must fully mitigate impacts to marine life and habitat, through either an in-lieu fee program, or mitigation under the proposed amendment. However, the CEQA already requires entities to mitigate identified significant impacts that cannot be avoided. Additionally, even if impacts are not significant pursuant to the CEQA, entities may be required to conduct mitigation under other regulations.

For example, the EIR for the Poseidon Resources desalination plant in Carlsbad does not identify the impingement and entrainment effects to be significant under the CEQA. Nonetheless, the CCC required Poseidon Resources to develop a Marine Life Mitigation Plan, which includes the restoration of at least 37 acres of estuarine wetlands, as a special requirement of its CDP (CCC, 2011). This mitigation acreage was imposed pursuant to the CCC's and the State Water Board's respective responsibilities under the Coastal Act and the California Water Code, both of which employ different standards of review than the CEQA's "significant impact" threshold. This suggests that mitigation requirements under the proposed amendment are unlikely to represent incremental activity. Nonetheless, the Sections below also provide information on mitigation compliance and costs.

o Compliance Methods

As discussed above, new and existing facility designs may include subsurface well intake structures, surface water intake screens, multiport diffusers for brine discharges, and mitigation. The Section below discusses subsurface intakes, surface water intake screens, and mitigation; see Section □o for discussion of multiport diffusers.

▪ Subsurface Well Intakes

There are four main types of intake technologies that provide subsurface feedstock water:

Vertical wells – drilled into sediments directly below the well site and require favorable geology and hydrology. For example, vertical wells require sand formations with adequate permeability and porosity to produce a sufficient supply of feedstock water.

Slant wells – drilled at an angle between vertical and horizontal (which is more costly than drilling straight down). These slant wells can be advantageous in locations where vertical depth is limited.

Ranney (radial) wells – horizontal water collection wells with a central concrete caisson from which lateral well screens are arranged in a radial pattern. Design options for the lateral screens are highly adaptable, so the wells can be installed in settings that may otherwise limit subsurface intakes (e.g., shallow bedrock, limited horizontal extent of target aquifer). They also use less area than a conventional well field and minimize groundwater entrance velocity, reducing the frequency of required maintenance (Riegert, 2006).

Infiltration galleries – can be constructed either offshore or onshore. Infiltration galleries intake water through a series of buried horizontal wells that lie underneath a specially-engineered filter bed that blocks sediment and debris but allows seawater to seep through. Because these beds provide filtration, infiltration galleries require less pretreatment for RO units, but require a particular substrate and wave energy to be feasible for offshore locations (RBF Consulting, 2009).

Subsurface intake wells are generally associated with higher capital and construction costs than open or screened surface intakes. Subsurface intakes also typically require a larger installation area than surface intakes in order to provide adequate source water to a facility, resulting in higher land acquisition costs. However, subsurface intake systems typically have much lower operating costs due to reductions in feedwater pretreatment, biofouling, and mitigation costs (since they eliminate impingement and entrainment).

- **Surface Water Intakes Screens**

The proposed amendment requires desalination facilities using surface water intakes to use wedgewire screens with 0.5 mm or smaller slot size, or other screening technology that is at least as effective as the wedgewire screen in reducing entrainment of juvenile organisms, larvae, and eggs. The screens must also be adequately maintained for the duration of the facility's operation.

Wedgewire technology reduces impingement and entrainment of aquatic life by (Bechtel, 2012):

Acting as physical barriers to prevent aquatic organisms sufficiently larger than the screen slot size from being entrained;

Using a sweeping current in the source water to move aquatic organisms away from the screen faces; and

Utilizing a slow through-slot intake velocity at the screens to further exclude early life stages of aquatic organisms.

The feasibility and costs of wedgewire screens varies based on facility design and site characteristics. However, screen costs generally represent a small portion of overall project costs, and can reduce operation, maintenance, pretreatment, and mitigation costs compared to an uncontrolled open intake.

- **Mitigation**

Under the amendment, the State Water Board's preferred mitigation strategy for desalination intake impacts is habitat creation, restoration, or enhancement (SWRCB, 2013). For operational impacts related to intakes, the mitigation acreage requirements will depend on the APF as determined by an empirical transport model (ETM). Foster et al. (2013; Appendix 4) describe this approach. APF models provide an estimate of the scale of loss resulting from the intake impacts, and as such, a measure of the mitigation needed to compensate for the loss. The approach yields a "currency" in the form of habitat acreage that is needed to offset the impact (Appendix 4, page 1). APF is based on impacts to a set of sample species, and this approach assumes that the mean of the samples represents the true loss rate across all affected species. The APF covers all losses, direct and indirect, for which mitigation is needed.

For operational mortality related to discharges from the facility, the owner or operator must estimate (and include in the Marine Life Mortality Report) the area or volume in which salinity will exceed 2 ppt above natural background, and the mortality associated with discharges. Similarly, the owner or operator must estimate mortality associated with construction of the facility. For both discharge and construction related impacts, the owner or operator can estimate the area of disturbance associated with mortality using any acceptable approach.

Mitigation requirements will depend on the type of habitat needed to compensate for losses. For example, as noted by Foster et al. (2013; Appendix 4, page 3), wetland creation and restoration (which may be used to compensate for losses in estuaries or soft-bottom open coastal areas) is more expensive per acre than reef creation (which compensates for losses in rocky bottom open coastal areas). Additionally, rather than completing a mitigation project, owners and operators may choose to instead provide in-lieu funding to a mitigation program run by an approved public agency.

o Compliance Costs

This Section provides cost estimates for subsurface well intakes, surface intake screens, multiport diffusers, and mitigation that may be employed for compliance under the proposed amendment.

▪ Subsurface Well Intakes

The incremental cost of using subsurface well intakes represents the difference between the cost of the baseline intake option (e.g., surface water intake) and the cost of the subsurface intake. Typically, costs for subsurface well intakes are more costly than surface intake structures. However, source water from subsurface intakes will have lower suspended solids, which decreases the amount of pretreatment needed and thus, total project costs.[2] Subsurface intakes also reduce biofouling in the seawater transmission pipeline and system, decreasing chemical usage and the frequency of maintenance activities.

However, most feasibility studies for proposed desalination plants show the cost of subsurface wells versus the cost of surface intakes without considering the decrease in pretreatment requirements and maintenance activities. Hence, data are limited for the comparison of costs for the two options. **Exhibit Error**! No text of specified style in document.**-4** shows the total project costs for surface and subsurface intakes for two proposed desalination plants, including differences in pretreatment.

[2] Note that in some areas subsurface water may be high in iron and manganese, which would need to be removed prior to the RO system to prevent fouling. This could increase pretreatment costs, although they would still likely be less than those required for surface intakes (Kennedy/Jenks Consultants, 2011).

Exhibit Error! No text of specified style in document.**-4: Comparison of Total Capital Costs for Subsurface and Surface Intake Structures (millions 2013$)**

Location	Source for Estimates	Total Capital Project Costs	
		Subsurface Intake	Surface Intake
Monterey Peninsula[1]	Leeper and Naranjo (2013)	$195 - $287	$199 - $300
Camp Pendleton[2]	RBF Consulting (2009)	$2,604 - $2,873	$2,875 - $3,144

1. Open intake structures require an additional $33 million in capital costs related to pretreatment.
2. Additional pretreatment for surface intakes includes a submerged ultrafiltration system and an underground ultrafiltration filtrate storage tank (RBF Consulting, 2009, Table 10-7).

As shown in the exhibit, costs for subsurface intake structures may decrease total capital costs by approximately 2% to 9%. This is due primarily to the decrease in pretreatment controls needed for the cleaner intake water from subsurface wells. For example, for Camp Pendleton, the subsurface infiltration gallery is almost twice as much as the surface water intake structure. However, the surface water intake option requires more than $200 million more in pretreatment controls than the subsurface intake option.

- **Surface Water Intake Screens**

Exhibit Error! No text of specified style in document.**-5** presents unit cost estimates for surface intake screens for proposed desalination plants in California. provides the details for each of the estimates.

Exhibit Error! No text of specified style in document.**-5: Estimated Unit Costs for Surface Water Intake Screens (2013$)**

Location	Source	Total Costs		Size[2] (mgd)	Unit Costs	
		Capital	Annual O&M		Capital[3] ($/gpd)	O&M[4] ($/MG)
Camp Pendleton	Malcolm Pirnie (2008)	$33,174,664	$366,149	330	$0.10	$3.04
Monterey Peninsula	Leeper and Naranjo (2013)	$310,010	-	23	$0.01	-
scwd[2]	Kennedy/Jenks Consultants (2011)	$1,810,745	$154,106	11.3	$0.16	$37.36
West Basin (20 mgd)	WBMWD (2013)	$1,775,243	$37,993	20	$0.09	$5.20
West Basin (60 mgd)	WBMWD (2013)	$2,644,229	$42,678	60	$0.04	$1.95

MG = million gallons
mgd = million gallons per day
O&M = operation & maintenance
scwd[2] = Santa Cruz Water Department and Soquel Creek Water District
WBMWD = West Basin Water Management District

1. Escalated to 2013 dollars using the Engineering New Record Construction Cost Index.
2. Represents total intake volume per day.
3. Estimated by dividing total capital costs by intake flow in gpd (mgd × 1,000,000).
4. Estimated by dividing total O&M costs by intake flow in mgd and 365 days per year.

To put these costs into perspective, we compared the overall project capital and O&M costs to the cost of just the intake screens as shown in **Exhibit Error**! No text of specified style in document.**-6**.

Exhibit Error! No text of specified style in document.**-6: Comparison of Surface Water Intake Screens to Total Project Costs (millions 2013$)**

Location	Source for Estimates	Capital Costs			Annual O&M		
		Total Project	Intake Screen	% of Total	Total Project	Intake Screen	% of Total
Camp Pendleton	Malcolm Pirnie (2008)	$2,875 - $3,144	$33.2	1.1% - 1.2%	$135 - $178	$0.4	0.3%
Monterey Peninsula[1]	Leeper and Naranjo (2013)	$199 - $300	$0.3	0.1% - 0.2%	$14 - $15	-	-
West Basin (20 mgd)	WBMWD (2013)	$275 - $342	$1.8	0.5% - 0.6%	$18	$0.04	0.2%
West Basin (60 mgd)	WBMWD (2013)	$664 - $827	$2.6	0.3% - 0.4%	$52	$0.04	0.1%

mgd = million gallons per day
O&M = operation and maintenance

1. Total Project capital cost range for Monterey represents cost estimates for surface and subsurface intakes.

Multiport Diffusers

As shown in **Exhibit** Error! No text of specified style in document.**-2**, unit costs for multiport diffusers could range from approximately $0.02 per gpd to $0.15 per gpd for capital and average approximately $1.46 per MG treated for O&M. **Exhibit Error**! No text of specified style in document.**-7** provides a comparison of diffuser costs to total project costs.

Exhibit Error! No text of specified style in document.**-7: Comparison of Multiport Diffuser Costs to Total Project Costs (millions 2013$)**

Location	Source for Estimates	Capital Costs			Annual O&M		
		Total Project	Diffuser	% of Total	Total Project	Diffuser	% of Total
Camp Pendleton	Malcolm Pirnie (2008)	$2,604 - $3,144	$21.9	0.7% - 0.8%	$117 - $178	$0.07	0.1%
Monterey Peninsula[1]	Leeper and Naranjo (2013)	$195 - $300	$0.5	0.2% - 0.3%	$13 - $15	-	-
West Basin (20 mgd)	WBMWD (2013)	$275 - $342	$1.0	0.3%	$18	$0.02	0.1%
West Basin (60 mgd)	WBMWD (2013)	$664 - $827	$1.1	0.1% - 0.2%	$52	$0.02	0.0%

1. Total project capital cost range for Monterey represents cost estimates for surface and subsurface intakes.

Mitigation

Desalination plant owners and operators must mitigate for impacts resulting from intake, construction, and discharges, through either the implementation of a mitigation project, or payment to a mitigation program run by an approved public agency. For intake-related impacts, the mitigation acreage required will be determined by the APF method, as described in Section □o□. In addition, owners and operators must also mitigate impacts resulting from construction and discharges, using at least a 1:1 mitigation ratio (i.e., one acre of mitigation for every acre impacted). As such, the size of required mitigation projects depends on the size of the impacts associated with both construction and operation (specific to intake and discharges).

Exhibit Error! No text of specified style in document.**-8** shows the estimated unit mitigation costs for several power plants, based on the APF method, shown in costs per acre of mitigation (Foster, et al., 2013). On average, compensation can be attained for an average of $36,000 per acre for wetlands and $154,000 per acre for rocky reefs.[3]

Note that desalination plants are likely to use smaller volumes of water compared with power plants, and as such may be associated with lower intake-based mitigation project costs. On the other hand, however, the amendment requires that desalination plant owners and operators also mitigate for construction- and discharge-related impacts, which will increase the required mitigation acreage relative to intake-only mitigation projects.

[3] Updated to 2013$ using ENR CCI.

Actual costs for individual mitigation projects will vary based on site-specific factors, and may be significantly higher or lower than averages.

Exhibit Error! No text of specified style in document.**-8. Estimated Mitigation Costs for Power Plant Intakes**[1]

Facility (year)	Intake Volume (mgd)	APF (acres)	Total Cost (millions; 2013$)[2]	Cost per Acre (2013$)[2]
Wetland/Estuary				
Moss Landing (2000)	360	840	$23.2	$27,601
Morrow Bay (2001)	371	760	$20.6	$27,145
Poseidon (2009)	304	37	$12.4	$334,368
Huntington Beach (2009)	127	66	$5.5	$82,748
Rocky Reef				
Diablo (2006)	2,670	543	$83.7	$154,098

APF = area production foregone
mgd = million gallons per day
Source: Foster et al. (2013), Appendix 4.
1. Costs likely do not include project monitoring and administration.
2. Updated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

o Summary

Depending on the outcome of an environmental impact analysis for a new or expanded plant, the proposed amendment could result in incremental costs or cost savings associated with the design and construction of subsurface intakes, surface intake screens, multiport diffusers, and mitigation measures. For example, when compared to the cost of surface water intakes, subsurface intakes could decrease total project capital costs by 2% to 9%, due primarily to reduce pretreatment costs. Surface intake screens could account for up to 1.2% of total project capital and 0.3% of annual total O&M costs. Multiport diffusers could account for up to 0.8% of total project capital and 0.1% of annual total O&M costs.

For mitigation, Foster et al. (2013; Appendix 4) indicates that compensation can be attained for between approximately $36,000 and $154,000 per acre, depending on the water body type.

o Limitations and Uncertainties

Once adopted, the proposed amendment will represent the regulatory baseline for any new facility or facility expansion. However, there is evidence that facility planners are already considering the feasibility of subsurface intakes and surface intake screens, and the potential environmental impacts to marine life associated with each option as part of the design process, under the current regulatory framework, as a way to avoid delays and denials of the necessary permits caused by insufficient consideration and analysis of environmental impacts. Further, entities may already have to mitigate for significant environmental impacts under CEQA and the Coastal Act, through avoidance, minimization, or compensatory actions. Thus, it is unclear whether the intake structure and mitigation costs in Section o are attributable to the amendment or would be incurred under the existing framework.

• References

Bechtel Power Corporation (Bechtel). 2012. Independent Third-Party Interim Technical Assessment for the Offshore Modular Wedge Wire Screens for San Onofre Nuclear Generation Station.

California Coastal Commission (CCC). 2011. W8a: Conditional Compliance for CDP No. E-06-013, Special Condition 8.

Foster, M.S., G.M. Cailliet, J. Callaway, K.M. Vetter, P. Raimondi, and P.J.W. Roberts. 2013. Desalination Plant Entrainment Impacts and Mitigation. Final Report Submitted to Mariela Paz Carpio-Obeso, Ocean Standards Unit, State Water Resources Control Board (SWRCB) in fulfillment of SWRCB Contract No. 11-074-270, Work Order SJSURF 11-11-019.

Gacia, E., O. Invers, M. Manzaneera, E. Ballesteros and AJ. Romero. 2007. Impact of the brine from a desalination plant on a shallow seagrass (Posidonia oceanica) meadow. Estuarine, Coastal and Shelf Science 72:579-590

Joyce, Ed. 2013. Poseidon withdraws Huntington Beach desalination permit application; coastal commission tables vote. Southern California Public Radio. Accessible electronically at: http://www.scpr.org/news/2013/11/14/40366/poseidon-withdraws-huntington-beach-desalination-p/

Latorre, M. 2005. Environmental impact of brine disposal on Posidonia seagrasses. Desalination 182: 517-524.

Leeper, S.E. and J.E. Naranjo. 2013. Supplemental Testimony of Richard C. Svindland, Attachment 6. California-American Water Company.

Kennedy/Jenks Consultants. 2011. scwd^2 Seawater Desalination Intake Technical Feasibility Study.

Malcolm Pirnie. 2008. Project Correspondence: Intake and Discharge Systems Conceptual Level Cost Estimate Assumptions. October 14, 2008.

RBF Consulting. 2013. Contingency Planning for the MPWSP (Update of November 1, 2012 TM). January 9, 2013.

RBF Consulting. 2009. Camp Pendleton Seawater Desalination Project Feasibility Study. Prepared for San Diego County Water District. JN: 25-101785.

San Diego Regional Water Quality Control Board (SDRWQCB). 2007. Carlsbad Seawater Desalination Project Flow Entrainment and Impingement Minimization Plan. Attachment 2: Cost Estimate of Subsurface Intake Alternatives.

Sánchez-Lizaso, J., J. Romero, J. Ruiz, E. Gacia, J. Buceta, O. Invers, Y. Torquemada, J. Mas, A. Ruiz-Mateo, and M. Manzanera. 2008. Salinity tolerance of the Mediterranean seagrass Posidonia oceanica: Recommendations to minimize the impact of brine discharges from desalination plants. Desalination 221:602-607.

State Water Resources Control Board (SWRCB). 2013. Draft Staff Report: Amendment to the Water Quality Control Plan for Ocean Waters of California addressing Seawater and Brackish Water Intakes and Brine Disposal from Desalination Facilities.

Voutchkov, N. 2010. Evaluation of Alternative Desalination Plant Subsurface Intake

Technologies. Memo from Water Globe Consulting to Poseidon Water.

West Basin Municipal Water District (WBMWD). 2013. Ocean Water Desalination Program Master Plan (PMP). Appendix 7:A.

• Unit Costs

This appendix provides the details for the unit cost estimates for brine controls, intake structures, and intake screens. The cells in the tables shaded in green are from the cited source document, whereas Abt Associates calculated the remaining cells based on the information in the source document.

A.1 Brine Controls

Exhibits A-1 through A-9 show facility-specific details used to develop unit costs for brine controls.

Exhibit A-1: Camp Pendleton Multiport Diffuser Capital Costs

Material / Equipment	Cost (2008$)	Cost (2013$) [2]
7' Diameter Diffuser Pipe Concrete Cover	$3,600,000	$4,055,802
Structure at outfall "Y"	$2,000,000	$2,253,223
Diffuser Orifices	$750,000	$844,959
Equipment Subtotal	$6,350,000	$7,153,984
Installation/Construction [1]	$5,243,792	$5,907,717
Equipment and Installation Subtotal	$11,593,792	$13,061,701
Contingency	40%	
Equipment, Installation, & Contingency Subtotal	$16,231,309	$18,286,381
Engineering + Construction Management:	20%	
Total Capital Cost	$19,477,571	$21,943,658
Percent of O&M attributable to diffuser [3]	50%	
Annual O&M	$65,000	$73,230

Source: Malcolm Pirnie (2008) for shaded cells.
1. Estimated installation as a percent of equipment costs by dividing the total project equipment cost by the total installation costs and assuming that installation is proportional to equipment cost (see Exhibit A-2).
2. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI). Used CCI of 8600 for 2008 dollar year as specified in Malcolm Pirnie (2008).
3. Estimated the percent of annual operation & maintenance (O&M) costs based on the facility needing annual inspection of the discharge and intake structures, and assuming that it takes the same amount of time to inspect each structure (i.e., 50% of O&M costs are attributable to the outfall/diffuser system).

Exhibit A-2: Camp Pendleton Project Costs used to Estimate Installation as a Percent of Capital Equipment

Component	Cost (2008$)
Capital Costs	
Intake Headers	$8,400,000
Intake Screens	$1,200,000
Brine Discharge Line	$10,440,000
WWTP Effluent Discharge Line	$3,480,000
Diffuser	$6,350,000
Gravel trench bedding	$1,300,000
Total Capital Equipment Cost	$31,170,000
Installation Costs	

Exhibit A-2: Camp Pendleton Project Costs used to Estimate Installation as a Percent of Capital Equipment

Component	Cost (2008$)
Barges	$3,960,000
Cranes	$1,620,000
Tugboat	$900,000
Diver Crews	$6,300,000
Tradesmen	$12,960,000
Total Installation /Construction Cost	$25,740,000
Installation as a percent of capital equipment	83%
Annual Inspection Cost [1]	$130,000
Source: Malcolm Pirnie (2008) for shaded cells. 1. Cost for a dive crew and support vessel for two weeks.	

Exhibit A-3: Monterey Peninsula Diffuser Capital Cost

Component	Cost (2012$)/Quantity	Cost (2013$) [1]
New Diffusers	$500,000	$516,684
Total intake flow (mgd) [2]	23	
Total product water flow (mgd)	9.6	
Calculated brine flow (mgd)	13.4	
mgd = million gallons per day Source: Leeper and Naranjo (2013) for shaded cells. 1. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI). 2. Source for intake flow: RBF Consulting (2013)		

Exhibit A-4: West Basin Diffuser Capital Cost, El Segundo Site, 20 mgd

Component	Cost (2012$)	Cost (2013$) [3]
Diffusers Materials and Installation (Labor) Costs	$659,933	$686,936
Diffuser Construction Costs, including add-ons [1]	$890,910	$927,363
Total Capital Cost - Diffusers [2]	$1,051,273	$1,094,289
mgd = million gallons per day Source: West Basin Municipal Water District (2013) for shaded cells. 1. Add-ons include mobilization/demobilization, bonds and insurance, overhead and profit, and contingency calculated as 35% of material and labor costs. 2. Total capital cost includes 18% of construction and add-on costs for professional services. 3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).		

Exhibit A-5: West Basin Diffuser Capital Cost, El Segundo Site, 60 mgd

Component	Cost (2012$)	Cost (2013$) [3]
Diffusers Materials and Installation (Labor) Costs	$765,960	$797,301
Diffuser Construction Costs, including add-ons [1]	$1,034,046	$1,076,357
Total Capital Cost - Diffusers [2]	$1,220,174	$1,270,101

mgd = million gallons per day
Source: West Basin Municipal Water District (2013) for shaded cells
1. Add-ons include mobilization/demobilization, bonds and insurance, overhead and profit, and contingency calculated as a percent of material and labor costs.
2. Total capital cost includes 18% of construction costs for professional services.
3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-6: West Basin Diffuser Capital Cost, Redondo Beach Site, 20 mgd

Component	Cost (2012$)	Cost (2013$) [3]
Diffusers Materials and Installation (Labor) Costs	$489,128	$509,142
Diffuser Construction Costs, including add-ons [1]	$660,323	$687,342
Total Capital Cost - Diffusers [2]	$779,181	$811,063

mgd = million gallons per day
Source: West Basin Municipal Water District (2013) for shaded cells.
1. Add-ons include mobilization/demobilization, bonds and insurance, overhead and profit, and contingency calculated as a percent of material and labor costs.
2. Total capital cost includes 18% of construction costs for professional services.
3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-7: West Basin Diffuser Capital Cost, Redondo Beach Site, 60 mgd

Component	Cost (2012$)	Cost (2013$) [3]
Diffusers Materials and Installation (Labor) Costs	$565,380	$588,514
Diffuser Construction Costs, including add-ons [1]	$763,263	$794,494
Total Capital Cost - Diffusers [2]	$900,650	$937,503

mgd = million gallons per day
Source: West Basin Municipal Water District (2013) for shaded cells.
1. Add-ons include mobilization/demobilization, bonds and insurance, overhead and profit, and contingency calculated as a percent of material and labor costs.
2. Total capital cost includes 18% of construction costs for professional services.
3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-8: West Basin Capital Cost Add-ons

Cost Component	Percent [1]
Mobilization/ Demobilization [2]	2%
Bonds & Insurance [2]	1%
Overhead & Profit [2]	12%
Contingency [2]	20%
Subtotal Construction Cost [2]	35%
Professional Services [3]	18%

Source: West Basin Municipal Water District (2013) for shaded cells
1. Represents Base scenario (study presents cost estimates for low, base, and high scenarios).
2. Cost components calculated as a percent of total material and labor costs.
3. Cost component calculated as a percent of total construction cost.

Exhibit A-9: West Basin Desalination Plant - O&M Costs

Component	Annual Cost (2012$)	Cost (2013$) [2]
El Segundo, 20 mgd	$16,000	$16,655
El Segundo, 60 mgd	$16,000	$16,655
Redondo Beach, 20 mgd	$16,000	$16,655
Redondo Beach, 60 mgd	$16,000	$16,655

mgd = million gallons per day
O&M = operation & maintenance
Source: West Basin Municipal Water District (2013) for shaded cells.
1. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

A.2 Intake Controls

Exhibits A-10 through A-28 show facility-specific details used to develop unit costs for intake controls.

Exhibit A-10: Camp Pendleton Intake Screens Capital Costs

Material / Equipment	Cost (2008$)	Cost (2013$) [2]
Intake Headers (2 pipes,10.5' diameter, 3500' each)	$8,400,000	$9,463,538
Intake Screens (6' diameter)	$1,200,000	$1,351,934
Equipment Subtotal	$9,600,000	$10,815,472
Installation/Construction [1]	$7,927,623	$8,931,352
Equipment and Installation Subtotal	$17,527,623	$19,746,824
Contingency	40%	
Equipment, Installation, & Contingency Subtotal	$24,538,672	$27,645,553
Engineering + CM:	20%	
Total Capital Cost	$29,446,406	$33,174,664

Source: Malcolm Pirnie (2008) for shaded cells.
1. Estimated installation as a percent of equipment costs by dividing the total project equipment cost by the total installation costs and assuming that installation is proportional to equipment cost (see Exhibit A-2).
2. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI). Used CCI of 8600 as specified in the report.

Exhibit A-11: Camp Pendleton Intake Screens O&M Costs

Material / Equipment	Annual Cost (2008$)	Cost (2013$) [1]
Inspection Cost as % of total Inspection cost [2]	50%	
Total inspection cost	$130,000	$146,460
Intake screen inspection	$65,000	$73,230
Intake Screen Semiannual Airbust Crew	$100,000	$112,661
Intake Screen Semiannual Airbust Vessel	$30,000	$33,798
Intake Screen Annual Cleaning Crew	$100,000	$112,661
Intake Screen Annual Cleaning Vessel	$30,000	$33,798
Annual O&M	$325,000	$366,149

O&M = operation & maintenance
Source: Malcolm Pirnie (2008) for shaded cells.
1. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI). Used CCI of 8600 as specified in the report.
2. Estimated the percent of annual inspection costs based on the facility needing annual inspection of the discharge and intake structures, and assuming that it takes the same amount of time to inspect each structure (i.e., 50% of costs are attributable to the intake system).

Exhibit A-12: Camp Pendleton - Subsurface Infiltration Gallery Capital

Component	Cost (2009$)	Cost (2013$) [3]
Deep Infiltration Gallery Intake - Phase 1 [1]	$54,817,150	$62,126,061
Deep Infiltration Gallery Intake - Phase 2 [2]	$24,070,950	$27,280,391
Deep Infiltration Gallery Intake - Phase 3 [2]	$14,830,950	$16,808,398
Deep Infiltration Gallery Intake - Total Equipment	$93,719,050	$106,214,850
Construction Contingency (percent of equipment)	40%	
Subtotal - Equipment + Construction Contingency	$131,206,670	$148,700,790
Implementation (percent of equip + constr contingency)	25%	
Total Capital	$164,008,338	$185,875,988

Source: RBF Consulting (2009) for shaded cells.
1. For 50 million gallons per day (mgd).
2. For addition of 50 mgd.
3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI) from January 2009$.

Exhibit A-13: Camp Pendleton - Subsurface Infiltration Gallery O&M

Component	Annual Cost (2009$)	Cost (2013$) [3]
Power Requirement Costs for Intake [1]	$4,730,354	$5,361,064
Feed Intake System Cleaning Costs [2]	$120,000	$136,000
Total O&M	$4,850,354	$5,497,064

O&M = operation & maintenance
Source: RBF Consulting (2009) for shaded cells.
1. Based on energy costs of $0.10/kWh in 2009 dollars.
2. Based on 2 weeks per year for cleaning and includes vessel and crew.
3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI) from January 2009$.

Exhibit A-14: Monterey Peninsula Slant Well Intake Capital Cost

Component	Cost (2012$)	Cost (2013$) [2]
Slant Cost [1]	$50,323,000	$52,002,187
Intake Pump Station Costs [1]	$6,363,000	$6,575,322
Intake Pipeline Costs [1]	$4,697,000	$4,853,730
Total Slant Wells Cost	$61,383,000	$63,431,239

Source: Leeper and Naranjo (2013) for shaded cells.
1. Includes implementation costs as 20% of equipment, and contingency and mitigation costs as 25% and 1%, respectively, of equipment and installation costs. Also includes land cost for well installation.
2. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-15: Monterey Peninsula Ranney Collector Intake Capital Cost

Component	Cost (2012$)	Cost (2013$) [4]
Ranney collectors	$23,000,000	$23,767,468
Temporary Sheet Piling and Wave Protection for Construction	$3,700,000	$3,823,462
Subtotal Base Construction	$26,700,000	$27,590,930
Implementation 20%	$5,340,000	$5,518,186
Land [1]	$1,100,000	$1,136,705
Subtotal for equip, installation, and land	$59,840,000	$61,836,752
Contingencies as percent of equip, installation, and land	25%	$0
Mitigation as percent of equip, installation, and land	1%	$0
Ranney Collector Total (equipment, installation, land, contingency, and mitigation)	$75,398,400	$77,914,307
Additional Beach Pipeline Cost [2]	$1,400,000	$1,446,715
Pump Station Costs [3]	$6,363,000	$6,575,322
Total Ranney Collector Cost	$83,161,400	$85,936,344

Source: Leeper and Naranjo (2013) for shaded cells.
1. Original estimate excludes land cost from the Ranney collector cost because they assume they would have already purchased the land for the preferred option. Thus, Abt Associates added the land cost to the estimate to obtain total stand-alone project costs.
2. Includes implementation costs as 20% of equipment, and contingency and mitigation costs as 25% and 1%, respectively, of equipment and installation costs.
3. Original estimate does not include pump station costs; however, for consistency with the slant well estimates, Abt Associates included the pump station costs (the report does not indicate that pump station costs would be avoided under the Ranney collector option).
4. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-16: Monterey Peninsula Intake Screen Capital Cost

Component	Cost (2012$)	Cost (2013$) [2]
Total Wire Screens Cost [1]	$300,000	$310,010

Source: Leeper and Naranjo (2013) for shaded cells.
1. Includes implementation costs as 20% of equipment, and contingency and mitigation costs as 40% and 1%, respectively, of equipment and installation costs.
2. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-17: scwd^2 Intake Screens Capital Cost

Component	Cost (2010$)	Cost (2013$) [2]
Intake Screens [1]	$1,645,000	$1,810,745

Source: Kennedy/Jenks Consultants (2011) for shaded cells.
1. Costs include 9.75% tax on total materials cost, 15% contractor overhead & profit (OH&P) on materials and installation cost, 30% of total cost for contingency, and 5% of total cost for mid-point of construction.
2. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-18: scwd^2 Intake Screens O&M

Component	Annual Cost (2010$)	Cost (2013$) [2]
Screen and pipeline cleaning (every 16 weeks)	$140,000	$154,106

O&M = operation & maintenance
Source: Kennedy/Jenks Consultants (2011) for shaded cells.
1. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-19: West Basin Capital Cost for Intake Screens - El Segundo Site, 20 mgd

Component	Cost (2012$)	Cost (2013$) [3]
Material and Labor for Screens	$1,086,776	$1,131,244
Construction costs (with add-ons) [1]	$1,467,148	$1,527,180
Total Capital Cost, including professional fees [2]	$1,731,234	$1,802,072

mgd = million gallons per day
Source: West Basin Municipal Water District (2013) for shaded cells.
1. Add-ons include mobilization/demobilization, bonds and insurance, overhead and profit, and contingency calculated as a percent of material and labor costs.
2. Total capital cost includes 18% of construction costs for professional services.
3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-20: West Basin Capital Cost for Intake Screens - El Segundo Site, 60 mgd

Component	Cost (2012$)	Cost (2013$) [3]
Material and Labor for Screens	$1,623,056	$1,689,467
Construction costs (with add-ons) [1]	$2,191,126	$2,280,781
Total Capital Cost, including professional fees [2]	$2,585,528	$2,691,322

mgd = million gallons per day
Source: West Basin Municipal Water District (2013) for shaded cells.
1. Add-ons include mobilization/demobilization, bonds and insurance, overhead and profit, and contingency calculated as a percent of material and labor costs.
2. Total capital cost includes 18% of construction costs for professional services.
3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-21: West Basin Capital Cost for Intake Screens - Redondo Beach Site, 20 mgd

Component	Cost (2012$)	Cost (2013$) [3]
Material and Labor for Screens	$1,054,416	$1,097,560
Construction costs (with add-ons) [1]	$1,423,462	$1,481,706
Total Capital Cost, including professional fees [2]	$1,679,685	$1,748,413

mgd = million gallons per day
Source: West Basin Municipal Water District (2013) for shaded cells.
1. Add-ons include mobilization/demobilization, bonds and insurance, overhead and profit, and contingency calculated as a percent of material and labor costs.
2. Total capital cost includes 18% of construction costs for professional services.
3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-22: West Basin Capital Cost for Intake Screens - Redondo Beach Site, 60 mgd

Component	Cost (2012$)	Cost (2013$) [3]
Material and Labor for Screens	$1,566,256	$1,630,343
Construction costs (with add-ons) [1]	$2,114,446	$2,200,963
Total Capital Cost, including professional fees [2]	$2,495,046	$2,597,137

mgd = million gallons per day
Source: West Basin Municipal Water District (2013) for shaded cells.
1. Add-ons include mobilization/demobilization, bonds and insurance, overhead and profit, and contingency calculated as a percent of material and labor costs.
2. Total capital cost includes 18% of construction costs for professional services.
3. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-23: West Basin Additional Project Capital Cost Components

Cost Component	Percent
Mobilization/ Demobilization [1]	2%
Bonds & Insurance [1]	1%
Overhead & Profit [1]	12%
Contingency [1]	20%
Subtotal Construction Cost [1]	35%
Professional Services [2]	18%

Source: West Basin Municipal Water District (2013) for shaded cells.
1. Given as a percent of total material and labor cost.
2. Given as a percent of total construction cost.
3. Study presents cost estimates for low, base, and high scenarios.

Exhibit A-24: West Basin Intake Screen O&M Cost

Component	Annual Cost (2012$)	Cost (2013$) [2]
El Segundo, 20 mgd	$35,000	$36,432
El Segundo, 60 mgd	$41,000	$42,678
Redondo Beach, 20 mgd	$38,000	$39,555
Redondo Beach, 60 mgd	$41,000	$42,678

mgd = million gallons per day
O&M = operation & maintenance
Source: West Basin Municipal Water District (2013) for shaded cells.
1. Assumed that costs were in 2012 dollars based on cost estimate date of 9/11/2012.
2. Escalated to 2013$ using the Engineering News Record Construction Cost Index (ENR CCI).

A.3 Total Project Costs

Exhibit A-25: Camp Pendleton Total Project Capital Cost Estimates (Grid Power)

Site	Phase 1	Phase 2	Phase 3	Total (2009$)	Total (2013$) [3]
SRTTP [1]	$1,245,000,000	$556,000,000	$502,000,000	$2,303,000,000	$2,603,669,146
MCTSSA [2]	$1,303,000,000	$642,000,000	$598,000,000	$2,543,000,000	$2,875,002,448

Source: RBF Consulting, 2009
1. Uses a subsurface intake.
2. Uses a surface intake.
3. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-26: Camp Pendleton Total Project Capital Cost Estimates (Cogeneration)

Site	Phase 1	Phase 2	Phase 3	Total (2009$)	Total (2013$) [3]
SRTTP [1]	$1,328,000,000	$635,000,000	$578,000,000	$2,541,000,000	$2,872,741,337
MCTSSA [2]	$1,387,000,000	$718,000,000	$676,000,000	$2,781,000,000	$3,144,074,639

Source: RBF Consulting, 2009
1. Uses a subsurface intake.
2. Uses a surface intake.
3. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-27: Camp Pendleton Total Plant O&M Cost Estimates (Grid Power)

Intake Type	Annual Cost	Total (2009$)	Total (2013$) [1]
Subsurface	$103,600,000	$103,600,000	$117,125,542
Screened Open Ocean	$119,300,000	$119,300,000	$134,875,262

O&M = operation & maintenance
Source: RBF Consulting, 2009
1. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-28: Camp Pendleton Total Plant O&M Cost Estimates (Cogeneration)

Intake Type	Annual Cost	Total (2009$)	Total (2013$) [1]
Subsurface	$130,800,000	$130,800,000	$147,876,650
Screened Open Ocean	$157,700,000	$157,700,000	$178,288,591

O&M = operation & maintenance
Source: RBF Consulting, 2009
1. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-29: West Basin 20mgd Total Plant Capital Cost Estimates

Site	Low (2012$)	Base (2012$)	High (2012$)	Low (2013$) [1]	Base (2013$) [1]	High (2013$) [1]
El Segundo	$261,767,000	$291,248,000	$325,803,000	$272,477,849	$303,165,137	$339,134,041
Redondo Beach	$265,833,000	$295,772,000	$330,864,000	$276,710,219	$307,874,248	$344,402,125

mgd = million gallons per day
Source: WBMWD (2013)
1. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-30: West Basin 60mgd Total Plant Capital Cost Estimates

Site	Low (2012$)	Base (2012$)	High (2012$)	Low (2013$) [1]	Base (2013$) [1]	High (2013$) [1]
El Segundo	$635,003,000	$706,520,000	$790,344,000	$660,985,729	$735,429,025	$822,682,893
Redondo Beach	$641,168,000	$713,379,000	$798,017,000	$667,402,985	$742,568,678	$830,669,853

mgd = million gallons per day
Source: WBMWD (2013)
1. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-31: West Basin 20mgd Total Plant O&M Cost Estimates

Site	Base (2012$)	Base (2013$) [1]
El Segundo	$17,669,000	$18,391,971
Redondo Beach	$17,656,000	$18,378,439

mgd = million gallons per day
O&M = operation & maintenance
Source: WBMWD (2013)
1. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-32: West Basin 60mgd Total Plant O&M Cost Estimates

Site	Base (2012$)	Base (2013$) [1]
El Segundo	$49,554,000	$51,581,625
Redondo Beach	$49,631,000	$51,661,776

mgd = million gallons per day
O&M = operation & maintenance
Source: WBMWD (2013)
1. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-33: Monterey Peninsula 9.6mgd - Total Plant Capital Cost with Subsurface Intakes

Cost Range	Capital Cost (2012$)	Cost (2013$) [1]
Low	$188,900,000	$195,203,248
Base	$222,200,000	$229,614,408
High	$277,800,000	$287,069,679

Cost Range	Capital Cost (2012$)	Cost (2013$) [1]
mgd = million gallons per day Source: Leeper and Naranjo (2013) 1. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).		

Exhibit A-34: Monterey Peninsula 9.6mgd - Total Plant O&M Cost with Subsurface Intakes

Cost Range	Annual O&M Cost (2012$)	Cost (2013$) [1]
Base	$12,970,000	$13,402,785
mgd = million gallons per day O&M = operation & maintenance Source: Leeper and Naranjo (2013) 1. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).		

Exhibit A-35: Monterey Peninsula 9.6mgd - Total Plant Capital Cost with Surface Intakes

Incremental Cost (2012$) [1]	Total Capital Cost – Low (2012$)	Total Capital Cost – Base (2012$)	Total Capital Cost – High (2012$)	Total Capital Cost - Low (2013$) [2]	Total Capital Cost - Base (2013$) [2]	Total Capital Cost - High (2013$) [2]
Contingency Plan I-2: Open ocean intake offshore from CEMEX property						
$3,600,000	$192,500,000	$225,800,000	$281,400,000	$198,923,374	$233,334,534	$290,789,804
Contingency Plan I-8: Construct a new open ocean intake near Moss Landing, with feedwater pumped to a desalination plant at the CBR site						
$12,200,000	$201,100,000	$234,400,000	$290,000,000	$207,810,340	$242,221,500	$299,676,770
mgd = million gallons per day Source: Leeper and Naranjo (2013) 1. Compared to a cost scenario using a slant well intake structure. 2. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).						

A.4 Surface Intake Structure Costs

Exhibit A-36: Camp Pendleton - Surface Intake Component Capital Cost

Component	Cost (2009$)	Cost (2013$) [3]
Surface Intake - Phase 1 [1]	$34,510,000	$39,111,306
Surface Intake - Phase 2 [2]	$11,400,000	$12,919,991
Surface Intake - Phase 3 [2]	$8,100,000	$9,179,994
Surface - Total Equipment	$54,010,000	$61,211,291
Construction Contingency (percent of equipment)	40%	
Subtotal - Equipment + Construction Contingency	$75,614,000	$85,695,808
Implementation (percent of equip+constr contingency)	25%	
Total Capital	$94,517,500	$107,119,760
Source: RBF Consulting, 2009 1. For 50 million gallons per day (mgd). 2. For addition of 50 mgd. 3. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).		

Exhibit A-37: Monterey Peninsula 9.6mgd Desalination Plant - Surface Intake Component Capital Cost

Contigency Intake	Additional Component Cost [1] (2012$)	Baseline Cost [2] (2012$)	Total Intake Component Capital Cost (2012$)	Total Intake Component Capital Cost - (2013$) [3]
Contigency Plan I-2: Open ocean intake offshore from CEMEX property	$46,200,000	$100,000	$46,300,000	$47,844,946
Contigency Plan I-8: Construct a new open ocean intake near Moss Landing, with feedwater pumped to a desalination plant at the CBR site	$71,863,000	$0	$71,863,000	$74,260,937

mgd = million gallons per day
Source: Leeper and Naranjo (2013)
1. Compared to a slant well intake structure.
2. Components used cost scenario for a slant well intake structure that are listed at no cost in contigency plans. For Contingency Plan I-2, this includes $100,000 in land.
3. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

Exhibit A-38: Monterey Peninsula 9.6mgd Desalination Plant - Surface Intake Component O&M Cost

Contigency Intake	Incremental Cost [1] (2012$)	O&M Cost – Base (2012$)	Total Capital Cost - Base (2013$) [2]
Contigency Plan I-2: Open ocean intake offshore from CEMEX property	$1,000,000	$13,970,000	$14,436,153
Contigency Plan I-4: Direct intake of water from Moss Landing Harbor, using existing Marine Refractory intake infrastructure, with feedwater pumped to a desalination plant at the CBR site	$1,400,000	$14,370,000	$14,849,501
Contigency Plan I-7: Convert existing Marine Refractory outfall into an open ocean intake, with feedwater pumped to a desalination plant at the CBR site	$1,400,000	$14,370,000	$14,849,501
Contigency Plan I-8: Construct a new open ocean intake near Moss Landing, with feedwater pumped to a desalination plant at the CBR site	$1,400,000	$14,370,000	$14,849,501

O&M = operation & maintenance
Source: Leeper and Naranjo (2013)
1. Compared to a cost scenario using a slant well intake structure.
2. Escalated to 2013$ using Engineering News Record Construction Cost Index (ENR CCI).

• Facility Information

Exhibit B-1 shows the information used to determine if incremental controls will be needed for existing NPDES-permitted desalination facilities.

Exhibit B-1: Existing Desalination Facility Information

NPDES ID	Desalination Facility Name	SIC Code	City	Brine Flow (mgd)	Total Flow (mgd)	Discharge Description /Controls	Existing Effluent Limits	Existing Monitoring Requirements	Other	Need for Incremental Controls?
CA0064581	West Basin Demonstration Plant	3559	West Basin	0.05	0.58	Desalinated water is combined with brine prior to discharge. 1300 ft offshore, 30ft deep	Minimum dilution of 10:1.	None specified	Permit indicates that facility is temporary/used to evaluate full-scale options for the future plant.	No
CA0003751	PG&E, Diablo Canyon	4911	San Luis Obispo	1.44	2540	Discharges up 2540 mgd of seawater, in-plant chemical wastes, low-level radioactive wastes, and stormwater runoff to Diablo Cove.	None related to salinity.	None related to salinity.		No
CA0050016	Ocean View Plaza	4941	Monterey	0.116	0.116	Facility discharges brine through a diffuser that extends approximately 1000 feet into Monterey Bay, at a depth of 50 ft. Mixing study indicates that under worst-case conditions discharge could increase ambient salinity of 33.5 psu by 2% (or by 0.67 psu).	Minimum initial dilution of 37:1.	Daily average flow (mgd) and daily peak rate (gpm).		No
CA0061191	Pebble Beach Desalination Plant	4941	Avalon	Not specified	0.72	Discharge of reverse osmosis brine, filter backwash, untreated seawater, and wastewater from flushing the seawater supply pipeline through a rip rap slope to the Pacific Ocean.	Minimum initial dilution factor of 5:1.	None related to salinity.	Permit notes that the 37% increase in effluent TDS is not expected to result in saline concentrations in the effluent that would result in the degradation of marine life or marine waters.	Possibly

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CA0061794	US Navy, San Nicholas	4941	San Nicholas Island	Not specified	0.067	Discharge of RO reject brine and filter backwash into a brine well 250 feet from the shore-line, which disperses through sand and enters the San Nicolas lsland Harbor.	None related to salinity.	Monthly sampling for TDS.		No
CA0064564	Naval Base Ventura County	4941	Port Hueneme	Not specified	0.95	Brine and permeate are discharged through a pipe positioned on a rock rip-rap 13 feet from to the Port Hueneme Harbor.	None related to salinity.	Annual monitoring for salinity.	Because they aren't using the permeate and are discharging it back into the water from which it came with the brine, it is essentially pass-through water and should not affect ambient salinity.	No
CA0109223	Carlsbad Desalination Project	4941	Carlsbad	54	540.5	Brine diluted from salinity of 67 ppt to sublethal level of 40 ppt prior to discharge through in-plant dilution. Remainder of dilution achieved through natural mixing via low velocity (1 to 3 feet per second) discharge into high energy surf zone seaward of the point of discharge.	Avg daily TDS = 40 ppt, avg hourly TDS = 44 ppt. Minimum initial dilution of 15.5:1.	Weekly monitoring of salinity.	Facility construction began early 2013. Depending on construction, proposed amendment adoption, and final design for outfall structure, the facility may incur incremental costs.	Possibly
CAG993001	City of Morro Bay	4941	Morro Bay	0.9	0.9	Discharge flows through an outfall diffuser system into the ocean.	None related to salinity.	TDS monitoring required upon plant start-up and annually thereafter.	Discharge salinity is less than or comparable to seawater per Regional Board Order to permit under a General Permit.	No

Exhibit B-1: Existing Desalination Facility Information

NPDES ID	Desalination Facility Name	SIC Code	City	Brine Flow (mgd)	Total Flow (mgd)	Discharge Description /Controls	Existing Effluent Limits	Existing Monitoring Requirements	Other	Need for Incremental Controls?
CAG99 3001	Chevron, Gaviota	494 1	Gavio ta	0.14	1.2	Wastewaters discharged through an outfall/diffuser system to the ocean include the following: 0.001 mgd of sewage from an aeration treatment/ultraviolet disinfection system, 0.14 mgd of reverse osmosis reject brine, 0.36 mgd of excess seawater, and 0.072 mgd of boiler blowdown.	Minimu m dilution of 72:1	TDS monitorin g required upon plant start-up and annually thereafter .		No
CA004 8143	Santa Barbara	495 2	Santa Barba ra	12.5	23.5	Effluent (secondary wastewater and brine) is discharged through a 8,720 foot diffuser to the Pacific Ocean into water approximately 70 feet deep. Provides a minimum initial dilution of 44:1 when brine is being discharged.	Minimu m initial dilution 120: 1 without brine, and 44: 1 with brine.	Weekly for salinity during discharge s of brine; may reduce to annually when brine is not discharge d.	Requires annual inspection of diffuser. Flow reported is maximum; may also discharge 3.9 mgd, 4.1 mgd, or 9.4 mgd.	No
CA010 7417	South Orange County Wastewater Authority - San Juan Creek Ocean Outfall	495 2		2.8	38.7 8	Discharge via the San Juan Creek Ocean Outfall through a multiport diffuser.	Minimu m 100:1 initial dilution.	None specified		No
CA010 7433	City of Oceanside	495 2	Ocean side	2	21	Combined waste discharge through the Oceanside Ocean Outfall, which ends in a 230ft diffuser. The diffuser has 14 5-inch diameter ports and 10 4-inch diameter ports.	Minimu m initial dilution of 87:1.	None related to salinity.		No

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NPDES ID	Desalination Facility Name	SIC Code	City	Brine Flow (mgd)	Total Flow (mgd)	Discharge Description /Controls	Existing Effluent Limits	Existing Monitoring Requirements	Other	Need for Incremental Controls?
CA0107611	South Orange County Wastewater Authority - Aliso Creek Ocean Outfall	4952		1	34	Discharge via the Aliso Creek Ocean Outfall through a multiport diffuser.	Minimum 237:1 initial dilution.	monthly offshore salinity		No
CAG993003	Monterey Bay Aquarium	8422	Monterey	0.04	>0.04	The brine discharge is blended with the exhibit water outfall. The effluent is effectively diluted due to the large volume of discharge water, which is at ambient salinity, and the effects of the brine effluent are considered to be negligible.	None.	None.		No

gpm = gallons per minute
mgd = million gallons per day
NPDES ID = National Pollutant Discharge Elimination System Identification
psu = practical salinity units
RO = reverse osmosis
SIC = Standard Industrial Classification
TDS = total dissolved solids
ZID = zone of initial dilution
Source: Current NPDES permits; for City of Morro Bay: http://www.swrcb.ca.gov/rwqcb3/board_info/agendas/2009/dec/item_17/stfrpt_17.pdf; for Monterey Bay Aquarium: http://montereybay.noaa.gov/resourcepro/resmanissues/pdf/110806desal_final.pdf