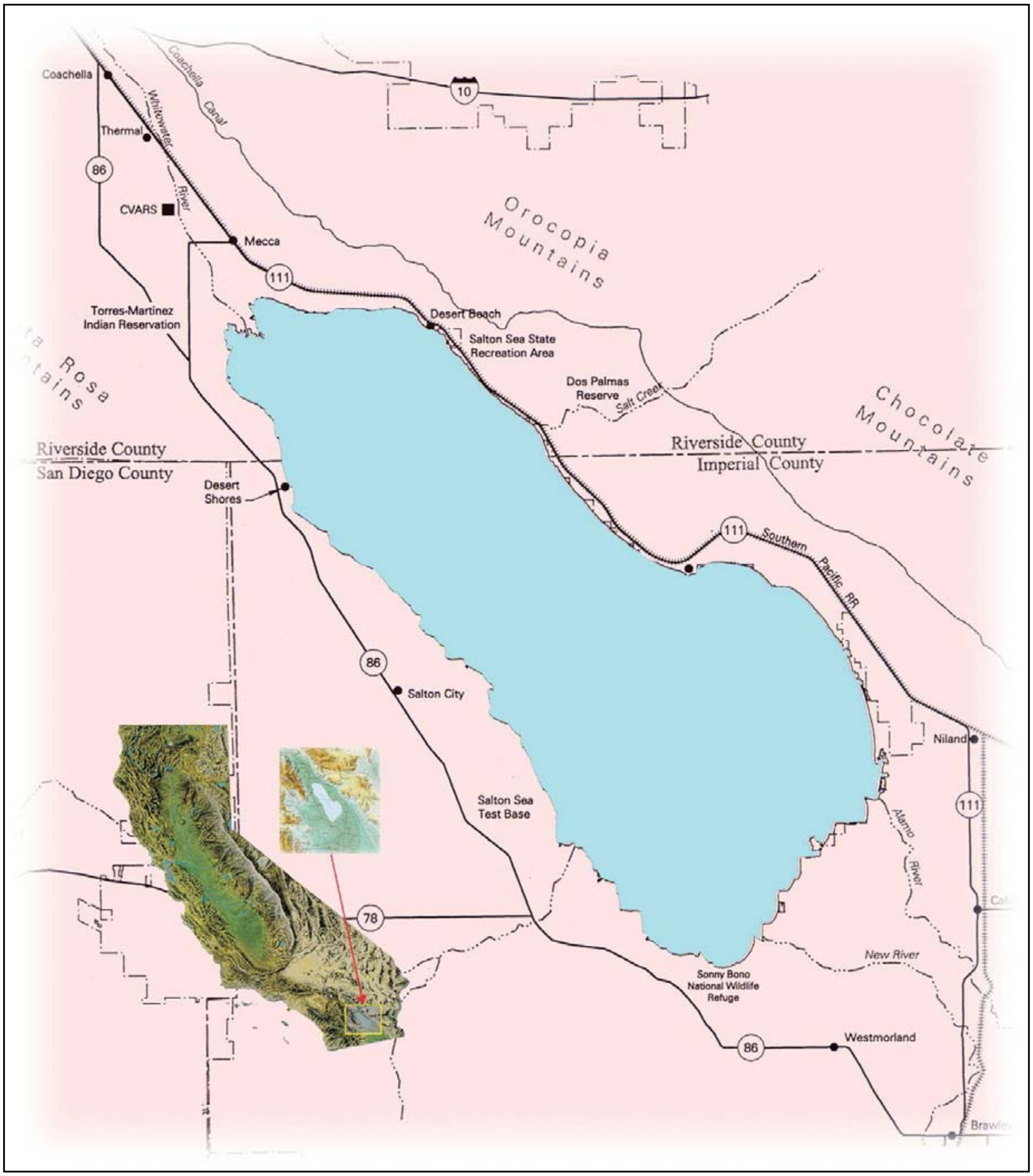
SALTON SEA RESTORATION

Final Preferred Project Report

Salton Sea Authority

July 2004

Document prepared by Tetra Tech, Inc.



Salton Sea Location Map

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EXECUTIVE SUMMARY

The Salton Sea is located in a closed basin in Riverside and Imperial Counties in southern California, south of Indio and north of El Centro. The Sea is more than 220 feet below sea level and has no natural outlet. The Salton Sea Basin is part of the Lower Colorado River Delta system and historically lakes have existed in this basin as the course of the Colorado River has shifted. The current body of water formed in 1905 when a levee break along the Colorado River caused flows from the Colorado River to enter the basin for about 18 months. Since 1905, the Sea has fluctuated in size with varying inflow, and it recently has had a surface area of 365 square miles.

A balance between inflowing water and evaporation has sustained the Sea in the past. However, with no outlet, any salts that are dissolved in the inflow are trapped, although some do precipitate. Salt concentrations are rising and are currently about 44,000 milligrams per liter (mg/L), or about 25 percent higher than ocean water. Salinity will continue to rise under current conditions. As a result of recently approved water transfers, the inflow to the Sea is expected to be less than it has been in the past. A reduction in inflow will cause the Sea to shrink and cause salinity to rise faster than it would have without a reduction in inflow.

The Salton Sea Reclamation Act of 1998 directed that studies be conducted to evaluate the feasibility of possible actions to allow continued uses at the Sea. Following the passage of the Act, a study was initiated to develop alternative measures to address rising salinity and other problems at the Sea.

In April 2003, the Salton Sea Authority (Authority) Board of Directors (Board) endorsed moving forward with an Integrated Water Management Plan for the Salton Sea. Recognizing that inflows to the Sea are likely to be reduced in the near future, the Plan evolved from recent concepts for a smaller Sea as well as earlier work by the Authority and the Bureau of Reclamation (Reclamation). The Authority subsequently commissioned the engineering feasibility studies and further analysis of the Integrated Plan documented in this report.

During 2003, the Quantification Settlement Agreement (QSA) was also in the process of being approved and legislation was developed to acknowledge the linkage between water transfers and the health of the Salton Sea. The QSA will allow for transfers of Colorado River Water out of the Imperial Valley. Such transfers are expected to substantially reduce the inflow to the Salton Sea. In association with the approval of the QSA, three bills were signed into law in September 2003 that specify a State-led program to develop a preferred restoration alternative by December 2006. The package of legislation also provides a mechanism to generate up to $300 million for Salton Sea restoration through the sale of transferred Colorado River water. The State is now in the process of implementing the planning requirements for this suite of legislative bills dealing with Salton Sea restoration.

Overview of Report

This report documents a two-step process that has led to the identification of a preferred project for Salton Sea restoration. It provides the background for this process by discussing how the Sea could respond to inflow reductions, and by providing an overview of restoration options. The report then presents the first step of the process, which is a logic-tree evaluation that illustrates how features of restoration options can be eliminated through a series of queries. For example, one query is "Would pump-in/pump-out systems work?" referring to the practicality of systems such as pipelines that would exchange Salton Sea water with ocean water. This first step of the process documents the logic that has been used to eliminate unreasonable options and to identify the most feasible restoration strategy. In the second step in the process, alternatives are formulated from this strategy and ranked with respect to the program objectives. This step leads to a preferred conceptual alternative. Finally, this report concludes with a complete discussion of the preferred alternative concept, including its features, cost analyses, water surface elevations, performance factors, program phasing, and implementation.

Program Objectives

On November 12, 1998, Congress enacted Public Law 105-372, The Salton Sea Reclamation Act of 1998. This Act authorized the Secretary of the Interior to complete studies of options that:

1. Permit the continued use of the Salton Sea as a reservoir for irrigation drainage,

2. Reduce and stabilize the overall salinity of the Salton Sea,

3. Stabilize the surface elevation of the Salton Sea,

4. Reclaim, in the long term, healthy fish and wildlife resources and their habitats, and

5. Enhance the potential for recreational uses and economic development of the Salton Sea.

Key program objectives have been developed to complement and provide more specifics to these goals that were included in the Reclamation Act and to incorporate work done by the Authority and Reclamation since 1998. These objectives reflect the current needs of the restoration effort with respect to the present understanding of the future volumes of water that will flow into the Sea. The current program objectives are as follows:

- Preserve the Sea as a repository for agricultural runoff
- Provide a large marine lake with stable elevation
- Improve water quality: salinity

- Improve water quality: nutrients/other constituents
- Maintain and improve habitat
- Achieve water quality and habitat objectives in a timely manner
- Respond to inflow changes
- Increase recreational and economic potential
- Address air quality concerns
- Provide high safety rating/low risk of failure
- Overcome institutional barriers/public acceptance
- Achieve reasonable cost/high probability of financing

Inflows to the Sea

With implementation of the QSA, the average inflow to the Sea is expected to decrease over about 15 to 20 years from over 1,300,000 acre-feet/year to an expected inflow of about 930,000 acre-feet/year. While the water transfer agreements contain predictable transfer schedules, there is an option for transferring up to 1.6 million acre feet of additional water if the water is not needed to mitigate effects to the Salton Sea. In addition, inflow to the New River from Mexico, where the flow originates, may also be subject to future reductions. For example, reductions in surplus Colorado River flows to Mexico could, in turn, affect New River flows back across the border. It is also possible that the Coachella Valley groundwater management program would affect inflows. These variables translate to an uncertainty with respect to actual Salton Sea inflows. Therefore, three inflow scenarios are considered in this report:

1. The anticipated QSA schedule that includes water releases to mitigate effects to the Salton Sea over the next 15 years;
2. The QSA schedule with the mitigation water terminated in 2006 and sale of additional water to generate restoration funds; and
3. A schedule that would reduce average inflow to about 800,000 acre-feet/year.

Under all three inflow scenarios, without restoration, salinity in the Sea would more than double over a period of 20 to 25 years, while the water surface elevation would decrease by about 20 feet over the same period.

Overview of Restoration Options

Restoration options have evolved through a process that has involved planning studies, engineering analysis, scientific oversight, and environmental reviews. Some salinity control methods discussed in this report date back to the 1960s and possibly earlier. The amount of salt that would have to be removed by these methods would depend on future inflows. With reduced inflow, the Sea will begin to shrink and salts will be concentrated; therefore, more salts would need to be removed to control salinity. If the inflow continues to be reduced in the future, greater amounts of salt would need to be removed to meet project objectives.

To address the rising salinity of the Sea, a surrogate outlet must be established. Three basic methods have been considered:

- Pump water out of the Sea and discharge it to some remote location. This could be accomplished by combinations of pipelines and canals to the ocean, the Gulf of California, or some other remote location.

- Pump water out of the Sea and discharge it to local desalting plants or evaporation ponds, possibly in combination with mechanical processes that enhance the rate of evaporation. This would require disposal of salt residues near or within impoundments in the Sea.

- Divide the Sea so that one portion acts as a receptor for the discharge from another portion. Through the construction of retention structures, salts would be allowed to concentrate in one area while salinity levels in the remaining area would be controlled.

A myriad of alternatives have been identified over the years to provide one or another of those outlet scenarios, some of which also help control the elevation of the water surface of the Sea. This report discusses those that have been viewed as the most promising in the past or that have passed earlier screening analyses.

Logical Process for Screening Alternatives

The various categories of alternatives for solving the problems at the Salton Sea can be reviewed through a logical sequence of decisions given the current and likely future conditions at the Sea. The process begins by developing a series of questions which provide a roadmap through a sequence of decision points leading to a logical preferred restoration strategy. This screening process reveals that most alternatives that have been considered in the past do not perform well under reduced inflow conditions. In addition, with reduced inflows most systems need to become very large to respond to rapidly increasing salinity, and consequently, they would become highly expensive. In addition, most processes that remove salt also remove water and thus would exacerbate concerns about elevation decreases under the QSA.

The logic process leads to the conclusion that a concept that bisects the Sea in half may be the most effective restoration strategy. This concept relies on building a causeway/retention structure across the midsection of the Sea to separate hyper-saline and marine basins of the Sea from one another. If the structure is placed at the approximate midsection of the Sea where the west and east shorelines are nearest, the length of the barrier would be around 8.5 miles, and less if it is designed to work with the Sea at a lower elevation than the current situation. This area is also attractive because the water is shallower than areas to the immediate south and north, which will help reduce construction costs.

A major challenge to this divided lake concept is the feasibility of constructing a facility that is cost effective. The foundation conditions of the Sea have been investigated and found to be composed of a relatively thick layer of fine-grained sediments that create an engineering design challenge. However, conceptual alternative designs of a mid-Sea facility are currently underway and based on preliminary engineering evaluations it is believed that a suitable structure could be constructed at a reasonable cost.

Evaluation of Reasonable Alternatives

The logical process for reviewing alternatives led to the conclusion that alternatives that employ a central dike or dam facility are worthy of further investigation. Such a concept would include a smaller marine lake, and could be developed along one of two options using a central dike or dam: a marine lake in the north or a marine lake in the south. The features and benefits of south and north marine lake concepts based on a dividing structure at this location are described briefly below. There is also a choice about whether or not to control elevation.

South marine lake—A marine lake in the south would have a maximum area on the order of 210 square miles and require an inflow of 980,000 acre feet per year to sustain it at current elevation of about -227 feet relative to mean sea level (msl). The area would be smaller if the lake was to be maintained at a lower elevation. A southern marine lake would be consistent with current wildlife refuge boundaries. The southern marine lake would also take advantage of inflows from the New and Alamo Rivers such that rerouting or transporting these flows would not be necessary. Concentrations of selenium and several other contaminants in the sediments are highest in the northern half of the Sea. Allowing portions of this basin to recede would expose the sediments creating the potential for human health and wildlife impacts.

North marine lake—A marine lake in the northern portion of the Sea would be on the order of 150 square miles and require an inflow of around 800,000 acre feet per year. A marine lake in the north would reduce the concern over selenium sediment effects by effectively capping the sediments with the marine lake. There are also established communities in the northern portion of the Sea such as Desert Shores, Salton City, and North Shore that would benefit from a restored Sea. These communities would likely experience renewed economic development including commercial, recreational, and residential developments. The Torres Martinez Tribe would also benefit from a restored Sea and could implement various economic and natural resource projects. The exposure of submerged areas in the south would allow for geothermal exploration and development of known geothermal resources.

Elevation control—The next issue to be addressed is whether or not to control the water elevation in the marine lake, and if so, what approach to use. A barrier could be used with no elevation control. A retention structure could be used that maintains elevation at current levels. Or, a retention structure could be used that takes advantage of a reduced water surface level.

Given the above considerations, four alternative configurations have been identified for evaluation:

- **South Marine Lake without Elevation Control**—The simplest configuration would be to construct a central barrier and allow the New and Alamo rivers to flow into the south basin and create a marine lake with hyper-saline conditions in the north.

- **South Marine Lake with Elevation Control**—This configuration would be similar to the previous alternative, except that the central barrier would need to be taller and more robust to impound water in the south and create a higher water surface than in the north.

- **North Marine Lake with Elevation Control**— This concept would be similar to the previous alternative with the north-south configuration reversed. In this case, the New and Alamo rivers would need to be extended to the north to provide freshwater inflows to control salinity in the north basin.

- **No Marine Lake**—This alternative is considered in case a mid-Sea barrier or impoundment structure proves to be infeasible or too costly. It would include wetland and habitat restoration elements to achieve as many objectives as possible without maintaining a large lake with a marine fishery.

Evaluation of Reasonable Alternatives

The four reasonable alternatives discussed above were evaluated against the program objectives. For each objective, the alternatives were ranked on the basis of best judgment as to how they would perform under inflows that would be expected with the QSA in place. Finally, an overall composite ranking was developed. A summary of the evaluation process is provided in Table ES-1, where the highest ranking is given a number "1" and the lowest is given a "4."

In addition to rankings against each objective, Table ES-1 shows: (1) an average ranking score calculated by taking a simple average of the rank values for each of the objectives; (2) the number of top rankings; (3) the number of lowest rankings; and (4) the overall average ranking based on the three previous statistics. Based on the data presented here, the **North Lake with Elevation Control alternative received the top ranking and is recommended for consideration as the preferred restoration strategy** for the Salton Sea. As indicated in Table ES-1, the North Lake

Table ES-1. Evaluation of Restoration Options

Objectives	Restoration Alternative			
Project Objectives Used in this Report ⇓	South Marine Lake wo Elevation Control	South Marine Lake w Elevation Control	North Marine Lake w Elevation Control	No Marine Lake
Preserve Sea as Repository for Agricultural Runoff	1	1	1	1
Provide Large Marine Lake with Stable Elevation	3	1	2	4
Improve Water Quality: Salinity	1	1	1	4
Improve Water Quality: Nutrients/Other Constituents	2	2	1	4
Maintain and Improve Habitat	3	2	1	4
Time to Achieve Water Quality and Habitat Objectives	3	1	2	4
Respond to Inflow Changes	2	4	3	1
Increase Recreational and Economic Potential	3	2	1	4
Address Air Quality (PM_{10}) Concerns	3	1	1	3
Provide High Safety Rating/Low Risk of Failure	2	3	3	1
Overcome Institutional Barriers/Public Acceptance	3	2	1	4
Reasonable Cost/High Probability of Financing	3	4	2	1
Average Score	2.4	2.0	1.6	2.9
Number of Top Rankings	2	5	7	4
Number of Lowest Rankings	1	3	1	8
Overall Ranking	3	2	1	4

with Elevation Control alternative received the highest ranking with respect to seven of the 12 objectives and the lowest ranking for only one objective.

The Preferred Project: A Vision for the Future

Starting with the north lake concept and adding other features, a preferred project emerges that has the potential to create outstanding opportunities for the Imperial and Coachella valleys. This vision of the future combines a healthier and more stable marine lake that has lower salinity with a variety of ecological and recreational features. It also includes measures to mitigate potential air quality degradation that may be associated with sediments exposed by declining lake levels that result from decreases in inflow. The concept is illustrated in Figure ES-1.

Figure ES-1 illustrates the wide range of habitat and recreational features that could be included as part of the vision of the future for the Salton Sea ecosystem. The features of the preferred project are conceptual. Some features have been developed in more detail, such as the central causeway/retention structure. Technical reports are underway to further describe the causeway/dike and other features, such as the shallow water habitat. Other features, such as fresh water recreational lakes and wetlands, were reviewed by an Outdoor Recreation Advisory Task Force.

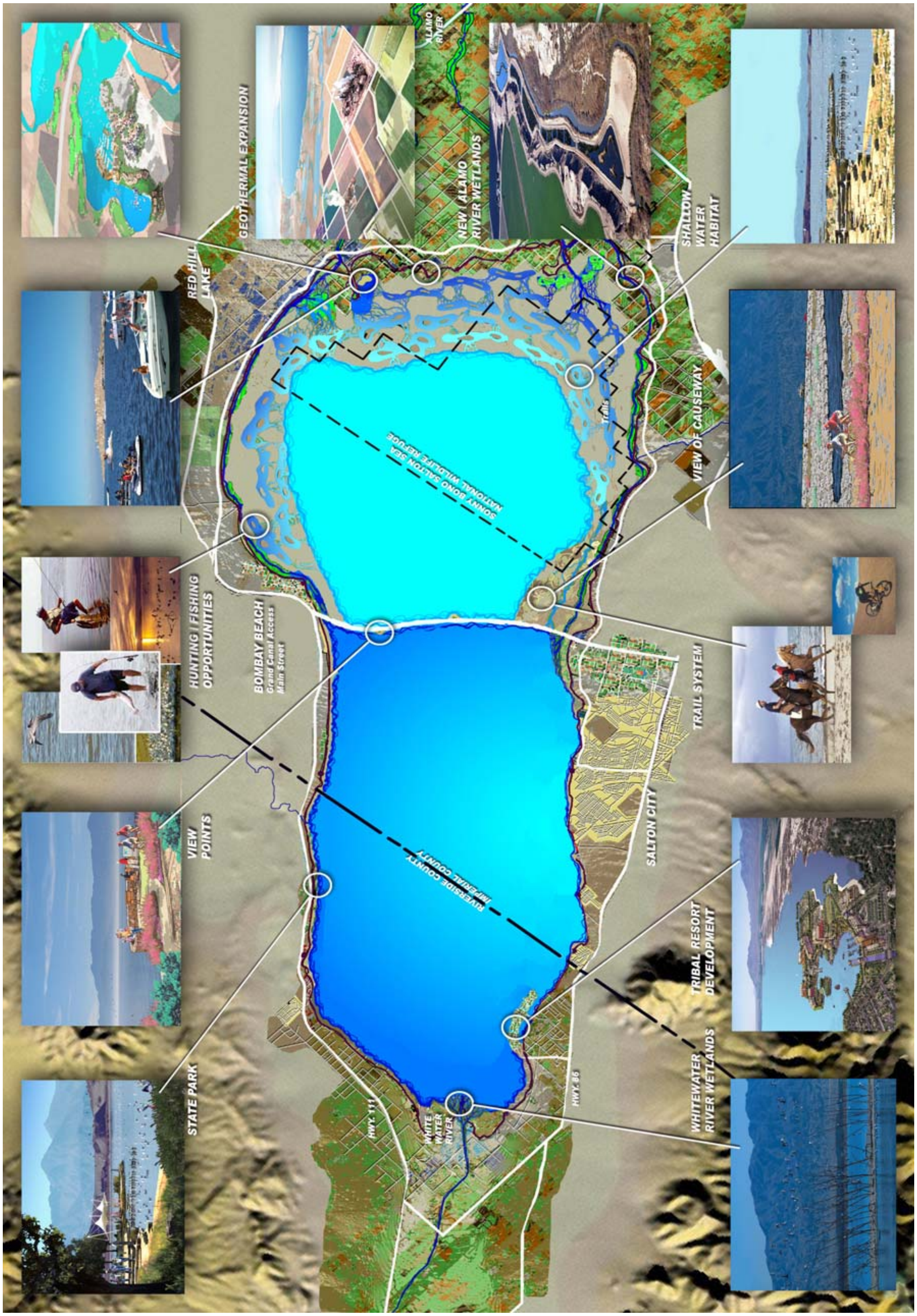

Figure ES-1. Preferred Alternative Concept Plan for the Salton Sea Area.

The Recreational Task Force included representatives of recreational groups, cities and other organizations, primarily from the north end of the Imperial Valley. During initial meetings of the Task Force, the members voiced support for many elements of the preferred project. The final report from the Task Force, including their recommendations, is provided in Appendix D of this report.

Design Features

Two of the most important design features of the preferred plan are the structural design of the central causeway/retention structure and the inflow requirement to support the plan. A working group of 15 civil and geotechnical engineers was convened to review the feasibility of constructing a dike, or retention structure/causeway anywhere within the Salton Sea. After considering several possible methods, the preliminary conclusions indicate that a rock filled embankment may be the most cost effective construction method. The preferred restoration plan could be sustained by an average annual inflow of 800,000 acre-feet/year, and possibly somewhat lower inflows. The inflow would need to include about 600,000 acre-feet/year to sustain the north lake, with the remaining 200,000 acre-feet plus salt water discharges from the north lake supporting other habitat and recreational features.

Performance and Phasing

The Salton Sea Accounting Model was used to evaluate the performance of the preferred project. The model indicates that if the marine lake is designed for a water surface elevation of -235 feet msl, and a decision is made to move forward with the program in the near future, then the target salinity of 35,000 mg/L could be achieved by 2013. The model suggests that the phasing schedule shown in Table ES-2 could be achieved for a design elevation of -235 feet msl.

Target Elevation

A design elevation of around -235 feet msl is recommended for consideration as the target elevation. It would have a number of benefits including: (1) High enough elevation to allow for gravity flow of salt water to shallow habitat areas and for dust control; (2) Minimal dredging for access to communities, (3) Low enough to provide fall for river extensions; (4) Minimal salinity spike and short time to target salinity; and (5) Reasonable cost…at -235 feet msl the cost estimate for the retention structure is about $150 million less than it would be for the current lake elevation. There may also be some circumstances where -240 feet msl could be beneficial as the design lake level. If it appears that the construction schedule would need to be extended and if additional water can be sold to raise funds and expedite the water surface reduction to -240 feet msl, then an additional savings of about $100 million could be realized, with other factors being equal.

Table ES-2. Proposed Timeline

Timeframe	Activity
2004	Federal, State & Local (SSA) Agencies Pledge to Work Together on Restoration, Enter an MOU
2004	State Advisory Committee Develops Criteria and Reviews Alternatives
2004	Begin Detailed Design
2005	SSA Establishes Tax Increment District
2005	Draft Project-Level Salton Sea Restoration EIR/EIS
2005	Final Project-Level Salton Sea Restoration EIR/EIS
2006	Complete Detailed Design
2006	Phase One Construction: Develop Quarry Site, Begin Wetlands and Interim Shallow Water Habitat Construction
2006	Mitigation Water Sold
2007	Phase Two Construction: Begin Extension of Rivers and Causeway
2009	Phase Three Construction: Begin Marina Dredging
2010	Complete Causeway
2013	North Lake Salinity Targets Met
2015-	Phase Four Construction: Phased In Shallow Water Habitat

Cost and Financing

The construction cost of the program for a design elevation of -235 feet msl is estimated at between $650 and $730 million based on a conceptual-level cost analysis. This estimate includes the mid-Sea retention structure/causeway, appurtenances, dredging to communities, greenbelt channels to the north lake, a fresh water recreational lake, Torres Martinez wetlands/habitat, upstream wetlands, and an initial phase of shallow water habitat construction. Total annual operating expenses are estimated at about $10 million, including costs for maintenance of the mid-Sea retention structure, appurtenances and channels, and for future expansion and maintenance of shallow water habitat areas.

Potential financing sources include funds from Proposition 50, funds generated through the QSA legislation, local funds generated through formation of a Tax Increment District, and possible other State and Federal sources.

Recommendation

The preferred project is an integrated multi-functional plan that is recommended as an opportunity to provide outstanding ecological, recreational and economic benefits to the Salton Sea area.

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Chapter 1: INTRODUCTION

The Salton Sea is subject to rising salinity and high levels of nutrients. The Salton Sea Reclamation Act of 1998 directed that studies be conducted to evaluate the feasibility of possible actions to allow continued uses at the Sea. Following the passage of the Act, a study was initiated to develop alternative measures to address rising salinity and other problems at the Sea. In response to the Act, a draft environmental impact statement/environmental impact report (EIS/EIR) was released in January 2000. The January 2000 EIS/EIR underwent agency and public review in the spring of 2000, and public hearings were conducted. In light of public and agency comments, further internal reviews of the alternatives presented in the draft EIS/EIR, and various congressional requests, further analyses and design work has been performed.

In April 2003, the the Salton Sea Authority (Authority) Board of Directors (Board) endorsed moving forward with an Integrated Water Management Plan. Recognizing that inflows to the Sea were likely to be reduced in the near future, the Plan evolved from concepts proposed by US Filter, the Pacific Institute, and others as well as earlier work by the Authority and the Bureau of Reclamation (Reclamation). The Authority subsequently commissioned the engineering feasibility studies and further analysis of the Integrated Plan documented in this report.

During 2003, the Quantification Settlement Agreement (QSA) was also in the process of being approved and agreements developed to acknowledge the linkage between water transfers and the health of the Salton Sea. Three bills were signed into law in September 2003 that specify a State-led program to develop a preferred restoration alternative by December 2006. The package of legislation also provides a mechanism to generate up to $300 million for Salton Sea restoration through the sale of transferred Colorado River water. The State is now in the process of implementing the planning requirements for this suite of legislative bills dealing with Salton Sea restoration.

1.1 Background and History of the Salton Sea

The Salton Sea Basin is part of the Lower Colorado River Delta system. The present-day Sea was formed in 1905 by flooding on the Colorado River, which accidentally breached an irrigation control structure on the River allowing the entire River to flow into the Salton Basin for a period of about 18 months. Since then, agricultural drainage flows from the surrounding watersheds of Imperial, Coachella, and Mexicali Valleys and smaller contributions from municipal effluent and stormwater runoff have sustained the Sea. This is not the first time the Salton Basin has contained a lake, however. Historical evidence and geologic studies have shown that the Colorado River has spilled over into the Salton Basin on numerous occasions over the last thousand years, creating intermittent lakes. Evidence of an ancient shoreline suggests that Lake Cahuilla occupied the Basin until about 300 years ago. From 1824 to 1904, Colorado River flows flooded the Salton Basin no fewer than eight times. Each time, the lake went through a cycle of fresh to salty water as the lake eventually evaporated.

The Salton Basin extends from Banning, California, on the north to near the international border with Mexico on the south. At present, the Sea itself is about 35 miles long and 15 miles wide. With a current surface elevation at about 227 feet below mean sea level, the Sea has a maximum depth of about 50 feet. The Sea's salinity concentration is about 44,000 milligrams per liter (mg/L), which is about 25 percent saltier than ocean water. Recent annual inflows have been in balance with the water that evaporates from the Sea's surface. Inflows contribute about 4 million tons of salt each year to the Sea. Since the Sea is a terminal body of water (it has no outlet), salinity continues to rise as salts are left behind while water evaporates from its surface.

In the early 1900s, the Sea was relatively fresh and thereafter salinity fluctuated, but with a general increasing trend. By the 1950s through the 1970s, the salinity was near ocean salinity levels, and the Sea became an attractive recreation site. Private land around the Sea was subdivided into lots, roads were bladed, and land speculation flourished. Fish were introduced into the Sea and several marine species have thrived. Tilapia, a fish commonly raised in fish farms, accidentally found their way into the Sea and are now the predominant fish species. The Sea is located along the Pacific flyway and provides habitat and seasonal refuge to many species of birds. A federal wildlife refuge, established at the south end of the Sea as a sanctuary for birds, provides viewing and educational opportunities. In 1956, a state recreation area was established along the east shore of the Sea to provide camping and boating access.

The Salton Sea fills a depression in a hot desert environment. Without an outlet, the natural progression of the Sea is for the water to become more saline over time and monumental efforts would have to be made to reverse that progression. As the Sea becomes saltier, the ecosystem will change in response to the more saline environment.

1.2 Past Studies

Rising salinity concentrations and the realization in the 1950s that salinity levels would eventually affect uses of the Sea, led to studies of ways to manage salinity. An early investigative report was prepared in 1965, a Federal-State Reconnaissance Investigation was conducted in1969, and a Federal-State Feasibility Study was completed in 1974. A rising water surface elevation and consequent stabilization of salinity muted the call for implementation of salinity control actions at that time. In the mid-1980s, federal and state agencies again began looking at ways of controlling salinity. Public Law 102-575, passed in 1992, gave Reclamation the authority to conduct salinity control studies. In response to that law, Reclamation and the Authority, which was established in 1993, published and provided a report to Congress in 1997 that contained an evaluation of a wide suite of alternatives that would address the salinity and elevation problems of the Sea.

1.3 The Salton Sea Reclamation Act of 1998

On November 12, 1998, Congress enacted Public Law 105-372, The Salton Sea Reclamation Act of 1998. This Act authorized the Secretary of the Interior to complete studies of options that:

1. Permit the continued use of the Salton Sea as a reservoir for irrigation drainage,
2. Reduce and stabilize the overall salinity of the Salton Sea,
3. Stabilize the surface elevation of the Salton Sea,
4. Reclaim, in the long term, healthy fish and wildlife resources and their habitats, and
5. Enhance the potential for recreational uses and economic development of the Salton Sea.

The Act also directed the Secretary to consider inflow reductions that could result in total inflows of 800,000 acre-feet or less per year. Options that were to be considered included segregating the Sea into one or more evaporation sections, pumping water out of the Sea, augmenting inflows, combinations of various options, and other options as the Secretary deems appropriate. The Act indicated that options that relied on importation of water from the Colorado River should not be included in the study. This is consistent with the Colorado River Compact, the Boulder Canyon Project Act, and the 1964 Supreme Court Decree in Arizona vs. California which limit beneficial use of Colorado River water to domestic and irrigation purposes. A copy of the Salton Sea Reclamation Act is included as Attachment A.

An alternative screening process was conducted in 1999 as part of the process of developing restoration strategies to be evaluated in the EIS/EIR (Tetra Tech 1999). An alternative that would have included construction of an impoundment structure in the central part of the Sea and create a smaller marine lake in the north was initially rated as one of the top two among 39 alternatives. This alternative was later eliminated from further analysis because of cost considerations at the time when future inflows were uncertain. The EIS/EIR was prepared evaluating five alternatives which involved combinations or large in-Sea evaporation ponds and/or on-land enhanced evaporation systems among numerous other elements.

On January 27, 2000, then Secretary of the Interior Babbitt transmitted certain reports to Congress as specified in the Act. Among these reports was an EIS/EIR, which was distributed for public review and comment. Comments were numerous and substantial. Consequently, subsequent to the publication of those reports, work on alternative formulation, further development of costs, and analysis of additional options have continued.

1.4 Current Program Objectives

Key program objectives have been developed to complement and provide more specifics to the goals provided in the Salton Sea Reclamation Act of 1998 and to incorporate work done by the Authority and Reclamation since 1998. These objectives reflect the current needs of the restoration effort with respect to the present understanding of the future volume of waters that flow into and sustain the Sea.

The restoration effort has been an open process that has involved input from the Authority Technical Advisory Committee (TAC) and Board of Directors (Board), broad involvement from agency personnel, and input from public workshops and a coalition of environmental interests. The process has included screening of alternatives using objectives and criteria developed with input from all of these sources. Program objectives have evolved over time in response to a number of external factors, including decisions on water transfers that will reduce inflows to the Sea. From this process, a set of objectives has evolved that is used in this report as a basis for evaluating alternatives and recommending a preferred project. A total of twelve objectives are included which would address the concerns that have been most often expressed by various stakeholders. Table 1-1 lists the current program objectives and shows how these objectives link to the goals identified in the Reclamation Act.

The objectives used in the identification of a preferred alternative are discussed below. Each of these project objectives has been considered as development of the preferred project has proceeded.

Preserve the Sea as a Repository for Agricultural Runoff

Agriculture constitutes the major economic base in Imperial County and a significant part of the economy in eastern Riverside County. The Imperial and Coachella valleys provide an important source of vegetables and other produce to the nation, particularly in the winter. Because of the importance of drainage to maintaining the agricultural economy and the lack of an alternative disposal site, the Sea serves as the repository for agricultural drainage. In 1924 and again in 1928, President Coolidge issued Executive Orders setting aside federal land under the Sea as a public water reserve for irrigation drainage. In 1968, the state of California declared by statute that

Table 1-1. Restoration Objectives and Goals of the Reclamation Act of 1998

Objectives	**Goals of the Salton Sea Reclamation Act of 1998**				
Project Objectives Used in this Report ⇓	Permit continued use as a reservoir for irrigation drainage	Reduce and stabilize the overall salinity	Stabilize the surface elevation	Reclaim healthy fish and wildlife resources and their habitats	Enhance potential for recreational uses and economic development
Preserve Sea as Repository for Agricultural Runoff	✓				
Provide Large Marine Lake with Stable Elevation		✓	✓	✓	✓
Improve Water Quality: Salinity		✓		✓	✓
Improve Water Quality: Nutrients/Other Constituents				✓	✓
Maintain and Improve Habitat		✓		✓	
Achieve Water Quality/Habitat Objectives Timely		✓		✓	
Respond to Inflow Changes			✓		✓
Increase Recreational and Economic Potential					✓
Address Air Quality (PM_{10}) Concerns				✓	✓
Provide High Safety Rating/Low Risk of Failure				✓	✓
Overcome Institutional Barriers/Ease of Permitting	✓	✓	✓	✓	✓
Reasonable Cost/High Probability of Financing	✓	✓	✓	✓	✓

the primary use of the Sea is for collecting agricultural drainwater, seepage, leaching, and control waters. Agriculture in its present form relies on the ability to discharge drainage into the Sea. Thus, the continued use of the Salton Sea as an agricultural drainage repository is a fundamental component of the Salton Sea Restoration Project.

Provide Large Marine Lake with Stable Elevation

Over the years, rising levels of the Salton Sea have flooded residential and agricultural properties around the Sea as well as tribal lands. More recently concerns have been focused on the likely decreases in Salton Sea elevation that would occur as a result of reductions of inflows to the Sea. In spite of these concerns, a broad range of interests including the TAC, Board, public, environmental groups and agencies have stressed the ecological and economic importance of maintaining a large marine lake. Therefore, maintaining a large marine lake with a stable water surface elevation is one of the primary objectives.

Improve Water Quality: Salinity

Increasing salinity in the Sea, which is currently about 44,000 mg/L, already may be threatening the reproductive ability of some parts of the biota. If the current trend of increasing salinity continues, sport fish in the Salton Sea will be eliminated over the next few decades. Therefore, controlling salinity is a critical need if the Salton Sea is to support biodiversity similar to what currently exists. In addition, the Sea is located along the Pacific Flyway, the most western of the major migration corridors for waterfowl and other species. Therefore, the fish populations in the Sea are an important food source to fish-eating birds that use the Pacific Flyway. Because of its affect on the ecology of the Sea, controlling salinity is a fundamental component of any restoration alternative.

Improve Water Quality: Nutrients/Other Constituents

The Salton Sea is a highly eutrophic water body characterized by high nutrient concentrations, high algal concentrations, high fish productivity, low clarity, very low dissolved oxygen concentrations, massive fish kills, and noxious odors. High nutrient loadings are due to the inflows of nitrogen and phosphorus as byproducts from the use of agricultural fertilizers in the Imperial Valley watershed. The eutrophic state of the Salton Sea with its high biomass translates to high fish production, especially for forage fish such as tilapia. If the Salton Sea were less eutrophic, there likely would be fewer tilapia, fewer and different algal blooms, and fewer occasions of fish kills associated with anoxic conditions. Other water quality issues include selenium, other chemicals, and bacteria. All of these issues must be addressed to benefit the fish and wildlife resources and habitats of the Salton Sea as well as human health concerns. As with salinity, effectively managing the Sea's water quality is linked to the general health of the Sea and will need to be integrated into restoration planning.

Maintain and Improve Habitat

The biological resources of the Sea and its value to society are linked through the Sea's avian diversity, the productivity of its sport fishery, and its attraction as a recreational destination. With approximately 400 species of birds reported in the area, the Salton Sea ecosystem is one of the greatest areas of avian biodiversity in the nation. It also provides habitat to several special status species such as the California brown pelican (*Pelecanus occidentalis*), Yuma clapper rail (*Rallus longirostris yumanensis*) and the dessert pupfish, all listed as Federal Endangered Species. Historically, the sport fishery has been the most productive of any California inland water body, and the large biomass of fish has been the food base for the large number of fish-eating birds at the Sea. Over the past two years there have been substantial decreases in the number of fish in the Sea, likely because of a number of stress factors.

Because of significant losses of interior wetlands, including over 90 percent of those within California, the Sea serves an important role in the international, regional, and local conservation of migratory birds. Significant proportions of some populations have become dependant on the Sea. For some of these species there may be no alternatives because of bioenergetics (the energy transformation and exchange between living organisms and their environment) associated with food availability (quantity and quality), travel distances between migration stopover points, and body condition relative to breeding success. The complex interrelationships of the Sea's ecosystem are a critical factor in developing a viable restoration scenario.

Achieve Water Quality and Habitat Objectives in a Timely Manner

According to fish survey data gathered by the California Department of Fish and Game, fish populations in the Salton Sea have decreased sharply in the last two years. There apparently has also been a corresponding decrease in the populations of fish eating birds present at the Sea. With projected decreases in baseline flows and implementation of the QSA, the salinity in the Sea is expected to increase at a greater rate than it has in the past, thus further stressing the fishery. Therefore achieving water quality and habitat objectives in a timely manner will be an important restoration objective.

Respond to Inflow Changes

With implementation of the QSA, it is likely that the average inflow to the Sea will decrease markedly over the next 15 to 20 years. While inflow to the Sea has historically varied from year to year, ten year averages for each of the past four decades have varied little, and the average inflow to the Sea during that period was greater than 1,300,000 acre-feet/year. With the QSA in place, in twenty years the expected value of inflow to the Sea will be about 930,000 acre-feet/year. Without any other actions, such an inflow reduction would cause the Sea to shrink to about 70 percent of its current size, a reduction of about 100 square miles.

The water transfer agreements contain predictable transfer schedules over the 75-year term of the program. However, options for up to 1.6 million acre feet of additional transferred water may or may not occur depending on a number of factors. In addition, inflow to the New River, one of the main tributaries of the Sea, is also variable from year-to-year due to usage patterns in Mexico, where the flow originates. These variables translate to an uncertainty with respect to actual Salton Sea inflows. Since a reasonable range of inflow patterns over time can be predicted, a preferred alternative will need to take the flow variability into consideration.

Increase Recreational and Economic Potential

Recreational use of the Sea includes waterfowl hunting, boating, fishing, bird watching, and photography. Waterfowl hunting is a long-standing tradition at the

Salton Sea and even during the 1920s attracted hunters from Long Beach, Los Angeles, and other areas. The sport fishery of the Sea is focused primarily on orange-mouth corvina (*Cynoscion xanthulus*), tilapia (*Oreochromis mossambieus* and other species and hybrids), bairdiella or Gulf croaker (*Bairdiella icistia*), and sargo (*Anisotremus davidsoni*). All of these are introduced species. Tilapia are the dominant component of the fish biomass and are a major food item for pelicans and other fish-eating birds at the Sea. The popularity of bird watching at the Sea has increased in response to the diversity of the Sea's avifauna and has resulted in the international bird festival becoming an annual event. An evaluation of the economic impacts associated with bird watching at the Sea disclosed a substantial economic benefit to the local communities and businesses.

An added benefit to the local economy of a restored Salton Sea would be the resulting development of residential, commercial, and retail land uses adjacent or in close proximity to the Sea. The increased economic development would also generate sales and property tax revenue that would benefit the local economy. Some studies have estimated the potential property tax revenue at between $1 billion and $2 billion over a 45-year time horizon.

Address Air Quality (PM10) Concerns

The reduction in inflow to the Sea in the future is expected to result in the exposure of large areas of currently submerged lakebed at the Salton Sea. As discussed above, inflow reductions could result in the exposure of about 100 square miles of sediments. The sediments beneath the Sea have not been exposed for a century and consist of fine-grained silts and clays. These soils may be prone to wind erosion when they are exposed to the atmosphere and become dry. The climate of the Salton Sea basin is such that high winds and sustained wind of moderate speed can cause substantial amounts of fine particulate matter to be suspended and transported long distances. The amount of particulate matter finer than 10 microns present in the atmosphere is monitored and referred to as PM_{10}. This fine particulate matter is of concern because it can be transported deep inside human lungs, and is especially harmful to young children, the elderly, and those with respiratory disease such as asthma. This issue will need to be addressed for any restoration to be a viable solution.

Provide High Safety Rating/Low Risk of Failure

Because of the magnitude of the investment necessary to develop and sustain a viable restoration alternative, a preferred restoration alternative must provide a high level of safety while at the same time having a low risk of failure. This is especially true for the construction of any water impoundment or barrier that could release substantial amounts of water in the event of catastrophic failure such as caused by an earthquake. Other features of the preferred restoration alternative should be designed to minimize safety risks to property, residents, and visitors to the Sea. This objective of the restoration planning process will need to be carefully evaluated through engineering evaluations and pilot projects and other scale-up projects before full implementation can occur.

Overcome Institutional Barriers/Public Acceptance

The evaluation of restoration alternatives must consider the reality involved in the permitting and approval process for projects of this magnitude. Projects that involve connecting the Sea to ocean water such as pipelines or canals are infeasible due to international barriers in the case of the Federal Republic of Mexico, and land use and multi-jurisdictional issues in the case of the west coast of California. Even if all activities to restore the Sea are contained within the Salton Sea Basin, there are many federal, State, and local agencies that will need to issue permits and approvals for a preferred restoration alternative. The time required to permit the preferred alternative and the support of the local community is a critical factor in restoration planning.

Reasonable Cost/High Probability of Financing

While a precise budgetary cap has not been established for the cost of a preferred alternative, there is a limit to the amount that society will be willing to spend for Salton Sea restoration. Due to competing needs and limited resources, the cost and benefit of a restored Sea will need to be demonstrated in order to obtain the financial backing of government at all levels. While the State has adopted legislation that would accrue up to $300 million for a Salton Sea restoration fund, other sources of funds may be available through the federal government or through specialized financing methods such as an Infrastructure Finance District around the Sea. This objective will need to be carefully considered in the evaluation of restoration scenarios.

1.5 Purpose of Report

This report is intended to document a two-step process that has led to the identification of a preferred project. Chapters 2 and 3 provide the background for this process, respectively, by discussing how the Sea would respond to inflow reductions, and providing an overview of restoration options. Chapter 4 presents the first step of the process, which is a logic-tree evaluation that illustrates how features of restoration options can be eliminated through a series of queries. For example, one query is "Would pump-in/pump-out systems work?" referring to the practicality of systems such as pipelines that would exchange Salton Sea water with ocean water. This step of the process documents the logic that has been used to eliminate unreasonable options and to identify the most feasible restoration strategy. The second step in the process is presented in Chapter 5. Here, alternatives are formulated from the strategy developed in the previous step and ranked with the respect to the program objectives. This step leads to a preferred conceptual alternative. Chapter 6 provides a more complete discussion of the preferred alternative, including its features, cost analyses, water surface elevations, performance factors, program phasing, and implementation.

Supporting technical information for the main report is provided in four appendices and a companion report, URS (2004).

Appendix A provides information about how shallow water habitat features could be developed for the project, and includes a report on the findings of a two-day workshop on shallow habitat.

Appendix B presents a preliminary cost assessment that has been prepared for the preferred restoration project. An important component of the overall cost of the plan would be a central, mid-Sea impoundment structure. Various conceptual designs have been considered for this structure. These concepts along with cost estimates for each are described in URS (2004). Appendix B provides supporting information for an overall preliminary cost estimate for the preferred project and includes costs for the central retention structure obtained from URS (2004).

Appendix C describes the results of the application of the Salton Sea Accounting Model (Model) which was used to forecast future salinity and elevation in the Sea. The Model was used to assess the performance of restoration alternatives, as well as to evaluate the effects water transfer agreements. The Model runs were performed by Reclamation. Appendix C focuses on the performance of the recommended preferred project, but also includes discussions of the performance of other alternatives considered in the main report along with comparisons to some other alternatives considered in the past.

In February 2004, the Authority appointed an Outdoor Recreation Advisory Task Force to evaluate recreational potential of a restored Salton Sea and present recommendations to the Authority Board. The Task Force presented their report to the Board on June 24, 2004. Appendix D provides the committee's report in its entirety.

Chapter 2: INFLOWS: RESPONDING TO REDUCTIONS

As discussed previously, with implementation of the QSA, the average inflow to the Sea is expected to decrease over about 15 to 20 years from over 1,300,000 acre-feet/year to an expected value of about 930,000 acre-feet/year. While the water transfer agreements contain predictable transfer schedules, there is an option for up to 1.6 million acre feet of additional transferred water if the water is not needed to mitigate effects to the Salton Sea. In addition, inflow to the New River from Mexico, where the flow originates, may also be subject to future reductions. For example, reductions in surplus Colorado River flows to Mexico could, in turn, affect New River flows back across the border. It is also possible that the Coachella Valley groundwater management program would affect inflows. These variables translate to an uncertainty with respect to actual Salton Sea inflows. Therefore, three inflow scenarios are considered in this report:

1. The anticipated QSA schedule that includes water releases to mitigate effects to the Salton Sea over the next 15 years;
2. The QSA schedule with the mitigation water terminated in 2006 and sale of additional water to generate restoration funds; and
3. A schedule that would reduce average inflow to about 800,000 acre-feet/year.

The three inflow scenarios are illustrated in Figure 2-1.

2.1 Quantification Settlement Agreement

With the signing of the QSA in September 2003 a high degree of certainty was achieved with respect to long-term usage and deliveries of Colorado River water users. The QSA was the result of seven years of intensive negotiations between federal and state government officials and the San Diego, Coachella, Imperial, and Metropolitan Water Districts. This agreement allows for California to ramp down water usage from historical highs of 5.3 million acre-feet annually to the amount entitled by law at 4.4 million acre-feet. The QSA included three California laws that affect the inflows to the Salton Sea and restoration efforts. These laws are briefly summarized in the following paragraphs.

Senate Bill No. 277 (SB 277) enacted the Salton Sea Restoration Act and establishes the Salton Sea Restoration Fund to be administered by the Director of Fish and Game. Moneys in this Fund are to be expended, upon appropriation by the Legislature, for restoration of the Salton Sea and the protection of fish and wildlife dependent on the Sea. This bill also authorizes the Department of Water Resources

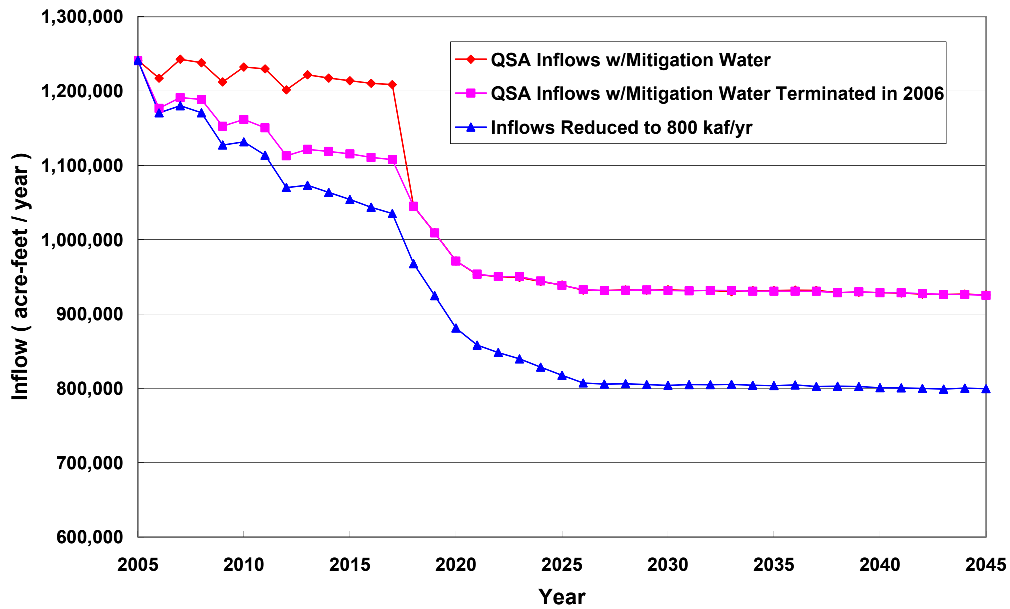

Figure 2-1. Possible Future Salton Sea Inflow Scenarios Evaluated in this Report.

(DWR) to contract with water suppliers to purchase and sell water to achieve the goals of the Act.

Senate Bill No. 317 (SB 317) amended Section 2081.7 of the Fish and Game Code (adopted by SB 482 in 2002) to state revised conditions to issuance of take permits for the QSA, including the take of fully protected species. These conditions require enforceable commitments by Imperial Irrigation District (IID) to provide two 800,000 AF increments of conserved water. SB 317 authorizes the Secretary of the Resources Agency to undertake a study to determine a preferred alternative for the restoration of the Salton Sea ecosystem and the protection of wildlife dependent on that ecosystem. The bill requires submittal of a study identifying the preferred alternative on or before December 31, 2006.

Senate Bill No. 654 (SB 654) amends Section 12562 of the Water Code to extend the deadline for completing the lining of portions of the All American Canal and the Coachella Canal from December 31, 2006 to December 31, 2008, in order to allow additional time to satisfy the requirements for state funding for these projects. In addition, it allocates environmental responsibility among the water agencies and the state for certain environmental mitigation requirements related to implementation of the QSA. The Bill provides a mechanism to implement funding of mitigation costs by authorizing California Department of Fish and Game to enter into a joint powers agreement with Coachella Valley Water District (CVWD), IID and the San Diego County Water Authority for the purpose of providing for payment of environmental mitigation costs.

2.2 Other Actions That May Affect Inflows

Efforts to develop a preferred restoration project are not the only actions that could affect conditions at the Sea. Some other actions—being pursued under other initiatives and by other parties—could also influence the effectiveness of salinity/elevation control projects.

- **Constructed Wetlands Projects**—Several pilot wetlands have been constructed on the New and Alamo Rivers. Expansion of constructed wetlands projects in Imperial Valley could improve the quality of water flowing into the Sea, but would also cause some reduction of inflows.

- **Total Maximum Daily Load Program (TMDL)**—This program, being implemented by the Regional Water Quality Control Board, is designed to provide a long-term reduction in key constituents in waters that flow into the Sea. While improving the quality of water that flows into the Sea would be beneficial, it is also possible that TMDL efforts could result in some flow reductions.

- **Mexicali Wastewater System Improvements**—Mexico has been pursuing construction of projects to improve the collection and treatment of wastewater in Mexicali. These projects will improve the quality of water flowing across the international border but will also divert water away from the Salton Sea. It is estimated that these projects could reduce inflows to Sea by 15,000 acre-feet/year in 2006, increasing to 22,507 acre-feet/year by 2014.

- **Mexicali Power Plants**—Baja California Power, Inc. (BCP) and Sempra Energy Resources (SER) operate power plants that use Colorado River water for cooling. These evaporative cooling systems cause reductions of flow to the Sea. The available data suggests that the range of inflow reductions could be on the order of between 3,000 acre-feet/year to as much as 16,000 acre-feet/year, and likely would be somewhere in between. The Department of Energy is currently preparing an Environmental Impact Statement to comply with a Federal Court order requiring additional environmental review.

2.3 Relationship Between Inflow, Salinity and Elevation

A delicate balance between inflow and evaporation has sustained the elevation of the Salton Sea in the past (see Appendix C). If the inflow to the Sea is reduced as is anticipated under the QSA, evaporation will outstrip inflow and the Sea will begin to shrink until a new balance is achieved. Shrinking of the Sea will cause the salts that are currently in the Sea to concentrate. Compounding this problem, approximately 4 million tons of salt are added annually to the Sea from inflows. In addition, sediments that are now under water would be exposed and could possibly add to the existing problems with blowing dust in the Imperial and Coachella Valleys. Figure 2-2 provides a visual simulation of how the future shoreline of the Salton Sea would appear after full inflow reductions have been implemented under the QSA without restoration.

Figure 2-3 illustrates expected trends in the water surface, salinity and exposed sediments at the Salton Sea that could be expected with the QSA in place. These charts were prepared by Reclamation using their Salton Sea Accounting Model. The graphs in Figure 2-3 should be viewed as a reasonable forecast of what could happen in the future without any restoration actions. Many factors could affect these future trends including the methods that are used to implement water transfers and actions in Mexico that could reduce flows from across the border.

Other possible sources of water have been considered to sustain the inflow to the Sea, but thus far none have been identified that would provide sustained replacement flows. For example, Reclamation and the Authority are investigating brackish groundwater resources in the East Mesa area south of the Sea as a possible source for replacement water. However, based on previous work, it is likely that there would not be enough water to replace transferred amounts and the source would not be sustainable in the long term. Furthermore, delivery costs are likely to be high.

2.4 Effect on Restoration Alternatives and Cost

The reduction of inflow to the Sea creates a more complex challenge to the development of feasible restoration alternatives and also would have a substantial effect on the cost of most restoration strategies. This is the case because less inflow will create a smaller and shallower Sea thereby concentrating salts in the remaining waters. This will leave less time to fully implement a restoration alternative that preserves the current ecosystem that depends on a fishery to sustain fish-eating bird populations. To combat rapidly rising salinity, traditional methods of removing salts such as solar-pond or pipeline systems would have to be much larger under reduced inflow conditions than they would be under historical inflow conditions.

Figure 2-2. Visual Simulation of Red Hill Marina County Park in 2077 after QSA without Restoration, from IID Conservation and Transfer Project EIS (CH2M Hill, 2002).

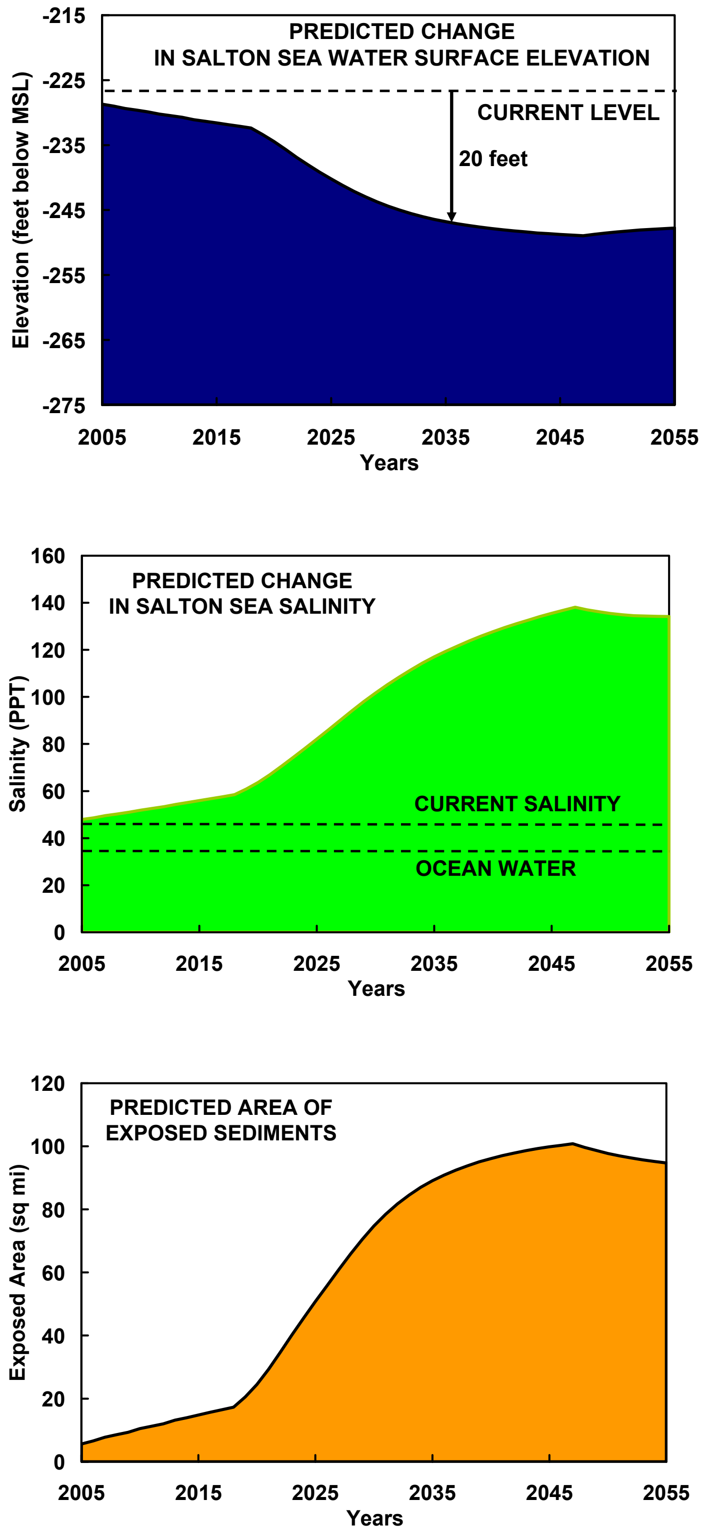

Figure 2-3. Predicted Trend of Water Surface, Salinity, and Exposed Sediments at the Salton Sea with Anticipated Reductions due to QSA Water Transfers without Restoration.

In its 2003 status report on the Salton Sea Study, the Department of Interior (Interior) estimated that the least expensive method to control salinity, on-land solar ponds, would have a present value of $820 million under an inflow scenario similar to what could be experienced with the QSA. The solar ponds and salt disposal areas would require an area of about 70 square miles. Under historic inflow conditions, the pond system could be less than half that size, and by scaling the cost would have a present value on the order of $400 million.

Figure 2-4 illustrates how the cost of an on-land pond system would vary with inflow to the Sea. Present value cost estimates were taken from Interior (2003) for an inflow of 1.0 million acre-feet/year (based on Interior's Inflow Scenario 1) and 0.8 million acre-feet/year (based on Interior's Inflow Scenario 3). The estimate of about $400 million for an inflow of 1.3 million acre-feet/year was extrapolated from those values.

Another complication that results from reduced inflow is the exposure of sediment currently inundated by the Sea. It is believed that the exposed sediment may be prone to being transported to the atmosphere by wind due to its fine grain sizes. This fine-grained material could increase airborne dust exposure to residents surrounding the Sea. The potential for dust generation requires further study and regardless of who pays the bill, it is likely that air quality mitigation will be required and the associated costs will need to be accounted for somewhere.

These and other factors result in less flexibility when developing restoration alternatives and higher costs as inflows to the Sea decrease.

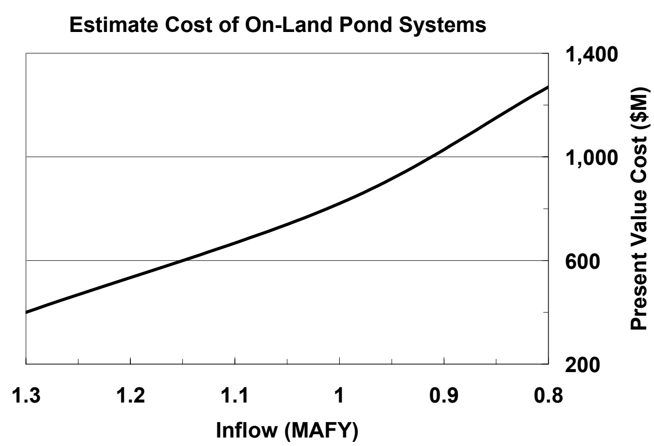

Figure 2-4. Estimated Cost of an On-Land Solar Pond System for Different Inflows, Derived from Interior (2003).

Chapter 3: OVERVIEW OF RESTORATION OPTIONS

Restoration options presented here have evolved through a process that has involved planning studies, engineering analysis, scientific oversight, and environmental reviews. Some concepts discussed here date back to the 1960s and possibly earlier. As stated above, the amount of salt that would have to be removed from the Sea would depend on future inflows. With reduced inflow, the Sea would begin to shrink and salts would be concentrated. If the inflow continues to be reduced in the future, greater amounts of salt would need to be removed to meet project objectives.

To address the rising salinity of the Sea, a surrogate outlet must be established. Three basic methods have been considered:

- Pump water out of the Sea and discharge it to some remote location. This could be accomplished by combinations of pipelines and canals to the ocean, the Gulf of California, or some other remote location.

- Pump water out of the Sea and discharge it to local desalting plants or evaporation ponds, possibly in combination with mechanical processes that enhance the rate of evaporation. This would require disposal of salt residues near or within impoundments in the Sea.

- Divide the Sea so that one portion acts as a receptor for the discharge from another portion. Through the construction of retention structures, salts would be allowed to concentrate in one area while salinity levels in the remaining area would be controlled.

A myriad of alternatives have been identified over the years to provide one or another of those outlet scenarios, some of which also help control the elevation of the water surface of the Sea. Many of the alternatives have been eliminated from consideration for various reasons; the ones discussed here were selected for review because they have been viewed as the most promising in the past or they have passed earlier screening analyses.

The annual inflow of water to the Sea has typically contained about 4 million tons of salt. Even if inflow to the Sea is reduced in the future, it is likely that conservation measures would serve to increase the salt concentration in the inflow such that the total annual salt load to the Sea would remain about the same. Although the salt load is about 4 million tons per year, some salts precipitate as they enter the Sea and, therefore, the amount of salt accumulating in the body of water is somewhat less than 4 million tons per year. However, for planning purposes, it has been assumed that under stable inflow conditions, about 4 million tons per year of salt would need to be removed to stabilize salinity in the Sea.

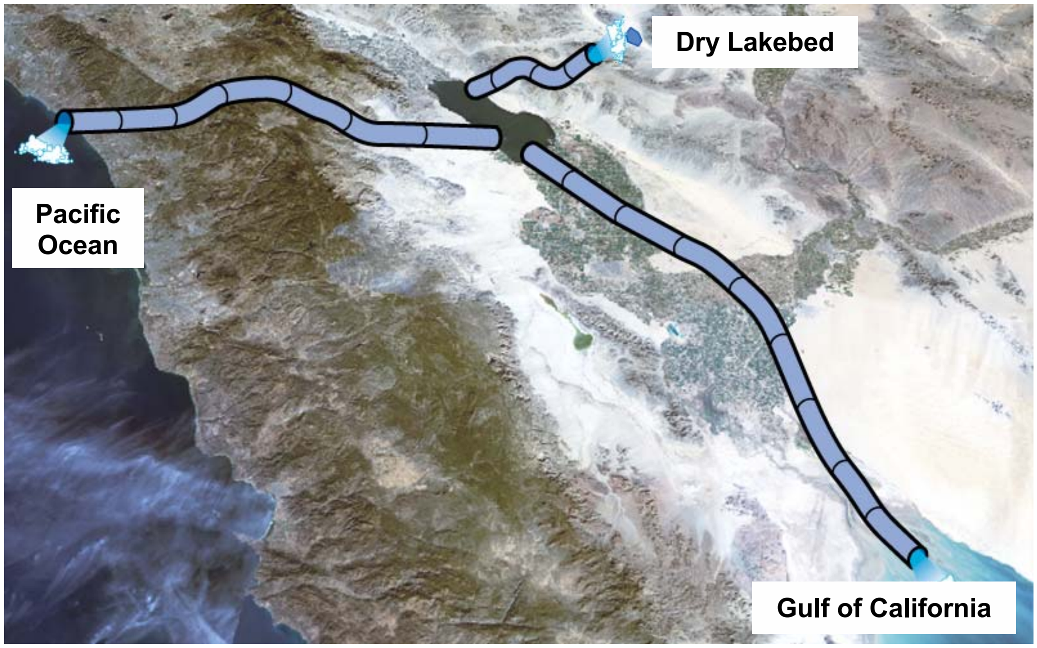

Figure 3-1. Potential Pipeline Routes.

During a transition period, when inflow would be decreasing, it has been assumed that a salinity control system would need to remove 4 million tons per year (to remove inflowing salt) plus an additional 4 to 8 million tons to avoid concentration of salt in the shrinking Sea. Once inflow would stabilize, such that a steady-state elevation could be achieved, salt removal could be reduced to about 4 million tons of salt per year or less depending on the amount of salt precipitation that may occur.

3.1 Pipelines and Canals

Import/export pipelines would convey water from the Salton Sea to the Gulf of California and return water from the Gulf to the Sea as illustrated in Figure 3-1. Pumping water from the Sea removes salt laden water and thus reduces the amount of salt and salinity in the Sea. Using other pipelines, water would then be pumped into the Sea to help maintain elevation. The water surface elevation of the Salton Sea would depend on a balance between water coming into the Sea and water leaving the Sea. Natural inflow, precipitation, and import quantities would be balanced by evaporation and export quantities. Likewise, salinity in the Sea would depend on the balance of salt coming in and salt going out. This alternative has two options: one would have pipelines to pump water in both directions, and another would use pipelines combined with channels. A pump out only alternative could include pumping out to a dry lake bed as shown in Figure 3-1. It has been estimated that pump-in/pump-out scenarios could cost in the $10s of billions and would face significant permitting challenges due to the international issues involved in developing a project that crosses into the Federal Republic of Mexico.

3.2 On-Land Solar Ponds and Enhanced Evaporation Systems

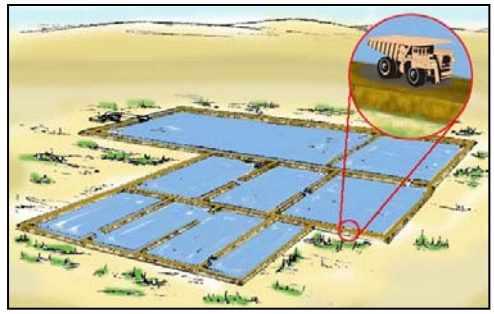

Figure 3-2. Sketch of On-Land Solar Pond System.

On-land solar ponds would be constructed using standard construction procedures for earthen berms or embankments. With the solar evaporation pond process, a series of shallow ponds would be constructed as shown in Figure 3-2. Salt water would be pumped to the upper-most pond and flow by gravity through the system. Evaporation would cause the water to become saltier from pond to pond. Concentrated brine from the final pond would be pumped to disposal ponds where crystallization would occur and residual salts would be disposed. The pond systems could be made smaller by adding ground-based enhanced evaporation system (EES) units that operate similar to snowmaking equipment as illustrated in Figure 3-3. A tower style enhanced evaporation system has also been considered.

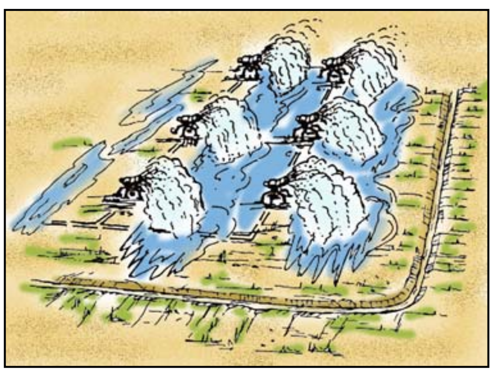

Figure 3-3. Sketch of Ground-Based EES Units.

Since land-based systems would not reduce the evaporative surface of the Sea, but would require water withdrawals, they would tend to lower the elevation of the Sea by 5- to 10-feet below any reductions that occur because of reduced inflows. Coupled with reduced inflow conditions, the Sea elevation could drop 30 feet below its current elevation during a transitional period and ultimately settle at an elevation 20 to 22 feet lower than the current level. Salinity would also exceed 60,000 mg/L during part of the transition, and would take 20 to 25 years until it returned to present levels (44,000 mg/L) or lower. In addition, on-land systems would need to be very large. Without enhanced evaporation units, on-land evaporation pond systems would need to occupy 60 or more square miles.

For methods requiring on-land salt disposal, the disposal options would involve crystallizing salts in an impoundment. Following concentration of salts through evaporative process or other processes, saturated brines would be conveyed to disposal ponds that would be constructed using earthen berms. Salts would crystallize in the ponds forming a rock salt similar to pea gravel that would cause the bottom of the pond to rise over time. As the pond bottom rises, berms containing the pond would have to also be raised. After about 30 years, the height of the berms would be about 25 feet. From the ground, the disposal facility would look like a large desert landfill. Salt disposal modules on land and on flat terrain would be the least expensive salt disposal method. Not all alternatives discussed below would require construction of disposal facilities.

Impoundments, such as those for either the salt removal or disposal components of solar pond systems, have the potential for accumulation of contaminants. A study (Tetra Tech, 2004) of constituent concentrations in solar pond pilot projects at the Salton Sea indicates that constituents including selenium will tend to concentrate in such ponds, particularly in those with the highest concentrations of salts. This finding is contrary to results from locations such as Kesterson Reservoir and numerous evaporation ponds in California's Central Valley where selenium was observed at the greatest concentrations in the initial few impoundments, probably due to high primary productivity. Primary and secondary productivity were observed to be very low in the solar pond pilot project at the Salton Sea. However, this study indicates that there could be some low-level ecological risks associated with concentration of constituents such as selenium in ponds with the highest salt concentrations.

During the recent stages of alternative development, specific locations where facilities could be sited were not identified. Instead, a siting analysis was conducted to identify areas that would be generally suitable for locating salt removal and disposal facilities. About 60 square miles of suitable area were identified for possible siting of facilities that would use enhanced evaporation salt removal methods, and more than 400 square miles were identified as suitable for on-land solar pond siting. More than 100 square miles were identified as suitable for on-land salt disposal.

In its 2003 Status Report, Interior estimated that for the reduced inflow conditions evaluated, the present value cost for on-land ponds could be as much as $1.3 billion; and with enhanced evaporation systems, the present value costs could be as high as $2.4 billion.

3.3 Desalination

Figure 3-4. Representation of Desalination Plant.

From a purely technical perspective, desalination of Salton Sea water has long been considered to be one of the most desirable strategies for controlling salinity in the Sea. A photo simulation of a desalination plant is illustrated in Figure 3-4. Desalination offers the ability to remove salt, while removing very little water. The desalination technologies that have been evaluated in the past have been eliminated from further consideration because of the high cost of energy associated with most processes. Recently an evaporative technology emerged that would take advantage of waste steam from geothermal operations at the south end of the Sea.

Applying desalination technologies would replace 70 to 80 percent or more of the feed water with fresh distilled water and would produce a concentrated brine stream of about 20 percent of the feed water. This fresh water could be returned to the Sea so that the process would have little effect on the elevation of the Sea or it could be sold to help pay for the restoration effort. Returning fresh water to the Sea would help with salinity control and would also help maintain the water surface elevation. The Sea elevation would still decline as a result of reduced inflow, but not much from the desalination process.

The brine concentrate, amounting to 20 or 30 percent of the feed-water flow, could be disposed of in one of three ways: (1) pumping the concentrate through a pipe into a suitable basin remote from the Sea for its evaporation over time, away from wildlife; (2) processing the brine through crystallizing evaporators to remove saleable sodium sulfate and other sulfates and injecting the sodium chloride and mixed salt residue into the geothermal aquifer, and (3) evaporating the brine to a salt residue using crystallizers and disposing the salt by landfill procedures. The gypsum precipitate could be disposed of at an approved disposal facility or sold for other commercial uses.

Interior (2003) estimated that an evaporative desalination system of the size needed at the Salton Sea would have a present value on the order of $1.2 to 1.5 billion. This estimate includes only the desalination system and brine disposal and not any other elements of a total restoration program. With this type of action, the Sea's water surface elevation would still decline by about 20 feet under an inflow scenario that would be expected with the QSA in place. Therefore, additional funds would need to be expended for control of dust and/or habitat enhancement in the roughly 100 sq. mi. of bottom sediments that would be exposed.

3.4 In-Sea Solar Evaporation Ponds

This alternative would involve the construction of in-Sea solar pond systems with in-Sea salt disposal as illustrated in Figure 3-5. The systems would operate similar to the on-land solar ponds discussed in Section 3.2 above. Salt water would be diverted by gravity flow or pumps through a series of ponds where salts would concentrate from evaporation until ultimately concentrated brine would be formed.

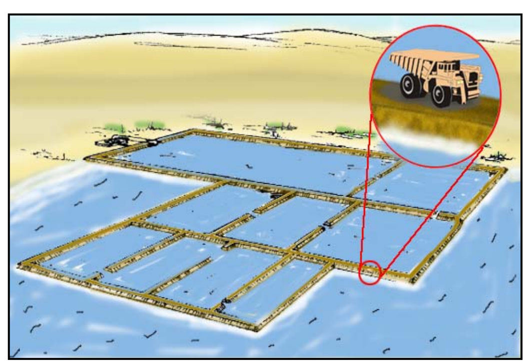

Figure 3-5. Sketch of In-Sea Solar Ponds.

The brine would be diverted to disposal ponds where salts would crystallize and build up over time. An advantage of in-Sea systems over similar on-land systems is that they reduce the surface area of the Sea. The surface reduction compensates for the water that is withdrawn. Therefore, operation of in-Sea pond systems potentially would not affect the elevation of the Sea. A second advantage is that on-land salt disposal areas would not be needed. Eventually salt disposal areas within the Sea could possibly be capped and converted to islands or peninsulas and used for recreational purposes.

Unfortunately, in-Sea construction would be much more expensive than construction on land. In addition, the cost of in-Sea pond systems would go up under reduced inflow conditions. Pond systems would need to be larger to remove more salt that would otherwise concentrate in the shrinking Sea. For the reduced inflow conditions investigated by Interior (2003), they put the price tag of in-Sea pond systems at between $2 and $3.5 billion.

In addition to the added size and cost of in-Sea pond systems with reduced inflow, there is a technical challenge. Under an inflow scenario as expected with the QSA in place, the Sea would drop by about 18 feet. Pond systems constructed in shallow water with today's elevations, would be well above the new water line of a smaller Sea. The surface area reduction benefit of constructing in-Sea would be eliminated and continued operation of the pond system would tend to further reduce the elevation of the Sea in that water would need to be pumped out of the Sea and into the pond system. Under this scenario, the added cost of constructing within the Sea would help with elevation and salinity control during the transition phase, but would not result in a long-term benefit. Alternatively, new ponds could be constructed within the smaller Sea, thus adding cost to the program.

3.5 Replacement Water

The salt removal systems discussed above do not function very well without replacement water. Various sources of replacement water have been evaluated in the past to compensate for reduced inflows to the Sea. Three potential sources that have been considered in the past are discussed below. These potential sources may not be available. Even if available, they would likely not be able to provide reliable and sustainable water in sufficient quantities to make up for inflow reductions.

Flood Flows. One source of replacement water that has been considered previously is flood flows from the Colorado River (flows in excess of the amount of the 1944 Treaty obligation to Mexico that cannot be used or stored within the U.S.). The quantity of these flood flows is expected to decrease over time as the storage and diversion capacity within the U.S. expands. It is very unlikely that this expanded diversion or storage capacity would be available to provide additional water to the Salton Sea.

Central Arizona Salinity Interceptor Project (CASI). Brine reject from the proposed CASI system was considered as a possible future source of water and included as part of some of the alternatives analyzed in the January 2000 Salton Sea EIS/EIR. Subsequently, uncertainties associated with this potential source removed it from consideration. However, if conditions change in the future, it could possibly be reconsidered.

Plan for Desalting the Colorado River Aqueduct Proposed by the City of Brawley, CA. The City of Brawley has proposed a plan to improve the quality of water flowing in the Colorado River Aqueduct. The plan would involve construction of a desalination plant along the Aqueduct. Reject water from the plant could be routed to the Salton Sea to help sustain the lake. The latest estimates indicate that about 60,000 acre-feet/year could be available to the Sea at a salt concentration of about 10,000 mg/L. There is uncertainty as to whether this project will be approved and funded for construction.

Groundwater Sources. Other sources of replacement water that have been studied include the use of brackish groundwater from the surrounding watershed. In the past, no cost-effective groundwater sources were identified. However, recently the East Mesa area of the Imperial Valley has been investigated as a possible transitional source that could be useful during periods of changing inflows. This potential source is also being investigated as a possible means of mitigation for the IID-San Diego Water Transfer Project.

East Mesa represents the triangular area east of East Highline Canal (EHC), West of the Algodones Dunes, and north of the U.S. border. Water quality for much of East Mesa is fairly good at 500 to 1000 mg/L TDS, but there is a large area with a TDS anomaly where the TDS levels are 2,500 mg/L or more. Groundwater of such quality would not be suitable for drinking and would be of little value for most applications. However, this quality of water would likely be acceptable as a source of import water for the Salton Sea.

Preliminary analysis suggests that up to 75,000 acre-feet/year could be imported into the Salton Sea for a period of 10 to 12 years. Depending on which part of the aquifer is tapped, conveyance distances could range from about 10 miles to nearly 50 miles. Preliminary cost estimates suggest that the present value cost of importing East Mesa area groundwater could range from $100 to $400 per acre-foot.

Lawrence Livermore National Laboratory has been provided federal funding to conduct a groundwater study in Fiscal Year 2004. This study may provide additional insight into groundwater storage capacity of aquifers surrounding the Sea. However, based on the current knowledge of groundwater availability it is generally believed that the brackish groundwater available could help the Sea during a transitional period, but would not serve a long-term replacement for reductions in base flow plus an annual transfer of up to 300,000 acre-feet.

3.6 Brackish Water Impoundments

The options discussed in Sections 3.1 through 3.4 have been considered for the Salton Sea in various reports over the past several decades. As discussed above, these methods do not perform well under reduced inflow scenarios. Therefore, in the early part of the present decade, other ideas began to emerge.

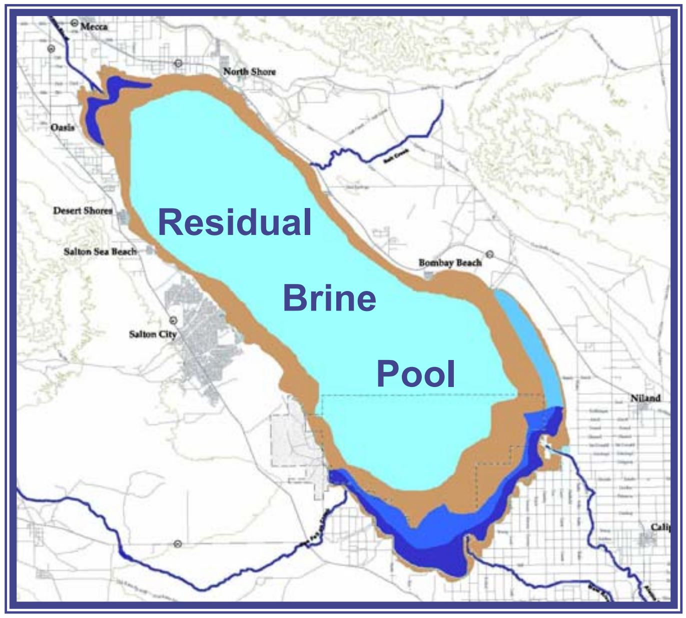

Figure 3-6. Impoundment Locations in Pacific Institute Proposal.

In October 2001, the Pacific Institute proposed a solution to the problems at the Salton Sea that they suggested would provide environmental and recreational benefits at the Sea, but would not control salinity or preserve the fishery within the main body of the Sea itself. The Pacific Institute for Studies in Development, Environment, and Security is an independent, non-profit center created in 1987 to conduct research and policy analysis in the areas of environment, sustainable development, and international security. The proposal was posted on their website at http://www.pacinst.org/saltonsea. html.

This proposal would involve placing treatment wetlands along the New and Alamo rivers and constructing dikes within the Sea near the north and south shores (Figure 3-6) to capture inflows and stabilize the water surface elevation at –230 feet. Water above elevation –230 feet would flow via gravity through pipes in the dikes to the main body of the Sea. Such a gravity fed system requires a reduction in inflows. The impounded north and south shore areas would transition to brackish, estuarine conditions. Actual salinity in these impounded areas would depend on several factors, including the volume and salinity of inflows (salinity of the Alamo and New rivers is currently about 2,900 mg/L) and the total volume of the impounded area.

A detailed review of the proposal was conducted by the Salton Sea Science Office (2002). The review was conducted by a group of nearly 30 scientists and engineers with diverse backgrounds in all aspects of the ecology of the Sea as well as the appropriate engineering disciplines to review the feasibility of the proposal. The review included an assessment of the costs associated with the dikes and other aspects of the proposal. The Pacific Institute estimated that the full proposal could cost $400 million, based on cost factors from an earlier Salton Sea Restoration Project report; however, the more recent estimate of the present value of the full dike construction program would be over $1 billion. This more recent estimate involves 45 miles of dike most of which would be constructed in 15 feet of water.

The review also identified a number of ecological concerns related to the proposal. The following paragraphs are extracted from the Executive Summary of the Salton Sea Science Office (2002) review:

> The ecological and recreational values of the impoundments would be determined primarily by salinity and contaminant levels and the fact that they would represent only about 12 percent of the area of the present Sea. As freshwater systems, they would quickly be colonized by large numbers of freshwater plants, invertebrates, and fish, with carp, tilapia, catfish, threadfin shad, and possibly largemouth bass dominating among the latter. These fish would be much more heavily infested with parasites than are present Salton Sea fish. As the impoundments would effectively be sluggish extensions of the rivers that feed them, they would have contaminant levels similar to those of the rivers. Selenium levels in impoundment waters would be roughly six times those in the present Sea. Fish and invertebrates in impoundments thus would be likely also to have much higher selenium concentrations than do fish and invertebrates of the present Salton Sea. These would pose significant increased risk to both sport fisherman and to fish- and invertebrate-eating birds, such as pelicans, grebes, ducks and shorebirds. The fish-eating birds would have fewer but more contaminated fish available to them than they do now.
>
> Even after flowing through treatment wetlands, inflow waters would have higher concentrations of microbial pathogens than does the present Salton Sea. These would further inhibit or advise against various types of recreational use of the impoundments. Dense aquatic and terrestrial vegetation would colonize possibly 50 miles of now barren shoreline within the impoundments. This would serve as excellent habitat for certain birds but also for mosquitoes, including Culex tarsalis. The latter is a known vector in the region of western equine encephalomyelitis, St. Louis encephalitis, and, potentially, West Nile encephalitis, as soon as that gets to California from eastern U.S. The 9000 ac of treatment wetlands could also serve as major new mosquito-producing habitat and might also be sites of selenium concentration in the food web. Other biting insects (horseflies, biting midges) would also likely increase in abundance.
>
> The residual Salton Sea would soon go fishless as salinity rose. The current aquatic invertebrate assemblage would also die out. For some years afterward, high densities of brine shrimp, brine flies and water boatmen would be found here and serve to attract large numbers of invertebrate-eating waterbirds. However, with increasing salinity the production of even such salinity tolerant

> species drops rapidly. A residual Salton Sea at a salinity of 200 g/L would be as barren of birds as is most of The Great Salt Lake of Utah. Selenium levels in these salinity tolerant invertebrates would also be much higher than those in invertebrates of the present Salton Sea.
>
> Though under the project proposed by the Pacific Institute the ecosystems in the region would initially continue to be as attractive to birdwatchers as the present ones, by most other criteria they probably would be less valuable for wildlife or human recreation and have negative economic repercussions for the region. Fishing, boating, swimming, and camping at the Sea would be less attractive options than they are now. Increased particulate matter air pollution would occur, might affect human health over a large region, and might affect agriculture as well.

A second concept for freshwater impoundments was proposed by US Filter Corporation in 2002. Under this concept, a dike would ring the Sea separating better quality water along the shoreline from hyper-saline water in the center. US Filter's proposal included a desalination plant at the north end of the Sea that would produce approximately 500,000 acre-feet/year of water with low salinity (< 150 mg/L total dissolved solids). This water would be transferred to urban water users via the Coachella Canal and the Colorado River Aqueduct. The concentrate from the Reverse Osmosis (RO) plant would be returned to the central Sea. This concept is illustrated in Figure 3-7.

A review of the US Filter proposal was conducted by Tetra Tech, Inc. (2003) in cooperation with the Salton Sea Science Office and a Citizens Advisory Committee. The review included an assessment of feasibility and cost. US Filter estimated that the costs of dikes for this option would be about $600 million. However, this estimate was based on cost factors from several years ago for dikes that were not designed to have differences in water surface elevation from one side to the other. In addition, US Filter estimated that the length of dikes would be about 80 miles. Current design concepts for impervious dikes that have differential water surfaces would be more costly. In addition, the actual length of dikes along the shoreline would be 95 miles if constructed in 10 feet of water, and 92 miles if constructed in 15 feet of water. Therefore, estimates of the current dike costs alone for the US Filter Corporation proposal, without the treatment plant, are $1.9 billion if constructed in 10-feet of water and $2.6 billion if constructed in 15-feet of water.

The review of the US Filter proposal also suggested that the shallow brackish water impoundments would have many of the ecological problems that would be associated with the Pacific Institute Proposal as discussed above in Section 3.6.

Figure 3-7. Sketch of US Filter Corporation Concept.

3.7 Multiple-Dike Proposals

Over the years, a large variety of diking schemes have been proposed at the Salton Sea. The 2000 EIS/EIR evaluated several alternatives that included diked impoundments. Under constant inflow conditions, dikes would serve to isolate saltier water from less salty water, and the water surface in the main Sea and in the diked impoundment areas would be at almost the same elevation. Under reduced inflows, dikes could be used in a different manner. Under such conditions, dikes could be used to help maintain the Sea's water surface at or near its current levels while the impounded areas would be dry or could be used for other purposes.

In 2003, representatives of the consulting firm Black & Veatch made a series of presentations involving various configurations of dikes. The proposals for stabilizing the Sea would utilize evaporation or brine ponds, created by dredging sand to create dikes that would be up to 1,000 ft wide. An evaluation of the Black & Veatch proposals (Brownlie and Kirk, 2003) suggested that for the reduced inflows under consideration, areas surrounded by dikes would need to be as large as those shown in Figure 3-8. The diked areas would provide an outlet for water to help lower salinity levels in the Sea. In addition, by reducing inflows into the Sea, a supply of

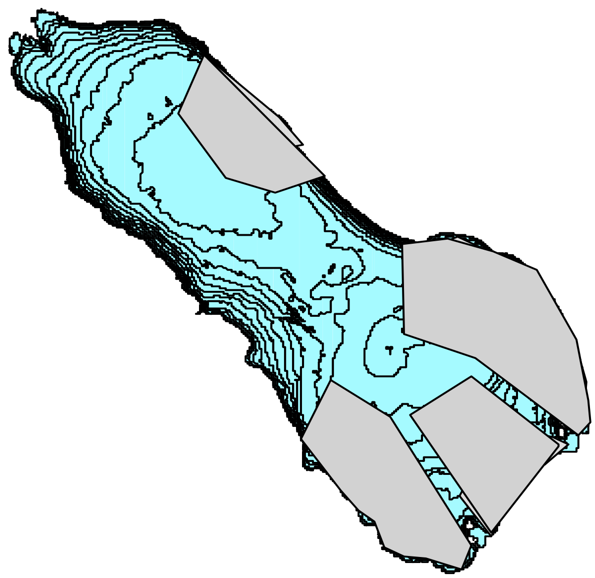

Figure 3-8. A Review of the Black & Veatch Concepts Suggested that the Area Needed to Achieve a Water Balance Would be Like the Gray Areas.

agricultural drainage water could be captured and treated at a proposed treatment plant, creating a water supply to be used for other purposes. These uses could include transfer to local water agencies or the Colorado River Aqueduct. Black & Veatch estimated that up to 400,000 acre-feet of transferred water could be produced under this concept. A shoreline canal would surround the dike system and evaporation/brine ponds to ensure continuity of the existing shoreline. A goal of this concept would be to maintain a significant portion of the overall Sea and its existing shoreline.

The Authority evaluated this concept (Brownlie and Kirk, 2003) and estimated the cost to range from $2.3 to $5 billion to construct the project. Subsequent to the Black & Veatch proposal, a preliminary geotechnical investigation of Salton Sea sediments was conducted by the Authority (URS and Tetra Tech, 2004). The investigation showed that bottom material consisted primarily of fine materials that may not be suitable to serve as hydraulically dredged and placed fill material for dikes. The cost estimates quoted for the Black & Veatch proposal could be updated with the latest design information, but the cost would still be expected to be well in excess of $1 billion because of the significantly greater length and amount of material.

3.8 Central Causeway Options

The reviews of the dike concepts discussed in Sections 3.6 and 3.7, above, suggested that the use of dikes to create a smaller marine lake coupled with other uses of water were worthy of further consideration. These considerations led to a concept that a causeway could be constructed across the central portion of the Sea to create a marine lake on one side and an area for habitat enhancement or other uses on the other side.

Concepts similar to this had been considered and highly rated several years ago but had been eliminated from further consideration because of costs. However, with the rising cost of other alternatives because of inflow reductions, this concept seemed worthy of renewed consideration and further development. There are several ways in which a central causeway could be used. For example, a central causeway could be used to serve as a salt barrier with no elevation control. Under such a scenario, the water level would be about the same on either side of the barrier, but one side could be maintained at ocean-like salinity while the salinity on the other side would continue to rise. Over time, with the QSA in place, the water on both sides of the barrier would decrease to about 18 feet lower than the current level Sea.

An alternative to the barrier concept discussed above, would be to build the causeway as an impoundment structure to maintain a managed lake level on one side and allow the water level on the other side to adjust according to inflows. The Salton or North Lake concept illustrated in Figure 3-9 would follow this premise and utilize a mid-Sea impoundment to create a marine lake in the north and a variety of habitat and recreational features in the south. The concept would also allow for the expansion of geothermal energy in the south, in an area that is now under water.

The Salton or North Lake concept was presented to the Authority Board of Directors in early 2003. The Board endorsed the concept as a highly promising solution to the problems at the Sea and authorized further development of the concept. Further discussion of the evolution and enhancement of this basic concept is provided later in this report.

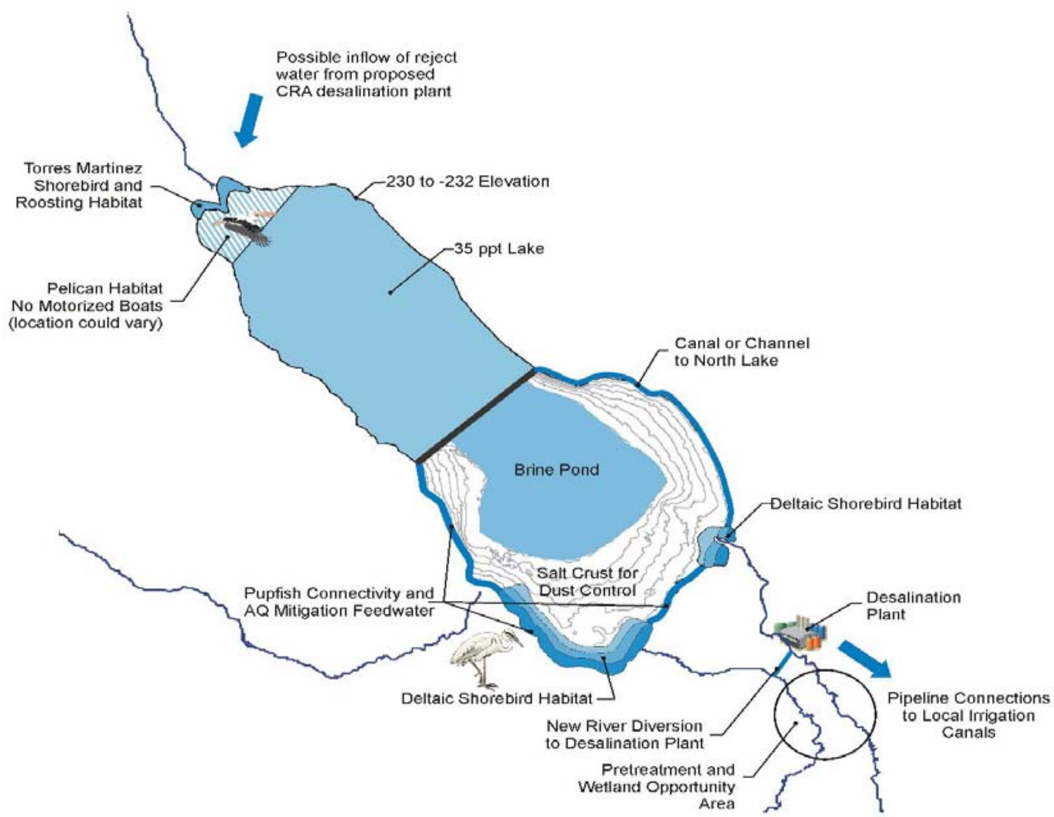

Figure 3-9. Salton or North Lake Concept.

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Chapter 4: LOGICAL PROCESS FOR ALTERNATIVE SCREENING

The various categories of alternatives for solving the problems at the Salton Sea can be reviewed through a logical sequence of decisions given the current and likely future conditions at the Sea. The process begins by developing a series of questions which provide a roadmap through a sequence of decision points leading to a logical preferred project. The questions and logical decision points are discussed below and diagramed in Figure 4-1.

4.1 Would pump-in/pump-out systems work?

Probably the largest and most critical issue for achieving a broad range of project objectives is the control of salinity. This is a far-reaching concern that has implications for both the ecology and the economy and recreational value of the area. Thus, probably the first logical question is: could we create an outlet to the Gulf of California or Pacific Ocean to remove salt and at the same time bring ocean water back in to help sustain the Sea? From the perspective of those interested in preserving the Sea, export of salts to a distant location is very appealing. In addition, a pipeline or pipelines combined with canals to the Gulf or Ocean would also offer the opportunity of developing a return line that would bring water with ocean-like salinity back into the Sea to help control the water surface elevation of the Sea. Pipelines for pumping water uphill from the Sea and the Gulf coupled with a canal system on the downslope side could also possibly provide a navigable waterway to the ocean.

As appealing as the pipeline/canal approaches may seem to be on the surface, there are many drawbacks, including extremely high costs. Ocean water is about 20 times more salty than the Sea's current inflow. To achieve a salt balance, and thereby control salinity, and also maintain the elevation of the Sea in a decreasing inflow environmental, massive amounts of water would have to be exchanged. The Interior's 2003 Status Report estimated that pipeline or pipeline and canal systems to exchange water between the Salton Sea and the Gulf of California could cost anywhere from more than $10 billion to $40 billion depending on the system and the extent of inflow reductions.

In addition to shear size and cost factors, the exchange of water with the Gulf or Ocean has other problems. For example, exotic species from the Sea could be introduced into the Gulf and vise versa. It is also possible that bacteria that create red tides in the ocean could be imported that would cause large fish mortality incidents in the Salton Sea. In addition, there would be a number of logistical and international issues that would need to be addressed related to construction in a channel in Mexico to the Gulf of California. Therefore, for the reasons discussed above, pump-in/pump-out systems are impractical. If pump-in/pump-out systems are impractical, would simple pump-out systems work?

4.2 Would pump-out only systems work?

The next question to be answered with respect to salt removal and disposal is: would systems that rely only on pumping salty water out of the Sea work without any pump-in features? A variety of pump-out systems have been investigated. The main problem associated with any of these systems would be size. Under historical inflow conditions, a pump-out system would need to be sized to remove about 5 million tons of salt each year to stabilize and gradually reduce salinity. For the assumed inflow conditions under the QSA, the systems would need to remove 10 to 15 million tons per year or more during the transitional period when the Sea is shrinking. During at least part of the transition period, it is likely that salinities would be too high to support the current fish population; therefore, the fishery would need to be re-established in the future. Eventually, after about 20 to 25 years, operation of any of the systems could be reduced to remove 4 to 5 million tons per year for long term maintenance of lower salinities. Removal of large quantities of salt water would further reduce elevations of the Sea below what would occur with transfers only. The Sea would drop in elevation to about 25 feet lower than its current level.

Some specific features of the various pump-out approaches are discussed below.

On-Land Solar Ponds or Solar Ponds with EES—The primary drawback to using on-land solar evaporation ponds would be the large areas of land that would be needed. It is estimated that the size of a multiple-pond system that could effectively manage salinity in the Sea is on the order of 60 square miles. This large an area presents unique challenges from acquisition and land ownership issues to the high cost of maintenance, volume of water displaced from the Sea and impacts to the fishery. The use of on-land solar evaporation ponds is estimated at around $1 billion. Enhanced evaporation systems (EES) could be added to reduce the land area required. These systems use spray techniques to enhance natural solar evaporation. Interior (2003) estimated that with about 1,000 or more ground-based spray units operating constantly, the area required for evaporation and disposal of salts would be reduced to about 20 square miles. However, there would be significant added cost as well as high on-going operating and energy costs. The cost to construct, operate, and maintain this system for 30 years, expressed as a present value, is estimated at between $1.7 and $1.9 billion for the assumed inflow conditions under the QSA.

Pump-Out to the Gulf of California, Pacific Ocean, or a Dry Lakebed—Pipelines to far-away locations would avoid the in-basin land area requirements that would be associated with solar ponds and their disposal areas. Functionally, they would affect the Sea in a manner similar to solar pond systems in that they would create an artificial outlet for the Sea and thereby remove salty water. The capacity of a one-way pipeline would be about one-tenth that required by the export component of a pump-in/pump-out system. This is because the large volumes of water needed

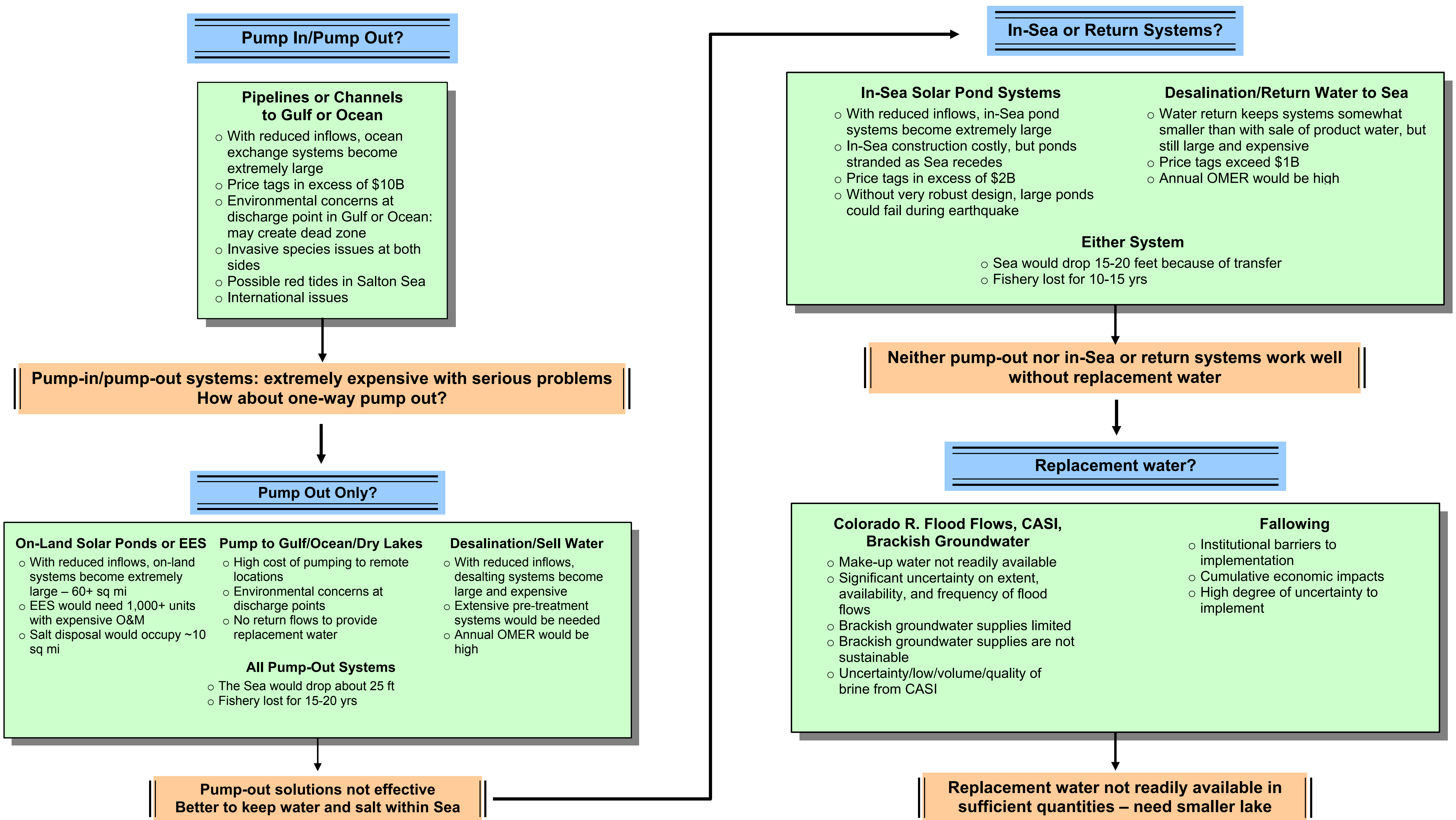

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Figure 4-1. Logical Process for Screening Salton Sea Restoration Alternatives (Part 1 of 2).

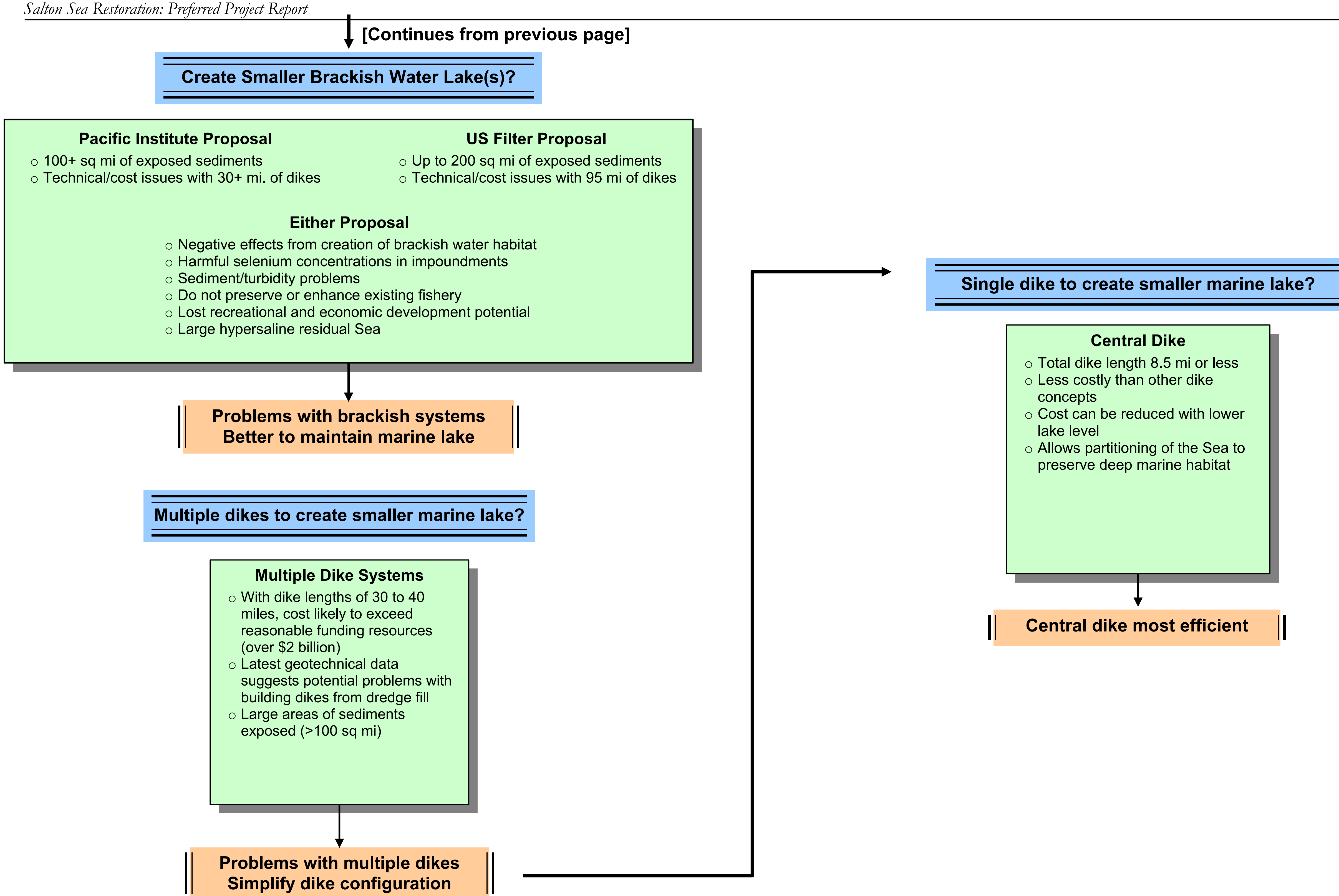

Figure 4-1. Logical Process for Screening Salton Sea Restoration Alternatives (Part 2 of 2).

to balance inflowing highly salty ocean water in a pump-in/pump-out system would not be needed. However, pipelines to remote locations would still be expensive, with price tags likely in excess of $1 billion. Energy and operating costs for pumping to dry lake beds or the Pacific Ocean would be high. Pumping to the Gulf would have a lower energy requirement, but the international issues would need to be addressed. In addition, for all three options, there would still be serious environmental issues at the discharge points that would need to be addressed.

Desalination with Sale of Product Water—The use of desalination technology has been evaluated as a means of controlling salinity. If the product water from a desalination system is sold to help pay for the project, from the Sea's perspective, the system would function as any other pump-out method. As discussed in Section 3, evaporative systems have been considered that would take advantage of waste steam from geothermal operations at the south end of the Sea. However, even with an expensive source of energy, with reduced inflows and the current salinity burden in the Sea, an effective desalination system would need to be extremely large and would be very costly to operate and maintain. In addition, a large volume of brine would need to be disposed and disposal areas could occupy on the order of 10 square miles. The cost for a vertical tube evaporation system would likely exceed $1.4 billion.

All Pump-Out Systems—To summarize, all pump-out systems would be expensive and, in all cases with the QSA, the Sea would drop in elevation to about 25 feet lower than its current level. Inevitably, elevated salinity would occur during a 15 to 20 year transitional period, and the fishery would likely be lost during this period and it would need to be re-established at some time in the future. Given all the drawbacks of pump-out systems, it is logical to explore in-Sea systems or other projects that do not require export of water from the Sea.

4.3 Would in-Sea ponds or systems that return water work?

At least two systems have been investigated that would remove salts from the main body of the Sea, but would not remove much water: in-Sea shallow water solar ponds and desalination systems with return of the fresh water product to the Sea. Again, a significant problem associated with either of these systems would be size. For the assumed inflow conditions under the QSA, the systems would need to remove 10 to 12 million tons per year during the transitional period when the Sea is shrinking. During at least part of the transition period, it is likely that salinities would be too high to support the current fish population; therefore, the fishery would need to be re-established in the future. Eventually, after about 15 to 20 years, operation of any of the systems could be reduced to remove 4 to 5 million tons per year for long term maintenance of lower salinities. Although these systems would not affect elevation of the Sea, there would still be a drop of 18 to 20 feet because of the inflow reductions.

Features of the various pump-out approaches are discussed in the following paragraphs.

In-Sea Solar Pond Systems—Due to reduced inflows, in-Sea pond systems would need to occupy around 55 square miles within the Sea. Since in-Sea ponds would reduce the surface area of the main body of the Sea, the water removed would be balanced by a reduction in the evaporative from the main Sea and there would be no effect on elevation. However, as discussed earlier, a drawback to in-Sea ponds is that the ponds would be stranded away from the Sea as it recedes under reduced inflow conditions thus requiring pumping or relocation of the ponds. The surface area reduction benefit of constructing in-Sea would be eliminated and continued operation of the pond system would tend to further reduce the elevation of the Sea in that water would need to be pumped out of the Sea and into the pond system. Cost to implement this approach has been estimated at over $2 billion. The added cost of relocating ponds as the Sea recedes has not been considered in this estimate.

Desalination with Return of Product Water to Sea—If the product water from a desalination system is returned to the Sea, salt could be removed without removing much water and the system would have little effect on the Sea's water surface elevation. The system could be perhaps 10 to 15 percent smaller than a system where the product water would be sold because the return water would provide some dilution effect. However, the system would still be large and nearly as expensive as where product water would be sold as discussed above and in this case there would be no sale of water to offset the cost. If brine from the process were disposed in in-Sea ponds, there would be no effect on elevation. However, again the Sea would drop because of inflow reductions.

Either System—Either in-Sea solar ponds or desalination systems would be effective under historical inflow conditions. In addition, they could be designed at about 1/3 the size required with QSA inflows at about 1/3 the cost. Therefore, they could be effective if replacement water were available to make-up for inflow reductions from the QSA transfers and other factors that may reduce inflow. Nearly 400,000 acre-feet/year would be needed. Is replacement water available?

4.4 Would pump-out or in-Sea systems work with replacement water?

If a reliable source of water to replace the volume that will be transferred could be identified, then restoration planning could be simplified. The potential sources of replacement water are described below.

Colorado River Flood Flows, CASI or Brawley Desalting Proposals, Brackish Groundwater—The use of Colorado River flood flows has been identified as a potential source of replacement water. Several limitations to this being a feasible solution include the highly uncertain nature of volume or frequency of flood flows in excess of currently allocated water on the Lower Colorado River and whether these flows could be made available to the Sea over the long term. The use of flood flows for habitat enhancement along the Lower Colorado River is currently under consideration and this use may supercede uses for the Salton Sea.

The use of brine reject streams from the proposed CASI system and the City of Brawley proposal for a desalting plant on the Colorado River Aqueduct have been considered in the past as a possible future source of water. The project is in the planning stages and may not come on-line for another 10 to 20 years. Uncertainties associated with this potential source removed it from consideration. The Brawley proposal could supply 60,000 acre-feet/year at about 10,000 mg/L, but its implementation is also uncertain and this quantity of water would not compensate for the projected flow reductions.

There is currently a study underway by Lawrence Livermore National Laboratory to evaluate the potential to use groundwater from the Imperial Valley Watershed as replacement water for the Salton Sea. However, based on currently available information, it is believed that this source of water could provide about 50,000 acre-feet/year for about 10 years, and would not be sustainable over the long-term. Thus, while this water could be helpful for restoration efforts, this source of replacement water would not be a viable means of making some of the above mentioned technologies more feasible.

Fallowing—Fallowing of farmland currently under production has been considered as a source of replacement water. Under this scenario, farmland that is currently under production would be taken out of production and the water normally used to irrigate the crops could be used as replacement water for the Salton Sea. This approach is expected to be used until on-farm conservation techniques are developed to such a degree as to achieve efficiencies approaching total land fallowing. Unfortunately, over the long term this approach has significant social and political challenges due to the resistance of local farmers to fallow even more land than is currently envisioned under the QSA. Large blocks of land would need to be taken out of production and would result in a loss of jobs and other socioeconomic impacts. It is highly unlikely given current conditions within the Imperial Valley that this approach could be implemented with certainty.

General Availability of Replacement Water—It does not appear that replacement water is available in sufficient quantities to make up for inflow reductions. Therefore, since the available methods discussed above do not work well with reduced inflows, it is necessary to consider ways to create a smaller lake.

4.5 Would it make sense to create one or more smaller brackish water lakes?

Two approaches to developing a smaller brackish water lake or lakes have been proposed…the Pacific Institute and US Filter concepts. While novel concepts, these proposals have significant drawbacks due to the reliance on brackish water systems as the primary habitat to sustain the ecosystem of the Sea, the negative effects of such a habitat in an arid desert environment, and the lost recreational and economic benefits from a large hyper-saline Sea. The US Filter concept first introduced the idea of desalinating water flowing into the Sea and to make this water available for transfer to other water users. The desalination concept is attractive because it creates a revenue stream that could be applied to restoration costs and could be incorporated into other restoration concepts. The Pacific Institute and US Filter concepts are discussed below.

Pacific Institute Proposal—The Pacific Institute proposal relies on creating brackish water impoundments at the north and south end of the Sea to utilize inflows from the main sources of water to the Sea (i.e., New, Alamo, and Whitewater Rivers). A group of more than a dozen scientist and engineers convened by the Salton Sea Science Office to review this proposal identified many serious concerns. The main body of the Sea would continue to increase in salinity eventually becoming hyper-saline and devoid of a viable fishery. This would result in loss of recreational opportunities for the vast majority of the Sea and would likely preclude economic development in communities surrounding the Sea. The impoundment of inflows to the Sea would create a brackish water habitat that would result in increased abundance of biting insects, parasites and pathogens, and an environment for selenium to concentrate at levels harmful to wildlife and humans. This would also significantly impact the sustainability and diversity of the fishery in the Sea. The resulting brackish water fishery would not resemble the current one and fish in the impoundments could pose health risks to humans and wildlife due to elevated selenium levels. Recent cost estimates are that this proposal would cost on the order of $1.2 billion.

US Filter Proposal—As with the Pacific Institute proposal, the US Filter proposal would create a large brackish water environment; however, the US Filter proposal would create this habitat around the entire periphery of the Sea. The Authority commissioned a technical review of this proposal that was conducted in association with the Salton Sea Science Office and a Citizens Advisory Group. The technical review identified many of the same concerns related to the ecosystem, recreation, and the local economy that surfaced during the review of the Pacific Institute Proposal.

The shallow brackish habitat would exacerbate the problems related to fish, bird, and human diseases associated with water borne parasites, contaminants, and mosquitoes. Because the brackish water ring around the Sea would be the primary habitat, the current food web would change to a fresh water web with algae as the major food base. Extensive growth of vegetation would occur along the shoreline. Temperature ranges in the brackish water ring would be similar to the inflowing rivers, but more extreme than the current Sea. The average water depth in the brackish water ring would be on the order of 5 feet. There would be a loss of recreational and economic development potential due to the loss of the Sea as a hyper-saline water body. It has been estimated that this restoration alternative could cost between $1.9 and $2.6 billion.

Brackish Water Lakes—The brackish-water-lake concepts considered above have serious drawbacks and also would be very expensive to implement. Therefore, it is logical to explore methods to maintain a smaller marine lake.

4.6 Could multiple dike configurations be used to create a smaller marine lake?

In the past, most concepts involving dikes had involved construction of dikes as a means of controlling salinity. Salty water would flow into the area surrounded by dikes and salts would concentrate through solar evaporation. In most cases, there would be no elevation difference between the main Sea and the area behind the dikes. As shown in Figure 3-6, the Salton Sea EIS/EIR (2000) also included alternatives that coupled dikes such as these with a displacement dike at the south end of the Sea. The displacement dike would be used to reduce the evaporative surface area of the Sea to help maintain elevation under reduced inflow scenarios. The area behind such a dike would be dry.

More recently, as discussed in Section 3.7, the consulting firm Black & Veatch proposed creating impoundments at various areas within the Sea to isolate and concentrate salt, thereby controlling salinity increases in the main body of the Sea. The size of the impoundments would be large, about 88,000 acres, and would require extensive dikes to contain the hyper-saline water. Because of the length of dikes required (34-51 miles) the costs associated with these dike configurations have been estimated at between $2.3 billion and $5 billion. The Black & Veatch concept also included desalination and water transfer components similar to the US Filter concept that are not included in these cost estimates. In addition, Black & Veatch assumed that the dikes could be constructed by using fill material from hydraulic dredging operations. Recent geotechnical information from the Salton Sea has shown that because of the fine material on the Sea bottom, this method may be impractical or at least more costly than previously anticipated.

In addition to high price tags and feasibility concerns, multiple dike schemes would have another drawback. They would not be sensitive to inflow reductions. A multi-billion dollar dike scheme could be designed for a certain inflow, but if the inflow was reduced in the future, additional dikes would be needed in the future to continue to stabilize elevation. Given these concerns, it is then logical to investigate a simpler configuration of a single structure across the middle of the Sea, that would be at most 8.5-miles long, compared to up to 51 miles for multiple-dike configurations.

4.7 Would the use of a central dike to create a smaller lake work?

Rather than creating extensive ring dikes within the Sea and the resulting high cost, a concept that bisects the Sea in half has been proposed. This concept relies on building a retention structure, barrier, or dike across the midsection of the Sea to separate hyper-saline and marine basins of the Sea from one another. The advantage of this concept is the reduction in distance needed to effectively separate these two basins. For example, if the structure is placed at the approximate midsection of the Sea where the west and east shorelines are nearest, the length of the barrier would be around 8.5 miles, and less if it is designed to work with the Sea at a lower elevation than the current situation. A major challenge to this concept is the feasibility of constructing a facility that is cost effective. The foundation conditions of the Sea have been investigated and found to be composed of a relatively thick layer of fine-grained sediments that create an engineering design challenge. However, alternative designs of a mid-Sea facility are currently underway and based on preliminary engineering evaluations it is believed that a suitable structure could be constructed at a reasonable cost.

Chapter 5: EVALUATION OF REASONABLE ALTERNATIVES

The logical process for reviewing alternatives discussed in Chapter 4 led to the conclusion that alternatives that employ a central dike or retention structure are worthy of further investigation. This chapter addresses how the individual components could be combined into alternatives. It also provides an evaluation of those alternatives with respect to the program objectives. All of the alternatives discussed in this chapter would include a wide range of habitat and recreational features that would need to be part of a complete alternative. Chapter 6 presents these features and how they would be integrated into the preferred alternative.

5.1 Formulation of Reasonable Alternatives

A smaller marine lake concept could be developed along one of two options using a central dike or retention structure: a marine lake in the north or a marine lake in the south. A logical location for dividing the Sea is an east-west orientation across central area of the lake. Here, the distance between shorelines is the least and the water depth is 5 to 8 feet shallower than deepest portions of the north and south basins. The features and benefits of south and north marine lake concepts based on a dividing structure at this location are described briefly below. There is also a choice about whether or not to control elevation.

South marine lake—A marine lake in the south would have a maximum area on the order of 200 square miles and require an inflow of 980,000 acre feet per year to sustain it at current elevation (about -227 feet msl). The area would be smaller if the lake was to be maintained at a lower elevation. A southern marine lake would be consistent with current wildlife refuge boundaries. The southern marine lake would also take advantage of inflows from the New and Alamo Rivers such that rerouting or transporting these flows would not be necessary. Concentrations of selenium and other contaminants in the sediments are highest in the northern half of the Sea. Allowing portions of this basin to recede would expose the sediments creating the potential for human health and wildlife impacts.

North marine lake—A marine lake in the northern portion of the Sea would be on the order of 140 square miles and require an inflow of around 800,000 acre feet per year. A marine lake in the north would reduce the concern over selenium sediment effects by effectively capping the sediments with the marine lake. There are also established communities in the northern portion of the Sea such as Desert Shores, Salton City, and North Shore that would benefit from a restored Sea. These communities would likely experience renewed economic development such as commercial, recreational, and residential developments. The Torres Martinez Tribe would also benefit from a restored Sea and could implement various economic and natural resource projects. The exposure of the shoreline in the south would allow geothermal exploration and development of the known geothermal resources in this area.

Elevation control—The next issue to be addressed is whether or not to control the water elevation in the marine lake, and if so, what approach to use. A barrier could be used with no elevation control. A retention structure could be used that maintains elevation at current levels. Or, a retention structure could be used that takes advantage of a reduced water surface level.

Given the above considerations, four alternative configurations have been identified for evaluation:

- **South Marine Lake without Elevation Control**—The simplest configuration would be to construct a central barrier and allow the New and Alamo rivers to flow into the south basin and create a marine lake with hyper-saline conditions in the north.

- **South Marine Lake with Elevation Control**—This configuration would be similar to the previous alternative, except that the central barrier would need to be taller and more robust to impound water in the south and create a higher water surface than in the north.

- **North Marine Lake with Elevation Control**— This concept would be similar to the previous alternative with the north-south configuration reversed. In this case, the New and Alamo rivers would need to be extended to the north to provide freshwater inflows to control salinity in the north basin.

- **No Marine Lake—**This alternative is considered in case a mid-Sea barrier or impoundment structure proves to be infeasible or too costly. It would include wetland and habitat restoration elements to achieve as many objectives as possible without maintaining a large lake with a marine fishery.

South Marine Lake Without Elevation Control: Example Configuration

As an example, a preliminary configuration for the first alternative listed above is illustrated in Figure 5-1 and discussed here. This alternative would involve construction of a low barrier across the middle of the Sea, thus creating two distinct bodies of water. The South portion of the Sea could be maintained at ocean-like salinities (35,000 mg/L), as it would be fed directly from the New and Alamo Rivers. The north portion of the Sea would become hyper-saline. Precise salinity levels could be maintained in the south by allowing some backflow of hyper-saline water from the north. There would be minimum elevation difference between the two bodies of water, but their habitat characteristics would be different.

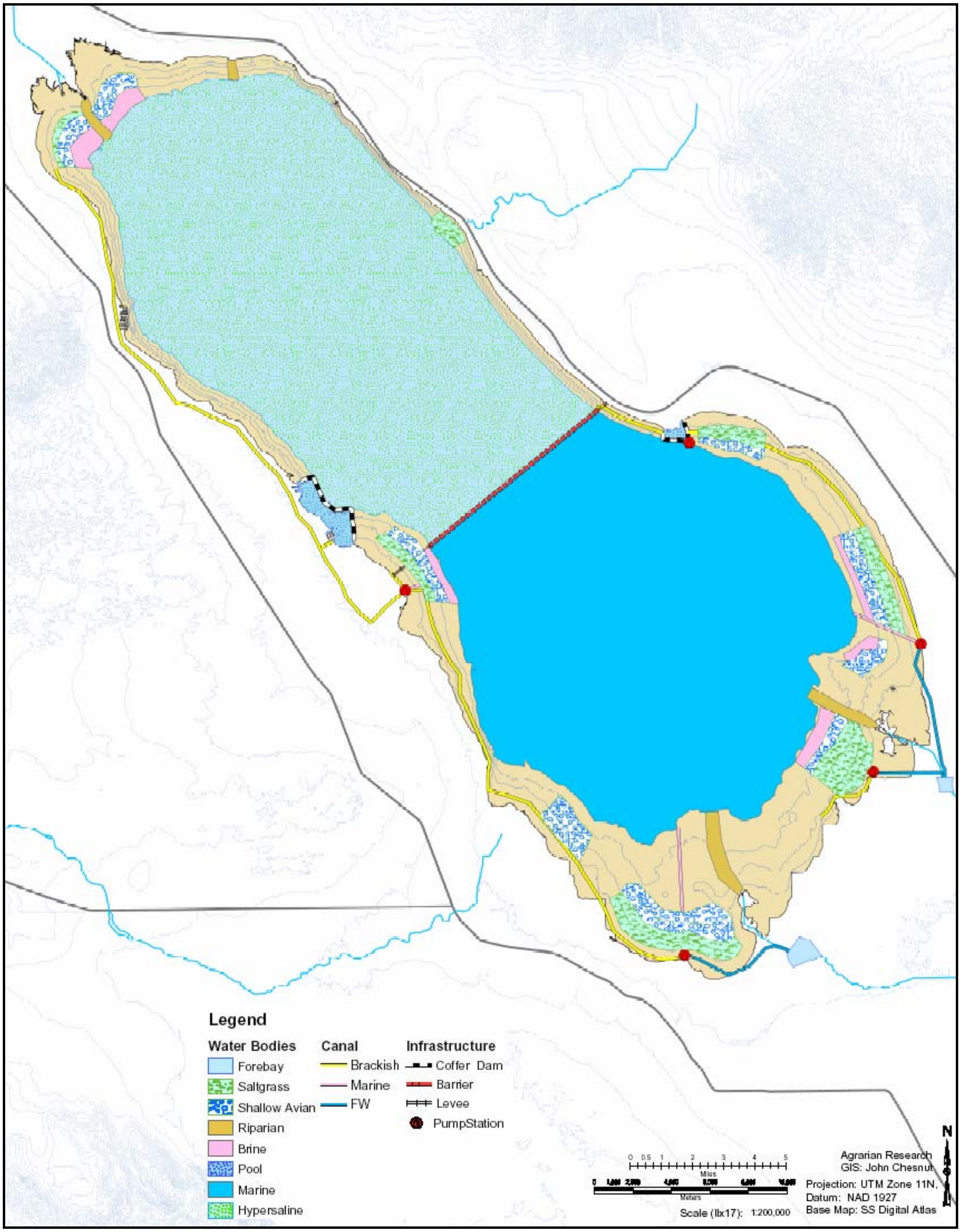

Figure 5-1. Possible Configuration for the South Lake without Elevation Control.

There would be several kinds of constructed habitats associated with this alternative. The canal on the east side of the Sea would deliver water to saltgrass and waterfowl habitats, and would also supply a recreational pool at Bombay Beach. The canal on the west side, which would consist of fresh water blended with Sea water pumped from the South portion of the Sea, would supply additional saltgrass and waterfowl habitat areas. It would also provide water for a recreational pool at Salton City. The west canal could double as pupfish connectivity habitat as well. Additional flooded saltgrass stands would be present at the north, provided with water blended from the west transmission canal and water from the Whitewater River. Saline waterfowl habitat at the north end would be supplied from the same blended water, arriving in the canals from both the east and the west. The outflow from all habitat types would be used to create solar salt concentrators and crystallizers downslope of the saline habitats.

This example alternative includes freshwater habitat in the forebays only, with short lengths of freshwater canals. There would be at least three pump stations required. One would be north of the Alamo River to supply the canals flowing north to Bombay Beach and south to the saltgrass and waterfowl habitats. A blending station would be required at both the New and Alamo Rivers to blend saline and river waters for the canals. Another pump would be at Niland, to augment flows to the north end of the Sea. The third would be near Salton City, to provide additional water to the canal and recreational pool on the west shore. A low mid-Sea barrier would also be required.

Similar examples can be developed for the other alternatives. Examples of how habitat areas could be developed for other alternatives are provided in Appendix A to be supplied.

5.2 Evaluation of Reasonable Alternatives

The four reasonable alternatives discussed above were evaluated against the current program objectives presented in Chapter 1. For each objective, the alternatives were ranked on the basis of best judgment as to how they would perform under inflows that would be expected with the QSA in place. Finally, an overall composite ranking was developed. Each of the objectives and the rankings are discussed below. As discussed in Chapter 1, the current objectives were derived from the goals identified in the Salton Sea Reclamation Act of 1998 as shown in Table 1-1 of Chapter 1.

Restoration Alternative			
South Marine Lake wo Elevation Control	South Marine Lake w Elevation Control	North Marine Lake w Elevation Control	No Marine Lake
1	1	1	1

Preserve the Sea as a Repository for Agricultural Runoff

The continued use of the Salton Sea as a repository for agricultural drainage is a fundamental component of the Salton Sea Restoration Project. All alternatives would preserve the Sea as an agricultural drainage repository. All alternatives are considered equal with respect to this objective, and therefore, all have been assigned a ranking of 1.

Provide Large Marine Lake with Stable Elevation

3	1	2	4

The South Marine Lake with Elevation Control is ranked slightly higher than the North Lake with Elevation Control because it would be 42 square miles larger. Elevation stability would be essentially the same for those two alternatives as the elevation control afforded by a mid-Sea barrier and other facilities would allow for management of Sea surface levels. Conversely, the South Marine Lake without Elevation Control is ranked third because of the lack of the ability to manage Sea surface level. The No Marine Lake scenario scores fourth because it would not meet either of the objectives of a large marine lake or provide any mechanism for stabilizing elevation.

Improve Water Quality: Salinity

1	1	1	4

With the exception of the No Marine Lake scenario, all of the remaining alternatives perform equally well with respect to salinity control. The South Marine Lake without Elevation Control achieves salinity control through the use of a permeable barrier that distributes higher saline water to the northern basin while taking advantage of the relatively fresh water entering the Sea through the New and Alamo Rivers. The South Marine Lake with Elevation Control and North Lake with Elevation Control likewise control salinity through the use of a mid-Sea barrier that uses either a north or south saline basin as a repository for salinity control.

Improve Water Quality: Nutrients/Other Constituents

Restoration Alternative			
South Marine Lake wo Elevation Control	South Marine Lake w Elevation Control	North Marine Lake w Elevation Control	No Marine Lake
2	2	1	4

The North Marine Lake with Elevation Control scores the highest with regard to achieving water quality objectives because it would employ water treatment wetlands and settling basins to reduce the input of nutrients into the Sea. This alternative would also act as a cap of the higher concentrations of selenium in the sediments of the Sea, thereby effectively reducing the potential for human and wildlife contact with this substance. The South Marine Lake without Elevation Control and South Marine Lake with Elevation Control score equally as well for this objective because they can make use of the same nutrient reduction techniques as the North Marine Lake with Elevation Control alternative. However, both of these alternatives would allow the exposure of sediments in the northern basin that contain higher concentrations of selenium (Figure 5-2) and other contaminants than in the southern basin. Although the No Marine Lake alternative would include source control measures similar to other alternatives, it would not provide an outlet for nutrients or other constituents and has therefore received the lowest ranking.

Maintain and Improve Habitat

3	2	1	4

The North Marine Lake with Elevation Control performs better than the other three alternatives in this category because it allows the continued use of the southern portion of the Sea for wildlife habitat. This alternative incorporates the use of shallow water habitat through a series of ponds that take advantage of inflows from the New and Alamo Rivers as well as the ability to blend saline water from the northern basin. This results in the greatest amount of flexibility among the alternatives to manage shallow water and wetland habitats. In addition, sediments in the north basin that have the highest levels of selenium (Figure 5-2) would continue to be covered by a deep-water lake that would isolate them from access by birds and other biota.

The South Marine Lake with Elevation Control functions similarly to the North Lake with Elevation Control, except the habitat is managed in the northern portion of the Sea and takes advantage of flows from the Whitewater River. However, the habitat created is not as extensive as in the south due to the reduced inflow from the Whitewater River as compared to the New and Alamo Rivers. In addition, selenium in the sediments of the north basin would be exposed. Therefore, this alternative is ranked second.

The South Lake without Elevation Control is ranked third. Without a head differential between basins, it would not be possible to use gravity flow from the marine lake to fill shallow water saline habitat areas. In addition, with an elevation drop of about 20 feet, sediments with higher selenium levels would be exposed around the perimeter of the north basin.

The No Marine Lake alternative is the worst performing alternative for this objective because the salinity in the Sea would reach a level where the fishery would be unsustainable resulting in the loss of a food source for fish-eating birds and no shallow-water shoreline habitat with any functional value.

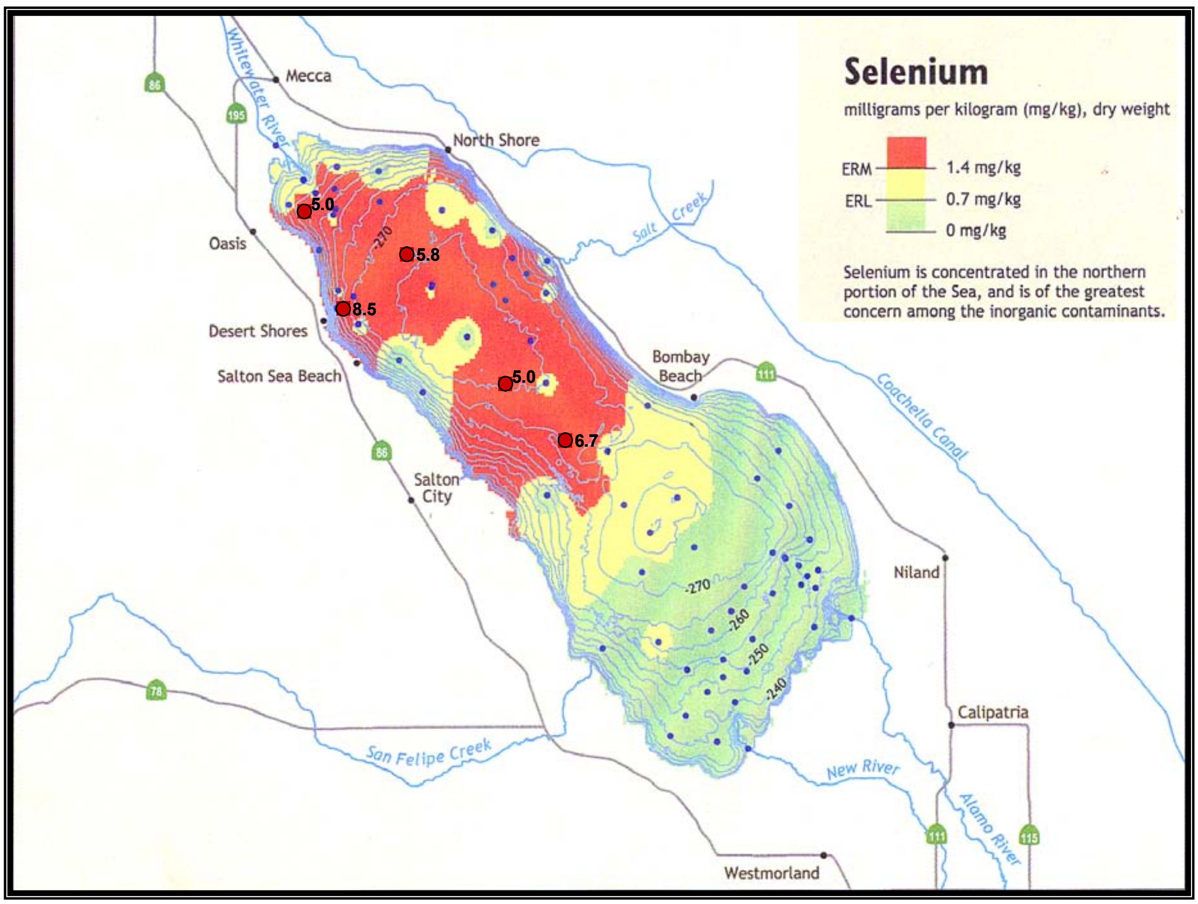

Figure 5-2. Selenium Levels in Salton Sea Sediments.

Restoration Alternative			
South Marine Lake wo Elevation Control	South Marine Lake w Elevation Control	North Marine Lake w Elevation Control	No Marine Lake
3	1	2	4

Time to Achieve Water Quality and Habitat Objectives

The South Marine Lake with Elevation Control is ranked slightly higher than the North Lake with Elevation Control because with direct flows into the south lake, it is estimated that water quality objectives could be achieved earlier upon closure of the lake. This conclusion is based on the assumption that the same design elevation is included for either alternative. The South Marine Lake without Elevation Control is ranked third because it is assumed that the central barrier would not be completed until a nearly stable elevation is achieved, which could be twenty or more years in the future. The No Marine Lake scenario scores fourth because it would not achieve water quality and habitat objectives.

Respond to Inflow Changes

2	4	3	1

The No Marine Lake alternative would perform the best for this objective because inflow would have relatively no affect on the hyper-saline lake, there would be little if any recreational uses, and no structures would be affected. The South Marine Lake without Elevation Control is the next best performing alternative because elevation would be the same in the two basins and could fluctuate depending on inflow scenarios with relatively little impact on the structures associated with this alternative. The North Lake with Elevation Control is ranked third because inflows would impact the water available for dust control and shallow water habitat development and management. The South Marine Lake with Elevation Control is ranked last because of the larger size of the marine lake in the south than for the North Lake alternative. Less inflow, therefore, would have a greater impact on the functioning of this alternative.

Increase Recreational and Economic Potential

3	2	1	4

The North Marine Lake with Elevation Control scores highest for this objective due to the improvement to recreational opportunities that would be available to the communities surrounding the northern basin. Marinas and other boating facilities in and around Salton City, Bombay Beach, Desert Shores, and North Shore would experience a renaissance due to the improved water quality and shoreline stabilization of this alternative. Additionally, these communities could experience significant economic development potential due to the linkage to the rapidly expanding southern Coachella Valley communities. As an added benefit, additional geothermal resources could be exploited in the southern portion of the Sea due to the exposure of areas of known geothermal potential adjacent to existing developed geothermal areas. Farmland in the south could also be reclaimed under this alternative.

The South Marine Lake with Elevation Control alternative, ranked second, would provide for increased recreational opportunities due to the improvement to the water quality and stabilization of the shoreline. Recreation associated with the Sonny Bono Wildlife Refuge and Imperial Wildlife Area would be improved as well as duck hunting that occurs in this area. However, existing marinas and other boating facilities are not as prevalent in the southern portion of the Sea as in the north and these recreational opportunities would not benefit as much as with the North Lake with Elevation Control.

The South Lake without Elevation Control, ranked third, would not perform as well as the two previously discussed alternatives because the northern basin would be saline and would not support a viable fishery or be attractive for recreational uses. However, the southern portion of the Sea could experience similar recreational benefits as the South Marine Lake with Elevation Control alternative.

The No Marine Lake alternative would not achieve these objectives because the Sea would eventually become hyper-saline and would not support a viable fishery or fish-eating bird populations. There would be little if any incentive to use the Sea for recreational purposes if this alternative is implemented.

Address Air Quality (PM10) Concerns

Restoration Alternative			
South Marine Lake wo Elevation Control	South Marine Lake w Elevation Control	North Marine Lake w Elevation Control	No Marine Lake
3	1	1	3

The South Lake with Elevation Control and North Lake with Elevation Control alternatives both score the highest for this objective. This is due to the ability to distribute saline or brackish water over exposed areas in the north and south basins, respectively. Conveyance canals incorporated into these alternatives would allow for gravity flow of water from the higher elevation marine lake over large areas that would not be inundated by a marine lake. These alternatives also allow the creation of salt crust over the exposed sediments thereby reducing the likelihood of fine-grained sediments being exposed to wind dispersion. This would reduce or eliminate exposed sediments that could provide a source of fine particulate matter and become windborne during high wind conditions. The South Marine Lake without Elevation Control and No Marine Lake both perform poorly against this objective because of the lack of flexibility to disperse water over large areas of exposed Sea sediments. This is due in part to the higher elevation of the exposed sediments relative to the reduced elevation of the Sea for these alternatives making distribution of water over these areas more difficult. For these alternatives, salt water or brine would have to be pumped to higher elevation to provide a mechanism to create salt crusts over the exposed sediments.

Provide High Safety Rating/Low Risk of Failure

Restoration Alternative			
South Marine Lake wo Elevation Control	South Marine Lake w Elevation Control	North Marine Lake w Elevation Control	No Marine Lake
2	3	3	1

The No Marine Lake alternative performs best against this objective because there is no structure that has the potential to fail during a seismic event. The South Marine Lake without Elevation Control alternative is the next best performing alternative because water elevation in the two basins is maintained at the same level. Consequently, even under catastrophic failure conditions where the barrier is breached, no change to shoreline water elevations would occur. The South Marine Lake with Elevation Control and North Lake with Elevation Control both perform equally for this objective. In the event of catastrophic failure of the impoundment structure, the water behind the barrier would flow into the opposite basin until equilibrium is reached. If recreational users or others are in the vicinity of the basin being inundated they could become flooded by the flow of water emanating from the upstream basin. Thus, even though there is a low risk of failure of the impoundment structure for these alternatives, the potential outcome is such that these alternatives score last compared to the other two.

Overcome Institutional Barriers/Public Acceptance

South Marine Lake wo Elevation Control	South Marine Lake w Elevation Control	North Marine Lake w Elevation Control	No Marine Lake
3	2	1	4

The North Lake with Elevation Control alternative is ranked first for this objective due to a number of factors that make it superior to the others under consideration. For example, this alternative has the support of many local influential community organizations as well as local government agencies. The local Congressional Representative also has endorsed this concept. Additionally, there are many features of this alternative such as the economic and recreational development potential that provide an added benefit to the local community, thereby increasing the acceptability and support from the community for the alternative. The South Lake with Elevation Control is the next best performing alternative because it includes many of the elements of the North Lake alternative. However, it does not afford the economic and recreational benefits in the northern portion of the Sea where these benefits would likely be more advantageous to economic growth. The South Marine Lake without Elevation Control is the next best performing alternative and has similar characteristics compared to the South Lake with Elevation Control except that the northern basin is a hyper-saline lake that would not afford much if any benefit for economic or recreational purposes. The No Marine Lake alternative is the worst performing alternative because it results in a large hyper-saline lake with little if any ecologic, economic, or recreational potential. It is highly unlikely that the local community, regional, state, or federal agencies would support this alternative.

Reasonable Cost/High Probability of Financing

Restoration Alternative			
South Marine Lake wo Elevation Control	South Marine Lake w Elevation Control	North Marine Lake w Elevation Control	No Marine Lake
3	4	2	1

The No Marine Lake has the lowest cost to construct and maintain of the four alternatives under consideration. Although the North Lake with Elevation Control alternative is the most costly to build and maintain, there is a higher likelihood of this alternative being financed due to the significantly greater benefits that would occur. Government and private financing would be more likely for this alternative because there is a higher degree of public support and the potential for economic development greater than for the other alternatives under consideration. In addition, the Authority is investigating creating an Infrastructure Finance District or similar means to generate tax revenue to assist with financing of the project. The South Marine Lake without Elevation Control is the next best ranked alternative because of the slightly lower cost involved in constructing and maintaining the Sea. However, the economic benefits are lower and consequently financing likelihood lower as well. The South Lake with Elevation Control alternative is the least likely to receive favorable financing because the cost to build and maintain it would be similar to the North Lake alternative but with significantly fewer economic benefits.

5.3 Evaluation Summary

The ranking of restoration alternatives carried out in this study is summarized in Table 5-1. Table 5-1 also shows: (1) an average ranking score calculated by taking a simple average of the rank values for each of the objectives; (2) the number of top rankings; (3) the number of lowest rankings; and (4) the overall average ranking based on the three previous statistics. Figure 5-3 illustrates the number of highest rankings for each alternative. Figure 5-4 illustrates the number of lowest rankings for each alternative. Figure 5-5 illustrates the overall ranking of the three alternatives.

Based on the data presented here, the North Lake with Elevation Control alternative received the top ranking and is recommended for consideration as the preferred restoration strategy for the Salton Sea.

Table 5-1. Evaluation of Restoration Options

Objectives	Restoration Alternative			
Project Objectives Used in this Report ⇓	South Marine Lake wo Elevation Control	South Marine Lake w Elevation Control	North Marine Lake w Elevation Control	No Marine Lake
Preserve Sea as Repository for Agricultural Runoff	1	1	1	1
Provide Large Marine Lake with Stable Elevation	3	1	2	4
Improve Water Quality: Salinity	1	1	1	4
Improve Water Quality: Nutrients/Other Constituents	2	2	1	4
Maintain and Improve Habitat	3	2	1	4
Time to Achieve Water Quality and Habitat Objectives	3	1	2	4
Respond to Inflow Changes	2	4	3	1
Increase Recreational and Economic Potential	3	2	1	4
Address Air Quality (PM_{10}) Concerns	3	1	1	3
Provide High Safety Rating/Low Risk of Failure	2	3	3	1
Overcome Institutional Barriers/Public Acceptance	3	2	1	4
Reasonable Cost/High Probability of Financing	3	4	2	1
Average Score	2.4	2.0	1.6	2.9
Number of Top Rankings	2	5	7	4
Number of Lowest Rankings	1	3	1	8
Overall Ranking	3	2	1	4

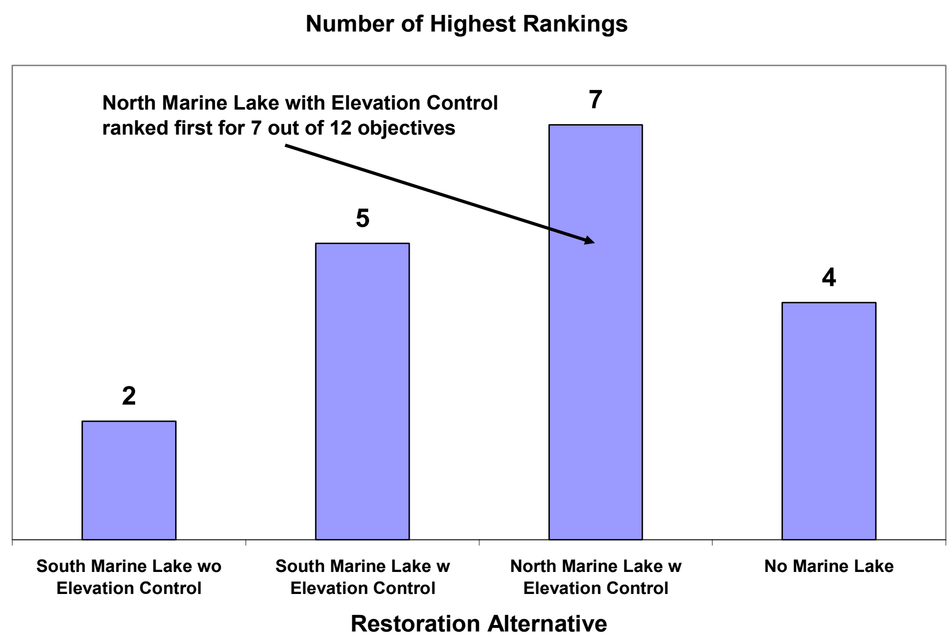

Figure 5-3. Number of Highest Rankings for Each Alternative.

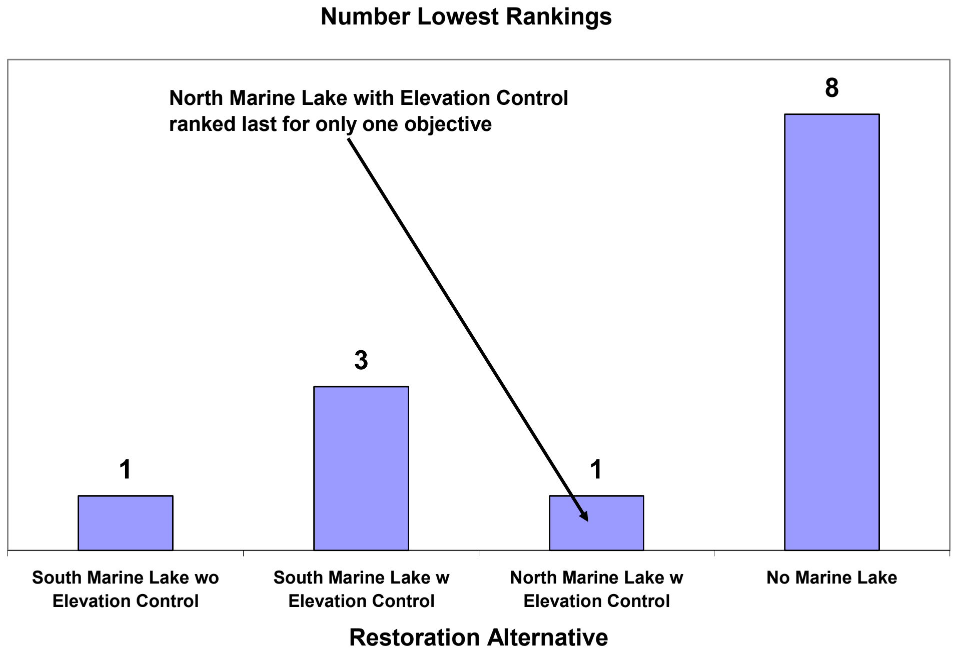

Figure 5-4. Number of Lowest Rankings for Each Alternative.

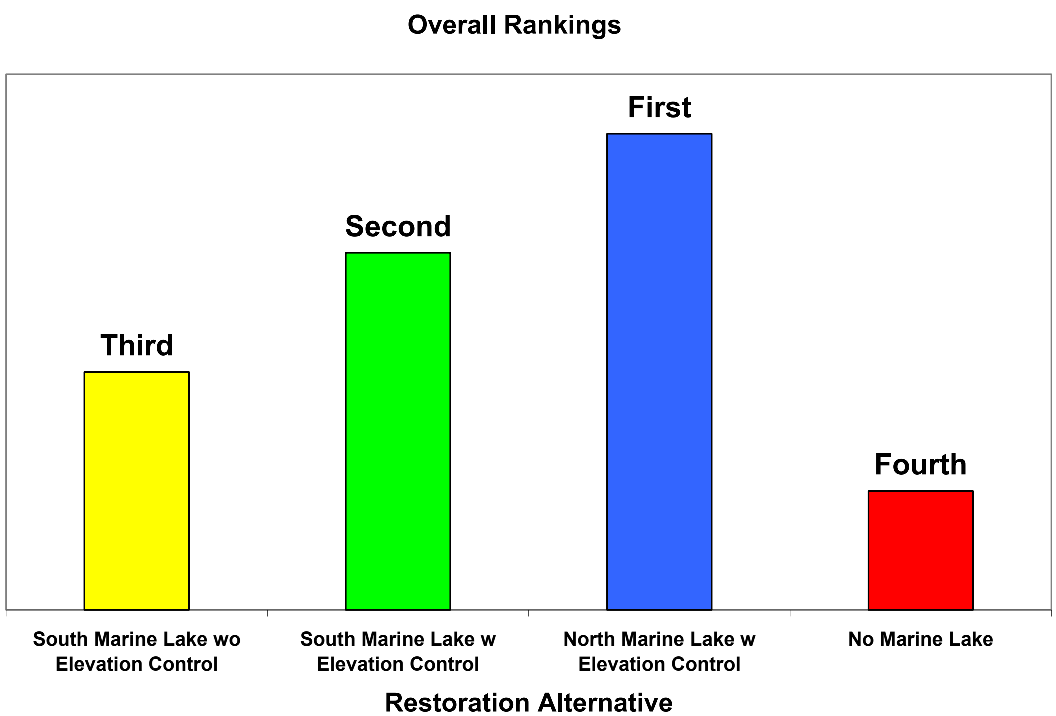

Figure 5-5. Overall Ranking of Alternatives.

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Chapter 6: PREFERRED PROJECT: A VISION FOR THE FUTURE

Starting with the north lake concept and adding other features, a preferred project emerges that has the potential to create outstanding opportunities for the Imperial and Coachella valleys. This vision of the future combines a healthier and more stable marine lake that has lower salinity with a variety of ecological and recreational features. It also includes measures to mitigate potential air quality degradation that may be associated with sediments exposed by declining lake levels that result from decreases in inflow.

The concept is illustrated in Figure 6-1. Features of the plan, preliminary cost estimates, lake elevations, performance, phasing of the project, and implementation of the plan are discussed in this chapter.

6.1 Features

Features of the preferred project concept are discussed below.

The Main Lake

The main lake (Figure 6-2) would be a marine lake with ocean-like salinity with an area of about 85,000 to 95,000 acres. It would be California's second largest lake, behind Lake Tahoe. It would be capable of supporting a marine sport fishery that would also provide a food source for the millions of fish eating birds that use the Salton Sea as a stopover point along the Pacific Flyway. The main lake could be controlled at an elevation lower than the current elevation which would help reduce the cost of the mid-Sea causeway. Access to communities would be provided by dredging channels to local communities which would also create islands and peninsulas that would have new recreation and development opportunities.

Habitat and Recreational Features

Figure 6-1 illustrates the wide range of habitat and recreational features that could be included as part of the vision of the future for the Salton Sea ecosystem. The features of the preferred project are conceptual. Some features have been developed in more detail, such as the central causeway/retention structure. Conceptual designs for the causeway are provided in URS (2004). Many other features, such as fresh water recreational lakes and wetlands, were reviewed by an Outdoor Recreation Advisory Task Force.

The Recreational Task Force included representatives of recreational groups, cities and other organizations, primarily from the north end of the Imperial Valley. Task Force recommendations are provided in Appendix D to this report.

Access to Deep-Water Fishery

In order to provide recreational opportunities with a smaller marine lake, access to the Sea would need to be maintained. If the elevation of the marine lake would be lower than the current Sea elevation, access could be provided by dredging to the existing seaside communities. Although not recommended, if the lake elevation is decreased significantly, dredging channels through the Sea-bottom areas exposed by lower lake levels could also create islands and peninsulas that would have additional recreational value. Access would also be enhanced by rehabilitation or expansion of existing marinas or creation of new marinas. Dredging could also create and enhance perimeter development and also could create development opportunities on Torres Martinez land (Figure 6-3).

Figure 6-2. Artistic Rendering of Lake Overlook Scenic Point.

Figure 6-1. Preferred Alternative Concept Plan for the Salton Sea Area.

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Figure 6-3. Artistic Rendering Peninsula/Resort Concept.

Water Quality

A number of measures would be undertaken to address water quality concerns to ensure that water quality in the main lake is significantly improved over current conditions. These measures are as follows:

- **Created wetlands and sedimentation basins**—Created wetlands and sedimentation basins would be installed to help remove fine sediments and nutrients from the waters that flow into the main lake (Figure 6-4). Locations of wetland habitats and sedimentation basins include areas along the New and Alamo rivers, extensions of those rivers that may be associated with the creation of a smaller marine lake, and areas near the mouth of the Whitewater River. In addition to having benefits for water quality, created wetland areas would provide a variety of habitats for birds as well as recreational opportunities for hunting, bird watching, and possibly fishing. Wetlands could also be designed to preserve snag habitat used by wildlife in the northern and other portions of the Sea.

  Reducing eutrophic conditions of the Salton Sea by reducing nutrients flowing into the Sea is a central project objective. Wetlands have been built through the efforts of the Citizen Congressional Task Force on the New River in the New and Alamo river drainages to, in part, improve water quality. They improve the turbidity of the water and its nutrient load. While improving turbidity is not the direct objective, reducing suspended sediments in the water column reduces the phosphorous and potential contaminants that are absorbed to those sediment particles.

There continues to be some debate about the value of wetlands along the New and Alamo rivers. Some scientists have expressed concerns that while wetlands do improve water quality downstream, contaminants, such as selenium could become trapped in the wetlands and create biological problems for resident and migratory birds. Limited data is available at this time to indicate that the wetlands are contaminant traps and more study is underway and necessary. Sedimentation basins and wetlands would need to be designed carefully to minimize contact between wildlife and selenium and other constituents.

The Authority has sponsored pilot projects to test other mechanisms to reduce nutrients flowing into the Sea, including use of biological processes upstream (concentrated ponds of algae and fish) and is in the process of evaluating chemical treatment through polyacrlymides (PAMs). These biological and chemical treatments do show early signs of promise. Notably, some farmers are

Figure 6-4. Pilot Wetland Project.

already utilizing PAMs to reduce sediments flowing in their tail water. As the Regional Water Quality Control Board recently noted (memo to Tom Kirk from Doug Wylie, March 23, 2004), total suspended solids (TSS) concentration in the Alamo River last year was 280 mg/L, significantly less than the 1980-2000 average concentration of 377 mg/L. As Mr. Wylie notes, this implies some success by farmers in the Imperial Valley in implementing agricultural management practices.

The Wylie memo indicates that the current wetlands along the New and Alamo rivers reduce total suspended solids by 93 percent from the waters flowing through the wetlands. Using the first two years of data for the New River Wetlands project referenced in the Wylie memo, the wetlands have a 40-50% total phosphorous efficiency. It is expected that this phosphorous efficiency will decrease as the wetlands are fully established due to the saturation of nutrient uptake by the vegetation. In addition, nutrient removal is less efficient as nutrient loads are decreased upstream.

A new wastewater treatment plant in Mexicali is expected to remove about 10% of total phosphorous from the loading to the Salton Sea when fully operational, according to the EPA (2003). Additionally, extending the rivers another approximately 21 miles each in the proposed plan will likely slow water velocities, dropping out additional solids along the way.

Total Maximum Daily Load Program (TMDL)—As mentioned briefly in Chapter 2, the TMDL program is being implemented by the Regional Water Quality Control Board to provide a long-term reduction in key constituents in waters that flow into the Sea. Congress, through the Clean Water Act (CWA), established the legal requirement that states list and rank impaired waterbodies, and that TMDLs be established for constituents that are causing impairment, in accordance with the priority ranking. The Salton Sea watershed has been identified as a priority watershed for the TMDL program.

The Colorado River Basin Regional Water Quality Control Board (RWQCB) in California is currently in the process of establishing TMDLs for these waters. The long-term goal of the TMDL process is to improve the quality of water flowing into the Sea. The sediment/silt TMDLs are now in-place for the New and Alamo rivers and will soon be implemented for some of the agricultural drains. Implementation of the Alamo River and New River silt TMDLs is expected to reduce total suspended solids to 200 mg/L in both rivers by 2015.

The process for implementing TMDLs for nutrients is nearly complete. While sedimentation basins and improvements in Mexico could reduce phosphorous loads to the Sea, opportunities for additional wetlands could reduce nutrient loading even more. Steps are underway to design a nutrient TMDL by the Regional Water Quality Control Board. Implementation of such a TMDL would further reduce nutrient inputs to the system, but no estimates are available yet as to its likely effect on the Sea.

Figure 6-5. Fresh Water Lake Concept—Lake Red Hill.

Smaller Recreational Lakes

Smaller recreational lakes could include a fresh/brackish water lake near Red Hill Marina (Figure 6-5) that could provide recreational opportunities for boating and water skiing in Imperial County. In addition, other lakes could include one near Red Hill Marina. During the transition period prior to closure of the north marine lake, these smaller lakes could possibly be operated as salt water lakes with managed salinity to act as fish refugios to sustain the marine fish breeding stock until the north lake salinity targets are achieved.

The Causeway

The causeway would be between 7 and 8.5 miles long depending on the elevation of the main lake. It would offer a convenient and time saving means to travel from one side of the Sea to the other, and could also offer shoreline access for people, fishing opportunities, and habitat for fish and birds.

Shallow Brackish and Salt Water Habitat Reclamation

Figure 6-6. Artistic Rendering Shallow Habitat Area.

The creation of shallow salt-water habitat would need to be an integral component of a successful comprehensive restoration strategy due to the ability of the habitat to address multiple issues. Creation of shallow water habitat would allow for reclamation of flooded areas of the Sony Bono Wildlife Refuge, providing more than twice the area of shallow water habitat than is currently present at the Sea (Figure 6-6). As a result of reduced inflow to the Sea and the corresponding reduction in size of the Sea, less shallow water habitat would be available to many of the bird species that use the Sea either seasonally or as permanent residents. Development of shallow water habitat would provide the important habitat necessary for these bird species.

In addition to habitat benefits, the development of shallow water areas has the potential to mitigate air quality impacts as discussed in the following paragraphs. It is proposed to begin by constructing about 2,000 acres of shallow habitat as an initial phase, and then add more as the lake level in the south basin recedes. The area between the existing shoreline and the one foot depth contour is currently just over 2,000 acres for the entire Sea.

Air Quality/Dust Control Mitigation

The legislation authorizing water transfers under the QSA requires mitigation for air quality impacts at the Sea that would be caused by reduced inflows that result from the transfer. Regardless of the funding source, it is important that air quality be addressed as part of an overall restoration strategy. Some measures that could be undertaken to address air quality concerns of the Salton Sea area as part of an integrated and comprehensive restoration strategy are as follows:

- **Shallow water habitat areas**—As mentioned above, creating shallow water habitat areas would have the added benefit of dust suppression. The development of shallow water habitat has the potential to mitigate some air quality impacts through the spreading and coverage of exposed sediments with shallow water habitat cells or ponds. This would reduce wind fetches and provide wetted areas to saltation of blowing dust particles.

- **Salt crusts**—In addition to dust suppression associated with the shallow water wetted areas, as salt water would be moved through a series of the shallow water ponds, salts would tend to concentrate in the water from solar evaporation. Ultimately, concentrated brine would be discharged from the shallow water habitat areas and the brine could then be used to create salt crusts in areas that would be particularly susceptible to wind erosion. Salt crusts would cover fine sediments that otherwise would be exposed to erosion.

- **Salt tolerant vegetation**—Another feature that could be associated with shallow water areas would be the presence of salt tolerant vegetation. Vegetation would probably need to be included with the overall dust suppression plan.

Geothermal Expansion

It is widely recognized that areas of known geothermal resource potential are located at the southern end of the Salton Sea that are currently inundated. With a receding Sea exposing these areas in conjunction with a restoration plan that would allow further access to these areas, a significant potential to exploit these resources would occur (Figure 6-7). Exposing a large geothermal anomaly would allow for a 1,400

MW expansion opportunity, that could triple the existing and planned capacity of existing geothermal operations.

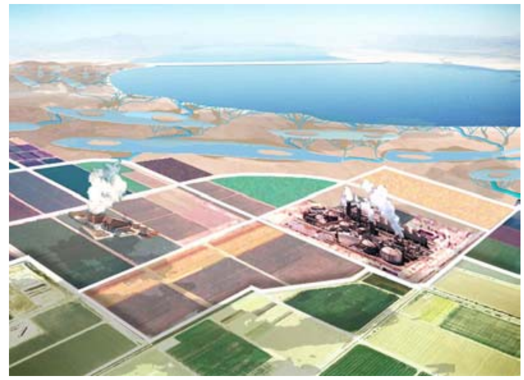


Figure 6-7. Rendering of Geothermal Expansion Area.

Other Economic and Recreational Opportunities

Other opportunities would include the possibility of reclaiming farmland that is now flooded; wide ranging hunting, bird watching, hiking, and water contact opportunities; marina and housing development; and off-road vehicle use areas. It could also facilitate additional water transfers through desalting of inflows or other reuse or conservation measures. As the Sea recedes, previously inundated farmland could be reclaimed and used for agricultural production. The most likely area for this to occur would be in the south adjacent to existing farmland due to economies of scale and because agricultural infrastructure is already in place on adjacent land.

Other Recreation and Public Information Opportunities

The recreational enhancements program should provide for improvements to recreational facilities around the Sea. Specific improvements would be designed to meet future needs, but may include a visitor center, improvements to access areas or creation of new access points associated with these facilities, upgrades to public use areas, and public outreach material. Other recreational facilities such as golf courses could be encouraged through land use planning and zoning designations for areas surrounding the Sea. Hunting and fishing opportunities could also be incorporated into a restoration plan that takes advantage of the new configuration of the Sea.

Wildlife Disease Control

A comprehensive restoration strategy should include an integrated approach to wildlife disease control to reduce the incidences of wildlife disease at the Sea. Avian disease at the Salton Sea has been a chronic problem resulting in an annual loss of several thousand birds. Major epizootics (quickly spreading disease among animals) increased in frequency during the 1990s, which greatly increased the level of losses. During 1992, more than 150,000 eared grebes (*Podiceps nigricollis*) died during a single event of undetermined origin. The deaths of thousands of white pelicans (*Pelecanus erythrorhynchos*) and more than 1,000 endangered California brown pelicans (*P. occidentalis*) during 1996 from type C avian botulism focused national attention on the Salton Sea. That event served as a catalyst to begin the current Salton Sea Restoration Project.

Other diseases affecting birds of this ecosystem are avian cholera, Newcastle disease, and salmonellosis. Algal toxins are a suspected, but unproven cause of grebe mortality. Outbreaks of avian cholera affect a wide variety of bird species and have become annual events, causing the greatest losses in waterfowl, eared grebes, and gulls. Newcastle disease devastated the Mullet Island double-crested cormorant (*Phalacrocrax auritus*) breeding colony at least twice during the 1990s. Salmonellosis has been primarily a cause of mortality in breeding colonies of egrets. Several other diseases have also been diagnosed as contributing to avian mortality at the Salton Sea.

The U.S. Fish and Wildlife Service (FWS), with support from the California Department of Fish and Game, have conducted an on-going program to combat disease at the Salton Sea by providing response to bird die-offs. An initiative of the Salton Sea Restoration Project in the early 2000s to augment FWS surveillance efforts enhanced the early detection of disease, and was another successful first step in minimizing losses. The existing efforts and activities are important steps to address disease impacts and should be continued and enhanced. Major bird mortality events have essentially not occurred in the past several years

An enhanced approach that provides a continual interface between environmental monitoring, disease surveillance and response, and scientific investigations of disease ecology would be the next step. Expanded wildlife rehabilitation would also be provided because the avian botulism problem continues to affect pelicans at the Salton Sea. Therefore, the goal for the long-term disease control effort would be to provide an integrated approach to controlling wildlife disease (including fish and birds) at the Salton Sea in a manner that enhances opportunities for wildlife managers to minimize disease events and associated losses. This approach would include programs to monitor environmental conditions; detect, diagnose, and respond to disease events; collect and rehabilitate afflicted wildlife; and further development of a sound understanding of disease ecology at the Sea.

Salt Pond

The salt pond would occupy about 60,000 acres and would provide for storage salt for at least 300 years to preserve the function of the Sea as repository for agricultural runoff.

6.2 Preliminary Cost Assessment

A preliminary cost assessment has been prepared for the preferred restoration project. An important component of the overall cost of the plan would be the central impoundment structure. Various conceptual designs have been considered for this structure. These concepts along with cost estimates for each are described in URS (2004). Appendix B provides supporting information for an overall preliminary cost estimate for the preferred project including costs for the central retention structure obtained from URS (2004) and other features of the project. A cost summary for the total project is provided in Table 6-1. The table includes cost estimates for two possible designs for the impoundment structure and two possible design elevations for the water surface of the marine lake. Lowering the design elevation would lower the cost of the impoundment structure.

Each of the features included in the cost estimate are discussed briefly below:

Impoundment Structure/Causeway— A working group of 15 civil and geotechnical engineers was convened to review the feasibility of constructing a dike, or retention structure/causeway anywhere within the Salton Sea. The group reviewed data from the recent geotechnical investigation of the Sea and suggested alternative design concepts. Cost estimates were developed based on the concepts identified by this group. Cost estimates are very preliminary at this point, and, as of this writing, have not yet undergone review by the work group.

Of the concepts proposed by the work group, the most cost effective structure appears to be a blanketed rockfill design. This concept would consist of an embankment built in the water and entirely out of rock fills. To mitigate seepage through the dam, a blanket of fine material would need to be placed on the upstream slope. Conventionally, this is usually an asphalt or concrete pavement. However, the Sea level would preclude those for this concept. The upstream blanket for this concept would consist of depositing fine-grained soils on the upstream slope to "plug" the rockfill. Ten to 25 feet of the weak soils below the embankment would be excavated and replaced with rock fills. This material could be used to provide the blanket. Alternatively, a bentonite slurry wall could be constructed through the dam along its crest to provide a seepage barrier. The slurry wall would add $60 to $70 million to the project. The conceptual design includes inclinations of 4:1 on the upstream slope and 7:1 on the downstream slope. The crest of the dam would be 30 feet wide and provide for 5 feet of freeboard above the lake. This concept is shown in Figure 6-8.

Lower marine lake levels would require less embankment volume for the impoundment structure, and would cost less. Table 6-1 presents the estimated costs for the Blanketed Rockfill structure for lake elevations of –235 and –240 feet msl. This evaluation indicates that the mid-Sea dam would cost about $100 million less with a 5 foot drop in lake level below -235 feet msl. Conversely, if the structure were designed to maintain the current water elevation, the cost estimates would go up by about $150 million.

Appurtenant Structures—The cost of appurtenances such as spillways and other outlet structures, and the channels leading to the shallow water habitat areas have been factored in as five percent of the impoundment structure.

Table 6-1. Preliminary Cost Estimate for Preferred Alternative Concept

Item	Cost ($M) at El=-235' msl		Cost ($M) at El=-240' msl	
Initial Construction Costs	Blanketed Rockfill	Rockfill w Slurry Wall	Blanketed Rockfill	Rockfill w Slurry Wall
Mid-Sea Retention Structure/Causeway	$ 418	$ 489	$ 354	$ 418
Appurtenant Structures (Spillways, etc.)	21	24	18	21
Dredging to Communities & Island Creation	6	6	20	20
Greenbelt Channels to North Lake (Incl. 20 sed. basins, 2,500 ac wetland, 20% planted)	76	76	66	66
Recreational Lake (approx. 1,000 ac)	45	45	45	45
Torres Martinez Wetlands/Habitat	20	20	20	20
Upstream Wetlands (Top 5 sites, 1376 ac)	58	58	58	58
Shallow Water Habitat Initial Phase (2,000 ac)	8	8	8	8
Total Construction Costs (rounded)	**$ 650**	**$ 730**	**$ 590**	**$ 660**
Annual Costs	Cost ($M/yr)		Cost ($M/yr)	
Causeway, Channel & Appurtenance O&M	$ 5.1	$ 5.9	$ 4.4	$ 5.0
Add Shallow Habitat (500-1,000 ac/yr)	3.0	3.0	3.0	3.0
Habitat O&M	2.0	2.0	2.0	2.0
Total Annual O&M ($M/yr)	**$ 10.1**	**$ 10.9**	**$ 9.4**	**$ 10.0**
Present Value of Annual Costs ($M) - based on 30 yrs	$ 150	$ 160	$ 140	$ 140
Total Present Value Cost ($M)	**$ 800**	**$ 890**	**$ 730**	**$ 800**

Note: Does not include costs for development of recreational facilities, new highways, or new lakeside development.

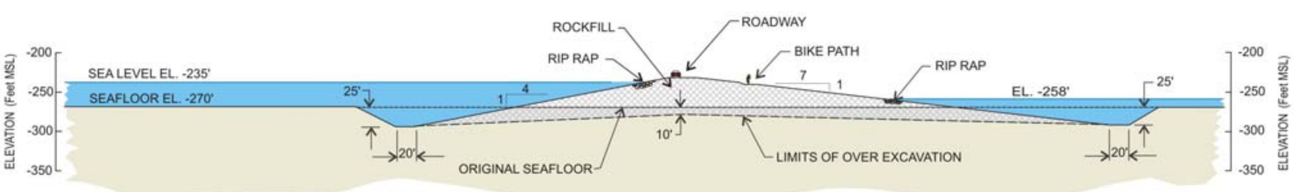


Figure 6-8. Typical Blanketed Rockfill Impoundment Structure Cross Section.

Dredging to Communities and Island Creation—With lowered lake levels, existing Sea-side communities would be at some distance from the Sea. Dredging is proposed to restore access to the Sea for these communities. Dredging could also create islands and peninsulas that would provide recreational and habitat value as well as create opportunities for development. Dredging cost estimates are based on preliminary estimates of the quantities that would need to be removed for different lake elevation targets. A raw unit cost of $2.90/cubic yard was then applied for dredging along with factors for mobilization, unlisted items, contingencies, and costs such as design and construction oversight.

Greenbelt Channels to the Lakes with Wetlands and Sedimentation Basins— The New and Alamo rivers would need to be extended to reach the north basin marine lake (Figure 6-9). The cost of constructing a wetland greenbelt area around these river extensions has been included along with the cost of constructing 20 sedimentation basins. The Nolte (2002) report commissioned by the Citizens Congressional Task Force to evaluate potential wetland sites that could be developed in the New and Alamo river channels was used as an important source of cost information.

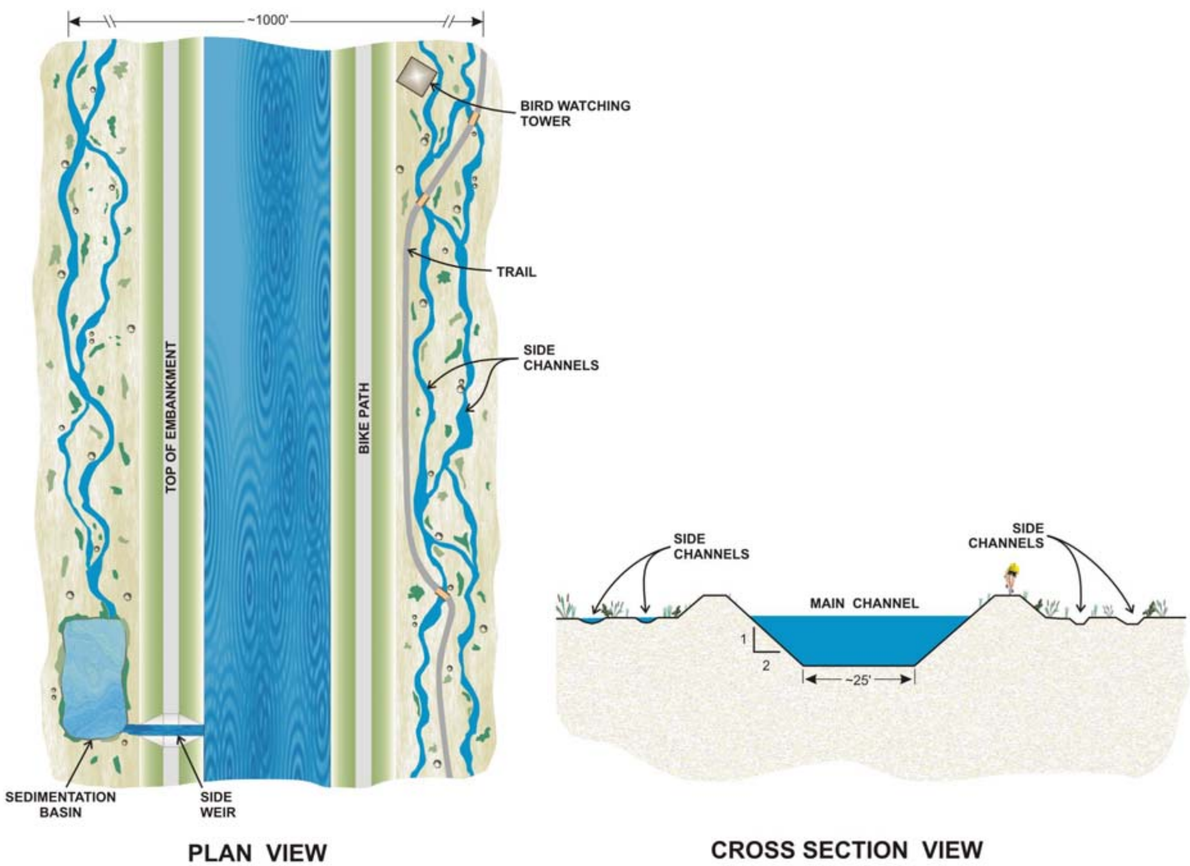


Figure 6-9. Schematic of Greenbelt Channel Extension Concept.

The wetland greenbelt for both channels was estimated at 2,500 acres and it was assumed that vegetation would be planted on 20 percent of this area. It was assumed that over time vegetation would grow to fill the area. The unit cost for vegetation was also taken from Nolte (2002). For purposes of providing costs of a preferred project, wetlands and sedimentation basins were assumed. However, if other biological or chemical treatments are found more effective some amount of wetlands or sedimentation basins could be replaced with such treatments.

Wetlands expansion could be justified on economic, habitat or other purposes. For this report, the projected amount of wetlands and sedimentation basins is a function of the water quality improvement that would accrue to the water bodies envisioned in the current Salton Sea boundaries. The Nolte (2002) report identifies 4,276 acres of potential wetlands for a cost of $182 million. To achieve water quality targets, this report assumes 1,376 acres in the five highest rated sites of those wetlands could be constructed in the first phase of the proposed project.

For sedimentation basins, estimates were derived from the evaluation of plans to desalt the Alamo and/or New Rivers. US Filter, Black & Veatch and others have, in the past, suggested desalting the rivers in the Imperial Valley to provide product water for sale to urban or other communities. To properly operate such desalting plants, river water must be very clear. To reduce turbidity, a rule of thumb is often used that sedimentation basins should have an area of about 10 square feet for every gallon per minute of flow. That translates to a requirement of 110 acres of sedimentation basins to treat a flow of 800,000 acre-feet/year. The base cost for these was taken from the Nolte (2002) report on constructing wetlands on the New and Alamo Rivers, for a typical 5.5 acre sedimentation basin. Constructing 20 5.5 acre sedimentation basins will provide the total 110 acres needed for sedimentation.

Other Features—Preliminary cost estimates have been included for three other features: a 1,000 acre shallow recreational lake, a Torres Martinez wetlands/habitat feature, and an initial phase of shallow water habitat construction.

Operation and Maintenance Costs and Other On-Going Costs—Preliminary estimates have been provided for operation and maintenance of the various features such as the mid-Sea retention structure, appurtenances, and channels. In addition, costs are included for maintenance and for future expansion of shallow water habitat areas. It is anticipated that 500 to 1,000 acres of new shallow salt water habitat could be added each year to full build-out of about 20,000 acres. These areas would provide habitat for birds as well as help with dust suppression.

6.3 Program Financing

As noted in Section 6.2, the total project capital costs are projected to be between $590 and $730 million. Several potential funding sources are discussed in this section, some of which the Authority might wish to pursue. A more detailed cost analysis and financing plan will be possible following final design decisions and completion of all environmental compliance requirements.

Proposition 50—Proposition 50 funds could be used to jump start restoration in the near term. California's legislature, through SB 654 (Machado), provides $50 million to assist in implementation of the Salton Sea preferred project. $20 million of that funding has been separately allocated to the State's new 3-year study of the Sea via a programmatic environmental impact report.

Should study funding instead be directed at a "project" level, construction could occur much sooner than the State's current stated intentions. In addition, much of this funding could be allocated for actual improvements related to Phase 1 construction activities (see Section 6.5), such as expansion of freshwater wetlands and creation of sedimentation basins, and process costs be kept to a minimum (e.g. $2 million).

California's Salton Sea Restoration Fund—The largest current committed funding source is related to the agreements to transfer water from the Imperial Valley to urban and other communities known as the QSA. The QSA and related legislation (SB 277, SB 317, SB 654) provide for $30 million to be contributed to a restoration fund by water transfer parties. The biggest QSA contribution to the restoration fund comes from the potential sale of mitigation water.

Under the terms of the QSA, potential impacts from water transfers to the Salton Sea are mitigated/addressed by sustaining inflows to the Sea for the first 15 years of the water transfer. However, if a restoration plan, such as the one proposed in this report, is found to not require the mitigation water, the water could be sold to urban water districts to generate approximately $200 million.

Additionally, $60 million could be generated for the restoration fund from the purchase and re-sale of additional water from the Imperial Irrigation District. Metropolitan Water District will also contribute to the restoration fund for all special surplus water received by MWD from the Colorado River. The total QSA-related contribution to restoration funding could reach $300 million.

Most of the $300 million QSA-related contribution to restoration funding involves, in many ways, accelerating the water transfers to the coast. The proposed project facilitates such an acceleration. In fact, the proposed project benefits from the acceleration due to the reduced time to achieve the target elevation as well as any money generated for the restoration fund from the acceleration.

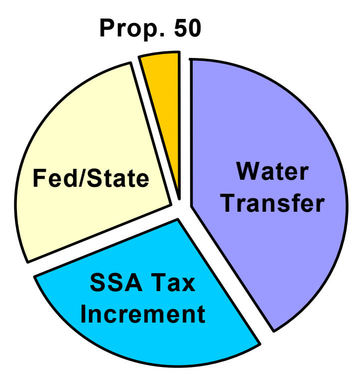
Interestingly, water transfers could be accelerated beyond that contemplated in the QSA to provide more water supply to urban communities during the initial ten to fifteen year period and, if designed similar to the above arrangements, could provide additional funding for Salton Sea restoration. However, the Imperial Irrigation District would need to be consulted in depth to determine the capability to accelerate efficiency improvements or other water savings beyond that contemplated in the QSA.

Local Tax Increment—With restoration of the Sea, it is expected that property values will increase. As a result, property tax revenues will also increase. Redevelopment project areas and infrastructure finance districts allow government to capture the new or "incremental" increased revenues to support capital projects without increasing the tax rate. This makes particularly good sense at the Sea given the direct link between the project, restoration of the Sea, and property value/tax revenue increases.

About five years ago, the Authority's Economic Development Task Force identified tax increment financing as a potential financial tool for the Authority. The Authority sponsored legislation that was authored by Senator Dave Kelley to allow the Authority to establish an Infrastructure Finance District around the Sea. The Authority commissioned a study by Rosenow Spevacek Group to conduct a tax increment financing feasibility study. The study indicated that several hundred million dollars could be generated through a tax increment district around the Sea. And that the revenue projects could significantly increase with an expansion of the Authority's boundaries.

Early in 2004, the Authority significantly increased its boundaries to increase the revenue potential. For purposes of this conceptual financing plan, we have conservatively estimated that $200 million, present value, could be generated for the project.

Federal Funding/State Bond Financing—Of the projected $730 million capital cost of the preferred project, approximately $500 million, or over 70%, could be generated within the region. Any remaining necessary funding could be provided by Federal appropriations and/or State bond financing. Such funding could be equal to the local, tax increment funding, or about $200 million.



Federal and State of funding is certainly a political challenge, particularly in an era of federal and state budget deficits and financial challenges. However, increasing broad based support for restoration, evidenced by the formation of the Salton Sea Coalition and recent state legislation is an encouraging sign. The availability of regional matching funding, the $500 million, also improves prospects for federal or state matching funds. In the past year, while to-date unsuccessful, federal and state legislators have floated various bond and authorization packages for restoration ranging from $300 million to $1 billion.

Total operations and maintenance costs of the project are projected to be less than $9 million annually, but must be addressed. Changes in the State's government code which allows the Authority to create a tax increment district could allow that funding source to pay for operations and maintenance requirements.

Given the amount of additional habitat created on the Sonny Bono National Wildlife Refuge, additional annual federal funding may be necessary to help manage what will likely be prolific bird habitat.

Access and Use Fees—Other aspects of the project could generate significant annual revenues. Access and use fees at the proposed freshwater lake in the Imperial Valley could defer maintenance costs on that facility (salt cedar control, etc.). If a roadway runs along the causeway, it could be tolled to help fund annual maintenance of the facility. Commercial leases of the facility and/or land sales of public land could also be used to support the capital or ongoing costs of the project.

6.4 Performance

The performance of the north marine lake has been evaluated by Reclamation using the Salton Sea Accounting Model (Appendix C). The salinity projections for two inflow scenarios are shown in Figure 6-10 and 6-11. Figure 6-10 provide salinity projections for the north lake with QSA inflows with mitigation water ending in 2006 for three possible lake level design elevations: -230, -235, and -240 feet msl. Figure 6-11 provide salinity projections for the north lake for the 800,000 acre-feet/year inflow scenario, for the same three possible lake level design elevations.

The performance data in Figure 6-10 shows that the lake could reach a salinity target of 35,000 mg/L by 2013 for the -235 feet msl design elevation case, for QSA inflows with mitigation water ending in 2006. For the -240 feet msl design elevation case, it would take an extra 5 years for the salinity to get back under 40,000 mg/L for this inflow scenario, and it would reach the 35,000 mg/L target by about 2020. However, Figure 6-11 shows that for the 800,000 acre-feet/year inflow case, the salinity could reach 35,000 mg/L by about 2016. In either case, the -240 feet msl design elevation project would have higher peak salinity during the transition period than the higher elevation design.

6.5 Target Lake Elevation

A design elevation of around -235 feet msl is recommended for consideration as the target elevation. It would have a number of benefits:

- High enough elevation to allow for gravity flow of salt water to shallow habitat areas and for dust control.
- Minimal dredging for access to communities.

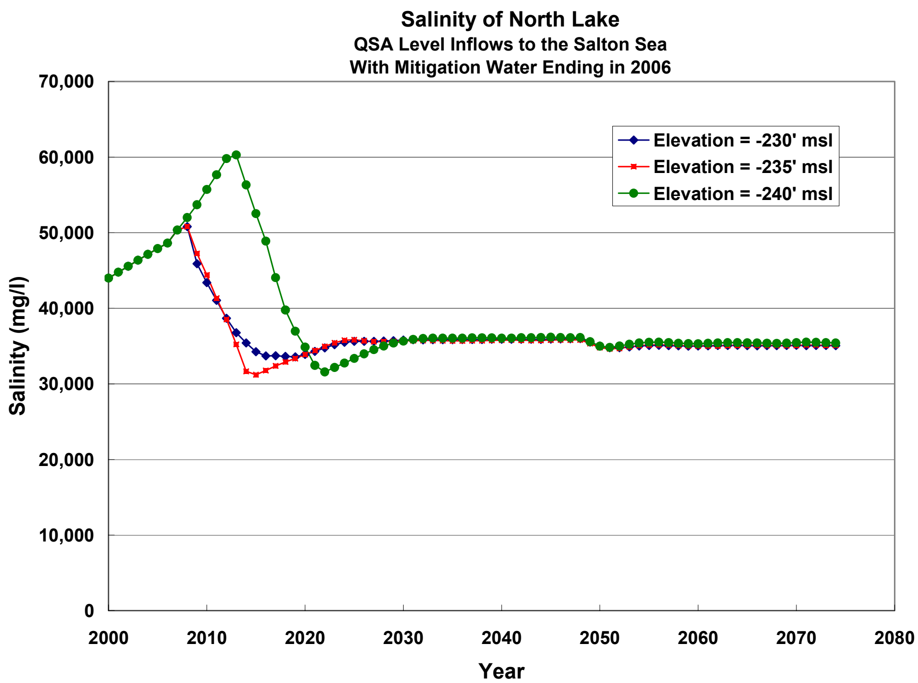


Figure 6-10. Projected Salinity in North Lake for QSA Inflows with Mitigation Water Ending in 2006.

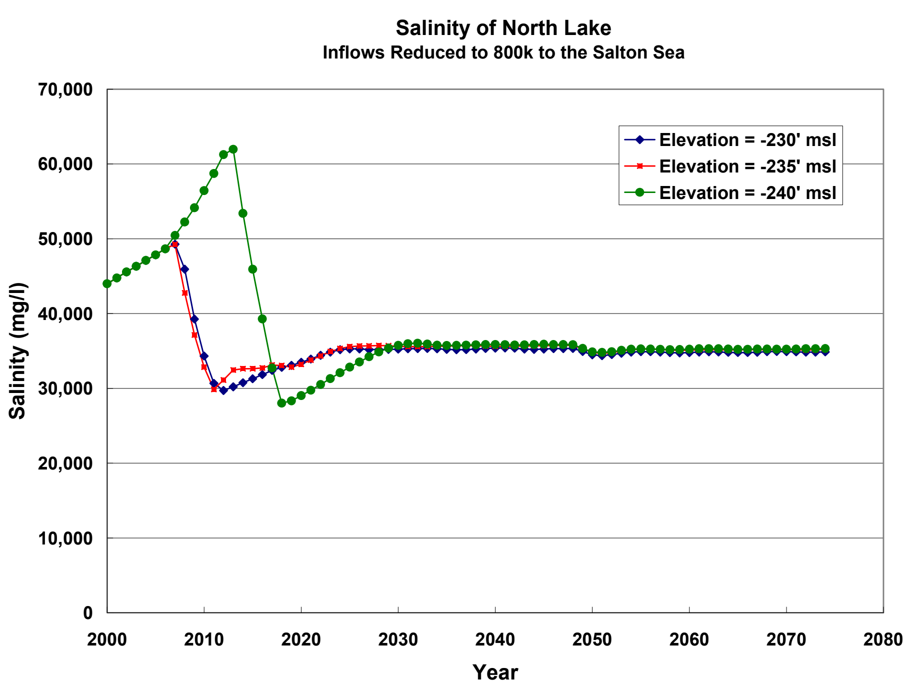


Figure 6-11. Projected Salinity in North Lake for 800,000 Acre-Foot/Year Inflow Scenario.

- Low enough to provide fall for river extensions.
- Minimal salinity spike and short time to target salinity.
- Reasonable cost…at -235 feet msl the cost estimate for the retention structure is about $150 million less than it would be for the current lake elevation.

While elevation -235 feet msl provides a reasonable design target, there are some considerations where -240 feet msl should be considered. If it appears that the construction schedule would need to be extended and the 800,000 acre-feet/year inflow is realistic, then -240 feet msl should be reconsidered as there could be a savings of about $100 million, with other factors being equal.

6.6 Program Phasing

Project phasing will depend on the design elevation of the north marine lake. Significant savings can be achieved in the embankment construction by lowering the lake elevation. In general, reducing the height of an embankment by a factor of two will decrease its cost by a factor of four. Because the lake will respond to inflow reductions gradually over a period of years, the lower the design elevation, the longer it will take to achieve closure of the lake. The north lake cannot be closed until the Sea elevation declines enough to match the desired design elevation. Figure 6-12 illustrates a preliminary phasing plan assuming a design elevation of -235 feet msl.

Phasing of restoration features could be accomplished in the following manner:

1. Installing upstream freshwater wetlands and sedimentation basins coupled with implementing TMDL measures to improve water quality of inflowing could be accomplished as the first step. This step would ensure that once the marine lake is created, the inflows would be of high quality. In addition, it would create recreational opportunities for hunting and bird watching.
2. Dredging of shoreline access areas would begin prior to substantial drops in lake elevation, to begin creating islands and peninsulas.
3. Constructing extensions of the New and Alamo river channels as the lake level begins to recede, in preparation for creating the main marine lake. Additional freshwater and brackish wetlands and sedimentation basins would be created along these channels. Smaller freshwater or brackish lakes and some shallow water habitat areas could also be created concurrently to create additional recreational opportunities and begin dust control measures.
4. Constructing the central causeway to create the main marine lake.
5. Completing the shallow water habitat areas and dust control measures.

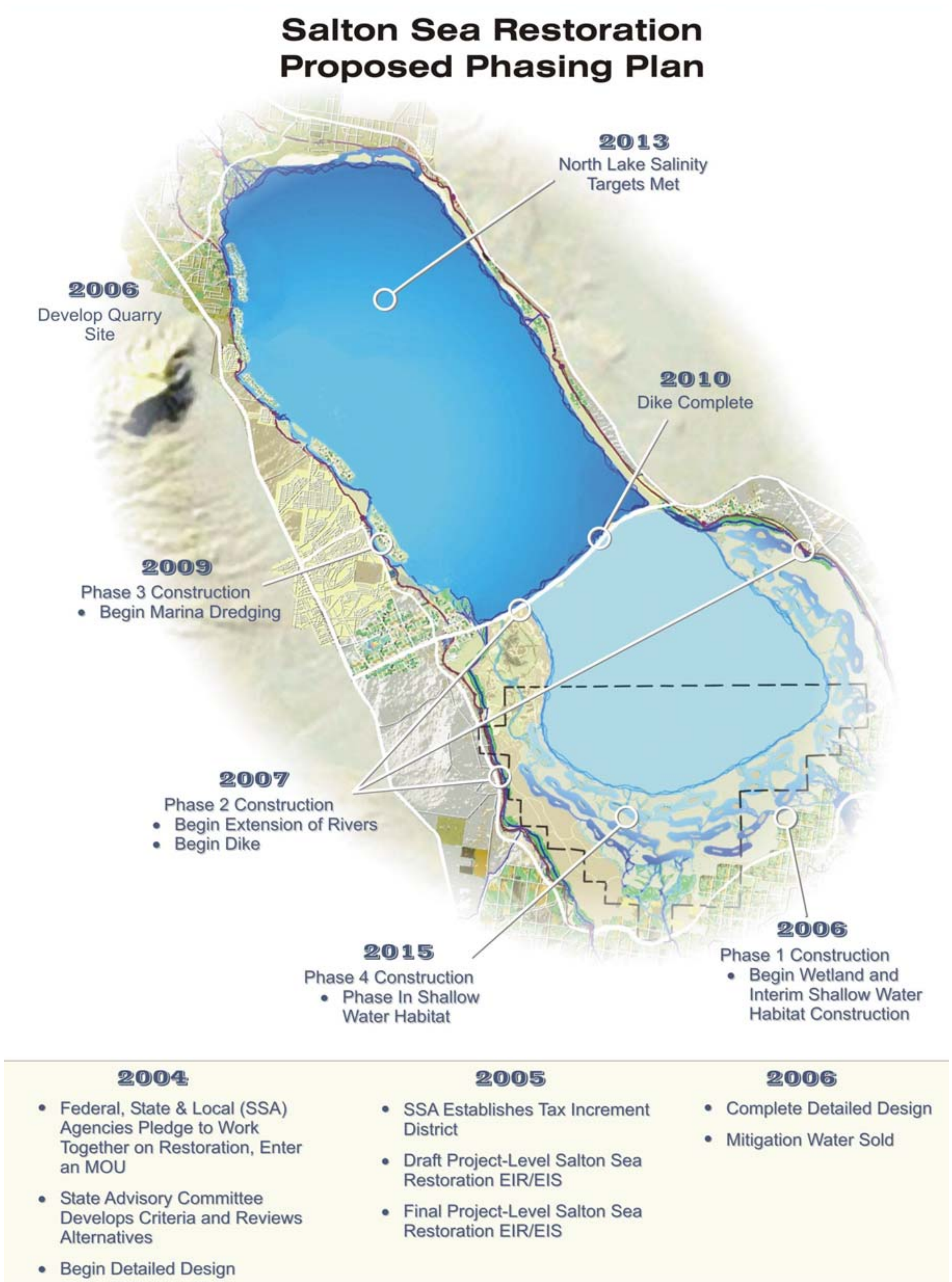


Figure 6-12. Proposed Preliminary Phasing Plan.

Table 6-2. Conceptual Implementation Schedule

Timeframe	Construction Phase	Expenditure
2004	Begin Detailed Design	2
2005	Design Continues, Environmental Compliance and Permitting	10
2006	Complete Detailed Design	10
2006	Phase One Construction: Develop Quarry Site, Begin Wetlands and Interim Shallow Water Habitat Construction	20
2007	Phase Two Construction: Begin Extension of Rivers and Causeway	110
2008	Construction Continues	160
2009	Phase Three Construction: Begin Marina Dredging	190
2010	Complete Causeway	148
	Initial Construction Program Complete: Total Expenditures	650
	Begin Operation Phase	**Annual Expenditures ($M/Year)**
2011-2014	Operation and Maintence (O&M)	5.1
2015-	O&M Plus Phased In Shallow Water Habitat	10.1

Based on Blanketed Rockfill Dike at Elevation -235 feet, msl.

6.7 Implementation

A conceptual implementation schedule is provided in Table 6-2 including a preliminary estimate of phasing of expenditures. The funding profile is illustrated in Figure 6-13. Implementation of the project would begin with contracting for detailed design, environmental compliance, and permitting. The detailed design phase would include a second phase of geotechnical investigations, geophysical surveys, seismic stability analysis for the embankment structure, identification of a quarry site, site surveys, detailed construction and operation cost estimates, and preparation of permit applications. For environmental compliance, the Authority could then begin preparation of a site specific Environmental Impact Statement/Environmental Impact Report (EIS/EIR) to analyze the preferred alternative and the other alternatives discussed in Chapter 5. Alternatively, the State could incorporate the preferred project into its CEQA documentation process. The major construction phase is anticipated to be about a four year program.

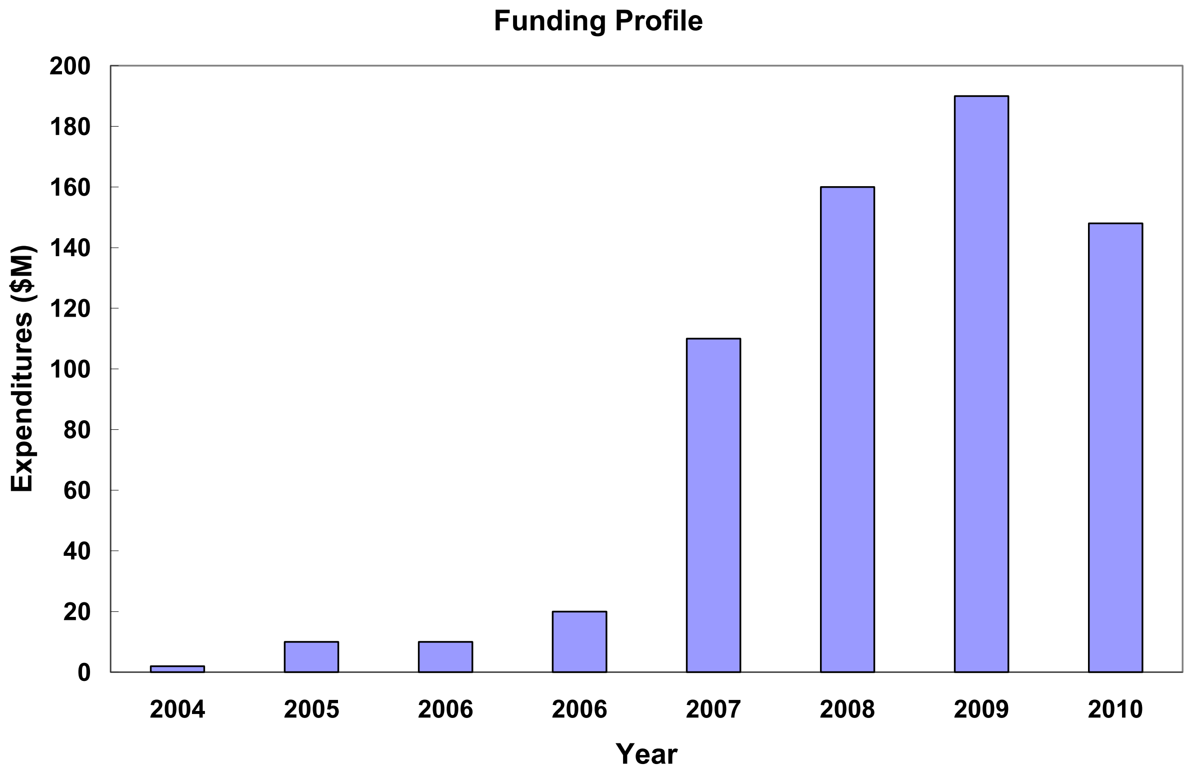


Figure 6-13. Preferred Project Preliminary Funding Profile.

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Appendix A
SHALLOW WATER HABITAT AT THE SALTON SEA

A.1 Overview

A workshop was convened in San Diego, California by the Salton Sea Science Office to address issues associated with the development of shallow habitat at the Salton Sea. As all of the proposed Salton Sea restoration or recovery scenarios include shallow habitat, the physical, chemical, biological, and engineering issues associated with such habitats are important to consider as the alternatives are being evaluated.

The workshop began with a tour of the shallow ponds at the Western Salt facility in Chula Vista, which has recently been acquired for management by the United States Fish and Wildlife Service. Berm structure and salinity profiles, in addition to use of the ponds by various bird species, were examined and discussed.

At the workshop, background information on shallow habitat evaluation associated with the US Filter proposal, data on eutrophication, the results of an environmental risk assessment of the shallow salt ponds of the Salton Sea solar pilot project, and a summary of the sediments of the Salton Sea were presented. Following these presentations, the group divided into three work groups to focus on biology (especially bird species), physical and chemical qualities of shallow habitat, and engineering considerations for construction of the habitat. The participants reported back on the major findings of each group.

The general conclusions can be summarized as follows:

- Shallow habitats should be developed using Salton Sea water rather than water from rivers or drains due to selenium concerns. Shallow water impoundments that begin with water containing more than 2 ppb selenium should be discouraged.

- Shallow habitats should be sited where they take optimum advantage of shallow slopes, of proximity to existing reserves or habitats, and of proximity to agricultural fields, as these siting considerations give the developed habitats their highest value.

- The salinity of the habitats is of minor concern, as any waters between about 30 and 150 parts per thousand total dissolved solids (PPT TDS) will provide foraging value to a variety of birds. If environments including brine at the saturation level for salts are present, however, proximity to lower salinity habitats is important. Salinity targets should be out of the range for avian botulism.

- Selenium is the most important water quality concern, although data on DDE should be carefully considered as well.

- Eutrophication level for shallow habitat areas is not a concern.

- Construction of the shallow habitats could utilize structures developed with low-cost agricultural specifications, subject to site-specific and risk assessment review.

There were no "data gaps" that were suggested as being critical to moving forward with developing a preferred alternative concept. It is now possible to develop conceptual level cost estimates for both the construction and the operation and maintenance (O&M) of shallow water habitat areas. More detailed cost estimates can be developed in concert with the preparation of site-specific habitat restoration plans.

As regards the applicability of shallow habitats to the alternatives under consideration, the results of the workshops suggest that overall, from the point of view of shallow habitat, a preferred alternative would have the following features:

- Construction opportunities at the south areas of the basin, on clay soils with shallow slopes adjacent to existing refuge and reserve lands. This requirement eliminates the South Marine Lake with Elevation Control alternative, but remains feasible with the other scenarios.

- Gravity delivery of water from a restored portion of the Sea, which would be low in selenium and of a salinity about that of ocean water. This requirement would be possible with the alternatives involving a south or north marine lake with elevation control.

- A pumped delivery of water from a restored portion of the Sea, which would be low in selenium and of a salinity about that of ocean water. This would be possible with all scenarios, but more pumping would be required with the barrier and the no barrier alternatives.

A.2 Background

The Salton Sea Science Office (SSS0) conducted a workshop on January 28-29, 2004 in order to evaluate the major considerations associated with the development of shallow water habitat at the Salton Sea. Experts in water quality, biology, and engineering who possess special expertise in saline conditions were invited to participate in this workshop. The goal of the workshop was to engage in discussion about the issues surrounding the creation of shallow water habitat at the Salton Sea, and to develop some recommendations for the restoration planning team that are based in sound science and pertinent experience. This paper reports on the findings of that workshop.

With inflows to the Salton Sea expected to decrease substantially in the future, there would be a considerable expanse of shoreline exposed by the retreating Sea. These exposed sediments could create significant air quality problems if they prove to be emissive of PM_{10} (particles smaller than 10 microns) during wind events. Furthermore, the retreating Sea will provide for less shallow water habitat than is currently present in the basin. Shallow water habitat is important for many of the bird species that use the Salton Sea either seasonally or as permanent residents. Development of new shallow water habitat, then, is a proposal that accompanies all of the restoration scenarios currently under consideration, as it both protects exposed sediments from wind erosion, and also provides important habitat for birds.

A.3 Approach

The planning committee for the workshop consisted of Dr. Douglas Barnum and Dr. Rey Stendall of the SSSO, Dr. William Brownlie of Tetra Tech, Mr. Robert Prohaska of Essex Environmental, and Ms.Carla Scheidlinger and Mr. Frank Stradling of Agrarian Research. This group developed the approach and the materials used for the workshop.

The overall approach was to provide appropriate and pertinent background material for all participants, to engage in a field trip to obtain some first-hand impressions of the kinds of habitats that would be under consideration, and to facilitate focused discussions on several aspects of shallow habitat development. The background material and field trip produced some common ground for discussion, which was augmented by a brief presentation of the six conceptual alternatives for Salton Sea restoration that are currently under consideration. In addition, the planning team developed a habitat grid that describes the kinds of habitats that would be associated with each alternative. From that grid, habitats that were characterized by shallow water were singled out for discussion at the workshop.

The major categories of issues associated with shallow water habitat were water quality, biological factors affecting bird use, and engineering concerns. Regarding water quality, the physical and chemical characteristics of the water that would supply the shallow habitats were judged to be highly variable, and a professional consensus regarding optimal as well as hazardous water quality conditions is desirable prior to the selection of a preferred alternative. The biological characteristics that each habitat develops are equally variable, and the quality of habitat that could be created for bird use is of great interest. Once again, a consensus as to optimal and hazardous habitat conditions was sought. Finally, the development of shallow water habitat involves engineering considerations regarding the kinds of infrastructure elements required for such habitat, and the construction constraints and opportunities that the Salton Sea environments offer.

In order to sort out and effectively discuss these three categories of issues, the workshop plan included separate break-out sessions where each set of considerations could get appropriate attention from the participants.

In summary, then, the approach was to provide an on-the-ground view of the kinds of habitats and infrastructures under consideration, put the habitats in the context of the restoration alternatives, provide sufficient background data to encourage fully informed discussion, and to focus on the three areas of evaluation for habitat and restoration planning.

A.4 Workshop Summary

Field Trip. The field trip took place on Wednesday January 28, 2004 at the Western Salt facility in Chula Vista, California. The tour was conducted by Brian Collins of the Tijuana Estuary Reserve in Imperial Beach, California, and by Gene Mullineaux of Western Salt Company.

Western Salt Company is located in the extreme south end of San Diego Bay, and has been in operation for decades. This 800 acre site was once a thriving estuarine system that was home to numerous fish and wildlife species. The United States Fish and Wildlife Service's Coastal Program, working with the Refuges and Endangered Species programs, acquired the entire 800 acres into the Refuge system, and is now preparing habitat management and restoration plans.

The ponds viewed on the tour were generally of medium depth, between 1 and 6 feet deep. They varied in salinity from that of ocean water (about 35 PPT TDS) in the primary system, to about 60 PPT in the secondary pools, to 280 PPT in the pickling pools, to saturation for sodium chloride, which is at about 340 PPT, or 34 percent salt. Gypsum precipitation in the ponds was said to be at about 110 PPT. The primary systems contained fish, and were used by terns, pelicans, and osprey. In ponds between 80-120 PPT, *Artemia* were found, although fish were absent. No salt had precipitated at that point. In ponds with a TDS of greater than 120 PPT, brine flies were the only invertebrates noted.

The ponds operate principally by gravity flow, with head differential built with depth. Some amount of pumping is necessary to move the brine, but it is minimal. Some odor has been reported from the ponds, presumably from the sediments, which are probably anoxic. The ponds are considered to be eutrophic, which is not a problem for the salt industry, but is not ideal for deep marine habitat.

The ponds were constructed with native material, which was a mixture of sand, silt, and clay, and which had been bailed up with an excavator during construction. Although the berms had to dry out and set up for almost a year before they could be formed into the roads the tour was driving on, they had been used for water ponding immediately after construction.

The general take-home messages from the field trip for the three areas of inquiry were as follows:

- Ponds can be built with fairly simple technology, including berm construction using dredging, or bailing up of sediments using an excavator. The sediments can take time (1-2 years) to fully dry, but the berms can be used to impound water immediately.

- The quality of the water as regards salinity produces a wide range of habitat conditions, from including fish, to providing only brine flies. At very high salinities where NaCl crystallizes, the habitat is essentially sterile, but can provide safe resting places for birds. Odors coming from eutrophic waters and anoxic sediments were noted.

- Bird habitat is variable, depending on salinity and depth. Nesting habitat can be improved by graveling levees, and making them wider. The deeper ponds support certain birds, including fish-eating birds. The shallower habitats (less than 8 inches) have more bird species diversity.

Orientation. An initial orientation presentation was provided to all participants. In addition, four presentations were made by workshop participants that introduced data that have bearing on the topic of shallow habitats. After the presentations, participants broke into focused workshops on either biology, water quality, or engineering. Although several participants “floated” between two workshop sessions, most individuals remained in a single workshop group. The discussions that took place in these three groups are summarized below.

A.4 Water Quality Panel

Participants. The participants in the Water Quality Panel were Dale M. Robertson (U.S. Geological Survey), Geoff Schladow (University of California, Davis), Chris Holdren (Reclamation), Chris Amrhein (University of California, Riverside), Sujoy.Roy (Tetra Tech), Francisco Costa (California Regional Water Quality Control Board), Rick Gersberg (San Diego State University), Debi Livesay (Torres Martinez Desert Cahuilla Indians), John Chesnut (Agrarian), and Carla Scheidlinger (Agrarian, moderator).

Freshwater Wetlands. The discussion began with an assessment of the potential for using freshwater (as defined by input from the New and Alamo Rivers, as well as from the drains of the Imperial Irrigation District farms) for supplying shallow habitats. Such habitats were discussed and compared to the wetlands that have been constructed for multiple purposes, including water treatment, along the New River, and which are proposed additionally for the Alamo River. Potential benefits included removal of sediment, nitrogen and phosphorus, as well as reduction of biological oxygen demand (BOD).

Data from the existing New River wetlands at Imperial and Brawley (unpublished data from Imperial Irrigation District, 2003) indicate that about 50 to 70 percent of the total nitrogen is removed from the water as well, although the form in which it is removed varies with the wetland area. Up to 45 percent of total phosphorus was removed in these wetlands, as well as a maximum of 28 percent of the incoming selenium. Almost none of the coliform bacteria remained in the water after passing through the wetlands. Such wetlands can, then, function reasonably effectively for water treatment, and industry standards suggest that treatment efficiencies can be improved in wetlands designed specifically for treatment, rather than for multiple uses including habitat.

Sedimentation basins, however, must be considered separately from wetlands or habitat areas. The sedimentation cells of the New River wetlands removed about 95 percent of the total suspended solids from the water entering the projects. It was agreed in the workshop that any areas that were expected to remove sediments would quickly fill up if they were shallow, and that wetlands should not be expected to double as sediment traps. If the removal of sediment is a goal, then deep sediment retention basins should be implemented upstream of shallow habitat areas. Such basins can be extremely effective at controlling sediment, and should be cost-effective to construct, operate and maintain.

The use of additional shallow freshwater wetlands outside of the river channels for treatment purposes was not generally encouraged. Phosphorus reduction would be more effectively achieved using best management practices (BMP’s) on farms rather than attempting to remove phosphorus in treatment wetlands. In any case, trapping sediment tends to remove about half of the phosphorus anyway, as the phosphorus is deposited with sediment. Although nitrogen removal can be accomplished by treatment wetlands, the Salton Sea is strongly phosphorus limited, so nitrogen removal is less of an issue.

Regarding habitat using freshwater, liabilities arising from the construction of extensive shallow freshwater wetlands included tamarisk infestations and mosquito problems. Overall, however, the show-stopper for freshwater wetlands using the available source water was selenium concentration. Data show that algae in the rivers contain up to 2 mg/kg of selenium, which is at the threshold of concern. Any water used for shallow habitat should contain no more than about 1.5 ppb selenium at the point where it is introduced into the shallow habitat system. This level is somewhat lower than the selenium concentration reported in the river systems. Shallow habitat using freshwater, then, has few benefits and serious liabilities. An exception would be large, deep ponds for sediment removal which would be managed to discourage use by birds that feed principally on insects.

There was some discussion about constructing shallow habitats with freshwater on exposed sediments of the Salton Sea instead of in the river channels, with the structure and function of rice paddies in the Central Valley proposed as a model. This concept was generally rejected, as the initial water quality that would be used here is characteristic of drainage water rather than of irrigation water, and is high in selenium and organics. Blue-green algae could pose serious odor problems in shallow habitats supplied with such water. If the ponds in this scenario were to be managed for seasonal use, the problems with selenium could become multiplied, as selenium could be mobilized from the sediments each time the areas are re-wetted, causing a spike in selenium concentration in the water, which could prove toxic to the wildlife attracted to the seasonal habitat.

Saline Habitats. The next kind of habitat considered was a saline shallow habitat that would be accomplished by blending Salton Sea water with the river or drain water. The participants were unanimous in their opinion that, in order for such water to comprise high quality habitat, river water would have to be blended with Salton Sea water to a final concentration of lower than 2 ppb selenium. The final salinity or eutrophication level of the water was of little concern; what matters is obtaining a low selenium concentration in the water supply to the shallow habitat. Such a blending scenario was deemed feasible, as the group concluded that it was reasonable to assume that the same selenium removal mechanisms that operate in the Salton Sea now would continue to function in a reduced Sea; that is, the Sea would continue to function as a selenium sink. The preferred scenario, however, was to use the remaining Sea as a selenium filter, and to construct shallow habitat using only water that had been obtained from the Sea itself. Blending, then, would not occur, and habitat would be constructed with salinity levels at or above the salinity of the Salton Sea. Furthermore, any reject water from a desalination plant should be discharged directly to the brine pool, without being passed through the Sea. This would remove some additional selenium from the water that would ultimately be available for habitat.

It was acknowledged that even if the water supplying the shallow habitats were to be introduced at a concentration of less than 2 ppb selenium, the selenium concentration could increase through evaporation. The habitat that would result would be of lower quality, but probably not enough to trigger unacceptable risks. The group offered the opinion that as the selenium concentration would increase, the risk of deformities in birds would also increase. However, the risk in this case is judged to be minimal because of the low selenium concentrations anticipated, and the idea that the risk to a few individuals would be offset by the expanded habitat that would beneficial to many more individuals. It could be envisioned, then, that the effect would be a net benefit

Pesticides. Although selenium was by far the greatest concern regarding water quality for this group, the concentration of DDE, which is a breakdown product of DDT and can appear in elevated concentrations in the eggs of birds, was also discussed. At this point, the data show that DDE concentrations are above safe levels in 40 percent of the egg samples taken around the Salton Sea. DDE is adsorbed onto soil particles, and therefore enters the food chain from sediments, which emphasizes the need to keep contaminated sediments isolated from bird habitat. Chris Amrhein provided an article that indicated that field observation of DDE in marine sediments suggests a half life of about 10 years. The process operating to reduce DDE levels in sediment is reductive dechlorination. Most researchers acknowledge that anaerobic dechlorination is not, on its own, a complete remedy for removal of DDE from sediments. Sediment-coring observations suggest that natural dechlorination is slow and occurs only to a limited extent. Although reductive dechlorination is a natural process, whether it is actually making a significant impact on the DDT contamination remains to be seen. For the Salton Sea, the implementation of BMP's that minimize the release of DDT into the environment would therefore reduce the DDE risk in the future.

As in the case of phosphorus, DDE could also be at least partially removed in a sediment trap. In addition to DDE, there are many organics, pesticides and fumigants that are known to be sediment associated, so they would be removed in a sediment trap or be sequestered in the Sea sediments. Others are not associated with sediments, although there are little data.

Trace Elements. Arsenic and boron were also discussed. Arsenic levels are elevated in fish tissues at the Sea, and could pose a risk of causing cancer in humans consuming the fish. However, the carcinogenic (organic) species of arsenic in fish in the Salton Sea is low. The arsenic levels do not pose a threat to wildlife, as the cancer risk is limited to humans. At the north end of the Salton Sea, monitoring at the Torres Martinez reservation has revealed concentration of arsenic of up to 110 ppb in shallow groundwater and surface water. Arsenic concentrations are as high as 55-58 ppb in the Whitewater River. These levels considerably exceed the drinking water standard of 10 ppb arsenic. Such elevated levels may or may not pose a threat to wildlife. As regards boron, this element concentrates linearly, and tracks salinity. It does not bioconcentrate, but at high levels could pose a wildlife risk. Birds accumulate boron through eating vegetation, not from ingestion of insects. Boron at a neutral pH takes the form of boric acid, which is not toxic. At high (alkaline) pH, boron becomes borate, which is toxic. Such high pH conditions would not be anticipated in shallow saline habitats.

Other trace elements occurring in water currently feeding the Salton Sea were also discussed, including mercury, chromium, cadmium, lithium, magnesium, and copper. No data regarding these elements were discussed, but it was agreed that they should be monitored. The water quality of the effluent from the geothermal wells should be monitored also. It was noted that there are industrial wastes from Mexico that are present in river water. Only about 10% of the water in the New River water will be treated by a new treatment plant, so such wastes will not be eliminated. There are no data that the group was aware of on hormones and hormone mimics.

Other Issues. It was mentioned that CO2 devolving from underground could also be an issue in shallow ponds, as it could effect a change in pH. The group felt that this would not constitute a serious problem.

Algal toxins were discussed as an issue, but there are not much data on this. Viruses, Newcastle's and bird diseases were mentioned, but no conclusions regarding water quality were reached.

The changing salinity of the bodies of water associated with a rehabilitated Salton Sea was discussed. The most frequently discussed scenario included a reduced volume Sea with a salinity somewhat lower than what is currently present, at a target of approximately that of ocean water (~35 PPT TDS). There would also be a brine pool or sump that would be hyper-saline. In the rehabilitated Sea, there would be less calcite, and therefore somewhat less phosphate removal. As eutrophication in shallow habitats was not a concern, higher phosphorus levels were not considered to be important. Selenium removal should not be affected by decreased salinity. Algal toxins, however, could be expected to increase if salinity falls much below 25 PPT. The target salinity should remain well above the avian botulism growth zone, which can be determined for specific water bodies with good accuracy from computer models.

As for the brine pool, it would be physically inaccessible to birds in most years, as it would be covered with a salt crust. In flood years, however, it could be a serious problem, as fresh water would float on top of it after rain storms and from any uncontrolled discharges. It was noted, however, that one of the federally designated roles of the Salton Sea is as an agricultural sump. Evolution of the Salton Sea to a hyper-saline condition would be anticipated with reduced inputs in any case, regardless of restoration efforts. There were two major concerns about this highly concentrated body. One was for selenium. Selenium concentration that is at 1-3 ppm qualifies a substance as a toxic waste, but farm evaporation ponds in the Central Valley have been determined to be exempt from the toxic waste regulation in this context A similar exemption could be anticipated for the Salton Sea, if selenium concentration was to reach that level. The salt crust, however, would isolate the selenium in the sediments, so the group felt that selenium would not be a problem in this high salinity environment.

Salinity. High salinity itself was another potential concern. It was suggested that there may be a high level of salinity beyond which contaminants are not an issue because there is no usage by birds. If this were the case, high salinity could decrease risk. It was noted that at 120 PPT, there is basically no food source. Between 44 and 120 PPT, however, data show low selenium, so again there is a low risk. A shallow pond at the mirabilite (decahydrated sodium sulfate crystal) concentration point could encrust bird feathers with the crystals, which poses a health hazard to birds so affected. Brine concentration data show that at 60 F the mirabilite concentration point is at about 100 PPT, so brines of that concentration could be discharged to the brine pool and get absorbed into the brine. It was also noted that in the shallow habitat scenarios discussed, there would be ample high quality habitat for the birds to escape to, where they could both clean their feathers from salts, and obtain food uncontaminated with selenium.

Habitat Acreage Estimates. A preliminary water balance calculated for the reduced Sea scenario indicated that there would be a requirement of discharging about 40,000 Acre-feet/year from the reduced Sea in order to maintain stable salinity. With such a discharge, approximately 8,000 acres of saline shallow habitat could be created. As this water is flushed to higher salinity ponds downslope, additional shallow habitat at a higher concentration could be obtained.

A.5 Biology Panel

Participants. The participants in the Biology Panel were John Y. Takekawa (US Geological Survey), Carol A. Roberts (U.S. Fish and Wildlife Service), Rick Soehren (California Department of Water Resources), Mark Rigby (Tetra Tech), Dan Cooper (Audubon California), Kathy Molina (Natural History Museum of Los Angeles County), Chuck Henny (USGS - Biological Resources Division), and Doug Barnum (Salton Sea Science Office and USGS, moderator).

Approach. The approach taken by the participants in the biology workshop was to consider various habitats and then discuss them according to usage by birds based on whether they were breeding or migratory, the guild or foraging type they represent, and whether or not they are state or federally listed species.

The group then discussed various habitats that are currently present at the Salton Sea, or which would be created under conditions of a declining Sea level or as part of the restoration scenarios.

Estuarine habitat, which is the fresh/salt mixing zone, is not expected to be a significant area under these scenarios.

Flooded agricultural fields (with fresh water) provide breeding habitat, but not nesting or foraging opportunities, for gull-billed terns. Non-breeding birds that would use this habitat include ibis, large waders, snow geese, curlew, gulls, shorebirds, waterfowl, and northern harrier hawks. Various roosting birds would also be expected to forage here.

Riparian zones of native vegetation (mesquite) were distinguished as a unique habitat, which also contain saltbush species and arrowweed. This habitat provides breeding grounds for resident desert bird species such as roadrunners, Gambel's quail, and blacktailed gnatcatchers. Non –breeding migrants such as Wilson's warbler would also utilize this habitat.

Riparian zones of tamarisk provide breeding habitat for cattle egrets, and foraging habitat for non-breeding migrant passerines, especially in the river channels that support the growth of Phragmites.

Earthen channels are important breeding areas for burrowing owls and large wading birds.

Typha marshes, which include standing water that is reasonably fresh comprise habitat for the endangered Yuma clapper rail, as well as for the least bittern, ibis, breeding waders, and breeding waterfowl including the fulvous whistling duck and wintering dabblers.

Salt pans support breeding snowy plovers, stilts, avocets, and wintering savannah sparrows.

Drain influenced lagoons and lagoon overwash areas are habitat for cormorants and roosting birds.

Mudflats, regardless of whether they are within impoundments or not, and regardless of salinity structure, do not provide breeding habitat, but are foraging locations for non-breeding and migrant gulls, waterfowl, shorebirds, a variety of sensitive species, waders, and roosting birds.

Shallow Water Habitat. The discussion then turned to specifically shallow water habitats. “Shallow” was defined as having a maximum depth of three feet, with an average depth of less than one foot. Anything deeper was classed as “deep marine” if it is saline.

Shallow freshwater habitat at the mouths of rivers and drains may include islands that are surrounded on all sides by water, and often feature snags and levees that provide habitat diversity and structure. This habitat could be termed mixosaline brackish, with a salinity of 5-30 PPT.

Salinity Regimes. Additional salinity regimes are overlain on habitat types, and the major impact of salinity changes is on invertebrate populations. That is, salinity is the key habitat modifier, and varies from low salinity to hyper-saline. Assuming that the shallow habitats proposed for development have their lowest salinity at approximately ocean water levels (which is proposed in several of the restoration scenarios), there were three salinity classes identified. In waters of 35-70 PPT TDS, both fish and a variety of invertebrates would be present. For waters between 70-150 PPT TDS, there would be selected invertebrates only. At salinity greater than 150 PPT TDS, micro-invertebrates would be excluded.

Shallow Water Habitat Siting Considerations. Siting considerations for shallow habitats were then considered. It was noted that for breeding birds, the broods need to have access to sources of fresh water, so some habitat heterogeneity is required.

At the least, constructed saline habitats should be near existing fresh water sources such as rivers or drains. Other siting considerations were:

- Develop shallow habitats within areas of shallow slope, which are conducive to maximum water distribution. This is perhaps the most important consideration in order to maximize the amount of habitat that can be created

- Proximity to agricultural lands is important for ibis, curlew, egrets, and gull-billed terns

- Proximity to existing refuges and/or Department of Fish and Game lands is desirable to maximize contiguous habitat opportunity. This requirement suggests that the constructed habitats should be as close to the current shoreline as possible

- Proximity to existing and/or potential breeding areas is important to assure that there is habitat available for use by broods

Conclusions. A summary of the general conclusions of this workshop group is that no single habitat type will be optimal for all species. Taking species of special concern (i.e., listed species) into account first will guide decisions about what habitats can be developed or protected for the benefit of these species. It may be that protection of existing habitat best addresses many of these species, such as maintaining *Typha* wetlands for Yuma clapper rails, or agricultural drains for burrowing owls. Given that the habitats under discussion were shallow water, it was suggested that siting considerations are more important than determining salinity gradients, as such considerations will determine how to optimize both total area and take advantage of synergistic interactions with nearby or adjacent habitats. Finally, as salinity increases, biological diversity in the shallow habitats decreases, although total biomass of food items may remain high.

The group wanted to acquire photos of each species of concern, and suggested consulting Birds of the Salton Sea and the text Cowardin's Wetland and Deepwater Habitats (Cowardin et al. 1979).

A.6 Engineering Panel

Participants. The participants in the Engineering Panel were Leo Handfelt (URS), Ted Schade (Great Basin Unified Air Pollution Control District), Cheryl Rodriquez (Reclamation), John Vrymoed (California Department of Water Resources), Frank Stradling (Agrarian), and Bill Brownlie (Tetra Tech, moderator).

Approach. This group began by coming to agreement on which types of structures were to be considered, developing definitions for those structures, and identifying issues and areas of inquiry that would be required in order to develop specifications and costs for infrastructure and O&M elements.

Infrastructure Elements. There were three infrastructure elements discussed: berms, dikes, and levees. ***Berms*** were defined as earthen structures less than three feet above the original ground level, with a top width of two to five feet, and with side slopes varying from 3:1 if they are vegetated, to 7:1 if they are not. No slope protection other than potentially vegetation would be associated with a berm. A berm would not support vehicular traffic, although it may or may not be compacted. The purpose of a berm is to control and advance sheet flows of water. Berms enjoy the lowest level of design standards, as they are not constructed to retain much standing water.

Dikes were defined as earthen structures less than 10 feet above the original ground level, with a top width of about 12 feet, with some turnouts included. Side slopes would typically be between 4:1 and 6:1, although further stability analysis was suggested to develop a firmer slope requirement. Slope protection could be vegetation, rock, or a flatter side slope to prevent accelerated erosion. A dike would support vehicular traffic, and would preferably be compacted, and generally capped. It may or may not be keyed into the parent material, depending on the site. The purpose of a dike is to impound and contain shallow water, of a depth of five feet or less. Dikes are not, however, jurisdictional dams.

Levees were defined as earthen structures more than 10 feet above the original ground surface, with a top width of 20 to 30 feet, and with side slopes of 6:1 or flatter. Slope protection would be with rock revetment. Levees are generally compacted, would be capped, and would support vehicular traffic. They may or may not be keyed into the parent material, depending on the site requirements. The purpose of a levee is the retention of water that is deeper than five feet. As such, it may or may not be a jurisdiction al dam.

Construction Issues. There are certain challenges associated with construction of such infrastructures in the sediments of the Salton Sea. Foundation support is of primary importance. Construction would need to be on fat clays, and could take place in shallow water or fully saturated soils. The structures would be constructed of native materials, which would be removed and placed using an excavator walking on mats. The material thus bailed up would need to be allowed to dry, after which it could be compacted. Grid-type geosynthetic mats could possibly be used to help stabilize embankments where soft sediments used in the construction.

Seismic issues are a concern as well. When the structures are designed, articulation of an acceptable level of damage that the structure could be allowed to sustain during a seismic event should be made, and an acceptable cost of repairs for that damage. The most common form of seismic damage is anticipated to be cracking, which can be largely avoided by compaction during construction.

There are certain limitations that will be faced in constructing these infrastructure elements. Cost is a primary consideration. Different foundation conditions may dictate construction methods and specifications that dramatically affect total cost.

Water is another consideration, as construction in shallow water may require alternative methods such as dredging. For the shallow habitats proposed in the restoration scenarios, a salinity break between the habitats and a salt crust developed for dust control must be anticipated, and the structural implications of that break taken into consideration. Finally, there may be a need to evaluate existing construction methods and develop modified or novel alternatives to assure that the methods produce competent structures.

The group discussed what available specification guidelines should be used for these infrastructures in this setting. It was decided to review the applicability of National Resource Conservation Service (NRCS) specifications for berms, dikes, and levees. These specifications were developed for use in agriculture, with assumptions of low cost and minor consequences resulting from damage or failure. Use of such specifications could substantially reduce the construction cost of developing shallow habitats.

The group raised the question of any critical data sets that are needed in order to proceed with detailed shallow habitat designs. The following issues were identified:

- Careful analysis of unit costs. Depending on the specifications adopted, costs could be quite variable for these infrastructure elements. Determination of the most appropriate specifications and thorough evaluation of costs is important.

- Native material vs. imports. Some materials may not be suitable for the sustainable development of infrastructures for shallow habitat. If site evaluations dictate that imported material is required, the costs associated with such materials should be evaluated.

- Seismic response analysis. The Salton Sea is in an active seismic zone. The infrastructure elements developed according to the selected specifications should be evaluated to determine the degree of vulnerability that they would have to seismic activity.

- Cost Factors/Considerations. Selecting the criteria against which costs will be evaluated remains to be done.

- Low risk of failure vs. higher O&M costs. Infrastructure elements constructed with low initial costs may prove to be more vulnerable to damage or failure. Maintenance costs associated with such structures, and the reliability of the structures must be evaluated in terms of costs and benefits associated with any construction specification. It may be most cost effective to build simple low cost berms and pay for O&M later if they get damageds.

Conclusions. In summary, this workshop group examined three infrastructure elements that would be associated with the development of shallow habitat, and proposed questions and concerns associated with their construction and maintenance. In general, it was agreed that low cost infrastructures designed according to specifications such as those developed by the NRCS deserved evaluation, as this could keep initial costs for a project low. Site specific considerations will have to be thoroughly evaluated to determine the benefits and costs of implementing such specifications, given variable parent material and seismic risk. Low initial costs may imply higher maintenance costs, but this balance may prove to provide a lower cost project overall.

A.7 Workshop Summary

Each panel presented a summary of its discussion to the group at large at the conclusion of the workshop. The general conclusions can be summarized as follows:

- Shallow habitats should be developed using Salton Sea water rather than water from rivers or drains due to selenium concerns. Shallow water impoundments that begin with water containing more than 2 ppb selenium should be discouraged.
- Shallow habitats should be sited where they take optimum advantage of shallow slopes, of proximity to existing reserves or habitats, and of proximity to agricultural fields, as these siting considerations give the developed habitats their highest value.
- The salinity of the habitats is of minor concern, as any waters between about 30 and 150 PPT TDS will provide foraging value to a variety of birds. If environments including brine at the saturation level for salts are present, however, proximity to lower salinity habitats is important. Salinity targets should be out of the range for avian botulism.
- Selenium is the most important water quality concern, although data on DDE should be carefully considered as well.
- Eutrophication levels for the shallow habitats is not a concern.
- Construction of the shallow habitats could utilize structures developed with low-cost agricultural specifications, subject to site-specific and risk assessment review.
- There were no "data gaps" that were suggested as being critical to moving forward with designing a preferred alternative, except the cost development for infrastructure and construction.

A.8 Alternatives Considered

Shallow habitat configurations that could be associated with five possible restoration alternatives for the Salton Sea are discussed in the following paragraphs. These alternatives are briefly described here, with note being made of the habitats that would be associated with each.

South Marine Lake without Elevation Control

This alternative would involve construction of a low barrier across the middle of the Sea, thus creating two distinct bodies of water. The South portion of the Sea would be fresher, as it would be fed directly from the New and Alamo Rivers. The North portion of the Sea would become hyper-saline. There would be minimum elevation difference between the two bodies of water, but their habitat characteristics would be different. A conceptual plan for this alternative is provided in Figure A-1.

The conceptual plan for this alternative has conveyance channels that provide water for constructed habitats along the margins of the shrinking Sea. One conveyance channel would originate in a forebay at the Alamo River and would run from south to north along the east edge of the Sea. Sea water would be blended into this channel for the purpose of providing brackish water to constructed habitats. Another conveyance channel would run from south to the north originating with water pumped from the south portion of the Sea into the channel.

There would be several kinds of constructed habitats associated with this alternative. The channel on the east side of the Sea would deliver water to saltgrass and waterfowl habitats, and would also supply a recreational pool at Bombay Beach. The channel on the west side, which would consist of fresh water blended with Sea water pumped from the South portion of the Sea, would supply additional saltgrass and waterfowl habitat areas. It would also provide water for a recreational pool at Salton City. The west channel could double as pupfish connectivity habitat as well. Additional flooded saltgrass stands would be present at the north, provided with water blended from the west conveyance channel and water from the Whitewater River. Saline waterfowl habitat at the north end would be supplied from the same blended water, arriving in the channels from both the east and the west. The outflow from all habitat types would be used to create solar salt concentrators and crystallizers downslope of the saline habitats.

The conceptual plan for this alternative includes freshwater habitat in the forebays only, with short lengths of freshwater channels. There would be at least three pump stations required. One would be north of the Alamo River to supply the channels flowing north to Bombay Beach and south to the saltgrass and waterfowl habitats. A blending station would be required at both the New and Alamo Rivers to blend saline and river waters for the channels. Another pump would be at Niland, to augment flows to the north end of the Sea. The third would be near Salton City, to

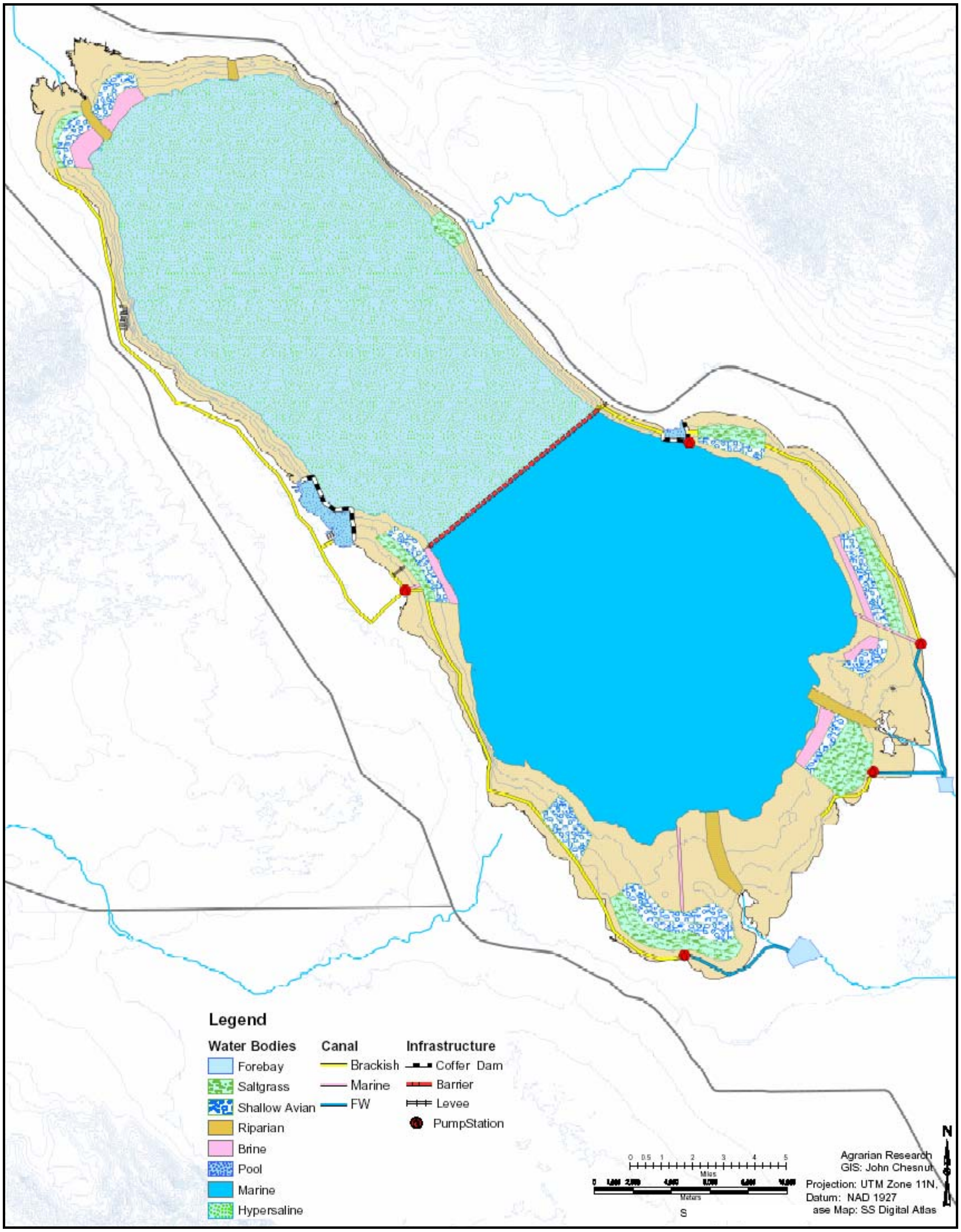

Figure A-1. Conceptual Plan for South Marine Lake without Elevation Control.

provide additional water to the channel and recreational pool on the west shore. A low mid-Sea barrier would also be required.

South Marine Lake with Elevation Control

This alternative would require a retention structure across the middle of the Sea, dividing it into two parts. There would be a large lake maintained at a stable elevation at about ocean water salinity (35 PPT) at the south end of the current Sea. This south lake would be discharged to conveyance channels for habitat development, thus maintaining a stable salinity. The North Basin would dry to a crystal body and salt flats. A conceptual plan for this alternative is provided in Figure A-2.

The Alternative requires conveyance channels that need to run in two directions. One conveyance channel runs along the west edge of the south lake from south to north, carrying water from forebays constructed on the New and Alamo Rivers to the north basin, to prevent increasing freshening of the South Sea. Thus, the New and Alamo Rivers both feed the South Sea directly, and supply water for habitat to be constructed at the west and north edges of the north basin. There are also conveyance channels on the west shore of the south basin that originate in the south lake and flow to the north, and have a salinity level the same as that of the lake. These channels serve as required discharge from the south lake, and also provide water for constructed habitat when blended with the freshwater river channels.

The exposed edges of the west and north end of the Sea would include constructed habitats using a blend of water from the New, Alamo, and Whitewater Rivers, and from the discharge from the south lake. The channels originating from both the southern rivers and from the south lake (after blending in both) would supply brackish water to flooded saltgrass stands that would be created on exposed areas of the north basin. Saline waterfowl habitats would be constructed as well at the northern margins of the Sea. Outflows from the waterfowl habitat and saltgrass habitats would be discharged to concentrator ponds downslope, where they can either form salt beds or be recycled for blending to assure adequate salt concentrations for the habitats.

The channel originating from the south lake could double as pupfish connectivity habitat, as it would allow the fish to migrate from one watercourse to another. A recreational pool would be formed offshore of Salton City, consisting of water blended from both the freshwater channel and the south lake, resulting in higher salinity water. A crystal body and salt flat would result from the shrinking Sea in the north basin.

The only freshwater habitat in this scenario is in the east channel and in the forebays of the rivers. Minimal pumping is required for blending of channel water to assure brackish concentrations for habitat. A mid-Sea dam is required.

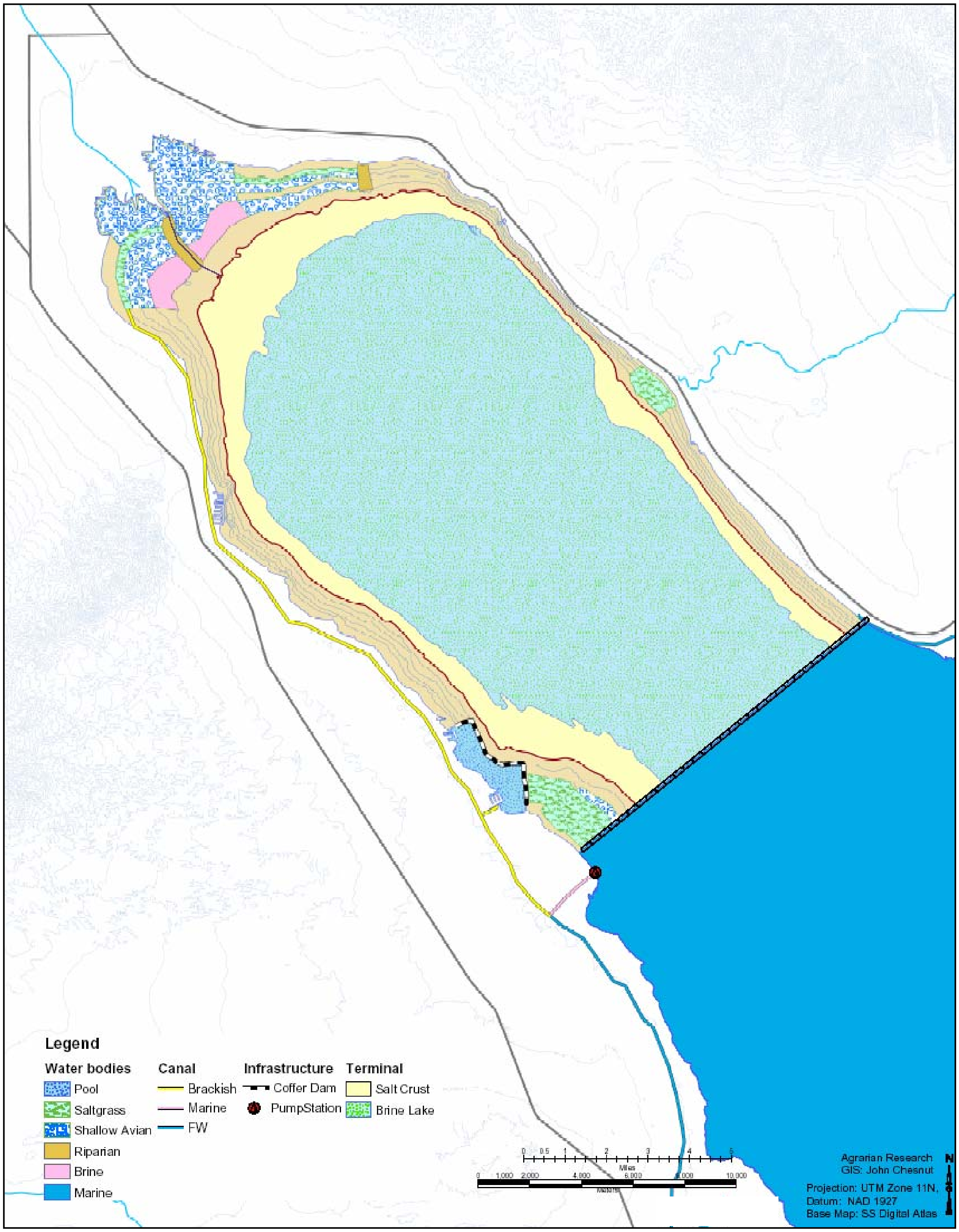

Figure A-2. Conceptual Plan for South Marine Lake with Elevation Control.

North Marine Lake with Elevation Control

This alternative would require a retention structure across the middle of the Sea, dividing it into two parts. There would be a large lake maintained at a stable elevation at about ocean water salinity (35 PPT) at the north end of the current Sea. This Lake would be discharged to conveyance channels for habitat development, thus maintaining a stable salinity. The South Basin would dry to a crystal body and salt flats. A conceptual plan for this alternative is provided in Figure A-3.

This conceptual plan for this alternative includes conveyance channels that need to run in two directions: from the south to feed the north lake with water from the New and Alamo Rivers, and from the north to provide discharge from the north lake to maintain elevation and salinity. Channels from the south to the north along the east shore of the Sea would consist of fresh water originating in forebays constructed on the Alamo and New Rivers. These forebays would give sufficient head to flow the water as far north as the mid-Sea dam, where sufficient water would be discharged to the north lake to maintain salinity and elevation. The remainder of the water would contribute to habitat or to recreational pools. The conveyance channels on the west shore of the south basin originate in the north lake, and have a salinity level the same as that of the lake.

The exposed edges of the south end of the Sea would include constructed habitats using a blend of water from the New and Alamo Rivers, and from the discharge from the

The channels originating from both the southern rivers and from the north lake (after blending in both) would supply brackish water to flooded saltgrass stands that would be created adjacent to the delta areas of the New and Alamo Rivers. Saline waterfowl habitats would be constructed as well at the southwest margin of the Sea. Outflows from the waterfowl habitat and saltgrass habitats would be discharged to concentrator ponds downslope, where they can either form salt beds or be recycled for blending to assure adequate salt concentrations for the habitats. The west channel originating from the north lake could double as pupfish connectivity habitat, as it would allow the fish to migrate from one watercourse to another. A recreational pool would be formed offshore of Bombay Beach, consisting of water blended from both the freshwater channel and the north lake, resulting in higher salinity water. A crystal body and salt flat would result from the shrinking Sea in the south basin.

The only freshwater habitat for this scenario would be located in the east channel and in the forebays. No extensive pumping is required, except for blending for channel water to assure a brackish supply for the habitats.

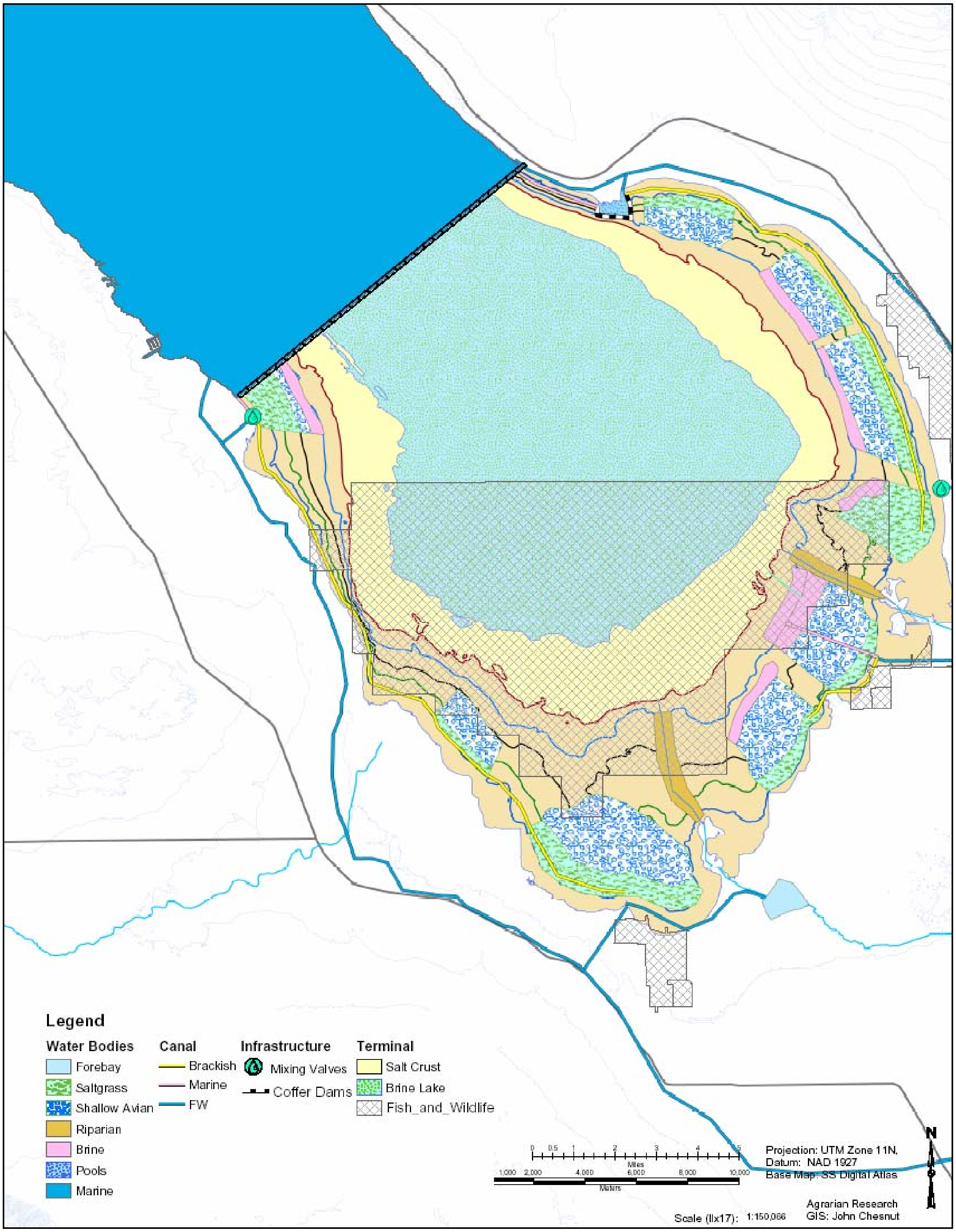

Figure A-3. Conceptual Plan for North Marine Lake with Elevation Control.

No Marine Lake (No Marine Fishery)

Two options are considered for the alternative where a marine fishery is not maintained. For the first option, pumping features would be included to provide brine from the residual Sea and blend it with fresh water to create shallow salt water habitat. For the second option, pumping systems would not be included. Conceptual plans for the pumping and no-pumping options are provided in Figures A-4 and A-5, respectively.

With Brine Pumping. This option provides for a single body of the Sea, with elevation declining by about 30 feet. The main body of the Sea would be hyper-saline, with a potential salinity of about 160 PPT. Constructed habitats would be developed along the exposed margins of the Sea using water delivered from conveyance channels.

This option would include two forebays to capture and build head with New and Alamo River water. There would also be two afterbays which would function as blending stations, receiving water from the conveyance channels delivered from the rivers, and blending it with water from the Sea, which would be delivered via a dredged channel and lifted into the afterbay with a pump. The resulting water would be at about 35 PPT, but any salinity level could be targeted. The blended water would then go into two major conveyance channels, one flowing along the east border of the Sea and the other along the west. These channels would supply constructed habitats.

The west channel could double as pupfish connectivity habitat. Discharges from the channels south of Niland and south of Salton City would form flooded saltgrass habitat, and saline waterfowl habitat. Widening of the channels at coastal communities, including Bombay Beach and Salton City would create recreational pools to a depth of a maximum of 30 feet. The east channel would terminate in such a pool at Bombay Beach, and the west channel would continue to the north end of the Sea. At the north end of the Sea, there would be additional waterfowl habitat supplied with water from the Whitewater River and the channel. Discharge from the areas of waterfowl habitat would form solar concentrators and crystallizers terminating in salt bodies at the north end of the Sea. Discharge from the shallow habitats at the southeast and southwest end would form several deep marine habitats with a salinity that could be blended to attain about that of ocean water (35 PPT) as habitat for pelicans and other fish-eating birds.

This option has freshwater habitat only at the two forebays on the New and Alamo Rivers, and in short segments of conveyance channels between the forebays and the blending stations. It would require several pump stations for blending. The only barriers required would be coffer dams for the deep marine habitats at the south area of the Sea, and the recreational pools at the shoreline communities.

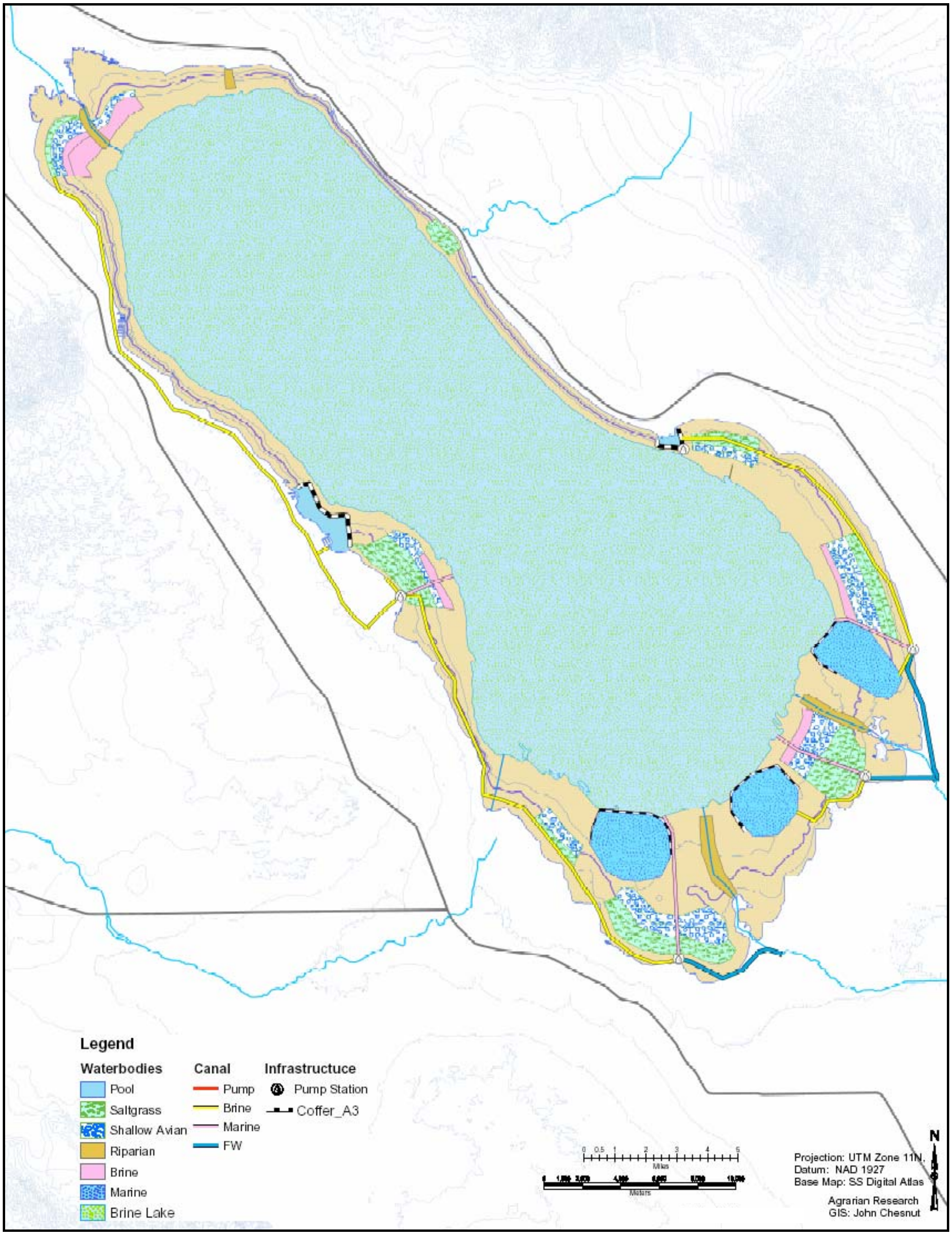

Figure A-4. Conceptual Plan for No Marine Lake (No Marine Fishery), with Pumping Option.

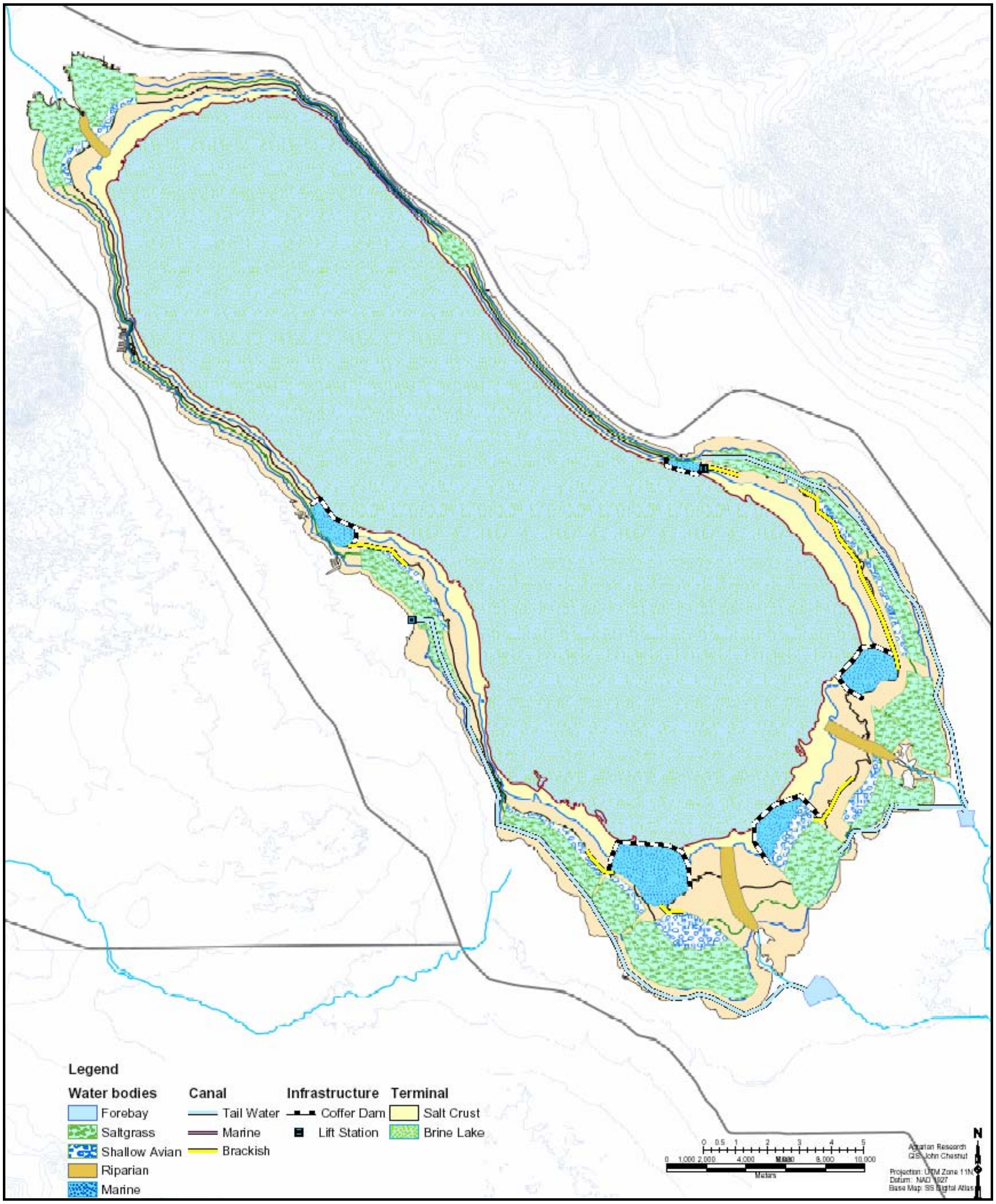

Figure A-5. Conceptual Plan for No Marine Lake (No Marine Fishery), without Pumping Option.

Without Brine Pumping. This option provides for a single body of the Sea, with elevation declining by about 30 feet. The main body of the Sea would be hyper-saline, with a salinity of about 220 PPT. This option would include two forebays to capture and build head with New and Alamo River water. The forebays would deliver water via conveyance channels, one flowing along the east border of the Sea and the other on the west. The west channel could double as pupfish connectivity habitat. Discharges from the channel south of Niland and of Salton City would form shallow water fowl habitat, both fresh and moderately saline, as the water from the upper ponds flowed through to the lower ones, with evaporative concentration. Also formed with water from the channel would be shallow basins planted with saltgrass for the purpose of dust control and seasonal flooding for waterfowl and wading bird habitat. Widening of the channels at coastal communities, including Bombay Beach and the western shore communities would create recreational pools to a depth of 30 feet. The east channel would terminate in such a pool at Bombay Beach, and the west channel would continue to the north end of the Sea. At the north end of the Sea, there would be additional waterfowl habitat supplied with water from the Whitewater River and the channel. Discharge from the areas of waterfowl habitat would form solar concentrators and crystallizers at the north end of the Sea, with some of these environments created at the south end downslope of the waterfowl habitats as well. Discharge at the southeast and southwest ends would form several additional deep marine habitats with a salinity that could approach that of ocean water (35 PPT) for habitat for pelicans and other fish-eating birds. Without additions of brine through pumping, however, these deep habitats may end up with fresher water in them.

This option has freshwater habitat at the two forebays on the New and Alamo Rivers, in the conveyance channels, in the flooded saltgrass and portions of the shallow waterfowl habitat, as well as potentially in the shoreline community pools. The deeper habitats identified as marine may in fact be merely brackish. It would not require any pumping, with the exception of potentially some smaller lift pumps associated with the movement of water in the conveyance channels. There are no Sea dams or mid-Sea barriers, but coffer dams would be required to retain the shoreline community pools and the deep marine environments.

A.9 Shallow Habitat Types

The habitats described below are considered to be the most important shallow habitat types with respect to the Salton Sea restoration process.

In-River Treatment Wetlands

Physical characteristics. This habitat is located within the existing flood plains of the New and Alamo Rivers, above the current level of the Salton Sea. It forms a part of all alternatives considered, except for the barrier alternative, and is a potentially important element of treatment before the water enters the Sea. These habitats would occur at an elevation of –200 to –205 feet, above the current shoreline of the Sea. They are supplied with water from either the New or the Alamo Rivers. The ponds are constructed on the floodplains, and vary in depth from 0.5 to 10 feet. The water is fresh, varying from about 2.5 to 5 PPT TDS. Suspended solids in the water are low, being removed by the sedimentation cells at the intake to the wetland systems. Nutrient content is medium, as the wetlands remove some amount of nutrients, especially nitrogen. The degree of eutrophication, then, is medium. . Selenium concentration is medium (6-15 ppb), as selenium is not removed efficiently by the wetlands and can concentrate evaporatively. The evaporation rate in these ponds would be the same as that of fresh water (5.6 feet per year), and the water would remain in any given pond for about 3-5 days, depending on season. Wind fetch across the ponds would be of very short length, and the ponds would in general border on streambank riparian habitat, either of native species such as mesquite, or of introduced species such as tamarisk.

Biological characteristics. This habitat would be rich in life forms, harboring bacteria, algae, and higher plants. The invertebrates present would be those characteristic of freshwater environments, as would the fish. Birds attracted to this area would be riparian birds and waterfowl, a well as wading birds which feed on the invertebrates and fish found in the freshwater environment.

Function of the habitat type. These ponds would provide foraging, resting, and nesting habitat for waterfowl and wading birds, and contribute to the richness of the riparian environment. Properly designed for the functions of water treatment, they may remove much of the suspended solids (up to 98 percent) and perhaps 50 to 70 percent of the nitrogen.

Environmental quality. The overall environmental quality of this habitat, if it is indeed constructed for the purpose of water treatment, is judged to be poor. Specifics of the environmental benefits and liabilities were discussed in the workshop. It is not recommended to construct large areas of this habitat type, due to selenium concerns.

Conveyance Channels

Physical characteristics. This habitat is located as a narrow band above the current level of the Salton Sea, moving along the contours above the current shoreline of the Sea at about –205 to –225 feet. It forms a part of all scenarios considered, and is a critical component of all scenarios, as it delivers water to a variety of other habitats. The conveyance channels may be either freshwater or moderately saline, depending on the scenario considered. They are supplied with water from either the New and/or Alamo Rivers, or from a blending facility that would mix river waters with brine from the Sea itself.

For the South Marine Lake without Elevation Control there is a freshwater conveyance channel that would originate from the Alamo River and would run from south to north along the east edge of the Sea, delivering water to a recreational pool at Bombay Beach. Additional Sea water could also be blended into this channel for the remainder of the distance to the north end of the Sea, creating a moderately saline environment. Another conveyance channel would run from south to north originating with water pumped from the north portion of the Sea into the channel. This channel would provide recreational pools at Salton City, Desert Shores, and other locations, consisting of saline water.

In the South Lake with Elevation Control Alternative, there is one conveyance channel that runs along the east edge from south to north, carrying water from the rivers to the north basin, to prevent increasing freshening of the South Sea. In addition, there is another conveyance channel running along the west edge from south to north carrying South Sea water at 35 PPT. The west channel supplies recreational pools at Salton City and the Desert Shores area.

In the North Marine Lake with Elevation Control Alternative, the channels originating in the south from the rivers are freshwater, and flow to the east of the Sea. The conveyance channels originating from the north lake are the salinity of ocean water, and flow south on the west side of the Sea.

For the No Marine Lake Alternative with Pumping Option, water would be blended from the rivers with Sea water pumped into an afterbay. The resulting water would be at about 35 PPT, but any salinity level could be targeted. The blended water would then go into two conveyance channels, one flowing along the east border of the Sea and the other on the west. The west channel could double as pupfish connectivity habitat.

For the No Marine Lake with No Pumping Option, there would be two freshwater conveyance channels originating in the rivers, one flowing north along the east border of the Sea and the other flowing north on the west. The west channel could double as pupfish connectivity habitat. The east channel would terminate in a recreational pool at Bombay Beach, and the west channel would continue to the north end of the Sea.

The channels in all alternatives are constructed more or less on contour, and are located outside the current shoreline, with a depth of 3 to 10 feet. If fresh, the water varies from about 2.5 to 10 PPT TDS. If saline, the water may be between 20-40 PPT TDS. Freshwater channels could have high levels of suspended solids, but there would be very little TSS in the saline channels, as the sediment would have been deposited in the Sea. Nutrient content would be medium in the freshwater systems, as some nutrients would have been removed by treatment wetlands. Nutrient content would be low in saline channels. The degree of eutrophication, is medium. Selenium concentration is medium (6-15 ppb). If the water is blended, selenium concentration could be lower, as selenium is sequestered in Sea sediments. The evaporation rate in these channels would be the same as that of fresh water (5.6 feet per year), and the water would remain in any given portion of a channel for about 1-5 seconds, depending on flow rate. Wind fetch across the channels would be of very short length, and the channels would in general border on streambank riparian habitat or on other upland habitat unassociated with the restoration scenarios..

Biological characteristics. This habitat would be rich in life forms, harboring bacteria, algae, and higher plants along the edges. The invertebrates present would be those characteristic of freshwater to saline environments, depending on the water source, as would the fish. Birds attracted to this area would be riparian birds and waterfowl, as well as wading birds and fisheating birds which feed on the invertebrates and fish found in the various waters.

Function of the habitat type. These channels function as conveyance of water to other habitat types, and are not designed to be habitat components in and of themselves. They will, however, have a generally riparian character, with water quality depending on source and development alternative.

Environmental quality. The overall environmental quality of this habitat ranges from good, if the water is saline, to poor if it is fresh. This habitat was not specifically discussed in the workshop, and may need some consideration. If wetlands associated with the channels are proposed, they should be minimal in size due to selenium concerns. Including sedimentation basins or traps before the water is discharged to the conveyance channels is highly recommended as a method of sequestering phosphorus and possibly DDE in addition to the sediment.

Flooded Saltgrass

Physical characteristics. This habitat is located near the shoreline and farther down in the basin, and is included in all restoration alternatives. The habitat would occur at elevations of about –220 to –240 feet, inside the margins of the current Sea. It is supplied with water in a variety of ways, making the habitat consist either of freshwater, or of moderately saline waters (between 2.5 and 15 PPT TDS). The habitat consists of shallow ponds constructed more or less on contour on exposed sediments or near-shore upland areas. Pond depth varies from 0.5 to 3 feet.

In the South Marine Lake without Elevation Control Alternative, flooded saltgrass stands would be present at the north, provided with water blended from the west conveyance channel and water from the Whitewater River. Additional saltgrass stands would be at the southwest edge of the Sea, provided with water blended from water pumped from the south Seaand mixed with water from the New River. All of these stands would be of moderately saline water.

In the South Marine Lake with Elevation Control Alternative, flooded saltgrass habitat is provided at the north end of the Sea with blended water from the Whitewater River and the South Sea as delivered in the channels, so the water quality could be up to about 15 PPT.

In the North Marine Lake with Elevation Control Alternative, flooded saltgrass plant substrate would be created at the delta areas of the New and Alamo Rivers, as freshwater habitats using river water.

In the No Marine Lake Alternative with Pumping Option, discharges from the channel south of Niland and of Salton City would form flooded saltgrass habitat, using blended water from the rivers and the Sea, for a moderately saline environment. In the No Marine Lake Alternative with No Pumping Option, flooded saltgrass would be provided with water from freshwater conveyance channels from the New and Alamo Rivers.

Suspended solids in the water are very low, as is the nutrient content, both being removed by physical and biological action in these ponds themselves. Eutrophication is therefore also low. Selenium concentration is medium (6-15 ppb), as it is not removed by the ponds themselves. If the water is blended with Sea water, selenium concentrations could be lower. The evaporation rate in these ponds would be about that of fresh water (5.6 feet per year), and the water would remain in any given pond for about 4-120 hours (5 days), depending on season and management practices. Wind fetch across the ponds would be of short length, and the ponds would in general border on similar habitat or other forms of waterfowl habitat, including wildlife sanctuaries.

Biological characteristics. This habitat would probably be rich in life, harboring bacteria, algae, and higher plants. The invertebrates present would be those characteristic of freshwater or moderately saline environments. Birds attracted to this area would be waterfowl and wading birds which feed on plants and invertebrates found in freshwater and moderately saline environments.

Function of the habitat type. These shallow ponds would provide important foraging, resting, and nesting habitat for waterfowl and wading birds. The ponds would evaporatively concentrate water for delivery to other habitat types downslope. The habitat would also be important for dust control, as it would occur on sediments exposed by the drying lake.

Environmental quality. The overall environmental quality of this habitat is judged to be fair. The habitat type was not specifically considered in the workshop, but if the habitat were seasonally flooded there would be concern with the re-mobilization of soluble forms of selenium from the sediments.

Fresh Water Waterfowl Fringe Habitat

Physical characteristics. This habitat is located near the shoreline in only the No Marine Lake with No Pumping Alternative, as this alternative has no options for blending of water to create upslope saline habitats. It would occur at elevations of about –220 to –240 feet, inside the margins of the current Sea. It is supplied with water directly out of the two river systems, via forebays and channels that deliver the water to ponds constructed more or less on contour on exposed sediments or near-shore upland areas. Pond depth varies from 0.5 to 3 feet. The water is quite fresh, varying from about 2.5 to a maximum of 15 PPT TDS. When it exceeds 15 PPT TDS, it would be considered to be saline waterfowl fringe habitat.(#10). Suspended solids in the water are low, as they should have been removed by sedimentation basins upstream. Nutrient content, however, is high, especially in phosphorus. Eutrophication is therefore also high. Selenium concentration is medium (6-25 ppb). The evaporation rate in these ponds would be about that of fresh water (6.5 feet per year), and the water would remain in any given pond for about 1-10 days, depending on season. Wind fetch across the ponds would be of medium length, and the ponds would in general border on similar habitat or other forms of waterfowl habitat.

Biological characteristics. This habitat would probably be rich in life, harboring bacteria, algae, and higher plants. The invertebrates present would be those characteristic of freshwater environments, as would the fish. Birds attracted to this area would be waterfowl, fisheating, and wading birds which feed on plants, invertebrates, and fish found in freshwater environments.

Function of the habitat type. These shallow ponds would provide foraging, resting, and nesting habitat for waterfowl, fisheating, and wading birds. There would be a high rate of return for reducing any remaining suspended solids, nutrients, and selenium, as the habitat would tend to be low in oxygen. It would promote the growth of a variety of higher plants in a wetland setting. The ponds would evaporatively concentrate water for delivery to other habitat types downslope. The habitat would also be important for dust control, as it would occur on sediments exposed by the drying lake.

Environmental quality. The overall environmental quality of this habitat is judged to be fair. The main problem is selenium, which would be in concentration too high for good quality habitat.

Saline Waterfowl Fringe Habitat

Physical characteristics. This habitat is the one that was principally discussed during the workshop, and would be present in all alternatives. In would be located downslope of freshwater habitats if they exist, or at somewhat higher elevations if freshwater habitats are a lesser or absent part of a restoration scenario. It would occur at elevations of about –240 to –255 feet, well inside the margins of the current Sea. It is supplied with water either from conveyance channels following blending of river water with water pumped from the larger body of the Sea, or as the downslope recipient of water flowing through freshwater habitats upslope following evaporative concentration. It could also be developed with discharge water from the restored portion of a divided Sea, which is the biologically preferred scenario. Shallow ponds are constructed more or less on contour on the exposed sediments and vary in depth from 0.5 to 3 feet. The water is saline, varying from about 15-50 PPT TDS. Suspended solids in the water are low, as they would have been removed either by sedimentation basins or by deposition in the Sea. Nutrient content is probably low-medium, as phosphorus may have been sequestered in the Sea sediments. Eutrophication is therefore also low to medium. Selenium concentration could be low (1-2 ppb), resulting from implementation with Salton Sea water which has acted as a selenium filter. The evaporation rate in these ponds would be slightly lower than that of fresh water (6.0 feet per year), and the water would remain in any given pond for about 1-4 weeks, depending on season. Wind fetch across the ponds would be of medium length, and the ponds would in general border on similar habitat or other forms of waterfowl habitat.

Biological characteristics. This habitat would probably be somewhat restricted in life form, harboring bacteria and algae, but largely excluding higher plants. The invertebrates present would be those characteristic of saline environments, as would the fish. Birds attracted to this area would be saltwater fisheating birds and wading birds which feed on the invertebrates and fish found in moderately saline environments.

Function of the habitat type. These shallow ponds would provide foraging, resting, and nesting habitat for waterfowl, fisheating, and wading birds. The ponds will evaporatively concentrate water for delivery to other habitat types downslope. The habitat would be important for dust control, as it would occur on sediments exposed by the drying lake.

Environmental quality. The overall environmental quality of this habitat is judged to be very good. If the habitat is implemented using only Salton Sea water, the selenium concerns are considerably ameliorated.

Shallow Flood Hyperbrine Concentrator Habitat

Physical characteristics. This habitat is located downslope of other saline habitats, or at somewhat higher elevations if water is pumped to them as part of a restoration scenario. It forms a part of all scenarios considered, and would occur at elevations of about –235 to –255 feet, well inside the margins of the current Sea. It is supplied with water either pumped directly from the larger body of the Sea, or as the downslope recipient of water flowing through saline habitats upslope following evaporative concentration. Shallow ponds are constructed more or less on contour on the exposed sediments and vary in depth from 0.5 to 4 feet. The water is hyper-saline, varying from about 50 to120 PPT TDS. Suspended solids in the water are low, as it will have been removed by either sedimentation basin or by deposition in the Salton Sea. Eutrophication is low to medium. Selenium concentration is low (1-2 ppb), having been removed by sequestration in the Salton Sea sediments. The evaporation rate in these ponds would be lower than that of fresh water (5.0 feet per year), and the water would remain in any given pond for only about 4-10 days, depending on season. Wind fetch across these small ponds would be of short length, and the ponds would in general border on similar habitat, salt flats, or other forms of waterfowl habitat.

Biological characteristics. This habitat would probably be somewhat restricted in life form, harboring bacteria and algae, but completely excluding higher plants. The invertebrates present are those characteristic of hyper-saline environments. There are no fish. Birds attracted to this area would be only wading birds which feed on the invertebrates found in these hyper-saline environments.

Function of the habitat type. These shallow ponds would provide foraging, resting, and possibly nesting habitat for certain wading birds. The ponds will evaporatively concentrate water for delivery to salt crystallizer and bittern ponds. The habitat would be important for the generation of brines for dust control, as it would occur on sediments exposed by the drying lake.

Environmental quality. The overall environmental quality of this habitat is judged to be fair. Specifics of the environmental benefits and liabilities [were?] discussed in the workshop.

A.10 Review of the Restoration Alternatives

In light of the results of the workshop on shallow habitat, the restoration alternatives can be discussed relative to their ability to provide the habitat qualities called out by the workshop participants. Although the workshop did not specifically evaluate each alternative in light of opportunities for shallow habitat, the workshop coordinators have taken the information generated by the workshop participants and undertaken the following conceptual analysis. We recognize that the actual configuration of the alternatives could be modified, but this discussion is intended to call out the advantages and disadvantages of each alternative as currently presented, as it relates to the shallow habitats discussed at the workshop.

South Marine Lake without Elevation Control. This alternative would provide minimal opportunities for diverting saline water into shallow shoreline habitats without pumping. With the barrier, the salinity of the water on each side of the barrier would be different, but the elevation would be essentially the same. Therefore, in order to provide saline water to shoreline habitats, pumping would be required. With pumping, however, there is ample opportunity to construct habitat near the shore and in proximity to existing refuge habitat on clay soils with shallow slope, in the south portion of the basin as well as near the Whitewater River at the north. An additional feature of this alternative is that almost all of the conveyance channels would be brackish water instead of fresh, and selenium could be diluted.

South Marine Lake with Elevation Control Alternative. This alternative would have fewer opportunities to develop shallow habitat on clay soils with shallow slope in the vicinity of existing preserve lands, as compared to the North Marine Lake with Elevation Control Alternative. The shoreline areas exposed in the north half of the Sea are generally steep and sandy, with the exception of the Whitewater River delta. The maintenance of the south lake at the elevation of the current Sea facilitates using the Sea water for shallow habitat near the shoreline with minimal pumping. If habitat is to be developed associated with the Whitewater River, however, pumping would be required in order to deliver Sea brine to that wetland to dilute the selenium sufficiently.

North Marine Lake with Elevation Control Alternative. This alternative would have the ability to provide saline or at least brackish water habitat in areas that would be close to the shoreline and in the vicinity of existing refuge or preserve lands, and which could be constructed where clay soils and shallow slopes are present. With the North Lake held at the elevation of the current Sea, the delivery of saline water to the shallow habitats could be accomplished with a minimum of pumping. This alternative could be modified to minimize habitat utilizing the relatively selenium-rich river and drain water, all of which could be diverted to the North Lake via conveyance channels. From the point of view of shallow habitat, this alternative is quite viable.

No Marine Lake, with Pumping Option. This alternative has also provides no opportunities for developing shallow habitat with saline water without pumping, but pumping is specifically provided for in this alternative. Since the residual Sea would be hyper-saline in this alternative, however, blending with river or drain water would be required in order to target the desired salinity for the habitat. Blending was not a preferred method of supplying water, due to selenium concerns. If blending were not used, the shallow habitat would be hyper-saline, as is the Sea. This alternative does provide ample location for habitat construction on clay soils with shallow slopes near existing refuges both at the north and south portions of the basin.

No Marine Lake, No Pumping Option. This alternative provides no opportunity to create shallow habitat with saline water, as the brine in the residual Sea could not be diverted using gravity to shoreline areas for habitat development. Any shallow habitats, then, would have to begin with river or drain water, and could concentrate to more saline conditions. The selenium concentration in the river and drain water, however, makes this an unattractive option. Even though exposed shorelines with clay soils and shallow slopes are present, any habitat constructed in them would be of poor to unacceptable quality.

Overall, from the point of view of shallow habitat, a preferred alternative would have the following features:

- Construction opportunities at the south areas of the basin, on clay soils with shallow slopes adjacent to existing refuge and reserve lands. This requirement eliminates the South Marine Lake with Elevation Control alternative, but remains feasible with the other scenarios.

- Gravity delivery of water from a restored portion of the Sea, which would be low in selenium and of a salinity about that of ocean water. This requirement would be possible with a south or north marine lake.

- A pumped delivery of water from a restored portion of the Sea, which would be low in selenium and of a salinity about that of ocean water. This would be possible with all scenarios, but more pumping would be required with the barrier and the no barrier alternatives.

A.11 Next Steps

The following actions were suggested specifically by workshop participants. The workshop coordinators have proposed some possibilities for accomplishing these actions, which should be part of the ongoing restoration efforts for the Salton Sea.

1. A responsible monitoring program for the entire Salton Sea, including the river and drain inputs, should be designed, funded, and implemented. The Salton Sea Science Office is the logical lead for this effort, which should include comprehensive data on physical and chemical characteristics of the Sea, taken from more than a single point, and repeated at least quarterly at standardized sampling locations over the course of at least a year. Participation for design of the studies and technical review of the data should be sought from the participants in the water quality workshop. This monitoring program should be implemented as soon as possible, but certainly before the end of 2004.

2. Review the applicability of National Resource Conservation Service (NRCS) specifications for berms, dikes, and levees. The planning team headed by Tetra Tech is a logical lead for this effort. The review should include an informed participant from the NCS who has had on-the-ground experience with the infrastructure elements under evaluation. The review should return a report that details the conditions of salinity, moisture, texture, and exposure to wind fetch that can be expected to result in effective implementation of each infrastructure element evaluated. This review should be accomplished as part of the current contract for developing a preferred alternative for Salton Sea restoration.

3. Develop a data base that would include photos of each bird species of concern and its habitat requirements. This could be accomplished by consulting Birds of the Salton Sea and the text Cowardin's Wetland and Deepwater Habitats (Cowardin et al. 1979). The Salton Sea Science Office is a logical lead for this project, which could be usefully contracted to any qualified individual of team. The Science Office, in consultation with participants from the biology workshop, should determine the list of species to be included in the data base. As it includes a compilation of existing data, it is a task that should be accomplished before the end of 2004.

Appendix B
COST ANALYSIS OF THE PREFERRED PROJECT

B.1 Introduction

A preliminary cost assessment has been prepared for the preferred restoration project. This appendix provides an overview of the assumptions and factors used for developing the cost estimate of the preferred project. The overall cost summary is provided in Table B-1. An important component of the overall cost of the plan would be the central impoundment structure. Table B-1 includes cost estimates for two possible designs for the impoundment structure and two possible design elevations for the water surface of the marine lake. Lowering the design elevation would lower the cost of the impoundment structure and affect the cost of some other features.

B.2 Cost Elements

Each of the features included in the cost estimate are discussed briefly below:

Impoundment Structure/Causeway—Various conceptual designs have been considered for the central impoundment structure. These concepts along with cost estimates for each are described in URS (2204). A working group of 15 civil and geotechnical engineers was convened to review the feasibility of constructing a dike, or retention structure/causeway anywhere within the Salton Sea. The group reviewed data from the recent geotechnical investigation of the Sea and suggested alternative design concepts. Cost estimates were developed based on the concepts identified by this group. Cost estimates are very preliminary at this point, and, as of this writing, have not yet undergone review by the work group.

Of the concepts proposed by the work group, the most cost effective structure appears to be a blanketed rockfill design. This concept would consist of an embankment built in the water and entirely out of rock fills. To mitigate seepage through the dam, a blanket of fine material would need to be placed on the upstream slope. Conventionally, this is usually an asphalt or concrete pavement. However, the Sea level would preclude those for this concept. The upstream blanket for this concept would consist of depositing fine-grained soils on the upstream slope to "plug" the rockfill. Ten to 25 feet of the weak soils below the embankment would

Table B-1. Preliminary Cost Estimate for Preferred Alternative Concept

Item	**Cost ($M) at El=-235' msl**		**Cost ($M) at El=-240' msl**	
Initial Construction Costs	Blanketed Rockfill	Rockfill w Slurry Wall	Blanketed Rockfill	Rockfill w Slurry Wall
Mid-Sea Retention Structure/Causeway	$ 418	$ 489	$ 354	$ 418
Appurtenant Structures (Spillways, etc.)	21	24	18	21
Dredging to Communities & Island Creation	6	6	20	20
Greenbelt Channels to North Lake (Incl. 20 sed. basins, 2,500 ac wetland, 20% planted)	76	76	66	66
Recreational Lake (approx. 1,000 ac)	45	45	45	45
Torres Martinez Wetlands/Habitat	20	20	20	20
Upstream Wetlands (Top 5 sites, 1376 ac)	58	58	58	58
Shallow Water Habitat Initial Phase (2,000 ac)	8	8	8	8
Total Construction Costs (rounded)	**$ 650**	**$ 730**	**$ 590**	**$ 660**
Annual Costs	**Cost ($M/yr)**		**Cost ($M/yr)**	
Causeway, Channel & Appurtenance O&M	$ 5.1	$ 5.9	$ 4.4	$ 5.0
Add Shallow Habitat (500-1,000 ac/yr)	3.0	3.0	3.0	3.0
Habitat O&M	2.0	2.0	2.0	2.0
Total Annual O&M ($M/yr)	**$ 10.1**	**$ 10.9**	**$ 9.4**	**$ 10.0**
Present Value of Annual Costs ($M) - based on 30 yrs	$ 150	$ 160	$ 140	$ 140
Total Present Value Cost ($M)	**$ 800**	**$ 890**	**$ 730**	**$ 800**

Note: Does not include costs for development of recreational facilities, new highways, or new lakeside development.

be excavated and replaced with rock fills. This material could be used to provide the blanket. Alternatively, a bentonite slurry wall could be constructed through the dam along its crest to provide a seepage barrier. The slurry wall would add $60 to $75 million to the project. The conceptual design includes inclinations of 4:1 on the upstream slope and 7:1 on the downstream slope. The crest of the dam would be 30 feet wide and provide for 5 feet of freeboard above the lake.

Lower marine lake levels would require less embankment volume for the impoundment structure, and would cost less. Table B-1 presents the estimated costs for the Blanketed Rockfill structure for lake elevations of –235 and –240 feet relative to mean sea level (msl). This evaluation indicates that the mid-Sea dam would cost about $100 million less with a 5 foot drop in lake level below -235 feet msl. Conversely, if the structure were designed to maintain the current water elevation, the cost estimates would go up by about $150 million.

Appurtenant Structures—The cost of appurtenances such a spillways and other outlet, and the channels leading to shallow water have been factored in as five percent of the impoundment structure.

Table B-2. Preliminary Cost Estimates for Dredging for Lake Access to Communities.

Elevation (ft msl)	El Drop (ft)	Ave. Dredge Depth (ft)	Dredge Area (ac)	Dredge Access Area (ac)	Total Dredge Area (ac)	Dredge Volume (mcy)	Base Dredge Cost ($M)	+Mob & Unlisted ($M)	+Contin-gencies ($M)	+Non-Contract ($M)
227	0	0	0	0	0	0.0	$0.00	$0.00	$0.00	$0.00
228	1	2	5	0.5	5.5	0.0	$0.05	$0.06	$0.07	$0.10
229	2	4	10	1	11	0.1	$0.21	$0.24	$0.30	$0.38
230	3	6	15	1.5	16.5	0.2	$0.46	$0.53	$0.67	$0.87
231	4	8	20	2	22	0.3	$0.82	$0.95	$1.18	$1.54
232	5	10	25	2.5	27.5	0.4	$1.29	$1.48	$1.85	$2.40
233	6	12	30	3	33	0.6	$1.85	$2.13	$2.66	$3.46
234	7	14	37	4	41	0.9	$2.59	$2.98	$3.72	$4.84
235	8	14	45	5	50	1.1	$3.28	$3.77	$4.71	$6.12
236	9	15	55	6	61	1.4	$4.14	$4.76	$5.95	$7.73
237	10	15	75	8	83	2.0	$5.82	$6.70	$8.37	$10.89
238	11	16	105	10	115	2.9	$8.34	$9.59	$11.99	$15.58
239	12	16	125	12	137	3.5	$10.26	$11.79	$14.74	$19.17
240	13	17	145	14	159	4.2	$12.27	$14.12	$17.64	$22.94
241	14	17	185	18.5	203.5	5.6	$16.19	$18.61	$23.27	$30.25
242	15	18	225	22.5	247.5	7.0	$20.26	$23.30	$29.13	$37.87
243	16	18	265	26.5	291.5	8.5	$24.55	$28.23	$35.29	$45.88
244	17	19	325	32.5	357.5	10.7	$30.94	$35.59	$44.48	$57.83
245	18	19	385	38.5	423.5	13.0	$37.65	$43.29	$54.12	$70.35

Dredging to Communities and Island Creation—With lowered lake levels, existing Sea-side communities would be at some distance from the Sea. Dredging is proposed to maintain access to the Sea for these communities. Dredging could also create islands and peninsulas that would provide recreational and habitat value as well as create opportunities for development. Dredging cost estimates are based on preliminary estimates of the quantities that would need to be removed for different lake elevation targets. A raw unit cost of $2.9 million/million cubic yard (mcy) was then applied for dredging along with factors for mobilization, unlisted items, contingencies, and costs such as design and construction oversight.

The areal extent of dredging and the quantity of material to be removed were estimated by first evaluating the most extreme lower lake elevation of -245 feet msl. For this lake elevation, the length of channels needed to provide access to all current Sea-side communities was calculated as 16 miles. Dredging these channels would create several islands and peninsulas around the Sea that would be available for future development or for recreational or wildlife habitat uses. Using a channel width of 200 feet, about 385 acres of exposed sediments would need to be dredged to create the channels. It was assumed that this area would be dredged to a water depth of 10 feet in the reclaimed areas. In addition, adjacent areas still under water, but with water depths less than 10 feet, would need to be dredged to provide access.

Estimates for other lake elevations were developed by a series of scaling assumptions from the calculation for elevation -245 feet msl discussed above. The dredging cost estimates for a range of elevations from the current level of -227 feet msl down to -245 feet msl are provided in Table B-2.

Greenbelt Channels to the Lakes with Wetlands and Sedimentation Basins— The New and Alamo rivers would need to be extended to reach the north basin marine lake (Figure B-1). The cost of constructing a wetland greenbelt area around these river extensions has been included along with the cost of constructing 20 sedimentation basins. The Nolte (2002) report commissioned by the Citizens Congressional Task Force to evaluate potential wetland sites that could be developed in the New and Alamo river channels was used as an important source of cost information.

The wetland greenbelt for both channels was estimated at 2,500 acres and it was assumed that vegetation would be planted on 20 percent of this area. It was assumed that over time vegetation would grow to fill the area. The unit cost for vegetation was also taken from Nolte (2002). For purposes of providing costs of a preferred project, wetlands and sedimentation basins were assumed. However, if other biological or chemical treatments are found more effective some amount of wetlands or sedimentation basins could be replaced with such treatments.

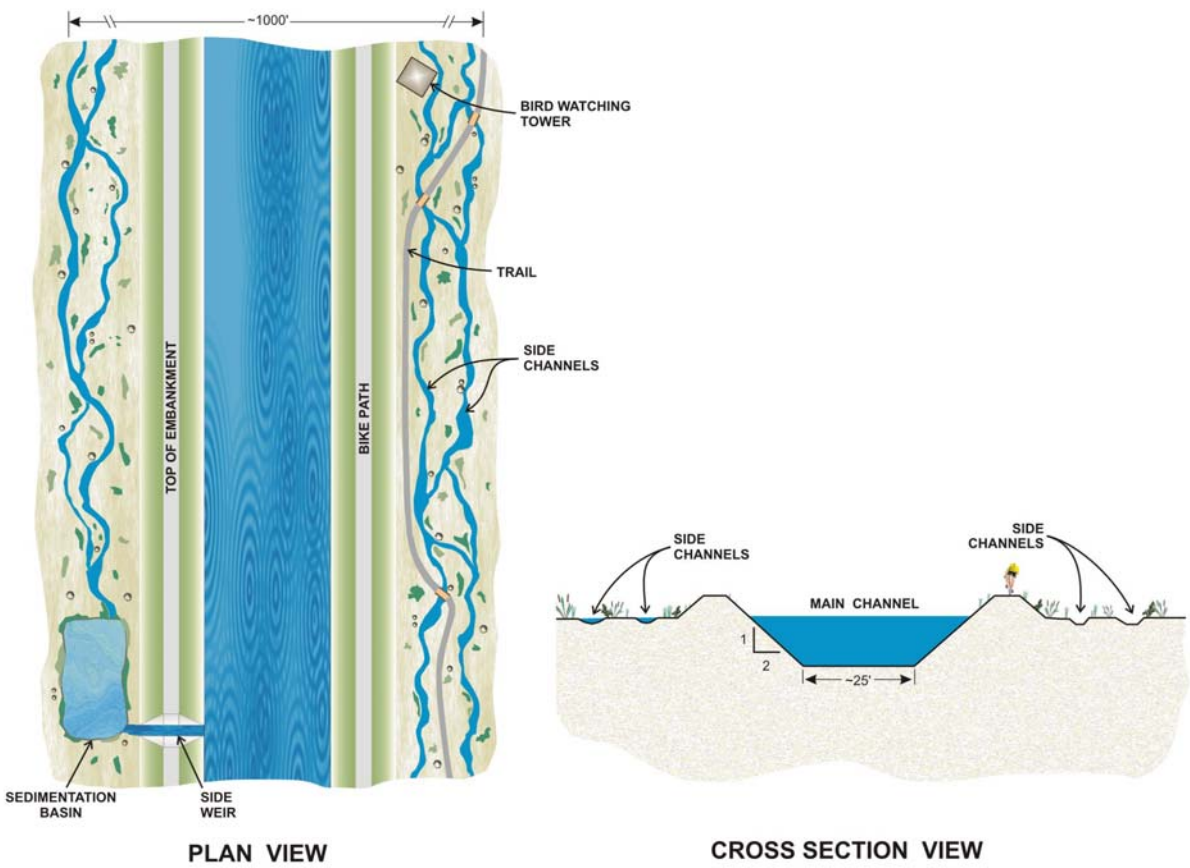

Figure B-1. Schematic of Greenbelt Channel Extension Concept.

Table B-3. Cost Estimate for Top 5 Wetland Sites from Nolte (2002).

Site	Ranking Score	Area (ac)	Cost Est.	Unit Cost ($/ac)
NR16	27	585	$24,640,000	$42,119.66
NR17	27	320	$13,380,000	$41,812.50
AR14	31	313	13,750,000	$43,929.71
NR32	33	93	$3,900,000	$41,935.48
NR26	34	65	$2,750,000	$42,307.69
Top 5 Sites		**1376**	**$58,420,000**	**$42,456.40**

The Nolte (2002) report identifies 4,276 acres of potential wetlands for a cost of $182 million. To achieve water quality targets, this report assumes 1,376 acres in the five highest rated sites of those wetlands could be constructed in the first phase of the proposed project (Table B-3).

For sedimentation basins, estimates were derived from the evaluation of plans to desalt the Alamo and/or New Rivers. US Filter, Black & Veatch and others have, in the past, suggested desalting the rivers in the Imperial Valley to provide product water for sale to urban or other communities. To properly operate such desalting plants, river water must be very clear. To reduce turbidity, a rule of thumb is often used that sedimentation basins should have an area of about 10 square feet for every gallon per minute of flow. That translates to a requirement of 110 acres of sedimentation basins to treat a flow of 800,000 acre-feet/year. The base cost for these was taken from the Nolte (2002) report on constructing wetlands on the New and Alamo Rivers, for a typical 5.5 acre sedimentation basin. Constructing 20 5.5 acre sedimentation basins will provide the total 110 acres needed for sedimentation.

Cost estimates for channel extensions including the greenbelt areas are provided in Tables B-4 and B-5, for marine lake elevations -235 feet msl and -240 feet msl, respectively. A lower marine lake elevation will allow for a greater channel slope, and thus a smaller cross section and lower construction costs. Channels were assumed to be excavated and unlined. Excavated material would be compacted and used to create embankments on either side of the channels.

Other Features—Preliminary cost estimates have been included for three other features: a 1,000 acre shallow recreational lake, a Torres Martinez wetlands/habitat feature, and an initial phase of shallow water habitat construction. Shallow habitat areas were assumed to be graded at a cost of about $2,000/acre as a base cost and $4,000/acre when all contingencies are included.

Operation and Maintenance Costs and Other On-Going Costs—Preliminary estimates have been provided for operation and maintenance of the various features. In addition, costs are included for future build-out of shallow water habitat which would be phased-in later. These areas would provide habitat for birds as well as help with dust suppression.

Table B-4. Channel Cost Estimate for Both River Extensions to North Lake
Lake Elevation = -235

Variable	New R	Alamo R	Totals
Q (AFY)	500,000	450,000	950,000
Q (cfs)	691	622	1,312
Ave. Side Slope (1:SS)	2	2	
Bottom Width (ft)	29	25	
Top Width (ft)	69	64	
Depth in Main Channel (ft)	10	10	
Ave. Depth (ft)	7	7	
Velocity (fps)	1.4	1.4	
Freeboard[1] (ft)	2.0	2.0	
Length (mi)	21.8	19.4	41.2
Length (ft)	115,104	102,432	217,536
Channel Excavation (cu yd)	2,757,618	2,187,292	4,944,910
Wetland Side Channel Area (%)	20%	20%	
Sinuosity	3.0	3.0	
Wetland Excavation (cu yd)	1,654,571	1,312,375	2,966,946
Total Excavation (cu yd)	4,412,189	3,499,667	7,911,856
Excavation Unit Cost ($/cu yd)	$2.35	$2.35	
Compact Embankment ($/cu yd)	$1.50	$1.50	
Channel Cost	**16,986,928**	**13,473,719**	**30,460,646**
Vegetation (ac/mi)	12	12	
Vegetation ($/ac)	$16,335	$16,335	
Vegetation Cost	**$4,273,236**	**$3,802,788**	**$8,076,024**
No. of Sedimentation Basins	10	10	
Sedimentation Basin Unit Cost	$114,422	$114,422	
Sedimentation Basin Cost	**$1,144,220**	**$1,144,220**	**$2,288,440**
Channel + Wetlands Base	$22,404,384	$18,420,727	$40,825,110
Mobilization (5%)	$1,120,219	$921,036	$2,041,256
Unlisted Items (+10%)	$2,240,438	$1,842,073	$4,082,511
Contingencies (25%)	$6,441,260	$5,295,959	$11,737,219
Noncontract Cost (30%)	$9,661,890	$7,943,938	$17,605,829
Total Cost	**$41,868,192**	**$34,423,733**	**76,291,925**
Evap. Losses in Channels (AFY)	1,101	907	2,008

[1] Additional freeboard would be provided by compacted embankments made from cut material.

Table B-5. Channel Cost Estimate for Both River Extensions to North Lake
Lake Elevation = -240

Variable	New R	Alamo R	Totals
Q (AFY)	500,000	450,000	950,000
Q (cfs)	691	622	1,312
Ave. Side Slope (1:SS)	2	2	
Bottom Width (ft)	15	23	
Top Width (ft)	59	58	
Depth in Main Channel (ft)	11	9	
Ave. Depth (ft)	7	6	
Velocity (fps)	1.7	1.7	
Freeboard[1] (ft)	2.0	2.0	
Length (mi)	21.8	19.4	41.2
Length (ft)	115,104	102,432	217,536
Channel Excavation (cu yd)	2,238,461	1,838,924	4,077,385
Wetland Side Channel Area (%)	20%	20%	
Sinuosity	3.0	3.0	
Wetland Excavation (cu yd)	1,343,076	1,103,354	2,446,431
Total Excavation (cu yd)	3,581,537	2,942,278	6,523,815
Excavation Unit Cost ($/cu yd)	$2.35	$2.35	
Compact Embankment ($/cu yd)	$1.50	$1.50	
Channel Cost	**13,788,919**	**11,327,770**	**25,116,689**
Vegetation (ac/mi)	12	12	
Vegetation ($/ac)	$16,335	$16,335	
Vegetation Cost	**$4,273,236**	**$3,802,788**	**$8,076,024**
No. of Sedimentation Basins	10	10	
Sedimentation Basin Unit Cost	$114,422	$114,422	
Sedimentation Basin Cost	**$1,144,220**	**$1,144,220**	**$2,288,440**
Channel + Wetlands Base	$19,206,375	$16,274,778	$35,481,153
Mobilization (5%)	$960,319	$813,739	$1,774,058
Unlisted Items (+10%)	$1,920,637	$1,627,478	$3,548,115
Contingencies (25%)	$5,521,833	$4,678,999	$10,200,831
Noncontract Cost (30%)	$8,282,749	$7,018,498	$15,301,247
Total Cost	**$35,891,913**	**$30,413,491**	**66,305,404**
Evap. Losses in Channel (AFY)	928	823	1,752

[1] Additional freeboard would be provided by compacted embankments made from cut material.

B.3 References

Nolte Beyond Engineering. 2002. Reconnaissance Inventory of Wetland and Sedimentation Basin Sites: New and Alamo Rivers Prepared for The Citizen's Congressional Task Force on the New River. May.

URS. 2004. Mid-Sea Dam and Barrier Concepts Salton Sea Study. Riverside and Imperial Counties, California. July.

Appendix C
PERFORMANCE

Reclamation, IID, and CVWD have studied historic and potential future inflows to Salton Sea in detail (Weghorst, 2001). This hydrology work has served as the basis for the development of the Salton Sea Accounting Model (Model) which is used to forecast future salinity and elevation in the Sea. The Model has been used to assess the performance of restoration alternatives, as well as to evaluate the effects water transfer agreements. The Model is a computer application used to simulate the response to historic and expected future inflows to the Salton Sea.

This appendix focuses on the performance of the recommended preferred project, the alternative that includes a marine lake in the north with elevation control. Discussions of the performance of other alternatives considered in the main report are also provided along with comparisons to some other alternatives considered in the past.

C.1 Historic Inflow, Salinity and Elevation

Inflows to the Salton Sea are not constant and have varied from a minimum of 1.19 million acre-feet per year in 1992 to a maximum of 1.50 million acre-feet/year in 1963. Figure C-1a depicts a history of inflows into the Salton Sea for the years 1950 to 1999 (Weghorst, 2001). The average annual inflow for this period was 1.34 million acre-feet/year. The historic salt load into the Salton Sea has also been variable. Figure C-1b presents a history of salt load to the Sea. A minimum load of 3.0 million tons occurred in 1950. A maximum salt load of 6.1 million tons occurred in 1977. The average annual salt load to the Salton Sea for the period 1950 to 1999 was 4.5 million tons per year (ton/yr). It appears that salt loading has leveled off at around 4 million ton/yr.

In 2000-2001, the Salton Sea had an average salinity level of about 44,000 milligrams per liter (mg/L) (Weghorst, 2001). Expectations are that salinity levels within the Sea will continue to increase as a result of evaporation and continuous inflows of salt-laden water from agricultural drainage water from irrigation districts around the Sea and from agricultural and municipal use in Mexico.

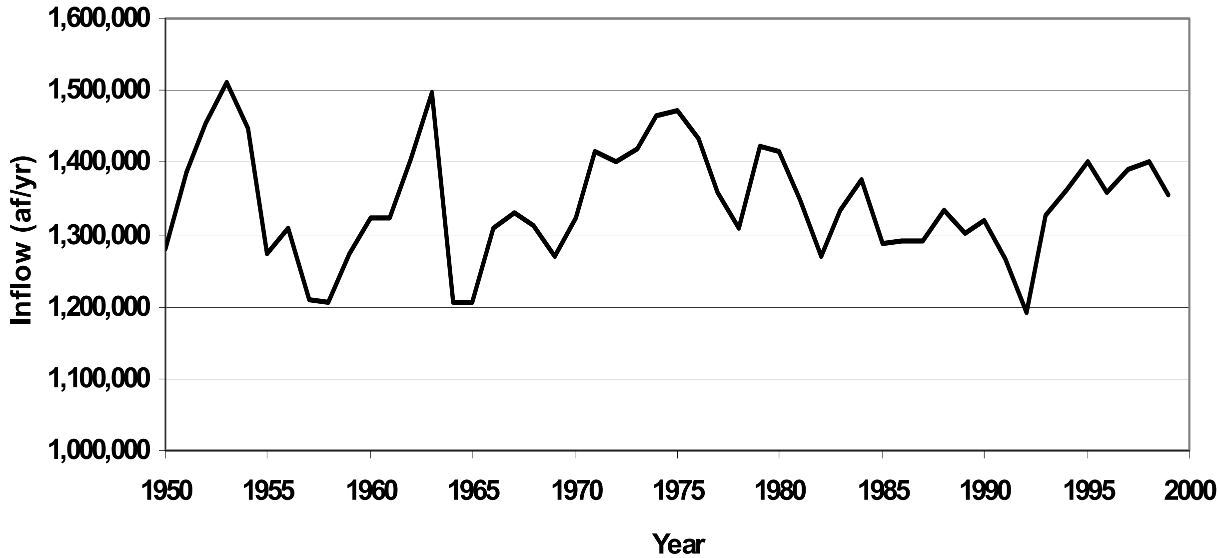

Figure C-1a. Total Historic Salton Sea Inflows (Source: Weghorst, 2001).

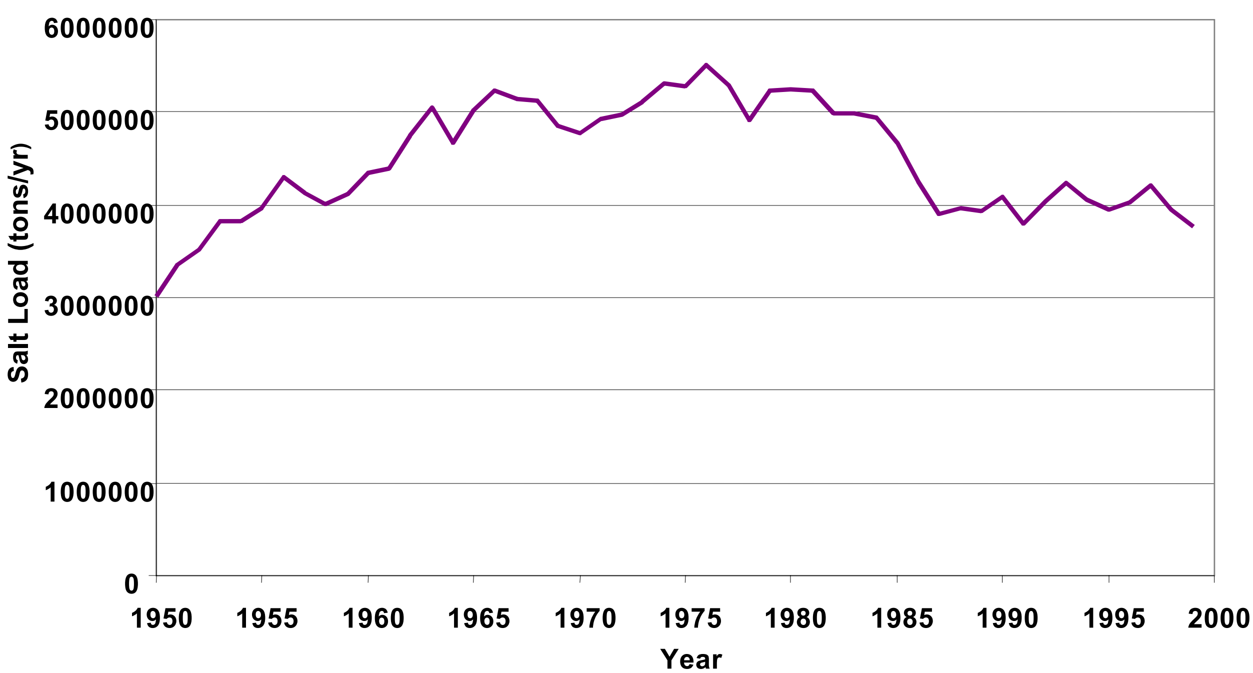

Figure C-1b. Total Historic Salton Sea Salt Load (Source: Weghorst, 2001).

IID estimates annual average salinity for the Sea from surface samples taken at Bertam Station, Desert Beach, Sandy Beach, and Salton Sea Beach. A historic record exists from 1950 through present, with data available up to 1999. Figure C-2a depicts historic Salton Sea salinity values through time. Beginning in 1992, the rate of salinity increase in the Sea began declining. A similar, but more pronounced, reduction in salinity occurred between 1972 and 1980. A much more dramatic reduction occurred from 1950 to 1955.

Inspection of the historic water surface elevations, presented in Figure C-2b, yields the conclusion that these early salinity changes occurred during periods of rising Sea elevations. Rising elevations were a result of increased inflows that provided significant dilution effects. When the elevation increases, salinity levels are observed to go down or level off. These trends were also observed during the post-1992 period where the trend indicated a leveling off of increases in salinity. However, the leveling of the increase in salinity from 1992 to 1999 was paired with only slight increases in elevation. This trend suggests that solids are precipitating or being biologically reduced from the Sea (Weghorst, 2001). This issue is discussed below.

The Sea's inverse relationship between salinity and water surface elevation is due to simple conservation of mass principles. Salinity can increase rapidly over a short period of time when evaporation exceeds inflows. Conversely, when inflows exceed evaporation, then dilution will occur and salinity will decrease. Under conditions of equal inflow and evaporation, only slight increases in salinity will occur due to salt loading from inflows.

C.2 Precipitation of Dissolved Solids

In December 2000, a Science Workshop was held in Riverside, California, to develop a joint opinion of scientists with knowledge in the field of salinity, salt precipitation, and biological reduction of sulfates within natural waters. It was concluded that dissolved solids are either being precipitated or biologically reduced within the Salton Sea as dissolved salts are added to Sea waters on an annual basis. It was concluded that, at a minimum, 0.7 million ton/yr of salts dissolved in inflow waters are being precipitated or reduced upon mixing in the Sea. It was also concluded that, at a maximum, 1.2 million ton/yr are either being precipitated and/or biologically reduced. If biologic reductions are occurring, then they could be reducing, for example, through actions of sulfate-reducing bacteria.

Given the wide range of possibilities that exist between 700,000 and 1.2 million ton/yr of salt loading, the Salton Sea Accounting Model was developed in a way so that this issue was handled as an uncertainty term. When the Model is operated in a stochastic mode, a different value for precipitation or reduction of dissolved solids is sampled from a uniform probability distribution defined by the above limits of 700,000 and 1.2 million ton/yr. The Model then reduces the salt load to the Sea on

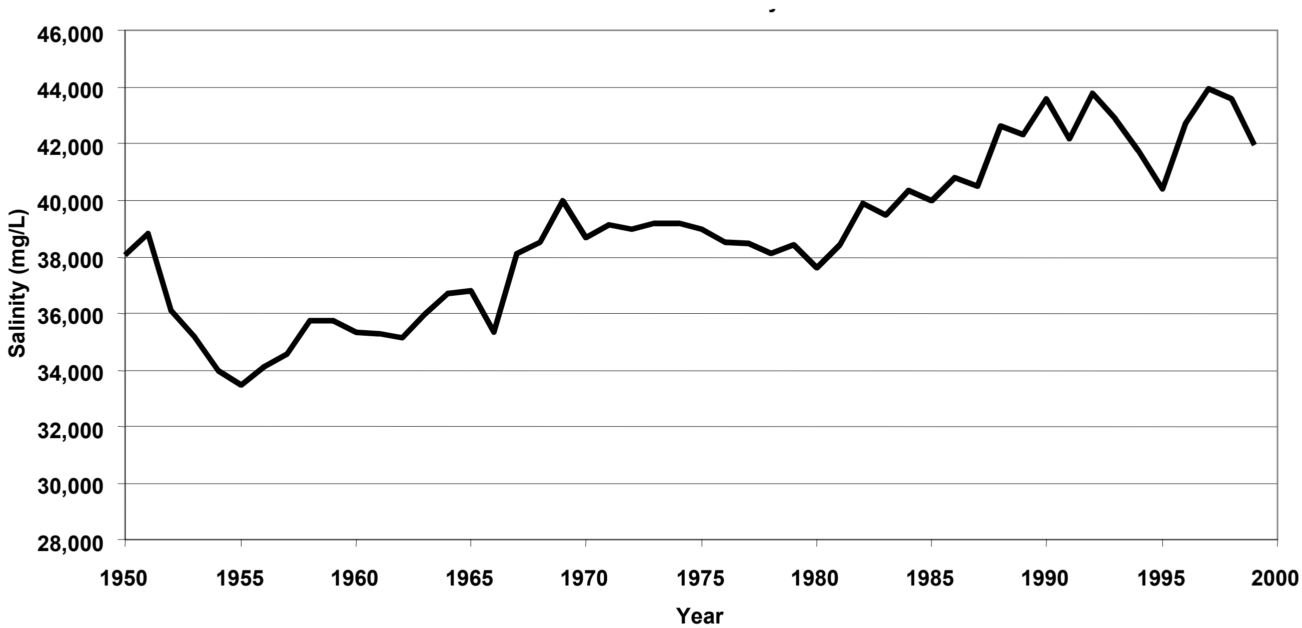

Figure C-2a. Historic Salinity Trend in the Salton Sea.

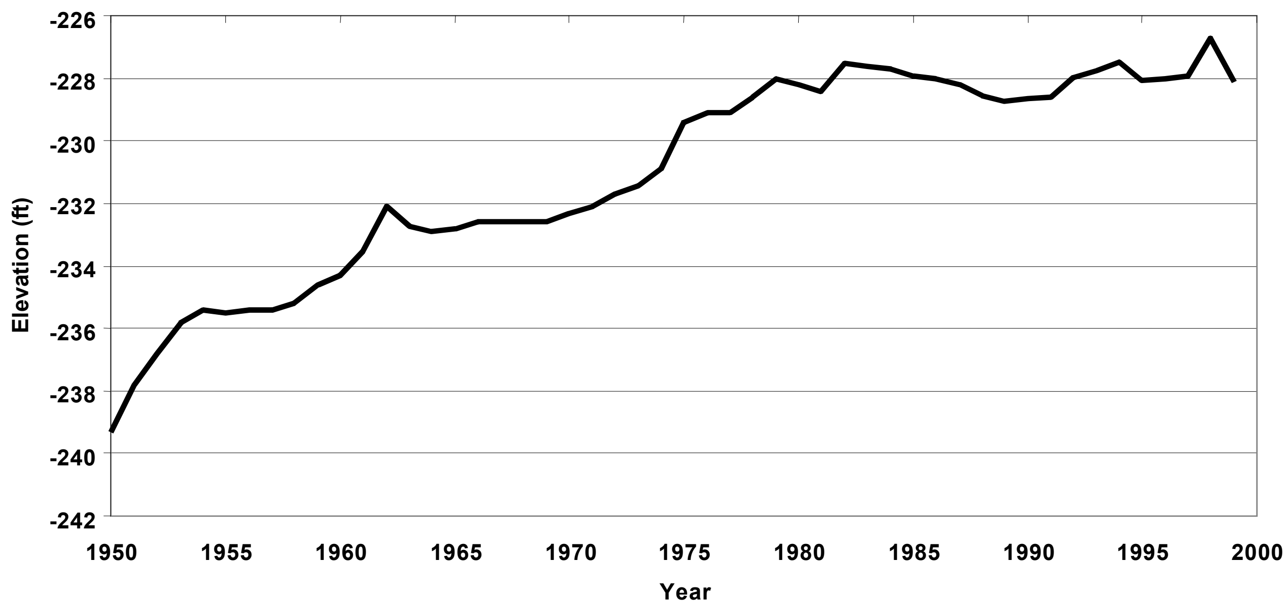

Figure C-2b. Historic Elevation Trend in the Salton Sea.

an annual basis by a corresponding amount to that which is sampled from the distribution. This results in Model simulations that account for the uncertainty of how dissolved solids are precipitating or reduced within the Salton Sea (Weghorst, 2001).

The Science Workshop participants were not able to come to any conclusions about whether or not the rate of precipitation and/or biological reduction would change at higher or lower salinities relative to current conditions. It was also not possible to ascertain whether or not salts that might have precipitated historically might be brought back into solution at lower salinities. There is good reason to believe that precipitation has not been occurring on a large scale and that biological processes are the dominate influence. Therefore if salts were to be re-dissolved at lower salinities then the amount available would be small. The Salton Sea Accounting Model therefore assumes that the uniform distribution used to stochastically simulate precipitation and/or reduction is applicable at both lower and higher salinities from current conditions.

C.3 Baseline Inflow Conditions

There are actions in place that are likely to affect, or have already affected, inflows to the Salton Sea. Included in these are a 4.4 million acre-feet/year normal year limited entitlement to Colorado River water for the State of California, increased salinity in the Colorado River, pre-existing conservation, historic aquifer pumping effects in the Coachella Valley, and activities in Mexico. The effects of these actions combined with meteorological, economic, and demand factors will define the near-term inflows. The exact effects of these historic actions are difficult to assess. For purposes of analysis in this report, the maximum future inflow conditions analyzed are similar to the baseline conditions used in the recently published Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the IID Water Transfer Program. The average future baseline inflow presented in this document is 1.23 million acre-feet/year.

The Model operates stochastically and, therefore, uses a different future sequence of inflows for each simulation. Figure C-3a presents a sample future inflow sequences with an average annual value of 1.23 million acre-feet/year.

The salt load to the Salton Sea is assumed to be equal to that forecasted by the water districts and presented by Weghorst (2001), which is consistent with an inflow of 1.23 million acre-feet/year. The average annual baseline salt load used in all simulations is 3.8 million ton/yr. Figure C-3b shows a sample stochastic sequence of inflowing salt load from the Model with an average annual value of 3.8 million tons/yr. The salt load is shown decreasing in the future because of Salton Sea water intrusion into the Coachella Aquifer.

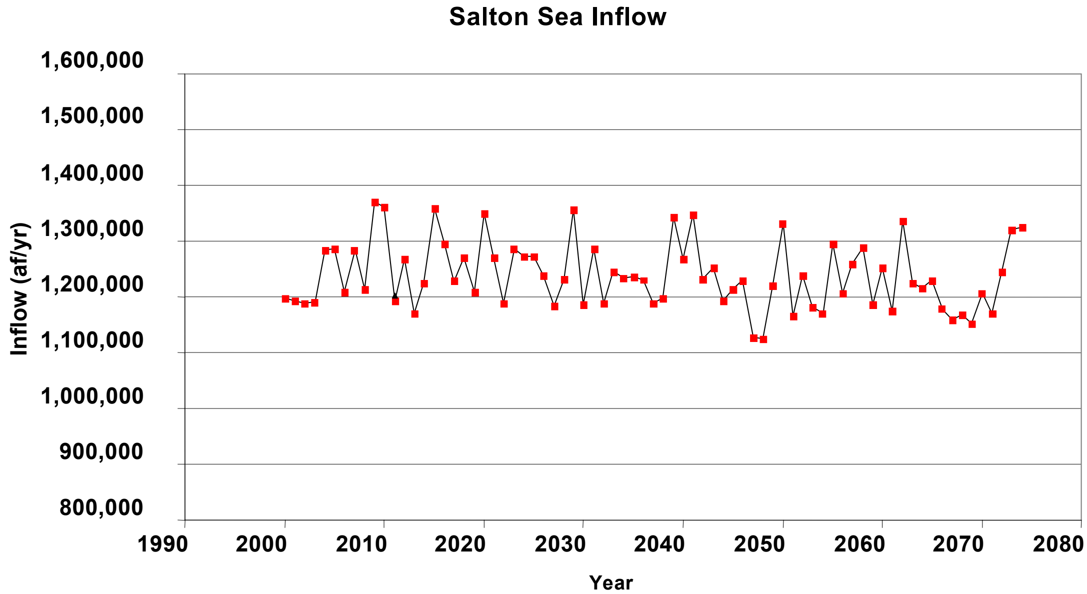

Figure C-3a. Forecasted Baseline Inflow Assumptions.

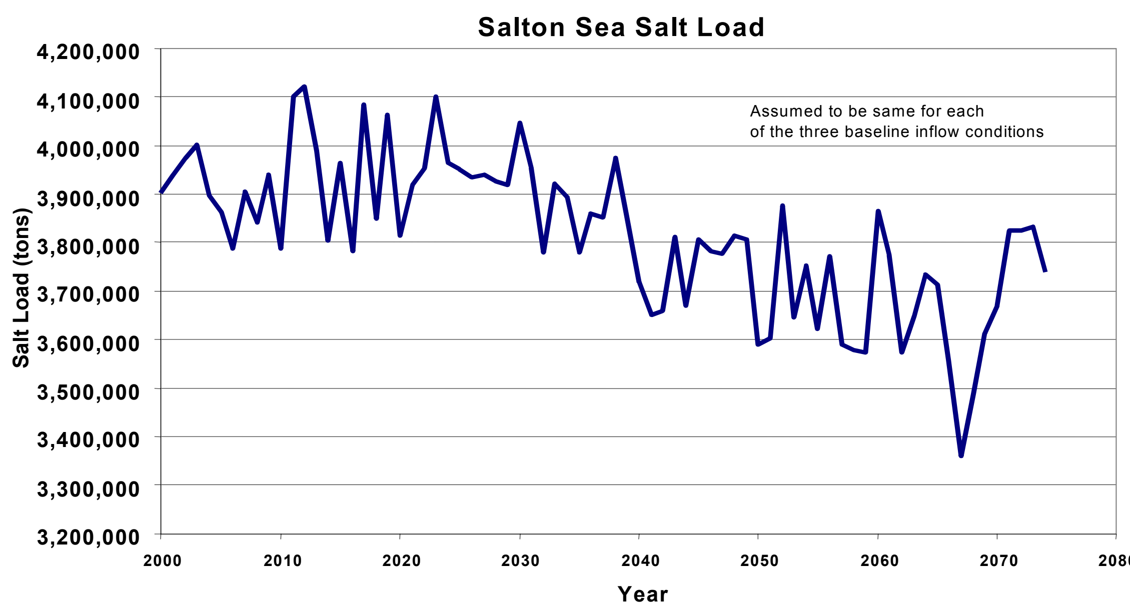

Figure C-3b. Forecasted Baseline Salt Load.

C.4 Future Inflow Projections

With implementation of the QSA, the average inflow to the Sea is expected to decrease over about 15 to 20 years from a baseline of 1.23 million acre-feet/year to an expected inflow of about 930,000 acre-feet/year. While the water transfer agreements contain predictable transfer schedules, there is an option for transferring up to 1.6 million acre feet of additional water if the water is not needed to mitigate effects to the Salton Sea. In addition, inflow to the New River from Mexico, where the flow originates, may also be subject to future reductions. For example, reductions in Colorado River flows to Mexico could, in turn, affect New River flows back across the border. It is also possible that the Coachella Valley groundwater management program would affect inflows. These variables translate to

an uncertainty with respect to actual Salton Sea inflows. Therefore, three inflow scenarios are considered in this report:

4. The anticipated QSA schedule that includes salinity management deliveries (mitigation water) to offset salinity effects to the Salton Sea over the next 15 years;

5. The QSA schedule with the salinity management water terminated in 2006 and sale of additional water to generate restoration funds; and

6. A schedule that would reduce average inflow to about 800,000 acre-feet/year.

The three inflow scenarios are illustrated in Figure C-4.

Under all three inflow scenarios, without restoration, salinity in the Sea would more than double over a period of 20 to 25 years, while the water surface elevation would decrease by about 20 feet over the same period.

C.5 Overview of Salton Sea Accounting Model

Assessment of the future of the Salton Sea is dependent on the ability to predict the hydrologic response of the Sea to changing conditions. Foreseeable changes include a range of water conservation programs within the Salton Basin, as well as possible restoration activities. Conservation programs would likely change inflows of both water and dissolved solids into the Sea. Predicting hydrologic response due to these possible changes requires a predictive computer model of the Salton Sea.

The Salton Sea Accounting Model was developed to predict hydrologic response to possible changes in the Sea (Weghorst, 2001). It allows the effective evaluation of historic, present, and future conditions within the Sea. Specifically, the Model

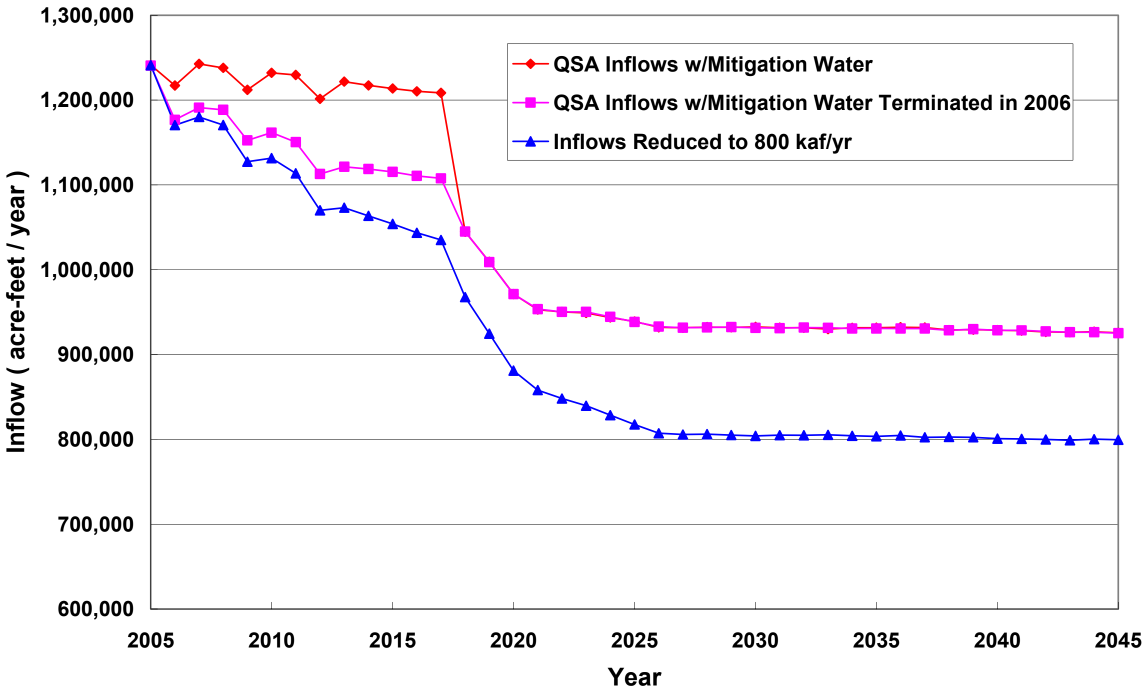

Figure C-4. Possible Future Salton Sea Inflow Scenarios Evaluated in this Report.

predicts changes in inflow, elevation, surface area, and salinity. Special operating requirements included the need to simulate:

- Future reductions in inflow
- Future changes in salt loads into the Sea
- Salt precipitation and/or biological reduction
- Imports of water
- Exports of water
- Dividing the Sea into two basins

The basics of the Model involve conservation of mass for both water and total dissolved solids (TDS). The Model maintains separate accounting of each and corresponding calculations of salinity. The Model follows the equations below for mass calculations (Weghorst, 2001):

- Water in Storage = Previous Water in Storage + Inflow – Evaporation + Rain

- Salt Content = Previous Salt Content + Salt Load – Precipitation (or reduction) of salts

The Salton Sea Accounting Model incorporates the ability to perform stochastic and deterministic simulations of Salton Sea conditions. The Model operates on an annual time step. Deterministic simulations of the Model assume that the hydrologic and salt load variability of the Sea will repeat in the future exactly in the same pattern each time the Salton Sea is simulated. Stochastic simulations imply that different hydrologic conditions are sampled and used in each simulation. Model results presented in this report are the result of stochastic simulations and represent mean futures for the Salton Sea. The term mean-future is used to represent the averaging of results from one thousand Model simulations. Therefore, any point removed from one of the simulation charts presented represents an average of one thousand simulations.

For the current modeling assessment, the full Salton Basin was divided into two basins with separate area-capacity tables for each. Inflows to the north end were optimized to achieve target water surface elevations and salinity in the shortest amount of time. Thereafter, inflows in the model were reduced to provide sufficient inflow to maintain Sea salinity close to the target value of 35,000 milligrams/liter. Any remaining inflows were diverted to the south basin and shallow habitat pond areas. Inflows to the south basin were a combination of diverted river flows and discharges from the north basin. In all model assessments it was assumed that the inflows were reduced as a result of evaporation or other losses in wetlands planned for development along the New and Alamo Rivers.

C.6 Salton Sea Accounting Model Results Without Project

Figures C-5a and C-5b illustrate the model results for the three inflow scenarios for salinity and elevation in the Salton Sea, respectively. Note that the QSA inflow case where mitigation water would be provided through 2018 is probably the most likely scenario for the no-project scenario. The model results for this case are also illustrated in Figure 2-3 in the main body of this report. The model results show that for this case, the salinity would double, reaching 90,000 mg/L in less than 25 years. For this inflow case, Figure C-5b shows that the elevation of the Sea is expected to drop about 20 feet.

C.7 Salton Sea Accounting Model Results for Preferred Project

The model was run by Reclamation for nine sets of conditions for the case where a causeway would be constructed across the central area of the Sea to divide it into north and south basins. The sets of runs were based on the three inflow scenarios shown in Figure C-4 and three possible design water surface elevations for the north marine lake: -230 feet above mean sea level (msl); -235 feet msl; and -240 feet msl.

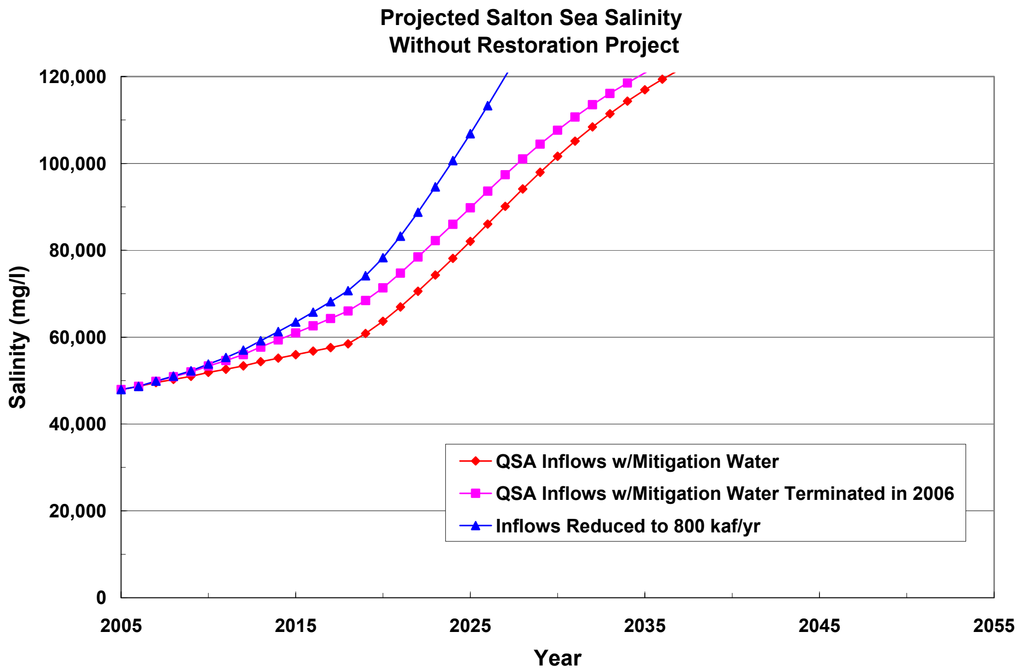

Figure C-5a. Projected Salinity in the Salton Sea for Three Inflow Scenarios, without the Restoration Project.

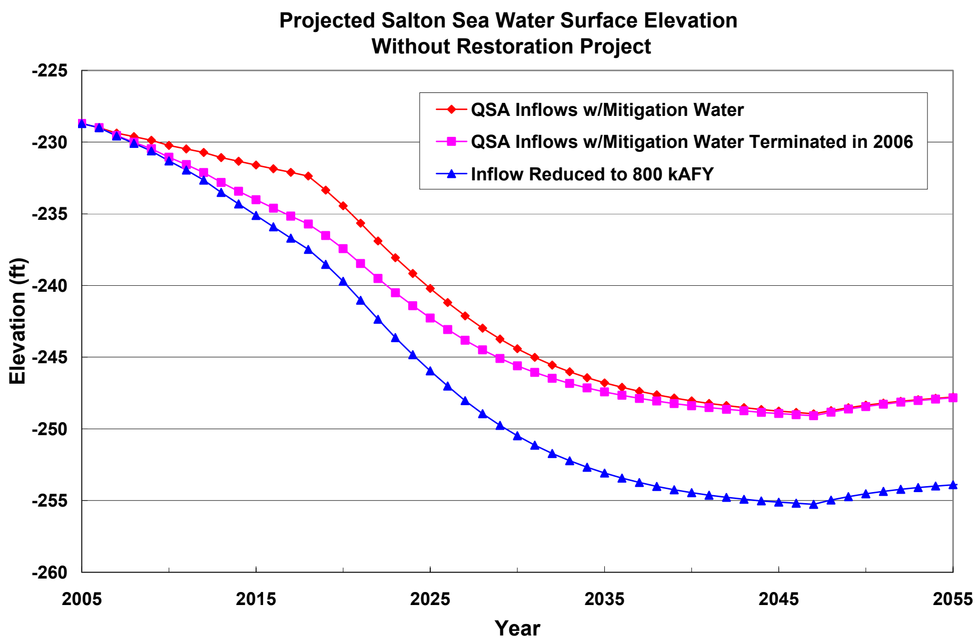

Figure C-5b. Projected Elevation in the Salton Sea for Three Inflow Scenarios, without the Restoration Project.

The simulations assume dam crests elevations of -225, -230, and -235 feet msl respectively with each assuming 5 feet of free board on the dam. Simulations of the -230 and -235 feet msl dam crests provide for salinity reduction benefits that would occur as a result of the dam crest surfacing after construction with an assumed spillway notch of 5 foot height. During this time salinity would begin to decrease in the north end even though the structure would not be acting as a dam. During this period, water would flow between both sides of the structure through the spillway notch. With greater inflows on the north end the salinity would reduce on the north end as saltier water that is displaced by these greater inflows migrates south. This temporary situation would not occur with a dam crest of -225 feet msl and an operating water surface elevation of -230 feet msl because by the time the dam was constructed the water surface elevation would already be at assumed spillway crest elevation of -230 feet.

In order to achieve the performance for the higher design lake elevations of -230 or -235 feet msl, based on the model assumptions discussed above, the extensions of the New and Alamo rivers would need to be constructed near or above the current lake shoreline. The channels would need to be constructed at or above the current water line to have sufficient slope to deliver water to the north with the lake at elevation -230 feet msl. For lower design lake elevations, the channel extensions could be accomplished within the existing lake footprint as the lake level would recede. Specific channel configurations and timings of water deliveries are details that would need to be developed during the feasibility design phase.

Figures C-6a, b and c illustrate the projected salinity in the north basin for the three inflow scenarios. Each chart shows the projected salinity profiles for the three design elevations for a given inflow scenario. Figure C-6a shows the projected salinity in the north basin for the scenario where mitigation water would be sold to help finance the project. Figure C-6b illustrates the most extreme inflow reduction case where all current inflows sources would be reduced to 800,000 acre-feet/yr (including flows into the south and north basins. Figure C-6c illustrates the case where mitigation water would not be sold, and thus this scenario would involve the greatest amount of inflowing water. Figures C-6a, b and c suggest that a north basin design elevation of either -230 feet msl or -235 feet msl, coupled with any of the inflow scenarios would provide the most reasonable times to achieve target salinity in the north basin. However, the lower the inflow, the faster the target salinity could be achieved.

Figure C-7 illustrates the projected salinity trends in the south basin for the scenario where mitigation water would be sold to help finance the project. This chart suggests that salinity in the south basin would reach saturation within 25 to 30 years. At this point salts would begin to crystallize. Similar trends would be seen with the other two inflow scenarios. Salinity projections above 250,000 to 300,000 mg/L are not considered accurate because the Model does not take into consideration salt precipitation above saturation. The Model does not simulate the phase chemistry of Salton Sea brines.

Figures C-8 and C-9 illustrate the projected elevation in the north and south basins, respectively, for the scenario where mitigation water would be sold to help finance the project. Figure C-9 suggests that the south basin would stabilize at around -260 feet msl. As an example, for the case where the design elevation in the north basin would be -235 feet msl, the water surface on the north side of the central causeway would be 25 feet higher than on the south side. Again, similar trends would be seen with the other two inflow scenarios.

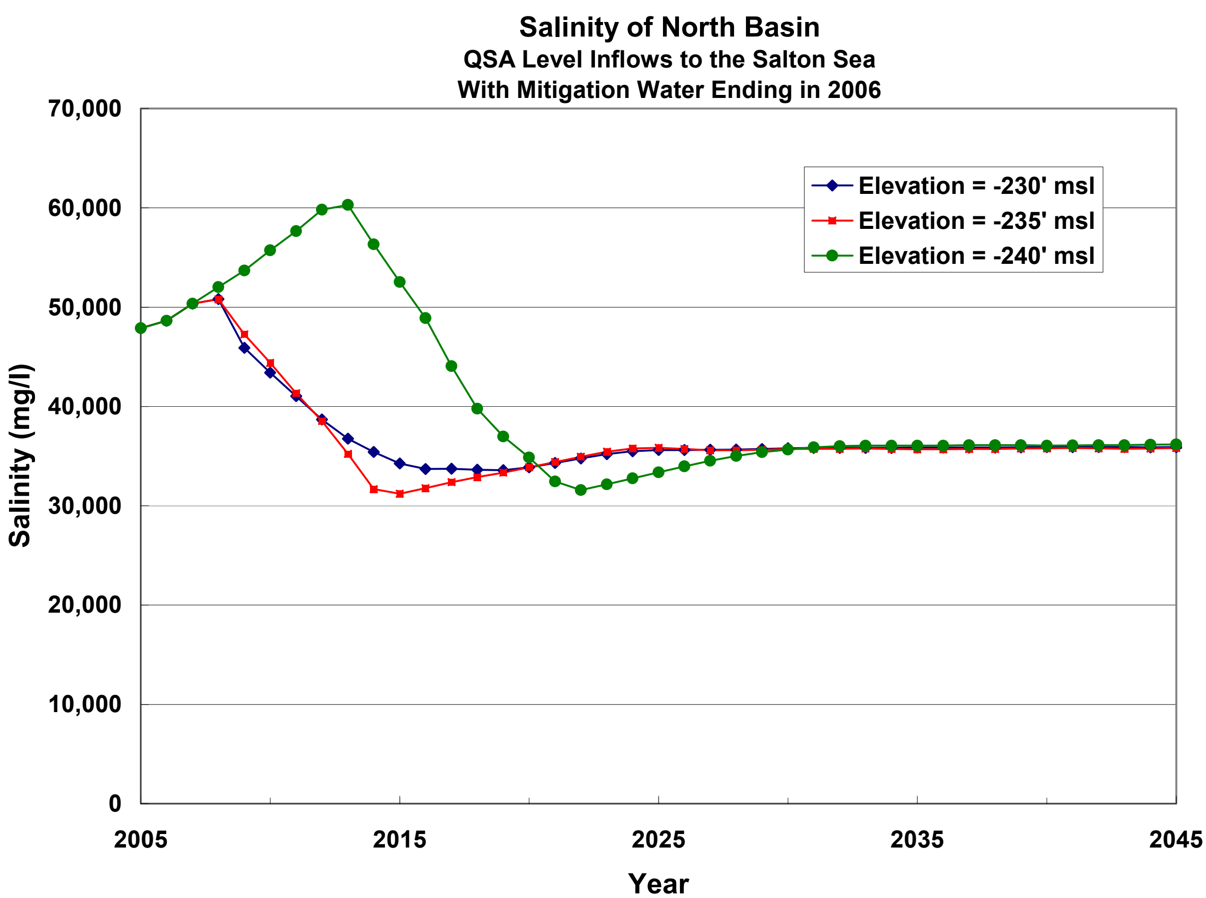

Figure C-6a. Projected Salinity in the North Basin for Three Target Lake Elevations, with Mitigation Water Ending in 2006.

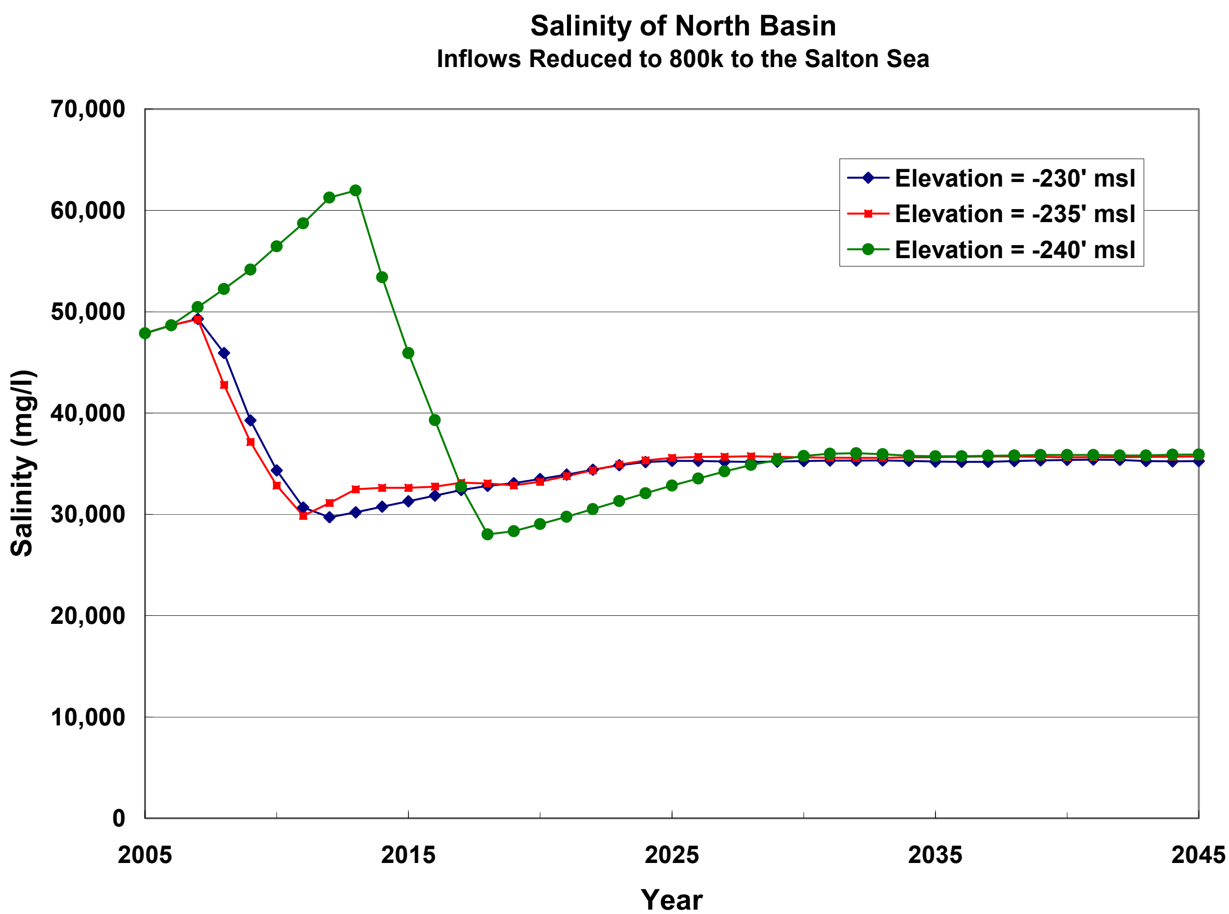

Figure C-6b. Projected Salinity in the North Basin for Three Target Lake Elevations, with Inflows Reduced to 800,000 Acre-Feet/Year.

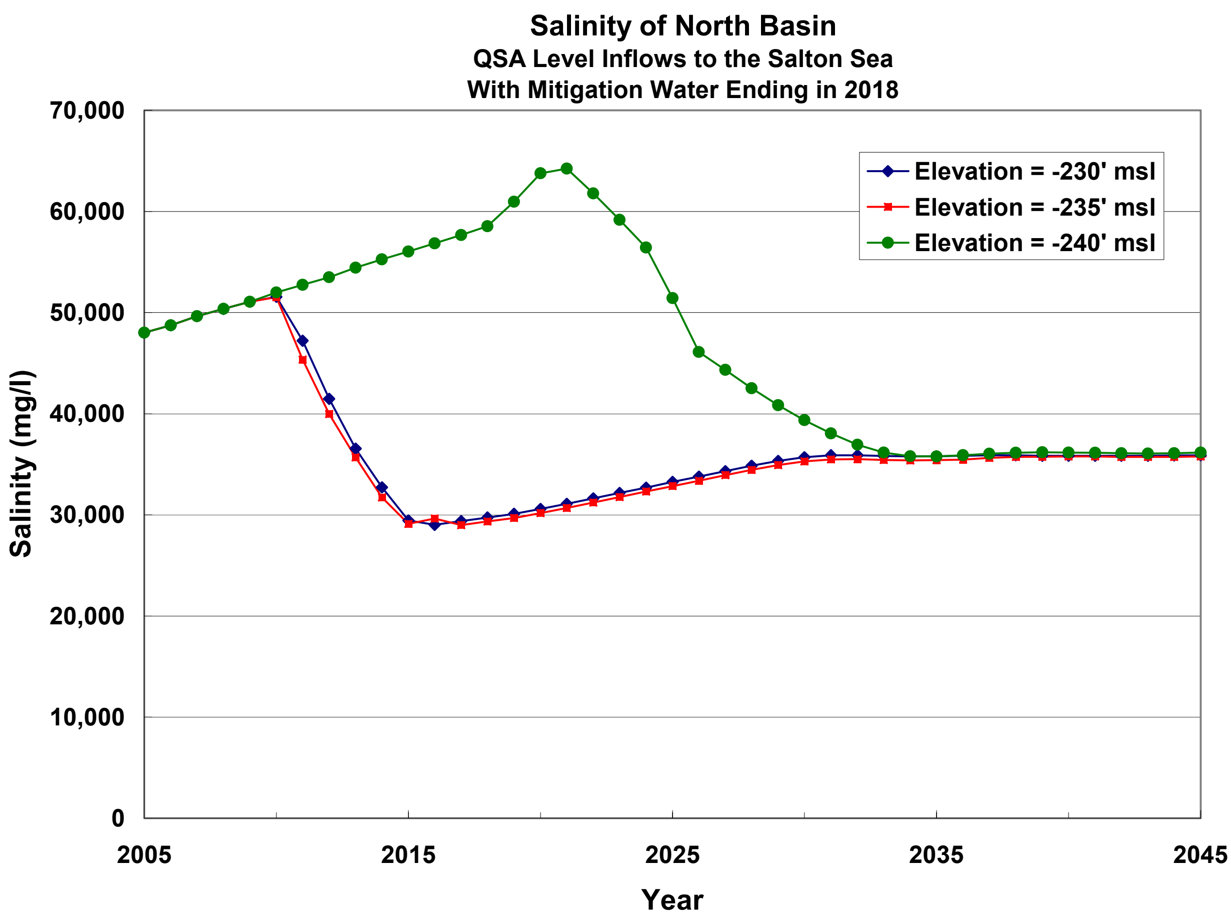

Figure C-6c. Projected Salinity in the North Basin for Three Target Lake Elevations, with Mitigation Water Ending in 2018.

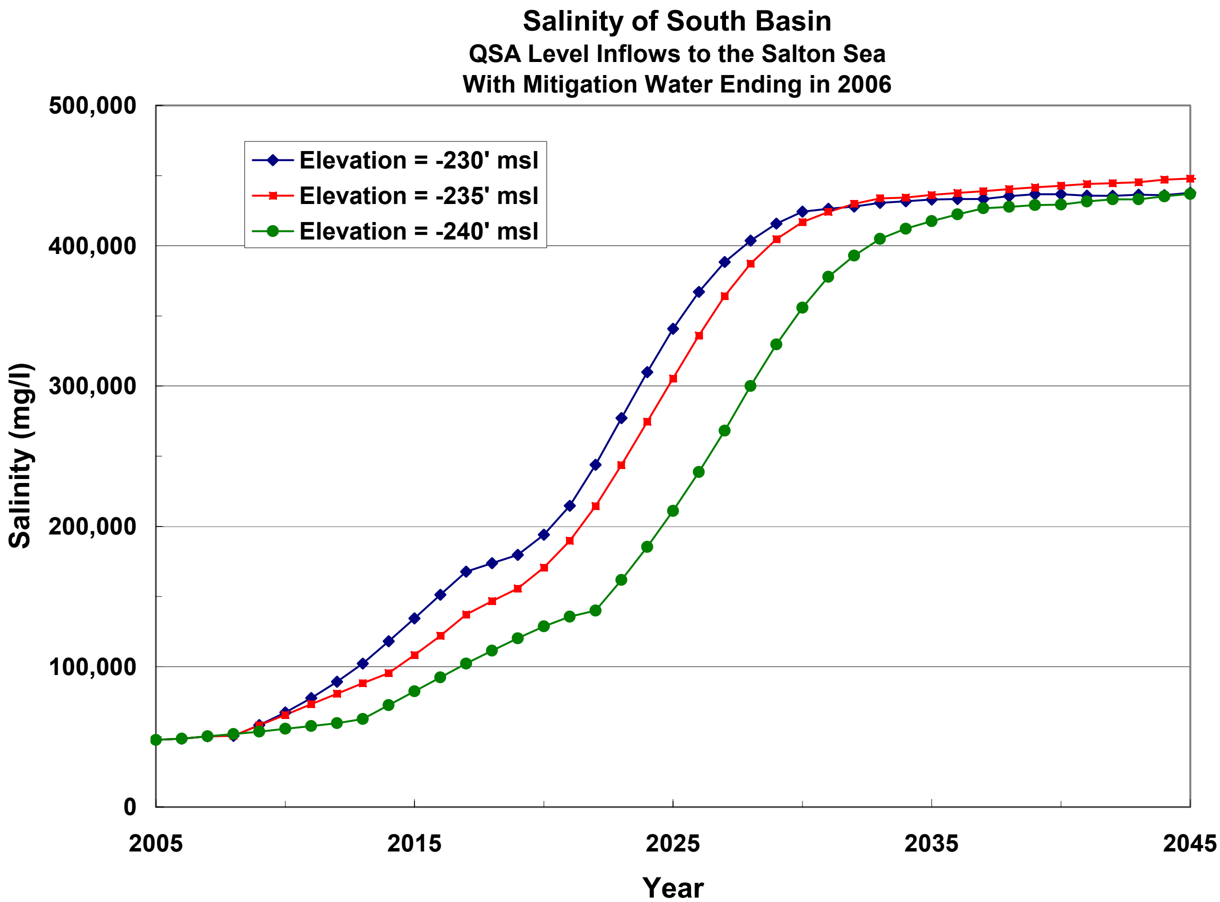

Figure C-7. Projected Salinity in the South Basin for Three Target Lake Elevations, with Mitigation Water Ending in 2006.

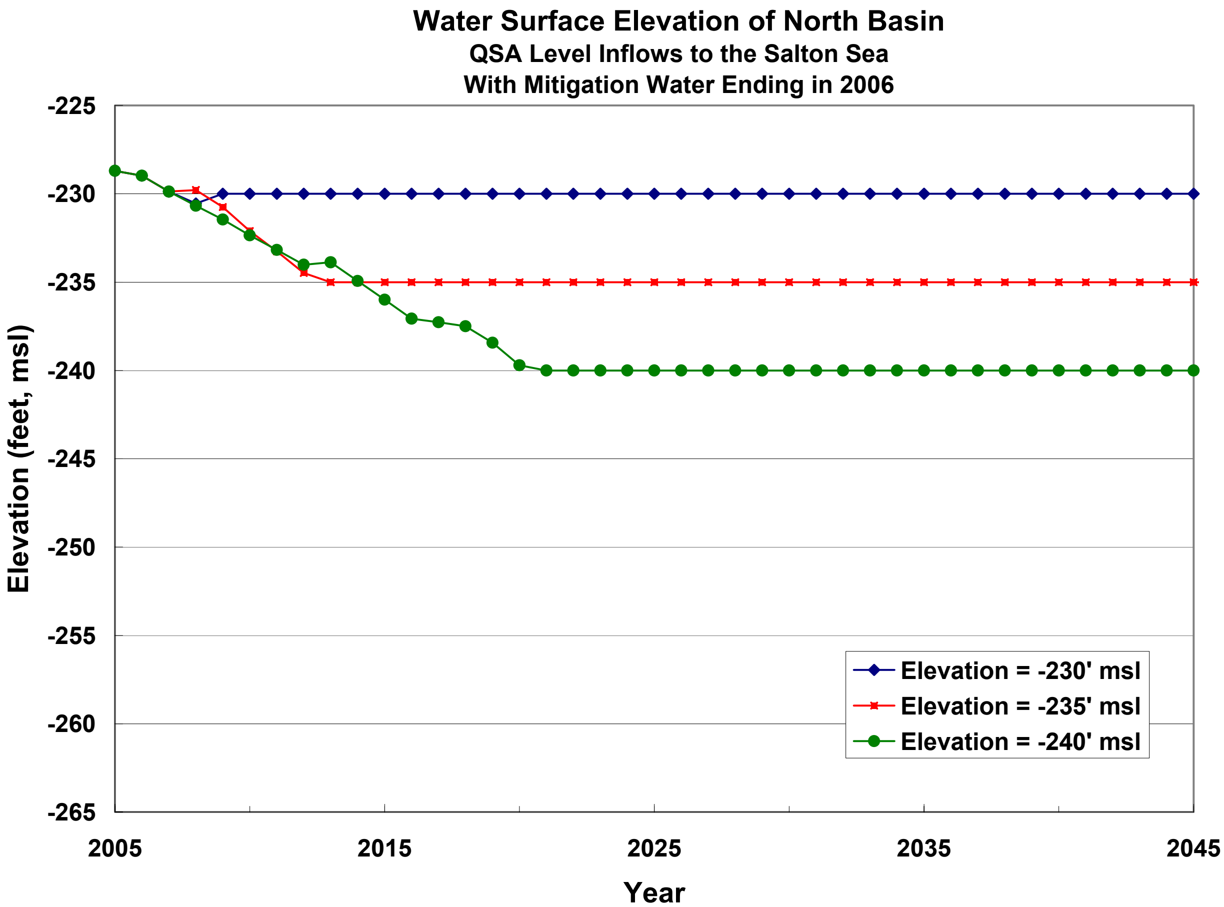

Figure C-8. Projected Elevation in the North Basin for Three Target Lake Elevations, with Mitigation Water Ending in 2006.

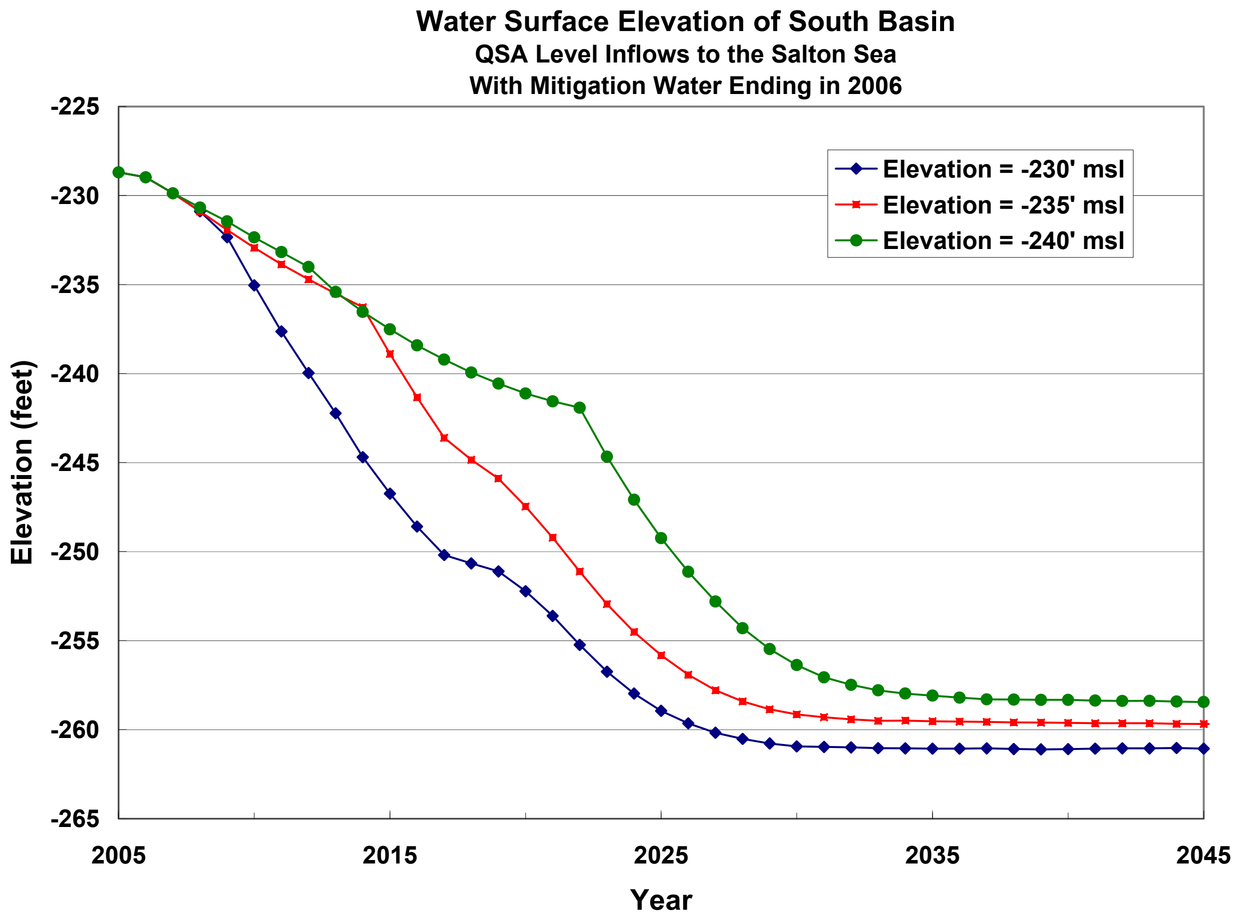

Figure C-9. Projected Elevation in the North Basin for Three Target Lake Elevations, with Mitigation Water Ending in 2006.

C.8 Performance of Other Project Alternatives

The performance of other alternatives discussed in the main body of this report is discussed below.

South Marine Lake without Elevation Control. Implementation of this alternative would involve a trade-off between saving on construction costs by waiting to build a smaller barrier after the Sea elevation receded, and over-designing the barrier to achieve objectives earlier. Regardless of how soon the barrier is constructed, the water elevation in both the north and south basins would be about the same at any given time and the trend would follow the no-project curves shown in Figure C-5b. A model run was prepared for the case where the barrier would be constructed with a crest elevation of -243 feet msl. This height was selected to be at a point where the elevation decline in the Sea would appear to begin to slow down.

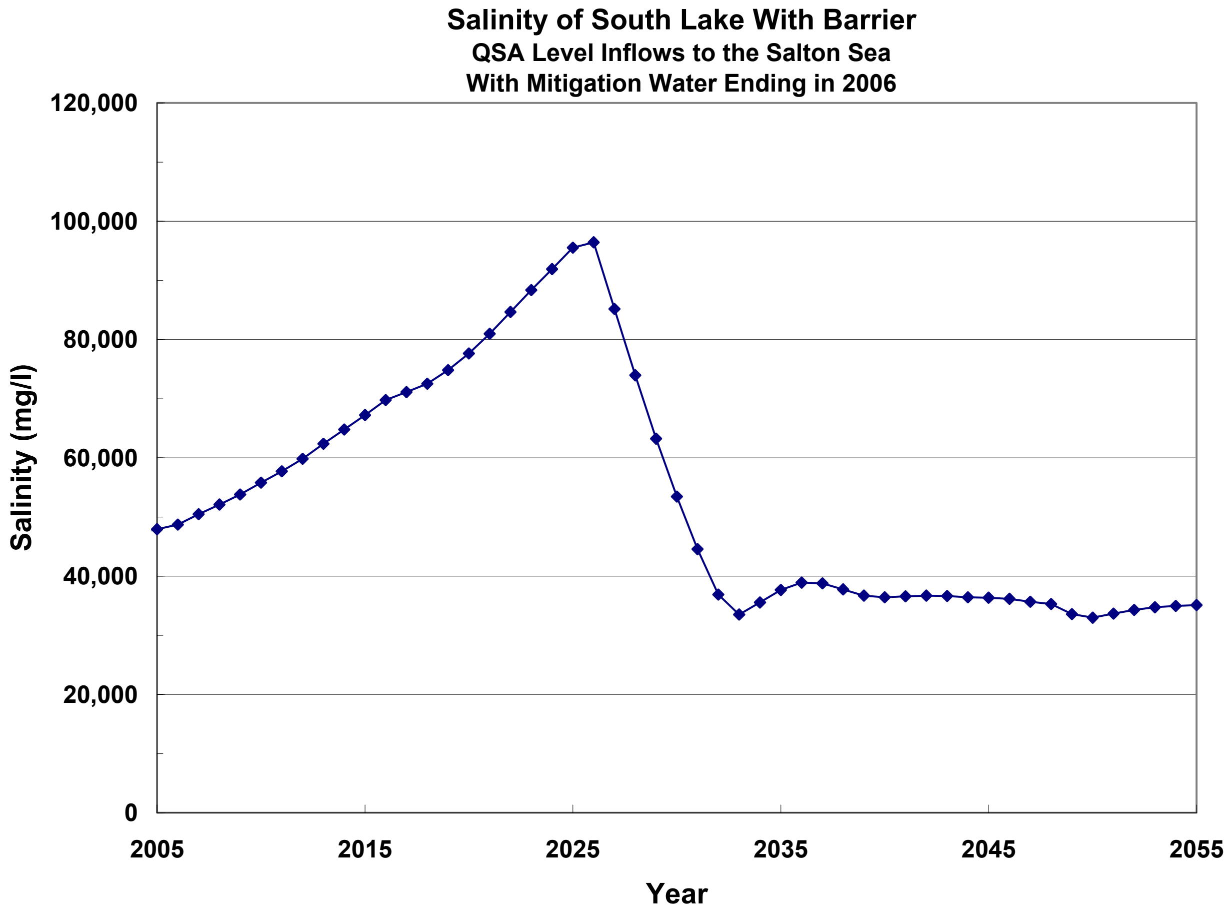

Figure C-10. Projected Salinity in the South Marine Lake without Elevation Control Alternative, for QSA Inflows with Mitigation Water Ending in 2006.

The salinity projections for this scenario are illustrated in Figure C-10 for the case of QSA inflows with mitigation water terminated in 2006.

South Marine Lake with Elevation Control. This alternative would have similar performance to the Preferred Project except that the results for north and south would be switched. The salinity in the south basin would be similar to that shown in Figures C-6a, b and c, and salinity in the north basin would be similar to the shown in Figure C-7. Elevation in the south and north basins would be similar to those shown in Figures C-8 and C-9, respectively.

No Marine Lake. The performance of the No Marine Lake alternative, either with or without brine pumping would be similar to the no project results shown in Figures C-5a and C-5b for salinity and elevation, respectively. However, depending on the degree to which wetland and other habitat features would be developed around the Sea, the elevation decline would be greater, perhaps decreasing and additional five feet. Likewise, the rise in salinity would be greater and more rapid.

C.9 Performance of Alternatives Considered in the Past

The only other known alternative considered in the past that would perform comparable the preferred project, but for a full Sea, would be a massive water exchange with the Gulf of California through the construction of pipelines and/or channels. Interior (2003) estimated that such an alternative could cost between $13 and $38 billion in total present value cost. In addition, while such a water exchange alternative could be used to control the elevation of the Sea, salinity could not be reduced below about 40,000 mg/L. This conclusion is based on the source if replenishing water being ocean water with a salinity of 35,000 mg/L. Even with very large exchange systems, evaporation in the Sea would cause the salinity to be greater than that value.

Interior also investigated the performance of alternatives that would export salt water without any replacement for water transferred out of the area. These would include on-land and in-Sea pond systems, enhanced evaporation systems, and desalination plants. For all of these alternatives, the elevation decline in the Sea would be similar to or more extreme than the no action case shown in Figure C-5b. In-Sea pond systems and desalination plants (with return of product water to the Sea) would have elevation trends similar to Figure C-5b. Whereas, on-land solar ponds and enhanced evaporation systems would tend to reduce elevation by an additional five to seven feet for any of the three inflow scenarios, for a total drop in the Sea's water surface of 25 to 30 feet. While all of these alternatives would ultimately control salinity, modeling by Interior showed salinity would peak around 60 mg/L and that it would take about 30 years for salinity in the Sea to be reduced to 40,000 mg/L.

C.10 References

Weghorst, Paul. A. 2001. Salton Sea Accounting Model, draft. Bureau of Reclamation, Lower Colorado Region, Boulder City, Nevada. November.

Department of Interior. 2003. Salton Sea Restoration Project Status Report, January.

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Appendix D
OUTDOOR RECREATION

In February 2004, the Authority appointed an Outdoor Recreation Advisory Task Force to evaluate recreational potential of a restored Salton Sea and present recommendations to the Authority Board. The Outdoor Recreation Advisory Committee presented their report to the Board on June 24, 2004. This Appendix provides the committee's report in its entirety.

With water transfers and the QSA resulting in a smaller sea, the Task Force was asked to address how to turn potential problems into potential opportunities. It was asked to create a new vision for the Sea that responds to the new water realities.

Its members included: John Benson, Victor Torres, Lea Anne O'Malley, Shirley Palmer, Christine Harris, Sue Giller, Bill Gates, Tim Kelley, Cliff Lawrence, Leon Lesicka, Roland Gaebert, Chris Schoneman, Jack Crayon, Vince Signorotti, Wayne Olesh, Jacob Ward, Fred Singh, Al Kalin, Jack Hart and Tom Raftican. Lea Anne O'Malley was appointed chairwoman.

The Task Force held its first meeting in March 29. Six subsequent meetings were held in West Shores (Salton City), Niland, Westmorland, Brawley and Calipatria.

D.1 A Vision for the Sea

The Task Force has found that the future for the Salton Sea can indeed be a bright one, even with diminished inflows. The Salton Sea will no longer be California's largest Lake, but, what is lost in quantity will be replaced by quality. For years, dreamers have envisioned economic development and a recreational Mecca around its shores. With proper funding and with the necessary political will at the Federal, State and local government levels, this lake will realize its potential.

Just visualize what can occur if this effort is successful.

In the next several decades, as inflows diminish and the shoreline recedes, new wetlands areas, shallow water ponds and Imperial County's largest fresh water lake will appear along the southern shores. Hunting and fishing, bird watching, hiking, equestrian trails and off-roading will attract thousands of visitors and local residents annually. The old Salton Sea Navy Base will possibly become another Glamis—a Glamis with a lake view.

In the northern marine lake, a stabilized body of water will attract sports fishermen and recreational boating. The Imperial County communities of West Shores, Bombay Beach, Calipatria and Niland will receive major economic benefits and development from this renewed ecotourism. The community of North Shore will again become a place to visit.

D.2 Issues Evaluated

In analyzing the issues, the Task Force identified several broad categories, with specific questions to evaluate in each category. The questions are cited below.

Extension of New/Alamo Rivers and Wetland Creation

A. Should 2,000 to 4,000 acres of wetlands be created in the New and Alamo Rivers and their extensions under the Restoration Plan?

B. Should small, sedimentation basins be designed throughout the River systems or medium sized to large ones be placed in a few locations?

C. Should the design of wetlands in the extensions be much different than the design of wetlands in existing river courses?

Freshwater Lakes

A. Should the Restoration Plan include a large freshwater lake fed by Alamo River water at Red Hill Marina?

B. Should the Restoration Plan include a small ski lake fed by Alamo River water around Mullet Island?

C. Should a lake be designated as being specifically for bird watching (with no power boats allowed?

D. Should there be a channel/lake in Bombay Beach area?

Marine Lake North Basin

A. Are there features of the marine lake in the North part of the Sea that should be added or changed to encourage different forms of recreation?

Shallow Water Ponds

A. Should trails or other public access be provided to the network of shallow water wetlands?

B. What sort of public uses should be allowed in the shallow water ponds?

Agriculture

A. Should land previously flooded by the Sea be reclaimed for farming?

Geothermal

A. What are the most compatible uses of land near potential geothermal expansion areas?

Off Road Vehicle Use

A. Can some lands be utilized for off road vehicle use?

B. Should a large (10,000 acre) off road racing course be developed?

Ownership

A. Are there special considerations for lands under the jurisdiction of FWS?

B. Are there special considerations for lands under the jurisdiction of State Parks?

C. Are there special considerations for lands under the jurisdiction of IID?

D. Are there special considerations for lands under the jurisdiction of Reclamation?

E. Are there special considerations for lands under the jurisdiction of the Torres Martinez Tribe?

F. Are there special considerations for lands under the jurisdiction of other agencies?

Hunting and Fishing

A. Are there special design considerations to maximize hunting opportunities?

B. Are there special design considerations to maximize fishing opportunities?

Other Issues

A. Are there other recreational and economic development issues that ought to be included in the plan?

B. Where will communities along the Salton Sea shores get their water to accommodate the expected growth?

C. Should there be a road on the dike?

D.3 Findings

Extension of New/Alamo Rivers and Wetland Creation

The Task Force was in agreement that wetlands should be extended in both rivers—at least 4,000 acres. The Salton Sea Science Office and other experts should determine the questions regarding the size of sedimentation basins. The Task Force also agreed that the current design should be continued.

The Wetlands projects are very important to the restoration of the Sea because of their ecological value to the region. They are a key political selling point in the total restoration effort.

Freshwater Lakes

The Task Force extensively evaluated the potential of freshwater lakes fed by the Alamo and New rivers and is in agreement that such lakes are crucial to expanded recreation use for the Sea.

Members also expressed concern that allowances be made on the lakes for recreational boating as well as restricted areas for wildlife preservation and bird nesting. It was felt that it will be difficult in advance to determine the location of the best wildlife areas: that will be determined by the wildlife. However, it was also felt this could be a seasonal situation and could be controlled by posting—similar to procedures used at Lake Perris.

The committee felt a small recreational freshwater lake near Bombay Beach could not be economically justified. However, the Task Force also said a channel linking Bombay Beach to the northern lake would be important to serve residents there to prevent that community from becoming totally isolated from access to the new Salton Sea

Two different concepts for a single freshwater lake of up to 2,000 acres were discussed for the region around the current Red Hill Marina. It would be the largest freshwater lake in Imperial County. Both concepts would have an extended channel running north to the main body of the northern lake—a drop of about eight feet over 15 miles. Additionally, dredging would probably be necessary to create the freshwater lake.

The first concept is a kidney-shaped body of water centered around Red Hill with an extended narrow channel running north to Bombay Beach. With this concept, there would be an option to continue Mullet Island as an island, but would leave much of the current wildlife refuge in a "dry" area.

The second concept is a longer and narrower lake that stretches from Obsidian Butte to Red Hill. It incorporates much of the current refuge. Additionally, Obsidian Butte and Red Hill are the only natural structures ("mountain peaks") for miles—incorporating them in the lake would add some beauty to the area. It also has a narrow channel extending to Bombay Beach. Mullet Island would become part of the dry area in this concept.

More evaluation is necessary on either concept, but the majority of the committee favored the "longer-narrow" option because it incorporates the current refuge area as well as the two "mountain peaks." However, the Fish and Wild Service expressed reservations regarding use of the refuge area and those must be considered.

Marine Lake: North Basin

The committee felt there would be many recreational opportunities in the northern marine lake, which will become very important as the region develops. It was also felt that a public access road across the dike dividing the North Sea and the salt settling pond would be a very valuable asset. The road could have turn-outs for parking and some extensions or piers to enhance fishing in the area.

Shallow Water Ponds

The Task Force felt a series of shallow water ponds around the southern portion of the current sea would be an excellent mitigation for the smaller sea. They not only would become excellent habitat for birds and other wildlife but also would offer extensive recreational opportunities.

Hiking and equestrian trails should be incorporated in the restoration plans as well as bike trails and a cultural component that will provide public education opportunities.

Agriculture

The Task Force thoroughly discussed whether land previously flooded by the Sea on its south end should be reclaimed for farming. The committee decided this is not a good option: shallow ponds are the best alternative.

Questions were raised over water availability to reclaim the land as well as whether the reclamation would be economically feasible.

Geothermal

Portions of the Salton Sea Geothermal Anomaly that are currently inundated by the Sea have high commercial potential for future development.

The potential expansion of the geothermal development near Obsidian Butte and Red Hill needs to be coordinated with the ultimate design of freshwater lakes.

Although market conditions and economics will play a large role in any future expansion of the development by CalEnergy, experts believe that areas with a high probability of having commercial quantities of geothermal resources are located under water in that area of the Sea.

Because of the prime Geothermal “hotspots” in the areas of the proposed freshwater lakes, it may be necessary to move the lakes somewhat to the east and north. If that means loss of one of the scenic “mountain peaks” in the lake (Red Hill and Obsidian Butte) another could possibly be constructed. While geothermal development is compatible with recreational uses, agriculture and the environment, it is less compatible with residential areas--such as mobile home parks or camp grounds that could develop near a lake.

Close coordination will be imperative between CalEnergy and the Authority regarding appropriate placement of the freshwater lakes to maximize the recreation/wildlife potential and not adversely impact potential geothermal development.

Off Road Vehicle Use

There are areas along the West Shore near the former Navy Test Base that could become excellent off road recreational areas. However, the Task Force had some concerns regarding development of an off road race track.

A Task Force member discussed this with some off road vehicle retailers in Imperial County to get opinions. The consensus was an off road area would serve people very well, but having an actual race track there would be difficult. Such tracks get very heavy use and require extreme amounts of maintenance, including mixing soils. The only way a track could possibly succeed would be one constructed and operated by private enterprise.

An alternative to a race track would be development of a recreational vehicle "parking area", similar to Glamis. With the Sea as a back drop, it would become a popular recreational site. Families could use the dike for fishing, etc. and have off road access all the way to popular areas near the Ocotillo Wells Recreation area and Plaster City. Fees could be assessed for use of this area.

Land Ownership Issues

United States Fish and Wildlife Service: There would be a need for land swaps in the hyper saline areas to resolve management conflicts.

State Parks: There were no issues identified. The new features of the Salton Sea that are being discussed are compatible with the State Parks goals.

Imperial Irrigation District: Cal Energy's use of land under the Sea is also an IID issue. IID will be sensitive to land use and liability issues that effect the land it owns in and around the current Sea.

Bureau of Reclamation: There were no special ownership issues identified regarding Reclamation Land.

Torres Martinez: There are some restrictions regarding use of Indian Lands. These would have to be identified by the Torres Martinez Tribe and incorporated into the planning.

County of Imperial: Red Hill Marina is currently a county park. The county will need to be involved in any planning regarding a freshwater lake in that area.

Hunting and Fishing

This committee feels strongly that hunting and fishing needs should be factored in to any restoration plan and should be maximized. Wetlands, shallow water ponds and lakes under discussion are designed to enhance recreational opportunities. It is agreed that certain areas may be designed for specific uses in an effort to balance recreational uses with environmental concerns. As budgets are put together, sufficient funds should be requested to cover operations and maintenance to maximize the hunting and fishing potential.

In addition to hunting and fishing, other areas should be set aside for bird watching, hiking, bicycling, equestrian and other compatible uses.

Other Issues

Regional Cooperation between Economic Development agencies and organizations in Coachella and Imperial Valleys: It is imperative that economic development interests in the Coachella and Imperial valleys work together to realize the vision and potential of a restored Salton Sea. It is also imperative that this region work cooperatively with representatives and agencies at the federal and state level and that they, in turn, give substantial value to local input.

Agricultural Issues: The Salton Sea serves as a model of how the interrelationship between agricultural needs and environmental, recreational and economic benefits create a valuable ecosystem. The committee wants to recognize the significance agriculture plays in creating this valuable resource and does not want agriculture's contributions to be diminished.

Budget Issues: State and local budget reductions will have an impact on development and management of recreational areas at a restored Salton Sea. However, this is considered to be a short term problem. While there are few agency resources at present, thought should be given to develop strong volunteer programs to assist in development and management of hunting and fishing areas.

Water to Salton Communities: While there were no specific recommendations, the committee discussed the need to develop a reliable water supply to the West Shores communities that will be needed if they are to develop.

Road on Mid-Sea Retention Structure: The committee felt a public access road across the dike would be an excellent idea. It could be a source of possible income and a major economic benefit to the region. It also would enhance recreational access to the Sea. Costs permitting, pullouts for parking and fishing off the dike could be designed into the roadway. Access roads should also be designed to the shallow water lakes without adversely affecting sensitive areas.

Enterprise Zone: The committee recognized the need for an expanded Enterprise Zone in the southern portion of the Sea that is currently being sought by the cities of Calipatria, Brawley and Westmorland. Any Enterprise Zone endeavors must be compatible with environmental and recreational development in the area.