RECLAMATION

Managing Water in the West

Restoration of the Salton Sea

Summary Report

U.S. Department of the Interior
Bureau of Reclamation
Lower Colorado Region

September 2007

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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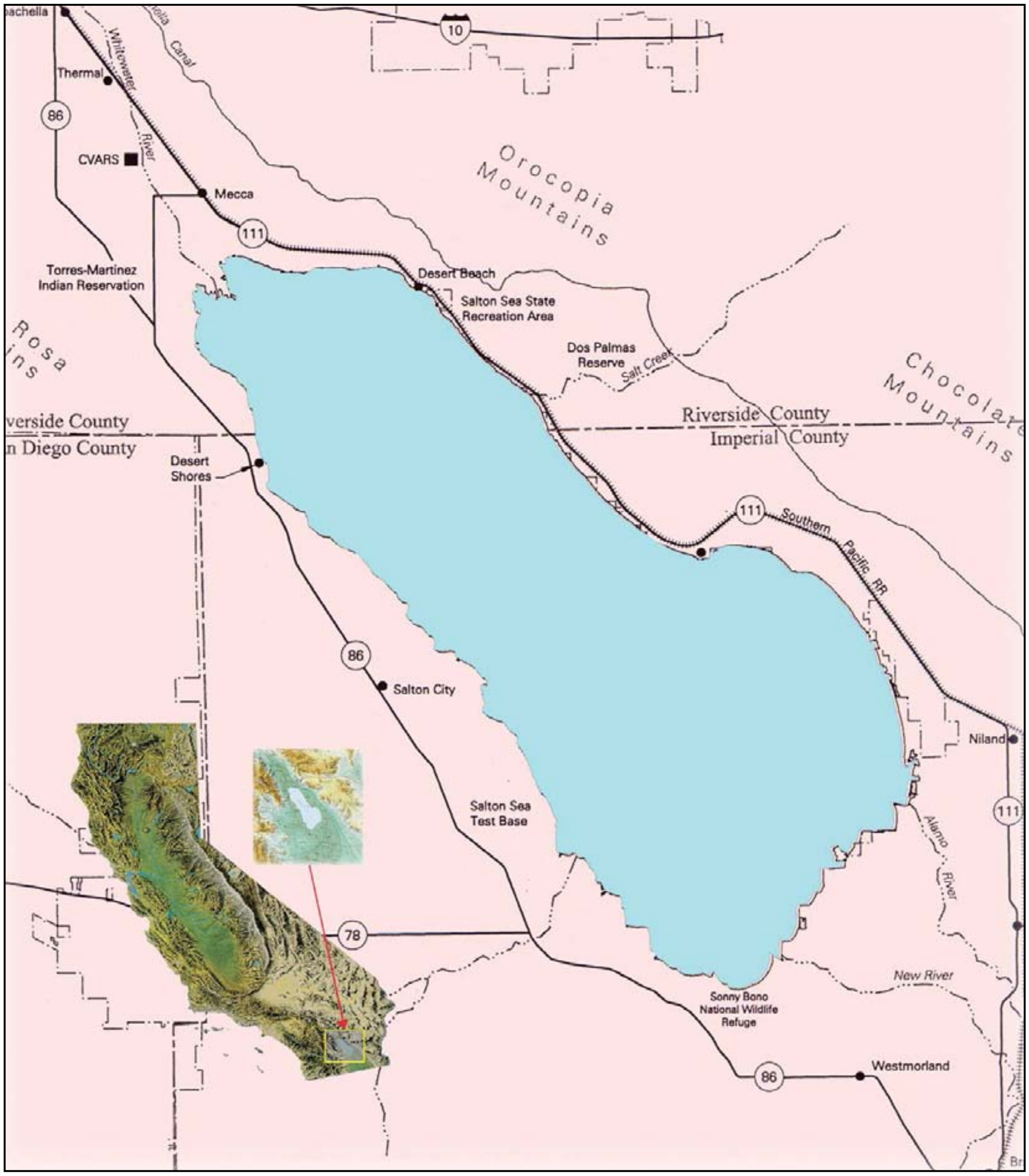

Salton Sea location map.

Abbreviations and Acronyms

ALL	Annualized Loss of Life
APF	Annualized Probability of Failure
AQM	air quality mitigation
BMPs	best management practices
CEQA	California Environmental Quality Act
CVWD	Coachella Valley Water District
DEIS	Draft Environmental Impact Statement
DO	dissolved oxygen
DWR	California Department of Water Resources
EIR	Environmental Impact Report
EPA	Environmental Protection Agency
ERS	Ecosystem Restoration Studies
H_2S	hydrogen sulfide
IID	Imperial Irrigation District
IMPLAN	IMpact Analysis for PLANning
IPCC	Intergovernmental Panel on Climate Change
LOL	loss of life
m	meters
µg/L	micrograms per liter
maf/yr	million acre-feet per year
mg/L	milligrams per liter
msl	mean sea level
NaCl	halite
NED	national economic development
NEPA	National Environmental Policy Act
NH_3	ammonia
NWR	National Wildlife Refuge
OMER&R	operation, maintenance, energy, replacement, and risk

Abbreviations and Acronyms (continued)

P	Phosphorus
P.L.	Public Law
PEIR	Programmatic Environmental Impact Report
P&Gs	Principles and Guidelines
PHDA	Progressive Habitat Development Alternative
PPG	Reclamation's Dam Safety Guidelines for Achieving Public Protection
QSA	Quantification Settlement Agreement
Reclamation	Bureau of Reclamation
RED	regional economic development
Se	selenium
Sea	Salton Sea
SHC	saline habitat complex
SSA	Salton Sea Authority
SSAM	Salton Sea Accounting Model
TMDL	total maximum daily load
TSI	trophic state index

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Executive Summary

This report provides a summary of the Bureau of Reclamation's (Reclamation) recent study to determine a preferred alternative action for restoring the Salton Sea (Sea). The study was performed in fulfillment of the requirements of Public Law (P.L.) 108-361, the Water Supply Reliability and Environmental Improvement Act, November 2004 which states:

> "Not later than December 31, 2006, the Secretary of the Interior, in coordination with the State of California and the Salton Sea Authority, shall complete a feasibility study on a preferred alternative for Salton Sea restoration."

The costs of all alternatives presented in this report are based on very limited geologic and geotechnical data that were obtained through exploration in years 2003 and 2004. Significant design uncertainties exist as a result of the limited amount of site information. Uncertainties also exist relative to constructability, seismic performance, static performance, and construction costs. As a result of these uncertainties, the designs and costs presented in this report are at an appraisal level and not at a feasibility level. It would not be possible to develop feasibility level designs and cost estimates without conducting significant geologic and geotechnical design data collection programs.

Study Objectives

The objective of this study is to identify and recommend a preferred action that attempts to provide an efficient and reasonable method for restoration of the Salton Sea ecosystem and permanent protection of wildlife dependent on that ecosystem. This objective is based on historic habitat capabilities for providing an abundant and diverse assemblage of fish and wildlife at a level sustainable: (1) within the constraints of predicted future water availability and water quality; (2) at a reasonable degree of risk associated with the viability of the project (relative to environmental issues); and (3) in a cost-effective manner. Although wildlife and wildlife habitat objectives were primary considerations for this study, all objectives listed in the Salton Sea Reclamation Act (P.L. 105-372) were given significant consideration and addressed to the greatest extent possible.

Emphasis was given to permitting the continued use of the Salton Sea for irrigation drainage and for reclaiming fish and wildlife resources and their habitats. An additional objective was considered relative to minimizing exposed areas subject to potential air quality problems. This additional objective was not included in the Salton Sea Reclamation Act. It was added for this study because of its importance to restoration feasibility and for consistency with the State of California's Salton Sea Ecosystem Restoration Study (ERS).

Project features are designed in this study to function at current and reduced inflows, as directed by P.L. 105-372 (the Salton Sea Reclamation Act of 1998).

Restoration Study Findings and Recommendations

This report recommends a potential action for consideration at the Salton Sea that attempts to provide an efficient and reasonable method for restoration of the Salton Sea ecosystem and permanent protection of wildlife dependent on that ecosystem. The recommendation takes into consideration the best available (but still limited) information as well as estimated risks, costs, and predicted outcomes. All five action alternatives considered in this report entail extreme costs and there are substantial uncertainties and risks associated with engineering, physical, and biological elements of the alternatives. These risks are directly associated with a lack of data and/or uncertainty involving the description, implementation, and subsequent performance of each of the proposed alternatives. The following risks were considered in the evaluation of alternatives:

- Selenium risks to fish-eating birds
- Selenium risks to invertebrate-eating birds
- Hydrodynamic/stratification risks
- Eutrophication risks
- Fishery sustainability risks
- Future inflow risks

While lack of data and the time and funding required to analyze these data did not allow a full feasibility level study, a more detailed evaluation would not resolve the hydrologic and biologic uncertainties. Therefore, Reclamation does not have a basis for recommending implementation of any of the action alternatives evaluated in this report. At an appraisal level of evaluation, all of the action alternatives considered in this report have been estimated to cost between $3.5 and $14 billion (**Table ES.1**). Annual costs associated with the alternatives are also very high. Estimated annual operations, maintenance, energy, and replacement costs for all the alternatives range from $119 million to $235 million (**Table ES.2**); and again, there are many risks and uncertainties associated with these estimates. However, given the degree of negative air quality impacts and related mitigation cost ($1.4 billion)[1] associated with the No-Project Alternative,

[1] An estimated dollar amount of $1.4 billion would be required to mitigate air quality impacts associated with the No-Project Alterative due to reduced inflows and resulting exposed lakebed sediments becoming emissive. Over time, approximately 92,000 acres of exposed sediments could be exposed and potentially become emissive under the No-Project Alternative. Mitigation

consideration could be given to a focused adaptive management study of shallow saline habitat complexes (habitat complexes as describe in Alternative 5). Current data indicate that these types of habitat complexes could minimize both risk and costs, while providing historic wildlife habitat replacement and partial mitigation of air quality impacts associated with reduced future inflows at the Salton Sea. Although there are presently many remaining unknowns, risks and uncertainties concerning these habitat complexes,[2] the development and study of approximately 2,000 acres of such habitat, over a 7- to 10-year period, could determine if these complexes are a feasible approach to replacing historic wildlife use values at the Sea.

While Reclamation does not support the recommendation of any preferred action alternative at this time, a focused and progressive adaptive management study initiative of saline habitat complexes could be undertaken to determine if such complexes are a feasible approach to replacing historic wildlife use values at the Sea. This concept could involve developing, studying, and monitoring relative small parcels of habitat in a phased approach of shallow saline habitat complexes (SHC) in an adaptive and flexible, yet progressive, manner. This concept could be described as a Progressive Habitat Development Alternative (PHDA).[3]

Each phase would include construction of between 200 and 500 acres of saline habitat complex (SHC), in which engineering designs and wildlife management criteria and strategies could be derived from a previous phase. During each phase, continuous detailed evaluations could be obtained concerning water quality, habitat values and use, biologic issues, and engineering performance. Information from these evaluations would be used to refine the designs and adaptive strategies for the next phase of complexes. Development of adaptive and flexible strategies would reduce risks and uncertainties associated with operating larger complexes. Actual habitat values would be determined through continuous observations and study.

Initial design of management strategies for the first phase would be based on what is being learned at the existing 100-acre shallow habitat pilot project currently being studied cooperatively by the United States Geological Survey and Reclamation. The goals of this study are to begin assessing the benefits of shallow water wetlands to breeding birds, and also to study potential risks due to contamination from agricultural drain water. Focus is being given to evaluating

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of these potentially emissive sediments is estimated to cost about $14,000 per acre and would ultimately be the responsibility of the existing landowner to mitigate.

[2] Of particular concern is the lack of species-specific values that these habitat types may provide and the uncertainty as to whether other Pacific Flyway problems might affect values derived from habitat areas developed at the Salton Sea. Estimates of bird densities that might be achievable, based on what is known today, may not be possible in the future.

[3] A PHDA feasibility study is estimated to involve approximately 2,000 acres, to be developed in phases over approximately 7 to 10 years, and to cost approximately $150 million (implementation) and $50 million in annual operation and maintenance.

post-hatchling survival and movement of birds nesting on the 100-acre site. Preliminary and non-peer-reviewed information from the 100-acre project indicates instances of wetland usage by large numbers of birds of multiple species.

It is recommended that PHDA would be implemented by committing to an initial 2,000 acres during the first 7 to 10 years, assuming phased construction of 300 acres per year. PHDA habitat areas could continue to be added beyond those constructed in the first 7 to 10 years up to what is determined to be historic values at the Sea. The maximum buildout of habitat acreage (beyond the initial 2,000 acres) would be dependent on what actual habitat values were derived from observation and study of previous phases and upon the success of developing adaptive and flexible strategies for managing and/or mitigating observed problems, risks, and uncertainties. All risks could not, however, be alleviated by the PHDA approach. There could be no guarantee that habitat values would be sustainable. Pacific Flyway impacts from actions and events occurring outside of the Salton Sea area could have a significant impact on bird densities and habitat values derived from SHC areas at the Salton Sea. **Figure ES.1** is a diagram displaying an example of a successional construction strategy of SHC, with each phase using lessons learned from previous phases of development.

PHDA could also allow for studying adaptations of embankment and water conveyance designs and construction methods with the purpose of determining the most cost-effective methods for constructing SHC areas. Each phase of design and construction would rely on lessons learned from previous phases.

The PHDA concept would need to be refined based on information being collected at the existing 100-acre complex in order to determine an accurate cost estimate for a phased project of 2,000 acres and beyond. However, the appraisal level cost of implementing projects of different sizes can be estimated on the basis of appraisal level estimates that have been compiled for SHC incorporated in alternatives evaluated for this study. Estimated PHDA implementation costs (in 2006 dollars) for the 2,000 acres are $150 million. Estimated PHDA annual operation, maintenance, energy and replacement costs would be $600,000 per year once the 2,000 acres were completed.

Restoration Alternatives

This present study of alternative concepts for restoring the Salton Sea uses information from both recent and past studies (1960s to present). The specific concepts evaluated in this present study were screened and selected from hundreds of ideas and concepts that ranged from circulating ocean water from the Gulf of California or the Pacific Ocean to removing salts at the Sea through the use of enormous desalination plants, solar pond systems, and/or enhanced evaporation systems. As a result of anticipated reduced future inflows (from

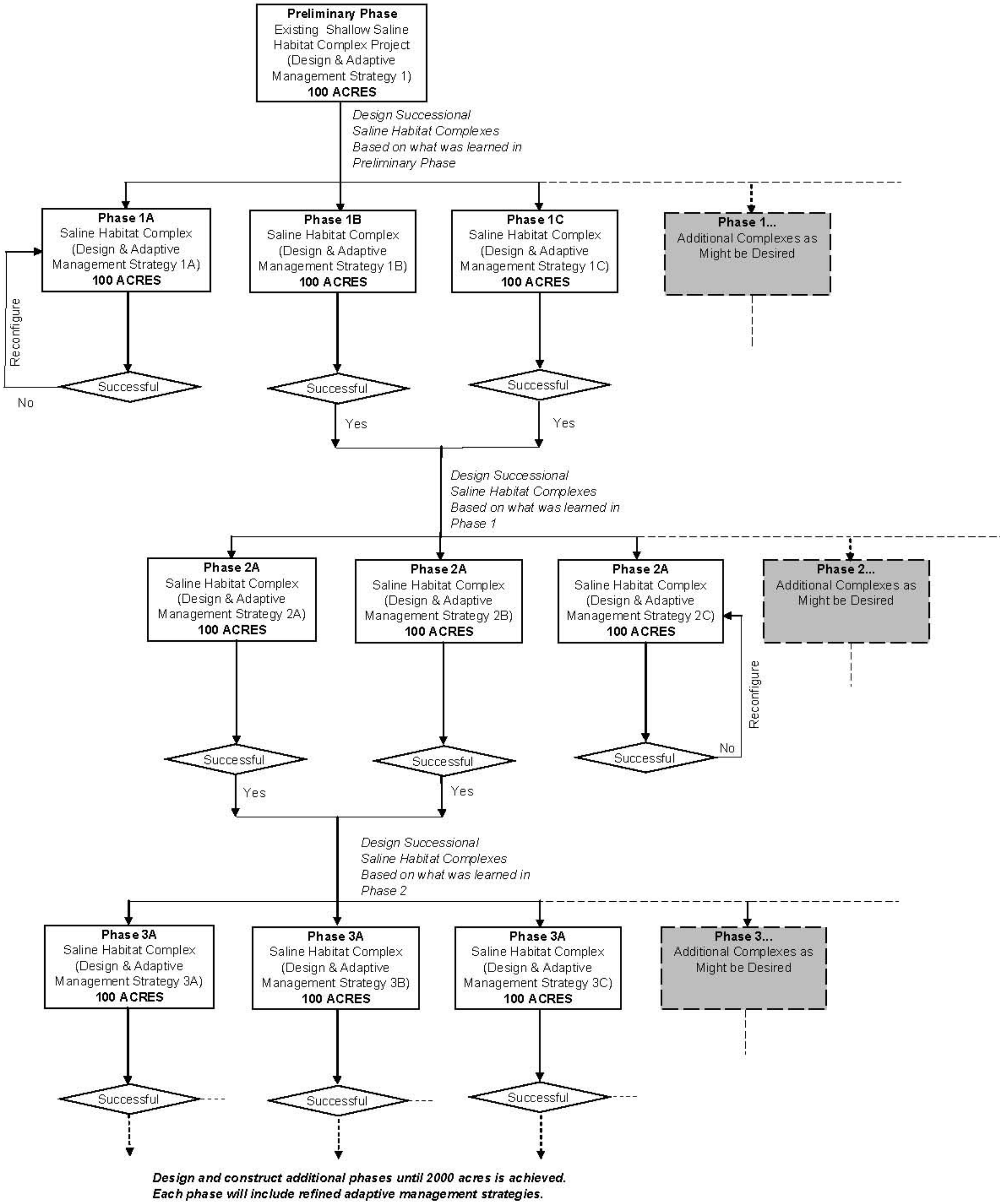

Figure ES.1 Progressive Habitat Development Alternative Conceptual Diagram.

implementation of the Imperial Irrigation District and San Diego Water Transfer Project), alternatives involving salt removal and disposal were abandoned in favor of partial restoration solutions such as equal head barriers and impervious dam alternatives as well as habitat-pond-based alternative concepts. Reclamation's current alternatives include only these types of alternatives. The current alternatives presented in this summary report are as follows:

1. Mid-Sea Dam with North Marine Lake (proposed by the Salton Sea Authority [SSA])
2. Mid-Sea Barrier with South Marine Lake
3. Concentric Lakes (proposed by the Imperial Group)
4. North-Sea Dam with Marine Lake
5. Habitat Enhancement without Marine Lake
6. No-Project

Reclamation coordinated closely with the State of California Department of Water Resources and the Salton Sea Authority in developing the alternatives presented in this report. Consequently, both the State and Reclamation have analyzed alternatives that are conceptually similar, yet have some differences. Variation between agencies in approaches to risk, uncertainty, complexity, and other factors contribute to differences in designs and costs. While Reclamation's design and cost estimating criteria and guidelines may be different than those used by other agencies and this may lead to different design conclusions and project costs, Reclamation makes no judgment relative to methods, assumptions, and criteria used by others.

Costs of Alternatives

Table ES.1 displays appraisal level estimates of subtotal construction and implementation costs of all alternatives, including the No-Project Alternative, using embankment designs that meet Reclamation's design criteria and guidelines. **Table ES.2** presents appraisal level annual recurring costs of all the alternatives. All appraisal level cost estimates are expressed in 2006 price levels for comparison purposes.

Total implementation costs for the action alternatives vary from a minimum of $3.5 billion to a maximum of $14.0 billion. The cost of the No-Project is estimated at $1.4 billion which is merely the estimated cost associated with AQM. Annual reoccurring costs for the action alternatives vary from a minimum of $119 million to a maximum of $235 million. The annual reoccurring costs for the No-Project Alternative are estimated at $164 million, again solely associated with AQM efforts.

Table ES.1 Alternatives and associated component construction costs[1]

Alternative Components	**Alternative No. 1A:** Mid-Sea Dam with North Marine Lake Using Sand Dam Design with Stone Columns	**Alternative No. 2A:** Mid-Sea Barrier with South Marine Lake Using Sand Dam Design with Stone Columns	**Alternative No. 3A:** Concentric Lakes Using Sand Dam Design with Stone Columns[3]	**Alternative No. 4:** North-Sea Dam with Marine Lake Using Sand Dam Design with Stone Columns	**Alternative No. 5:** Habitat Enhancement without Marine Lake	**Alternative 6:** No-Project
1. Mid-Sea Dam	$2,210,287,846					
2. West and East Perimeter Dikes	$543,400,979					
3. South-Sea Dam	$954,557,582					
4. Mid-Sea Barrier		$605,723,577				
5. Three Concentric Lake Dikes			$6,749,460,260			
6. Concentric Lakes – Habitat Islands and Deep Areas			$181,119,163			
7. Concentric Lakes – Lake Cell Divider Structures			$44,346,843			
8. North Sea Dam				$4,519,967,738		
9. Earthen Dikes for Habitat Ponds	$215,568,000	$292,364,100		$501,195,600	$568,560,600	
10. Habitat Ponds – Habitat Islands and Deep Areas	$246,651,333	$334,514,933		$573,455,600	$650,532,267	
11. Water Conveyance Features	$314,915,017	$201,680,735	$799,914,684	$193,488,011	$272,282,161	$58,896,420
12. Water Treatment Facilities	$218,000,000					
13. Air Quality Mitigation – via Water Vegetation Features	$762,930,000	$540,960,000	$477,750,000	$674,730,000	$596,820,000	$677,670,000
14. Air Quality Mitigation – via Other Features	$152,586,000	$108,192,000	$95,550,000	$134,946,00	$119,364,000	$135,534,000
Subtotal Construction Costs[2]	**$5,618,896,757**	**$2,083,435,345**	**$8,348,140,949**	**$6,597,782,949**	**$2,207,559,028**	**$872,100,420**
Unlisted Items: 10%	$581,103,243	$216,564,655	$851,859,051	$702,217,051	$192,440,972	$87,899,580
Total Contract Costs	$6,200,000,000	$2,300,000,000	$9,200,000,000	$7,300,000,000	$2,400,000,000	$960,000,000
Contingencies: 25%	$1,500,000,000	$600,000,000	$2,300,000,000	$1,800,000,000	$600,000,000	$240,000,000
Total Field Costs	$7,700,000,000	$2,900,000,000	$11,500,000,000	$9,100,000,000	$3,000,000,000	$1,200,000,000
Non-Contract Costs: 20%	$1,500,000,000	$600,000,000	$2,500,000,000	$1,900,000,000	$600,000,000	$200,000,000
Total Project Implementation Costs	**$9,200,000,000**	**$3,500,000,000**	**$14,000,000,000**	**$11,000,000,00**	**$3,600,000,00**	**$1,400,000,000**

[1] Costs presented are for alternatives using embankment designs that meet Reclamation design criteria and standards.
[2] Includes mobilization costs estimated at 5 percent.
[3] Total project implementation costs assuming four concentric lakes for Alternative No. 3A is $17, 800,000,000.

Table ES.2 Summary of annual re-occurring costs of restoration alternatives ($ million)

Alternative	Annual Operations, Maintenance, and Energy (OM&E) Costs	Annual Replacement Costs	Annual Operations, Maintenance, Energy, and Replacement (OME&R) Costs	Annual Risk Costs [2]	Annual Operations, Maintenance, Energy, Replacement, and Risk (OMER&R) Costs
Alternative No. 1A: Mid-Sea Dam with North Marine Lake using Sand Dam Design with Stone Columns	148	87	235	5	240
Alternative No. 2A: Mid-Sea Barrier with South Marine Lake using Sand Dam Design with Stone Columns	71	62	133	3	136
Alternative No. 3A: Concentric Lakes using Sand Dam Design with Stone Columns [1]	64	55	119	1	120
Alternative No. 4: North-Sea Dam with Marine Lake using Sand Dam Design with Stone Columns	89	77	166	6	172
Alternative No. 5: Habitat Enhancement without Marine Lake	79	68	147	7	154
Alternative No. 6: No-Project	87	77	164	0	164

[1] Costs shown are for three concentric lakes as required under mean possible future inflow conditions.

[2] Risk costs are defined as the annualized cost of repairing structures calculated from estimated annualized probabilities of failure (from major seismic events) and from estimates of how much of a structure would have to be repaired as a result of the failure.

Chapter 1. Introduction

Purpose

This report is intended to provide a summary of the Bureau of Reclamation's (Reclamation) recent study to determine a preferred alternative action for restoring the Salton Sea (Sea). This study was performed in fulfillment of the requirements of Public Law (P.L.) 108-361, the Water Supply Reliability and Environmental Improvement Act, November 2004.

Authority

This study is being conducted under the authority of P.L. 108-361, titled the Water Supply Reliability and Environmental Improvement Act. Specifically, the act requires that:

> "Not later than December 31, 2006, the Secretary of the Interior, in coordination with the State of California and the Salton Sea Authority, shall complete a feasibility study on a preferred alternative for Salton Sea restoration."

The costs of all alternatives presented in this report are based on very limited geologic and geotechnical data that were obtained through exploration in years 2003 and 2004. Significant design uncertainties exist as a result of the limited amount of site information. Uncertainties also exist relative to constructability, seismic performance, static performance, and construction costs. As a result of these uncertainties, the designs and costs presented in this report are at an appraisal level and not at a feasibility level. It would not be possible to develop feasibility level designs and cost estimates without conducting significant geologic and geotechnical design data collection programs.

Study Location

The Sea, a terminal hypersaline lake, is the largest inland body of water in California. It is located in the southeastern corner of the State and spans Riverside and Imperial Counties (location map). The closest cities include Palm Springs, Indio, Brawley, and El Centro.

The northern portion of the study area is drained by the Whitewater River and its tributaries, reaching the northern end of the Salton Sea within the Coachella Valley not far from the town of Mecca. Salt Creek drains the southern slope of the Orocopia Mountains and the northern end of the Chocolate Mountains, entering the northeast portion of the Sea within the Salton Sea State Park boundaries. The most important western drainage is San Felipe Creek, with headwaters near Julian, about 50 miles west of the Salton Sea. The New and Alamo Rivers drain the Imperial Valley and, to a lesser extent, the Mexicali Valley to the south.

Study Objectives

The primary purpose of this study is to identify and recommend a preferred action that attempts to provide an efficient and reasonable method for restoration of the Salton Sea ecosystem and permanent protection of wildlife dependent on that ecosystem. This objective is based on historic habitat capabilities for providing an abundant and diverse assemblage of fish and wildlife at a level sustainable (1) within the constraints of predicted future water availability and water quality, (2) at a reasonable degree of risk associated with the viability of the project (relative to environmental issues), and (3) in a cost effective manner. Although wildlife and wildlife habitat objectives were considered primary for this study, all objectives listed in the Salton Sea Reclamation Act (P.L. 105-372) were given significant consideration and adopted to the greatest extent possible. P.L. 105-372 identified the following objectives:

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

Emphasis was given to permitting the continued use of the Salton Sea for irrigation drainage and for reclaiming fish and wildlife resources and their habitats. An additional objective was considered relative to minimizing exposed areas subject to potential air quality problems. This additional objective was not included in the Salton Sea Reclamation Act. It was added for this study because of its importance to restoration feasibility and for consistency with the State of California's Salton Sea Ecosystem Restoration Study (ERS).

Project features are designed in this study to function at current and reduced inflows, as directed by P.L. 105-372.

History and Physical Setting of the Sea

The Salton Sea lies at the northern reach of the former delta of the Colorado River (Sykes, 1937) in a large, seismically-active rift valley that was once the northernmost extent of the Gulf of California. Before 1900, the river periodically emptied northwest into the Salton Basin, forming the ancient Lake Cahuilla, which was several times the size of the current Sea. The present-day Sea formed in 1905, when Colorado River flood flows breached an irrigation control structure in Mexico and were diverted into the Salton Basin for about 18 months. Since then, agricultural drainage flows from nearby Imperial, Coachella, and Mexicali Valleys and smaller contributions from municipal effluent and storm water runoff have sustained the Sea.

The present-day Salton Sea occupies a below-sea-level desert basin known as the Salton Basin (or Salton Sink or Salton Trough). The Salton Basin is located in a highly active tectonic region with frequent earthquakes. Tectonically, the vicinity is dominated by the San Andreas, Imperial, San Jacinto, and Elsinore fault systems. Many moderate-to-large earthquakes have occurred on faults in the Salton Basin. **Figure 1.1** displays historic earthquakes in the Salton Basin from the 1860s through the year 2005.[4]

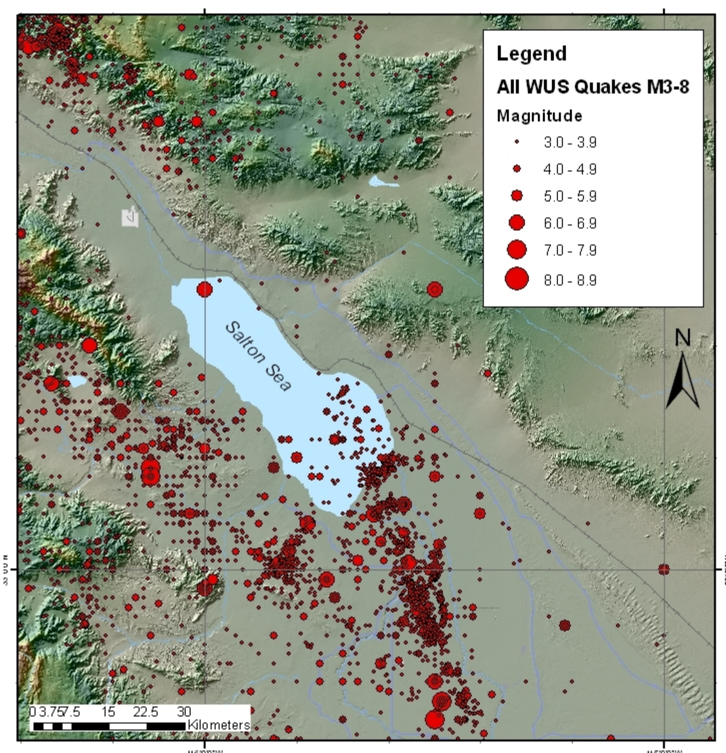

Figure 1.1 Historic Earthquakes Magnitude 3 to 8.

[1] This map was obtained from Reclamation's Western United States Earthquake Database.

The Salton Basin extends from Banning, California, on the north to near the international border of Mexico on the south. The Sea itself is about 35 miles long and 15 miles wide. Recently, the elevation of the Sea has been about -228 feet mean sea level (msl) (228 feet below sea level), with annual fluctuations of about 1 foot. At this elevation, the Sea has a maximum depth of about 50 feet, with an estimated surface area of 232,000 acres (362 square miles). The lowest Seafloor elevation is about -278 feet msl. The current Sea has a storage volume of approximately 7.2 million acre-feet.

The Sea's recent salinity concentration (48,000 milligrams per liter [mg/L]) is about 37 percent saltier than ocean water. In the recent past, annual inflows to the Sea have been in balance with its annual evaporation. Inflows add about 4 million tons of salt each year. Because the Sea has no natural outlet, the salinity in the Sea continues to rise each year as salts (or total dissolved solids) are left behind when water evaporates from the Sea surface. Salton Sea salinity will increase dramatically in the near future as inflows to the Sea are reduced due to implementation of existing water transfer agreements. This accelerated increase will occur because of an imbalance between inflow and evaporation. Rising salinities have affected, and are expected to continue to affect, the once highly productive fishery of the Sea.

Important Resources

Fishery

The fishery of the Salton Sea is an important (but declining) resource for both fish-eating birds and the local economy through recreational sport fishing. Beginning in 1929, the California Department of Fish and Game introduced more than 30 marine fish species to the Salton Sea. Only three of those species, sargo (*Anisotremus davidsoni*), Gulf croaker (*Bairdiella icistia*), and orangemouth corvina (*Cynoscion xanthulus*), adapted and became established. A fourth species, tilapia (*Oreochromis mossambicus* x *O. urolepis hornurum*), was unintentionally introduced to the Sea from agricultural drains in 1964-65. By the early 1970s, tilapia dominated the fish community in the Sea. Extensive surveys in 1999–2000 (Reidel et al., 2002) indicated that growth rates of tilapia in the Salton Sea were among the highest reported anywhere in the world as a result of the high nutrient concentrations and warm temperatures. In addition to the game fish, the endangered desert pupfish (*Cyrinodon macularius*) inhabits the Sea and adjoining drains and creeks and is of concern with respect to restoration alternatives.

Increasing salinity and dissolved oxygen (DO) levels currently pose the greatest threat to the Salton Sea fishery, although temperature fluctuations may become of concern as water levels drop. Reidel et al. (2002) reported that the optimum salinity range for food consumption and conversion, growth, and respiration for sargo, croaker, and orangemouth corvina was 33-37 grams per liter. Furthermore, current salinities in the Sea appear to be nearing the upper tolerance limits for all four of major species. In fact, recent increases in salinity may have already impaired the Salton Sea fishery. Crayon et al. (2005) recently reported that populations of sargo, Gulf croaker, and orangemouth corvina have been below detectable levels since May 2003. Tilapia populations have also been drastically reduced. Although tilapia numbers appear to be increasing, current populations are still more than 90 percent lower than the levels reported in 1999–2000.

Migratory Birds

The seasonal movements of migratory species of birds follow general, but complex, pathways that take birds from their breeding grounds to wintering areas and, subsequently, back to these breeding grounds. That journey must be supported by the availability of appropriate habitat and an adequate food base. Those essential factors must be satisfied within the limits of flight and bioenergetic considerations to provide for the return of sufficient numbers of birds in a physical condition that facilitates long-term population maintenance. The Pacific Flyway is an important migratory pathway for birds traveling between the breeding grounds in Canada, Alaska, the Pacific Northwest, and the Northern Great Plains and wintering grounds along the Gulf of California, extending into Central and South America (**Figure 1.2**).

The Salton Sea is an important link in the habitat and food chain that sustains the perpetual migratory cycles for many species of birds within Western North America. This linkage is that of a habitat for all seasons by providing an important crossroad and way station for seasonal resting and feeding needs, wintering, spring conditioning, and breeding habitat. Records of the U.S. Geological Survey's Bird Banding Laboratory disclose that birds banded at the Salton Sea have been reported from Russia and the North American Arctic to Latin America and from Hawaii to the Maritime Provinces of Eastern Canada (**Figure 1.3**). The considerable interchange evident with birds of the Pacific and Central Flyways indicates that the importance of the Sea is far greater than transient local and regional bird use.

The Salton Sea ecosystem supports some of the highest avian biological diversity in North America as well as the world. The more than 400 bird species that have been reported within the Salton Sea ecosystem comprise approximately 70 percent of all the bird species recorded in California. In addition, approximately 100 species, or one-third of all species that are known to breed in California, are breeders

Wood Storks

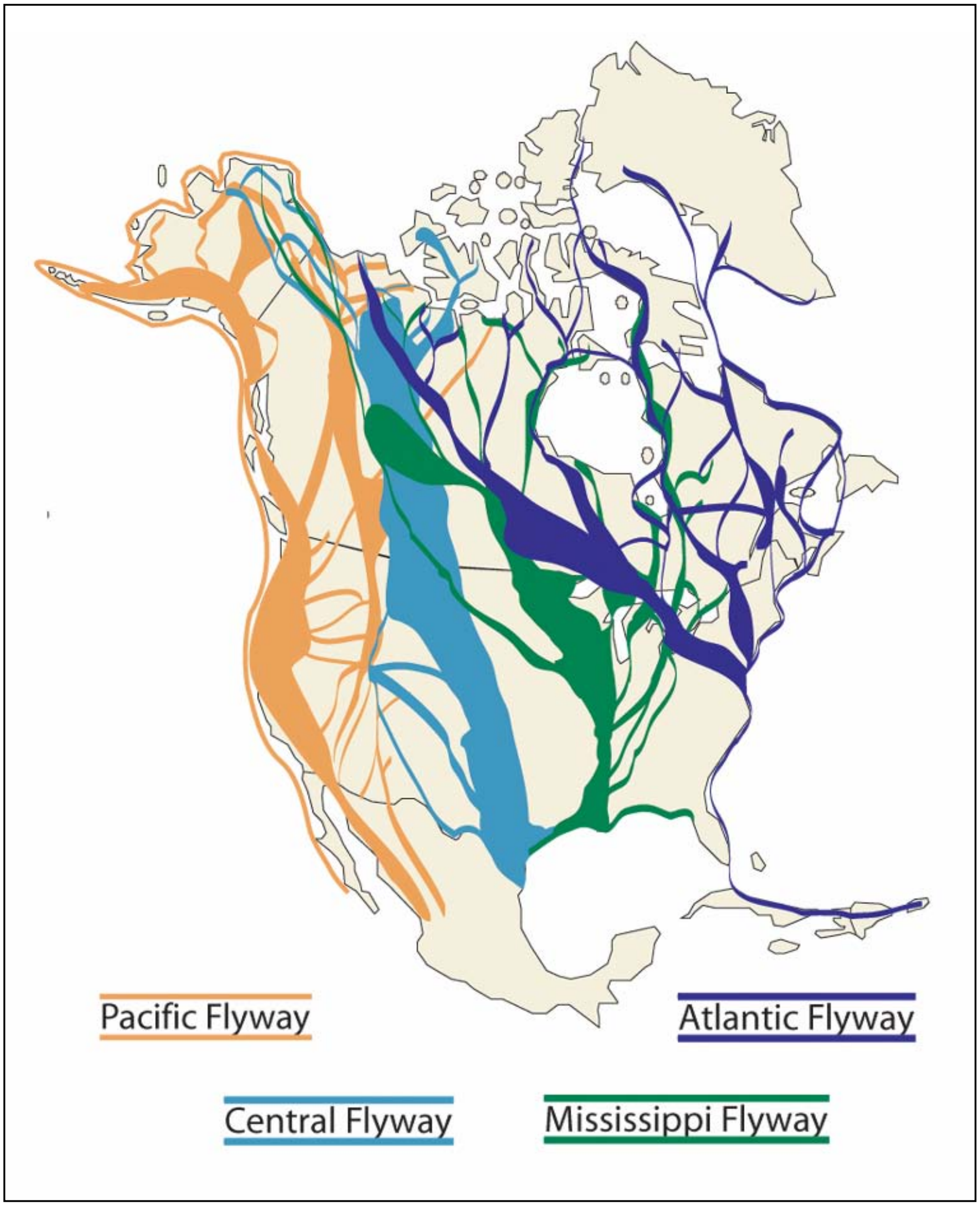

Figure 1.2 Flyways for migratory birds.

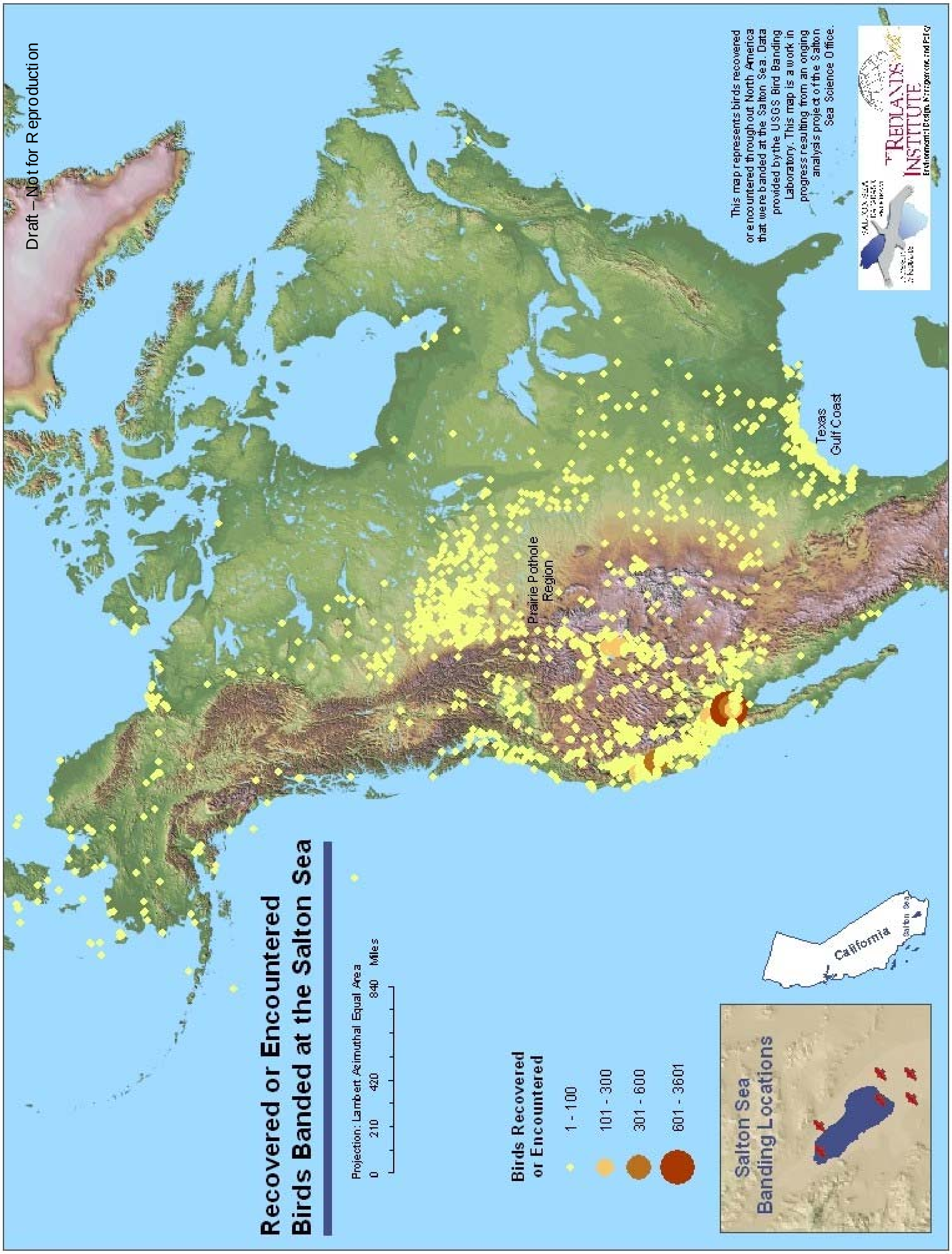

Figure 1.3 Recovered and encountered birds banded at the Salton Sea.

within the Salton Sea ecosystem. This combination of avian biodiversity and importance as breeding habitat is unsurpassed by any limited geographic area within the contiguous 48 states and Latin America.

Among the birds using the Salton Sea are 19 species of waterbirds classified by the Federal government, California, or both, as species of high conservation concern because of their population status. More than 14,000 pairs of colonial breeders, comprised of 11 species representing three families of birds, were tallied during a 1999 survey (Shuford et al., 2000).

The Salton Sea ecosystem is also an important area for landbirds. Investigators from the Point Reyes Bird Observatory during surveys in 1999 in areas adjacent to the Salton Sea tallied numerous neotropical migrants. More Wilson's warblers (*Wilsonia pusilla*) were caught at the Salton Sea during spring migration than at any other mist-netting site in California. The abundance of neotropical migrants recorded during spring and fall included 11 species of statewide concern in riparian habitats and is evidence that the area is used extensively by migrating passerines (Shuford et al., 2000).

In general, the Salton Sea is of regional or national importance to various groups of birds such as pelicans and cormorants, wading birds, waterfowl, shorebirds, gulls and terns, and some passerines. The Salton Sea ecosystem is a migratory bird habitat for all seasons that serves waterbirds and landbirds alike.

Recreation

Soon after its creation, the Salton Sea became a mecca for outdoor recreation. By 1958, the North Shore Beach area had been developed with an airfield and a yacht club. The North Shore Yacht Club was touted as a $2 million marine paradise, with one of the largest marinas in Southern California. The development of Salton City also began in earnest during the 1950s on the west side of the Salton Sea.

The development included a championship golf course and the Salton Bay Yacht Club, both of which were frequented by Southern California sportsmen and Hollywood celebrities. Developers claimed that Salton City would become the most popular marine resort in all of Southern California. The Salton Sea State Park (later the Salton Sea State Recreation Area) was dedicated on February 12, 1955. It served as an important inland recreation area until the late 1970s when visitation declined markedly because of the deteriorating environmental quality of the Sea. This facility has 1,400 campsites, hundreds of day use sites, and other amenities. Current annual visitor use at the park is about 250,000 people.

Waterfowl hunting has been a popular activity at the Salton Sea since at least the 1920s. There are numerous private duck clubs along the Sea and on adjacent areas. Hunters are also provided waterfowl opportunities on portions of the

Sonny Bono Salton Sea National Wildlife Refuge (NWR) and on the State's Imperial Wildlife Area Wister Unit.

The annual Salton Sea International Bird Festival attests to the popularity of the Salton Sea ecosystem as a haven for bird watching. An earlier economic analysis of bird watching at the Salton Sea reported substantial contributions to the economy of the small local communities around the Salton Sea.

A variety of other recreational activities also take place at the Salton Sea, including photography, camping, and kayaking. Because of its relative proximity to the large metropolitan areas of San Diego and Los Angeles, the Salton Sea is a valuable recreation resource.

Endangered Species

Several species listed under the Federal Endangered Species Act use habitat resources associated with the Salton Sea; however, four species are directly linked to future changes in Salton Sea water quantity and quality. For example, the desert pupfish is the only native fish inhabiting the Salton Sea. Designated critical habitat includes San Felipe Creek, Carrizo Wash, and Fish Creek Wash; however, pupfish also occur in wastewater drains discharging into the Sea, in shoreline pools of the Sea, artificial refugia, and in washes at San Felipe and Salt Creeks (Sutton, 2000). There is some indication that pupfish may use the Sea to move between sites providing habitat resources. As the Sea becomes more saline and the shoreline recedes in the future, there is concern that local pupfish populations may become isolated as they loose habitat connectivity with adjacent populations. All alternatives contain some provisions to maintain connectivity among local pupfish populations.

Two listed bird species may also be affected by future changes in the Sea. Brown pelicans use the Sea for feeding, nesting, and roosting. As the Sea becomes more saline and the shoreline recedes in the future, fish will disappear and the small islands used by pelicans will become connected to shore—thus loosing their security value. There are also concerns of selenium (Se) bioaccumulation in food chains used by fish-eating birds such as pelicans. Yuma clapper rails use freshwater marshes managed as wildlife habitat at the south end of the Sea, and some brackish sites associated with wastewater drains and river deltas. These brackish areas will likely disappear as the Sea becomes more saline and the shoreline recedes. There is also concern of Se bioaccumulation in food chains used by invertebrate-eating birds such as rails as Se concentrations in wastewater increase.

Significant Problems and Challenges

Among the problems and challenges facing the Salton Sea are increasing salinity, air quality concerns, Se, and eutrophication, as discussed in this section.

Salinity

Salinity is the more time-sensitive problem and must be dealt with so that the Sea survives long enough for the other, more complex problems to be addressed. This is not an either/or situation, as the investment in controlling salinity will be lost if the other problems are not also addressed.

As noted previously, the Sea has salinity measured recently at about 48,000 mg/L. In the absence of more definitive current information, at a salinity of 60,000 mg/L, the majority of the fishery is projected to be lost. Historically, the fishery supported species with differing levels of tolerance to salinity. In recent years, the sport fishery has declined dramatically. Sargo, croaker, and orangemouth corvina currently are not being detected in gill net samplings. Tilapia currently are rebounding from dramatic reductions that occurred over the last few years. It has been predicted that some age classes and species would likely to be lost at lower levels of salinity, thereby initiating a general decline in the fishery several years before a salinity of 60,000 mg/L is reached. This could be what has been occurring over the last few years.

The impacts of salinity on invertebrate populations also have significant biological ramifications. The pileworm (*Neanthes succinea*) is a major food source for some species of fish and birds. As salinity increases, a time will occur in the near future when pileworms will no longer be present in this ecosystem. Other invertebrates, such as brine flies (*Ephybra spp.*), will be favored by increased salinity. The shift in invertebrate populations will be beneficial for a few species of birds, but not for many others.

Air Quality Concerns

Winds in the Salton Sea basin generate large dust storms. As the Sea recedes in the future, there could be as much as 140 square miles of lake bed ("playa") exposed that could significantly increase fugitive dust in the basin. Human health is a concern related to these potential increases. Particles with a diameter of less than 10 microns (PM_{10}) are of primary concern. The Imperial Valley already suffers from the highest childhood asthma rate in the State. Furthermore, elderly people are especially susceptible to poor air quality (Cohen, 2006).

Sediment moisture, salt and sediment composition, and the extent of vegetation establishment all have major influences on the susceptibility of exposed sediments to wind erosion. Active disturbance of any exposed sediments can significantly increase the potential for wind erosion. Many major reservoirs experience significant seasonal changes in water elevation without generating serious fugitive dust problems during periods of low water levels. But serious fugitive dust problems have developed at two alkaline lakes in California—Owens Lake and Mono Lake. It is not known to what extent the Salton Sea will contribute to dust emissions, but it is assumed there is a risk that exposed playa areas would be emissive. Potential air quality mitigation projects are discussed in Chapter 3.

Selenium

Se is a naturally occurring semi-metallic trace element with biochemical properties similar to sulfur, and it is an essential trace nutrient necessary for normal metabolic functions. However, there is a narrow margin between nutritionally optimal and potentially toxic dietary exposure concentrations of Se for vertebrates. Effects of Se toxicity can range from hair/feather loss to death. Reproductive impairment—a common concern in Se studies—is exposure responsive, meaning the higher the concentration, the greater the effect. Se is a consideration in Salton Sea studies because of the potential for bioaccumulation in aquatic food chains supporting abundant and diverse bird use of the area. Bioaccumulation can occur when Se is acquired from one level of a food chain and passed on to the next higher level. For example, Se can be accumulated from water and/or sediments by bacteria and algae and passed on to macro-invertebrates that feed on them. Birds that feed on the macro-invertebrates would then accumulate larger amounts of Se. Under certain conditions, Se can accumulate to toxic levels in food chains (e.g., in birds).

Se cycling involves the interaction of physical, chemical, and biological components of aquatic systems. The processes and interactions are complex and can possess system unique characteristics. For example, Se concentrations in drainage water entering the Salton Sea are at levels that would normally cause concern for bioaccumulation within the Sea's food chains. However, the interaction of system components currently characterizing the Sea results in a sequestering of Se in bottom sediments. Se levels available for accumulation in food-chains originating in the Sea are, therefore, lower than would be expected from a different blend of system components. Se concerns for the Salton Sea focus on the uncertainties associated with the interactions of the physical, chemical, and biological components that would characterize the future under the No-Project Alternative and/or the future under the restoration alternatives. The future Salton Sea system may support Se cycling similar to the current situation, or a different system—with different Se risk to local food chains—may be supported.

Eutrophication

Eutrophication is the enrichment of lakes by nutrients, typically nitrogen and phosphorus (P). High concentrations of nutrients can lead to increased growth of algae and aquatic plants and decreased species diversity. Eutrophication is a natural aging process in some lakes, but it is frequently accelerated by nutrient loadings arising from human activity.

Nutrient loadings to the Salton Sea are very high because of the variety of both nonpoint sources (primarily agricultural runoff) and point sources (wastewater treatment plant effluent) of nutrients in the watershed. As a result, the Sea is classified as hypereutrophic, a term used for lakes with the highest nutrient and chlorophyll *a* concentrations and the lowest transparency. In hypereutrophic lakes, algae and other organic matter decompose, creating severe oxygen depletion. Oxygen depletion at the Salton Sea has caused fish kills and has contributed to other chemical changes that create odors and other nuisance conditions.

The size of the Sea would be reduced under the various alternatives, which could result in intense and persistent thermal stratification at depths greater than 10 meters (m) (33 feet). (Thermal stratification refers to the layering that occurs, particularly in the warmer months, when a warmer, less dense layer of water [the epilimnion] overlies a colder, denser layer [the hypolimnion]). As a result, the Sea would switch from a system with several mixing events per year, to a system that is mixed for a relatively brief period in the winter. This stability and the expected continuing eutrophication would make the hypolimnium of the Sea anoxic (i.e., contain no DO) for most of the year.

With this extensive anoxia, hydrogen sulfide (H_2S) and ammonia (NH_3) could build up to unprecedented levels because of the lack of mixing. When the Sea does mix, the rapid breakdown of the stratification could potentially lead to a sudden redistribution of anoxia, H_2S, and NH_3 throughout the water column and the release of gaseous NH_3 and H_2S to the air. The effect of this could be an annual die off of most fish in the Sea and serious odor problems. There are also potential human health impacts, including headache and nausea, as well as more serious problems for sensitive individuals.

Responses to Comments on Draft Summary Report

Reclamation has incorporated comments received on the January 31, 2007, draft of this Summary Report. Where appropriate changes have been made to this report as a result of these comments. Attachment B contains the comments that were received, as well as Reclamation's responses. The responses to comments are indexed according to numbers assigned to each specific comment as depicted on the letters from each agency or individual. The numbers were assigned by Reclamation.

Chapter 2. History of Plan Formulation

This present study to attempt to determine a reasonable alternative concept for restoring the Salton Sea uses information from both recent (1998–2005) and past (1960s to 2003) studies. The specific concepts evaluated in this present study were screened and selected from hundreds of ideas and concepts that ranged from circulating ocean water from the Gulf of California or the Pacific Ocean to removing salts at the Sea through the use of enormous desalination plants, solar pond systems and/or enhanced evaporation systems.

Rising salinity concentrations and the realization in the 1960s that increased salinity levels would eventually affect uses at the Sea led to various study efforts to determine methods to manage salinity. Early efforts and investigations to determine methods to reduce salinity in the Sea began in 1965 and resulted in the preparation of a 1969 Federal/State Reconnaissance Investigation Report and the 1974 Salton Sea Project Feasibility Report (Reclamation and State of California, 1974). Although numerous concepts for reducing salinity were studied and reported, rising water surface elevations at the Sea, due to increased agricultural development and subsequent drainage inflows into the Sea, muted the need for project implementation at that time.

In the mid-1980s, Federal and State agencies again began looking into ways of controlling salinity. P.L. 102-575, passed in 1992, gave Reclamation the authority to conduct salinity control studies. In response to that law, Reclamation and the Salton Sea Authority (SSA), which was established in 1993, published and provided a report to Congress in 1997 that contained an evaluation of a wide suite of proposed alternatives intended to address the salinity and elevation problems of the Sea.

In 1996, an initial screening study was conducted through an agreement with the SSA, the California Department of Water Resources (DWR), and Reclamation. In an effort to include a wide variety of potential solutions to the problems of the Sea, media announcements and public meetings were used to invite submittals of restoration alternatives. Through these efforts, 54 alternatives were identified and evaluated through a preliminary technical screening process. This preliminary screening effort provided the framework for developing alternatives in 1998 that would be analyzed and documented by various efforts, including a cooperative federal and state National Environmental Policy Act and California Environmental Quality Act (NEPA/CEQA) initiative.

Subsequent to the passage of the Salton Sea Reclamation Act of 1998, Reclamation and the SSA began the process of developing a Draft Environmental Impact Statement/Environmental Impact Report (DEIS/EIR). As part of this NEPA/CEQA process, required public scoping meetings resulted in further alternative suggestions, as well as comments concerning the 54 alternatives that were derived from the previously mentioned screening process.

All 54 original alternatives were re-assessed, and new alternatives were considered, including those suggested by the public in 1998. The reassessment yielded 39 alternatives that were carried forward for additional screening analysis. A description of these alternatives is provided in the Salton Sea Alternatives Final Pre-Appraisal Report (November, 1998).

Subsequently, a January 2000 DEIS/EIR considered five project alternatives and compared each against three No Action/No-Project scenarios. Analysis of alternatives continued following publication of the DEIS/EIR and the receipt of public and agency comments. In addition, more information became available about the range of possible inflows to the Sea that could occur in the future. Restoration alternatives studies also continued following publication of the DEIS/EIR. In these studies, the strategy for salinity control presented in the DEIS/EIR was replaced by a strategy involving two basic types of modules for salinity control: salt removal modules and salt disposal modules. Using the modular strategy, eight salinity control alternatives, three salinity and elevation control alternatives, an alternative that would have involved construction on an impervious barrier across the middle of the Sea, and two specialized diking proposals were considered in a January 2003 status report (Reclamation, 2003).

After publication of the 2003 status report, the Quantification Settlement Agreement (QSA) was reached, and the associated Imperial Irrigation District (IID)/San Diego Transfer Agreement was approved. As a result of anticipated reduced inflows, alternatives involving salt removal and disposal were abandoned in favor of partial restoration solutions such as equal head barriers and impervious dam alternatives as well as habitat-pond-based alternative concepts. Reclamation's current alternatives include only these types of alternatives. The current alternatives presented in this summary report are as follows:

- Mid-Sea Dam with North Marine Lake
- Mid-Sea Barrier with South Marine Lake
- Concentric Lakes
- North-Sea Dam with Marine Lake
- Habitat Enhancement without Marine Lake
- No-Project

Chapter 3. Restoration Alternatives

This chapter describes the primary structural and physical features of each alternative, including the No Project Alternative. Included are descriptions of alternative-specific features, such as water quality treatment systems and innovative construction methods. This chapter also describes common features associated with alternatives, e.g., saline habitat complexes (SHC), associated early start projects, and air quality mitigation (AQM) projects. Lastly, this chapter describes embankment designs, design criteria, design considerations, and comparisons to Reclamation's design criteria and guidelines for each of the action alternatives.

This report evaluates the following alternatives:

1. Mid-Sea Dam with North Marine Lake (proposed by the SSA)
2. Mid-Sea Barrier with South Marine Lake
3. Concentric Lakes (proposed by the Imperial Group)
4. North-Sea Dam with Marine Lake
5. Habitat Enhancement without Marine Lake
6. No-Project

Reclamation coordinated closely with the State of California DWR and the Salton Sea Authority in developing the alternatives presented in this report. Consequently, both the State and Reclamation have analyzed alternatives that are conceptually similar, yet have some differences. Variation between agencies in approaches to risk, uncertainty, complexity, and other factors contribute to differences in designs and costs. While Reclamation's design and cost estimating criteria and guidelines may be different than those used by other agencies and this may lead to different design conclusions and project costs, Reclamation makes no judgment relative to methods, assumptions, and criteria used by others.

Reclamation recognizes that any site-specific evaluation and/or alternative implementation would require consultation with the U.S. Fish and Wildlife Service, the Torres Martinez Nation, and others to ensure consistency with other missions and land uses.

It was Reclamation's intention to provide the highest quality design and cost estimates within the constraints of funding, schedule, and available information. Available knowledge of geologic conditions, in particular, was limited.

These factors should be taken into consideration when comparing costs of alternatives presented in this report to those presented in DWR's Salton Sea

Ecosystem Restoration Program draft programmatic environmental impact report (PEIR) and to reports prepared by other organizations.

The drains that flow directly into the Salton Sea are potential habitat for the desert pupfish. In the future, IID will provide for connectivity among the direct-to-sea drains in areas on the south end of the Salton Sea; this will be required as mitigation for the IID/San Diego water transfer project. These mitigation requirements are not directly reflected in any of the alternative depictions presented in this chapter. However, it is recognized that future implementation of any of these alternatives would need to address these mitigation actions.

Common Features

Alternative Nos. 1, 2, 4, and 5 include SHCs formed by earthen embankments. All alternatives include an early start for development of SHCs or habitat areas. All alternatives also include facilities for performing AQM. A discussion of these common features follows.

Saline Habitat Complexes


Saline habitat complex.

About 20 percent of the total SHC would be deep open water (up to 10 feet) for fisheries. These deep-water pond areas would be constructed through excavation; the excavated material would be used to create islands behind cell embankments. The remaining portion of the SHC would be divided into areas suitable for different species and their use. The majority of these shallow-water pond habitats would be less than 3 feet deep; up to a quarter of these areas would be land. **Figure 3.1** depicts a cell in a typical SHC.

Inflows to the SHCs would be managed to achieve an average salinity of more than 20,000 mg/L and less than 35,000 mg/L through the mixing of waters from the rivers and alternative-specific marine lakes or brine pools. Water would flow by gravity through each of the habitat complex cells. The salinity would increase in each cell until it reaches about 150,000 mg/L, whereby discharges from the last cell would be made to the brine pool specific to each alternative. The water is expected to have habitat value up to a salinity of about 150,000 mg/L.

The SSA has recently proposed a different set of assumptions for the SHC design in its alternative. The SSA has proposed *not* to include deep-water pond areas in

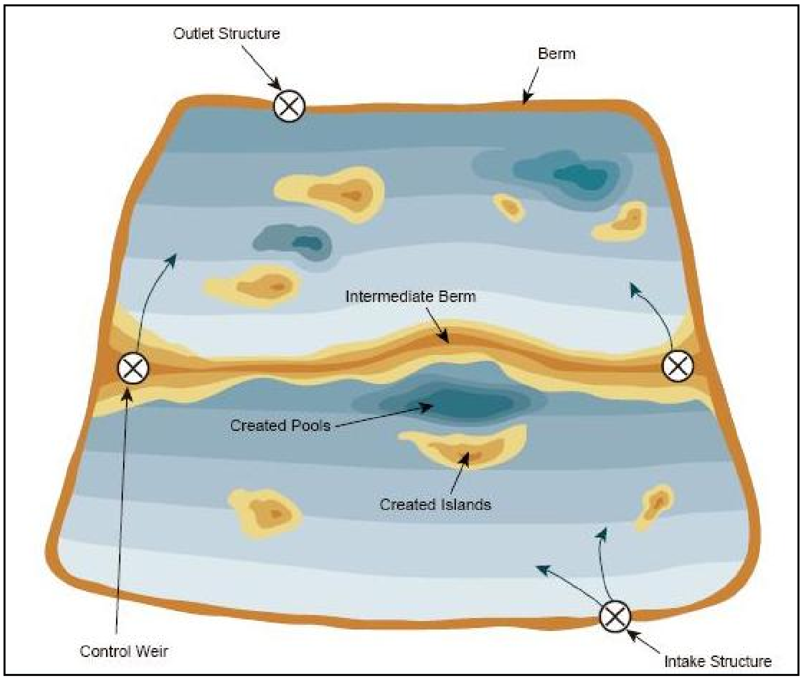

Figure 3.1 Cell in a typical SHC.

its SHC design. The SSA is also assuming that the SHC would be 50 percent water and 50 percent land. To ensure that all alternatives were evaluated and compared on an equal basis, Reclamation assumed the SSA alternative had the same type of SHC as the other alternatives, which includes deep water pond areas. Without deep holes for a fishery in the SHC, there would be no opportunity for an early start fishery under this alternative.

Early Start Projects

For all alternatives, it was assumed that construction would be completed in the year 2024. Assumptions for project completion are discussed in Chapter 4. Prior to completion of project construction the Sea is expected to experience environmental degradation involving the complete loss of the fishery and the collapse of the invertebrate food base. In order to provide some replacement habitat, all alternatives were assumed to include early start SHC development features. These early start features would be designed to offset negative habitat impacts during the construction period and could be implemented in phases in 200 to 500-acre units. These units would be located in areas compatible with the SHC complex build out for each alternative and would likely be constructed in the south end of the Sea that would be exposed in the near future. Each phase would be constructed every 3 to 5 years.

The Concentric Lakes Alternative would also have an early start project and could involve the construction of small ring dike impounded areas that could be operated consistent with concentric lakes operation concepts as well as SHC operation concepts.

Early start areas would need to be monitored and adaptively managed over time to develop procedures to mitigate Se, eutrophication, and fishery sustainability problems. These areas would also be studied for habitat values and uses by functional bird groups, such as fish-eating birds, divers, shorebirds, long-legged waders, etc.

Air Quality Mitigation Projects

Each alternative (including No-Project) includes an AQM project for control of emissions from exposed playa areas. The AQM project for all of the alternatives adheres to the methods described in DWR's Salton Sea Ecosystem Restoration Program Draft PEIR, Appendix H-3: "Identify and Outline Measures to Control Playa Emissions." The California legislature enacted certain laws in 2003 providing for preparation of the Salton Sea ERS and PEIR that include specific air quality monitoring and mitigation steps to be taken. Under the California State Water Resources Control Board Order (SWRCB, 2002) and the IID Water Conservation and Transfer Project Mitigation, Monitoring, and Reporting Program (IID, 2003) potential air quality impacts from exposed Salton Sea playa must be monitored and mitigated. It is assumed the State of California will manage AQM in coordination with landowners and other stakeholders. For the No Project Alternative, AQM for the IID/San Diego water transfer project would be implemented by IID in coordination with California State regulating agencies.

The SSA has proposed use of salt crusting to eliminate most AQM requirements. SSA made this proposal under the premise that relatively pure halite (NaCL) crusts can be formed to eliminate the opportunity for playa emissions. The potential effectiveness of this approach has a high level of uncertainty. Research at the Salton Sea (Reclamation, 2004) indicates that the crusts that will be formed will predominantly be mixed-salts with continuous formation of a mixture of NaCL and bloedite ($Na_2Mg(SO_4)_2 4H_2O$). Based on these research observations, it is possible that sulfate salt transformations and associated crust friability could lead to airborne particulate emissions from the salt crust areas. As a result, the SSA proposal to use salt crusting as a means of AQM was not used in the evaluation of the SSA alternative. A cost estimate that assumed use of salt crusting for AQM was made of the SSA's original alternative. These costs are presented for comparison purposes in **Attachment A** of this report.

The approach used by DWR in the PEIR (for most alternatives) assumes that 30 percent of the exposed area would not require active AQM. This approach also assumes that 50 percent of the exposed area would require AQM using water-efficient vegetation, and 20 percent of the exposed area would require AQM using other methods. This approach to AQM was applied to all alternatives studied by Reclamation.

Table 4.1 in Chapter 4 lists exposed playa surface areas for each alternative and the acreages of each to be mitigated with water-efficient vegetation and non-water based control measures. These acreages were predicted using computer modeling, as described in Chapter 4.

Alternative No. 1: Mid-Sea Dam with North Marine Lake (SSA Alternative)

Alternative No. 1 was proposed by the SSA. It would provide both salinity and elevation control and up to 16,000 acres of SHC. **Figure 3.2** presents the alternative under mean possible future inflow conditions (727,000 acre-feet per year) as described in Chapter 4. The mid-Sea embankment location of this alternative was originally proposed by the SSA to be located approximately 1.5 miles south of the position shown in **Figure 3.2**. The SSA proposed the new location to allow for enhanced capabilities to manage for future salinity concentrations in the north marine lake. **Figure 3.2** and all analyses presented in the main body of this report are based on this new dam alignment. **Table 3.1** lists physical features associated with Alternative No. 1 under mean future inflow conditions in the year 2040. All depictions of alternatives in this chapter are associated with year 2040. In this year, all alternatives are expected to reach (or nearly reach) equilibrium with respect to environmental conditions.

Alternative No. 1 (**Figure 3.2**) includes a total of four embankments: (1) an impervious mid-Sea dam, (2) an east-side perimeter dike, (3) a west-side perimeter dike, and (4) a south-Sea dam. These structures would be built using the sand dam with stone columns concept described later in this chapter. The embankment design would provide for both static and seismic risk reduction. Reclamation evaluated the rockfill embankment concept proposed by the SSA and determined that it would not meet Reclamation's general design criteria. The embankments would be constructed so the water north of the mid-Sea dam would be maintained at a higher elevation than the brine pool on the south side. The area south of the mid-Sea dam would serve as an outlet for water and salt from the north and would rapidly shrink in size and increase in salinity to form a brine pool. In addition to the north marine lake, a smaller south marine lake would be created by the south-Sea dam. These

Original SSA Alternative: The SSA's original alternative incorporated a mid-Sea dam about 1.5 miles farther south than what is presented in **Figure 3.2**. This alternative also included a smaller SHC of 12,000 acres. Cost estimates were prepared for the SSA's original alternative. These estimates provide a basis for making comparisons to cost estimates prepared by DWR and the SSA for this same original alternative. **Attachment A** of this summary report contains these cost estimates assuming that embankments would be built using rockfill embankments similar to those being proposed by the SSA (Alternative 1B). The estimate presented in Attachment A assumes the use of salt crusting (as originally proposed by the SSA) via construction of small earth embankments (2.5 feet tall) to impound brine released from the SHC. Reclamation evaluated the rockfill embankment concept and determined it would not meet Reclamation's general design criteria.

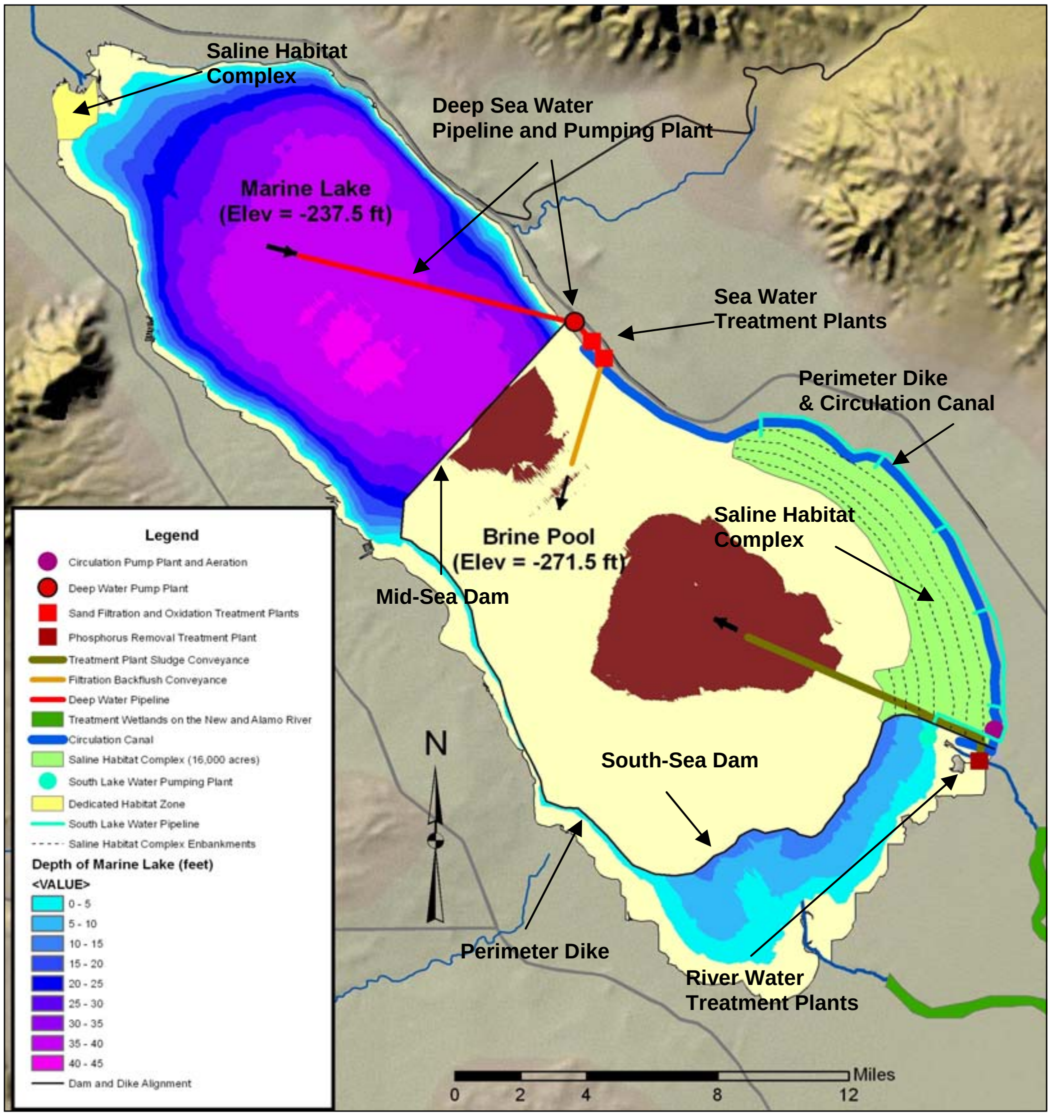

Figure 3.2 Alternative No. 1: Mid-Sea Dam with North Marine Lake (SSA Alternative).

Table 3.1 Physical features of Alternative No. 1: Mid-Sea Dam with North Marine Lake

Physical Feature	Value
Marine lake surface area	98,900 acres
Marine lake maximum depth	43.5 feet
SHC surface area	16,000 acres
Total open water habitat surface area	106,900 acres
Total shoreline habitat surface area	26,600 acres
Brine pool surface area	17,600 acres
Exposed playa surface area	103,800 acres

> ***Mean Possible Future Inflows:*** Without future assurances of inflows to the Salton Sea, there will be some degree of performance uncertainty (risk) for any Salton Sea restoration alternative. Under some scenarios, inflows to the Sea might be reduced to a level that puts the success of restoration in jeopardy. The impacts of the risks and uncertainties of inflows on each restoration alternative were assessed in this study. These assessments were made using advanced computer modeling techniques. Each alternative was modeled using a risk-based approach to inflows in which 10,000 different possible future Salton Sea inflows scenarios were simulated. The mean (or average) inflow computed from of all these possible futures is described as the "Mean Possible Future Inflow Condition" and would have a value of 727,000 acre-feet per year. The risk-based approach to inflows is described further in Chapter 4.

two bodies of water would be connected along the western edge of the Sea by the west-side perimeter dike and along the eastern edge by the east-side perimeter dike and canal. The north marine lake would have a mean future water surface elevation of about -238 feet msl under mean possible future inflows as described in Chapter 4. The estimated long-term elevation of the brine pool is about -272 feet msl. The alternative includes 16,000 acres of SHC and a dedicated habitat area on the north end of the Sea. It also includes a deep water pipeline, an ozonation treatment plant, a water circulation system, and a phosphorous removal treatment plant.

The conveyance features included in this alternative consist of a circulation canal, sludge conveyance pipeline, back-flush waste pipeline, three pumping plants, and two associated pipelines. These conveyance features would be used to provide water to AQM projects, to handle discharge to and from treatment plants, and to circulate water. These features also would provide marine lake water to be mixed with river water delivered to the SHCs.

This alternative was not studied under the assumption of a guaranteed minimum water supply. The Salton Sea has no assured water supply in the future. Therefore, the alternative was studied using the risk-based approach to inflow described in Chapter 4. On the basis of this risk-based approach to inflows, it was necessary to adjust the operating elevation of the marine lake to -238 feet. Without this flexibility in the operating elevation of the lake, the salinity levels cannot be reduced sufficiently (by the year 2040) to maintain a fishery under mean possible future inflow conditions. The SSA has proposed an operating elevation in the marine lake of -230 feet. On the basis of the risk-based approach to future inflows, this may not be possible until after the year 2055 when the salinity in the marine lake is reduced to 45,000 mg/L, stabilized, and then only under certain higher possible inflow conditions. If future inflow conditions are above mean possible estimates, then the operating elevation of the marine lake could be higher and potentially at a level consistent with the SSA's target if -230 feet. If future inflows are below mean possible future conditions, then the lake would have to be operated at elevations of less than -238 feet to maintain salinities at fishery-compatible levels.

Alternative No. 2: Mid-Sea Barrier with South Marine Lake

Alternative No. 2 would provide salinity control but no elevation control and up to 21,700 acres of SHC. **Figure 3.3** presents the alternative under mean possible future inflow conditions (727,000 acre-feet per year). **Table 3.2** lists physical features associated with Alternative No. 2 under mean future conditions in the year 2040.

The alternative includes a mid-Sea barrier designed to generally be operated with equal heads on both sides and to accommodate a differential head of up to 5 feet.

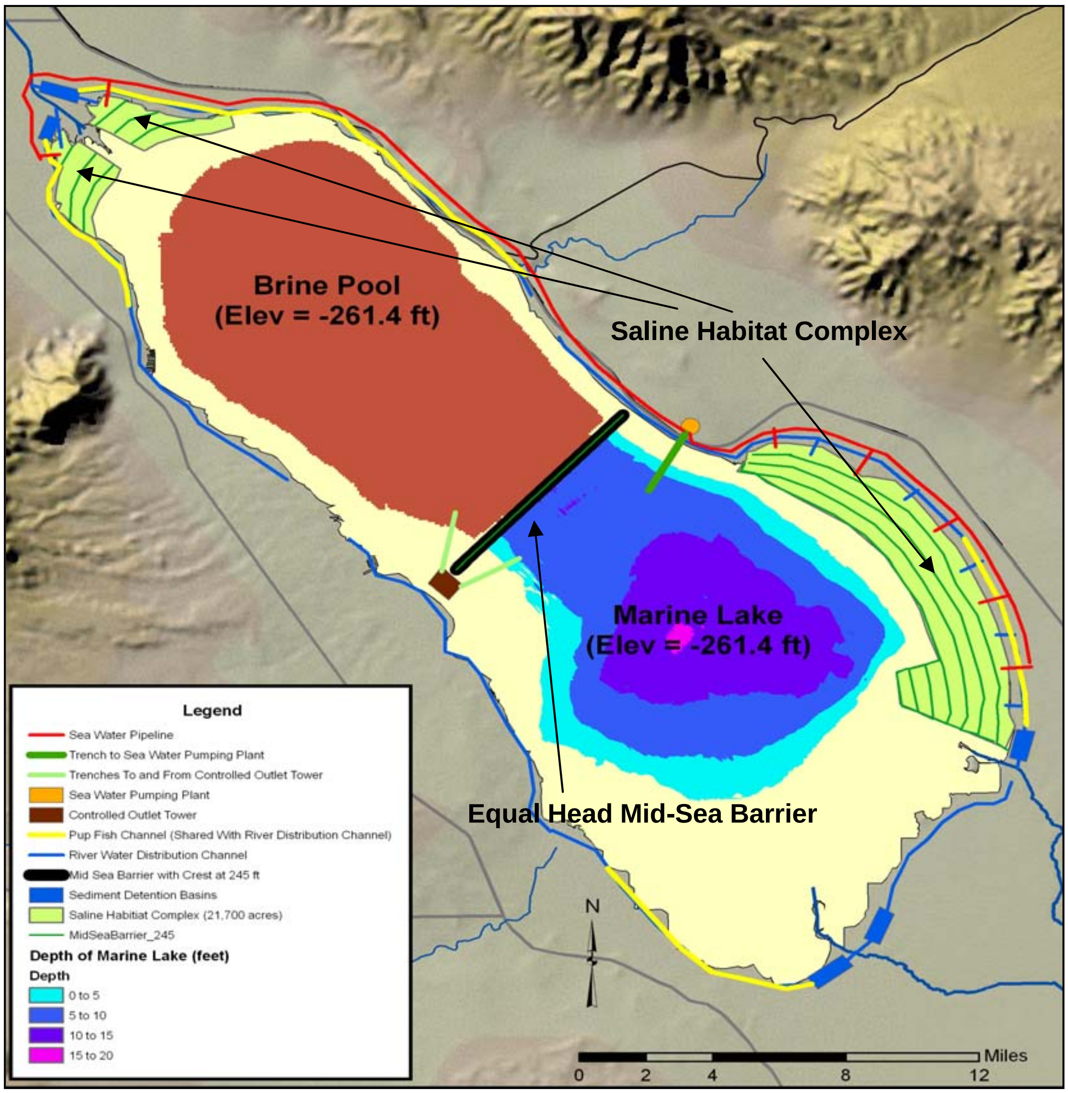

Figure 3.3 Alternative No. 2: Mid-Sea Barrier with South Marine Lake.

Table 3.2   Physical features of Alternative No. 2: Mid-Sea Barrier with South Marine Lake

Physical Feature	Value
Marine lake surface area	59,700 acres
Marine lake maximum depth	15.5 feet
SHC surface area	21,700 acres
Total open water habitat surface area	49,000 acres
Total shoreline habitat surface area	34,700 acres
Brine pool surface area	66,000 acres
Exposed playa surface area	73,600 acres

The water entering the Sea from the south into the south marine lake would support a large marine habitat. The estimated long-term elevation of the marine lake and brine pool under mean future conditions is -261 feet msl. The majority of inflows are expected to occur from the south end; therefore, the area north of the barrier embankment is expected to serve as an outlet for water and salt from the south side. The north side would quickly form a brine pool. As the main body of the Sea shrinks, embankments would be constructed to create SHC. The mid-Sea barrier would be constructed with a crest elevation of -245 feet and would accommodate the forecasted reductions in inflows when mitigation water is terminated under the IID/San Diego Transfer Agreement.

The 21,700 acres of SHC would be constructed on the southeast and north ends of the Salton Sea.

The conveyance features included in this alternative consist of five diversion crests and sediment detention basins, four pupfish/river water channels, five river water channels, and a pumping plant and two associated pipelines. These conveyance features would be used to provide water to AQM projects as well as to provide marine lake water to be mixed with river water delivered to the SHCs. A controlled outlet tower on the west end of the barrier would provide the ability to maintain up to a 5-foot head differential between the marine lake and brine pool.

The mid-Sea barrier embankment would be built using the fundamental concepts of the sand dam with stone columns described later in this chapter. It would provide for both static and seismic risk reduction. Two designs were developed for the mid-Sea barrier to compare the annual risk costs of a structure that reduces both seismic and static risks (i.e., with stone columns) with the annual risk costs of a structure that reduces only static risks (i.e., without stone columns). Risk costs are described in Chapter 7. Annual risk costs can be compared using information presented in **Table 7.2** and **Attachment Table A-2**.

Alternative No. 3: Concentric Lakes (Imperial Group Alternative)

Alternative No. 3 was proposed by the Imperial Group. It provides both elevation and salinity control. **Figure 3.4** presents the alternative under mean possible future inflow conditions (727,000 acre-feet per year). **Table 3.3** lists physical features associated with Alternative No. 3 under mean future conditions in the year 2040.

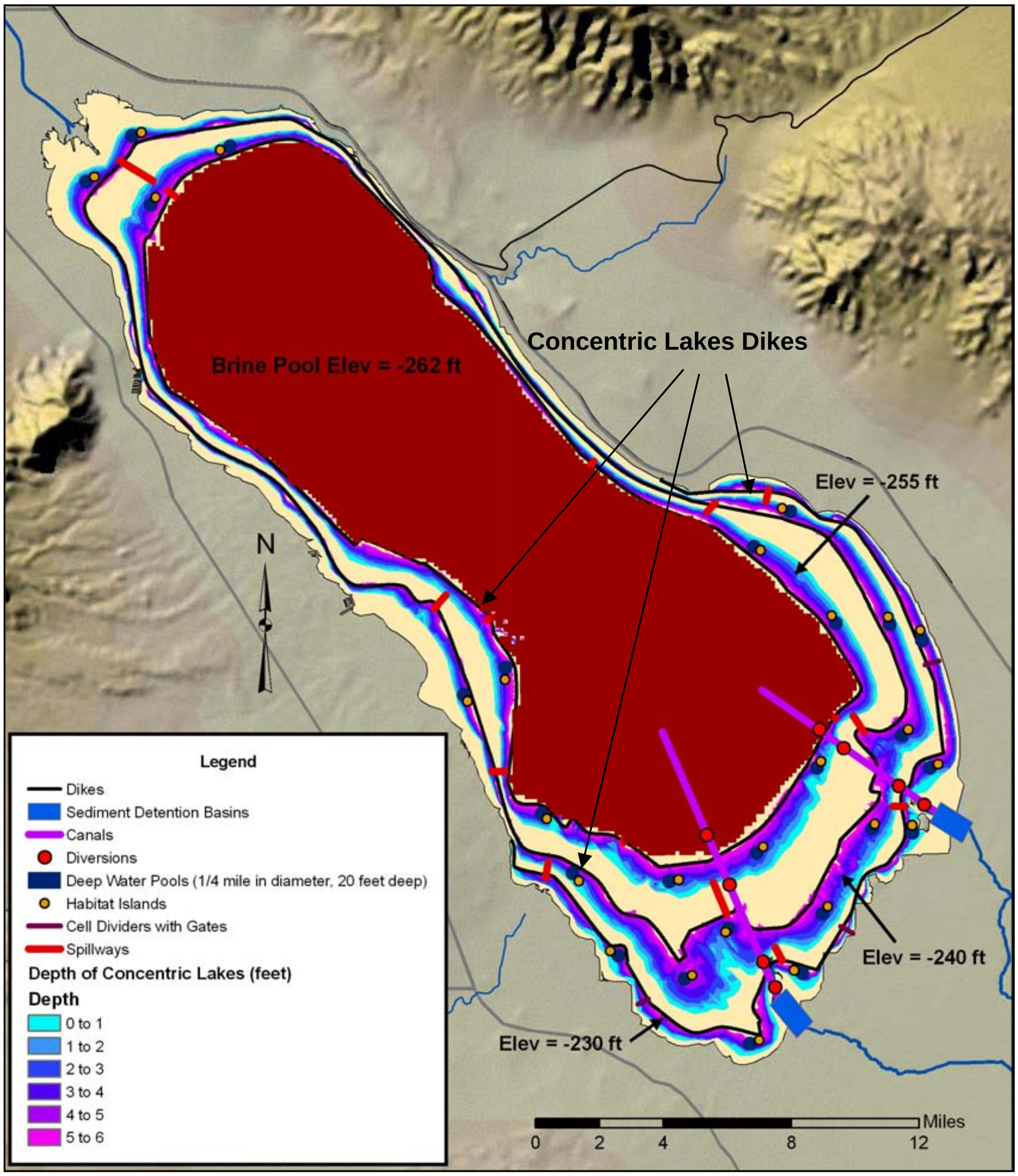

Figure 3.4 Alternative No. 3: Concentric Lakes.

Table 3.3 Physical features of Alternative No. 3: Concentric Lakes

Physical Feature	Value
Marine lakes surface area	47,600 acres[1]
Marine lakes maximum depth	6 feet
SHC surface area	0 acres[2]
Total open water habitat surface area	817 acres
Total shoreline habitat surface area	46,800 acres
Brine pool surface area	127,800 acres
Exposed playa surface area	65,000 acres

[1] The 47,600 acres shown are for three concentric lakes. The fourth lake proposed by the Imperial Group is not necessary under the risk-based approach to future inflows described in Chapter 4. Including the fourth lake proposed by the Imperial Group would result in a total marine lakes surface area of 88,000 acres.

[2] This alternative has habitat areas that are similar to SHC, which is reflected in the shoreline habitat surface area listed in this table.

The Imperial Group's proposal for this alternative included four lakes. Under the risk-based inflows discussed in Chapter 4, the alternative would require only three lakes. The alternative consists of a series of three (or four) independent lakes, with deep pools and habitat islands. Each lake would receive water directly from canals from the New and Alamo Rivers. Each lake would operate at increasingly higher salinities, with evaporation concentrating salinities from 20,000 to 60,000 mg/L. The lakes would be formed by constructing dikes in a concentric ring pattern. The outermost lake would be formed by a partial ring dike located at the south end of the project. A brine pool would exist within the area of the innermost dike. Deep pool areas would be formed within the lakes with adjacent habitat islands. Up to 20 feet in depth, these pools could support a sustainable fishery. Outside of the deep areas, the maximum lake depth would be 6 feet.

The outer lake is shown with cell dividers that could allow different habitat types to be managed in a way similar to that under the SHC concept. The cell divider concept could be applied to any of the concentric lakes. However, costs presented in Chapter 7 of this report assume that the cell dividers are only incorporated into the outer partial concentric lake.

This alternative would be constructed in stages. The outermost lake features would be constructed first. The second, third, (and fourth) reservoir lakes would be constructed as the water surface of the residual Sea recedes to the target reservoir water surface elevation of the next lake to be constructed. The estimated time frame for completion of all construction stages is 40 years. The conveyance features included in this alternative consist of two river water channels to convey all flows from the Alamo and New Rivers into the concentric lakes and brine pools area. Diversion structures would provide for control of flows into each lake to manage salinity levels.

The Imperial Group has proposed using Geotube® technology to construct the concentric lakes dikes. Reclamation has studied three dike design options, one of which incorporates the Geotube® technology. The other two are sand dam with (and without) stone column embankment designs described later in this chapter. One sand embankment design includes features to reduce static loading risks (without stone columns). The other design includes features to reduce both static and seismic loading risks (with stone columns). The Geotube® design (Alternative No. 3C) would not reduce seismic or static loading risks.

The three designs were developed for the purpose of comparing the costs of constructing structures that reduce seismic and static risks with annual risk costs for structures that do not. Risk costs are described in Chapter 7. Annual risk costs can be compared using information presented in **Table 7.2** and **Attachment Table A-2**. Constructing concentric lakes dikes using Geotubes® would likely result in significant seismic, static, and constructability problems.

Alternative No. 4: North-Sea Dam with Marine Lake

Alternative No. 4 would provide both elevation and salinity control and up to 37,200 acres of SHC. **Figure 3.5** presents the alternative under mean future inflow conditions (727,000 acre-feet per year). **Table 3.4** lists physical features associated with Alternative No. 4 under mean future conditions in the year 2040.

Table 3.4 Physical features of Alternative No. 4: North-Sea Dam with Marine Lake

Physical Feature	Value
Marine lake surface area	19,500 acres
Marine lake maximum depth	33 feet
SHC surface area	37,200 acres
Total open water habitat surface area	23,800 acres
Total shoreline habitat surface area	32,900 acres
Brine pool surface area	91,300 acres
Exposed playa surface area	91,800 acres

Under Alternative No. 4, an impervious dam embankment would be constructed to impound Whitewater River inflows. The impervious dam would include an embankment built using the sand dam with stone columns concept as described later in this chapter. The embankment design would provide both static and seismic risk reduction. Water north of the embankment would be maintained at a higher elevation than the brine pool on the south side. The area south of the embankment would serve as an outlet for water and salt from the north and would shrink in size to achieve equilibrium with inflows from the south and discharges from the north marine lake. The salinity of the brine pool would increase over

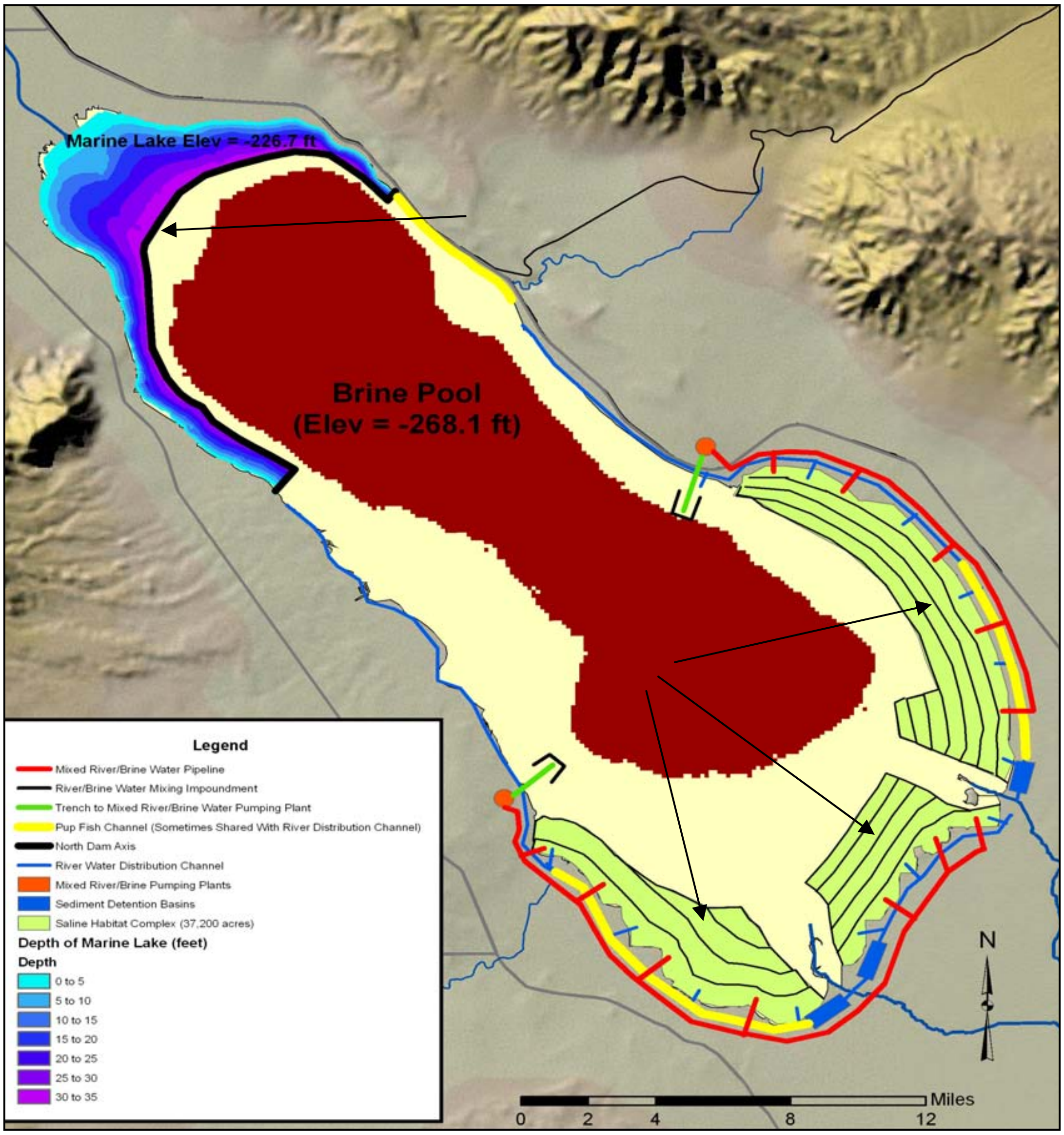

Figure 3.5 Alternative No. 4: North-Sea Dam with Marine Lake.

time. The north marine lake would have a water surface area of up to 19,500 acres at elevation -229 msl and would be operated to maintain a salinity of 35,000 mg/L or less.

SHC (37,200 acres) would be constructed on the south end of the Salton Sea. As the main body of the Sea shrinks, these complexes would be constructed on the exposed Seabed to take advantage of the gently sloping Seafloor. The conveyance features included in this alternative consist of three diversion crests and sediment detention basins, three pupfish/river water channels, three river water channels, and two pumping plants and associated pipelines. These conveyance features would be used to provide water to AQM projects as well as to provide brine to be mixed with river water delivered to the SHCs. The brine and river water would be mixed in impoundments constructed in the Seabed. These mixing impoundments would need to be moved through time as the residual Sea recedes.

The 19,500-acre lake was designed to reduce as much as possible the requirement to achieve acceptable salinity levels without dependence on long detention times in the marine lake. Smaller lakes would require evapoconcentrating salt without making releases from the lake for many years, which would result in the concentration of contaminants.

Alternative No. 5: Habitat Enhancement Without Marine Lake

Alternative No. 5 provides no structural solution for a marine lake. The alternative would rely entirely upon SHC to provide open water and shoreline habitat. Under this alternative, SHCs would be constructed at the south and north ends of the Sea. Five separate complexes would be constructed, with a combined surface area of 42,200 acres as shown on **Figure 3.6**. **Table 3.5** lists physical features associated with Alternative No. 5 under mean future conditions in the year 2040.

Table 3.5 Physical features of Alternative No. 5: Habitat Enhancement without Marine Lake

Physical Feature	Value
Marine lake surface area	0 acres
Marine lake maximum depth	---
SHC surface area	42,200 acres
Total open water habitat surface area	8,400 acres
Total shoreline habitat surface area	33,800 acres
Brine pool surface area	117,400 acres
Exposed playa surface area	81,200 acres

Figure 3.6 presents the alternative under mean possible future inflow conditions (727,000 acre-feet per year). No in-Sea marine habitat would be provided. About 20 percent of the SHC would be deep open water (up to 10 feet) for fisheries. These deep-water pond areas would be constructed through excavation; the excavated material would be used to create islands behind cell embankments. The remaining portion of the SHC would be divided into areas suitable for different species and their use; up to a quarter of these areas would be land. The majority of these shallow water pond habitats would be less than 3 feet deep.

Inflows to the SHCs would be managed to achieve an average starting cell salinity of more than 20,000 mg/L through the mixing of waters from the rivers and

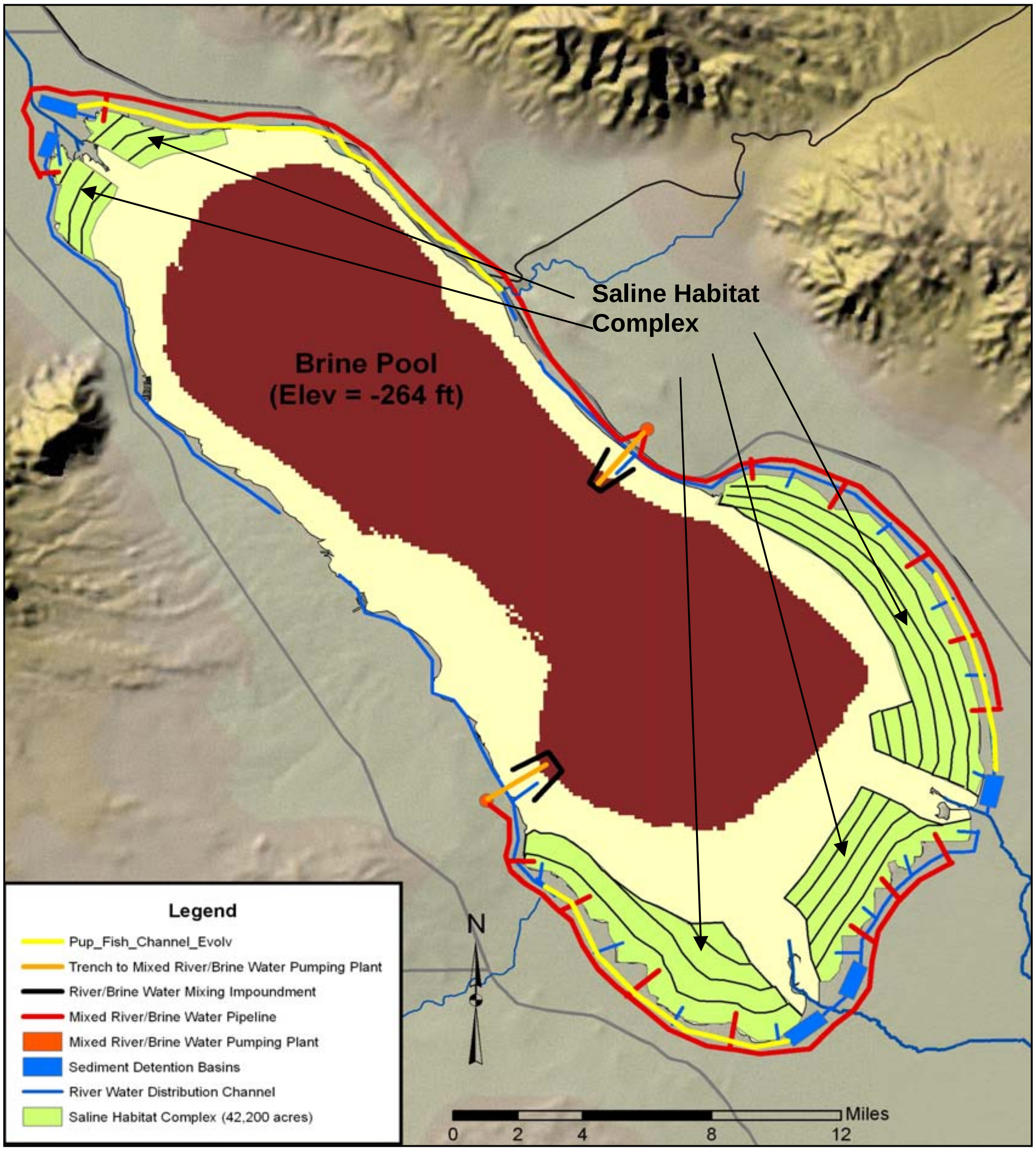

Figure 3.6 Alternative No. 5: Habitat Enhancement without Marine Lake.

residual Sea brine pool. The brine and river water would be mixed in impoundments constructed in the Seabed. These mixing impoundments would have to be moved through time as the residual Sea recedes. Water would flow by gravity through each of the SHC cells. The salinity of each cell would increase until it reaches about 150,000 mg/L, when discharges from the last cell would be made to the brine pool. The water is expected to have habitat value up to a salinity of about 150,000 mg/L.

The conveyance features included in this alternative consist of five diversion crests and sediment detention basins, three pupfish/river water channels, five river water channels, two mixing impoundments, three pipelines, and two pumping plants. These conveyance features would be used to provide water to AQM projects as well as to provide brine to be mixed with river water delivered to the SHCs.

Alternative No. 6: No-Project

Without a restoration project, the future Salton Sea would change dramatically. **Figure 3.7** presents the No-Project Alternative under mean possible future inflow conditions (727,000 acre-feet per year). **Table 3.6** lists the physical features associated with Alternative No. 6 under mean future conditions in the year 2040.

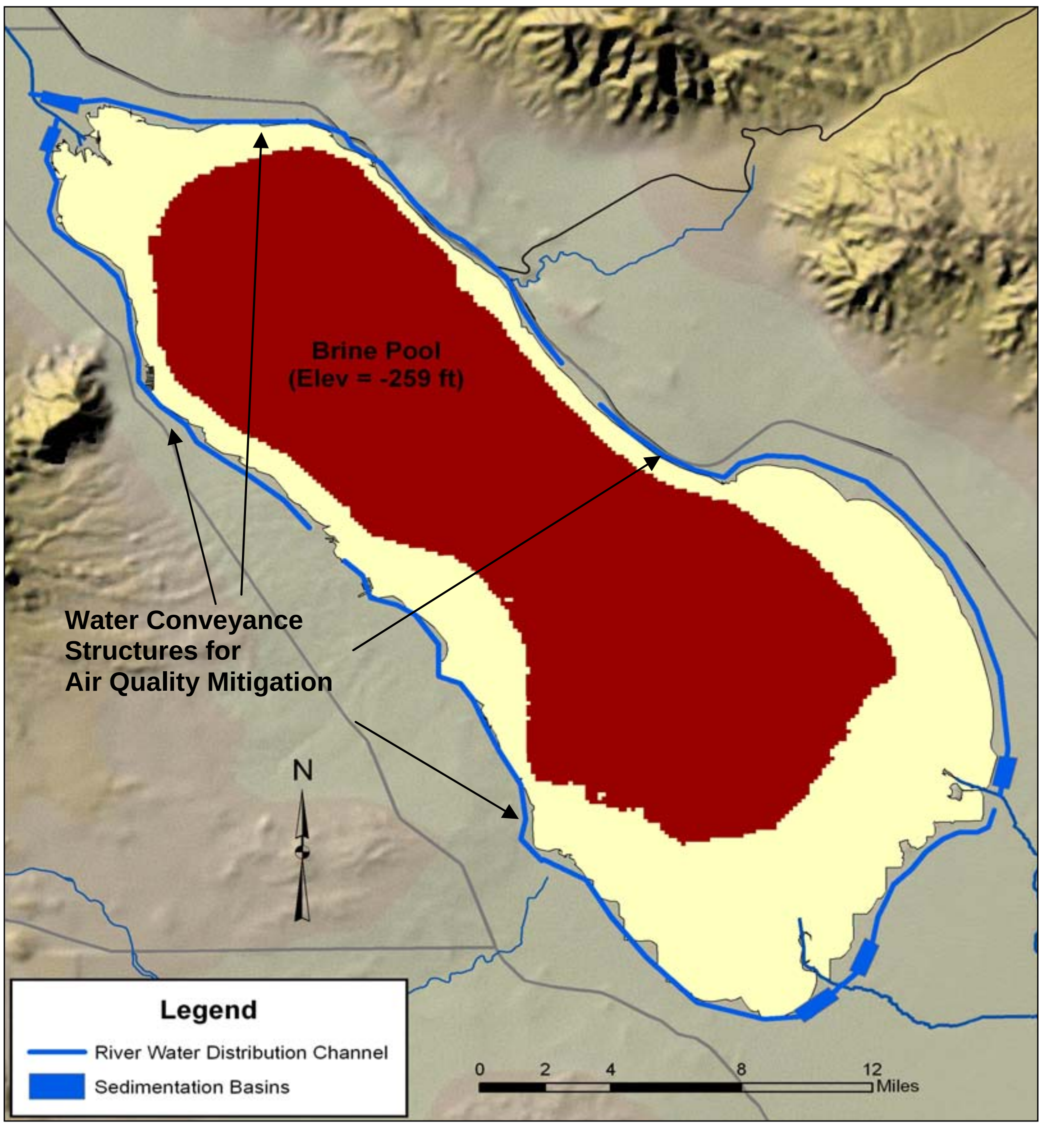

Figure 3.7 Alternative 6: No-Project.

Table 3.6 Physical features of Alternative No. 6: No-Project

Physical Feature	Value
Marine lake surface area	0 acres
Marine lake maximum depth	---
SHC surface area	0 acres
Total open water habitat surface area	0 acres
Total shoreline habitat surface area	0 acres
Brine pool surface area	138,400 acres
Exposed playa surface area	92,200 acres

Water would be required for AQM and the corresponding water distribution system is shown. The Salton Sea would suffer from “creeping environmental problems” similar to those at the Aral Sea (Glantz, 1999). The No-Project Alternative could carry significant costs in human health, ecological health, and economic development.

Water conveyance features included in this alternative consist of five diversion crests and sediment detention basins, and five river water channels. These conveyance features would be used to provide water to AQM projects.

By the year 2040, the Salton Sea would quickly shrink by 60 percent under mean possible future inflow conditions, and salinity levels would increase dramatically. During this time, the Sea would still receive additional loadings of salt, Se, nutrients, and other contaminants. Thus, the contaminant concentration could roughly triple in this period. Under the No-Project Alternative, the Salton Sea would experience degradation of environmental conditions, with the complete loss of the fishery and invertebrate food base, as discussed in more detail in Chapter 5.

Actions that would occur under the No-Project Alternative and all other alternatives include:

- Implementation of California’s QSA of 2003, which would increase water moved from Imperial Valley to San Diego and decrease inflows to the Salton Sea, subsequent to the cessation of mitigation inflows.
- Implementation of Best Management Practices (BMPs) in Imperial Valley to meet the total maximum daily loads (TMDL) for nutrients and sediments, which would reduce standing water habitat for birds and reduce the annual input of biologically available P to the Sea by 13 to 20 percent.
- Implementation of water conservation measures from IID, which could increase Se concentrations in river inflows by as much as 46 percent.

- Construction of connections between individual drains in IID to facilitate pupfish movement between drains after salinity exceeds about 90,000 mg/L.

- Implementation of IID-San Diego Transfer Agreement, which would include a mitigation program to address potential dust emissions.

- Implementation of a four-step air quality monitoring and mitigating plan, as required by California's State Water Resources Control Board.

- Uncertainty in possible future inflows as described in the risk-based approach described in Chapter 4.

Embankment Design

Design Criteria and Considerations

The restoration alternatives include embankment structures at various locations around the Salton Sea. All embankment designs were developed consistent with Reclamation's Dam Safety Program and to meet Reclamation's general design criteria and Public Protection Guidelines (Reclamation, 2003) where applicable.

The general design criteria determined for the mid-, south-, and north-Sea dams; the perimeter dikes; the concentric ring dikes; the mid-Sea barrier; and the habitat pond embankments would be as follows:

- Resist and control embankment seepage, foundation seepage, internal erosion, and static settlements

- Resist large offsets, slope instability, and deformations due to seismic loading, and flooding

- Provide for constructability using proven methods and safe construction

Reclamation's Dam Safety Program is authorized under the Reclamation Safety of Dams Act of 1978 (P.L. 95-578). The Act provides for action to be taken when it is determined that a structure presents an unacceptable risk: "In order to preserve the structural safety of Bureau of Reclamation dams and related facilities, the Secretary of the Interior is authorized to perform such modifications as he determines to be reasonably required." To determine the risks associated with its structures, Reclamation has established procedures to analyze data and assess the condition of its new and existing structures. Reclamation has established a risk-based framework to meet the objectives of its program, the Dam Safety Act, and the Federal Guidelines. Risk-based procedures are used to assess the safety of new and existing Reclamation structures. Addressing risks in a technically consistent and timely fashion is an important part of sustaining the public's trust in Reclamation to construct and manage facilities in the best interest of the Nation.

Reclamation is responsible for about 370 storage dams and dikes that form a significant part of the water resources infrastructure in the western United States. A high level of national safety and stewardship of public assets is expected of Reclamation as an agency specifically entrusted to manage a large inventory of dams. The greater the inventory of dams and the time of exposure, the more difficult it becomes to ensure that the agency will not experience a dam failure. Reclamation has developed guidelines to assist in the management of risk associated with its existing dam inventory and in considering new structures. These guidelines for public protection are published in the following document:

> Bureau of Reclamation, June 2003, *Guidelines for Achieving Public Protection in Dam Safety Decisionmaking*

Reclamation's guidelines focus on two assessment measures of risks related to Reclamation structures: (1) the estimated probability of a dam failure and (2) the potential life loss consequences resulting from the unintentional release in the event of failure. The annual probability of failure guideline addresses agency exposure to dam failure. As a water resource provider, Reclamation must maintain and protect its dams and dikes that store water. The second measure addresses the potential life loss component of societal risk. Protection of human life is of primary importance to public agencies constructing, maintaining, and/or regulating civil works.

Within these guidelines, it is specified that to ensure a responsible performance level across the inventory of Reclamation's dams, it is recommended that decisionmakers consider taking action to reduce risk if the estimated annual probability of failure exceeds 1 chance in 10,000.

For dam safety decisionmaking, risk of life loss is measured as the product of the probability of dam failure and the estimated consequences (life loss) associated with that failure. This product is the expected annualized life loss at a given dam for a given loading condition and is referred to as the estimated annualized risk of life loss.

In cases of small populations at risk (such as at the Salton Sea), the guidelines related to annual probability of failure serve as a limit of exposure. With an annual probability of failure equal to 1 chance in 10,000 (0.0001) and a loss of life of one person, the annualized risk of life loss would be 1 times 0.0001, which is equal to 0.0001 lives per year. This is analogous to a probability of life loss of 1 chance in 10,000. Reclamation guidelines specify that the justification to reduce risk of life loss diminishes as estimated annualized life loss risk becomes smaller than 0.001. These same guidelines also specify that the justification to reduce risk increases as the annualized risk of life loss exceeds 0.001.

In cases of small populations at risk (as at the Salton Sea), it is the annual probability of failure that drives the need to reduce risk. A zero loss of life at the upper probability of failure limit of 1 in 10,000 would result in unacceptable risk. The only way to achieve compliance with Reclamation guidelines under such circumstances is to ensure that the annual probability of failure of any embankment at the Salton Sea is below 1 in 10,000. This would be true regardless of whether or not the embankments are classified as significant or high hazard structures.

Evaluation of Embankment Designs

Detailed seepage, stability, deformation, risk, constructability, and cost evaluations were completed to support the evaluation of the various dam, dike, barrier, and habitat pond embankments that comprise the alternatives. The sequence of study tasks was as follows:

1. Existing information and construction material sources assessment
2. Seepage and stability evaluations
3. Seismic deformation evaluations
4. Formulation and initial screening of embankment cross-section options
5. Supplemental seepage and stability evaluations
6. FLAC (Fast Lagrangian Analysis of Continua) deformation evaluations
7. Finalize decision criteria and cross-section requirements
8. Final screening of embankment cross-section options
9. Selection of preferred cross-section option
10. Initial preferred cross-section optimization
11. Risk analysis
12. Final cross section optimization
13. Cost estimates for optimized embankments.

Following evaluation of numerous embankment design options, including the SSA's rockfill design and DWR's rock dam design, Reclamation determined that an optimized "sand dam with stone columns" was the preferred basic configuration for all of the various embankments, except habitat pond embankments, which were optimized as earthfill embankments. Overviews of both configurations are provided in the following sections.

Embankment Risk Analysis

A risk analysis was conducted on the optimized embankment designs considered for the alternatives in this study. The purpose of the risk analysis was to provide decision inputs regarding conformance with Reclamation's Dam Safety

Guidelines for Achieving Public Protection (PPG). On the basis of the PPG, the Salton Sea risk analysis provides estimates of life loss, expressed as the "Annualized Loss of Life" (ALL) and Probability of Failure, expressed as the "Annualized Probability of Failure" (APF) of the alternatives.

The sand dam with stone columns design was applied to each of the alternatives and the estimated APF and ALL values were compared with Reclamation's PPG and found to meet the guideline requirements.

Sand Dam with Stone Columns Embankment Design

Figure 3.8 provides the cross-section view of the basic sand dam with stone columns embankment design for a mid-Sea dam. Configurations for the shorter mid-Sea barrier, south and north-Sea dams, and concentric lakes dikes would be similar but with different heights. This design would meet Reclamation's general design criteria and PPG (Reclamation, 2003).

Existing very soft and weak foundation materials would be removed beneath the entire footprint of the embankment, and additional soft and weak materials would be removed beneath the central section. The sand dam with stone columns embankment would consist of sand/gravel materials forming the central section and the outer shells. To resist static loadings, the embankment cross-section would include filter and drainage zones to help control embankment and foundation seepage. To resist seismic loadings, the central section's sand/gravel material would be densified using stone columns. A soil-cement-bentonite wall would be constructed down through the middle of the central section and into the foundation. Riprap slope protection would be placed over the upstream and downstream embankment slopes.

To resist seismic loadings, the embankment would be constructed using a combination of placement methods. Placement methods would include: (1) dumping/placing directly into the water from barges for the lower portion of the central section and for the outer portions of the embankment, including riprap slope protection and (2) end dumping or conveyor placement for the upper portions of the central and outer portions of the embankment. The size of this basic sand dam with stone columns design would be adjusted as required to meet the location and configuration requirements of the mid-Sea, south-Sea, and north-Sea dams; perimeter dikes; concentric ring dikes; and mid-Sea barrier embankment designs. The basic embankment design also would be adjusted to address certain potential risks, such as the possibility of fault offsets of 2 to 5 m (6.6 feet to 16.4 feet) in the foundation beneath the south-Sea dam and the concentric ring dikes in the southern Sea.

Reclamation's sand dam with stone columns design provides for partial failure without compromising the structure as a whole. Incorporation of stone columns to improve seismic resistance is not the major cost item in the embankment

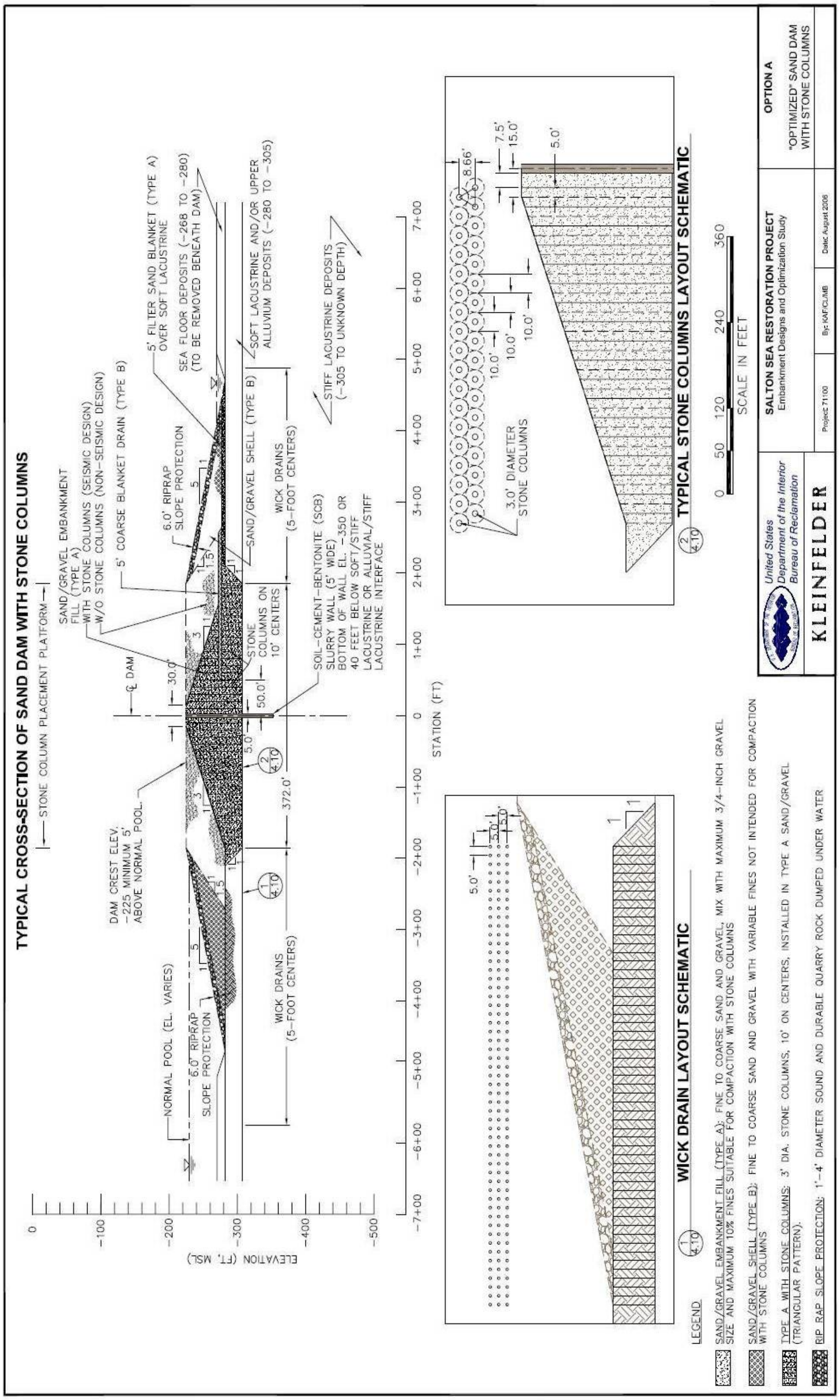

Figure 3.8 Typical cross-section of sand dam with stone columns.

designs. The stone columns account for 10, 9, and 25 percent of the subtotal construction costs for Alternative Nos. 1A, 2A, and 3A, respectively.

Sand Dam without Stone Columns Embankment Design

The sand dam concept was considered with and without stone columns for the significant hazard structures in the following alternatives:

- Alternative No. 2: Mid-Sea Barrier with South Marine Lake
- Alternative No. 3: Concentric Lakes

The sand dam concept without stone columns was applied to these alternatives to allow comparison of the annual risk costs of structures that reduce both seismic and static risks (with stone columns) with the annual risk costs of structures that reduce only static risk (without stone columns). Costs are presented in Chapter 7 for the design that includes stone columns. The costs for Alternative Nos. 2 and 3 that do not include stone columns are presented in Attachment A. This sand dam without stone columns design would not meet Reclamation's general design criteria and PPG (Reclamation, 2003). Risk costs are described in Chapter 7. Annual risk costs can be compared using information presented in **Table 7.2** and **Attachment Table A-2**.

Habitat Pond Embankments Design

Figure 3.9 provides the cross-section view of the habitat pond embankment design. This design would be applied to habitat pond embankments associated with the SHC components in each of the alternatives. These low earthfill embankments would be very simple designs that would be constructed in the dry. The existing soft and weak foundation materials would be removed beneath the entire footprint of the embankment to achieve a competent foundation. The excavated material would be dried and reused as earthfill to construct the habitat pond embankments. The embankment cross-section would include a blanket layer of sand filter/drain material under the embankment's downstream shell. There would be no riprap slope protection. Because of its small size and shallow water depth, the habitat pond embankment design would likely not need to meet Reclamation's PPG.

Geotube® Embankment Design

The Imperial Group has proposed using Geotube® technology to construct the concentric lakes dikes. Reclamation considered three concentric lake dike design options, and one incorporates the Geotube® technology (**Figure 3.10**). The other two options are zoned embankment designs based on the sand dam approach discussed above. One zoned embankment design includes features to reduce only static loading risks (without stone columns), and the other includes features to reduce both static and seismic loading risks (with stone columns). The Geotube® design would not reduce either seismic or static loading risks to a level that meets Reclamation's design criteria and guidelines.

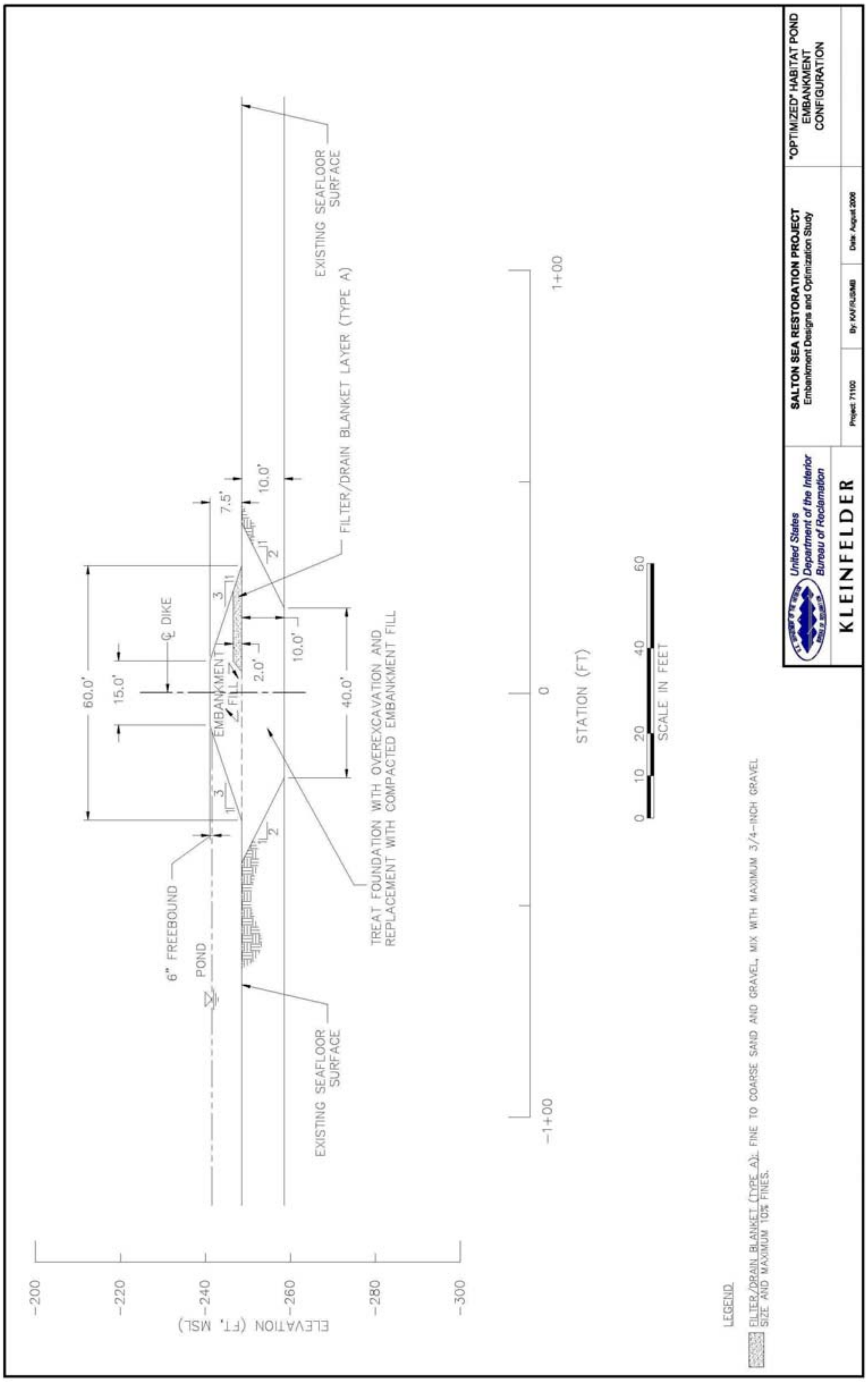

Figure 3.9 Typical cross-section of habitat embankment.

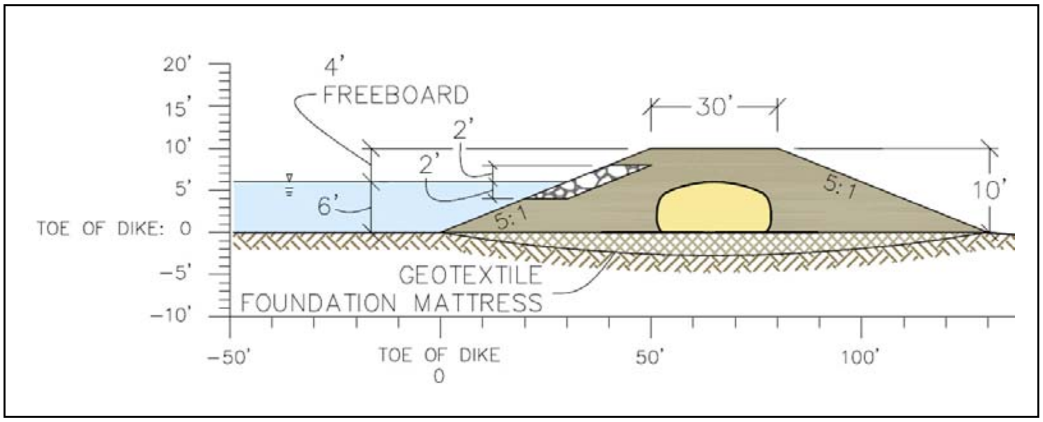

Figure 3.10 Typical Geotube® design.

The sand dam without stone columns and Geotube® designs would not meet Reclamation's general design criteria and PPG (Reclamation, 2003). Constructing concentric lakes dikes using Geotubes® would likely result in significant seismic, static, and constructability problems.

SSA Rockfill Embankment Design

The SSA has proposed using a rockfill embankment design for its proposed alternative as shown in **Figure 3.11.** Reclamation evaluated the rockfill embankment concept and determined it would not meet Reclamation's general design criteria. Use of traditional sand and gravel horizontal filters would not be possible without sacrificing stability under seismic loadings. Use

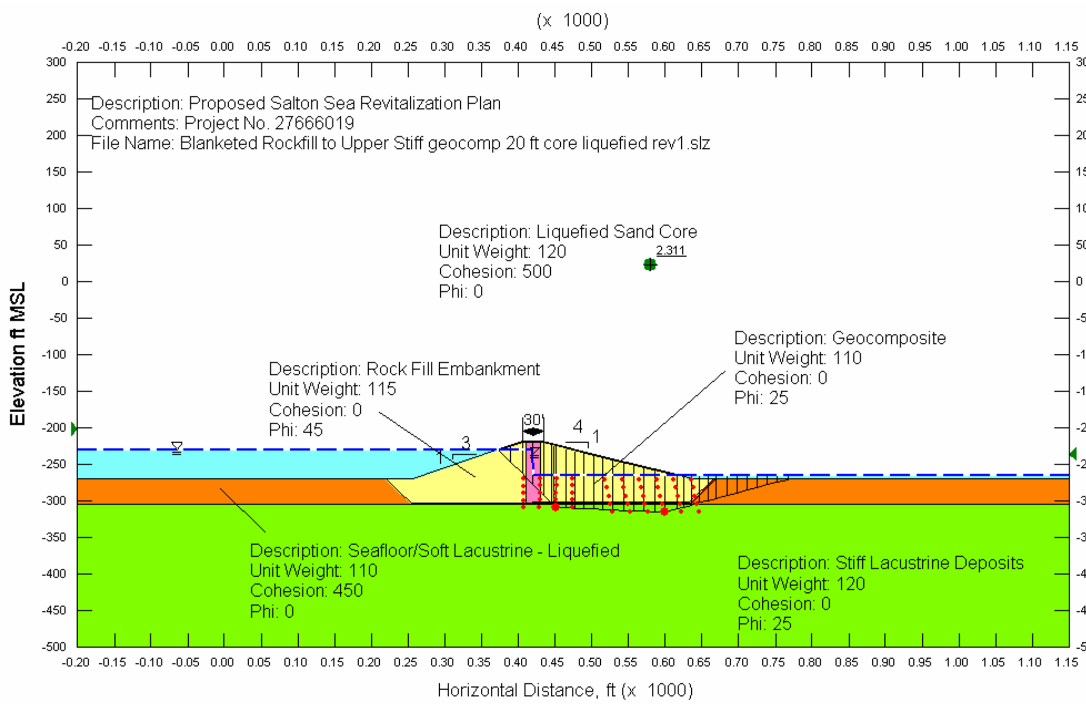

Figure 3.11 Typical cross-section of the SSA rockfill embankment.

of geocomposite filters would result in constructability problems and would result in unreliable filter performance. Cost estimates were prepared for the SSA's original alignment using the current rockfill concept. **Attachment A** of this summary report contains these estimates. The SSA's original alternative incorporated a mid-Sea dam about 1.5 miles farther south than what is presented in **Figure 3.2**. This alternative also included a smaller SHC of 12,000 acres.

Reclamation's cost estimates using the SSA rockfill design provide a basis for making comparisons to cost estimates prepared by DWR and the SSA for this same original alternative. The estimates presented in Attachment A assume the use of salt crusting (as originally proposed by the SSA) via construction of small earth embankments (2.5 feet tall) to impound brine released from the SHC.

Comparisons to Design Criteria and Guidelines

Table 3.7 presents a comparison of embankment design concepts as applied to each restoration alternative and whether or not the designs meet Reclamation's general design criteria and PPG (Reclamation, 2003). On the basis of this comparison, the following alternatives have been identified as meeting Reclamation's requirements:

- Alternative No. 1A: Mid-Sea Dam with North Marine Lake – SSA Revised Alignment (sand dam design with stone columns)
- Alternative No. 2A: Mid-Sea Barrier with South Marine Lake (sand dam design with stone columns)
- Alternative No. 3A: Concentric Lakes (sand dam design with stone columns)
- Alternative No. 4: North-Sea Dam with Marine Lake (sand dam design with stone columns)
- Alternative No. 5: Habitat Enhancement Without Marine Lake (habitat pond embankment design)

Costs are presented in Chapter 7 for the alternatives that meet Reclamation's requirements. **Attachment A** provides cost estimates for the alternatives that do not meet Reclamation's requirements.

Table 3.7 Salton Sea Restoration Study: Embankment/Alternative Comparisons to Reclamation's Design Criteria and Guidelines

Alternative	Reclamation's general design criteria and guidelines	Notes
Alternative No. 1A: Mid-Sea Dam with North Marine Lake – Revised Alignment (sand dam design with stone columns)	Meets requirements	
Alternative No. 1B: Mid-Sea Dam with North Marine Lake –Original Alignment (SSA rockfill design)	Does not meet requirements	Use of traditional filters would not be possible without sacrificing stability under seismic loading. Use of geocomposite filters would result in constructability problems and would result in unreliable filter performance
Alternative No. 2A: Mid-Sea Barrier with South Marine Lake (sand dam design with stone columns)	Meets requirements	
Alternative No. 2B: Mid-Sea Barrier with South Marine Lake (sand dam design without stone columns)	Does not meet requirements	High probability of failure under seismic loading
Alternative No. 3A: Concentric Lakes (sand dam design with stone columns)	Meets requirements	
Alternative No. 3B: Concentric Lakes (sand dam design without stone columns)	Does not meet requirements	High probability of failure under seismic loading
Alternative No. 3C: Concentric Lakes (Geotubes® design)	Does not meet requirements	High probability of failure under seismic loading. High probability of static failure due to foundation seepage. Numerous constructability problems
Alternative No. 4: North-Sea Dam with Marine Lake (sand dam design with stone columns)	Meets requirements	
Alternative No. 5: Habitat Enhancement Without Marine Lake (habitat pond embankment design)	Meets requirements	

Chapter 4. Future Conditions

Water Supply Overview

The Salton Sea receives the majority of its water supply from agricultural runoff from the IID and the Coachella Valley Water District (CVWD). A very small percentage of inflows to the Salton Sea are derived from tributaries and direct precipitation. The closed basin lake has no guaranteed future water supply. The Salton Sea has historically received a total annual water supply of 1.34 million acre-feet per year (maf/yr). Under conditions identified as the baseline for the IID-San Diego Transfer Agreement and QSA, the Salton Sea would receive 1.23 maf/yr (IID, 2002). The projected future inflows to the Salton Sea, considering the effects of the IID-San Diego Transfer Agreement, would reach a low of 0.93 maf/yr (IID, 2002).

There are no guarantees that other actions that could occur in the future would not affect inflows. For example, the possibility exists that Mexico could significantly reduce deliveries across the border in the New River. The possibility also exists that competing demands for water and/or water market conditions could result in additional reductions of tailwater discharges to the Salton Sea. In addition, uncertainty exists in future groundwater discharges from the Coachella aquifer as a result of the Coachella Valley Water Management Plan. With implementation of the Water Management Plan, CVWD expects (based on uncertain groundwater model predictions) future groundwater levels in the lower valley to increase, which would increase future discharges to surface drains and inflows to the Salton Sea by about 60,000 acre-feet per year. Currently, the Coachella Valley groundwater basin is in an overdraft condition and, as a result, discharges to the Salton Sea are being affected.

Without future assurances of inflows to the Salton Sea, there will be risk to any Salton Sea restoration project. Under such risk, inflows to the Sea might be reduced to a level that puts the success of restoration in jeopardy. The impacts of the risks and uncertainties of inflows on each restoration alternative were assessed. These assessments were made using stochastic computer modeling techniques. This chapter describes future risks and uncertainties relative to inflows and the results of computer model simulations of the future of each alternative.

Risk-Based Future Inflows

Each alternative was modeled using a risk-based approach to inflows. Under this approach, the full ranges of uncertainty in each of the major inflow sources were considered. The full ranges of uncertainty were considered without assigning specific probabilities of occurrence or specific actions that might contribute to the uncertainty. This method was developed and coordinated with modeling studies conducted within the DWR. The same type of approach to future inflows and alternative modeling is being used by DWR (DWR, 2006).

Under the risk-based approach, it is recognized that alternative concepts are subject to risk due to potential water conservation that could occur in response to non-specific reasons. For example, the Salton Sea could be subject to responses due to the following:

- Economic conditions
- Competing water demands
- Water market conditions

Uncertain responses could occur in Mexico, IID, or CVWD. When something is uncertain, it is possible to describe potential variability in the form of a distribution that describes the range in possible values that might be expected. The application of a risk-based method involved the development of distributions of the possibilities that depict full ranges in uncertainty of responses from Mexico, IID, or CVWD and resulting uncertainty of Coachella Valley surface-water and groundwater interactions. These distributions do not describe probability of occurrence but, instead, describe the full range of possibilities. The approach was applied within the Salton Sea Accounting Model (SSAM), starting with QSA level inflows and the implementation of the CVWD groundwater management program. Within SSAM, the uncertainty distributions were randomly sampled and applied to compute 75-year inflow traces. These traces were then used to perform the SSAM simulations.

Total Future Inflows

In the risk-based approach to future inflows to the Salton Sea, possibility distributions for Mexico, IID, and CVWD were sampled 1,500 times and combined with estimates of tributary and direct precipitation estimates for a 75-year future period. **Figure 4.1** shows the total inflow possibility distribution for average annual future inflow to the Salton Sea from all sources. Two lines are presented on **Figure 4.1**: the first (dashed line) represents average annual inflow conditions for the period 2003 to 2077, and the second (solid line) shows average annual inflow conditions for the period 2018 to 2077.

The curves presented in **Figure 4.1** represent the cumulative frequency of average annual inflows resulting from the random sampling of 1,500 different futures from each source possibility distribution. The range in average annual inflows from all sources for the period 2018 to 2077 can be described statistically as follows:

> *5 Percent of All Futures:* Inflows will be less than or equal to 570,000 acre-feet per year

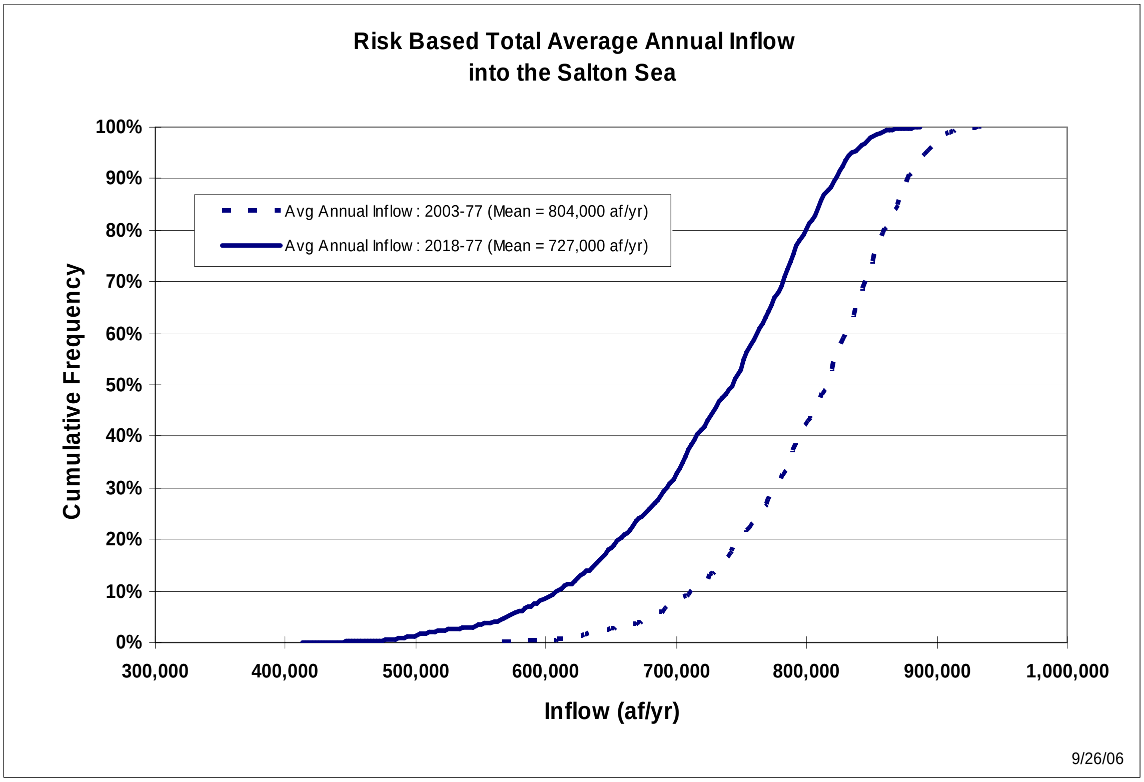

Figure 4.1 Risk-based possibility distribution of total inflows from all sources.

5 Percent of All Futures: Inflows will be less than or equal to 570,000 acre-feet per year

Mean of All Futures: Inflows will be 727,000 acre-feet per year

95 Percent of All Futures: Inflows will be less than or equal to 835,000 acre-feet per year

Climate Change Effects on Evaporation

Evaporation has a strong influence on the Salton Sea. In recent history, inflows to the Salton Sea have been in balance with evaporation–each equaling 1.34 maf/yr. Historic average annual net evaporation has averaged 66 inches at the Salton Sea. There is general scientific consensus that climate changes will occur in the future as a result of increasing concentrations of greenhouse gasses in the Earth’s atmosphere (Intergovernmental Panel on Climate Change [IPCC], 2001). The highest and lowest IPCC emission scenarios and associated impacts to California were evaluated by Hayhoe et al. (2004). Information extracted from this study indicates that temperature increases by the end of century in the Salton Sea area will be between 2 and 4 degrees Celsius (3.6 and 7.2 degrees Fahrenheit). An analysis of historic California Irrigation Management Information System data from the Westmorland station (south of the Salton Sea) yields the conclusion that average annual evaporation will increase 5.4 percent per degree Celsius increase in temperature in the future, which translates to a 9-to-13-inches-per-year increase in evaporation by the end of the century.

The ranges in uncertainty of these increases in evaporation were incorporated into the SSAM. SSAM was used to predict future conditions relative to each restoration alternative. Within SSAM, increases in evaporation rates due to climate change were conservatively applied by assuming that evaporation would change linearly from no change in the present to a maximum increase by the year 2074. The maximum impacts of climate change were represented in SSAM by increases in evaporation based on an uniform distribution from 9 to 13 inches.

Assumptions Modeled Related to Project Completion

In the SSAM simulations of restoration alternatives, the following assumptions were made about alternative project construction and completion. It was assumed that this schedule would begin in year 2008:

- 3 years to complete environmental compliance work
- 1 year authorization to proceed
- 5 years final design data acquisition and design
- 1 year to obtain construction funding
- 7 years of construction
- Project construction completed in 2024

Alternatives Modeling Results

Each alternative was simulated using the stochastic capabilities of SSAM. Each model was executed 1,500 times while sampling from the risk-based inflow distributions as described previously. SSAM model results include water surface elevation, water surface area, salinity, and exposed lake playa for all marine lakes and residual brine pools. A discussion of model results for these parameters follows.

Water Surface Elevations

Hydrographs of mean future water surface elevations (not including brine pools) for each restoration alternative are shown in **Figure 4.2,** which depicts elevations through time for years 2025 to 2074. These elevations are based on mean future risk-based inflows. Three elevation curves are shown for the Concentric Lakes Alternative; each curve represents one of three concentric lakes that would be

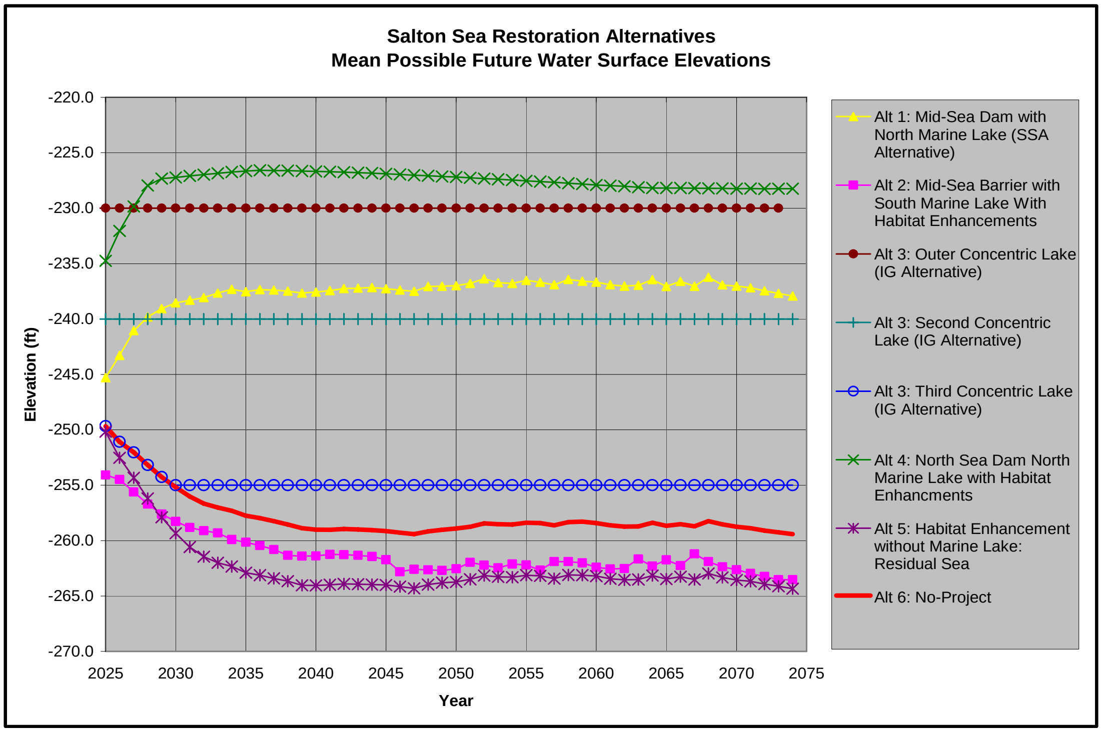

Figure 4.2   Mean future water surface elevations for restoration alternatives.

constructed. The fourth and innermost concentric lake proposed by the Imperial Group would not be required under the risk-based inflows used in this study.

Water Surface Areas

Hydrographs of mean future water surface areas (not including brine pools) for each restoration alternative are shown in **Figure 4.3,** which depicts areas through time for years 2025 to 2074. These areas are based on mean future risk-based inflows. Three surface area curves are shown for the Concentric Lakes Alternative; each curve represents one of three concentric lakes that would be constructed.

Salinities

Hydrographs of mean future salinity in the marine lakes for each restoration alternative are shown in **Figure 4.4**, which depicts salinity through time for years 2025 to 2074. These salinity results are based on mean future risk-based inflows. Three curves are shown in **Figure 4.4** for the Concentric Lakes Alternative; each curve represents one of three concentric lakes that would be constructed.

Exposed Lake Playa and Air Quality Mitigation Water Requirements

SSAM also makes predictions of exposed lake playa surface areas in the future. For all alternatives, the exposed playa areas are determined from a baseline Sea

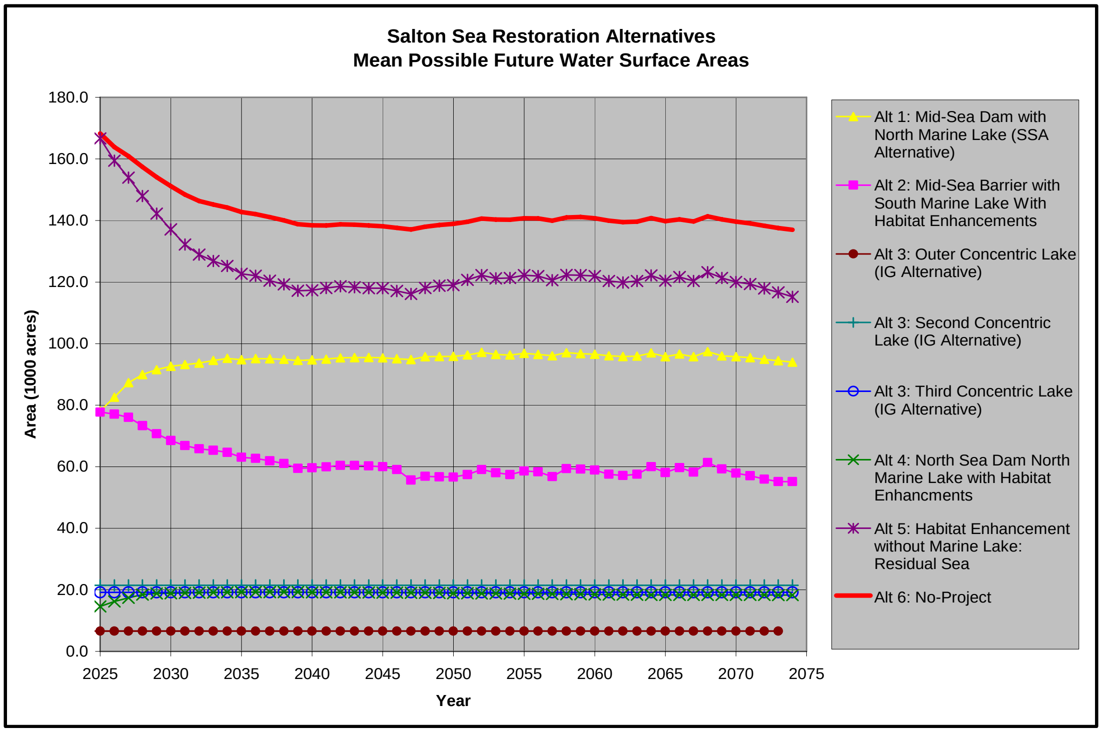

Figure 4.3 Mean future water surface areas for restoration alternatives.

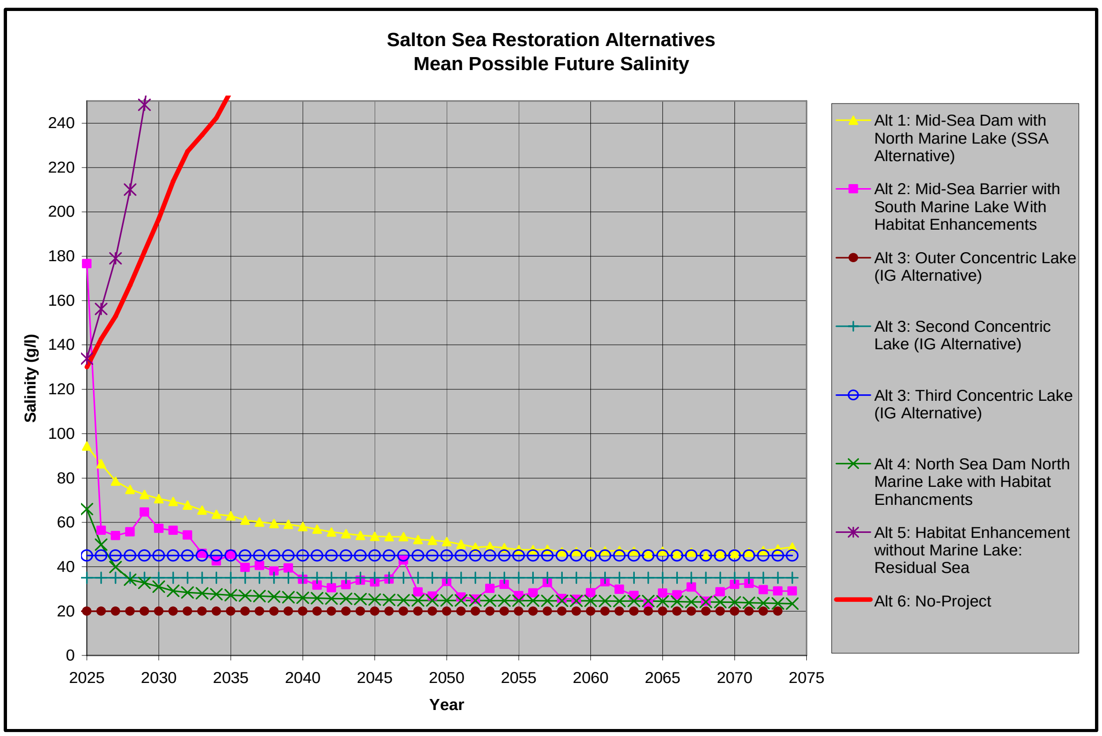

Figure 4.4 Mean future salinity for restoration alternatives.

elevation of -228 feet. Total exposed lake playa surface areas predicted by SSAM are presented in **Table 4.1**. The data presented are based on mean future stochastic model results for year 2040. On the basis of these predicted areas, SSAM estimates and takes into account AQM water and brine requirements. General AQM requirements are discussed in Chapter 3. The approach taken in this study adheres to the current DWR Salton Sea Ecosystem Restoration Program approach to AQM. DWR's approach identifies the need to make 1 acre-foot per acre of inflow water available for AQM purposes using water-efficient vegetation. In addition, DWR identifies the need to allocate 0.2 acre-feet per acre of brine water for AQM purposes. Exposed acres to be mitigated with water-efficient vegetation and other methods are also listed in **Table 4.1**.

Table 4.1   Exposed lake playa surface areas

Alternative	Exposed Lake playa surface areas (acres)	Exposed lake playa mitigated with water-efficient vegetation[1] (acres)	Exposed lake playa mitigated with other methods[2] (acres)
Alternative No. 1: Mid-Sea Dam with North Marine Lake	103,800	51,900	20,760
Alternative No. 2: Mid-Sea Barrier with South Marine Lake	73,600	36,800	14,720
Alternative No. 3: Concentric Lakes	65,000	32,500	13,000
Alternative No. 4: North-Sea Dam with Marine Lake	91,800	45,900	18,360
Alternative No. 5: Habitat Enhancement without Marine Lake	81,200	40,600	16,240
Alternative No. 6: No-Project	92,200	46,100	18,440

[1] 50 percent of exposed area is assumed to require mitigation using water-efficient vegetation.

[2] 20 percent of exposed area is assumed to require mitigation using other methods.

Viability of Alternatives Relative to Future Inflows

Without a guaranteed water supply, each of the alternatives would be subject to the risk-based inflows discussed above. The performance of each alternative under the range of future possible inflow helps to describe the viability of the alternatives. **Figure 4.4** presents future salinities of the marine lakes associated with each alternative under mean possible future inflows. A salinity of 60,000 mg/L has been identified as the threshold beyond which it will not be possible to maintain a fishery. This section includes a discussion of the viability of each alternative relative to future inflows. Viability is presented in terms of risk as defined by the following:

- ***Fatal*:** Nothing can be done to alleviate the problems and issues associated with variability in inflows.
- ***High Risk***: Problems are extreme and cannot be dealt with through changes in project feature operating criteria but instead would require relocating project structural elements.
- ***Serious Risk***: Problems threaten project performance but can be dealt with by making significant changes in project feature operating criteria.
- ***Moderate Risk***: Problems are evident that may require changes in project feature operating criteria.
- ***Low Risk***: Problems are not likely to occur.

Alternative No. 1: Mid-Sea Dam with North Marine Lake

The mean possible future inflow to the Salton Sea is expected to be 727,000 acre-feet per year. As shown in **Figure 4.4**, in year 2040, under Alternative No. 1 the mean future salinity would be 58,000 mg/L, which is very close to the 60,000 mg/L salinity threshold for a sustainable fishery. After construction is completed in 2024, salinity in the marine lake would not fall below 60,000 mg/L until year 2038. Not until after this time would a fishery be potentially viable. The early start features described in the discussion of SHC in Chapter 3 would be necessary to maintain a viable fishery prior to 2038.

Figure 4.4 depicts salinity conditions under mean possible inflow conditions. Alternative No. 1 was modeled assuming an operating water surface elevation of -238 feet so that salinity in the lake could be maintained below 60,000 mg/L in year 2040. The SSA desires to operate the lake at elevation -230 feet. From **Figure 4.4**, it can be seen that a salinity of 45,000 mg/L would not be reached until year 2055. Thus, if 45,000 mg/L were the target salinity, the SSA would not be able to slowly increase the operating elevation of the lake to -230 feet until after 2055. This salinity sensitivity to inflows and operating water surface elevation indicates that the viability of this alternative would be at **serious risk** relative to future inflows. This classification indicates that problems can be dealt with by making significant changes in project operating criteria which in this instance would be lake water surface elevation. If future inflow conditions are significantly above mean possible estimates then the operating elevation of the marine lake could be higher (and much sooner) and potentially at a level consistent with the SSA's target of -230 feet. Under lower-than-mean possible future inflow conditions, the operating surface elevation criteria for the marine lake would need to be reduced below the -238 feet simulated at mean possible future conditions.

If project construction were completed earlier than year 2024, it might be possible to raise the operating water surface elevation closer to the SSA's desired -230-foot elevation prior to year 2040. However, even if construction were completed earlier than year 2024 and lower-than-mean possible future inflow conditions prevail, the operating water surface elevation of the marine lake would have to be substantially lower than -230 feet.

Alternative No. 2: Mid-Sea Barrier with South Marine Lake

Under the risk-based inflow approach described above, it is expected that Alternative No. 2 salinity would be 34,000 mg/L by the year 2040. Salinity in the marine lake would decrease only slightly beyond year 2040. By the year 2074, salinity would be 29,000 mg/L. Other stochastic model simulation results (not shown in **Figure 4.4**) for Alternative No. 2 indicate that salinities in the south marine lake would be highly variable, ranging from 5,000 to 52,000 mg/L. Thus, large variability would exist for inflows significantly below mean future levels. As a result of this potentially negative variability in salinity, the viability of this alternative would be at **serious risk** relative to future inflows. Problems could be dealt with by accepting a variable salinity operating criteria for lower inflow conditions.

Alternative No. 3: Concentric Lakes

Under the risk-based inflow approach described above, it is expected that Alternative No. 3 target salinities and elevations would be achieved in each concentric lake. By year 2040, target salinities of 20,000, 35,000, and 45,000 mg/L would be achieved in the first (outer), second, and third concentric lakes, respectively. These salinities would be maintained under all possible futures through the year 2074. Because there would likely be no future problems associated with maintaining target salinities and elevations, the viability of this alternative would be at **low risk** relative to future inflows.

Alternative No. 4: North-Sea Dam with Marine Lake

Under the risk-based inflow approach described above, it is expected that adequate salinities and elevations in the north marine lake would be achieved for Alternative No. 4. Under mean possible future inflow conditions, future salinities would vary from 26,000 to 34,000 mg/L. Similar ranges in salinities would be maintained under all possible futures through the year 2074. Because there would likely be no future problems with maintaining salinities and elevations, the viability of this alternative would be at **low risk** relative to future inflows.

Alternative No. 5: Habitat Enhancement without Marine Lake

Under the risk-based inflow approach described above, it is expected that adequate water surface elevations and salinities in the SHC would be achieved for Alternative No. 5. Under mean possible future inflow conditions, future salinities in deep holes provided for fish refuge would vary from 20,000 mg/L to 45,000 mg/L. Similar ranges in salinities would be maintained under all possible futures through the year 2074. Because there would likely be no future problems with maintaining salinities and elevations in the SHC, the viability of this alternative would be at **low risk** relative to future inflows.

Alternative No. 6: No-Project

Under the risk-based inflow approach described above, it is expected that under Alternative No. 6, salinities in the year 2040 would be greater than 250,000 mg/L. As a result, the viability of this alternative would be **fatal** relative to maintaining salinities capable of supporting a fishery.

Chapter 5. Biological Resource Issues

Introduction

The Salton Sea and adjacent land and wetlands have historically provided abundant habitat resources to a wide range of fish and wildlife species. However, the Sea has recently experienced water quality issues that have adversely affected the fishery and other resources. Future reductions in water inflow will exacerbate this situation until, ultimately, water quantity and quality conditions will adversely affect most of the biota currently supported by the Sea. Current projections indicate that in 35 years or less, the Sea will support only the most salt tolerant micro-organisms and once-abundant habitat resources will be gone (Cohen and Hyun, 2006). Resource agencies are evaluating mechanisms and approaches that would reduce the negative impacts of lost resources to wildlife using the Sea. This chapter addresses biology issues and provides an assessment of how anticipated No-Project conditions, and estimated conditions associated with five restoration strategies, would affect future habitat resources.

Snowy Plover.

Issues Overview

Habitat is a concept that requires an operational definition. Habitat provides resources for specific species, and, in the case of the Salton Sea, abundant habitat resources have supported abundant and diverse wildlife. For example, the abundance and diversity of avifauna (400+ bird species recorded with about 270 species observed on a regular basis [Cooper, 2004]) using the Sea and associated landscapes illustrates the area's ability to provide resources and its value to such a wide range of species. This ability to provide resources to a diverse assemblage of birds, coupled with their high visibility, render birds an ideal assessment tool for evaluating potential changes in future resource abundance. Birds are, therefore, used in this assessment to define the landscape features or habitat types providing resources at risk, and as indicators of how successful future restoration strategies may be in providing habitat resources to area wildlife.

Not all habitat types currently providing resources would be affected by future reductions in water inflow to the Sea and associated changes in water quality.

Essentially, habitat types of interest include components of the Sea (shoreline, open water, islands, and constructed wetland complexes), and associated unmanaged wetlands (associated with the three rivers, major drains, and ephemeral pools that may develop in the exposed Seabed). Other types, such as freshwater marshes managed by wildlife agencies or agricultural fields providing food for numerous species, would not be directly affected by future changes in water management (DWR, 2006). These habitat types and the birds that use them are not addressed in this assessment.

Birds that use the habitat types that would be most affected by reduced water inflow and changes in water quality are generally known as semi-aquatic water birds, and can be grouped into several functional groups, such as fish-eating divers, shorebirds, long-legged waders, etc. (Shuford et al., 2000). The principal resources provided by habitat types at risk are food and cover (secure sites used for roosting, loafing, and or nesting). Principal food resources are fish and invertebrates; snags and small islands provide security (DWR, 2006). The habitat types of interest in this assessment and the bird groups that use them are identified in **Table 5.1**.

Table 5.1 Avifauna functional groupings associated with various habitat types present within and/or adjacent to the Salton Sea

Avifauna functional groups[1]	Shoreline[2]	Open water[3]	Islands and snags[4]	Wetlands[5]
Fish-eating divers	x	x	x	x
Gulls, terns, and skimmers	x	x	x	x
Invertebrate-eating divers	x	x		x
Diving ducks	x	x		x
Shorebirds	x			x
Long-legged waders	x		x	x
Rails and moorhens	x			x
Dabbling ducks	x			x

[1]Groupings generally follow the descriptions provided by Shuford et al. (2000). The groupings imply that representatives occur in or use the indicated habitat types. An exception would be found in the last three groups (grey shaded) where individual species may use the delta areas of rivers, but most group use occurs in adjacent wetlands.

[2]Shoreline is operationally defined as the wetted surface area (acres) of the Sea from the edge of water to a depth of 6 feet.

[3]Open water is operationally defined as the wetted surface area (acres) of the Sea from a depth of 6 feet to the maximum depth.

[4]Islands and snags are used by some avian groups for nesting sites and/or roosting sites. These features are generally located at the north and south ends of the Sea.

[5]These wetlands occur along canals, drains, creeks, and other locations, and are not managed as habitat. Principal vegetation includes cattail-bulrush marshes and/or varying densities of salt cedar (tamarisk).

Both features that provide security, and sites that provide food, can be developed and operated to provide habitat resources for wildlife using the Salton Sea area.

Food is the major issue confronting resource agencies and the relevant questions involve “how much” and of “what quality.” Current approaches generally look at bird use of existing habitat types to provide insight into future area requirements for habitat restoration features. For example, the shoreline habitat type is generally recognized as providing abundant food resources as defined by high bird use (Shuford et al., 2000; DWR, 2006). Recent estimates of the areal coverage of “shoreline,” based on depth, range from about 6,000 acres (0-3 feet deep, DWR, 2006) to about 12,000 acres (0 to 6 feet deep, Reclamation, unpublished data). The area producing abundant food resources—again defined by bird use—increases to about 38,000 acres when a “nearshore” habitat type (water’s edge to 1 kilometer offshore) is considered (DWR, 2006). One could infer that the area—or “how much”—needed to provide or replace this food resource ranges between 6,000 and 38,000 acres depending upon management objectives. Potential restoration strategies evaluated in this report address the question of “how much” through different sized marine lakes, or different sized SHC, or different combinations of the two food-producing concepts.

Addressing the question of “how much” food also requires an evaluation of “what quality.” The question of food quality is important when addressing Salton Sea issues because of the presence of Se in agricultural waste water that would be used in restoration efforts. Se effects associated with avian reproductive impairment have been widely studied and extensively documented. In aquatic birds that feed on fish and/or invertebrates, accumulated Se can impair reproduction by affecting egg viability and/or producing deformities in developing embryos. Bioaccumulation is a concern because some species at the Salton Sea currently exhibit Se egg concentrations associated with reduced egg viability in other locations (Setmire et al., 1993; Bennett, 1998). Consequences of these elevated Se concentrations have not been determined, but it is assumed that any increase in Se levels in area food chains would increase the risk of additional Se bioaccumulation for breeding birds. Because Se-induced reproductive impairment is dose responsive (Skorupa, 1998), an increased risk of Se bioaccumulation—to birds that may be currently on the threshold of experiencing reduced egg viability—should be avoided.

Objectives

Reclamation’s principal objective in this study is to attempt to identify a restoration approach that retains the Salton Sea’s historic habitat function of providing quality habitat resources:

- To an abundant and diverse assemblage of fish and wildlife species.
- At a level sustainable within the constraints of future water availability and water quality.

This assessment of restoration alternatives evaluates the acreages of habitat type developed—with a focus on shoreline and open water—and then attempts to characterize, to the extent possible, the risk of increased Se bioaccumulation in both fish-eating and invertebrate-eating birds that may be associated with features of each alternative management plan.

Assessment Methods

As presented in Chapter 4, the Sea will become smaller and more saline in the future. These changes will affect the surface area available (e.g., shoreline and open water) to produce food and also the ability (e.g., increasing salinity) of the reduced surface area to produce food. Although multiple variables are likely associated with the production of food (fish and invertebrates) and its use by birds, a simple approach of comparing habitat type (shoreline, open water, and wetlands) area, as modified by salinity and possibly Se risk, was used to evaluate effects on avian groups using the Salton Sea.

Both Reclamation's analysis and DWR's Salton Sea Ecosystem Restoration Program draft PEIR analysis focus on acres of available habitat types now and in the future. Both approaches recognize bird use numbers as an indicator of habitat quality. Area (acres) is one of the two generally accepted components defining habitat quality. The second component—resource abundance as supported by the physical attributes of the area—was treated qualitatively by Reclamation using modifiers such as salinity, eutrophication, and potential for selenium bioaccumulation. The PEIR approach treats resource abundance through weighted bird density values for a select group of species using the Sea. Because bird- use numbers are highest at shallow shoreline sites, alternatives that include large areas of facilities mimicking shallow shoreline (i.e., through incorporation of saline habitat complexes) rank high using both approaches.

Any bird-density approach should be carefully evaluated to determine how numbers of individual birds would affect management goals. For example, DWR's PEIR habitat capacity ranking approach currently relies on data for 14 species. The brown pelican and Yuma clapper rail—species of Federal concern—are not included. Of the included species, annual use of the Salton Sea ranges from a few hundred individuals to more than one million, and seasonal use ranges from one or two seasons to year-around. The species were selected based on density-data availability and illustrate how such information can be used. No species specific management goals currently exist to date for Salton Sea resources.

It is recognized that some individuals may have a preference for one habitat type over another. Depending on species considered, some habitat types may have higher values. Reclamation treated all habitat types uniformly relative to bird values in general. However, it is recognized that more birds at the Salton Sea tend to use the shallow water areas in and around the sea. This study emphasizes the importance of shallow saline habitat areas through incorporation of Saline

Habitat Complex features. Regardless of whether you evaluate habitat values in terms of densities acquired by past observations or by landscape feature values, both approaches incorporate inherent subjectivity. Neither approach tries to give weight to one habitat type over another.

Both of the above approaches attempt to deal with the uncertainties of a complex system that will continue to change throughout the life of the proposed project to 2078. Reclamation believes that a bird-density approach to defining habitat quality may be a valuable tool once additional studies identify the capability of constructed facilities to provide safe and abundant food, and nesting and loafing sites; and specific management goals are developed that address and prioritize individual species needs by season within the constraints of water availability and water quality. A progressive and adaptive approach to habitat development would provide the framework for further exploration of these issues.

Area Determinations

The area of shoreline and open water habitats were determined for the marine lakes, residual Sea (brine basin), and SHC proposed for each alternative, including the No-Project Alternative. Different features would be developed at different times and, thus, would provide varying amounts of habitat resources. The actual future timing of events, including feature development associated with the alternatives, is unknown. However, for the purposes of analysis, four time periods were evaluated. Changes in acres of marine lakes, brine basins, and SHC were estimated for each period, and descriptions of conditions at the end of each period were developed. The following periods were evaluated:

- 1999–2006 (i.e., current conditions) (2006)
- 2007–2023 (2023)
- 2024–2040 (2040)
- 2041–2078 (i.e., the conclusion of the study period) (2078)

It was assumed that because of the time needed to complete analyses, obtain the necessary permits, secure funding, and complete design and construction, the various features of the alternatives would not become functional until 2024. Therefore, conditions under the first period (1996–2006) and second period (2007–2023) would be the same under all alternatives, including No-Project. Following a rapid reduction in inflow after year 2018, the Sea would begin a rapid reduction in surface area and increase in salinity.

It was assumed that during the third and fourth periods (2024–2040 and 2041–2078), the various features of the alternatives would be in place and functional. All alternatives would approach environmental equilibrium by year 2040. The residual Sea would continue its decline during these periods. During the third period (2024–2040), salinity concentrations within the brine basin would likely reach levels favoring brine flies and brine shrimp and would mark a significant change in the character of residual food chains.

Salinity concentrations, important in defining the type and relative abundance of food present for bird use, were estimated for each habitat type and time period. Nutrient levels are also important in determining food item abundance. The Sea is currently in a hypereutrophic condition and is expected to remain that way for some time. In this analysis of bird habitat resources abundance, nutrients were assumed to be non-limiting.

Selenium Concerns

Brine fly larvae.

Dilution is likely a significant process in reducing initial inflow Se concentrations (5-10 micrograms per liter [µg/L]) to observed Sea concentrations (1-2 µg/L). The Sea currently contains about 7.2 million acre-feet of water with an annual inflow of about 1.23 million acre-feet. When a large volume of water (the Sea) with a low concentration of some constituent receives a smaller flow of water with a higher concentration of that constituent, dilution occurs. Setmire et al. (1993) described the dilution process for sample sites at the mouth of the Alamo River. At these sites, total Se concentration in river water went from 6.35 µg/L to less than 2.4 µg/L in the interface mixing zone between the river and the Sea. Se species composition went from about 60 percent selenate to predominantly selenite.

Dilution alone cannot explain current Se concentrations in Sea water. Indeed, Schroeder and Orem (2000) have estimated that if Se were to have continued to accumulate within the water column, as have other constituents such as chloride, its concentration would have risen to about 400 µg/L. It is currently believed that anaerobic bacteria play a significant role in the removal of Se from the water column (Setmire et al., 1993). Schroeder et al. (2002) found no selenate in Sea water—even in the oxygenated surface water. Selenite composed about 33 percent of total Se in the upper 4 m, but no selenite was detected in deeper water. The bulk of Se entering the Sea is sequestered in bottom sediments in the elemental form and as non-volatile organic selenides. Any change in future conditions that would alter the dilution functions and/or affect the anaerobic bacterial Se processing mechanisms currently in place should be carefully evaluated for increased Se concentrations. For this study, the potential for increased risk of Se bioaccumulation in future food chains was evaluated qualitatively. The evaluation was based on the predicted depth, salinity, Se levels, and other factors of the alternative features. Five risk categories were identified:

- ***Low Risk***: Problems are evident but do not require mitigation measures
- ***Moderate Risk***: Problems are evident and may require mitigation
- ***Serious Risk***: Problems create significant threats—mitigation required
- ***High Risk***: Problems require extreme measures that may result in additional unforeseen problems and risks
- ***Fatal***: No solution for problems currently exists

Summary of Conditions under No-Project Alternative

As recently as 1999, the Salton Sea provided abundant food and secure nesting, roosting, and resting sites for large numbers of birds (Shuford et al., 2000). Several functional groups—primarily fish-eating and invertebrate-eating birds—used the habitat resources provided by the Sea's shoreline, open water, and islands and snags (**Table 5.1**). Rising salinity levels, along with water quality issues, further reduced the already declining fish populations between 1999 and 2006.

The description of the period 2006 to 2023, while presented here for the No-Project Alternative, would generally describe conditions under all alternatives. Therefore, during this period—under all alternatives—significant changes would occur in biota supported by the Sea and bird populations using the Sea and its habitat resources (Cohen and Hyum, 2006). An accelerated reduction in the Sea's elevation after the termination of mitigation water in 2017, with an accompanying accelerated increase in salinity, would change the structure of food chains historically supported by the Sea. Tilapia, pileworms, and most other macro-invertebrates that now populate the Sea's food chains and support the fish-eating and invertebrate-eating bird groups would decrease. In addition, secure sites (islands and snags) would be connected to land as water levels decrease and lose their habitat value. Currently, there are no known significant elevated land masses that would be exposed to create replacement habitat as the Sea recedes. Fish-eating divers and gulls, terns and skimmers—represented by pelicans, cormorants, terns, and others—would lose their food supply and nesting/roosting sites. Other groups, such as invertebrate-eating divers (e.g., eared grebes), shorebirds (e.g., snowy plovers), and diving ducks (ruddy ducks) would lose their traditional food items during this period and be forced to use brine flies and brine shrimp, or abandon the Sea. Some fish and some invertebrate communities would persist in the mixing zones and fresh water lenses at the mouths of the three rivers. However, the food biomass needed to support the abundance and diversity of avifauna historically supported by the Sea would not survive this period because of increasing salinity levels. Without a diverse prey base, the abundance and diversity of birds using the Sea would decline during this period.

Biological change in response to chemical and physical changes in the residual Sea would continue during the 2024–2040 period. For example, by the end of this period, salinity would exceed 250,000 mg/L, which is the level expected to impact brine flies and brine shrimp. Above this salinity, the Sea would be functionally devoid of macro-invertebrates. However, there is the potential for areas at the interface of the rivers and the Salton Sea that may support macro-invertebrates and possibly even fish. But before reaching this level of 250,000 mg/L, salinity would rise during the 2023–2040 period through levels that would provide optimum conditions for these two macro-invertebrates, and densities should reach maximum levels. Certain species within the functional groups identified in **Table 5.1** (e.g., eared grebes, ruddy ducks, and some shorebirds) may exploit this abundant food supply. Numbers of these birds using the Salton Sea during this period may be high. However, as salinity values exceed optimum levels for brine flies and brine shrimp, bird numbers would likely decline until both prey and the birds using them would reach low numbers.

Salt encrustation on the feathers of birds using the residual Sea/brine basin may be a concern as salinity levels continue to increase in the future. Under certain conditions—reported from saline wetlands, salt ponds, and evaporation ponds—encrustation can adversely affect birds' abilities to swim, dive, fly, and, in some cases, can cause mortality (Wobeser and Howard, 1987; Euliss et al., 1989; Gordus et al., 2002). Birds are generally attracted to saline waters by abundant food such as brine shrimp and brine fly larvae. Ruddy ducks, eared grebes, and some shorebirds that use saline impoundments with high brine shrimp/brine fly productivity may be at specific risk from salt encrustation, but several other affected bird species have also been documented in the above references.

Salt encrustation appears to be associated—at least in saline impoundments smaller than the Sea—with high salt concentrations (conductivity ≥77,000–90,000 micromhos per centimeter [≥ about 54,000-63,000 mg/L]), and low air and water temperatures approaching freezing (≤ 4° C) (Wobeser and Howard, 1987, Gordus *et al*., 2002). Future conditions that may facilitate salt encrustation, e.g., high salinities, high food productivity (brine shrimp/brine flies), and cold temperatures, are likely at both the residual Sea/brine basin and saline habitat complexes. However, the potential for salt encrustation on birds using the residual Sea/brine basin and/or saline habitat complexes has received little study to date.

Future Se levels in the residual Sea are a concern. If current anaerobic reduction mechanisms continue to function, then Se levels may remain similar to current levels. However, it is possible that Se concentrations in the residual Sea could increase for the following reasons:

- The residual Sea would be shallower than under current conditions and may be more prone to wind mixing. Mixing may re-suspend Se bearing sediments. Re-suspension may facilitate changes in Se speciation that result in increased concentrations within the water column.
- If additional mixing occurs, it may result in a more oxygenated system. More oxygen may reduce the effectiveness of anaerobic bacteria in removing Se from the water column.
- Sediments would be exposed as the Sea is reduced in size. Alternate wetting and drying of exposed sediments via drains, seepage, and/or dust mitigation may facilitate the formation of ephemeral pools with high Se levels.
- Agricultural drainage concentrations entering the Sea would increase as drainage volumes decrease. Concentrations of Se in the New and Alamo Rivers could increase to as high as 8 to 18 ug/L in the future with future conservation actions (Setmire, 2005).

Any increases in Se levels in the residual Sea, coupled with the assumed abundance of brine fly larva and brine shrimp during this period, create uncertainty regarding increased risk of Se bioaccumulation.

Finally, the period 2041–2078 would be marked by low resource abundance and low numbers of birds using the Salton Sea.

Summary of Conditions under Restoration Alternatives

An assessment of how best to replace habitat resources that would be lost in the future is actually an evaluation of concepts. In the present study, the principal concepts involve (1) large saline ("marine") lakes, (2) large SHC, and (3) combinations of marine lake and various sized saline complexes. The alternatives resulting from these concepts are assumed to provide varying quantities of food—represented here by acreage estimates for both shoreline and open water habitats—for marine lakes and/or SHC. Most alternatives also contain additional features (e.g., brine basins, sediment retention basins, conveyance channels) with primary functions other than providing habitat resources, but that would also provide invertebrate and/or fish prey items for area birds. Food produced by alternative features must, therefore, also be subject to a quality modification by salinity and/or potential Se levels that may be associated with alternative features in the future.

Several cautionary notes are in order when evaluating these alternatives. First, the current Sea supports a unique combination of physical, chemical, and biological components that provide both food for birds and deal with Se input by sequestering it in sediments. Although the eggs of some birds nesting at the Salton Sea exhibit Se levels associated with reduced egg viability in other studies, no major reproductive impairment issues have been identified in area birds to date. Note however, that all proposed alternatives—including No-Project—would alter the current combination of physical, chemical, and biological components in features by increasing or decreasing salinity levels and generally increasing Se concentrations. Major features and their associated concerns are as follows:

- Marine Lake—As discussed in other sections of this report, most marine lakes would likely experience salinity and/or nutrient problems. Salinity may be difficult to reduce to levels that would support a viable fishery in some lakes, and/or eutrophication issues may result in frequent fish kills. Food for fish-eating birds using such lakes may be limited. Invertebrates produced by marine lakes are assumed to contain Se levels similar or somewhat higher than current levels—if Se sequestering mechanisms in future marine lakes function as efficiently as in the current Sea.

- Residual Sea/Brine Pool—The residual Sea would be the dominant feature of all alternatives until about 2024. Existing food chains would disappear as salinity increases and be replaced for a time by brine fly larvae and brine shrimp. Although the residual Sea/brine basin would likely not produce food by the end of the third time period (2024–2040) because of salinity levels greater than 250,000 mg/L. Optimum conditions for brine flies and brine shrimp would occur at some time during the period. This food resource may be so abundant for a time after 2024 that some birds may use the residual Sea rather than facilities constructed for their use. A proactive plan is needed that would address the potential for Se accumulation within this future food source supported by the residual Sea.

- SHC—These features are large constructed wetlands with varying salinities. The majority of these shallow wetland habitats would be less than 3 feet deep. SHC are described in more detail in Chapter 3. These constructed wetlands would use a mix of river, marine lake (or brine pool) water to mimic shallow shoreline with dispersed deep pools of open water for fish. As Se levels rise in the rivers, and water within the complexes is concentrated to increase salinities, Se concentrations would also increase. Unless some mechanism is used to reduce or eliminate Se in water used in the complexes, food chains that develop would experience increased Se levels.

- Sediment Retention Basins—These constructed freshwater wetlands receiving drain water could pose a risk for Se bioaccumulation in the food chains they would support (Setmire, 2005). The assumed shallow water and relatively low salinities would support vegetation that would rapidly develop into “marsh-like” conditions. These conditions would be attractive to several bird groups, including the federally listed Yuma clapper rail. Unless some mechanism is used to reduce or eliminate Se in water used in the basins, food chains that develop would experience increased Se levels.

- Other Wetlands—Other wetlands would develop in response to a receding Sea shoreline and/or in association with various alternative features. For example, ponded water on exposed Sea-floor sediments would present an opportunity for increased Se concentrations. Alternate wetting and drying—which would occur during dust mitigation actions—could result in high Se concentrations. Increased Se concentrations would then be available for incorporation into local food chains.

All of the proposed alternatives would provide some level of food for fish- and invertebrate-eating birds. Food abundance would vary, but all alternatives would include operational uncertainties and, therefore, would present some level of increased risk for Se bioaccumulation at levels higher than currently exhibited by area birds. These uncertainties are discussed below and summarized in **Table 5.2**. Note that **Table 5.2** addresses alternatives as fully operational and near equilibrium in the year 2040. Although **Table 5.2** lists salinity values for the residual Sea/brine pool as greater than 250,000 mg/L, this level would not likely be reached until the latter part of the 2024–2040 period. Before reaching this salinity level, the residual Sea would provide optimum conditions for brine fly larvae and brine shrimp. If Se concentrations increase, this abundant food supply could result in increased Se bioaccumulation in birds using this resource.

Following is a discussion of potential benefits and uncertainties relative to each restoration alternative.

Alternative No. 1: Mid-Sea Dam with North Marine Lake

Potential Benefits

This alternative would provide about 13,800 acres of the shoreline habitat type in the marine lake component and another 12,800 acres of shoreline habitat within SHC (**Table 5.2**). About 103,700 acres of open water would be available within the marine lake and 3,200 acres within SHC. The total surface area the SHC in this alternative is 16,000 acres.

Uncertainties

Model simulations indicate that the marine lake may not reach salinities that would support a viable fishery until late (after 2038) in the study period. The risk to fish-eating birds of increased Se bioaccumulation is assumed moderate—if Se sequestering mechanisms continue to efficiently function in the marine lake. Uncertainties surrounding the SHC, residual Sea/brine basin, sediment retention

Table 5.2 Summary comparison of shoreline habitat, open water habitat, and food provided under restoration alternatives and No-Project Alternative in the year 2040

	Alternative No. 1 - Mid-Sea Dam with North Marine Lake			Alternative No. 2 – Mid-Sea Barrier with South Marine Lake			Alternative No. 3 – Concentric Lakes			Alternative No. 4 – North-Sea Dam with Marine Lake			Alternative No. 5 – Habitat Enhancement without Marine Lake			Alternative No. 6 – No-Project		
	Marine lake																	
	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided
Acres	13,800	103,700	Inverts Fish	17,300	44,700	Inverts Fish	46,800	817	Inverts Fish	3100	16,400	Inverts Fish	No lake	No lake	No lake	No lake	No lake	No lake
Salinity (g/L)[3]	58[4]	58[4]	58[4]	34	34	34	20 to 45	20 to 45	20 to 45	26	26	26	No lake	No lake	No lake	No lake	No lake	No lake
Selenium	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	No lake	No lake	No lake	No lake	No lake	No lake
	Brine pool																	
Acres	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food
Salinity (g/L)[3]	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250
Selenium	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food
	Saline habitat complex																	
Acres	12,800	3,200	Inverts	17,400	4,300	Inverts Fish	No complex	No complex	No complex	29,800	7,400	Inverts Fish	33,800	8,400	Inverts Fish	No complex	No complex	No complex
Salinity (g/L)[3]	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	No complex	No complex	No complex	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	No complex	No complex	No complex
Selenium	Increase probable	Increase probable	Increase probable	Increase probable	Increase probable	Increase probable	No complex	No complex	No complex	Increase probable	Increase probable	Increase probable	Increase probable	Increase probable	Increase probable	No complex	No complex	No complex

[1] Shoreline habitat is defined as habitat with depths of water between 0 and 6 feet with selenium in sediments less than or equal to 2.5 milligrams per kilogram (mg/kg) and salinity <= 250,000 mg/L.
[2] Open water habitat is defined as habitat with depths of water greater than 6 feet and salinity less than or equal to 60,000 mg/L
[3] Salinities are for mean possible future conditions as described in Chapter 4.
[4] Salinities for the Alternative No. 1 will exceed 60,000 mg/L under all possible inflow conditions less than mean possible future inflows (as described in Chapter 4) unless the marine lake is operated at elevations below than -238 feet

basins, and other constructed wetlands previously discussed, indicate the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious.

Alternative No. 2: Mid-Sea Barrier with South Marine Lake

Potential Benefits

This alternative would provide about 17,300 acres of the shoreline habitat type in the marine lake component and another 17,400 acres of shoreline habitat within SHC (**Table 5.2**). About 44,700 acres of open water habitat type suitable for fish would be provided by the marine lake, and an additional 4,300 acres of open water habitat would be provided by saline complexes.

Uncertainties

The risk to fish-eating birds of increased Se bioaccumulation is assumed moderate—if Se sequestering mechanisms continue to efficiently function in the marine lake. Uncertainties surrounding the SHC, residual Sea/brine basin, sediment retention basins, and other constructed wetlands previously discussed, indicate the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious.

Alternative No. 3: Concentric Lakes

Potential Benefits

No "SHC" are proposed for this alternative. However, the concentric lakes would likely function as "linear complexes" under this alternative, with similar habitat areas to those created in SHC. The concentric lakes would provide about 46,800 acres of the shoreline habitat type and about 817 acres of open water habitat (**Table 5.2**).

Uncertainties

This alternative would use river water (with increased future Se levels) and then concentrate it to reach desired salinity levels in the various lakes. Uncertainties surrounding the ring lakes, water management, and residual Sea/brine basin previously discussed, indicate the risk of increased Se bioaccumulation to both fish- and invertebrate-eating birds is assumed serious.

Alternative No. 4: North-Sea Dam with Marine Lake

Potential Benefits

This alternative would provide about 3,100 acres of the shoreline habitat type in the marine lake component and another 29,800 acres of shoreline habitat within SHC (**Table 5.2**). About 16,400 acres of open water suitable for fish would be provided by the marine lake, and an additional 7,400 acres of open water habitat would be provided by saline complexes.

Uncertainties

The risk to fish-eating birds of increased Se bioaccumulation is assumed moderate—if Se sequestering mechanisms continue to efficiently function in the marine lake. Uncertainties surrounding the SHC, residual Sea/brine basin, sediment retention basins, and other constructed wetlands previously discussed, indicate the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious.

Alternative No. 5: Habitat Enhancement without Marine Lake

Potential Benefits

This alternative does not include a marine lake component, but would provide about 33,800 acres of the shoreline habitat type, and an additional 8,400 acres of open water habitat via constructed SHC (**Table 5.2**).

Uncertainties

The risk of increased Se bioaccumulation to fish-eating birds is assumed moderate. Uncertainties surrounding the SHC, residual Sea/brine basin, sediment retention basins, and other constructed wetlands previously discussed, indicate the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious.

Alternative No. 6: No-Project

The conditions that would likely exist into the future for the residual Sea/brine basin have been previously described. As noted earlier, **Table 5.2** indicates that no food would be produced after salinity levels exceed about 250,000 mg/L. Because most fish except tilapia have disappeared, and tilapia will likely functionally disappear soon, the risk of increased Se bioaccumulation to fish-eating birds is assumed to be low under this alternative. However, before the residual Sea/brine basin loses its ability to support macro-invertebrates (salinity > 250,000 mg/L), it would support an abundant prey base of brine fly larvae and brine shrimp. Because of the uncertainties involved with future Se cycling in the residual Sea, the risk to invertebrate-eating birds of increased Se bioaccumulation is assumed serious.

Alternative Assessment

All of the proposed alternatives would provide some level of food resources for future bird populations using the Salton Sea area. In terms of the shoreline habitat type, Alternative No. 3, Concentric Lakes, would provide the largest area, with Alternative No. 2, Alternative No. 5, and Alternative No. 4 providing similar acreages, and Alternative No. 1 providing the smallest acreage (**Table 5.2**). Alternative No. 1, Mid-Sea Dam with North Marine Lake, would provide the largest open water area, followed by Alternative No. 2 and

Alternative No. 4. Alternative Nos. 3 and 5 would provide limited open water when compared to the other alternatives (**Table 5.2**).

Although Alternative No. 3 would provide the largest area of the shoreline habitat type, and Alternative No. 1 would provide the largest area of open water, there are concerns for both of these approaches. Specifically, there are questions of salinity levels under Alternative No. 1 and the ability of this approach to provide a marine lake that would support a viable fishery within the study period. In addition, Alternative No. 3 would concentrate river water within the various ring lakes and thus increase the risk of Se exposure to birds (Setmire, 2005). The remaining alternatives—Alternative Nos. 2, 4, and 5—have potential of providing shoreline and open water resources if Se levels can be managed at safe levels. The uncertainties surrounding the risk for increased Se bioaccumulation at this stage of planning requires caution, and, thus, ratings for all alternatives range from moderate to serious.

There appear to be many unanswered questions concerning how best to provide adequate food resources for area wildlife, and how to ensure that food produced would not increase the risk of Se bioaccumulation in area food chains. These unanswered questions should be addressed before a large and irretrievable commitment of resources is dedicated to a long-term approach to restoration. For example, the U.S. Geological Survey is currently collecting data on a 100-acre experimental saline pool near the Alamo River Delta. This experimental pool is yielding valuable information on construction techniques, salinity levels, bird use, etc. An expanded version of this approach—in 200-to-500-acre-sized pools—should perhaps be considered for future implementation. Benefits may include a better understanding of:

- Water depths and salinities that maximize food production and bird use.
- Construction techniques that are efficient and cost effective in producing water depths that maximize food production and bird use.
- Mechanisms to safely deal with Se in water used for food production.

Such an approach would provide some habitat resources while improving our understanding of how future systems may operate. Such an approach would also maintain needed flexibility until a consensus approach can be developed. Further study and experimentation appears warranted.

Finally, the residual Sea would be the only source of substantial habitat resources (not considering early start projects) until about 2024, when proposed plan features would become operational. Sometime during the 2006–2023 period, increasing salinity levels would eliminate existing food chains, and brine flies and brine shrimp would become the dominant food items in the Sea. Although these species may reach an impressive abundance, they will not support the numbers and diversity of avifauna found at the Sea in recent years. An experimental SHC approach would not only provide important information but may also provide needed habitat resources as resource agencies determine how best to address the questions of “how much” and of “what quality” resources are needed in the long-term.

Chapter 6. Environmental Factors Affecting Project Viability

This chapter summarizes information on environmental issues that could affect project viability. Some of this information was derived from a workshop held on July 26-27, 2005, to evaluate risks from proposed alternatives with respect to eutrophication, DO, and Se issues. Several reports (Amrhein, 2005; Amrhein and Anderson, 2005; Anderson, 2005; Horn and Holdren, 2005; Robertson, 2005 [see also Robertson and Schladow, in review; Robertson et al., in review]; Schladow, 2005; and Setmire, 2005), were produced for the workshop.

All of the alternatives currently under consideration, including No-Project, have potentially serious environmental consequences with respect to eutrophication, DO, Se, and fish and bird health. It is likely that some combination of treatment, mitigation, and/or active management will be required to minimize adverse environmental impacts of the project, regardless of which alternative is selected.

All configurations of a smaller Sea are projected to be more eutrophic than the current Sea, as existing nutrient loads enter smaller bodies of water and water conservation efforts further increase concentrations of nutrients and other pollutants entering the Sea. As a result, the remaining Salton Sea and created habitat features are likely to face problems with high algal productivity and subsequent low DO levels.

Se would be of increasing concern under all alternatives. Under all restoration alternatives, currently inundated sediments would be exposed, increasing selenium solubility, mobility and the risk of bioaccumulation in food chains. Se concentrations also are expected to increase as a result of shrinking receiving waters and rising concentrations in inflow waters resulting from water conservation measures. The extensive SHC created by most alternatives are also of concern with respect to Se.

An area of significant concern with respect to the viability of each of the restoration alternatives could be fugitive dust and exhaust emissions from construction and maintenance equipment and vehicles. It is expected that all alternatives (not including the No-Project Alternative) would result in emissions that exceed thresholds established by regulatory agencies. Both Imperial and Riverside Counties already hold status designations of “non-attainment” related to Federal and State of California PM_{10} air quality standards (DWR, 2006). Reclamation acknowledges that construction emissions could affect the timing and duration of construction and maintenance of any restoration alternative.

However, for the purposes of this study, it was assumed that the construction and maintenance of all the restoration projects could be permitted such that the timing and duration would not be affected.

Eutrophication

The Salton Sea has been eutrophic for many years. High productivity was responsible for the very large fish populations that were found in 1999 and 2000 (Reidel et al., 2002), but it also leads to periodic low DO concentrations caused by the decomposition of organic matter in the Sea and high sulfide levels created by bacterial sulfate reduction when oxygen levels drop.

Nutrient ratios indicate that phosphorus is the nutrient limiting algal growth in the Sea, and efforts to control eutrophication should concentrate on reducing P inputs; however, P concentrations in the Sea changed very little between 1968 and 1999 in spite of an increase in P loading of about 55 percent (Holdren and Montaño, 2002; Robertson et al., in review). The Sea did not significantly respond to the loading increases, indicating that proposed total maximum daily load and other treatment options would have little impact unless total P loads are drastically reduced by 60 percent or more. Modeling results (Robertson, 2005; Robertson and Schladow, in review) indicate that P levels would increase under all proposed alternatives, and that eutrophication would be as bad, if not worse than under existing conditions unless significant P removal is achieved.

Walker (2006) proposed target inflow concentrations of 80 to 200µg/L to meet an in-lake P concentration of 35 µg/L that is consistent with the goals of a proposed phosphorus TMDL. Achieving these targets would require 75- to 90-percent reductions in total P inflows. The technology exists for reducing P by these amounts, but implementation of best management practices (BMPs), treatment wetlands, and other watershed measures are unlikely to meet TMDL goals in the absence of other, more advanced, treatment methods. Evidence of the inability of TMDLs/BMPs to reverse eutrophication by themselves has been repeatedly demonstrated in restoration projects throughout the country. Additional evidence is provided by projects that have already been implemented in the Imperial Valley. A silt/sedimentation TMDL was implemented to control particulate runoff, and presumably phosphorus, along with various agricultural BMPs to control phosphorus. While these projects should have theoretically reduced the amount of silt and phosphorus in the New and Alamo Rivers, Reclamation's monitoring has not shown significant reductions in either phosphorus or suspended solids loadings to the Salton Sea. In fact, phosphorus and suspended solids concentrations from Reclamation's monitoring of the New and Alamo Rivers from 2004-2006 (sample size (n)=11) are not statistically different from those measured in 1999 (n=18). Alamo River orthophosphate and total suspended solids concentrations were slightly lower in 2004-2006 than in 1999, but Alamo River total phosphorus concentrations and New River orthophosphate, total phosphorus, and total suspended solids concentrations were all higher in 2004-2006 than in 1999. All differences were within one standard deviation of mean values and the differences are not viewed as significant. This supports the argument that implementation of BMPs alone will not have a measurable impact on eutrophication.

The addition of treatment plants to remove P is likely to be required to reduce P loadings to the point where eutrophication is no longer a problem. Because of the volume of water involved, such treatment plants would need to be on the scale of the largest existing treatment plants in the United States.

The trophic state index (TSI) developed by Carlson (1977) is a relative expression of biological productivity in a lake. Use of the TSI permits comparisons among different lakes and also allows managers to track the progress of restoration projects. The TSI can be calculated from total P, chlorophyll *a* concentrations, and Secchi depth. Total P was used for this analysis because P is the limiting nutrient in the Salton Sea and because P models are more advanced than models for most other water quality variables. The total P TSI was calculated for existing conditions based on 1999 data (Holdren and Montaño, 2002) and for the proposed alternatives from P modeling conducted by Robertson (2005).

Increasing TSI values are indicative of increasing productivity. A TSI of less than 35 indicates oligotrophic conditions; a TSI between 35 and 50 indicates mesotrophic conditions; and a TSI greater than 50 indicates eutrophic conditions. Hypereutrophic, or excessively productive, lakes have TSI values greater than 70. Results for the Salton Sea summarized in **Table 6.1** indicate the Sea will progress from its current eutrophic state to a hypereutrophic state (TSI $\geq$ 70) for all alternatives, except Alternative No. 3, at high inflows, under the expected range of risk-based inflow volumes and resulting depths.

The results in **Table 6.1** do not include any as yet unquantified reductions in P loadings that may occur through implementation of agricultural BMPs or construction of treatment plants to remove P from water flowing into the Sea. Using the target P inflows of 80 to 200 µg/L proposed by Walker (2006), the total P TSIs for the north marine lake under Alternative No. 1 would range from 55 to 63 (in-lake total P concentrations of 22 and 34µg/L, respectively). These values still indicate eutrophic conditions. Additional modeling would be required to predict the impacts of any such proposed reductions in P loading for other alternatives and inflow concentrations.

Selenium

Se is an important consideration for Salton Sea restoration alternatives because of the risk of bioaccumulation in fish and wildlife. The largest “step” in the bioaccumulation process occurs when Se concentrations go from parts per billion

Table 6.1. Calculated TSI for Salton Sea alternatives

Alternative	Total P (µg/L)		TSI	
	Low Flow[1]	High Flow[2]	Low Flow[1]	High Flow[2]
Current Salton Sea (1999)	69		65	
Alternative No. 1: Mid-Sea Dam with North Marine Lake	94	95	70	70
Alternative No. 2: Mid-Sea Barrier with South Marine Lake	152	147	77	76
Alternative No. 3: Concentric Lakes	131	91	74	69
Alternative No. 4: North Marine Dam with Marine Lake	145	141	76	76
Alternative No. 5: Habitat Enhancement without Marine Lake[3]	131	98	74	70
Alternative No. 6: No-Project	N/A			

[1] Inflow = mean - one standard deviation
[2] Inflow = mean + one standard deviation
[3] Conditions in habitat ponds

in water to parts per million (ppm) in plants and invertebrates. As additional layers, or trophic levels, of fish and wildlife feed on the levels below, Se can reach concentrations resulting in reproductive impairment or death.

Se concentrations are expected to increase in both the Salton Sea and influent waters as conservation measures are implemented in future years. Cohen and Hyun (2006) predicted that expected changes in hydrodynamics and sediment resuspension could also dramatically reduce, or even eliminate, the Sea's current ability to sequester incoming Se, which would result in increases in Se concentrations in the Sea, in aquatic organisms, and in birds.

Se concentrations in the Alamo, New, and Whitewater Rivers are currently in the range of 2 to 6 µg/L (Holdren and Montaño, 2002), a level generally believed to represent a toxicity threshold (**Table 6.2**). These concentrations will increase in the future as conservation measures are implemented. IID (2002) projected that Se concentrations in river inflows could increase by up to 46 percent as a result of reductions in tailwater drainage and operational losses. A panel of experts convened by the Salton Sea Science Office in 2003 (Selenium and the Salton Sea, undated) projected that conservation, water transfers, and desalination could result in Se concentrations in the New and Alamo Rivers of 12 to 36 µg/L. Furthermore, concentrations in puddles on exposed playa could exceed 1,000 µg/L, a level far exceeding the concentrations found at Kesterson Reservoir. Finally, Setmire (2005) suggested that the flow in the New and Alamo Rivers would be composed almost entirely of subsurface drainwater after all tailwater and operational loss is eliminated and flow from Mexicali is significantly reduced. Under those conditions, Se concentrations in the Alamo

Table 6.2 Selenium effect levels (U.S. Department of the Interior, 1998)

Medium	No Effect	Level of concern	Toxicity threshold
Water (parts per billion, total recoverable)	<1	1-2	>2
Sediment (ppm, dry weight)	<1	1-4	>4
Dietary (ppm, dry weight)	<2	2-3	>3
Waterbird eggs (ppm, dry weight)	<3	3-6	>6
Warmwater fish (parts per milllion, whole body dry weight)	<3	3-4	>4
Coldwater fish (ppm, whole body dry weight)	<2	2-4	>4

River are expected to approach the median concentration of 28 ug/L found in sumps and gravity tile outlets throughout the Imperial Valley (Setmire et al., 1993; Setmire and Schroeder, 1998). Although the magnitude of the increase in selenium concentrations may be open to debate, there is no argument that flows to the Salton Sea will be reduced. As a result of those reductions in inflow, less dilution water will be available and selenium concentrations in surface waters in the Imperial Valley will increase. Selenium concentrations are already at or above the 5 µg/L level that the Environmental Protection Agency (EPA) recommends for protection of aquatic life and will almost certainly be well above that level following the planned diversions and water conservation measures. Furthermore, EPA may be reducing this level to 2 µg/L in the near future. Reclamation believes that it is reasonable to assume that selenium concentrations could present a health risk to aquatic life.

Several authors have published similar guidance with minor variations in values. All indicate a small range of values between "no effect" and "toxicity threshold" levels.

The cycling of Se within the Salton Sea system involves a number of complex interactions among physical, chemical, and biological components. Some of these interactions are understood, and others are not. Thus, in order to conduct a viability assessment on the Se risk to aquatic birds, it was first necessary to make assumptions that establish boundaries for the Salton Sea system and its components of the future. These assumptions attempted to characterize parameters that may affect Se concentrations in future alternative components. The following assumptions were identified for this analysis:

- Se levels would increase in rivers and drains emptying into the Salton Sea (or future restoration features) as dilution water (tailwater) is reduced.
- A deep marine lake behind a mid-Sea dam—because of a smaller-cross sectional area and shorter fetch—would be less prone to sediment re-suspension and wind/wave mixing.

- A deep marine lake behind a mid-Sea dam would experience persistent stratification (Schladow, 2005).
- Bacterial reduction in the bottom sediments would continue for some time.
- Salinity concentrations would continue to increase until they reach a level that negatively affects existing primary producers.
- P would continue to increase from present conditions until a state of very low inflow is reached.
- Primary producers would continue to remove Se from the water column to a level of 1 to 2 µg/L, or somewhat higher, until salinity levels reach a level that disrupts and/or reduces the current assemblage of micro-organisms (including bacteria). This disruption would likely continue until salinity levels stabilize at a lower level.

It appears that biological uptake, with subsequent deposition, is currently sequestering most Se entering the Sea, resulting in Se concentrations <2 µg/L, and the anoxic conditions in the sediments prevent this Se from being oxidized and mobilized through the food chain. Although Se concentrations are expected to increase in water entering the Sea as water conservation measures are implemented, Se should remain low in the low-oxygen marine environments created.

For the shallower, SHC and concentric lakes with higher concentrations of DO created under Alternative Nos. 1, 2, 3, 4, and 5, the uptake and bioaccumulation of Se by primary producers would likely increase because of higher Se concentrations entering the system from tributaries and drains. In addition, it is reasonable to assume that increasing salinity in downstream SHC areas and concentric lakes would act to reduce the current assemblage of micro-organisms that play a key role in Se cycling in the Salton Sea. Such a disruption may lead to higher Se levels until salinity levels stabilize. This same disruption may occur in the marine lakes and brine pools. If such situations develop, they would translate into a high-risk level of increased Se bioaccumulation for aquatic birds.

Unless adequate mitigation can be provided, water entering SHC and concentric lakes may need to be treated to remove Se to make those areas safe for wildlife. Unfortunately, no current, proven technologies are available that are capable of treating the large volumes of water that will continue to enter the Sea. More research is needed to determine whether or not available processes are capable of providing the necessary treatment. As an alternative, additional mitigation habitat could be created to help compensate for damages to wildlife resulting from increased Se concentrations.

Fishery Sustainability

Maintaining a marine fishery is a goal of all alternatives, except Alternative No. 6. Salinities are expected to reach at least 93,000-123,000 mg/L under all alternatives during the transition from the current Sea to a new equilibrium state. This salinity spike is primarily due to cessation of mitigation inflows in year 2017. This salinity spike would eliminate the existing sport fishery and require the establishment of a new fishery once equilibrium is achieved. The loss of the fishery is also likely to cause at least a temporary relocation of fish-eating birds.

Under existing conditions, low DO concentrations appear to be the major factor adversely impacting the Salton Sea fishery. Low DO levels have led to massive, periodic fish kills. With eutrophication expected to increase, DO would continue to be of major concern under all alternatives. Increasing salinity, temperature fluctuations, and increases in Se concentrations may also adversely impact the Salton Sea fishery in the future.

A DO risk assessment model (Horn and Holdren, 2005) shows that there is a potential for DO levels to drop below 4 mg/L in the upper 3 m of the water column over 60 percent of the Sea's surface on any given night during the summer under current conditions. Similar results were predicted under most of the alternatives, indicating that low DO concentrations would continue to be a problem for fish in the Sea.

Hydrodynamic and thermodynamic modeling conducted by University of California-Davis was used to evaluate the hydrodynamics of the Salton Sea under various alternatives involving bisecting the Sea with a dam (Schladow, 2005). This modeling indicated that reducing the size of the Sea under various alternatives could result in intense and persistent thermal stratification for water depths greater than 10 m (33 feet). The main consequence of this stable stratification is that the Sea would switch from a polymictic system, i.e., with several mixing events per year, to a monomictic system, i.e., mixed for a relatively brief period in the winter. As a result of this stability and the expected continuing eutrophication, the hypolimnium of the Sea would be

Recent fish kill.

anoxic for most of the year. With the expected, extensive anoxia, H_2S and NH_3 would build up to unprecedented levels because of the lack of mixing.

> ***Hydrodynamic and Thermodynamic Modeling:*** The field of hydrodynamics deals with the study of fluids in motion through the application of the physical laws pertaining to the conservation of mass, momentum, and energy. The field of thermodynamics is associated with the branch of physics that studies the effects of changes in temperature, pressure, and volume in physical systems. The models applied by the University of California at Davis combine hydrodynamic and thermodynamic principals. These models were used to evaluate changes in the Salton Sea that might occur as a result of implementation of Restoration

The predicted rapid breakdown of the stratification would lead to a sudden redistribution of anoxia, H_2S, and NH_3 throughout the water column and to gaseous NH_3 and H_2S to the air. The effect of this could be an annual die off of most fish in the Sea and serious odor problems. There are also potential human health impacts, including headache and nausea, as well as more serious problems for sensitive individuals. Sediment re-suspension studies (Anderson, 2005) supported the results of the hydrodynamic model. Mixing is affected by lake morphometry; a sediment transport model developed by Hakanson (1982) indicated sediment transport and resuspension would be curtailed by those alternatives that divide the current Salton Sea.

Results presented by Amrhein (2005) indicate that the Sea currently generates about 75,000 to 78,000 metric tons of sulfide per year, resulting in a calculated sulfide concentration of 7.5 mg/L. At this concentration, sulfide oxidation alone could consume 14.5 mg/L of DO when the Sea mixes each year. This concentration is far higher than DO saturation levels in the Sea. Although this calculation is based on limited information, the results support the possibility that all oxygen could be eliminated by the predicted annual mixing events.

An analysis by Ruane (2006) found that oxygen demands in the Salton Sea were the largest reported in that author’s experience, which includes study of more than 110 large reservoirs. Oxygen demands in the Sea originate from decomposition of organic matter (algae) in the water column. When there is sufficient organic matter to consume all available oxygen during the decomposition process, bacterial processes then consume sulfate and nitrate, producing H_2S and NH_3. Salton Sea sediments contribute additional oxygen demand that could continue to be exerted even if algal growth was reduced in the future by controlling nutrient loadings to the Sea, although sediment oxygen demand would decrease over time in the absence of additional inputs of organic material.

Ruane (2006) calculated the total oxygen demands for the hypolimnion of a south marine lake alternative using the assumptions that the hypolimnetic volume was 1,600,000 acre-feet. This value corresponds to a thermocline originating at 4 m, which is typical of levels observed during the monitoring program and is also consistent with the thermocline depth predicted by Schladow (2005). The calculated total daily DO demands for the hypolimnion of the Sea ranged from

6.9 to 9.5 mg/L per day over the ranges of observed data and assumptions made, which equates to a daily oxygen demand of 15,000 to 20,600 tons that would have to be satisfied by external means to prevent the possibility of fish kills under future conditions. These results depend upon the thermocline depth and hypolimnetic volume, but not on the location of the marine lake.

Five main approaches could be used to reduce risks associated with low DO levels in the Salton Sea: (1) reduce nutrient inputs to a level that would lower algal productivity to acceptable levels, (2) avoid deep water to improve the efficiency of wind mixing, (3) mechanically circulate Sea water to improve reoxygenation, (4) use aeration/oxygenation/ozonation to directly increase DO concentrations, and (5) pump water out of the Sea and treat it by ozonation/oxygenation before returning the treated water to the Sea. Each of these approaches potentially has serious limitations and flaws.

Viability of Alternatives Relative to Environmental Factors

None of the current alternatives appear to be free of environmental concerns. In general, environmental conditions are likely to deteriorate, regardless of which alternative is selected. There are significant concerns for all alternatives with respect to increasing Se concentrations and requirements for dust abatement.

In addition to loss of the Sea's fishery during the transition period when salinities will spike at 80,000 to 100,000 mg/L, the new equilibrium state for all alternatives including marine lakes (Alternatives Nos. 1, 2, and 4) is expected to be hypereutrophic, and low DO concentrations are expected without significant, and possibly unattainable, nutrient reductions from the watershed. Eutrophication and low DO levels, high Se concentrations, and fluctuating temperatures and salinities are potential problems in the SHC and concentric lakes created under Alternatives Nos. 1 thru 5.

Establishment of a viable fishery would be difficult under all alternatives with open water. All of the alternatives have significant adverse viability impacts. A progressive strategy that could adapt to changing conditions and new information as the restoration proceeds should be considered. **Table 6.3** summarizes alternative viability study results. This table identifies variability in these results where appropriate. A summary of potential viability concerns for each alternative follows.

Table 6.3 Alternative viability assessment summary[1]

Alternative	Se risk to fish-eating breeding birds	Se risk to invertebrate-eating breeding birds	Hydrodynamic/ stratification risk	Eutrophication risk	Fishery sustainability risk
Alternative No. 1: Mid-Sea Dam with North Marine Lake	Moderate risk	Serious risk	Serious to high risk	Moderate risk	In Sea –Serious to High Risk: Salinity, DO, H_2S, NH_3 In Ponds – Moderate to Serious Risk: DO, temperature extremes
Alternative No. 2: Mid-Sea Barrier with South Marine Lake	Moderate risk	Serious risk	Low risk	Moderate to serious risk	In Sea –Serious to High Risk: DO, temperature extremes, salinity variations In Ponds – Moderate to Serious Risk: DO, temperature extremes
Alternative No. 3: Concentric Lakes	Serious risk	Serious risk	Low risk	Low to moderate risk	Moderate to Serious Risk: DO, temperature extremes
Alternative No. 4: North Sea Dam with Marine Lake	Moderate risk	Serious risk	Low risk	Moderate to serious risk	In Sea – Moderate to Serious Risk: DO, temperature extremes In Ponds – Moderate to Serious Risk: DO, temperature extremes
Alternative No. 5: Habitat Enhancement w/o Marine Lake	Moderate risk	Serious risk	Low risk	In ponds moderate risk	In Ponds – Moderate to Serious Risk: DO, temperature extremes
No-Project	Low risk	Serious risk	Low risk	Low risk	Fatal: Salinity

[1]Risk classified according to the following categories:

Fatal: Nothing can be done to alleviate the problems and issues

High risk: Problems can be dealt with by taking extreme measures that would likely result in other significant problems

Serious risk: Problems create significant threats that may be tolerable with significant mitigation measures in place

Moderate risk: Problems are evident and potentially significant and may require mitigation measures

Low risk: Problems are evident but would not require immediate mitigation measures

Alternative No. 1: Mid-Sea Dam with North Marine Lake

Under Alternative No. 1, the possibility of prolonged stratification, major die-offs of aquatic life, and salinity levels that would be too high to support a viable fishery could exist under the risk-based inflow approach. Eutrophication and hypolimnetic oxygen depletion are expected. Although the exact level of risk is uncertain, Reclamation estimates the risk (as shown in **Table 6.3**) of stratification to vary from serious to high. Existing modeling studies indicate that this risk could be reduced if operating water depths in the marine lake were reduced below 10 m (33 feet) (Schladow, 2005) which would correspond to an operating water surface elevation of -245 feet. Temperature fluctuations in the SHC also would be greater than those currently experienced, which could further limit the establishment of a viable fishery. Areas of potential concern with respect to Se for Alternative No. 1 include conveyance channels, 16,000 acres of created SHC, and the brine pool. The 4,000 acres of treatment wetlands on the New and Alamo

Rivers included for P removal are also of concern, as the same processes that remove P could also concentrate Se. Reclamation is currently studying Se issues at existing New and Alamo Rivers wetlands projects. These studies will provide additional insight into potential concerns relative to the concentration of Se in SHCs.

Approximately 103,800 acres of lake playa could be exposed under Alternative No. 1, and it is estimated that 70 percent of this acreage would require dust mitigation by 2040. Reclamation modeling indicates that there may not be sufficient quantities of brine available to use for the treatment method proposed under Alternative No. 1 for AQM.

Alternative No. 1 includes treatment plants to remove P if watershed measures do not remove enough P to reduce eutrophication. The SSA proposed this alternative and the treatment plant but has not provided designs. There is uncertainty that this treatment may or may not produce the desired results and, as such, there exists significant risk of eutrophication.

While Alternative No. 1 also includes ozonation to address DO problems, the amount of treatment proposed may be several orders of magnitude too low to solve the problem. Therefore, there is uncertainty that the ozonation process would be effective.

The treatment plants proposed by the SSA in Alternative No. 1 have not been proven for conditions existing at the Salton Sea. Even if they were to work, the plants would be as large as the biggest treatment plants in the United States.

Alternative No. 2: Mid-Sea Barrier with South Marine Lake

The marine lake in Alternative No. 2 is expected to have hypereutrophic conditions with occasional, severe oxygen depletion. Temperature fluctuations also would be greater than those currently experienced, which could further limit the establishment of a viable fishery. Furthermore, it is expected that it would be difficult to maintain a constant salinity under low inflow conditions in the south Sea formed by the barrier, which could create additional challenges for establishing a viable fishery. Areas of potential concern with respect to Se for Alternative No. 2 include conveyance channels, 21,700 acres of created saline habitat, and the brine pool. Under mean risk-based inflows, approximately 73,600 acres of lake playa could be exposed under Alternative No. 2, and it is estimated that 70 percent of this acreage would require dust mitigation by 2040.

Alternative No. 3: Concentric Lakes

The concentric lakes in Alternative No. 3 are expected to be shallow enough to be subjected to frequent mixing, but some oxygen depletion could still occur during the summer months as a result of the expected hypereutrophic conditions. Temperature fluctuations also would be high under this alternative, creating additional problems for establishment of viable fishery. Se is of particular concern for Alternative No. 3 because each of the lakes would form large shallow water habitats directly receiving and concentrating New and Alamo River water. Se concentrations are expected to be greater than 5 µg /L in each lake. These levels would create significant threats that may be tolerable with significant mitigation measures in place. Under mean risk-based inflows, approximately 65,000 acres of lake playa would be exposed under Alternative No. 3, and it is estimated that 70 percent for this acreage would require dust mitigation by 2040.

Alternative No. 4: North-Sea Dam with Marine Lake

Hypereutrophic conditions with occasional, severe oxygen depletion are also expected to occur under Alternative No. 4. Temperature fluctuations also would be greater than those currently experienced, which could further limit the establishment of a viable fishery. Areas of potential concern with respect to Se for Alternative No. 4 include conveyance channels, 37,200 acres of created saline habitat, and the brine pool. Under mean risk-based inflows, approximately 91,800 acres of lake playa could be exposed under Alternative No. 4, and it is estimated that 70 percent of this acreage would require dust mitigation by 2040.

Alternative No. 5: Habitat Enhancement without Marine Lake

No marine lake is associated with Alternative No. 5, and any fishery would be restricted to rivers, conveyance channels, and deep pools within the SHC. The shallow depths, expected eutrophic conditions, and fluctuating temperatures in these complexes would further limit creating a fishery. Areas of potential concern with respect to Se for Alternative No. 5 include conveyance channels, 42,200 acres of created saline habitat, and the brine pool. Under mean risk-based inflows, approximately 81,200 acres of lake playa could be exposed under Alternative No. 5, and it is estimated that 70 percent of this acreage would require dust mitigation by 2040.

Alternative No. 6: No-Project

Alternative No. 6, the No-Project Alternative, has no marine lake or created habitat, and has significant environmental concerns. Areas of potential concern with respect to Se for Alternative No. 6 include exposed sediments, river channels, and the brine pool. Under mean risk-based inflows, approximately 92,200 acres of lake playa could be exposed under Alternative No. 6, and it is estimated that 70 percent of this acreage would require dust mitigation by 2040.

Chapter 7. Costs of Alternatives

Reclamation coordinated closely with the State of California DWR and the Salton Sea Authority in developing the alternatives presented in this report. Consequently, both the State and Reclamation have analyzed alternatives that are conceptually similar, yet have some differences. Variation between agencies in approaches to risk, uncertainty, complexity, and other factors contribute to differences in designs and costs. While Reclamation's design and cost estimating criteria and guidelines may be different than those used by other agencies and this may lead to different design conclusions and project costs, Reclamation makes no judgment relative to methods, assumptions, and criteria used by others.

It was Reclamation's intention to provide the highest quality design and cost estimates within the constraints of funding, schedule, and available information. Available knowledge of geologic conditions, in particular, was limited.

These factors should be taken into consideration when comparing costs of alternatives presented in this summary report to those presented in DWR's draft PEIR and to reports prepared by other organizations.

Table 7.1 displays appraisal level estimates of subtotal construction and implementation costs of all alternatives, including the No-Project Alternative, using embankment designs that meet Reclamation's design criteria and guidelines. **Table 7.2** presents appraisal level annual recurring costs of all the alternatives. All appraisal level cost estimates are expressed in 2006 price levels for comparison purposes.

The costs of all alternatives are based on very limited geologic and geotechnical data that were obtained through exploration in years 2003 and 2004. Significant design uncertainties exist as a result of the limited amount of site information. Uncertainties also exist relative to constructability, seismic performance, static performance, and construction costs. These uncertainties can only be reduced by conducting significant geologic and geotechnical design data collection programs.

Specific schedules that take into account the construction duration of each alternative feature have not been developed. Without consideration of construction durations, cost escalation during construction cannot be properly evaluated. The appraisal level cost estimates provided in this chapter do not include funds for escalation during construction and the time leading up to construction. Escalations during construction are expected to be a very significant dollar amounts given the size and cost magnitude of the various restoration alternatives presented here.

Table 7.1 Alternatives and associated component construction costs[1]

Alternative Components	**Alternative No. 1A:** Mid-Sea Dam with North Marine Lake Using Sand Dam Design with Stone Columns	**Alternative No. 2A:** Mid-Sea Barrier with South Marine Lake Using Sand Dam Design with Stone Columns	**Alternative No. 3A:** Concentric Lakes Using Sand Dam Design with Stone Columns[3]	**Alternative No. 4:** North-Sea Dam with Marine Lake Using Sand Dam Design with Stone Columns	**Alternative No. 5:** Habitat Enhancement without Marine Lake	**Alternative 6:** No-Project
1. Mid-Sea Dam	$2,210,287,846					
2. West and East Perimeter Dikes	$543,400,979					
3. South-Sea Dam	$954,557,582					
4. Mid-Sea Barrier		$605,723,577				
5. Three Concentric Lake Dikes			$6,749,460,260			
6. Concentric Lakes – Habitat Islands and Deep Areas			$181,119,163			
7. Concentric Lakes – Lake Cell Divider Structures			$44,346,843			
8. North Sea Dam				$4,519,967,738		
9. Earthen Dikes for Habitat Ponds	$215,568,000	$292,364,100		$501,195,600	$568,560,600	
10. Habitat Ponds – Habitat Islands and Deep Areas	$246,651,333	$334,514,933		$573,455,600	$650,532,267	
11. Water Conveyance Features	$314,915,017	$201,680,735	$799,914,684	$193,488,011	$272,282,161	$58,896,420
12. Water Treatment Facilities	$218,000,000					
13. Air Quality Mitigation – via Water Vegetation Features	$762,930,000	$540,960,000	$477,750,000	$674,730,000	$596,820,000	$677,670,000
14. Air Quality Mitigation – via Other Features	$152,586,000	$108,192,000	$95,550,000	$134,946,00	$119,364,000	$135,534,000
Subtotal Construction Costs[2]	**$5,618,896,757**	**$2,083,435,345**	**$8,348,140,949**	**$6,597,782,949**	**$2,207,559,028**	**$872,100,420**
Unlisted Items: 10%	$581,103,243	$216,564,655	$851,859,051	$702,217,051	$192,440,972	$87,899,580
Total Contract Costs	$6,200,000,000	$2,300,000,000	$9,200,000,000	$7,300,000,000	$2,400,000,000	$960,000,000
Contingencies: 25%	$1,500,000,000	$600,000,000	$2,300,000,000	$1,800,000,000	$600,000,000	$240,000,000
Total Field Costs	$7,700,000,000	$2,900,000,000	$11,500,000,000	$9,100,000,000	$3,000,000,000	$1,200,000,000
Non-Contract Costs: 20%	$1,500,000,000	$600,000,000	$2,500,000,000	$1,900,000,000	$600,000,000	$200,000,000
Total Project Implementation Costs	**$9,200,000,000**	**$3,500,000,000**	**$14,000,000,000**	**$11,000,000,00**	**$3,600,000,00**	**$1,400,000,000**

[1] Costs presented are for alternatives using embankment designs that meet Reclamation design criteria and standards.
[2] Includes mobilization costs estimated at 5 percent.
[3] Total project implementation costs assuming four concentric lakes for Alternative No. 3A is $17, 800,000,000.

Table 7.2 Summary of annual re-occurring costs of restoration alternatives ($ million)

Alternative	Annual Operations, Maintenance, and Energy (OM&E) Costs	Annual Replacement Costs	Annual Operations, Maintenance, Energy, and Replacement (OME&R) Costs	Annual Risk Costs [2]	Annual Operations, Maintenance, Energy, Replacement, and Risk (OMER&R) Costs
Alternative No. 1A: Mid-Sea Dam with North Marine Lake using Sand Dam Design with Stone Columns	148	87	235	5	240
Alternative No. 2A: Mid-Sea Barrier with South Marine Lake using Sand Dam Design with Stone Columns	71	62	133	3	136
Alternative No. 3A: Concentric Lakes using Sand Dam Design with Stone Columns [1]	64	55	119	1	120
Alternative No. 4: North-Sea Dam with Marine Lake using Sand Dam Design with Stone Columns	89	77	166	6	172
Alternative No. 5: Habitat Enhancement without Marine Lake	79	68	147	7	154
Alternative No. 6: No-Project	87	77	164	0	164

[1] Costs shown are for three concentric lakes as required under mean possible future inflow conditions.

[2] Risk costs are defined as the annualized cost of repairing structures calculated from estimated annualized probabilities of failure (from major seismic events) and from estimates of how much of a structure would have to be repaired as a result of the failure.

The following sections of this chapter describe the various components of the appraisal level cost estimates**.**

Total Project Implementation Costs

The estimating process for alternative features involved application of models and equations to determine major construction material quantities and placement requirements. Unit prices per physical quantity were developed and then applied to physical quantities to develop the subtotal construction cost estimates. Unit prices included estimates of initial mobilization of contractor personnel and equipment to the project site during start-up.

Some appraisal level cost estimates for other less costly features were developed in a different manner. For example, the construction costs for the AQM features relied heavily on estimates presented by the State of California in its Salton Sea Ecosystem Restoration Program Draft Programmatic Environmental Impact Report (DWR, 2006). The construction costs for the water treatment facilities in Alternative No. 1 were based on estimates developed by the SSA. Given the limited information that is available relative to the proposed treatment plants, there is uncertainty that the level of treatment would provide the desired results. As such, these treatment plant cost estimates could be understated.

In accordance with the Reclamation's cost estimating guidelines, a 10-percent allowance, based upon engineering judgment, was added to subtotal construction costs to cover unlisted items of work that would appear in the specifications and would be required for a fully finished feature. The sum of subtotal construction costs and unlisted items is termed "contract costs", as shown in **Table 7.1**.

A 25-percent allowance for "contingencies", based upon engineering judgment, was added to contract costs to address the differences between actual and estimated quantities, unforeseeable difficulties at the site, possible minor changes in plans, and other uncertainties. As shown in **Table 7.1**, the sum of contract costs and contingencies equals "total field costs."

"Non-contract costs" were estimated to be 20 percent of the total field costs. This allowance was based on review of non-contract costs from past large Reclamation projects. Non-contract costs reflect some or all of the following items: services facilities, investigations and studies including environmental compliance, design data collection, final designs and specifications, permits, construction engineering and management, and other general expenses.

The sum of total field costs and non-contract costs is equal to the "total project implementation costs", which are the total estimated costs of putting any of the alternatives fully in service. As shown in **Table 7.1**, these costs range from a low of $1.4 billion for the No-Project Alternative (Alternative No. 6) to a high of $14.0 billion for Alternative No. 3A, expressed in 2006 prices.

Costs provided in **Table 7.1** reflect application of embankment designs to the alternatives that would meet Reclamation's general design criteria and guidelines as listed in **Table 3.7**. **Attachment A** presents subtotal construction and implementation costs for the alternatives using embankment designs that would not meet Reclamation's general design criteria and guidelines as follows:

- Alterative No. 1B: Mid-Sea Dam with North Marine Lake – Original SSA alignment using SSA rockfill design. This alternative includes 12,000 acres of saline habitat complex.
- Alternative No. 2B: Mid-Sea Barrier with South Marine Lake using sand dam design without stone columns.

- Alternative No. 3B: Concentric Lakes using sand dam design without stone columns.
- Alternative No. 3C: Concentric Lakes using Geotube® embankment design (as proposed by the Imperial Group).

Alternative No. 1B uses the SSA's rockfill embankment design which includes the use of geocomposite filters. Use of geocomposite filters would likely result in constructability problems and unreliable filter performance.

Alternative No. 2A includes stone columns to reduce seismic risk; Alternative No. 2B does not include stone columns. These two sets of costs provide for an understanding of the costs associated with reducing seismic risk.

Costs provided in **Table 7.1** and in **Attachment A** for the Concentric Lakes Alternative Nos. 3A, 3B, and 3C assume the need for three concentric lakes as described in Chapter 3. Footnotes are provided in both **Table 7.1** and **Attachment A** that show implementation costs of four concentric lakes as proposed by the Imperial Group. Alternative No. 3A uses an embankment design that includes stone columns and, as such, would provide for reduction of both static and seismic risks. Alternative No. 3B does not include stone columns and would carry with it seismic risks that would not occur in Alternative No. 3A, which does include stone columns. Alternative No. 3C involves use of Geotubes® as proposed by the Imperial Group. Constructing concentric lake dikes using Geotubes® would result in significant seismic, static, and constructability problems. These three sets of costs for the Concentric Lakes Alternatives provide an understanding of the costs associated with reducing static and seismic risk.

Annual Operation, Maintenance, Energy, Replacement, and Risk Costs

Annual operations, maintenance, energy, replacement, and risk (OMER&R) costs (**Table 7.2**) were developed by Reclamation at a relatively low level of detail because those costs for the restoration alternatives, incremental to the No-Project Alternative, are small relative to initial project implementation costs. Costs were included for staff, office space, vehicles, materials, and pumping energy. Reclamation relied on information from DWR's Salton Sea Ecosystem Restoration Program Draft PEIR (DWR, 2006) for operation and replacement costs of AQM features. Finally, for Alternative No. 1, only, Reclamation relied on an estimate for operation of the water treatment facilities prepared by the SSA. Given the limited information that is available relative to the proposed treatment plants, there is uncertainty that the level of treatment would provide the desired results. As such, these treatment plant operations and maintenance cost estimates could be understated.

The Salton Sea is located in an area with a history of earthquakes of sufficient magnitude to cause significant damage to the constructed features of the various alternatives, i.e., the dams, dikes, barriers, habitat islands, conveyance facilities, and treatment facilities. Repair and replacement costs for each of these features were estimated to range from 10 to 50 percent of original project implementation costs, depending on the type of structure and how it was designed. No damage from potential seismic activity was assumed for the AQM features. The annual probability of failure was estimated for each of the facilities susceptible to earthquake damage for all alternatives. The annual probability of failure for each potentially earthquake-damaged feature was multiplied by the estimated repair and replacement costs for that feature to derive the "annual risk cost" associated with its location in an active seismic area. For the Concentric Lakes Alternative with Geotubes® (No. 3C) an additional annual risk cost was considered for repair and replacement of significant portions of the dikes due to expected foundation piping and erosion problems (static risk problems).

The annual operation, maintenance, replacement, and energy costs were added to the annual risk cost for each alternative to derive the total OMER&R costs, as shown in **Table 7.2**. These costs are lowest for Alternative No. 3A and highest for Alternative No. 1A.

Summary of Restoration and Air Quality Mitigation Costs

AQM costs would be incurred whether or not any of the restoration features are constructed, as playas are exposed over time. As noted previously, the No-Project Alternative consists entirely of this cost. AQM costs for all alternatives were estimated using construction costs consistent with DWR's Salton Sea Ecosystem Restoration Plan. Construction costs for mitigation using water-efficient vegetation were assumed to be $14,000 per acre. Construction costs for mitigation using other methods was $7,000 per acre. **Table 7.3** presents implementation costs of restoration features and AQM features separately. OMER&R cost data for each alternative are also summarized in **Table 7.3,** divided between restoration features and AQM. The values presented in **Table 7.3** for the Concentric Lakes Alternatives assume the need for three lakes, as discussed in Chapters 3 and 4. Only three lakes would be required under mean possible future inflows. It is assumed the State of California will manage AQM in coordination with landowners and other stakeholders as may be applicable by Federal and State laws, regulations, ordinances, and legal agreements.

Table 7.3 Summary of Restoration and Air Quality Mitigation Project Implementation and OMER&R Costs ($ million)

Alternative	Restoration project implementation costs	AQM project implementation costs	Total project implementation costs	Annual restoration OMER&Risk costs	Annual AQM OM&R costs	Total OMER&R costs
Alternative No. 1A: Mid-Sea Dam with North Marine Lake using Sand Dam Design with Stone Columns	7,600	1,600	9,200	56	184	240
Alternative No. 2A: Mid-Sea Barrier with South Marine Lake using Sand Dam Design with Stone Columns	2,400	1,100	3,500	5	131	136
Alternative No. 3A: Concentric Lakes using Sand Dam Design with Stone Columns [1]	13,000	1,000	14,000	5	115	120
Alternative No. 4: North-Sea Dam with Marine Lake using Sand Dam Design with Stone Columns	9,700	1,300	11,000	9	163	172
Alternative No. 5: Habitat Enhancement without Marine Lake	2,400	1,200	3,600	10	144	154
Alternative No. 6: No-Project	0	1,400	1,400	0	164	164

[1] Costs shown are for three concentric lakes as required under mean possible future inflow conditions.

Chapter 8. Economic Analyses

Conceptual Overview

Federal standards for planning and economic evaluation of water resource projects are contained in the 1983 *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, commonly referred to as the P&Gs. In terms of economic analysis, the P&Gs establish two accounts to facilitate the evaluation and display of the effects of alternative plans: national economic development (NED) and regional economic development (RED). As implied, the NED account shows effects on the entire national economy, while the RED account shows the regional (or local) income and employment effects. Most “multiplier” effects, which occur as dollars initially spent in the regional economy are successively re-spent, are considered to be transfers from other locations in the Nation and are not counted as NED benefits.

The P&Gs establish that the beneficial and adverse effects of all alternative plans should be measured incrementally against the most likely future condition without a plan -- the No-Project Alternative. To the extent possible, the economic analysis quantified NED benefits and costs for a 72-year period of analysis, 2006–2077. This period of analysis was selected because the 75-year project period for the existing Salton Sea Ecosystem Restoration Program ends in 2077. In accordance with the P&Gs, quantifiable benefits and costs over this period of analysis were converted to 2006 present worth values using the fiscal year 2006 Federal discount rate of 5.125 percent. Any economic effects beyond the period of analysis have minimal value in present worth terms.

The present worth costs presented in this chapter differ from the implementation costs shown in Chapter 7. Present worth analysis requires the conversion of all cash flows to a common point in time—the present. As such, it requires consideration of the time value of money, and all future cash flows are discounted back to the present. Comparison of the equivalent worth of competing alternatives allows comparison of alternatives on the basis of economics. This type of analysis is normally prepared when conducting Reclamation feasibility studies, and the process is followed to the best degree possible in this study.

For the purposes of comparing cost of alternatives as designed and estimated by other agencies, such as the DWR and the SSA, care should be taken to determine what types of costs they are reporting. Most likely they are not performing present worth analyses and are presenting implementation costs as presented in **Table 7.1**.

National Economic Development (NED) Costs

From a national perspective, all costs potentially incurred for the Salton Sea restoration alternatives and the No-Project Alternative are relevant without respect to whether those costs are incurred by the Federal Government, the State of California, local governmental agencies, or private citizens. In this study, NED costs consist of initial implementation costs for construction and program development, plus recurring annual operation, maintenance, energy, replacement, and risk (OMER&R) costs, as described and displayed in Chapter 7.

All NED costs were adjusted for time of occurrence and converted to present worth values in year 2006 dollars, as shown in **Table 8.1**. For purposes of this analysis, it was assumed that project implementation costs would begin to be expended in year 2008 and would be expended in equal annual increments. It was further assumed that construction of restoration features for any of the alternatives would be completed in year 2024, and AQM construction costs would be incurred through 2040. Under this schedule, prorated OMER&R costs for AQM would begin in 2009, but OMER&R costs for restoration features would not begin until 2025, the first year after those features are complete.

The incremental NED costs of each alternative, over and above those of the No-Project Alternative, also are shown in **Table 8.1**. NED costs are only provided for embankment design concepts that have been determined to meet Reclamation's design criteria and guidelines as described in Chapter 3. NED costs in **Table 8.1** for the Concentric Lakes Alternative (Alternative No. 3A) represent costs for three concentric lakes as required under mean possible future inflow conditions.

The present worth project implementation costs are less than the project implementation costs displayed in **Table 7.1** to represent the fact that project costs would be expended over time, and, due to interest accumulation, the amount needed in 2006 would be less than if all costs were expended in that year. The present worth OMER&R costs in **Table 8.1** are more than the OMER&R costs in **Table 7.1** because **Table 7.**1 displays costs for only one year, and **Table 8.1** displays the present worth of the total amount for the 72-year period of analysis.

NED Benefits

The potential environmental improvements at the Salton Sea, as compared to the No-Project Alternative, represent the basis for NED benefits for each alternative. Although there are risks and uncertainties, each of the alternatives might prevent further environmental degradation in varying degrees. These risks and uncertainties involve future inflows, biology, and environmental viability issues as presented in Chapters 4, 5, and 6 of this report.

Table 8.1 NED costs of alternatives, present worth basis, expressed in 2006 millions of dollars using 5.125% discount rate

Alternative	Project implementation costs	OMER&R costs	Total	Incremental to No-Project Alternative
Alternative No. 1A: Mid-Sea Dam with North Marine Lake using Sand Dam Design with Stone Columns	5,500	1,900	7,400	5,400
Alternative No. 2A: Mid-Sea Barrier with South Marine Lake using Sand Dam Design with Stone Columns	2,000	1,100	3,100	1,100
Alternative No. 3A: Concentric Lakes using Sand Dam Design with Stone Columns [1]	8,600	1,000	9,600	7,600
Alternative No. 4: North-Sea Dam with Marine Lake using Sand Dam Design with Stone Columns	6,600	1,400	8,000	6,000
Alternative No. 5: Habitat Enhancement without Marine Lake	2,000	1,300	3,300	1,300
Alternative No. 6: No-Project	600	1,400	2,000	0

[1] Values shown are for three concentric lakes as required under mean possible future inflow conditions.

Economists typically distinguish between use values and nonuse values in addressing benefits to be gained from enhancement of environmental resources. Use values refer to the values derived by individuals who physically “use” the resource; in the case of Salton Sea, these are the recreation visitors who come to the Sea. Nonuse values relate to the values ascribed by other individuals who may never visit or otherwise “use” the resource. Some people may derive satisfaction, or value, from potential habitat improvements at the Salton Sea, both for their own sake and for future human generations. However, as explained later in this chapter, it was not possible to compute dollar estimates of nonuse value for the Salton Sea alternatives considered in this study.

Recreation Benefits

Although recreation visitation at the Salton Sea has diminished from historical highs, current visitation is still significant, estimated at approximately 340,000 visits annually. The most popular activities include bird-watching, fishing, boating, camping, picnicking, and hunting. The largest single recreation attraction is the Salton Sea State Recreation Area, followed by the Sonny Bono Salton Sea NWR, and the Wister Unit of the Imperial Wildlife Area. Recreation also occurs at a number of unmanaged public and private access points around the Sea. Based on a number of studies across the West, the average value for primary recreation activities was estimated be about $63 per visit, or $21.4 million total annually.

Under the No-Project Alternative and all restoration alternatives, the present worth of recreation is expected to significantly decline, as compared to the current level. Under the No-Project Alternative, there would be large reductions in surface elevation and area of the Sea. It is estimated that even under the restoration alternatives, environmental degradation would occur at the Sea for the next 18 years in the same pattern as under the No-Project Alternative, until facilities and programs are in place and the process of restoration begins. Therefore, under such a future, because benefits are measured against the No-Project Alternative, there would be no recreation benefits realized in that time period.

Most recreation benefits for the restoration alternatives would be realized in the years after the Sea begins to recover, when they are worth much less than current value in present worth terms. Some small benefits would be realized early on as the early start habitat areas are constructed. Given the significant risk and uncertainty associated with alternatives and the distant time frame involved, recreation benefits were not estimated individually for each of the alternatives. However, under an assumed recovery period with restoration, the present worth of NED recreation benefits would be about $106 million. These benefits are far less than the present worth of incremental NED costs for any of the restoration alternatives, which range from $1.1 to $7.6 billion, as presented in **Table 8.1**.

Nonuse Environmental Benefits

Reclamation acknowledges that the Salton Sea has non-use environmental benefits. The Salton Sea ecosystem supports some of the highest avian biological diversity in North America as well as the world. The more than 400 bird species that have been reported within the Salton Sea ecosystem comprise approximately 70 percent of all the bird species recorded in California. In addition, several species listed under the Federal Endangered Species Act use habitat resources associated with the Salton Sea. This combination of avian biodiversity and importance as breeding habitat is unsurpassed by any limited geographic area within the contiguous 48 states and Latin America. As such, the benefits of Salton Sea environmental enhancements may be higher to some individuals across the Nation who never visit the Sea than to the individuals who do. A common technique used to determine nonuse values is "contingent valuation," a rather complex and lengthy survey process in which individuals are asked to express their willingness to pay for enhancements. It is important in this technique to be specific about the nature of the environmental improvements, and it is desirable to quantify the improvements in physical terms. There are significant risks and uncertainties concerning the quantity of future inflows, quality of habitat, and associated water quality conditions to be achieved under each of the alternatives. Due to a lack of funding and adequate time, a site-specific contingent valuation survey was not conducted. If a survey had been conducted that presented to the participants the high uncertainty of success associated with any of the alternatives, it is likely that respondents would have returned relatively low willingness to pay values. A survey would have to clearly identify these uncertainties. The fact that restoration alternatives have continued to evolve through the study would have further complicated a survey process.

Reclamation acknowledges the $1-5 billion annual non-use economic benefit estimated by K2 Economics in its report prepared for the Salton Sea Authority (K2 Economics, 2007). However, the K2 study does not take into consideration risks and uncertainties associated with alternatives to restore the Salton Sea. The study also fails to differentiate between alternatives.

Without a dollar measure of nonuse benefits, it is not possible to complete the benefit-cost analysis of alternatives contemplated by the P&Gs. However, with such high NED costs and the potential that survey responses could result in low willingness to pay values, it is not clear that that any of the restoration alternatives would have NED benefits that exceed NED costs.

As a means to analyze the worth of alternatives in a relative sense, a cost effectiveness technique was employed that considered risk and uncertainty. Cost effectiveness cannot be used to identify whether the NED benefits of any or all of the alternatives exceed the NED costs, but it can be used to assess the relative cost between alternatives of creating habitat acres whereby it is assumed that habitat acres are proportionate to the economic benefits.

Cost Effectiveness and Risk

For the cost effectiveness analysis for the Salton Sea, the incremental NED cost of a restoration alternative was divided by the number of habitat acres (combined open water and shoreline habitat) developed by the alternatives by the year 2040, resulting in a derived “dollars per acre” value. Habitat acres serve as a “proxy” for environmental improvement benefits; in other words, it is assumed that habitat acres are proportionate to the economic benefits, had the latter been quantified. With substantial risks associated with each alterative this approach must be tempered with consideration of risk, and the potential variability in these risks, in an attempt to minimize costs per acre while at the same time minimizing risks. Without consideration of risk, alternatives with lower costs per acre could be viewed more favorably than other alternatives with higher costs per acre. Risk factors considered are as follows:

- Se risks to fish-eating birds
- Se risks to invertebrate-eating birds
- Hydrodynamic / stratification risks
- Eutrophication risks

- Fishery sustainability risks
- Future inflow risks

The risks for each of these factors are qualitatively identified in Chapters 4 and 6.

Figure 8.1 displays the results of the cost effectiveness and risk evaluation for the Salton Sea. Both NED costs and habitat acres are incremental to the No-Project Alternative. (There are no productive habitat acres in 2040 under the No-Project Alternative.) Composite risks are not quantified numerically, but are displayed in **Figure 8.1** as low, moderate, serious, or high. The relative composite risks shown are an average of all the risks listed above and represent an index of risk to be used for comparison purposes. Some viability risks shown in **Table 6.3** are shown as ranges. The variability in composite risks shown in **Figure 8.1** are in a lighter color of red. The mid-Sea barrier alternative (No. 2A) minimizes the costs per acre of habitat created without consideration of risk and would appear to be the most cost effective. However, the risks associated with this alternative are higher than for all other alternatives, except Alternative No. 1. Of the alternatives that offer less risk than Alternative No. 2A, Habitat Enhancement without Marine

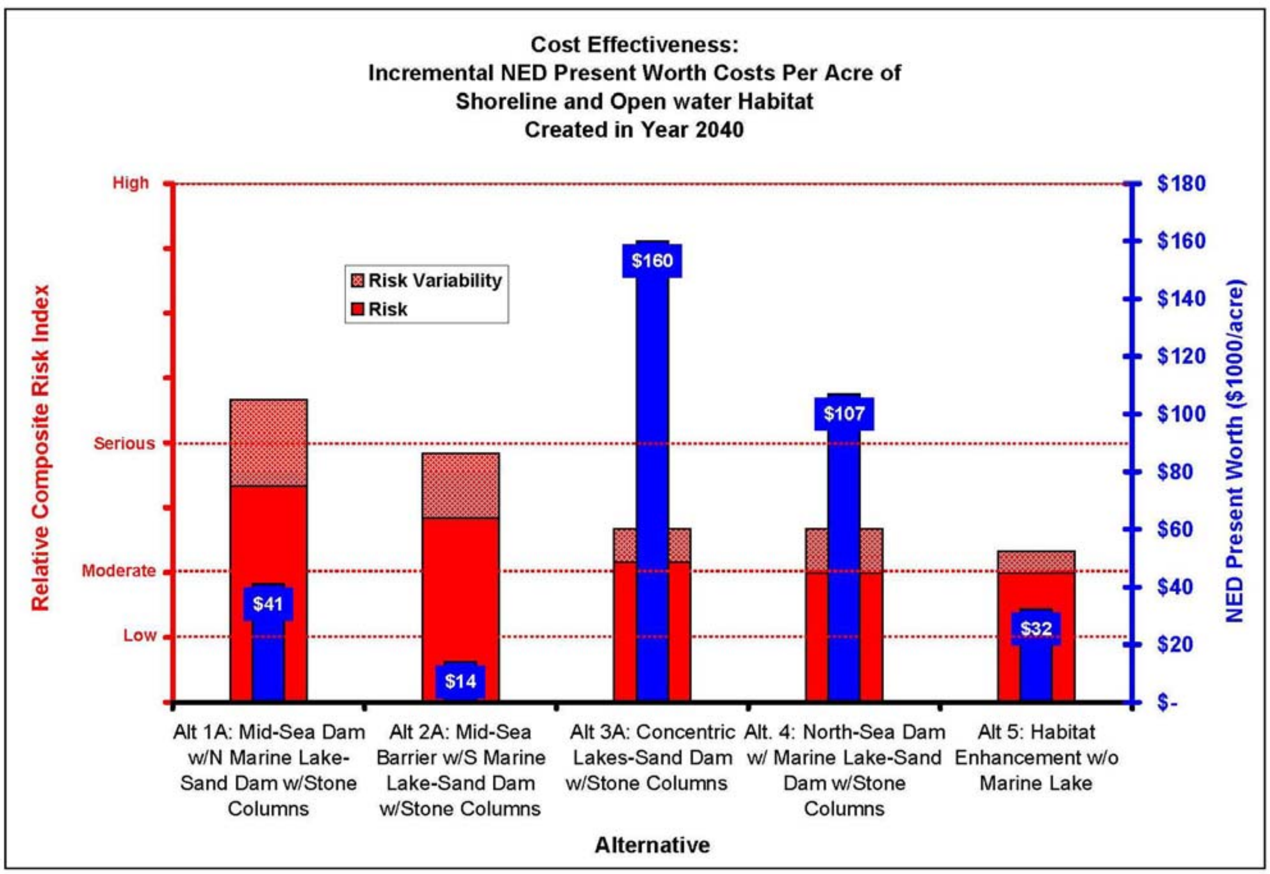

Figure 8.1 Cost effectiveness (NED present worth costs per acre of shoreline and open water habitat created in year 2040).

Lake (Alternative No. 5), has the next lowest cost and is the alternative that has the least risk. In consideration of both costs and risks, Alternative No. 5 minimizes both risk and costs as a means for providing shoreline and open water habitat. The composite risks index for this alternative is **moderate,** which would indicate that "on average" problems would potentially be significant and may require mitigation. When looking at specific risks listed in **Table 6.3,** it is clear that Se risks to breeding birds and fishery sustainability problems would be serious under this alternative, which implies that these problems would create significant threats that may be tolerable with significant mitigation measures in place.

Regional Economic Development (RED)

The preceding discussion dealt with the NED account. At the regional level, any of the restoration alternatives would cause positive economic output, as compared to the No-Project Alternative. There are three potential sources of these regional effects: recreation visitor expenditures, induced economic growth, and project construction and operation expenditures. Of these, construction expenditures is considered to be the most significant and is the only impact evaluated in dollar terms.

It was assumed that because the No-Project and the restoration alternatives would result in the same pattern of environmental degradation for the next 18 years until restoration facilities and programs are operational, there will be no differences in recreation expenditures or in residential and commercial activity around the Sea in that time frame. As previously noted, recreation visitation will increase after year 25 as the Sea recovers, as compared to No-Project. To the extent that the increased visitation comes from individuals outside the region, and they spend money for food, lodging, gasoline, and other travel-related items, then RED effects (income and employment) would occur.

Similarly, to the extent that the Sea starts becoming a more aesthetically pleasing location to reside and work after year 18, and any increased residential and commercial development near the Sea would not have occurred elsewhere in the region, there would be a positive impact on the regional economy. Growth has recently been occurring around the Sea, but it is likely due to the availability of affordable housing for service workers in the relatively more expensive greater Palm Springs area.

Property values could diminish from current levels until restoration begins, and increase after that. Because there is no incremental impact on property values for nearly two decades, with the restoration alternatives compared to the No-Project, these values were not estimated.

The main near-term RED effect between the restoration alternatives and the No Project Alternative would be the considerable construction expenditures that occur as soon as one of the alternatives is implemented.

The modeling package used in this study to assess the regional economic effects of construction of each alternative is IMPLAN (IMpact Analysis for PLANning). IMPLAN is an economic input-output modeling system that estimates the effects of economic changes in an economic region.

IMPLAN data files were compiled for the study area from a variety of sources, including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor, and the U.S. Census Bureau. This analysis uses 2003 IMPLAN data for California's Imperial and Riverside Counties. The total of these two counties comprises the study area for the RED analysis.

The expenditures associated with each of the alternatives were placed into categories that represent different sectors of production in the economy. The expenditures that are made inside the study region were considered in the regional impact analysis. Expenditures made outside the two-county area were considered "leakages" and would have no impact on the local economy.

Because of the enormous scale of the restoration alternatives, it was assumed that local suppliers and contractors would be able to supply only a small portion (1 percent) of the necessary materials, equipment, and expertise. Construction of the restoration alternatives would involve major construction companies that do not have a presence within the study area. Therefore, the RED study assumed that the workforce associated with these major construction companies would temporarily move to the region and spend their wages inside the area during the construction period. In contrast to the restoration features, 50 percent of the water efficient vegetation AQM expenditures (for AQM projects) take place in the region because of the large number of irrigation related suppliers and service companies within the region. The analysis also assumed that 30 percent of the other AQM expenditures would take place within the region.

This analysis also assumed that the vast majority of the construction expenditures would be funded from sources outside the two-county study area. Money from outside the region that is spent on goods and services within the region would contribute to regional economic impacts, while money that originates from within the study region is much less likely to generate regional economic impacts. Spending from sources within the region represents a redistribution of income and output rather than an increase in economic activity.

For the purpose of this study, the total implementation costs less non-contract costs were used to measure the overall regional impacts. These overall impacts would be spread over the construction period and would vary year-by-year proportionate to actual expenditures.

RED Results

Regional economic impacts, incremental to the No-Project Alternative, for each restoration alternative that includes embankment design concepts that have been determined to be acceptable relative to Reclamation's design criteria and guidelines are shown in **Table 8.2**. Impacts shown in **Table 8.2** for the Concentric Lakes Alternative (Alternative No. 3) are representative of developing three concentric lakes as required under mean possible future inflow conditions.

Table 8.2 Regional economic impacts from construction of each alternative, incremental to No-Project Alternative, compared to the economy of Imperial and Riverside Counties

	Employment [1] (number of jobs)		Output [2] (millions $)		Income [3] (millions $)	
Alternative	Total	Percent of the total regional economy	Total	Percent of the total regional economy	Total	Percent of the total regional economy
Regional Economy	771,690		75,488		16,306	
Alternative No. 1A: Mid-Sea Dam with North Marine Lake using Sand Dam Design with Stone Columns	22,767	3%	2,302	3%	760	5%
Alternative No. 2A: Mid-Sea Barrier with South Marine Lake using Sand Dam Design with Stone Columns	4,819	1%	485	1%	151	1%
Alternative No. 3A: Concentric Lakes using Sand Dam Design with Stone Columns [4]	35,493	5%	3,590	5%	1,171	7%
Alternative No. 4: North-Sea Dam with Marine Lake using Sand Dam Design with Stone Columns	27,250	4%	2,756	4%	903	6%
Alternative No. 5: Habitat Enhancement without Marine Lake	5,258	1%	528	1%	165	1%

[1] Employment is measured in the number of jobs.

[2] Output represents the value of industry production.

[3] Income is the value of total payroll (including benefits) for each industry in the region plus income received by self-employed individuals located within the region.

[4] Values shown are for three concentric lakes as required under mean possible future inflow conditions.

The employment, output, and income generated from each alternative's expenditures are compared to the overall regional economy. The majority of the employment, output, and income impacts are due to the expenditures of the wages earned by the workforce involved in the construction project. Employment is measured in the number of jobs. Output represents the dollar value of industry production. Income is the dollar value of total payroll (including benefits) for each industry in the region plus income received by self-employed individuals located within the region.

Chapter 9. Restoration Study Findings and Recommendations

This chapter describes a recommendation for a potential action at the Salton Sea that attempts to provide an efficient and reasonable method for restoration of the Salton Sea Sea ecosystem and permanent protection of wildlife dependent on that ecosystem. These recommendations take into consideration the best available (but still limited) information as well as estimated risks, costs, and predicted outcomes. Substantial risk and uncertainties are associated with all the restoration alternatives proposed in this study. These risks are directly associated with a lack of data and/or uncertainty involving the description, implementation, and subsequent performance of each of the proposed alternatives. Risk must be considered in economic analyses to determine the most favorable method of replacing lost habitat (primary objective) at the Salton Sea. Following is a discussion of risks, uncertainties in the costs of the alternatives, cost effectiveness, and considerations for the future.

Risks to Alternatives

A comparison of alternative viability risks and costs for creating habitat for each of the restoration alternatives is presented in **Figure 8.1**. This chart contains information for alternatives with embankment design concepts that have been determined to be meet Reclamation's design criteria and guidelines as described in Chapter 3. The relative risk comparison was developed by averaging risks associated with inflows and environmental factors that are discussed in Chapters 4 and 6. Viability risks are presented in detail in **Table 6.3**. The following risks were considered in the development of the comparison chart:

- Se risks to fish-eating birds
- Se risks to invertebrate-eating birds
- Hydrodynamic / stratification risks
- Eutrophication risks
- Fishery sustainability risks
- Future inflow risks

Alternative No. 1: Mid-Sea Dam with North Marine Lake

Alternative No. 1 offers the highest risk of the action alternatives. This alternative is proposed by the SSA. The water surface in the marine lake would need to be allowed to fluctuate with inflow. Limited fluctuations were considered in evaluating this alternative. The alternative was evaluated assuming an operating water surface elevation in the lake of -238 feet, which is 8 feet lower than the elevation originally proposed by the SSA. Operating at a constant elevation of -230 feet would require a guaranteed minimum water supply. All alternatives were modeled using the risk-based approach to inflows as described in Chapter 4. Model results for Alternative No. 1 indicate that in 2040 that mean future salinity would be 58,000 mg/L (**Figure 4.4**), which is very close to the 60,000 mg/L salinity threshold for a sustainable fishery. After construction is completed in 2024, salinity in the marine lake would not fall below 60,000 mg/L until year 2038. A fishery would not be potentially viable until after this time. The early start features described in the discussion of SHCs in Chapter 3 would be necessary to maintain a viable fishery prior to 2038. With an operating water surface elevation of -238 feet, the salinity threshold of 60,000 mg/L would be exceeded in year 2040 in more than half of the possible future inflow conditions unless the lake elevation was dropped further below -238 feet. If future inflow conditions are significantly above mean possible estimates then the operating elevation of the marine lake could be higher and potentially at a level consistent with the SSA’s target of -230 feet.

The alternative could pose serious to high risks associated with thermal stratification and associated H_2S and NH_3 problems. The alternative could also pose serious Se risks to invertebrate eating breeding birds, with potentially moderate risk of eutrophication problems (**Table 6.3**).

Alternative No. 2: Mid-Sea Barrier with South Marine Lake

Alternative No. 2 offers the second highest risk of the action alternatives. The serious to high composite risk shown in **Figure 8.1** for this alternative is the result of potentially high risks to the fishery from DO problems, temperature extremes, and salinity variations. The alternative could also pose serious Se risks to invertebrate eating breeding birds, with potentially serious risk of eutrophication problems (**Table 6.3**).

Alternative No. 3: Concentric Lakes

Alternative No. 3 offers the higher risk than Alternative No. 5. The moderate to high composite risk shown in **Figure 8.1** for this alternative is the result of potentially serious risks to the fishery from DO problems and temperature extremes. The alternative could also pose serious Se risks to invertebrate eating breeding birds, with potentially moderate risk of eutrophication problems (**Table 6.3**).

Alternative No. 4: North-Sea Dam with Marine Lake

Alternative No. 4 offers similar risk to Alternative No. 3. This alternative provides for a marine lake on the north end of the Sea that would receive only Whitewater River inflows. Large habitat enhancements would be provided on the south end of the Sea through construction of SHC. Maintaining a fishery in the marine lake could pose potentially serious risks from DO problems and temperature extremes. This alternative could also include serious Se risks to invertebrate eating breeding birds, with moderate to serious risk of eutrophication problems (**Table 6.3**).

Alternative No. 5: Habitat Enhancement without Marine Lake

Alternative No. 5 offers the lowest risk of the action alternatives. This alternative provides for habitat enhancement without a marine lake. The habitat enhancements would be provided through construction of SHC on a very large scale that could exceed historic shoreline habitat values. This alternative could pose serious Se risks to invertebrate eating breeding birds, with a potentially moderate risk of eutrophication problems (**Table 6.3**).

Discussion of Cost of Alternatives

Table 7.1 displays appraisal level estimates of construction and initial implementation costs for each alternative. **Table 7.2** presents recurring operational costs of all alternatives, including the No-Project Alternative. The costs of all alternatives are based on very limited geologic and geotechnical data that were obtained through exploration in years 2003 and 2004. Significant design uncertainties exist as a result of the limited amount of site information. These design uncertainties, in turn, create uncertainties regarding embankment constructability, seismic performance, static performance, and construction costs. These uncertainties can only be reduced by conducting additional significant geologic and geotechnical design data collection programs.

Specific schedules that take into account the construction duration of each alternative feature have not been developed. Without consideration of construction durations, cost escalation during construction cannot be properly evaluated. The appraisal level cost estimates provided in **Figure 7.1** do not include costs for escalation during construction. Escalation during construction is expected to be a very significant dollar amount given the size and cost magnitude of the various restoration alternatives presented here.

Cost Effectiveness and Risk

As a means to analyze the worth of alternatives in a relative sense, a cost effectiveness technique was employed that considered risk and uncertainty. Cost effectiveness cannot be used to identify whether the NED benefits of any or all of the alternatives exceed the NED costs, but it can be used to assess the relative cost between alternatives of creating habitat acres whereby it is assumed that habitat acres are proportionate to the economic benefits.

The cost effectiveness analysis and risk evaluation was performed, and the results are presented in Chapter 8. This evaluation shows that Alternative No. 2 (Mid-Sea Barrier with South Marine Lake) minimizes the costs per acre of habitat created without consideration of risk. However, the risks associated with this alternative are higher than for all other alternatives, except Alternative No. 1. Of the alternatives that offer less risk than Alternative No. 2A, Habitat Enhancement without Marine Lake (Alternative No. 5), has the next lowest cost and is the alternative that has the least risk. Alternatives No. 3A and 4 also offer lower risk than Alternative 2A but with costs per acre of habitat that are 5 and 3 times costs per acre for Alternative 5, respectively.

In consideration of both costs and risks, Alternative No. 5 (Habitat Enhancement without Marine Lake) minimizes both risk and cost as a means for providing replacement shoreline and open water habitat at the Salton Sea. Alternative No. 5 would still provide for significant problems. The composite risks index for this alternative is moderate, indicating that "on average" problems would potentially be significant and could require mitigation. Selenium risks to breeding birds and fishery sustainability problems could be serious under this alternative. This implies that these problems could create significant threats that may be tolerable with significant mitigation measures in place. With additional study, mitigation measures could be developed that may offset these potential threats. The size of the SHC studied in Alternative No. 5 was based on maximizing use of gentle slopes around the Sea and not upon a complete understanding of habitat values associated with SHC.

Recommendations for the Future

All five action alternatives considered in this report entail extreme costs; and there are substantial uncertainties and risks associated with engineering, physical, and biological elements of the alternatives. While lack of data and the time and funding required to analyze these data did not allow a full feasibility level study, a more detailed evaluation would not resolve the hydrologic and biologic uncertainties. Therefore, Reclamation does not have a basis for recommending implementation of any of the action alternatives evaluated in this report. At an appraisal level of evaluation, all of the action alternatives considered in this report have been estimated to cost between $3.5 and $14 billion (**Table 7.1**). Annual costs associated with the alternatives are also very high. Estimated annual operations, maintenance, energy, and replacement costs for all the alternatives range from $119 million to $235 million (**Table 7.2**); and again, there are many risks and uncertainties associated with these estimates. However, given the degree of negative air quality impacts and related mitigation cost ($1.4 billion)[1]

[2] An estimated dollar amount of $1.4 billion would be required to mitigate air quality impacts associated with the No-Project Alterative due to reduced inflows and resulting exposed lakebed sediments becoming emissive. Over time, approximately 92,000 acres of exposed sediments could be exposed and potentially become emissive under the No-Project Alternative. Mitigation

associated with the No-Project Alternative, consideration could be given to a focused adaptive management study of shallow saline habitat complexes (habitat complexes as describe in Alternative 5). Current data indicate that these types of habitat complexes could minimize both risk and costs, while providing historic wildlife habitat replacement and partial mitigation of air quality impacts associated with reduced future inflows at the Salton Sea. Although there are presently many remaining unknowns, risks and uncertainties concerning these habitat complexes,[1] the development and study of approximately 2,000 acres of such habitat, over a 7- to 10-year period, could determine if these complexes are a feasible approach to replacing historic wildlife use values at the Sea.

While Reclamation does not support the recommendation of any preferred action alternative at this time, a focused and progressive adaptive management study initiative of saline habitat complexes could be undertaken to determine if such complexes are a feasible approach to replacing historic wildlife use values at the Sea. This concept could involve developing, studying, and monitoring relative small parcels of habitat in a phased approach (250 to 500 acres per phase) of shallow saline habitat complexes (SHC) in an adaptive and flexible, yet progressive, manner. This concept could be described as a Progressive Habitat Development Alternative (PHDA).[2]

A PHDA could involve a successional and phased approach to developing habitat. Each phase could include construction of between 200 and 500 acres of saline habitat complex, in which engineering designs and wildlife management criteria and strategies could be derived from a previous phase. During each phase, continuous detailed evaluations could be obtained concerning water quality, habitat values and use, biologic issues, and engineering performance. Information from these evaluations could be used to refine the designs and adaptive strategies for the next phase of complexes. Development of adaptive and flexible strategies would reduce risks and uncertainties associated with operating larger complexes. Actual habitat values would be determined through continuous observations and study.

The design of management strategies for the first phase could be based on what is being learned at the existing 100-acre shallow habitat pilot project currently being studied cooperatively by the United States Geological Survey and Reclamation. The goals of this study are to begin assessing the benefits of shallow water

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of these potentially emissive sediments is estimated to cost about $14,000 per acre and would ultimately be the responsibility of the existing landowner to mitigate.

[3] Of particular concern is the lack of species-specific values that these habitat types may provide and the uncertainty as to whether other Pacific Flyway problems might affect values derived from habitat areas developed at the Salton Sea. Estimates of bird densities that might be achievable, based on what is known today, may not be possible in the future.

[4] A PHDA feasibility study is estimated to involve approximately 2,000 acres, to be developed in phases over approximately 7 to 10 years, and to cost approximately $150 million (implementation) and $50 million in annual operation and maintenance.

wetlands to breeding birds, and also to study potential risks due to contamination from agricultural drain water (USGS, 2007). Focus is being given to evaluating post-hatchling survival and movement of birds nesting on the 100-acre site. Preliminary and non-peer-reviewed information from the 100-acre project indicates instances of wetland usage by large numbers of birds of multiple species.

It is recommended that PHDA could be considered for implementation by committing to an initial 2,000 acres during the first 7 to 10 years assuming phased construction of 300 acres per year. PHDA habitat areas could continue to be added beyond those constructed in the first 7 to 10 years up to what is determined to be historic values at the Sea. The maximum buildout of habitat acreage (beyond the initial 2,000 acres) would be dependent on what actual habitat values were derived from observation and study of previous phases and upon the success of developing adaptive and flexible strategies for managing and/or mitigating observed problems, risks, and uncertainties.. All risks could not, however, be alleviated by the PHDA approach. There could be no guarantee that habitat values would be sustainable. Pacific Flyway impacts from actions and events occurring outside of the Salton Sea area could have a significant impact on bird densities and habitat values derived from SHC areas at the Salton Sea. **Figure 9.1** is a diagram displaying an example of a successional construction strategy of SHC, with each phase using lessons learned from previous phases of development.

PHDA could also allow for studying adaptations of embankment and water conveyance designs and construction methods with the purpose of determining the most cost effect methods for constructing SHC areas. Each phase of design and construction would rely on lessons learned from previous phases.

The PHDA concept would need to be refined based on information being collected at the existing 100-acre complex in order to determine an accurate cost estimate for a successional project of 2,000 acres and beyond. However, the appraisal level cost of implementing projects of different sizes can be estimated on the basis of appraisal level estimates that have been compiled for SHC incorporated in alternatives evaluated for this study. **Table 9.1** lists appraisal level PHDA implementation and annual operation, maintenance, energy, and replacement costs assuming an initial project of 2,000 acres and for projects beyond 2,000 acres in increments of 10,000 acres.

The appraisal level costs presented in **Table 9.1** do not consider cost escalation during construction and the time leading up to construction. Escalations during construction are expected to be a very significant dollar amounts. During the lengthy period over which SHC areas could be constructed, there could be significant escalations in labor, materials, and fuel costs.

In **Table 9.1** costs have been divided between PHDA feature implementation costs and AQM costs. The AQM costs shown coincide with those listed for the No-Project Alternative in **Table 7.2**. It is assumed the State of California will manage AQM in coordination with landowners and other stakeholders as may be applicable by Federal and State laws, regulations, ordinances, and legal agreements. Estimated PHDA implementation costs (in 2006 dollars) for the 2,000 acres are $150 million. Estimated PHDA annual operation, maintenance, energy and replacement costs would be $0.6 million per year once the 2,000 acres were completed. Estimated PHDA implementation costs (in 2006 dollars) for 60,000 acres are $3.4 billion. Estimated PHDA annual operation, maintenance, energy and replacement costs are estimated at $3.5 million per year once the 60,000 acres are completed.

Table 9.1 Summary of Progressive Habitat Development Alternative and AQM project implementation and OME&R costs ($million)

Alternative	PHDA implement-ation costs	AQM project implement-ation costs	Total project implement-ation costs	Annual PHDA OME&R costs	Annual Air quality mitigation OME&R costs	Total OMER costs
Progressive Habitat Development up to 2,000 acres	150	1,400	1,550	0.6	163.6	164.2
Progressive Habitat Development up to 10,000 acres	570	1,400	1,970	1.0	159.7	160.7
Progressive Habitat Development up to 20,000 acres	1,100	1,400	2,500	1.7	154.9	156.6
Progressive Habitat Development up to 30,000 acres	1,700	1,300	3,000	2.3	150.0	152.3
Progressive Habitat Development up to 40,000 acres	2,200	1,300	3,500	3.0	145.2	148.2
Progressive Habitat Development up to 50,000 acres	2,800	1,200	4,000	3.6	140.3	143.9
Progressive Habitat Development up to 60,000 acres	3,400	1,200	4,600	3.5	135.5	139.0

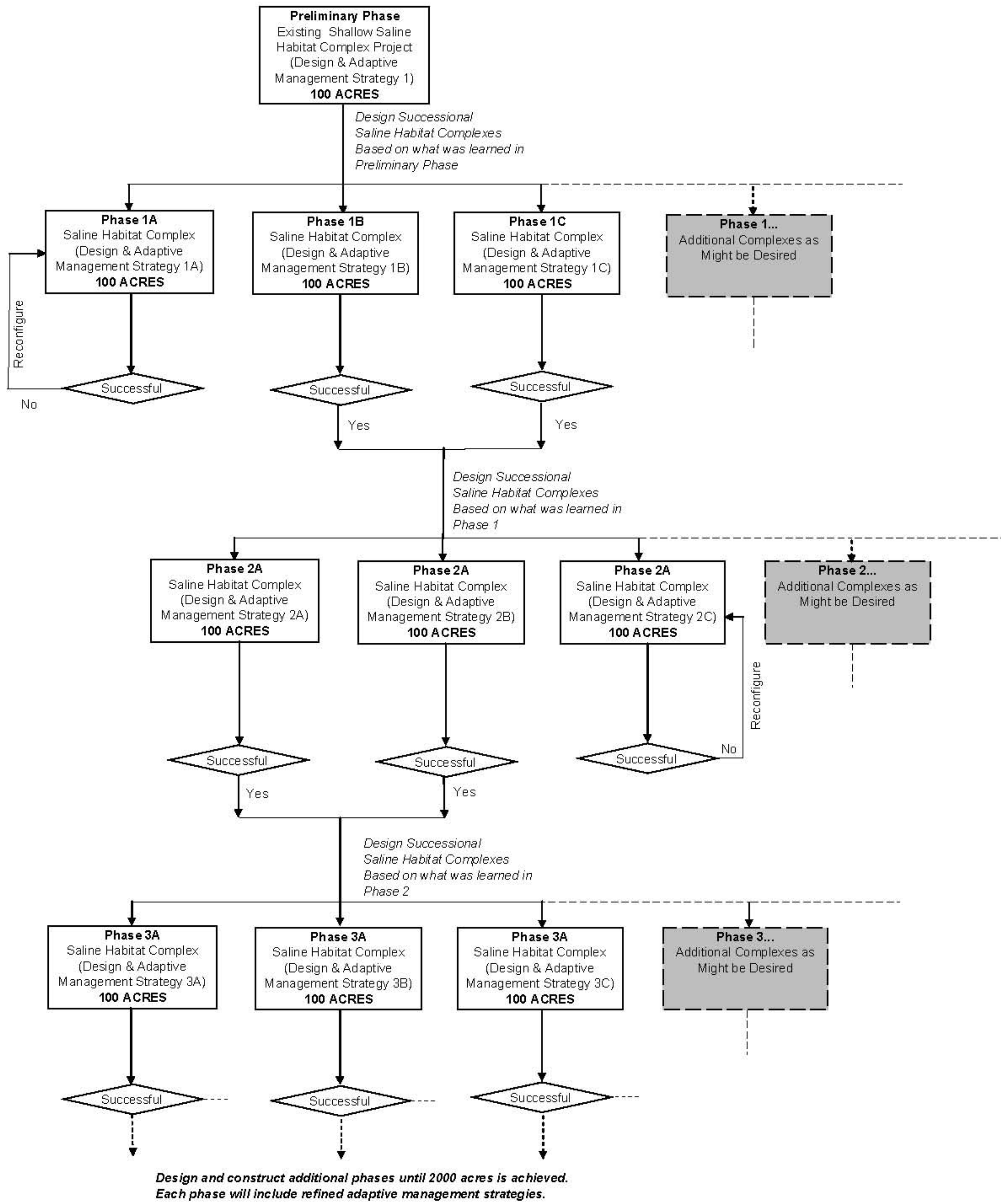

Figure 9.1 Progressive Habitat Development Alternative Conceptual Diagram.

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Attachment A – Cost of Alternatives Using Embankment Designs that do not Meet Reclamation Design Criteria and Guidelines

Table A-1 Alternatives and Associated Component Subtotal Construction Costs and Implementation Costs for Alternatives with Embankment Designs that Do Not Meet Reclamation Design Criteria and Guidelines

Alternative Components	Alterative No. 1B: Mid-Sea Dam with North Marine Lake – Original Salton Sea Authority alignment using SSA rockfill design	Alternative No. 2B: Mid-Sea Barrier with South Marine Lake using sand dam design without stone columns	Alternative No. 3B: Concentric Lakes using sand dam design without stone columns [2]	Alternative No. 3C: Concentric Lakes using Geotube® embankment design (as proposed by the Imperial Group) [2]
1. Mid-Sea Dam	$1,042,379,866			
2. West and East Perimeter Dikes	$687,199,238			
3. South-Sea Dam	$883,674,869			
4. Mid-Sea Barrier		$414,728,079		
5. Three Concentric Lake Dikes			$5,208,686,051	$1,711,029,675
6. Concentric Lakes - Habitat Islands and Deep Areas			$181,119,163	$181,119,163
7. Concentric Lakes - Lake Cell Divider Structures			$37,593,185	$8,987,800
8. Earthen Dikes for Habitat Ponds	$161,676,000	$292,364,100		
9. Habitat Ponds - Habitat Islands and Deep Areas		$334,514,933		
10. Water Conveyance Features	$314,915,017	$201,680,735	$617,309,280	$202,783,291
11. Water Treatment Facilities	$218,000,000			
12. Air Quality Mitigation - via Water Vegetation Features		$540,960,000	$477,750,000	$477,750,000
13. Air Quality Mitigation - via Other Features	$6,578,000	$108,192,000	$95,550,000	$95,550,000
Subtotal Construction Costs[1]	**$3,314,422,990**	**$1,892,439,847**	**$6,618,007,679**	**$2,677,219,928**
Unlisted Items: 10%	$285,577,010	$207,560,153	$681,992,321	$222,780,072
Total Contract Costs	$3,600,000,000	$2,100,000,000	$7,300,000,000	$2,900,000,000
Contingencies: 25%	$1,000,000,000	$500,000,000	$1,800,000,000	$800,000,000
Total Field Costs	$4,600,000,000	$2,600,000,000	$9,100,000,000	$3,700,000,000
Non-Contract Costs: 20%	$900,000,000	$500,000,000	$1,900,000,000	$700,000,000
Total Project Implementation Costs	**$5,500,000,000**	**$3,100,000,000**	**$11,000,000,000**	**$4,400,000,000**

[1] Includes mobilization costs.
[2] Total project implementation costs assuming four concentric lakes for Alternative No. 3B is $14,000,000,000 and Alternative No. 3C is $5,400,000,000

Table A-2 Summary of Annual Reoccurring Costs of Restoration Alternatives($ million) for Alternatives with Embankment Designs that Do Not Meet Reclamation Design Criteria and Guidelines

Alternative	Annual Operations, Maintenance, and Energy (OM&E) Costs	Annual Replacement Costs	Annual Operations, Maintenance, Energy, and Replacement (OME&R) Costs	Annual Risk Costs	Annual Operations, Maintenance, Energy, Replacement, and Risk (OMER&R) Costs
Alterative No. 1B: Mid-Sea Dam with North Marine lake – Original Salton Sea Authority alignment using SSA rockfill design	53	0.3	53	Not Estimated	Not Estimated
Alternative No. 2B: Mid-Sea Barrier with South Marine Lake using sand dam design without stone columns	71	62	133	6	139
Alternative No. 3B: Concentric Lakes using sand dam design without stone columns [1]	64	55	119	30	149
Alternative No. 3C: Concentric Lakes using Geotube® embankment design (as proposed by the Imperial Group) [1]	66	55	121	13	134

[1] Costs shown are for three concentric lakes as required under mean possible future inflow conditions.

Attachment B – Response to Comments

Carol A Roberts/CFWO/R1/FWS/DOI
02/28/2007 12:02 PM

To broper@lc.usbr.gov
cc Christian Schoneman/SALSE/R1/FWS/DOI@FWS
bcc
Subject Draft Salton Sea Restoration Summary Report

Attn: Mike Walker, Salton Sea Study Program Manager

Staff of the Carlsbad Fish and Wildlife Office has reviewed the above-mentioned document, and we would like to offer the following comments for your consideration. Overall, the document was thorough and concise, and we congratulate the Bureau of Reclamation for developing a set of feasible and reasonably-scaled alternatives.

1 All of the alternatives appear to place exposed playa and/or brine pool on National Wildlife Refuge lands. We would like to work with you and the other partners in Salton Sea restoration to ensure that the Refuge is able to support its mission on its lands. Exposed playa and brine pond (particularly in the long-term) would not appear to provide the functions and values needed to support that mission.

2 One point of clarification involves the Western snowy plover (*Charadrius alexandrinus nivosus*). The population occurring at the Salton Sea is not part of the listed entity.

3 Regarding the desert pupfish (*Cyprinodon macularius*), the Service considers all drains that flow directly into the Salton Sea as potential habitat for the desert pupfish. This includes such drains between the Alamo and New Rivers. We have required the Imperial Irrigation District to provide for connectivity among direct-to-Sea drains in five subareas of the Salton Sea: northeast of the Alamo Delta, between the Alamo and New River deltas, southwest of the New River delta, west of the Whitewater River (Coachella Valley Storm Channel) delta, and east of the Whitewater River delta. All of these areas need to be addressed in any alternative considered for restoration of the Salton Sea.

4 We fully support the concept of providing additional mitigation habitat to offset the impacts of selenium. This will require additional water, however; the source of which has yet to be identified.

The Service looks forward to continuing to work with you on restoration planning for the Salton Sea. Please feel free to contact me at the contact information below if you have any questions or would like to discuss this information further.

Carol A Roberts
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Carlsbad Fish and Wildlife Office
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Post-it® Fax Note 7671

To Bonnie Rober		Date 3/2/02	# of pages ▶ 1
Co./Dept. USBR		From Carol Roberts	
Phone # 702-293-8129		Co. USFWS	
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		Fax # 760-431-5902	

Response to Comments

US Fish and Wildlife Service
Draft Summary Report Comments
Dated February 28, 2007

Response to Comment 1:

- Reclamation recognizes that any site specific evaluation and/or alternative implementation would require consultation with the US Fish and Wildlife Service to ensure consistency with other missions and land uses.

Response to Comment 2:

- The report was changed to reflect that the Western snowy plover population occurring at the Salton Sea is not part of the listed entity.

Response to Comment 3:

- The report has been changed to reflect that the future implementation of any of the alternatives would require consideration of these mitigation requirements of the IID/San Diego transfer project.

Response to Comment 4:

- Reclamation acknowledges that a source of water would have to be found for providing mitigation habitat to offset the impacts of selenium.

COMMENTS ON DRAFT SUMMARY REPORT ON RESTORATION OF THE SALTON SEA

Submitted by:

Imperial Irrigation District

March 5, 2007

1. Introduction.

Imperial Irrigation District ("IID") appreciates the opportunity to comment on the Draft Summary Report on Restoration of the Salton Sea dated January 31, 2007 ("Report"), issued by the Bureau of Reclamation ("Reclamation").

Our comments focus on the inter-relationship between the Report and the PEIR for the Salton Sea Restoration Project ("SSRP/PEIR") recently issued by the California Department of Water Resources ("DWR") and the findings included in the Report which may affect the selection of a preferred restoration alternative.

2. Coordination with SSRP PEIR Process.

1 The Report assesses a range of restoration alternatives and features similar to those described in the SSRP PEIR. However, the Report adds a number of significant concerns to the SSRP PEIR evaluation, in terms of environmental and implementation risks, increased estimated costs, and overall project viability. IID is concerned about the differences in information and approach between the Report and the SSRP PEIR, and recommends development of a coordinated process for resolving those differences. Reclamation has issued only a draft, summary report, and the underlying technical studies and information should be provided to DWR and others involved in the alternative selection process.

2 Both Reclamation and DWR intend to select a preferred restoration alternative over the next few months, and it appears clear, given the complexity and costs of alternative options, that an effective Restoration plan will require the support of both the state and federal governments. We urge Reclamation and DWR to coordinate their preferred alternative selection processes, as well as further environmental and technical analyses, in order to facilitate development of the most feasible and appropriate Restoration plan. This process should involve IID, agencies with jurisdiction over the project, and interested members of the public:

3. IID's Objectives.

3 IID has not endorsed a particular restoration alternative evaluated in either the SSRP or the Report. In evaluating the two studies, IID seeks to ensure that the restoration plan will be compatible with IID's specific policies and objectives, including the requirements that the restoration plan:

3

- Must preserve and protect IID's water rights and uses of water, and should not be used to facilitate or promote more water transfers out of the Imperial Valley.

- Must not restrict the use of the Salton Sea as a repository for IID's agricultural drainwater.

- Must not restrict IID's right to recapture and reuse agricultural drainwater or require any guarantee by IID of drainwater inflows to the Sea in the future.

- Must accommodate fluctuations in Sea elevation and salinity.

- Must recognize IID's limited responsibility and liability for environmental impacts and restoration costs pursuant to State legislation and IID's contracts with State agencies.

- Must allow for the conservation of water by efficiency improvements to enable farmers to farm the same amount of land with less water, and allow IID to switch, before 2018, from fallowing to efficiency conservation measures to implement the IID Water Conservation and Transfer Project ("Transfer Project").

- Must not impede IID's compliance with existing contractual obligations and permit requirements, especially those related to the "Transfer Project" and the Quantification Settlement Agreement (QSA").

4. Preferred Alternative.

4 The Report concludes that all of the alternatives raise environmental concerns and that environmental conditions at the Salton Sea are likely to deteriorate regardless of which alternative is selected [page 6-9]. The Report finds that implementation of any of the alternative would be "speculative" given the substantial uncertainties and risks described in the Report and that none of the alternatives should be implemented [page 9-4].

5 Instead, the Report recommends that an additional alternative be considered that could adapt to changing conditions and new information as the restoration proceeds. This new alternative, referred to as the "Progressive Habitat Development Alternative" (PHDA), incorporates a go-slow, more-study, incremental approach to development of shoreline habitat. It would focus on developing, studying and monitoring relatively small parcels (250-500 acres per phase) of SHC in an adaptive, sequential manner. The Report suggests committing to an initial 2,000 acres during the first 7 to 10 years, assuming phased construction of 300 acres per year [page 9-5]. The construction costs for the PHDA are estimated to be $1.55 million and annual OME&R costs are estimated to be $164.5 million.

6 The PHDA approach is only briefly described in the Report; it is not assessed as a separate alternative. Thus, it is not clear what further assessment may be required to implement this approach or whether Reclamation intends to recommend or implement it. Given the Report's rejection of all assessed alternatives, we request Reclamation to confirm its commitment to Salton Sea restoration, its willingness to pursue evaluation of the PHDA alternative, and its

6 intention to seek federal funding for restoration. We also request Reclamation to clarify how the environmental assessment of the preferred alternative will be conducted and related to the SSRP PEIR process. We also request clarification regarding the effectiveness o the PHDA in reducing the potential air quality emissions from exposed shorelines.

5. Early Start Component.

7 All alternatives were assumed to include "early start" SHC development features, designed to offset negative habitat impacts during the construction period [page 3-3]. The Report indicates that early start features will be constructed during the construction period (expected to commence in 2018 and be completed by 2024); thus, this component does not appear to mitigate near-term effects caused by salinity increases and elevation changes. The Report appears to assume that environmental degradation will continue until construction starts and that this degradation will involve the complete loss of the fishery and collapse of the invertebrate food base by 2019 [page 3-3].

8 As stressed in IID's comments on the SSRP PEIR, IID believes that interim solutions should be developed to mitigate impacts in the near-term. IID recommends accelerating the necessary design study, environmental assessment and permit process so that it can be implemented as soon as possible, and whether or not a long-term restoration plan has been fully approved and permitted.

9 The Report raises concerns about the implementation of early start SHC without further study of associated risks, especially selenium bioaccumulation [page 5-13]. This conclusion discourages near-term implementation of early start SHC. This conclusion appears to be more negative than the assessment in the SSRP PEIR. The SSRP PEIR assumed that the existing Sea processes transferring selenium to sediments would continue, it evaluated the environmental risk to fish and wildlife from selenium as relatively low, and it concluded that the benefits of restoration outweigh any selenium exposure [SSRP PEIR, pages 6-26, 8-16 and Table 8-7].

10 We assume that the PHDA alternative could provide a means of assessing and developing mitigation for these risks. The Report suggests that an expanded version of the USGS experimental saline pool near the Alamo River Delta should be considered for future implementation [page 5-14]. It is not clear, however. how this suggestion relates to the recommendation to assess the PHDA alternative or whether it could be incorporated into an accelerated early start SHC component. In any event, IID urges Reclamation to work with DWR and the wildlife agencies to reach a consistent conclusion regarding selenium risk, the appropriate level of study to clarify these risks, and the steps necessary to implement accelerated commencement of the SHC component.

6. Inflows.

The Report is careful to point out that the Salton Sea "has no assured water supply in the future" [page 3-7]. IID agrees that this is an important factor in evaluating the risks and effectiveness of restoration alternatives.

7. Habitat Benefits.

11 IID is interested in Reclamation's approach to assessing the amount of habitat needed to support restoration objectives. The Report describes that the amount of habitat needed is determined based upon the need to provide food resources for birds. Reclamation infers that 6,000 to 38,000 acres of shoreline habitat would be needed to replace the existing shoreline habitat, based upon the potential to serve as a food resource [page 5-3]. The SSRP PEIR does not define or justify the basis for calculating the appropriate amount and type habitat, although it evaluates relative quantities among alternatives. Please clarify whether Reclamation has consulted with USFWS and/or CDFG regarding this approach to habitat quality and whether they agree that it is an acceptable method for sizing restoration habitat goals.

8. Selenium Bioaccumulation.

12 The Report's description of the selenium bioaccumulation risk associated with the SHC is discussed above [see Section 5]. According to the Report, selenium bioaccumulation also affects other features included in the restoration alternatives, including the Residual Sea, Marine Lakes, and Sediment Retention Basins [pages 5-7, 5-8]. The Report also identifies a serious concern regarding eutrophication [pages 1-12, 6-1]. Eutrophication is expected to be as bad as, if not worse than, existing conditions under all proposed alternatives unless significant phosphorus removal is achieved [page 6-2]. The Report further concludes that unless adequate mitigation can be provided, water entering SHC and concentric lakes may need to be treated to remove selenium to make those areas safe for wildlife; however, the Report acknowledges that no current proven technologies are available to treat the large volumes of water that will continue to enter the Sea [page 6-6]. More research is needed to determine whether or not available processes are capable of providing the necessary treatment.

When compared to the SSRP PEIR assessment, the Report appears to predict more serious effects on habitat resulting from selenium and eutrophication and to reflect more serious concerns regarding the viability of restoration alternatives alternatives. We urge Reclamation to consult with DWR and the wildlife agencies to resolve the differences in the findings regarding these issues and their impact on the beneficial effects of restoration.

9. Air Quality Issues.

The Report projects the amount of exposed shoreline under each alternative. These estimates of exposed playa are not consistent with those projected in the SSRP PEIR. For example:

13

- The SSRP PEIR projected 97,000 exposed acres for the Salton Sea Authority proposal (SSRP PEIR Alternative 7), compared to Reclamation's estimate of 103,800 for its Alternative 1.
- The SSRP PEIR projected 111,000 exposed acres for the Imperial Group's concentric lakes proposal (SSRP PEIR Alternative 4), compared to Reclamation's estimate of 65,000 for its Alternative 3.

13

- The SSRP PEIR projected 81,000 exposed acres for the No Project Alternative, compared to Reclamation's estimate of 92,200.

We request an explanation of these discrepancies.

14

The Report does not independently assess the need for air quality measures ("AQM") for the exposed playa. Rather, it includes, for each alternative (including No-Project) an AQM component in conformance with the SSRP PEIR [page 3-4]. IID maintains that the preferred restoration alternative must include implementation of all feasible mitigation measures to address air quality impacts resulting from both shoreline emissions and construction emissions. IID request a more thorough analysis of the potential for each alternative to reduce shoreline emissions, including changes in the design, location and configuration of components. Uncertainties regarding the extent of emissions and the effectiveness of mitigation measures should be reduced by accelerating further study of these issues.

15

The Report states in several places that it assumes that "the State of California will manage AQM in coordination with landowners and other stakeholders" [page 3-4]. A qualification is appropriate relating to the No-Project alternative, because, for this scenario, air quality mitigation for the IID Transfer Project would be implemented by IID in coordination with California state regulatory agencies.

10. Construction Schedule.

16

Construction is not estimated to commence until approximately 2018, and construction is assumed to be completed by 2024. This scheduled is even more delayed than the SSRP PEIR schedule, which anticipated commencement of construction in 2014. IID is concerned about the delay in construction and the lack of interim mitigation features. Reclamation's recommendation for incremental implementation of SHC should be accelerated and used to reduce interim impacts.

Response to Comments

Imperial Irrigation District
Draft Summary Report Comments
Dated March 5, 2007

Response to Comment 1:

- Reclamation has undertaken an independent assessment of alternatives that are similar to those addressed by DWR in their Salton Sea Restoration Project PEIR. Reclamation's study is of the potential feasibility of Salton Sea Restoration. DWR's study involves environmental compliance requirements that are not part of Reclamation's effort. As such there are differences in approach and methods applied. Reclamation has coordinated with DWR on a regular basis and information has been exchanged between the two agencies as necessary.

Response to Comment 2:

- Close coordination between Reclamation and DWR has occurred and is continuing to occur relative to the selection of a preferred action for Restoration of the Salton Sea. DWR's study involves environmental compliance requirements that are not part of Reclamation's effort. As such there are differences between Reclamation and DWR in the level of involvement that each has enlisted from other outside agencies.

Response to Comment 3:

- Reclamation recognizes IID's desire that a restoration plan be consistent with listed policies and objectives. Reclamation feels that the analysis of the alternatives presented in the Summary Report are not inconsistent with those stated policies and objectives.

Response to Comment 4:

- The final Summary Report recommends that Progressive Habitat Development Alternative (PHDA) as a preferred course of action relative to Salton Sea Restoration. This alternative minimizes risks and uncertainties relative to replacement of open water and shoreline habitat in the most cost effective manner.

Response to Comment 5:

- The total implementation cost for committing to 2000 acres under the PHDA is $1.55 billion and not $1.55 million.

Response to Comment 6:

- The final Summary Report recommends the Progressive Habitat Development Alternative (PHDA) as a preferred course of action relative to Salton Sea Restoration. This alternative minimizes risks and uncertainties relative to replacement of open water and shoreline habitat in the most cost effective manner.

- Reclamation has not been authorized to conduct an environmental assessment of the preferred PHDA. Reclamation has only been authorized by Public Law 108-361 (“Water Supply Reliability and Environmental Improvement Act”) to conduct the present study.
- The effectiveness of the PHDA in reducing the potential for air quality emissions from exposed playa areas is not yet known. This would have to be studied and monitored as exposed areas are selected for Saline Habitat Complex (SHC) construction. However, it seems to reason that placement of SHC on emissive areas could reduce the likelihood of emissive conditions.

Response to Comment 7:

- The time to begin construction of “Early Start” SHC would be dependent on time to:
    - Complete environmental compliance work
    - To obtain authorization and permits to proceed
    - To perform design data collection and design work
    - To obtain construction funding

- Making an assessment of how long this will take is highly speculative at this point in time. The ability of Early Start features to mitigate near-term effects caused by salinity increases and elevation changes would depend on accomplishing these tasks. Reclamation has not been authorized to conduct further work relative to these listed tasks. Reclamation has only been authorized by Public Law 108-361 (“Water Supply Reliability and Environmental Improvement Act”) to conduct the present study.

Response to Comment 8:

- The final Summary Report recommends the Progressive Habitat Development Alternative (PHDA) as a preferred course of action relative to Salton Sea Restoration. The “Early Start” concept is entirely consistent with PHDA and as such would offer the best opportunity for interim solutions.
- Reclamation as not been authorized to conduct an environmental assessment of the preferred PHDA or any further design or data collection activities. Reclamation has only been authorized by Public Law 108-361 (“Water Supply Reliability and Environmental Improvement Act”) to conduct the present study.

Response to Comment 9:

- The final Summary Report recommends that the Progressive Habitat Development Alternative (PHDA) as a preferred course of action relative to Salton Sea Restoration. The “Early Start” concept is entirely consistent with PHDA and as such the adaptive nature of PHDA would apply. During each phase of construction of “Early Start” habitat areas, it would be necessary to perform evaluations of water quality and biologic issues. Adaptive strategies for dealing with Selenium problems would be developed and applied to the expansion of the SHC areas.

Response to Comment 10:

- Lessons learned from the existing 100 acre USGS experimental SHC would be applied in the design of any "Early Start" features of any PHDA related action.
- Selenium risks would have to be studied and monitored during each phase of the PHDA. Adaptive strategies would be developed and applied to the expansion of the SHC areas.
- Reclamation has only been authorized by Public Law 108-361 ("Water Supply Reliability and Environmental Improvement Act") to conduct the present study. The determination of how Selenium concerns would be specifically studied and monitored under PHDA is beyond the scope of the present study. However, information that will be collected in the future at the 100 acre USGS experimental SHC will provide valuable information to any future effort in pursuit of PHDA.

Response to Comment 11:

- Reclamation's analysis compared the amount of acreage within various habitat types potentially providing food resources for select groups of birds under each alternative. Bird-survey data indicate that birds using the Sea are most abundant near the shoreline. Various measures of depth and/or distance from shore yield acreage estimates (i.e., 6,000 to 38,000 acres) of this important habitat type. The "sizing" of future facilities needed to provide food and other habitat resources is an ongoing process.
- Reclamation has discussed various approaches to habitat assessment with staff of the USFWS, CDFG, and others. "Habitat quality" is generally considered to consist of two components; area and the ability of the area to produce resources as defined by the area's physical attributes. Thus habitat quality management can be addressed via both area and the area's productivity.

Response to Comment 12:

- Selenium is sequestered in the Sea's bottom sediments via physical, chemical, and biological interactions within the current system. Selenium concentrations are higher than the Sea in adjacent wetlands and drains. All predictions indicate that the Sea will become more saline as less water drains into it. The reduced water entering the Sea will carry higher concentrations of selenium as the proportion of subsurface drainwater increases in wastewater. The Sea/Brine Basin and all other landscape features and constructed facilities that use irrigation wastewater will be exposed to increased concentrations of selenium unless selenium issues are addressed.
- No proven and/or efficient technologies are available that can remove all selenium from the volume of water necessary to support the proposed facilities. New approaches will have to be developed and tested until a mechanism is found that can safely provide desired habitat functions.
- The SSRP PEIR predicts an increase in the selenium risk hazard quotient for all but one action alternative when compared to both existing and no action

conditions. Studies indicate that some bird species may be currently experiencing some level of selenium-linked reduced egg viability. Increased selenium concentrations would likely increase the number of birds affected. Reclamation believes that issues surrounding selenium bioaccumulation should be addressed under a progressive habitat development approach before full implementation of restoration facilities.

Response to Comment 13:

- Reclamation studied different Salton Sea Authority alternative dam and perimeter dike alignments than those studied by DWR. DWR's alignment was based on older information provided by the Salton Sea Authority. Reclamation studied a mid-Sea alignment that was further north with longer perimeter dikes as provided by the Salton Sea Authority. This results in more lake playa being exposed on the south end of the Sea.
- Under the risk based approach to inflows applied in Reclamation's study it was concluded that only 3 concentric lakes would be required in the future. The fourth lake would not be necessary because the residual brine pool would be covering the areas identified by the Imperial Group as being needed for the fourth lake. DWR based their calculations on the assumption that 4 concentric lakes would be required with exposed areas being consistent with those estimated by the Imperial Group.
- Reclamation estimated No-Project exposed lake playa areas from a baseline elevation of -228 feet. DWR estimated exposed areas between -235 feet and -248 feet. Areas beyond this elevation interval were not considered by DWR. Their approach was identified as being accordance with the provisions of the Quantification Settlement Agreement (QSA).

Response to Comment 14:

- Reclamation recognizes that any future study of an alternative for Restoration of the Salton Sea would require site specific analyses of AQM methods. The focus of Reclamation's current study has been to study the feasibility of restoration alternatives. Reclamation has been careful not to duplicate the efforts of DWR in their study and development of potential methods for AQM. Reclamation has coordinated with DWR to ensure that the approach taken in the current study is consistent with work performed by DWR.

Response to Comment 15:

- Reclamation has included the suggested qualification in the Final Summary Report.

Response to Comment 16:

- Reclamation has considered a conservative construction schedule in the current study. There exist substantial possibilities that the schedule for construction could be much longer than that assumed in the report. For example, it could take much longer to obtain construction funding for any project.

- Reclamation has only been authorized by Public Law 108-361 ("Water Supply Reliability and Environmental Improvement Act") to conduct the present study. Consideration of construction schedules at a level of detail greater than that presented in the Summary Report is not possible at this point in time.

IMPERIAL COUNTY FARM BUREAU
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March 5, 2007

Imperial County Farm Bureau's (ICFB) suggested response to the:

U.S. Department of the Interior
Bureau of Reclamation – Lower Colorado Region
Draft
RESTORATION OF THE SALTON SEA
Summary Report

Page 1-4
Statement: Increasing salinity and dissolved oxygen (DO) levels pose the greatest threat to the Salton Sea fishery, although temperature fluctuations may become of concern as water levels drop.
Response: Only tilapia and pupfish remain in the Salton Sea. Low temperature levels
1 have always posed the greatest threat to tilapia. The largest fish kills in the Salton Sea history occurred in the mid-80s when winter temperatures dropped the Salton Sea levels below 50° F. Dead and dying Tilapia were windrowed three feet deep along the shore line. Tilapia has been affected by the colder water temperatures this winter and began washing up on the shore January 21, 2006.

Page 1-11 - First Paragraph, last sentence:
Statement: It is not known to what extent the Salton Sea will contribute to dust emissions.
Response: USGS scientist, Pat Chavez, has been studying the effects of wind in the Salton Sea for some years using all available information including CIMIS weather stations. He has been doing remote recording of dust plums around the Salton Sea using various satellite imagery. During significant dust events Chavez orders satellite photos every 15 minutes to watch and record dust plumes along with land based cameras which begin recording when wind velocities exceed 15 mph.

2

Desert Research Institute, a subcontractor of CH2MHill, working for DWR, has completed an in-depth draft report of wind studies in and around the Salton Sea. The document information is: Etyemezian, V., Sweeney, M. January 3, 2006. "Measurement of Windblown Dust Emission Potential and Soil Characteristics at the Salton Sea in Support of the Programmatic Environmental Impact Report"

There is valuable information in these two documents which could be used by the Bureau of Reclamation to assess to what extent the Salton Sea will contribute to dust emissions.

Page 3-1 - Third Paragraph, first sentence:
3 **Statement:** Reclamation coordinated with the State of California DWR and the Salton Sea Authority in developing the alternatives presented in this report.

3 **Response:** If Reclamation coordinated with the Salton Sea Authority in developing the alternatives presented in this report why did they not also coordinate with the Imperial Group regarding information about the Concentric Lakes Plan?

4 **Chapter 3: General comment**
Reclamation has included very current information about the SSA plan and even makes assumptions in some instances, (Page 3-3), yet fails to acknowledge new input regarding the Concentric Lakes Plan. In all fairness all plans must be treated equally.

Page 3-6 – Side bar “Mean Possible Future Inflows”
General comment

5 Reclamation has determined through numerous computer modeling techniques that the mean average inflow into the Salton Sea will be 727,000 acre feet per year. These models have fatal flaws in that they predict future inflows from past history.

Conditions have changed drastically since the signing of the QSA. Farmers are now capped on the amount of water they can use. Water is being transferred out of the Imperial Valley and land is being fallowed to generate the conserved water. In the near future new and innovative conservation measures will be used to conserve water to transfer. As the QSA continues, farmers will be looking for even more ways to conserve water as thirsty people on the coast look at the farmer’s water rights and try to figure out how to get some of it.

In January, 2003 political pressure from urban interests forced the Department of Interior to file a 417 action against IID claiming IID was not using its water beneficially and cut their entitlement by 350,000 acre feet per year. IID quickly brought suit to challenge the Department of Interior’s action. This process was moving to the stage of appellate review by the Secretary when the QSA documents were executed in October of 2003, and the IID litigation and the government’s 417 proceeding were thereafter withdrawn by both parties as a part of the package of QSA settlements however there was nothing in QSA, or legislation which accompanied the QSA, that would prevent the Department of Interior of bringing action against IID again if enough pressure was brought to bear from urban interests.

It is very likely that future inflows may be drastically reduced in coming years due to conservation measures, increased value of water and new technology.

For these reasons the ICFB believes the amount of water calculated by both the State DWR and IID, to flow into the Salton Sea for the next 75 years, is greatly exaggerated.

List METs claim on the rivers

6 Page 3-12 - First paragraph, last sentence and second paragraph, last sentence:
1st Statement: The Geotube® design (Alternative No. 3C) would not reduce seismic or static loading risks.
2nd Statement: Constructing concentric lakes dikes using Geotubes® would likely result in significant seismic, static, and constructability problems.
Response: Both DWR and Reclamation have refused to travel to Holland where they can talk with engineers first hand and review projects which have been using the Geotube® successfully for over 20 years. Before Reclamation can truthfully make the two statements above they would need to travel to Holland.

7 Page 3-17 - Last paragraph, third bullet:
Statement: Implementation of water conservation measures from IID, which could increase Se concentrations in river inflows by as much as 46 percent.
Response: The ICFB wonders at what inflows Se concentrations would increase by 46 percent.

8 Page 4-1 - Second paragraph, second sentence:
Statement: For example, the possibility exists that Mexico could significantly reduce deliveries across the border in both the New and Alamo Rivers.
Response: A treatment facility below Mexicali is already in operation according to Jose Angel of the local Regional Water Quality Control Board in Palm Desert. With the continued operation of this plant Mr. Angel believes the flows of the New River, crossing the border, will be reduced by 25,000 acre feet. Additional plans will reduce the flow of the New River from Mexico considerably more in future years.

The Alamo River begins in the United States at the All American Canal. Any water generated from Mexico is actually seepage from the All American Canal and this amount should remain constant in the future and will not be affected by water conservation methods employed by Imperial Valley farmers unless they individually use this small amount of water to blend with their irrigation water.

9 Page 4-3 - First paragraph, the three Indented points:
Statement:

> *5 percent of All Futures: Inflows will be less than or equal to 570,000 acre feet per year.*
>
> *Mean of All Futures: Inflows will be 727,000 acre-feet per year.*
>
> *95 percent of All Futures: Inflows will be less than or equal to 835,000 acre-feet per year.*

Response: See **General comment** Page 3-6 – Side bar "Mean Possible Future Inflows" …The same comments apply to three indented statements on Page 4-3.

10 Page 4-4 – First paragraph, first and second sentences:
Statement: Information extracted from this study indicates that temperature increases by the end of the century in the Salton Sea area will be between 2 and 4 degrees Celsius (3.6 and 7.2 degrees Fahrenheit). An analysis of historic California Irrigation Management Information System data from the Westmorland station

Response: The ICFB finds it very questionable that the data obtained from the CIMIS stations near Westmorland, at the south end of the Salton Sea, could be used to accurately predict temperature trends out to the end of the century.

Station No. 180, at the southwest end of the Salton Sea, was activated November 8, 2002 and removed to a location 8.75 miles southeast only 8 ½ months later on July 31, 2003. No data was generated for eight months until the new station, (Station No. 181), was activated on April 1, 2004. Station 181 recorded information until July, 2005 when its solar panel was stolen. It was inoperable for six months and was moved again, 1.65 miles northwest, to its present location and began recording data in January, 2006. The ICFB finds it improbable that four years of data in three different locations with no data for 14 months of the total 48 months of operation could produce any viable information for this study, especially when this information is used to predict weather changes to the end of the century.

11 Page 4-6 - Last paragraph, first and second sentence:
Statement: SSAM also makes predictions of exposed lake playa surface areas in the future. For all alternatives, the exposed playa areas are determined from a baseline Sea elevation of -228 feet.
Response: Salt dust producing playas were formed at much higher elevations when the Salton Sea reached its maximum height in the late 80's and early 90's. The ICFB believes the SSAM predictions should be made from these higher elevations.

12 Page 5-2 – Table 5.1:
Comment: The table shows which groups of birds associate with shoreline, open water, islands and snags, and wetlands. Fish-eating divers, gulls, terns, and skimmers, as well as shorebirds are not listed as being associated with wetlands. Current wetlands around the Salton Sea most definitely support all of these birds and they can be found in great numbers in the various wetlands.

13 Page 5-8 - Third paragraph, third and fourth sentence:
Statement: First, the current Sea supports a unique combination of physical, chemical, and biological components that provide both food for birds and deal with Se input by sequestering it in the sediments. Although the eggs of some birds nesting at the Salton Sea exhibit Se levels associated with reduced egg viability in other studies, **no major reproduction impairment issues have been identified in area birds to date.**
Response: The ICFB believes the above highlighted statement is very important. There are many wetlands in and around the Salton Sea, which are fed by farm runoff. Some have been in existence for over 75 years and birds nesting in these areas have shown no reduced egg viability. It would appear that the importance being put on Se problems have no foundation for concern locally.

14 Page 5-10 – Table 5.2:
Comment: In this table the Concentric Lakes Plan has 817 acres of open water listed. The ICFB believes this figure is closer to 6,000 acres with a water depth in excess of six feet.

15 Page 5-12 – Paragraph titled **Potential Benefits**, first sentence:
Statement: No "SHC" are proposed for this alternative.
Response: The ICFB believes this statement is incorrect. The current plan for the Alternative No. 3, (Concentric Lakes), includes over 15,000 acres of SHC.

16 Page 5-12 – Paragraph titled **Uncertainties**, Last sentence:
Statement: Uncertainties surrounding the SHC, residual Sea/brine basin, sediment retention basins, and other constructed wetlands previously discussed, indicate the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious.
Response: The ICFB believes that most of the invertebrate-eating birds which feed in and around the Salton Sea do not nest here. Many studies show that high concentrations of Se are quickly purged from the bird's system when it stops feeding in a high Se area and migrates on to its breeding ground.

17 Page 6-2 - **Eutrophication,** Third paragraph, first sentence:
Statement: Walker (2006) proposed target inflow concentrations of 80 to 200 µg/L to meet an in-lake P concentration of 35 µg/L which is consistent with TMDL goals.
Response: The ICFB has been closely associated with the Salton Sea Nutrient TMDL since its inception. The technical advisory committee is chaired by Al Kalin, an ICFB

17 board member. These goals were never set at any TMDL TAC meeting nor was the Salton Sea Nutrient TMDL ever completed.

18 Page 6-2 - Third paragraph, third sentence:
Statement: The technology exists for reducing P by these amounts, but implementation of BMP's, treatment wetlands, and other watershed measures are unlikely to meet TMDL goals in the absence of other, more advanced, treatment methods.
Response: The ICFB believes this sentence is incorrect. The Imperial Valley Silt/Sedimentation TMDL, in only four years of operation, has reduced the amount of silt in the New River by 50% and in the Alamo River by 38%. With the exception of soluble phosphate applied in the irrigation water, all other phosphate can only travel in the water when attracted to a clay particle. By reducing silt in the drains and rivers there is a reduction of phosphate entering the Salton Sea. Currently this reduction has been estimated between 20 and 30 percent. A future Salton Sea Nutrient TMDL will key on phosphate. Before any more expensive methods of P removal are considered, it would be wise to allow the farmers to implement phosphate BMP's that key on reduction of surface run-off while applying liquid phosphate during an irrigation. This would have a significant affect in reducing the phosphate entering the Salton Sea just as the reduction of silt in the drains and rivers have had. In addition the ICFB believes there will be very little surface run-off from farmer's fields in 25 years. If this is the case very little phosphate will be transported in the drains and rivers entering the Salton Sea and the expensive treatment plants will not be needed.

19 Page 6-4 – **Selenium** - Third paragraph, third sentence:
Statement: IID (2002) projected that Se concentrations in river inflows could increase by up to 46 percent as a result of reductions in tailwater drainage and operational losses
Response: The ICFB questions the validity of this statement and also questions what science documents this statement.

20 Page 6-4 - Third paragraph, last sentence :
Statement: Under those conditions, Se concentrations in the Alamo River are expected to approach the median concentration of 28 µg/L found in sumps and gravity tile outlets throughout the Imperial Valley (Setmire et al., 1993; Setmire and Schroeder, 1998).
Response: The ICFB questions whether the flow was calculated in these studies. Many of the tile outlets sampled by Setmire and Schroeder flowed at a very small volume. Even though the Se readings may be high, the flow from these sites when compared to the total flow of the Alamo River may not cause an increase in Se concentrations to the magnitude reported by Setmire and Shroeder.

21 Page 9-5 – **Air Quality Mitigation** Fourth paragraph, third sentence:
Statement: Estimated implementation cost (in 2006 dollars) for the 2,000 acres are $150 million dollars.
Response: The ICFB believes this cost is unrealistically high and should not cost $75,000 per acre to mitigate 2,000 acres of salt playa. Some farmers have already reclaimed existing areas around the Salton Sea at a fraction of that cost.

Response to Comments

Imperial County Farm Bureau
Draft Summary Report Comments
Dated March 5, 2007

Response to Comment 1:

- It is true that temperature is a major threat to tilapia, but tilapia populations have been able to rebound from low temperature events. Low dissolved oxygen levels have resulted in even larger and more frequent fish kills. Salinity remains the greatest long-term threat to maintaining a fishery in the Salton Sea. The apparent recent loss of corvine, croaker, and sargo populations provide evidence of this threat.

Response to Comment 2:

- Reclamation agrees that there is valuable information from the cited sources. However, it will not be possible to know to what extent dust emissions will be a problem until the shoreline of the Salton Sea recedes and exposes the under lying playa.

Response to Comments 3 & 4:

- Reclamation met with representatives, consultants, and legal council of the Imperial Group two times. These meetings were held on the following days:
    - April 7, 2006 in the afternoon
    - August 15, 2006 in the morning.
- At these meetings the Imperial Group presented their alternative and embankment design concepts were discussed. Reclamation and the Imperial Group came to a common understanding of what alternative Reclamation would be evaluating. There were also extensive discussions related to the embankment design concepts that would be considered in Reclamation's evaluation, one of which included the Imperial Group's proposal for the use of Geotubes®.
- Reclamation staff participated in multiple phone calls with representatives of the Imperial Group. The Imperial Group never provided Reclamation any update on changes to be made to their alternative. Reclamation offered an additional coordination meeting subsequent to release of the Draft Summary Report.

Response to Comment 5:

- Each alternative was modeled using a risk-based approach to inflows. Under this approach, the full ranges of uncertainty in each of the major inflow sources were considered. The full ranges of uncertainty were considered without assigning specific probabilities of occurrence or specific actions that might contribute to the uncertainty.
- Under the risk-based approach, it is recognized that alternative concepts are subject to risk due to potential water conservation that could occur in response

to non-specific reasons. For example, the Salton Sea could be subject to responses due to the following:

Economic conditions

Competing water demands

Water market conditions

- This approach to predicting uncertainty in inflows to the Salton Sea is less dependent on past history and more dependent on the full range of possible future inflows from each major source of inflow.

<u>Response to Comment 6:</u>

- Reclamation was able to evaluate the Geotube® embankment design concept without travel to Holland.

<u>Response to Comment 7:</u>

- The projected 46 percent increase in selenium concentrations in river inflows was taken from the Final Environmental Impact Report/Environmental Impact Statement prepared by the Imperial Irrigation District (IID) in support of the Water Conservation and Transfer Project

<u>Response to Comment 8:</u>

- In the risk based approach applied by Reclamation, the lowest possible inflow to the Salton Sea that was considered from Mexico is zero.

<u>Response to Comment 9:</u>

- See "Response to Comment 5" as listed above.

<u>Response to Comment 10:</u>

- Data obtained from the CIMIS station near Westmoreland was not used to predict temperature trends out to the end of the century.
- The Summary Report identifies temperature trend estimations as follows:

  > "There is general scientific consensus that climate changes will occur in the future as a result of increasing concentrations of greenhouse gasses in the Earth's atmosphere (Intergovernmental Panel on Climate Change [IPCC], 2001). The highest and lowest IPCC emission scenarios and associated impacts to California were evaluated by Hayhoe et al. (2004). Information extracted from this study indicates that temperature increases by the end of century in the Salton Sea area will be between 2 and 4 degrees Celsius (3.6 and 7.2 degrees Fahrenheit)."

- The citations for the listed publications are as follows:

IPCC, 2001. Climate Change 2001: Synthesis Report, Summary for Policymakers.

Hayhoe K, D. Cayan, C.B. Field, P.C. Frumhoff, E.P Maurer, N.L. Miller, S.C. Moser, S.H. Schneider, K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L.S. Kalkstein, J. Lenihan, C.K. Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville, 2004. Emissions Pathways, Climate Change, and Impacts on California.

<u>Response to Comment 11:</u>

- Reclamation has applied a baseline elevation of -228 feet for the calculation of exposed lake playa areas because this elevation most accurately reflects current conditions.

<u>Response to Comment 12:</u>

- Your point is noted and Table 5.1 has been modified.

<u>Response to Comment 13:</u>

- The statement: "…no major reproductive impairment issues have been identified in area birds to date", is true. However, it should be noted that the last comprehensive study (Setmire et al. 1993) was completed at the end of the 1980s. Subsequent studies (e.g., Bennett 1998) have been somewhat limited in scope. All studies however, have found selenium in some sampled eggs at concentrations linked to reduced viability. Although reduced egg viability is not as dramatic an effect as is teratogenesis, the results—fewer young—are the same. Because selenium-induced reproductive impairment is dose responsive, future increases in selenium within a system in which some birds have already exhibited egg concentrations linked to reduced viability, is cause for concern.

<u>Response to Comment 14:</u>

- Information transmitted to Reclamation during the meetings listed above in "Response to Comments 3 & 4", was that the plan called for 26 deep holes, ¼ mile in diameter, and 20 feet deep. This results in only 817 acres of water associated with the deep holes. Open water habitat is defined in this study as habitat having depth of water greater than 6 feet. All other areas behind the concentric lakes are classified as shoreline habitat which is based on water less than 6 feet in depth.

<u>Response to Comment 15:</u>

- Information transmitted to Reclamation during the meetings listed above in "Response to Comments 3 & 4", was that the plan called for no SHC as described in Chapter 3. However it was recognized that the concentric lakes would likely function as "linear complexes" with similar habitat areas to those created in SHC.

<u>Response to Comment 16:</u>

- Birds do purge selenium from their systems once the exposure is terminated (Heinz et al., 1990[1]). However, information is limited on chronic effects of long-

[1] Heinz, G.H., G.W. Pendleton, A.J. Krynitsky, and L.G. Gold. 1990. Selenium accumulation and elimination in mallards. Arch. Environ. Contam. Toxicl. 19:374-379.

term exposure to elevated but sublethal selenium concentrations for non-breeding birds such as the large numbers of migrants that currently use the Salton Sea. Information on the potential collective effects of selenium and other contaminants is also limited. The primary concern for increased selenium bioaccumulation is focused on year-around resident and breeding birds. This concern has been addressed in other responses. However, Reclamation and other Federal agencies have legal responsibilities for all migratory and special status species regardless of where they may breed.

Response to Comment 17:

- The ICFB is correct. The nutrient TMDL was proposed but is waiting for a final alternative before final action is taken. We will change the wording in the final report to indicate that this was a proposed TMDL.

Response to Comment 18:

- Reclamation agrees that expensive treatment plants are not a good solution to the problem, but also questions the effectiveness of proposed BMPs. We are aware of no lake restoration projects where implementation of BMPs and watershed measures were able to successfully reverse eutrophication in the absence of additional treatment methods. Although the Imperial Valley Silt/Sedimentation TMDL may have theoretically reduced the amount of silt in the New River by 50% and in the Alamo River by 38%, Reclamation's monitoring has not shown significant reductions in either phosphorus or suspended solids loadings to the Salton Sea. In fact, phosphorus and suspended solids concentrations from Reclamation's monitoring of the New and Alamo Rivers from 2004-2006 (n=11) are not statistically different from those measured in 1999 (n=18). Alamo River orthophosphate and total suspended solids concentrations were slightly lower in 2004-2006 than in 1999, but Alamo River total phosphorus concentrations and New River orthophosphate, total phosphorus, and total suspended solids concentrations were all higher in 2004-2006 than in 1999. All differences were within one standard deviation of mean values and the differences are not viewed as significant. This supports our argument that implementation of BMPs alone will not have a measurable impact on eutrophication.

Response to Comment 19:

- The IID projection was based on analyses of data available at the time that their Final Environmental Impact Report/Environmental Impact Statement in support of the Water Conservation and Transfer Project was prepared. The analysis used both the Imperial Irrigation Decision Support System (IIDSS) to model both water quality and quantity and the Bureau of Reclamation Accounting Model to model water quantity. The 46% increase in selenium concentrations was derived from model results based on the assumption that the water transfer would remove 300 KAFY of water from the basin. Model results predicted that this transfer would reduce collective drain discharges to the New and Alamo Rivers by 32.4 and 31.3%, respectively; surface flows in the Alamo River by 30%; surface flows in the New River by 22%; and direct surface drain discharges to the Salton Sea by

35%. An increase in selenium concentration entering the Salton Sea from a current value of 6 to a projected value of 9 µg/L resulted from the modeled reductions in inflow. While the initial selenium concentration is slightly higher than the levels of 3-6 µg/L that Reclamation typically sees in our monitoring of the New and Alamo River outlets to the Salton Sea, neither the initial or predicted values reported by IID (2002) appear to be completely out of line.

- Although the exact magnitude of these reductions can be, and has been, debated, there is no argument that flows to the Salton Sea will be reduced. As a result of those reductions in inflow, there will be less dilution water available and selenium concentrations in water entering the Salton Sea will increase.

<u>Response to Comment 20:</u>

- ICFB is correct in their assumption that flows were not calculated during the Setmire et al., 1993 and Setmire and Schroeder, 1998, studies. The projection that selenium concentrations in the Alamo River would approach 28 µg/L was made by Setmire in a separate supporting document to this Summary Report. Although the final selenium concentration is open to debate and the concentration projected by Setmire (2005) is near the high end of the range of predicted values, there appears to be little doubt that selenium concentrations in surface waters in the Imperial Valley will increase in the future as flows decrease. Selenium concentrations are already at or above the of 5 µg/L that EPA recommends for protection of aquatic life and will almost certainly be well above that level following the planned diversions and water conservation measures. Furthermore, EPA may be reducing this level to 2 µg/L in the near future. As a result, Reclamation believes that it is reasonable to assume that selenium concentrations in future inflows will likely present a health risks to aquatic life.

<u>Response to Comment 21:</u>

- The $150 Million quoted in the comment was misinterpreted as being for the cost of 2000 acres of Air Quality Mitigation. The $150 Million is for 2000 of SHC created under the recommended Progressive Habitat Development Alternative.

March 5, 2007

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via email: broper@lc.usbr.gov

Re: Restoration of the Salton Sea Summary Report

Dear Mr. Walker:

We submit these comments on Reclamation's *Restoration of the Salton Sea Summary Report* on behalf of the Pacific Institute and the Sierra Club. Our groups have been working actively to identify and implement a feasible Salton Sea restoration plan for nearly a decade. We welcome the federal and state efforts to improve the ecological health of the Salton Sea ecosystem, and offer these comments in the hopes that they might benefit Reclamation's planning efforts and the Salton Sea ecosystem.

We commend Reclamation for producing a well-written report. We especially appreciate Reclamation's candid analysis, with statements such as "In general, environmental conditions are likely to deteriorate, regardless of which alternative is selected." (Summary Report, p. 6-9). However, statements such as these, and the report more generally, point to the failure of the study to meet its own stated objective:

1

> "The primary focus of this study is to identify and evaluate a preferred action that ensures the restoration of the Salton Sea ecosystem and permanent protection of wildlife dependent on that ecosystem." (1-2)

This signal failure alone requires that Reclamation redo its analysis and develop an alternative that satisfies the above objective.

With the passage and adoption of P.L. 102-575, P.L. 105-372, and P.L. 108-361, Congress and the President have demonstrated their interest in restoring the Salton Sea. The study's lack of a viable alternative, however, suggests that Reclamation would prefer not to take action at the Salton Sea. The massively-engineered, exorbitantly expensive alternatives designed and reviewed in this study, and the explicit findings within the economic analysis, imply that
2 restoration of the Salton Sea is simply too costly. Rather than thinking creatively and addressing the variety of challenges threatening the long-term existence of fish and wildlife dependent on the Salton Sea ecosystem, Reclamation developed a dated set of structural alternatives that focus narrowly on managing salinity. It appears that rather than designing for success, Reclamation sought to demonstrate infeasibility. As discussed in more detail in the following, Reclamation could and should do better.

Alternatives

3 The report describes four significant problems and challenges at the Sea: salinity, air quality concerns, selenium, and eutrophication (pp. 1-10 to 1-12). Yet, with the exception of the Salton Sea Authority's alternative, none of the alternatives in this study seeks to manage eutrophication or selenium. This is a critical failure, one that has been identified repeatedly in the past. The Pacific Institute's May 15, 2000 comments on the Salton Sea Restoration Project Draft EIS/EIR, submitted to Reclamation and the Authority, specifically note the importance of addressing these broader water quality concerns. Reclamation's July 2005 workshop and subsequent reports clearly identified these problems. The Summary Report describes, in some detail, the threat posed to fish and wildlife – and subsequently to recreation and economic development – by unmanaged eutrophication and selenium. Yet the Report simply notes that such impacts should be mitigated.

4 This is the wrong approach. Managing external and internal nutrient and selenium loadings must be a central component in each of the alternatives themselves; it cannot be deferred to subsequent, undefined mitigation. As noted by the report itself, the study's primary objective cannot be satisfied without addressing these key challenges.

5 The report notes that flows of the Whitewater River are uncertain (4-1), yet the 19,500 acre lake in Alt. 4 apparently assumes that annual Whitewater River flows will increase by 60,000 acre-feet and that all such flows should be captured by the north lake. This risky assumption then leads to the inclusion of a 16-mile long embankment to capture these flows. To reduce the risk of insufficient flows and to decrease the costs of this alternative, the embankment could readily be shortened by about 10 miles, eliminating the 'wings' on either end. Excess flows could be routed to air quality management canals on either end, discharged into saline habitat complexes at the toe of the structure, or spilled into the brine pool.

Embankment Design

6 The report should clearly describe Reclamation's Dam Safety Guidelines and their applicability to the Salton Sea, where there will be no measurable risk to life or property downstream of the proposed facilities.[1] It is wholly appropriate that Reclamation take great care not to waste public funds on a structure likely to fail under static or seismic conditions. It is not appropriate to over-design a structure to such an extent that it will never be built, thereby dooming the project as a whole. Given the exorbitant costs of the sand dam with stone column design – costs which likely make any large structure infeasible – we suggest that Reclamation develop a risk-management approach, rather than the current risk-avoidance approach. That is, Reclamation should design embankments with the expectation that seismic events could cause partial failure that could be repaired, without causing the loss of the structure as a whole. The proposed stone column design is simply an argument for no action.[2] It should be replaced with a design meant to succeed.

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[1] The revised report should include actual estimates of ALL and APF for the alternatives, and not simply refer to such estimates.

[2] The report neglects to include information on the length of the embankments under the various alternatives, the amount of material required, or other pertinent information. According to the specifications in the report, the embankment in Alt. 4 would require roughly 85 million cubic yards of material.

Hydrology

7 We support the risk-based approach to modeling future inflows. Please clarify why Reclamation projects mean future inflows for the period 2018-77 to be 727 kaf/y, while DWR projects inflows for this period to be 717 kaf/y.

Biology

8 Chapter 5 should be re-titled 'Biological Resources'; "issues" has a negative connotation inconsistent with the project objective. Hydrogen sulfide is an issue at the Salton Sea; birds are a resource to be protected.

9 The study assessed the alternatives' impacts on bird use by simply quantifying various habitat types, "as modified by salinity and possible Se risk" (5-4). However, the discussion of potential benefits and uncertainties for the alternatives simply lists the acreages of two habitat types, and then, for each alternative, states that "the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious." This is an extremely weak analysis, even given the study's limited methods. Given the primary objective (see p. 1 of this letter), Reclamation should employ a much more robust, replicable analysis than the opaque, ad hoc approach used by the study. Reclamation should incorporate the results of the Point Reyes Bird Observatory's Salton Sea habitat modeling, as appropriate, and should consult with the USGS Salton Sea Science Office on potential impacts to biological resources.

Selenium

10 The study's assessment of the risk posed by selenium appears to be weak and speculative. What criteria distinguish between the five risk categories identified on p. 5-6? What is the source for the risk levels identified in Table 6.2, and why do these categories differ from those on p. 5-6?

11 The report correctly notes that the risk of selenium toxicity should be a significant consideration in the selection of the preferred action. Unfortunately, the report provides little credible information on the extent of this risk. The study should include a robust ecorisk assessment, one that evaluates selenium concentrations in both food sources and in water.

12 The report states that 'unless adequate mitigation can be provided," (6-6), inflows may need to be treated to remove selenium. Rather than adding mitigation to the project, all of the alternatives should include – as central components – measures to manage or minimize the risk of selenium toxicity. For example, the Salton Sea Science Office has suggested that the provision of low selenium, freshwater ponds would attract breeding and other birds, enabling them to flush accumulated selenium from their systems.

Eutrophication

13 On p. 6-2, the report makes several claims that should be clarified and substantiated. The report states that "implementation of BMPs, treatment wetlands, and other watershed measures are unlikely to meet TMDL goals in the absence of other, more advanced, treatment methods." The basis for this statement is not clear. Mexico has decreased the volume of high-phosphorus flows discharged to the New River. The implementation of BMPs in the Imperial Valley has already

13 significantly reduced phosphorus loadings. As the valley shifts from fallowing to efficiency-based conservation, phosphorus-rich tailwater volumes will decrease markedly, further decreasing phosphorus loadings. Such current and future actions should be incorporated into the study's projections.

14 The report implies that a decrease in (external) phosphorus loadings of 60% would improve the future Sea's trophic status, though as noted elsewhere in the report, the volume of the receiving water body will greatly influence the magnitude of the needed reductions. That is, a 60% reduction in external phosphorus loadings might improve the trophic status of the current Sea, but would not be expected to improve conditions when the volume of the Sea drops by 60% or more.

15 Again, the study should use a more robust analysis, integrating existing and future reductions in phosphorus loadings, as well as changes in internal loadings and volumes of the Sea under the various alternatives. The results of this analysis should drive the development of project components to manage or treat such loadings, as appropriate, to meet the water quality needs of key species.

Economic Analysis

16 The economic analysis compares detailed cost estimates against speculative, discounted benefits. The analysis makes several unsubstantiated assumptions[3] that lead to an apparently pre-determined conclusion. The section on *Nonuse Environmental Benefits* notes but one of many techniques to estimate such values, observes that no such survey was performed, and then speculates as to what the results of such a survey would have been had it been performed. This flawed chapter offers little beyond support for the thesis that Reclamation prefers to avoid involvement in any Salton Sea restoration effort.

Progressive Habitat Development Alternative

17 Given its benign description, the 'Progressive Habitat Development Alternative' (PHDA) – based in large part on DWR's proposed 'Early Start Habitat' (ESH) – appears to be Reclamation's preferred action. While we strongly support the prompt implementation of ESH, such habitat must be part of a much larger restoration project. ESH/PHDA is necessary but not sufficient.

18 Reclamation's proposed construction schedule for PHDA would lag six years behind DWR's proposal to implement all 2000 acres of ESH by 2011. The implementation of ESH should be expedited, not delayed; Reclamation's proposed construction schedule is not acceptable.

19 Furthermore, it is wholly unclear how Reclamation can project the cost of such habitat at $75,000/acre. The small-scale pilot wetlands projects on the New River cost about $40,000/acre. Economies of scale suggest that the ESH/PHDA unit cost would be less, rather than nearly double, the cost of these wetlands. Reclamation should revise or clarify its cost estimates.

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[3] Such as, "All recreation benefits would be realized in the years after the Sea begins to recover," (8-4) discounting the expected rise in wildlife viewing and related activities associated with implementation of early start habitat.

20 PHDA will be a necessary part of any preferred action, but will not be sufficient as a stand-alone action.

Conclusion

21 The Summary Report candidly notes that none of the alternatives under consideration would meet the study's own primary objective. That Reclamation has distributed the report despite this admitted failure suggests that a demonstration of infeasibility was a higher priority than developing a feasible restoration plan for the Salton Sea.

22 We strongly encourage Reclamation to redo the study, by developing one or more alternatives that:

- incorporate components to address nutrient and selenium loadings;
- adopt a risk-management (rather than risk-avoidance) approach to embankment design;
- decrease the size of the north lake to reflect realistic Whitewater River inflows and a shorter embankment; and
- incorporate PHDA as part of a broader restoration alternative.

Thank you for your consideration of these comments and suggestions. We look forward to continuing to work with you and Reclamation toward implementing a viable restoration plan that ensures the restoration of the Salton Sea ecosystem and the permanent protection of wildlife dependent on that ecosystem,

Sincerely,

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cc: Dale Hoffman-Floerke, DWR
Mike Morgan, Imperial Group
Rick Daniels, Salton Sea Authority

Response to Comments

Pacific Institute and Sierra Club Letter
Re: Restoration of the Salton Sea Summary Report
Dated: March 5, 2007

Response to Comment 1:

- Reclamation recognizes that the objective described in the Draft Summary Report may have been vague. The objective has been clarified to read as follows: "The primary focus of this study is to identify and evaluate a preferred action that **attempts to provide for** the restoration of the Salton Sea ecosystem and permanent protection of wildlife dependent on that ecosystem while taking into consideration availability of water, water quality, and the need to minimize both risks and costs."

Response to Comment 2:

- The study presents a fair and accurate description of the costs, risks, and uncertainties associated with alternatives to restore the Salton Sea.
- Reclamation agrees that the cost of restoration of the Salton Sea would be very expensive. This is also recognized within the DWR's Salton Sea Ecosystem Restoration Program draft PEIR and more recently by the Salton Sea Authority (Press quote: Brawley City Council Meeting, Imperial Press 3/25/07).
- Reclamation has put much effort into finding engineering solutions to the very complex geotechnical challenges associated with restoration work at the Salton Sea. Reclamation has enlisted assistance of a highly respected geotechnical engineering firm to assist in solving these problems. The joint team contractors and Reclamation experts has developed embankment design concepts that are technically defensible.
- The alternatives studied by Reclamation focus on development of replacement open water and shoreline habitat areas and are not narrowly focused on managing salinity.
- Reclamation has identified Progressive Habitat Development Alternative (PHDA) as a potentially viable alternative.

Response to Comments 3 and 4:

- Reclamation has considered technologies for management of external and internal loadings. Construction of water treatments plants on the Sea's inlets provides the only proven technology for controlling phosphorus and selenium from external sources, and even that is not likely to be a practical solution on the scale required.
- Passive control by settling in habitat cells may provide at least some of the needed removal, but that needs further evaluation to determine if it would be possible and practical on the scale required. Reclamation proposed the PHDA to provide additional information for this and other questions that have yet to be answered, in spite of all of the research that has been done.
- Internal phosphorus loading may reasonably be expected to diminish when/if external loads are reduced, but not until then.

- Dealing with internal selenium loading may require remediation of sediments with high selenium levels. This is not a reasonable consideration given the already high costs and technically challenging issues associated with Salton Sea restoration.

<u>Response to Comment 5:</u>

- Alternative No. 4 was designed to adequately provide both salinity and elevation control under a full range of possible inflows from the Coachella Valley. A risk based approach to inflows was used in the study. Under this risk based approach, the uncertain inflows from the Coachella Valley are expected to be as follows:
    - 5 percent of all futures: Inflows will be less than or equal to 80,000 af/yr
    - 95 percent of all futures: Inflows will be less than or equal to 136,000 af/yr
- The 19,500 acre lake was designed to reduce as much as possible the requirement to achieve acceptable salinity levels without dependence on long detention times in the marine lake. Smaller lakes would require evapoconcentrating salt without making releases from the lake for many years. This would result in the concentration of contaminants.

<u>Response to Comment 6:</u>

- Reclamation manages risk through the use of our Dam Safety Guidelines and by avoiding public risk to the degree necessary to retain public confidence in our agency and the safety of our structures.
- Reclamation's documentation associated risk management and analysis is available to the public at the following web site: http://www.usbr.gov/ssle/dam_safety/risk/references.html
- Reclamation's sand dam with stone columns design is designed for partial failure without compromising the structure as a whole. Incorporation of stone columns to improve seismic resistance is not the major cost item in the embankment designs. The stone columns account for 10%, 9%, and 25% of the Subtotal Construction Costs for Alternatives 1A, 2A, and 3A, respectively.
- Reclamation's sand dam with stone columns design is an intelligent solution to the complex static and seismic loading conditions present at the Salton Sea.

<u>Response to Comment 7:</u>

- Reclamation and DWR independently developed their risk based approaches to inflows. As a result there are minor differences in opinions on the ranges of possible inflows for each of the sources of inflows to the Salton Sea.

<u>Response to Comment 8:</u>

- The "Biology Issues" chapter of the report includes significant information on issues affected biological resources at the Salton Sea. The title of the chapter has been changed to "Biological Resource Issues".

Response to Comment 9:

- Both Reclamation's analysis and the SSRP PIER analysis focus on acres of available habitat types now and in the future. Both approaches recognize bird use numbers as an indicator of habitat quality. Area (acres) is one of the two generally accepted components defining habitat quality. The second component—resource abundance as supported by the physical attributes of the area—was treated qualitatively by Reclamation using modifiers such of salinity, eutrophication, and potential for selenium bioaccumulation. The State's PIER approach treats resource abundance through weighted bird density values for a select group of species using the Sea. Because bird- use numbers are highest at shallow shoreline sites, alternatives that include large areas of facilities mimicking shallow shoreline (i.e., saline habitat complexes) rank high using both approaches.
- Both of the above approaches attempt to deal with the uncertainties of a complex system that will continue to change throughout the life of the proposed project to 2078. Reclamation believes that a bird-density approach to defining habitat quality may be a valuable tool once additional studies identify the capability of constructed facilities to provide safe and abundant food, and nesting and loafing sites; and specific management goals are developed that address and prioritize individual species needs by season within the constraints of limited water availability. Without site specific studies, both methods are prone to subjectivity. A progressive habitat development approach would provide the framework for further exploration of these issues.
- The SSRP PEIR employed a robust analysis of selenium risk and concluded that an increase in the selenium risk hazard quotient was likely for all but one action alternative when compared to both existing and no action conditions. These predictions were for conditions in 2078. Reclamation believes conditions will deteriorate and pose a serious risk of selenium bioaccumulation before safe restoration features can be deployed. Issues surrounding selenium bioaccumulation should be addressed under a progressive habitat development approach before full implementation of restoration facilities.

Response to Comment 10:

- Table 6.2 and the text have been modified to improve clarity.

Response to Comment 11:

- The extent of the risks to system biota posed by increased selenium concentrations are difficult to predict. Studies such as those associated with the 100 acre experimental pond near the New River should provide additional information relevant to selenium bioaccumulation. As mentioned previously, issues surrounding selenium bioaccumulation should be addressed under a progressive habitat development approach before full implementation of restoration facilities.

Response to Comment 12:

- One of the purposes of the PHDA is to determine whether or not alternative, but unproven, methods such as this can be used. The availability of sufficient freshwater is likely to be a major issue with the suggested approach.

Response to Comment 13:

- The basis for this statement: "implementation of BMPs, treatment wetlands, and other watershed measures are unlikely to meet TMDL goals in the absence of other, more advanced, treatment methods" is practical experience from lake projects throughout the world. Reclamation is aware of no lake restoration projects where implementation of BMPs and watershed measures were able to successfully reverse eutrophication in the absence of additional treatment methods.
- Mexico may have decreased the volume of high-phosphorus flows discharged to the New River, but there is no evidence that "implementation of BMPs in the Imperial Valley has already significantly reduced phosphorus loadings." In fact, phosphorus concentrations from Reclamation's monitoring of the New and Alamo Rivers from 2004-2006 (n=11) are not statistically different from those measured in 1999 (n=18), with most values actually increasing (Alamo River: orthophosphate = 0.408 mg/L in 1999, 0.352 mg/L in 2004-2006, total phosphorus = 0.719 mg/L in 1999, 0.739 mg/L in 2004-2006; New River: orthophosphate = 0.697 mg/L in 1999, 0.714 mg/L in 2004-2006, total phosphorus = 1.11 mg/L in 1999, 1.36 mg/L in 2004-2006). This supports our argument that implementation of BMPs will not have a measurable impact on eutrophication.

Response to Comment 14:

- The report actually states that "…proposed TMDL and treatment options would have little impact unless total P loads are drastically reduced by 60 percent or more." This statement was based on an analysis of historical phosphorus loadings which showed little change in phosphorus concentrations between 1968 and 1999, in spite of an increase of about 55% in P loading.

Response to Comment 15:

- Modeling was performed by Dale Robertson for Reclamation to evaluate phosphorus loading under various alternatives. All model results projected eutrophic to hypereutrophic conditions.

Response to Comment 16:

- Reclamation acknowledges that some small recreation benefits would be realized from wildlife viewing and related activities associated with implementation of an early start program. The text of the report has been revised to reflect this.
- Reclamation has not avoided involvement in the Salton Sea and is concluding this present study with the recommendation that PHDA be considered as the basis for future Restoration efforts at the Salton Sea.

Response to Comment 17:

- PHDA habitat areas could continue to be added beyond those constructed in the first 7 to 10 years up to what is determined to be historic values at the Sea. It is not known how many acres would be needed to replace historic values. This information will not be available until comprehensive studies are conducted during the operation, and maintenance of the initial 2000 acres that would be progressively built. Continuous detailed evaluations would be made of water quality, habitat values and use, biologic issues, and engineering performance of each progressive phase. Information from these evaluations would be used to refine the designs and adaptive management strategies for the next phase.

Response to Comment 18:

- Reclamation agrees that implementation of PHDA could be expedited. However, without authorizations and appropriations, construction of the initial 2000 acres of PHDA could not begin.

Response to Comment 19:

- The construction of the small scale New River Wetlands did not include the need to excavate deep holes for fish refugia and did not include the complex infrastructure that would be necessary to pump, convey, and mix Salton Sea brine with river water. If PHDA only involved the construction of simple embankments and minor water conveyance features (similar to the New River Wetlands) then the implementation costs would be substantially less than $40,000 per acre.

Response to Comment 20:

- Reclamation's study has concluded that the construction of Saline Habitat Complex would minimize both risk and cost as a means of replacing shoreline and open water habitat. Without comprehensive studies during the operation, and maintenance of the initial 2000 acres, it will not be possible to determine what habitat values could be derived from the constructed shoreline and open water habitats.

Response to Comment 21:

- Reclamation has not sought to demonstrate infeasibility and is recommending that PHDA be considered as the basis for future Restoration efforts at the Salton Sea.

Response to Comment 22:

- The comments provided above address each of the issues that are cited.

Salton Sea Authority

March 5, 2007

Bureau of Reclamation
Att: Mike Walker
Salton Sea Study Program, YAO-2500
7301 Calle Aqua Salada
Yuma, AZ., 85364

RE: Draft Summary Report Comments

Dear Mike,

Thank you for the opportunity to review the “Draft Summary Report on Restoration of the Salton Sea” which constitutes the Bureau of Reclamation’s analysis of the options available to restore the Salton Sea Ecosystem. As the primary landowner of the underlying land upon which the Sea sits and the abundance of threatened and endangered species the Bureau and it’s affiliated federal agencies within the Department of Interior have a direct and vital interest in the Sea’s Restoration.

1 Attached are the comments from TetraTech, Inc the Authority’s environmental and engineering consultant. They address the fundamental disagreement on the design requirements that exists between the Bureau and the Authority. The Authority disagrees with the Bureau’s designation of whatever in sea barrier is proposed as being “High Hazard”. The purpose of the barrier is to partition off the area where transferred water would have been in order to maintain existing shorelines. Within this dry area is a salt sink where high level overflows and a salt flow outlet exists. There are no people permitted in the area. There are no structures permitted in the area. There are no private properties in the area.

2 To maintain that the barrier would be a high hazard facility unnecessarily and dramatically increases the overall project costs and does not give Congress a fair and accurate assessment of the restoration opportunities. The Salton Sea Authority recently commissioned a report that documents that the restoration of the Salton Sea will provide between $1-5 Billion annually of non-use economic benefit to the nation. That report is also attached.

3 The Authority requests that the Bureau reconsider the “High Hazard” designation and utilize a more appropriate standard. Alternatively the Authority requests that the Bureau grant a waiver to the federal design standards and defer to the state standards.

Respectfully,

Rick Daniels
Executive Director

Cc: Senator Barbara Boxer
Senator Dianne Feinstein
Representative Mary Bono
Representative Bob Filner
SSA Board of Directors

78-401 Highway 111, Suite T ϖ La Quinta, CA 92253 ϖ (760) 564-4888 ϖ Fax (760) 564-5288

URS Memorandum

To: Bill Brownlie – Tetra Tech

cc:

From: Leo Handfelt

Office: San Diego

Date: March 19, 2007

Subject: Comments on Reclamation's Draft Summary Report

This memo provides comments on the Draft Summary Report on Restoration of the Salton Sea that Reclamation issued on January 31. 2007. Specifically, our comments address only the embankment design proposed, and additional comments on the rockfill embankment concept proposed by SSA.

Sand Dam with Stone Columns Embankment

The embankment proposed by Reclamation in the summary report is described on page 3-19 of the report, and a cross section of the embankment is provided in Figure 3.8. The very soft and weak foundation materials would be removed from beneath the entire footprint of the embankment, with deeper removals beneath the central part of the embankment. The embankment would be constructed out of coarse sand and gravel (maximum ¾-inch gravel) with less than 10% fines so it can be effectively densified with stone columns (Type A). Outer shell material (not to be densified) would consist of fine to coarse sand and gravel with variable fines (Type B).

The embankment would have 5 feet of freeboard (to elevation -225 feet MSL), have 5:1 (horizontal:vertical) slopes on the outer shells, and a crest width of 372 feet. A 6-foot thick layer of riprap would protect both the upstream and downstream shells. Wick drains would be used to accelerate strength gain in the weak foundation materials left below the outer shells. Three-foot diameter stone columns would be installed in a triangular 10 foot spacing in the central core of the embankment.

For seepage control, a 5-foot thick soil-cement-bentonite slurry wall will be installed along the axis of the embankment. A 5-foot thick filter sand blanket (of Type A material) would be constructed between the foundation soils and the downstream outer shell to mitigate the potential for piping of the foundation materials into the shell materials. A 5-foot thick coarse blanket drain (of Type B material) would be constructed within the downstream core and shell.

SSA Rockfill Embankment

The embankment design incorporated into the Salton Sea Revitalization Plan (Tetra Tech, 2006) consists of a rockfill embankment. The rockfill would have high enough porosity and strength to resist seismically induced liquefaction. The very soft and weak foundation materials would be removed from beneath the entire footprint of the embankment. The embankment would have 10 feet of freeboard (to elevation -220 feet MSL); we are currently anticipating that the embankment could be constructed with side slopes of 3 or 4:1 or steeper, and a crest width of 30 feet. Riprap would protect both the upstream and downstream slopes.

For seepage control, a soil-cement-bentonite cutoff wall constructed using slurry trench methods will be installed along the axis of the embankment. A geosynthetic filter blanket would be placed between the foundation soils and the rockfill to provide a second line of defense against the potential for piping of the foundation materials into the rockfills. The cutoff wall is the first line of defense against seepage and piping because it is expected to reduce seepage gradients to levels below those expected to cause piping of the foundation soils.

<u>Comments on Reclamation's Summary Report</u>

We have the following comments on Reclamation's Summary Report:

4 1. The 3-foot diameter stone columns at a spacing of 10 feet gives a replacement ratio of 8%. For the expected high seismicity anticipated at the Salton Sea, it is expected that a replacement ratio of 10% to 15% would be required (Barksdale and Bachus, 1983). This would require 3-foot diameter stone columns to be spaced at 7 to 8 feet on center.

5 2. It is presumed that the stone columns will extend for the full depth of the sand dam. How will piping of foundation materials into the stone columns be prevented?

6 3. The effectiveness of stone columns is very sensitive to the fines content of the materials being densified. What is the source of the Type A materials with less than 10% fines?

7 4. The shell and filter materials will not be densified and will have a high potential for liquefaction. Extensive repairs will be required after large earthquakes to repair the embankment's slope protection.

8 5. An extremely wide crest is incorporated into the design, presumably to be able to install all of the stone columns from the ground surface at the crest. The quantity of embankment required could be substantially reduced if the outermost stone columns are installed by deploying the vibrator by reaching over water with a large crane (see Photo 1). This arrangement was successfully used to densify an underwater slope for a port development for a distance of 60 feet away from the shoreline bulkhead (Handfelt and Nevius, 2007). This could reduce the quantity of embankment materials by probably one-third to one-half.

9 6. Reclamation discounts the use of geocomposite (geosynthetic) filters in SSA's rockfill embankment design because it would "result in constructability problems and would result in unreliable filter performance." Geosynthetic filters have been extensively used in marine construction. They were recently deployed from a barge in San Diego Bay (see Photo 2) to separate a rockfill cap over contaminated sediments (O'Connor, 2006). The filters can be sewn on the barge, or placed with sufficient overlap to assure continuity. An especially robust filter material could be specially manufactured for this project (see Photo 3). Alternatively, prefabricated armoring units could be placed over the geosynthetic filters. Other underwater deployments of prefabricated armoring units have been constructed (see Photos 4 and 5).

10 7. Geosynthetic filters are commonly used below rockfill shoreline revetments to prevent wave and tidal erosion of the shoreline materials into the rock revetment; similar to the proposed application at the Salton Sea. The foundation soils are generally nondispersive, and of very low permeability. As a result, the seepage velocities under the moderate differential heads are anticipated to be low, further mitigating the potential for piping. If the geosynthetic filter were to eventually clog, the heads for the embankment are sufficiently low that there should not be detrimental uplift pressures on the embankment.

11 8. Geosynthetics have been used as filters in various locations within embankment dams, both for new construction and rehabilitation purposes (Bertacchi and Cazzuffi, 1985). The main

11 use has been as a replacement or supplement for granular filters. However, many of the uses have been in non-critical locations because of uncertainities about the longevity of the geosynthetics (ICOLD, 1986). However, significant advances have been made in the durability of geosynthetics and consideration should be given to using them in this application.

12 9. The Reclamation report states that a sand dam embankment without stone columns "would not meet Reclamation's general design criteria and PPG [Public Protection Guidelines]," while the report states that SSA's rockfill dam "would not meet Reclamation's general design criteria." Is there a reason that Reclamation did not include mention of the PPG in its evaluation of the SSA's rockfill dam? Did Reclamation complete a risk analysis for the SSA's rockfill dam, and, if so, what was the estimated annual probability of failure? If the risk analysis was completed for the SSA rockfill dam, can Reclamation provide the event tree used and the estimated probabilities for individual events on the tree, as well as the comparable event tree information for the sand dam with stone columns?

References

Barksdale, R.D., and Bachus, R.C. 1983. "Design and Construction of Stone Columns, Volume I," Report No. FHWA/RD/83/026, Federal Highway Administration.

Bertacchi, P. and Cazzuffi, D. 1985. "Geotextile Filters for Embankment Dams," Water Power and Dam Construction, Vol. 37, Issue 12, pp. 11-18.

Handfelt, Leo D. and Nevius, Jennifer L., 2007. "Geotechnical Considerations for National City Marine Terminal Development," American Society of Civil Engineers Ports 2007 Conference, in press.

ICOLD – International Commission on Large Dams, 1986. "Geotextiles as Filters and Transitions in Fill Dams," ICOLD Bulletin 55, 130 p.

O'Connor, Sarah, 2006. "San Diego Bay Gets an Underwater Facelift," in Geosynthetics Magazine, Vol. 24, No. 5, November/December 2006, pp. 16-23.

Tetra Tech, Inc., 2004. "Salton Sea Restoration, Final Preferred Project Report," dated July 2004.

Photo 1: Installation of Stone Columns over Water

Photo 2: Deployment of Filter Fabric from Barge

Photo 3: Three Layer Geosynthetic Filter

Photo 4: Deployment of Prefabricated Armoring in Canal

Photo 5: Barge used to Deploy Prefabricated Scour Protection in Mississippi River

Response to Comments

Salton Sea Authority Letter
RE: Draft Summary Report Comments
Dated March 5, 2007

Response to Comment 1:

- FEMA provides straight forward hazard potential classification definitions that can be applied by federal and state dam safety agencies. These classifications are described in the following document:

  Federal Emergency Management Agency, April 2004, "Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams"

  These guidelines do not prescribe how the classification system is to be used, nor does it prescribe specific design criteria. These responsibilities are held by each agency. Reclamation deals with these responsibilities under its Dam Safety Program.
- Reclamation's Dam Safety Program is authorized under the Reclamation Safety of Dams Act of 1978 (Public Law 95-578). The Act provides for action to be taken when it is determined that a structure presents an unacceptable risk: "In order to preserve the structural safety of Bureau of Reclamation dams and related facilities, the Secretary of the Interior is authorized to perform such modifications as he determines to be reasonably required." To determine the risks associated with its structures, the Bureau of Reclamation (Reclamation) has established procedures to analyze data and assess the condition of its new and existing structures. Reclamation has established a risk-based framework to meet the objectives of its program, the Dam Safety Act, and the Federal Guidelines. Risk-based procedures are used to assess the safety of new and existing Reclamation structures. Addressing risks in a technically consistent and timely fashion is an important part of sustaining the public's trust in Reclamation to construct and manage facilities in the best interest of the nation.

  Reclamation is responsible for about 370 storage dams and dikes that form a significant part of the water resources infrastructure in the western United States. A high level of national safety and stewardship of public assets is expected of Reclamation as an agency specifically entrusted to manage a large inventory of dams. The greater the inventory of dams and the time of exposure, the more difficult it becomes to ensure that the agency will not experience a dam failure. Reclamation has developed guidelines to assist in the management of risk associated with its existing dam inventory and in considering new structures. These guidelines for public protection are published in the following document:

  Bureau of Reclamation, June 2003, "Guidelines for Achieving Public Protection in Dam Safety Decisionmaking"

Reclamation's guidelines focus on two assessment measures of risks related to Reclamation structures: 1) the estimated probability of a dam failure and 2) the potential life loss consequences resulting from the unintentional release in the event of failure. The annual probability of failure guideline addresses agency exposure to dam failure. As a water resource provider, Reclamation must maintain and protect its dams and dikes that store water. The second measure addresses the potential life loss component of societal risk. Protection of human life is of primary importance to public agencies constructing, maintaining, and/or regulating civil works.

Within these guidelines it is specified that to ensure a responsible performance level across the inventory of Reclamation's dams, it is recommended that decisionmakers consider taking action to reduce risk if the estimated annual probability of failure exceeds 1 chance in 10,000.

For dam safety decisionmaking, risk of life loss is measured as the product of the probability of dam failure and the estimated consequences (life loss) associated with that failure. This product is the expected annualized life loss at a given dam for a given loading condition and is referred to as the estimated annualized risk of life loss.

In cases of small populations at risk (such as at the Salton Sea), the guidelines related to annual probability of failure serve as a limit of exposure. With an annual probability of failure equal to 1 chance in 10,000 (0.0001) and a loss of life of one person, the annualized risk of life loss would be 1 times 0.0001, which is equal to 0.0001 lives per year. This is analogous to a probability of life loss of 1 chance in 10,000. Reclamation guidelines specify that the justification to reduce risk of life loss diminishes as estimated annualized life loss risk becomes smaller than 0.001. These same guidelines also specify that the justification to reduce risk increases as the annualized risk of life loss exceeds 0.001.

In cases of small populations at risk (as at the Salton Sea), it is the annual probability of failure that drives the need to reduce risk. A zero loss of life at the upper probability of failure limit of 1 in 10,000 would result in unacceptable risk. The only way to achieve compliance with Reclamation guidelines under such circumstances is to ensure that the annual probability of failure of any embankment at the Salton Sea is below 1 in 10,000. This would be true regardless of whether or not the embankments are classified as significant or high hazard structures.

Response to Comment 2:

- The cost of reducing seismic risks does not dramatically increase overall project costs. The cost of reducing risks to meet Reclamation guidelines accounts for about 10 percent of the subtotal construction costs for Alternative 1. This is the cost of including stone columns within the in-Sea embankments.
- Reclamation acknowledges within the Summary Report that the Salton Sea has non-use environmental benefits. The benefits of Salton Sea environmental enhancements may be higher to some individuals across the Nation who never visit the Sea than to the individuals that do. Determination of these benefits would require application of

a common technique called "contingent valuation." This involves a complex and lengthy survey process in which individuals are asked to express their willingness to pay for enhancements. It is important in this technique to be specific about the nature of the environmental improvements, and it is desirable to quantify the improvements in physical terms. There are significant risks and uncertainties concerning the quantity of future inflows, quality of habitat, and associated water quality conditions to be achieved under each of the alternatives. Due to a lack of funding and adequate time, a site-specific contingent valuation survey was not conducted by Reclamation. If a survey had been conducted that presented to the participants the high uncertainty of success associated with any of the alternatives, it is likely that respondents would have returned relatively low willingness to pay for the enhancements. A survey would have to clearly identify these uncertainties.

- Reclamation acknowledges the $1-5 Billion annual non-use economic benefit estimated by K2 Economics in their report prepared for the Salton Sea Authority and dated January 10, 2007. However, The K2 economics study does not take into consideration risks and uncertainties associated with alternatives to restore the Salton Sea and as such the results are not reliable. The K2 study also fails to differentiate benefits among alternatives. Reclamation agrees with K2 Economics in there suggestion that the study results be used with caution.

Response to Comment 3:

- A zero loss of life at the upper probability of failure limit of 1 in 10,000 would result in unacceptable risk. The only way to achieve compliance with Reclamation guidelines is to ensure that the annual probability of failure of any embankment structures at the Salton Sea is below 1 in 10,000. This would be true regardless of whether or not the embankments are classified as significant or high hazard structures.

Response to Comment 4:

- The estimated 10-foot triangular spacing between stone columns is based on Reclamation's experience on dams, and would need to be optimized during final design and by constructing a test fill embankment in the Sea.
- Closer stone column spacing would increase the cost.

Response to Comment 5:

- Piped foundation material potentially filling stone columns could not escape past the downstream Type A/B interface, so there is no failure mode in this event.
- Design of the stone columns would be optimized during final design and by constructing a test fill embankment in the Sea. The optimization phase could explore the possibility of placing variably located course sand to fine gravel filter layers within the lower portion of each stone column.

Response to Comment 6:

- Reclamation anticipates the API Pit and adjacent alluvial fan deposits as the source of the Type A material used in the embankments, with processing required to remove excess fines to the 10% limit.

Response to Comment 7:

- Reclamation agrees that repair of the Type B shells and riprap slope protection would be required after a large earthquake event. The amount of repair required could be significant, but access for re-construction would be relatively easy.
- Internal filters would be densified by the stone columns and should not need much repair after a large earthquake event.

Response to Comment 8:

- This is a good suggestion. The outer slopes of the Type A sand/gravel zone are 3H:1V and the height is around 70 to 80 feet. That slope distance would require construction of stone columns out to 210 to 240 feet beyond the edge of Type A zone at the dam crest. The use of a crane with a horizontal boom of 60 to 100 feet could reduce the width of the Type B shells at the dam crest by the 60 to 100-foot crane-boom distance both upstream and downstream.
- It may be possible to use a jack-up barge as a platform for the crane with a horizontal boom to similarly reduce the required width of the Type B shells even further. However, the sand dam with stone columns design does need to include at least the downstream Type B shell because it must filter the Type A zone.
- The processes for construction of stone columns would be optimized during final design including the construction of a test fill embankment.

Response to Comment 9:

- Use of geocomposite/geosynthetic/geotextile materials in marine construction does not equate to or justify their use in dam engineering practice. The two design practice situations are not that similar.
- Marine use of geosynthetic filters in the cited case involves relatively small/limited tidal hydraulic heads (those produced in San Diego Bay are about 3.0 to 5.9 feet). Reclamation considers the use of geosynthetic filters within an embankment dam with a hydraulic head of up to 40 feet as being inappropriate.
- The marine revetment's potentially failed geotextile filter would be relatively easy and inexpensive to access and repair.
- Reclamation is skeptical about the ability of a geotextile filter layer to withstand a possible fault offset rupture in the rockfill embankment foundation.

Response to Comment 10:

- See responses to comment 9 above.

Response to Comment 11:

- Reclamation's Design Standards, Embankment Dams, No. 13 – Chapter 19 – Geotextiles, dated September 25, 1992, states on page 1:

  > "Specifying a geosynthetic material as the sole substitute for a major internal component of a large dam is unlikely without the assurance of adequate performance data. Presently, Reclamation is interested in using geosynthetics in combination with conventional designs and multiple lines of defense to increase safety or realize cost savings."

- Current work by FEMA, Reclamation, the U.S. Army Corps of Engineers, and others has produced "Draft - Geotextiles in Embankment Dams – Status Report on the Use of Geotextiles in Embankment Dam Construction and Rehabilitation", dated September 2006; the report's 1.1 Overview section states on page 1:

> "Current policy in the U.S. federal sector, and some state regulatory agencies and among many private consultants, prohibits the use of geotextiles for stand alone applications and or in deeply buried locations in an embankment dam where poor performance could jeopardize the safety of the dam or require costly repairs to the dam."

- The use of a geotextile as the downstream filter in this rockfill dam design would make it the sole line of defense against piping of foundation materials up into the downstream rockfill, assuming some seepage will travel down through the foundation, beneath the bottom of the SCB slurry wall, and up through the foundation and the geotextile filter layer into the downstream rockfill.
- The SCB slurry wall does not prevent such foundation seepage from occurring, which makes the geotextile filter layer the sole line of defense against piping failure.
- Reclamation has used geotextiles as filters in certain limited, accessible applications such as beneath upstream slope protection and along the downstream toe of an embankment dam. Reclamation has not used geotextiles as filters deep within an embankment dam as would be the case in the proposed rockfill dam design.
- Reclamation is skeptical about the ability of a geotextile filter layer to withstand a possible fault offset rupture in the rockfill embankment foundation.

<u>Response to Comment 12:</u>

- Reclamation has not yet received the final details and information on SSA's rockfill dam design. Hence, Reclamation does not know whether SSA's rockfill dam design would or would not meet the PPG criteria.
- Reclamation was not able to evaluate SSA's evolving rockfill dam design (which more recently includes a downstream geotextile filter layer) in the August 2006 risk analysis of alternative concepts. Details of the SSA design were not available at that time.
- Based on Reclamation's design standards for embankment dams, the use of geotextile is considered not appropriate and the SSA's current rockfill dam design would not be adequately protected against foundation seepage/piping problems.
- The rockfill dam with rock notches concept evaluated by Reclamation, (referred to in the Summary Report as Alternative 1D) in which natural soil filter layers were included beneath the downstream rockfill, would not meet Reclamation's general design criteria due to seismic stability problems.