State Water Resources Control Board
Hearing Name IID Transfer - Phase 2
Exhibit: 102
For Ident: _____ In Evidence: _____

SALTON SEA RESTORATION PROJECT

Draft Alternatives Report

Final Administrative DRAFT

U.S. Department of the Interior
Bureau of Reclamatin
Lower Colorado Region
Boulder City, Nevada

Salton Sea Authority
LaQuinta, Califfornia

September ~~14~~, 2001
21

Elston Grubaugh

From: "Steve Knell" <srknell@iid.com>
To: ""\"Elston K. Grubaugh\"" (E-mail)" <ekgrubaugh@iid.com>
Sent: Thursday, October 04, 2001 6:39 AM
Attach: Restoration Alternatives Memo.doc
Subject: FW: Salton Sea Restoration Alternatives Report

-----Original Message-----
From: Steve Robbins [mailto:srobbins@cvwd.org]
Sent: Monday, October 01, 2001 4:58 PM
To: tkirk@saltonsea.ca.gov
Cc: srknell@iid.com
Subject: Salton Sea Restoration Alternatives Report

Tom

Attached are my comments on the Alternatives Report. I assume that everyone on the TAC got a copy of the report. I cc'd my comments to Steve Knell but didn't have the other TAC members e-mail addresses. Feel free to forward my comments to them if you want to.

Once you read my comments I think you will understand that I feel that this report isn't even close to being ready for public consumption. We need to get this right the first time because I don't think there will be a second shot.

Steve

MEMORANDUM

DATE: October 4, 2001

TO: Tom Kirk, Executive Director, Salton Sea Authority

FROM: Steve Robbins

RE: **Restoration Alternatives Report**

I have reviewed the "Final Administrative Draft" of the Alternatives Report and have the following comments:

Chapter 2. In PROJECT GOALS AND OBJECTIVES reference should be made to PL 105-372. The goals of the project should be to comply with PL 105-372. In that transfers are specifically mentioned in the act, the stated goals of the project should be to comply with the act, which is to accommodate the transfers.

Page 2-2, Goal 1-Maintain the Sea as a Repository of Agricultural Drainage. This discussion is not complete without a complete discussion of the transfers. Nowhere in this document are the proposed transfers adequately discussed or portrayed.

Page 2-8, Imperial Irrigation District (IID) Water Transfer Program. This section should once again state that the proposed transfers are consistent with PL 105-372. In the second paragraph, second sentence change to read, "An additional 100,000 af/y of conserved water ***will*** be made available in the future to Coachella Valley Water District."

Should the Coachella Valley Water Management Plan be discussed as a "relevant action by others"? It would seem to me that not to implement the CVWMP would have negative impacts (reduced inflow) and that implementing the plan would have positive impacts (increased impacts). Also it would seem that we would want to discuss the synergy between the IID Transfers and the CVWMP.

Page 2-15, ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION. The discussion on import and export seems light. This doesn't seem to want to go away as an alternative. Should we devote more energy in this document to making it go away?

Page 2-18, Modular Strategy for Developing Alternatives. In the first full paragraph on the page, third sentence; delete the word "significantly". This tends to prejudice the reader without all of the facts being presented.

Page 2-27, Summary of Restoration Alternatives in This Document. In the partial paragraph at the top of the page, last sentence, what differentiation are we trying to make? By not including the transfer in one of the baselines we seem to be saying that this project has control over the transfer. PL 105-372 says that the restoration shall include the transfers. This should be a baseline condition and not put out such that there are any options about it.

In the first full paragraph on page 2-27, the first baseline inflow assumption is not realistic and gives the public the false impression that a scenario exists where flows will not be reduced. I think we are doing the public and ourselves a disservice if we don't make a point of explaining that under all likely scenarios flows to the Sea **will** be reduced. Also, we need to make it clear that with the proposed transfer, the middle scenario is the range of reductions that we would be looking at. Not the flow reduced to 800,000 af/y. Without this explanation, many will assume that the transfer equals worst case of 800,000 af flows.

Page 2-28, Alternative 4: In-Sea and On-Land Ponds with Land Use Conversion. The statement is made, "Construction of facilities on agricultural land would free up water that had been used for irrigation and allow it to flow to the Sea." I think we need to discuss how this could take place. An open-ended statement like this may lead to problems. Some would argue that any water freed up by a change in land use should flow through the priority system and not be allowed to "flow to the Sea." The sentence "In addition, depending on the baseline inflow scenario, additional land that is currently in agricultural production may be purchased or leased and allowed to be fallow" brings in a new concept that has not been discussed i.e. make up water. The whole idea of make up water needs to be thoroughly discussed and explained outside the context of any individual alternative. As I understand it make up water would be required in any of the alternatives so why is it first discussed inside one of the alternatives? Further down in the paragraph the sentence "No additional land use conversion would be required for the case where baseline and future inflows remain at 1.3 maf/yr." leads the reader to the false assumption that this is a real life possibility. It is not. Just as the next two sentences lead the reader to think that the reduced flow of 0.8 maf/yr is being considered as an option. This document does not adequately explain the bookends that we are looking at and that the likely future flows are somewhere in the middle.

Page 2-29, Alternative 6: On-Land Ponds with Land Use Conversions - next to the last sentence, change "AS" to "As".

Pages 2-30 through 2-35, Figures 2-3 though 2-8, the baseline assumptions here do not match the text on page 2-27.

Pages 2-37 through 2-40, Figures 2-9 though 2-12, the baseline assumptions here do not match the text on page 2-27.

Page 2-41, Figure 2-13, the baseline assumptions here do not match the text on page 2-27. We need to get this straight.

Page 2-42, Baseline and Future Inflow Both Equal 1.3 maf/yr. This discussion needs again to emphasize that this is not a realistic scenario and has been included to bookend the ranges. The entire discussion of the model results is hard to follow and will confuse the reader. It confuses me. The descriptions are inadequate and out of place. It seems to me that before you start talking about alternatives you need to have the discussion of baseline assumptions and what they mean. Again there also needs to some recognition of which of these is the most likely future flow scenario. Page 2-25 discusses three different baseline assumptions. The discussion of model results seems to look at four different assumptions. We need to be clear and consistent. The entire discussion of baselines needs to be expanded.

Chapter 3. Page 3-3, Precipitation of Dissolved Solids, first paragraph, next to the last sentence, it appears that the word "being" should simply be "be".

Page 3-5, FUTURE INFLOWS. The discussion seems out of order. The first three sentences of the second paragraph should go after the first sentence in the first paragraph and the remainder of the first paragraph should become a separate paragraph. Before we discuss the transfers we should discuss the likely declines in flow that will occur under any circumstances.

This is vitally important to the entire process. I'm not so sure that this entire chapter shouldn't be reversed with chapter two. The hydrology of the Sea should be discussed and understood before you start talking about alternatives. We are doing this backwards.

In the next to the last sentence of the second paragraph the word "baseline" should be "baselines." We are once again talking about three baselines where the model results look at four baselines. The entire subject of future baselines is confusing, inadequate and needs to be expanded. What is with baseline at one number and future flows at another number? This does not make sense. The baseline you are comparing it against is whatever it is. Current flows are current flows and future flows are future flows. Whatever you assume for these is the baseline that your project is compared against.

In the third paragraph the last two sentences, I believe, misrepresent the future. All of CVWD's assumptions are that increases in groundwater levels and flows to the Salton Sea are a result of transfers of water to CVWD. The likeliest source of this transfer water is IID. To assume that CVWD flows go up and IID transfers no water to CVWD and therefor IID flows do not go down is highly improbable. Also it appears that by making the assumption that CVWD flows increase without the transfer don't allow a credit for the water that stays within the basin or the water that CVWD gets that comes from outside the basin. This unfairly skews the numbers against the transfer.

The last paragraph on page 3-5, following onto page 3-6, also assume the increased flows from CVWD without including the offsetting effects of the transfer. This is not a realistic assumption.

Figure 3-3a is confusing when compared to the model scenarios. This seems to show three parallel tracks that are based on 1.3, 1.2 and 1.1 maf/yr. If that is the case these tracks are useless because they don't represent any realistic forecast of future flows. Page 2-27 indicates that the three assumptions are 1.3, 1.0 and 0.8 maf/yr. We really, really need to get the baseline assumptions worked out.

In Figure 3-3b it is not clear which baseline assumption this refers to. All of the other Figures have three lines when looking at future scenarios or in some cases four depending on which set of baseline assumptions are used.

Page 3-7, shouldn't the equation for salt content be **"Salt Content = Previous Salt Content + Salt Load - Precipitation"** or is precipitation figured into the salt loading component of the formula? Either way we should clarify what we are assuming.

Chapter 4 Page 4-2, in the bulleted list at the bottom of the page, I thought Salton Sea Evaporation was in the range of 70± inches per year? I have never seen a number as high as 102.5 inches. Is this correct?

Page 4-20, in the general discussion of evaporation ponds on agricultural land there is a lot of discussion regarding permeability of the soils. If in fact these lands were used would not the soils "silt up" rather rapidly with lots of applied Seawater? Shouldn't this at least be a topic of discussion? It is not even mentioned.

Page 4-21; last sentence on the page, the punctuation after the word "land" is incorrect.

Chapter 5 Page 5-1, I am not comfortable with the term "Economic Development Assistance". I'm not sure what term to use but Economic Development Assistance has a bad ring to it.

Page 5-30, FISH RECOVERY SYSTEMS. I find it interesting that this section does not include a discussion regarding on-water recovery of dead fish and yet we are currently considering spending $500,000 on a pilot program. If on-water recovery is not part of the long rang

recovery plan then under no circumstances should we be funding a pilot program. If on the other hand it is part of the ultimate recovery plan we should discuss it here.

Page 5-37 and 5-38, ECONOMIC DEVELOPMENT ASSISTANCE. This section needs to be completely rewritten and reworked.

In the first paragraph we talk about flows to the Sea being "reduced by 300,000 acre-feet because of transfer agreements..." This is a false and misleading statement. The transfers as proposed do not reduce flows by 300,000 af/yr. This does not take into account the additional flows to the Sea as a result of CVWD getting 100,000 af/yr of the IID transfer water and the additional water that CVWD gets out of the QSA. We need to get the numbers straight. We once again state "The excess irrigation water available from the converted lands can be utilized to replace the reduced inflow and to maintain the water elevation of the Sea." Somewhere in the document we need to have a frank discussion on how this can take place. I don't see how we can or should avoid the subject. We also seem to be elevating maintaining the elevation of the Sea at its current level to a goal. Page 2-4, Goal 3 includes "Stabilize Salton Sea water surface elevation". Stabilize and maintain current elevations are not the same goal. I was under the impression that some reduction of the surface level was inevitable under all scenarios. If this is true then we should not raise false hopes that we will keep it at its current elevation. The end of this paragraph talks about 72,960 acres of agricultural land being converted under Alternative 6. What flow future assumptions are used to get to this number and where in the report does it tell you. Is this based on future flows of 1.3, 1.2, 1.0 or 0.8 maf/yr to the Sea and is this a realistic future flow assumption? As currently written this will scare the hell out of people.

The first sentence in the second paragraph confuses me and I believe is just flat out wrong. From the farmer's point of view, if the Authority purchases or leases agricultural land at fair market value for whatever uses the Authority intends, isn't that landowner fully compensated for any loss of livelihood? It seems to me that farmers are fully compensated and that third party impacts are the only ones we need to discuss. I don't have a clue what is meant by "if the project actions reduce the amount of irrigation water available..." What are we talking about? Also we will be laughed at if we have a discussion regarding "dry crops" in the Imperial or Coachella Valleys. We need to "get real."

The first paragraph on page 5-37 is also confusing. We seem to be mixing economies. We talk about "dollars spent at the Sea" and then seem to translate that to the economies of the Imperial and Coachella Valleys. I don't believe that the agricultural economy has anything to do with the economy of the "Sea."

I would be careful about the second paragraph on page 5-37. This seems to be a full-blown acknowledgment of "growth inducing effects." Most projects have to mitigate for these types of effects. Is this project ready to do this? Many would find it hard to swallow if their own project was required to mitigate for questionable growth inducing effects and this project was somehow not required to mitigate for blatant growth inducing effects.

The last paragraph on page 5-37 refers to some preliminary estimates that have been included. Where and what are these? Also it refers to "the next version of this report". Is there going to be another version of this report?

All and all this section needs quite a bit of work before it goes public. If we are going to talk about "Economic Development Assistance" then we need to say what we mean and put our money where our mouth is. If I were on the opposition side of this I would blast this as being nothing but a bunch of double talk. The people affected by potential land fallowing want to know what if anything we are going to do to offset any real or perceived impacts of change of

use and/or fallowing. We have done nothing to ease their fears and concerns. We need to tell them what we intend on doing to offset the impacts and at least some order of magnitude value per acre that goes back to the community. I also think we need to differentiate between land that is truly converted to a different use vs. land that is fallowed. The impacts are different and we need to say that they are different and indicate the differences.

Conclusion This document is not even close to being ready to go out in its current form. There are way too many inconsistencies, inaccuracies and unanswered questions. As badly as this document needs to get out for public review and input, it needs to be accurate and complete or we will be thrown to the wolves.

SALTON SEA AUTHORITY

Transmittal

To: **Steve Knell**
From: **Tom Kirk**
cc:
Date: **September 21, 2001**
Enclosed: **9-21 SS Restoration Alternatives Report**

Enclosed is an internal administrative draft of the Salton Sea alternatives report. The 3rd party impact analysis is not included in this report. That analysis is pending receipt of information from IID and revisions by the Bureau's economist.

Please keep this document within your organization/department. I would appreciate receiving your comments by October 4. Once we have completed the internal review and incorporated the 3rd party impacts, we'll send the document out to cooperating agencies and others.

Thanks.

RECEIVED
SEP 24 2001
RESOURCES PLANNING & MANAGEMENT DEPARTMENT

78-401 Highway 111 ◆ La Quinta, CA 92253-2066 ◆ (760)564-4888 ◆ Fax (760)564-5288

SALTON SEA RESTORATION PROJECT

Draft Alternatives Report

Final Administrative Dravt

U.S. Department of the Interior
Bureau of Reclamatin
Lower Colorado Region
Boulder City, Nevada

Salton Sea Authority
LaQuinta, California

September 14, 2001

CONTENTS

Executive Summary — to be completed

Tables

Figures

Chapter 1
INTRODUCTION

The present-day Salton Sea (Sea) is a body of water that currently occupies the Salton Basin, but it is not the first to do so. Historic evidence and geologic studies have shown that the Colorado River has spilled over into the Salton Basin on numerous occasions over the millennia, creating intermittent lakes that in some cases lasted decades to centuries. For example, Lake Cahuilla is believed to have formed around 700 A.D., when the Colorado River silted up its normal egress to the Gulf of California and swung northward through two overflow channels. Evidence of an ancient shoreline suggests that Lake Cahuilla occupied the basin until about 300 years ago. From 1824 to 1904, Colorado River flows flooded the Salton Basin no fewer than eight times.

The present-day Sea was formed in 1905, when Colorado River flood flows breached an irrigation control structure and were diverted into the Salton Sea Basin for about 18 months. Since that time, agricultural drainage flows from nearby Imperial, Coachella, and Mexicali Valleys and smaller contributions from municipal effluent and stormwater runoff have sustained the Sea. Over the years, the Sea has developed into a recreation area, wildlife refuge, and sport fishery.

The Salton Basin extends from Palm Springs, California, on the north to near the Gulf of California on the south. The Sea itself is about 35 miles long and 15 miles wide. At its current (1999) elevation of about -227 feet mean sea level (msl) (227 feet below sea level), the Sea has a maximum depth of 51 feet, with an estimated surface area of 234,000 acres (366 square miles). The lowest seafloor elevation recorded has been about -278 feet msl. The Sea has a storage volume of approximately 7.6 million acre-feet at -227 feet msl.

The Sea's current salinity concentration is 43,500 milligrams per liter (mg/L) (25 percent saltier than ocean water). Annual inflows of approximately 1.3 million acre-feet contribute about 5 (4.8) million tons of additional salt each year. Since the Sea has no natural outlet, the salinity in the Sea has the potential to rise by several hundred mg/L each year if salinity control measures are not implemented. The rise in salinity could increase substantially in the future as a result of an imbalance with evaporation if inflows to the Sea are reduced because of increasing demands for water in the western states.

Rising salinity is threatening the highly productive fishery in the Sea. The Sea's fishery is important for recreational reasons as well as for ecological reasons. The Salton Sea and nearby wetlands are a critical part of the Pacific flyway, providing habitat and seasonal refuge to millions of birds and hundreds of species. The fish in the Sea are a critical source of food for many of those bird species. In addition to salinity, other issues are of concern at the Sea, including high levels of nutrients.

The Bureau of Reclamation (Reclamation) and the Salton Sea Authority (Authority), working as joint leads with stakeholders and members of the public, developed five goal statements. The goal statements are consistent with the direction contained in P.L. 105-372, address the underlying purpose and need for the project, and provide guidance for developing project alternatives.

This report describes the alternatives that are being developed as part of the Salton Sea Restoration Project. A number of more specific project objectives have been developed to address ecological, recreational, and economic issues at the Sea. The five goals of the Salton Sea Restoration Project are discussed in chapter 2. The alternatives described in this document were developed to address these goals and the more specific objectives. Chapter 2 also provides an overview of the alternatives and a guide to the contents of the remainder of this document.

Chapter 2
DEVELOPMENT OF PROJECT ALTERNATIVES

The Salton Sea Restoration Project alternatives have evolved within the context of the basic goals of the program and the specific objectives that provide the basis for defining project alternatives. The project goals and objectives are described in this chapter, along with the restoration project framework that provides a linkage between possible project actions and actions by others that could affect the Salton Sea (Sea). A review of the alternatives from previous studies is also provided along with a summary of the alternatives presented in this document and the process that has been used to evaluate alternatives and develop the joint lead agencies' preferred alternative.

PROJECT GOALS AND OBJECTIVES

Reclamation and the Authority, working jointly with stakeholders and members of the public, developed five goal statements that address the underlying purpose and need for the project. The five goals of the Salton Sea Restoration Project are as follows:

1. Maintain the Sea as a repository of agricultural drainage
2. Provide a safe, productive environment at the Sea for resident and migratory birds and endangered species
3. Restore recreational uses at the Sea
4. Maintain a viable sport fishery at the Sea
5. Enhance the Sea to provide economic development opportunities

To measure the effectiveness of any actions designed and implemented to achieve the five project goals, objectives were developed in cooperation with stakeholders to further define each goal. In many cases, objectives overlap and result in mutual benefits. The goals and objectives have been used to guide the development of alternatives. These same objectives ultimately would be used to guide efforts to monitor and evaluate the effectiveness of any restoration actions that are implemented.

The objectives presented in the Draft EIS/EIR in January 2000 have been re-evaluated in light of public and agency comment on the draft document and ongoing analysis and design work. The ongoing work included investigations of the reasonable and achievable targets for salinity and water surface for the Sea. The Draft EIS/EIR identified a salinity objective to reduce and maintain salinity at 40,000 mg/L or lower, and a preferred elevation objective of +/- 230 msl. It is not likely that these objectives will be attainable under all possible inflow scenarios. The updated objectives are discussed in the following paragraphs.

Goal 1—Maintain the Sea as a Repository of Agricultural Drainage

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

Agriculture in its present form relies on the ability to discharge drainage into the Sea. Thus, the continued use of the Salton Sea as a repository for agricultural drainage is a fundamental component of the Salton Sea Restoration Project. It is both a goal defined by the joint lead agencies for the NEPA/CEQA effort and a basic assumption contained within P.L. 105-372. The Salton Sea will not exist as a major waterbody without agricultural drainage; therefore, the availability of the Sea as a drainage repository is essential for achieving all other project goals. However, those goals are also dependent on a suitable environmental quality. A separate program under the auspices of the California Regional Water Quality Control Board is attempting to determine the Total Maximum Daily Load (TMDL) of various constituents of the water, including agricultural drainage water, that should be allowed in the major tributaries to the Sea. The goal of the TMDL program is to determine what, if any, measures should be implemented to improve the quality of water that enters the Sea. The TMDL program is separate from the Salton Sea Restoration Project, but may contribute to the overall restoration of the Sea. Since the TMDL process is on-going, the Restoration Project objectives do not attempt to duplicate the TMDL program objectives and do not address water quality in the tributaries. Specific objectives that will be pursued to maintain the sea as a repository of agricultural drainage are as follows:

- Maintain Salton Sea elevations at or below current levels (to avoid inundation of agricultural lands)

- Maintain accessibility to the Sea for agricultural drainage water

Goal 2—Provide a Safe, Productive Environment at the Sea for Resident and Migratory Birds and Endangered Species

A number of avian and fish species are highly dependent on a healthy Salton Sea ecosystem. These species include threatened and endangered species (including both avian and fish species), federal species of management concern, and trust species of migratory birds. Additionally, various shorebirds, marsh birds, gulls, terns, and passerines contribute to the biodiversity at the Sea and within the watershed. Specific objectives that will be pursued to provide a safe, productive environment at the Sea for resident and migratory birds and endangered species are as follows:

- Control salinity to maintain forage base for fish-eating birds

- Control salinity to maintain invertebrate foodbase for birds

- Enhance quality and quantity of wetland habitat

- Protect/provide quality roosting and nesting habitat for waterbirds

- Maintain/provide a broad array of avian habitats

- Maintain and enhance the quality and accessibility of habitat for desert pupfish

- Minimize losses of avian species at the Sea from disease

Goal 3—Restore Recreational Uses at the Sea

Recreational opportunities at the Salton Sea continue to draw visitors to the area. However, recreational use of the Sea was greater and more varied in the past than it is today, with visitors camping, picnicking, and participating in numerous water sports, such as boat racing, water skiing, and swimming. The availability of these different recreational opportunities at the Sea attracted many visitors to the region. Over the years, increasing surface water elevations flooded recreational facilities along the shoreline. In addition, decreasing water quality and the increasing public perceptions of potential health risks at the Sea led to visitor decline. A fish consumption health advisory, reports of pathogens being transported to the Sea via the New River, algal blooms and the attendant odors resulting from their decay, and large-scale fish and bird die-offs may have led to a decrease in visitation and particularly water/body contact recreational uses. Specific objectives that will be pursued to restore recreational uses are as follows:

- Maintain and improve access to the Sea for a variety of recreational activities and enhance the shoreline condition to encourage use
- Stabilize Salton Sea water surface elevation
- Evaluate health implications from fish consumption
- Minimize objectionable odors
- Minimize occurrence of algal blooms
- Maintain salinity at or below existing levels

Goal 4—Maintain a Viable Sport Fishery at the Sea

The Salton Sea became widely known for its sport fishery following the successful introduction by the California Department of Fish and Game (CDFG) of several species from the Gulf of California. The orange-mouth corvina, a fish that can weigh in excess of 30 pounds, is the most prized of the Sea's sport fish. In addition, bairdiella, sargo, and tilapia have added to sport fishing opportunities. Specific objectives that will be pursued to maintain a viable sport fishery are as follows:

- Maintain a fish community of desired species and population levels to support a high quality sport fishery as a recreational activity at the Salton Sea

- Maintain or reduce salinity at or below current levels

- Minimize occurrence of large scale fish die-offs

Goal 5—Enhance the Sea to Provide Economic Development Opportunities

A healthy Salton Sea ecosystem with its associated bird life, sport fishing, and the surrounding natural beauty of the area are fundamental attractions for people to visit and settle at the Sea. This human use provides a foundation for economic development that extends beyond the productive agriculture of the area. Specific objectives that will be pursued to enhance economic development opportunities are as follows:

- Minimize objectionable odors

- Implement objectives for a safe productive environment

- Implement recreational and sport fishery objectives

- Maintain a clean shoreline

RESTORATION PROJECT FRAMEWORK

The Salton Sea Restoration Project is one of a number of actions that could affect conditions at the Sea. The restoration project framework provides a linkage between the goals and objectives of the project, actions that the joint lead agencies could take as part of the project itself, and other parties' actions. Other parties could include local, State, and federal agencies, and private and tribal organizations that have an interest at the Sea. Table 2-1 illustrates the restoration project framework in a matrix presentation of the linkages between the project goals and objectives, possible actions by the joint leads, and possible actions by others. The restoration project framework provides the context within which restoration actions would take place. Some objectives of the project may be partially met by others actions; therefore, it will not be necessary for the project to duplicate these efforts.

Possible actions of the restoration project are described in more detail through this alternatives report. Some relevant actions by others are shown on table 2-1 and are discussed in the following paragraphs.

Table 2-1 Restoration Project Framework

Goals	Objectives	Joint Lead Agencies Contributing Actions and Programs	Other Agency Actions/Programs
Maintain Agri-cultural Drainage Repository	Maintain Salton Sea elevations at or below current levels	• **Use salinity control measures that help manage elevations**	• IID-SDCWA Water Transfer Project IID/SDCWA/CVWD/MWD
	Maintain accessibility to the Sea for agricultural drainage water	• Incorporate design features in restoration actions that maintain drainage accessibility	• IID on-going maintenance programs IID/CVWD
Provide a Safe, Productive Environment at the Sea for Resident and Migratory Birds and Endangered Species	Control salinity to maintain forage base for fish-eating birds	• **Implement salinity control measures (such as solar evaporation ponds or EES)**	No other programs have been identified that address this objective
	Control salinity to maintain invertebrate foodbase for birds	• **Implement salinity control measures**	No other programs have been identified that address this objective
	Enhance quality and quantity of wetland habitat	• Conduct an assessment of open-water habitat needs of fish-eating birds and control salinity to maintain foodbase	• **IID-SDCWA Water Transfer Mitigation** • **~~Brawley~~ Imperial & Ca DFG Wetlands** • **Torres Martinez Wetlands**
	Protect/provide quality roosting and nesting habitat for waterbirds	• **Possible use of solar evaporation ponds to add to the habitat mosaic for waterbirds** • Develop permanent wetland to sustain snag habitat at northern area of the Sea	• Nesting habitat projects at the Salton Sea National Wildlife Refuge
	Maintain/provide a broad array of avian habitats	• Possible use of solar evaporation ponds to add to the habitat mosaic	• ~~IID-SDCWA~~ QSA Water Transfer Mitigation
	Maintain and enhance the quality and accessibility of habitat for desert pupfish	• Conduct an assessment of habitat needs to sustain Salton Sea desert pupfish populations • Fishery management to enhance pupfish habitat • Include habitat features that would support pupfish on any in-Sea structures near pupfish	• Possible mitigation measures of the ~~IID-SDCWA~~ Water Transfer Projects QSA
	Minimize losses of avian species at the Sea from disease	• **Organize integrated long-term wildlife disease monitoring and response effort**	• USFWS/CDFG disease response and rehabilitation • USGS disease investigations
Restore Recreational Uses	Maintain and improve access to the Sea for a variety of recreational activities and enhance the shoreline condition to encourage use	• Sponsor shoreline cleanup of dead fish • When feasible, incorporate access needs within the design and construction of project landscape alterations	• Improvements to the Salton Sea State Recreation Area • Improvements to local boat ramps and marinas

Goals	Objectives	Joint Lead Agencies Contributing Actions and Programs	Other Agency Actions/Programs	
	Stabilize Salton Sea water surface elevation	• **Possible use of In-Sea solar evaporation ponds or disposal impoundments that provide displacement** • Manage Sea elevations by adjusting operations of salinity control actions • Minimize withdrawals from salinity control actions • Use of water from change in land use associated with project facilities	No other programs have been identified that address this objective	
	Evaluate health implications from fish consumption	• Assess contaminant levels in fish	• RWQCB Selenium TMDL	
	Minimize objectionable odors	• Sponsor shoreline cleanup of dead fish • Conduct an assessment of eutrophication in the Sea • Determine sources of objectionable odor	• RWQCB Phosphate TMDL • Tribal Phosphate TMDL	Silt TMDL
	Minimize occurrence of algal blooms	• Develop a nutrient cycle model • Implement sport fishery objectives • Seek means for nutrient impact reduction	• RWQCB Phosphate TMDL • Tribal Phosphate TMDL • Mexicali Treatment Plant/Program	Silt TMDL
	Maintain salinity at or below existing levels	• **Implement salinity control measures**		
Maintain Viable Sports Fishery	Maintain a fish community of desired species and population levels to support a high quality sport fishery as a recreational activity at the Salton Sea	• **Implement salinity control measures** • Establish baselines for fish populations and monitor populations • Evaluate fish harvest as a means for removal of excess numbers of tilapia	• RWQCB Phosphate TMDL • Tribal Phosphate TMDL	Silt TMDL
	Maintain or reduce salinity at or below current levels	• **Implement salinity control measures** • Evaluate salinity tolerance for life cycle of Salton Sea sportfish and their food base	No other programs have been identified that address this objective	
	Minimize occurrence of large scale fish die-offs	• **Fishery management to avoid overcrowding of fish during periods of oxygen deficiency** • Conduct an assessment of eutrophication in the Sea	• RWQCB Phosphate TMDL • Tribal Phosphate TMDL	Silt TMDL
Provide Economic Development Opportunities	Minimize objectionable odors	• **Fish recovery program** • Conduct an assessment of eutrophication in the Sea • Determine sources of objectionable odor	• RWQCB Phosphate TMDL • Tribal Phosphate TMDL	Silt TMDL
	Implement objectives for a safe productive environment	• **As stated above**	Other programs discussed above could also contribute to this objective	
	Implement recreational and sport fishery objectives	• **As stated above**	Other programs discussed above could also contribute to this objective	
	Maintain a clean shoreline	• **Fish recovery program**	No other programs have been identified that address this objective	

Note: Primary actions are shown in **bold typeface**; other actions are expected to have some or minor impact on an objective.

QSA ~~Imperial Irrigation District (IID)~~ Water Transfer Programs

The San Diego County Water Authority (SDCWA) has negotiated an agreement for the long-term transfer of conserved water from the Imperial Irrigation District (IID). Under the proposed contract, IID customers would undertake water conservation efforts to reduce the use of Colorado River water within IID. Water conserved through these efforts would be transferred to SDCWA. Since the production of conserved water will depend on the level of voluntary landowner participation, the agreement does not specify an amount of water to be transferred. The agreement instead sets the transfer quantity at a maximum of 200,000 af/yr. minimum of 130,000 af/yr and a ...

The initial transfer quantity could be 20,000 af for the first year, with a build up of 20,000 af/yr thereafter for 10 years or until the transfer amount is reached. An additional 100,000 af/yr of conserved water may be made available in the future to Coachella Valley Water District (CVWD). The water transfer program would likely reduce inflows to the Sea. The extent inflows would be reduced would depend on the specific measures that would be adopted to support the transfer. Regardless of the specific measures, the transfer program would contribute to the objective of maintaining the Sea at or below current levels, through reduced inflows. Mitigation measures for the transfer program are expected to contribute to the objectives of enhancing wetland habitats and maintaining or providing a broad array of avian habitats.

Constructed Wetlands Projects

Several wetlands projects have been planned or are already implemented around the Salton Sea. These projects include two constructed wetlands projects funded by Congress on the New River near Brawley, projects by the California Department of Fish and Game, and a project at the north end of the Sea proposed by the Torres Martinez band of the Desert Cahuilla Indian Tribe. ~~One of the Brawley area wetlands has already been constructed and another is planned.~~ These projects will provide additional wildlife habitat in the area and may also provide some improvement to the water quality of the inflows to the Sea. Pilot Projects - Authors need to contact Steve Smith, BOR for update.

Nesting Habitat Projects at the Sony Bono National Wildlife Refuge

The Fish and Wildlife Service continually assesses habitat values at the Refuge and seeks methods to enhance nesting habitat. For example, in 2000 a small island habitat (slightly less than an acre) was created in a pond adjacent to the Sea, in Wildlife Unit 1 (the southernmost of two units on the Refuge). The island currently provides nesting habitat to a number of species of birds.

Disease Response and Rehabilitation Programs

Ongoing efforts to combat disease at the Salton Sea have involved crisis response by the U.S. Fish and Wildlife Service (FWS) with support provided by the California Department of Fish and Game (CDFG). Historically these efforts have largely involved recovery and disposal of bird remains. More recently, rehabilitation of birds afflicted with avian botulism has been a major activity. It is proposed that these reactive efforts be integrated into a more comprehensive program as discussed in chapter 5 of this alternatives document.

Improvements to Recreational Facilities

Existing recreational facilities at the Sea include the State Recreation Area, operated by the California Department of Parks and Recreation, and a number of smaller facilities, such as boat ramps, that are operated under county, local government, and private ownership. Improvements to existing recreational facilities, independent of the Restoration Project, are currently being planned at number of locations, including a significant upgrade by the California Department of Parks and Recreation at the State Recreation Area and by Imperial County at Red Hill Marina. These projects would contribute to the objective of maintaining and improving access to the Sea for a variety of recreational activities and enhancing the shoreline condition to encourage use. Further discussion of recreational projects planned by other organizations can be found in Chapter 5 of this alternatives report.

Total Maximum Daily Load (TMDL) Program

Congress, through the Clean Water Act (CWA), established the legal requirement that states list and rank impaired waterbodies, and that TMDLs be established for constituents that are causing impairment, in accordance with the priority ranking. The Salton Sea watershed has been identified as a priority watershed for the TMDL program. The California Regional Water Quality Control Board (CRWQCB) is currently in the process of establishing TMDLs for these waters. A TMDL implementation plan that is economically reasonable and technically feasible will be developed as part of this process. The long-term in tributaries

goal of the TMDL process will be to improve the quality of waters flowing into the Sea. This goal will at least partially address several project objectives as shown in Table 2-1. The TMDL program could also have some adverse consequences on the Sea, if it results in any reduction of inflows to the Sea

Mexicali Wastewater System Improvements

Untreated or partially treated wastewater from Mexicali, Mexico, currently is discharged into the New River, which flows north into the United States and ultimately empties into the Salton Sea. The United States and Mexico, through the International Boundary Water Commission (IBWC), are planning short- and long-term improvements to the Mexicali wastewater system. These improvements include, among others, rehabilitating and expanding the Mexicali I wastewater treatment plant and constructing a Mexicali II wastewater treatment plant. Improved sanitation in Mexicali would improve the quality of water discharged to the New River, and contribute to several project objectives as indicated in Table 2-1. However, after improvements, Mexicali may opt to redirect some or all of the treated wastewater for uses south of the border instead of discharging to the New River. Such actions could potentially affect the quantity of inflows to the Salton Sea and thus have an adverse effect on other project objectives.

BACKGROUND ON RESTORATION ALTERNATIVES

Restoration alternatives are designed to address a broad array of objectives as discussed for the Restoration Project Framework. The restoration alternatives have evolved through a process that has involved planning studies, engineering analysis, scientific oversight, and environmental reviews. The background for this process is discussed in the following paragraphs.

Early Phases of Restoration Planning

Although projects to stabilize salinity and surface water elevation problems at the Sea have been proposed for many years, the initial planning process for the current set of alternatives began in 1996. Prior to initiation of a NEPA/CEQA process, an initial screening study was conducted in 1996 through an agreement with the Authority, 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 subjected to the preliminary screening analysis. This preliminary screening effort provided the framework for developing the alternatives that were analyzed in the draft EIS/EIR. The NEPA/CEQA process that began in June 1998 built on the early efforts to incorporate concerns, issues, and comments made during these public meetings into the analysis of alternatives.

All original alternatives were reassessed, and new alternatives were considered, including those suggested by the public. 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 Preappraisal Report (November 1998), which is also available on the worldwide web at www.lc.usbr.gov and incorporated by reference.

Review of Alternatives in Draft EIS/EIR

Following the initial screening process, additional engineering analysis was conducted on the top ranked alternatives. As a result of additional analysis, the alternatives continued to evolve, leading to those that were analyzed in the January 2000 Draft EIS/EIR. The environmental assessment of alternatives in the draft EIS/EIR addressed the effects of a range of inflows from the current conditions of around 1.3 million acre-feet per year (maf/yr) to a future condition of as low as 0.8 maf/yr. Project alternatives were identified for two phases of the project. The first phase represented the immediate planning horizon for which detailed alternatives could be defined (about 30 years). Second phase alternatives would be more speculative and would depend on events and changes in inflows during the first phase.

The draft EIS/EIR considered five project alternatives that were each compared against three No Action/No Project scenarios. Each alternative had components that would be implemented during Phase 1 of the program (roughly within 30 years) and during Phase 2 (generally, after 30 years). Each alternative also included Common Actions that would be the same regardless of which alternative was selected. Key features of the No Action/No Project Alternative, each of the five project alternatives, the Common Actions, and Phase 2 Import and Export Options are discussed briefly in the following paragraphs.

No Action— Projecting hydrologic conditions for this project is complicated by uncertainties of future water flows into the Sea. The timing and quantities of water that flows into the Sea will depend on external factors not associated with the Salton Sea Project. Thus, possible No Action conditions were defined at both current and reduced inflow volumes. Project effects were evaluated against three No Action/No Project inflow scenarios:

- Current (present-day) inflow conditions continue throughout both Phases 1 and 2, with average annual inflows of 1.36 maf/yr
- Average annual inflows are incrementally reduced throughout Phase 1 to 1.06 maf/yr at the beginning of Phase 2; inflows remain at 1.06 maf/yr throughout Phase 2
- Average annual inflows are incrementally reduced throughout Phase 1 to 1.06 maf/yr at the beginning of Phase 2, and continue to decline at the same rate into Phase 2 until they reach 0.8 maf/yr

These potential future inflow conditions were considered reasonable future scenarios, in light of the varied projects currently under consideration, such as the ~~IID-San Diego Water Transfer~~ QSA projects that could affect flows into the Sea.

Evaporation Ponds, Alternative 1— Alternative 1 would have involved construction of two evaporation ponds within the southwest area of the Sea. The combined surface area of the ponds would have been approximately 33 square miles but would depend on the elevation of the water surface in the ponds and may also fluctuate seasonally. The ponds were designed to concentrate salts from the Sea and assist in stabilizing the Sea's surface elevation. Approximately 98,000 af/yr of water would have been pumped into these ponds from the Sea each year. Evaporation of this water would tend to concentrate salts in the ponds and allow the salinity in the remainder of the Sea to be maintained at an acceptable level. The ponds would have also created a displacement, which would have assisted in maintaining the target elevation level of the Sea (+/- -230 feet), should inflows to the Sea later decrease. Because the brine concentrations in the ponds would have quickly approached saturation, this alternative would have required construction of an export facility by 2015.

Enhanced Evaporation System at Bombay Beach, Alternative 2—Alternative 2 would have involved construction of an Enhanced Evaporation System (EES) on a site north of Bombay Beach. The EES is a method to remove salts from the Sea by increasing evaporation rates through spraying. Alternative 2 would have line showers which involved constructing tower modules to process 150,000 af/yr of Salton Sea water. Most EES methods are discussed in chapter 4. The system would have operated on average 18 hours per day and automatically shut down when winds exceed 14 miles per hour (mph). Each module would have consisted of a line of towers and precipitation ponds. The 80- to 130-foot high towers would have been connected with hoses extending from the main line to the others through which water would be delivered. Nozzles attached to the hoses would have sprayed Salton Sea water from a height sufficient to allow the water to evaporate and the salts or brines to precipitate into a catchment basin, and then be moved to precipitation ponds constructed below the towers.

EES at Salton Sea Test Base, Alternative 3—Alternative 3 would have been similar to Alternative 2, except that the EES would have been constructed at the Salton Sea Test Base.

Evaporation Pond and EES, Alternative 4—Alternative 4 would have combined the technology of Alternatives 1 and 3 to increase the effectiveness and speed at which salts would be removed from the Sea. The EES would have been constructed on the Salton Sea Test Base site, but the size of the EES would be reduced to a capacity of 100,000 af/yr. A single evaporation pond would have been constructed in place of the two described for Alternative 1. The evaporation pond would receive approximately 68,000 af/yr through pumping from the Sea. Construction techniques for both the pond and the EES would have been the same as for alternatives 1 and 3, respectively.

In-Sea EES in Evaporation Pond, Alternative 5— Under Alternative 5, an evaporation pond would be constructed within the Sea near the Salton Sea Test Base. This pond would have been the same as one of the ponds used in Alternative 1. In addition, a 150,000 af/yr EES would be incorporated within the pond itself. The EES used in this alternative would involve technology typically used in artificial snowmaking and agricultural spraying. Instead of dropping water from the tower configuration described in Alternative 2, this method would use a series of portable, turbo-enhanced EES. Each unit would use turbine-like blowers to spray Salton Sea water up into the air above the evaporation pond. The blower units would have been mounted along the top of the dikes used to enclose the evaporation pond. Similar to Alternative 1, because the brine concentrations in the pond would have quickly approached saturation, this alternative would have required construction of an export facility by 2030.

Common Actions—These actions would have been common to all alternatives described in the previous paragraphs. Taken together these common actions, integrated with one of the alternatives described above, define plans that would more completely address the project's multiple goals and objectives. The proposed Common Actions were as follows:

- **Fish harvesting**—An effort to control the population of tilapia in the Sea and also reduce nutrient loading by about 10 percent
- **Improved recreational facilities**—Improvements to boat launching facilities around the Sea
- **Shoreline cleanup program**—A continuing program to remove dead fish from the water surface and shoreline
- **Integrated Wildlife Disease Program**—A multi-agency effort to monitor avian diseases and implement timely responses to disease outbreaks as a means for reducing loses
- **Long-term management strategy**—A long-term strategy for implementing the program that would respond and adapt to the changing requirements of the future
- **Strategic Science Plan**—A long-term strategy to provide scientific evaluations to guide management actions for the restoration of the Sea

Certain elements of the Integrated Wildlife Disease Program and the Strategic Science Plan are administrative and have already been implemented.

Import and Export Actions—Phase 2 actions were developed on a programmatic level; thus, descriptions provided represented typical alignments and pipeline details that could be used. Phase 2 actions, taken in conjunction with Phase 1 actions, would be intended to provide long-term solutions to the problems at the Sea.

Export of water from the Sea was included as an accelerated Phase 2 action as part of Alternative 1 and as part of Phase 2 action for Alternative 5, if current average annual inflows continue. The following export options were considered:

- Export to expanded EES
- Export (by pipeline or canal) to the Gulf of California

- Export (by tunnel, pipeline, and canal) to the Pacific Ocean
- Export (by pipeline and canal) to Palen Dry Lakebed

The following possible source of imported water was considered for Phase 2:

- **Import through Yuma, Arizona**—This action would involve the import of water that originates as a brine stream from the proposed Central Arizona Salinity Interceptor (CASI), through Yuma to the Salton Sea.

In addition to this Phase 2 import action, the possibility of using periodic flood flows from the Colorado River as a source of water was also analyzed as a Phase 1 and Phase 2 action under reduced inflow scenarios. Likewise, displacement dikes constructed in the year 2015 were considered as part of some alternatives under reduced inflow scenarios. Either of these actions would help maintain and stabilize Sea elevations under reduced inflow scenarios.

ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION

Analysis of the best solutions to the problems at the Sea has continued since the January 2000 publication of the Draft EIS/EIR and the public and agency comment on that document. In addition, more information has become known about the range of possible inflows to the Sea that could occur in the future. The Phase 1/Phase 2 strategy presented in the Draft EIS/EIR has been replaced by the modular strategy discussed later in this chapter.

A number of the technologies considered in the Draft EIS/EIR have been eliminated or substantially modified because of technical and cost considerations. Technologies that have been eliminated or modified, include the following:

Large, in-Sea, deepwater ponds—The concept of large deepwater ponds has been replaced by a strategy that involves smaller shallower multiple pond systems that are less expensive and less susceptible to catastrophic earthquake failure.

Import and export of water through canals or pipelines, either from or to the Gulf of California or the Pacific Ocean, or exports to Palen Dry Lake—Since the EIS/EIR was published, further analysis of these options has shown that the quantities of water that would have to be pumped in and out made them economically unfeasible, and other issues made them highly susceptible to regulatory challenges, and long-term delays.

Import of water from either periodic Colorado River flood flows or from the CASI project—These sources of water were determined to be too speculative to be considered as alternatives. It is possible that either of these sources of water could be considered in the future if their availability would become more likely.

The tabulation below presents additional information about the features of the export options, particularly the high costs of construction, OM&R, and energy that make them economically infeasible.

Features of Export Options Considered and Eliminated

	Export to Gulf of CA	Export to Pacific Ocean	Export to dry Lakebed
Discharge capacity			
(acre-feet per year)	250,000	250,000	250,000
(cfs)	345	345	345
Total distance (miles)	140	101	49
Pipeline (miles)	140	34	27
Diameter (inches)	112	112	112
Pumping plants, No.	2	5	4
Head (feet)	453	375	400
Tunnel (miles)		28.2	
Diameter (inches)		8.5	
Depth of shaft (feet)		1,500	
Pipeline (miles)		39	22
Diameter (inches)		89	89
Powerplants, No.		3	3
KW each		7,330	7,330
Costs			
Construction	$1,500 M	$1,140 M	$800 M
Annual OM&R	$1.7 M	$3.03 M	$3.25 M
Annual energy	17.3 M	$15.4 M	$19.0 M

cheap compared to the 5-7 Billion mitigation USFWS wants.

OVERVIEW OF PROJECT ALTERNATIVES

As previously mentioned, the Phase 1/Phase 2 strategy presented in the Draft EIS/EIR has been replaced by a modular strategy. The modular strategy has enabled the project planners to develop restoration alternatives that can be increased in capacity by adding modules. The modular strategy has facilitated the development of alternatives in parallel with the continued evaluation of possible future inflows to the Sea.

Using a modular approach allows for the planning and design of a base system that works if current inflow conditions extend into the future, and that can be expanded if inflows decrease in the future. At the same time, if during the planning process, decisions are made on the IID Transfer Project or any other projects that could affect future inflows, then the most likely future inflow scenario can be better defined. In such a case, project alternatives could be sized to respond to these inflows by selecting the appropriate number of modules that would be needed.

Modular Strategy for Developing Alternatives

The modular strategy involves two basic types of modules for salinity control:

- Salt removal modules
- Salt disposal modules

For each of these two types of modules, several technologies and configurations are being considered. Each salt removal module would remove about 1 million tons of salt per year from the Sea. The quantity of salt removed by a single module would increase if the salinity in the Sea should increase in the future. The salt products that would be extracted from the Salton Sea would be stored in a salt disposal module. Therefore, for every salt removal module constructed, one salt disposal module would be required.

The inflow of water to the Sea is about 1.3 million acre-feet per year, which contains about 5 (4.8) million tons per year of total dissolved solids (TDS). Water enters the Sea from the New, Alamo, and Whitewater Rivers; numerous agricultural drains; and other miscellaneous sources. It appears that between 0.25 and 1.4 million tons of that inflowing TDS precipitates each year. Therefore, to maintain the current salinity in the Sea, if there are no elevation changes, at least 4 million tons of TDS would need to be removed each year. More would need to be removed to reduce salinity.

If the amount of water that evaporates in a given year exceeds the amount of inflow, the elevation of the Sea's water surface will start to decline. This could occur because of withdrawals for restoration purposes, declining inflows resulting from water transfers from the basin, a combination of these factors, or other reasons. The Sea's elevation would continue to decline until the water surface becomes smaller and the amount of evaporation decreases to the point that it is once again in balance with inflows. Since evaporation does not remove salt, the salt concentration in the Sea will tend to increase because of declining elevation. If the Sea's water surface elevation begins to decline, more salt than just the inflow amount would need to be removed to maintain the current salt concentration.

The minimum configuration for a restoration alternative would involve four modules. This configuration would compensate for the incoming salt load. A significantly larger number of modules would be needed under reduced inflow scenarios. The number of modules needed under reduced inflow scenarios would depend on the type of module and the amount of inflow reduction. The number of modules needed for each alternative under reduced inflow scenarios is discussed later in this chapter.

Salt Removal

Two basic strategies are being considered for salt extraction: enhanced evaporation systems (EES) and solar evaporation ponds. Within each of these strategies, there are some variations in the specific technologies that are being considered.

The EES process involves spraying water in the air to accelerate the rate at which water evaporates. Two EES technologies are being considered: a tower system that would spray water from in-line showers and ground-based blower units that operate similar to snow-making equipment and agricultural spraying. After Salton Sea water passes through either type of EES, concentrated brine would remain that would be piped to a disposal module.

With the solar evaporation pond process, a series of shallow ponds would be constructed in series for each module. Salton Sea water would be pumped to the first pond and flow by gravity through the other ponds. The evaporative process would produce a brine that is saturated with salts in the last pond that would be pumped to the disposal module. Solar evaporation ponds could be located within the Salton Sea by constructing dikes, or on land, through the construction of berms.

Any reference to solar ponds later in this document should be understood to mean solar evaporation ponds.

The following types of modules are being evaluated for salt removal:

- EES using towers with in-line shower technology

- EES technology using turbo-enhanced units
- Solar evaporation ponds constructed on land
- Solar evaporation ponds constructed in the Salton Sea

In addition to these basic technologies, flat and steeper terrain factors were considered for on-land pond systems and shallow and deeper water conditions were considered for in-Sea pond systems. Table 2-2 provides basic information about five of the promising combinations of salt removal technology and terrain factors. The table includes information about the possible amount of area to site such facilities, based on a siting analysis discussed in a later section.

Table 2-2. Features of Salt Removal Modules

<table>
<tr><th></th><th>EES</th><th></th><th colspan="3">Solar Ponds</th></tr>
<tr><th>FEATURES</th><th>Ground-based EES</th><th>Tower EES</th><th>In-Sea Ponds (shallow water)</th><th>On-Land Ponds (flat terrain)</th><th>On-Land Ponds (steep terrain)</th></tr>
<tr><td>Liquid Inflow (ac-ft/yr)</td><td>17,000</td><td>17,000</td><td>17,000</td><td>17,000</td><td>17,000</td></tr>
<tr><td>Area Required (ac)</td><td>255</td><td>530</td><td>2,800</td><td>2,800</td><td>2,800</td></tr>
<tr><td>On-Land Area (sq mi)</td><td>0.4</td><td>0.8</td><td></td><td>4.4</td><td>4.4</td></tr>
<tr><td>In-Sea Area (sq mi)</td><td></td><td></td><td>4.4</td><td></td><td></td></tr>
<tr><td>SYNOPSIS</td><td>Ground-based turbo-enhanced evaporator units would spray water onto a sloping area; brine would be collected at the downslope side and recirculated or pumped to a disposal area; 288 units, arranged in a 6 X 48 array would operate 80% of the time.</td><td>Water would spray from "shower lines" strung between 32 towers constructed at heights of 100' and 150'. Brine would collect in ponds and be pumped to a disposal facility. The system would operate 60-65% of the time during the year.</td><td colspan="3">For each module a series of 10 ponds would be constructed, with the largest being about 1 sq mi. Water would be pumped into the largest pond and flow by gravity through the others in an essentially continuous flow process, with salinity increasing in successive ponds. Concentrated brine would be pumped from the final concentrator pond into a crystalizer/disposal facility. Ponds could include islands and snag/nesting and roosting features to enhance and diversify habitat. In-Sea dikes include a service road on top and rip-rap protection on the Sea-side. Total length, height, and width of dikes/berms for a single capacity module would be as follows:
<u>Location</u> <u>Length (mi)</u> <u>Height (ft)</u> <u>Top (ft)</u> <u>Base (ft)</u>
In-Sea 18.9 11' 30' 104'
Land-Flat 18.9 6' 12' 44'
Land-Steep 24.1 10' 12' 64'</td></tr>
<tr><th>COST FACTORS</th><th>Ground-based EES</th><th>Tower EES</th><th>In-Sea</th><th>Flat Land</th><th>Steeper Land</th></tr>
<tr><td>Initial Capital Cost ($M)</td><td>17.1</td><td>22.6</td><td>94.5</td><td>13.6</td><td>22.6</td></tr>
<tr><td>Yearly OM&R Cost ($M)</td><td>0.41</td><td>0.90</td><td>0.29</td><td>0.29</td><td>0.29</td></tr>
<tr><td>Yearly Energy Cost ($M)</td><td>3.17</td><td>0.30</td><td>0.02</td><td>0.13</td><td>0.12</td></tr>
<tr><td>Total PV ($M)</td><td>60.8</td><td>37.3</td><td>98.3</td><td>18.7</td><td>27.6</td></tr>
<tr><td>Cost Per Ton ($/ton)</td><td>2.03</td><td>1.24</td><td>3.28</td><td>0.62</td><td>0.92</td></tr>
</table>

Figure 2-1 provides a graphic comparison of cost estimates of the salt removal modules, showing both the initial construction (capital) cost and the total net present value. Net present value represents how much money would be needed today to provide for construction and the long-term operation, maintenance, repair and energy of a system.

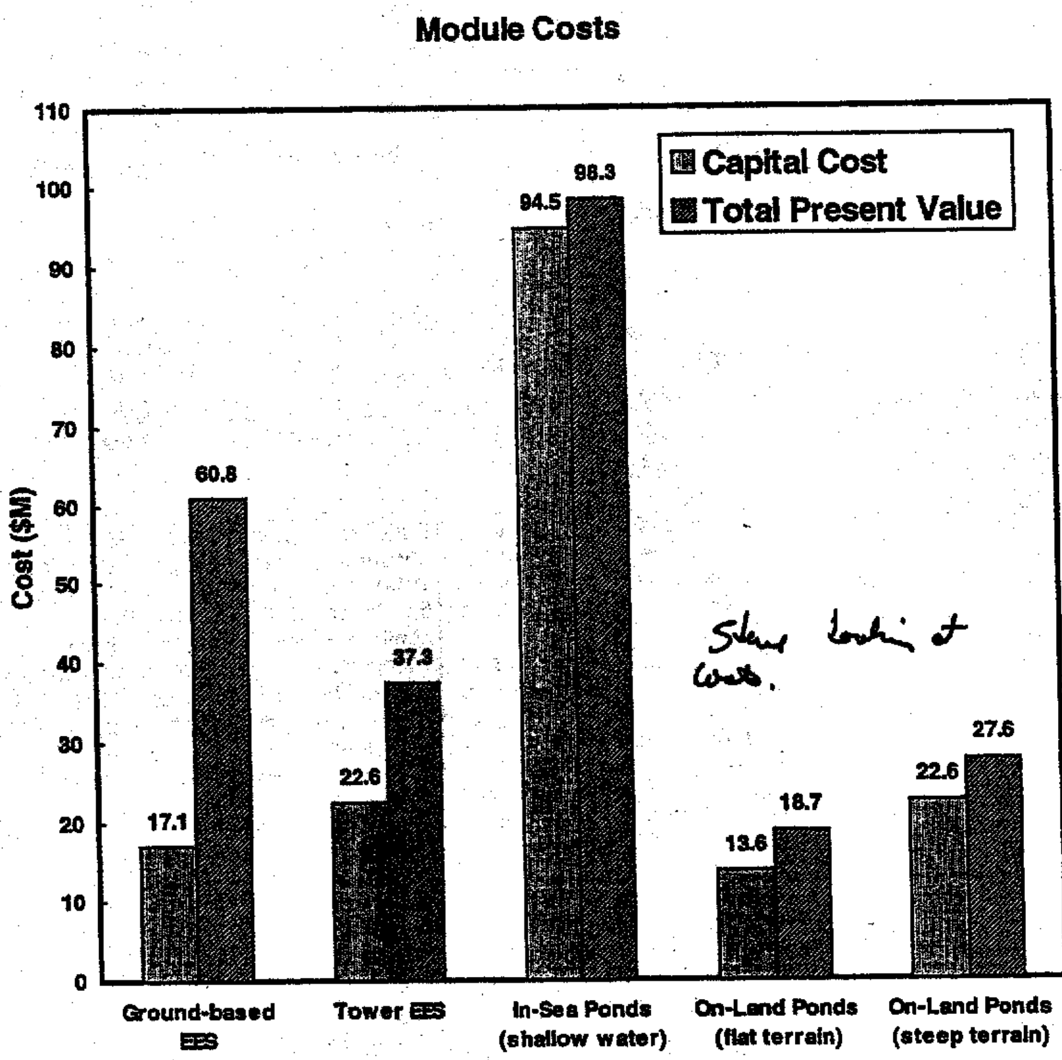

Figure 2-1. Estimated Cost of Salt Removal Modules

Salt Disposal

Restoration of the Sea may require disposal of crystallized salt and other solids. It is likely that crystallizer beds will be used to dispose of most of this material. Two types of products are commonly produced at commercial salt works: solid salts and bitterns. Solid salts typically form as a pavement-like bed in the final ponds of the salt works, which are known as crystallizer beds. Bittern is a general term for products that remain after most of the sodium chloride is crystallized. In some cases bittern products may form a semi-solid material that has the potential to attract atmospheric moisture and, therefore, may remain in a fluid-like state for an extended period of time. The chemical composition of the salts within the Salton Sea suggests that bittern products will consolidate. Pilot tests are now being conducted to more precisely define what products can be expected to form. The disposal facility designs are based on the assumption that virtually all salts and bitterns will be removed in crystallizer beds. An alternate design(s) with a separate bittern impoundment has been included in attachment A of this document.

Conceptual designs have been prepared for both on-land and in-Sea disposal of salt products. Table 2-3 provides basic information about these designs. The cost data provided in the table is based on siting in-Sea disposal facilities in shallow water and an average between costs for flatter and steeper terrain for on-land facilities.

For solid salt disposal, either on-land or in-Sea, the disposal options involve terracing the salts in what eventually would be comparable to a sanitary landfill. Initially, shallow ponds would be constructed using earthen berms where the solid salts would crystallize. As the salt deposits form, the berms would be built up higher on top of the existing salt deposits.

Table 2-3. Features of Salt Disposal Modules

FEATURES	In-Sea Terrace	On-Land Terrace
Liquid Inflow (ac-ft/yr)	2,225	2,225
Area Required (ac)	1,023	1,023
On-Land Area (sq mi)		1.6
In-Sea Area (sq mi)	1.6	
SYNOPSIS	Solid salts would be extracted in a series of 3 crystallizer ponds. On-land berms or in-Sea dike heights would be raised through a series of lifts throughout their design life. After 30 years, the total volume of fill in berms would be about six times the initial volume. During initial construction, berms/dikes would be similar in size to those described for solar ponds; after all lifts are constructed, maximum berms heights would be about 25 feet. The total length of berms or dikes for a single capacity module would range from about 7.6 miles in-Sea or on flat on-land terrain to 13.9 miles on steep terrain. Efficiencies in dike/berm construction could be achieved by constructing more than module at a given location.	
COST FACTORS	**In-Sea**	**On-Land**
Initial Capital Cost ($M)	34.9	5.0
Yearly OM&R Cost ($M)	0.31	0.29
Yearly Energy Cost ($M)	--	--
Total PV ($M)	38.6	8.5
Cost Per Ton ($/ton)	1.29	0.28

In addition to disposal of salt products, the joint lead agencies are also investigating possible commercial sale or recycling options for some of the salt products. At this time, no commercially viable options have been identified. However, if commercial options are identified, then disposal requirements would be reduced.

Siting Analysis

At the current stage of alternative development, specific locations where facilities can be sited have not been identified. Instead, a siting analysis was conducted to identify areas that would be generally suitable for locating salt removal and disposal modules. Separate analyses were conducted to identify areas suitable for each method of salinity control as well as for disposal of waste salts. The siting analyses included suitable areas for facilities that would be located on land as well as for facilities that would be constructed in the Salton Sea. In each case, different criteria were considered. For example, for on-land ponds the assessment involved the following criteria in order of importance from most to least: slope of land, soil characteristics, elevation above the Sea, distance from developed areas, and distance from the Sea. The analyses were conducted at the University of Redlands by the staff of the Salton Sea Database Program. Data layers were created for each criteria using Geographic Information System (GIS) software. Suitable areas were then modeled by assigning different weights to each layer and creating a composite suitable areas layer. The amount of land area identified through this process, for different facilities is identified in Table 2-4. A sample map showing suitable areas for on-land ponds is illustrated in Figure 2-2.

Table 2-4. Land Area Identified for Potential Siting of Salinity Control Facilities

Potential Siting Areas in Square Miles

	Salt Removal					Salt Disposal	
FEATURES	Tower EES	Ground-based EES	In-Sea Ponds	On-Land Ponds	On-Land Ponds on Ag Land	In-Sea	On-Land
Total Available Area (sq mi)	464	480	72	543	356	66	543
Most Suitable (sq mi)	53	36	9	41	34	15	41
Suitable (sq mi)	402	406	61	405	286	40	405
Least Suitable (sq mi)	9	38	1	96	37	10	96

Potential Siting Areas in Acres

	Salt Removal					Salt Disposal	
FEATURES	Tower EES	Ground-based EES	In-Sea Ponds	On-Land Ponds	On-Land Ponds on Ag Land	In-Sea	On-Land
Total Available Area (ac)	296,862	307,005	46,142	347,320	227,898	41,926	347,320
Most Suitable (ac)	34,044	22,961	5,993	26,489	21,582	9,795	26,489
Suitable (ac)	257,227	259,682	39,255	259,249	182,919	25,785	259,249
Least Suitable (ac)	5,591	24,362	894	61,582	23,397	6,346	61,582

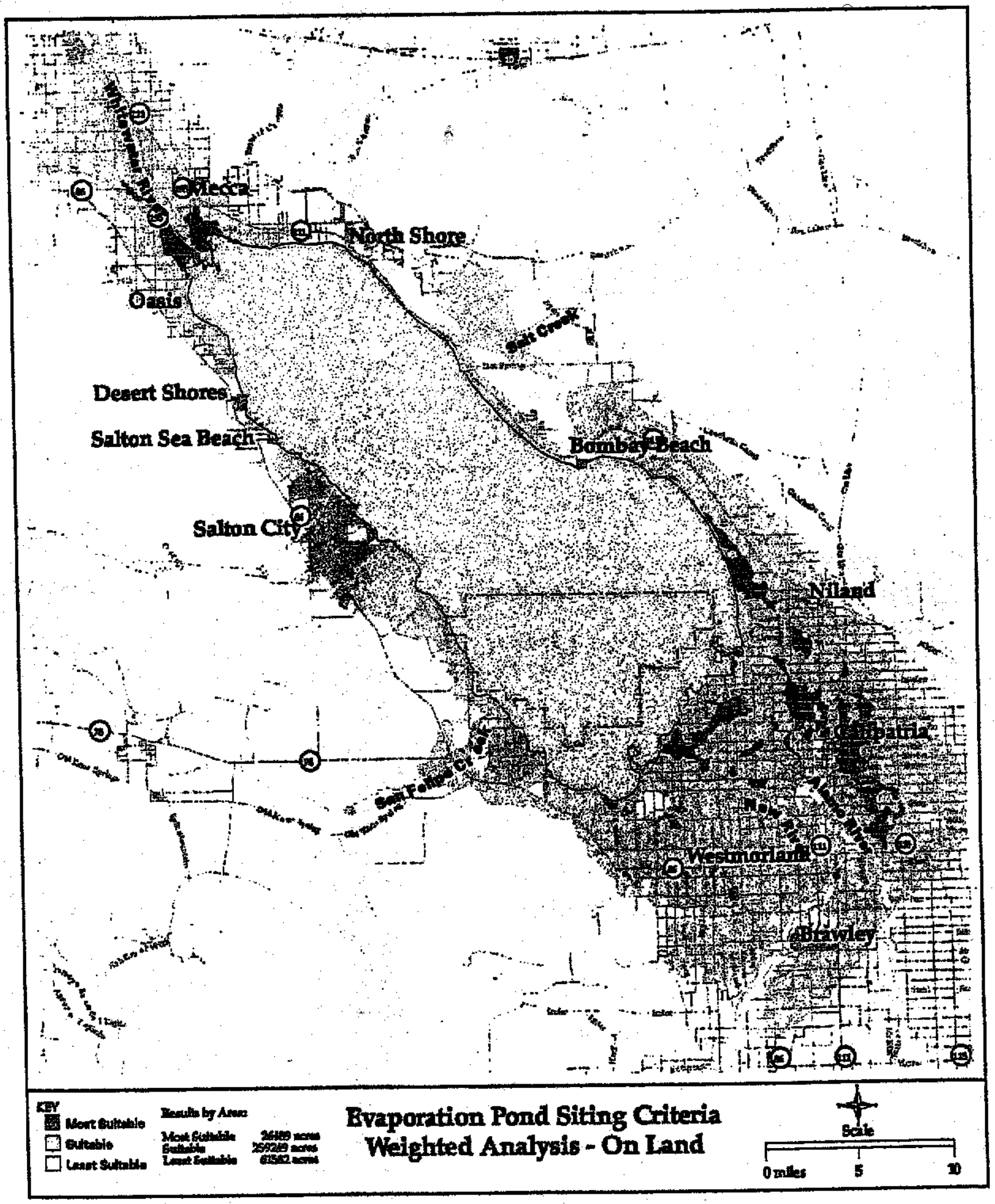

Figure 2-2. Sample Map Showing Suitable Areas for Solar Evaporation Ponds On Land.

Other Restoration Elements

In addition to salinity control measures, the following restoration elements could be included with any alternative. These elements are designed to address the project's multiple goals and objectives, when combined with salt removal and disposal actions. These elements are designed to help stem further degradation of the Sea and may be supplemented by later actions developed under the adaptive management efforts of the Salton Sea Restoration Project. The other restoration elements consist of the following possible actions:

- Wildlife disease control
- Created wetlands
- Recreational improvements
- Eutrophication assessment
- Shoreline clean up
- Fish harvesting
- Economic development assistance in lieu of TIF payment

Each of these elements is discussed in more detail in chapter 5 of this alternatives document. For planning purposes, it has been assumed that each of these elements will be included in each of the alternatives, except for the economic development assistance program. The economic development assistance program would be included in any alternative that would involve conversion of land currently in agricultural production to another use. As discussed below, two alternatives include conversion of agricultural land to other uses, and therefore, include economic development assistance.

Summary of Restoration Alternatives in This Document

The salt removal and disposal modules, along with other restoration elements have been grouped into six alternatives. The alternatives vary by the method of salt removal, solar ponds or EES, and the location, in Sea or on land. The number of salt removal modules required for each alternative will depend on the assumptions used for both baseline and future inflows. The number of modules and the land area requirements associated with each alternative for three different baseline inflow assumptions, combined with three possible future inflows are shown in Table 2-5.

The three baseline assumptions reflect the near-term uncertainties in the quantities of agricultural runoff of water that could be expected to reach the Sea

Table 2-5. Summary of Salinity Control Alternative Requirements for Different Baseline and Future Inflows

Baseline Inflow = 1.3 maf/yr

Alternative No.	Future Inflow Same as Baseline Inflow					Future Inflow = 1.0 maf/yr					Future Inflow = 0.8 maf/yr				
	Facility Requirements				Change in Land Use (acres)	Facility Requirements				Change in Land Use (acres)	Facility Requirements				Change in Land Use (acres)
	Number of Modules		Surface Area (acres)			Number of Modules		Surface Area (acres)			Number of Modules		Surface Area (acres)		
	On Land	In Sea	On Land	In Sea		On Land	In Sea	On Land	In Sea		On Land	In Sea	On Land	In Sea	
1	0	4	0	15,292	0	0	10	0	38,230	0	0	12	0	45,876	0
2	6	0	22,938	0	0	12	0	45,876	0	0	12	0	45,876	0	0
3	6	0	22,938	0	0	12	0	45,876	0	0	12	0	45,876	0	0
4	2	2	7,646	7,646	8,819	2	2	7,646	7,646	83,819	2	2	7,646	7,646	133,819
5	6	0	22,938	0	0	12	0	45,876	0	0	12	0	45,876	0	0
6	4	0	15,292	0	17,638	4	0	15,292	0	92,638	4	0	15,292	0	142,638

Baseline Inflow = 1.2 maf/yr

Alternative No.	Future Inflow Same as Baseline Inflow					Future Inflow = 1.0 maf/yr					Future Inflow = 0.8 maf/yr				
	Facility Requirements				Change in Land Use (acres)	Facility Requirements				Change in Land Use (acres)	Facility Requirements				Change in Land Use (acres)
	Number of Modules		Surface Area (acres)			Number of Modules		Surface Area (acres)			Number of Modules		Surface Area (acres)		
	On Land	In Sea	On Land	In Sea		On Land	In Sea	On Land	In Sea		On Land	In Sea	On Land	In Sea	
1	0	6	0	22,938	0	0	12	0	45,876	0	0	12	0	45,876	0
2	12	0	45,876	0	0	12	0	45,876	0	0	12	0	45,876	0	0
3	12	0	45,876	0	0	12	0	45,876	0	0	12	0	45,876	0	0
4	2	2	7,646	7,646	33,819	2	2	7,646	7,646	83,819	2	2	7,646	7,646	133,819
5	12	0	45,876	0	0	12	0	45,876	0	0	12	0	45,876	0	0
6	4	0	15,292	0	42,638	4	0	15,292	0	92,638	4	0	15,292	0	142,638

Baseline Inflow = 1.1 maf/yr

Alternative No.	Future Inflow Same as Baseline Inflow					Future Inflow = 1.0 maf/yr					Future Inflow = 0.8 maf/yr				
	Facility Requirements				Change in Land Use (acres)	Facility Requirements				Change in Land Use (acres)	Facility Requirements				Change in Land Use (acres)
	Number of Modules		Surface Area (acres)			Number of Modules		Surface Area (acres)			Number of Modules		Surface Area (acres)		
	On Land	In Sea	On Land	In Sea		On Land	In Sea	On Land	In Sea		On Land	In Sea	On Land	In Sea	
1	0	10	0	38,230	0	0	12	0	45,876	0	0	12	0	45,876	0
2	12	0	45,876	0	0	12	0	45,876	0	0	12	0	45,876	0	0
3	12	0	45,876	0	0	12	0	45,876	0	0	12	0	45,876	0	0
4	2	2	7,646	7,646	58,819	2	2	7,646	7,646	83,819	2	2	7,646	7,646	133,819
5	12	0	45,876	0	0	12	0	45,876	0	0	12	0	45,876	0	0
6	4	0	15,292	0	67,638	4	0	15,292	0	92,638	4	0	15,292	0	142,638

in the coming years. The upper value of 1.3 maf/yr reflects a condition that approximately represents the average inflow over the past few years. The values of 1.2 and 1.1 maf/yr have been used as two possible reduced baseline inflow scenarios. These values were selected because it is believed that they cover the range of possible near-term inflows. Baseline inflows may be lower than in the recent past as a result of a number of factors. For example, reduced flows may occur as a result of existing conservation agreements. Other factors are discussed in Chapter 3. The potential ~~IID-San Diego Water Transfer~~ project is not considered to be part of the reduced baseline inflows, but is included in the consideration of possible reduced future inflows.

In addition to evaluating three baseline inflow assumptions, three future inflow scenarios have been evaluated. The first scenario assumes that the future conditions are the same as the baseline. The second scenario, assumes that the baseline inflow is reduced by 20,000 af/yr until it reaches 1.0 maf/yr. The third future scenario assumes that the baseline inflow is reduced by 20,000 af/yr until it reaches 0.8 maf/yr. These scenarios recognize that future inflows to the Sea may be reduced by a number of factors, including the potential ~~IID-San Diego Water Transfer~~ Project.

Figures 2-3a and 2.3b through Figure 2.8 illustrate the estimated construction cost and present value of each alternative and the land requirements for the different baseline assumptions and future inflows. The estimated present value of an alternative is the amount of money that would be needed to cover the capital cost of land acquisition and construction and to establish a fund that would pay for OME&R costs over a 30-year period. Thirty years is selected as baseline period for comparing costs for planning purposes. In developing cost estimates for the alternatives, it has been assumed that each alternative would include all of the "Other Restoration Elements" discussed on page 2-26 of this report.

The six alternatives are as follows:

- **Alternative 1: In Sea Ponds** – In-Sea solar ponds with in-Sea terraced salt disposal would be constructed using standard dike construction procedures. As shown on Table 2-5, under the assumption that average baseline inflow is 1.3 maf/yr, and future inflow is the same as the baseline inflow, then the number of modules required would be four. Ten to twelve modules, depending on inflow assumption, would be needed if the inflow is reduced to 1.0 or 0.8 maf/yr.

- **Alternative 2: Ground-based EES** – Ground-based EES turbo-enhanced blower units would be constructed on land, and concentrated brine products would be pumped to an on-land terraced salt disposal facility or facilities. Under the assumption that average baseline inflow is 1.3 maf/yr, and future inflow is the same as the baseline inflow, then the number of EES modules required would be six. Twelve modules would be needed if the future inflow is reduced to either 1.0 maf/yr or 0.8 maf/yr.

- **Alternative 3: Tower EES** – An on-land EES tower configuration would be constructed with in-line showers and an on-land terraced salt disposal facility. The number of modules required would be the same as the requirements for Alternative 2 for all inflow scenarios.

- **Alternative 4: In-Sea and On-Land Ponds with Land Use Conversion** – This alternative would involve the construction of a combination of in-Sea solar ponds with in-Sea terraced salt disposal, and solar ponds constructed on agricultural lands with an on-land terraced salt disposal facility. Construction of facilities on agricultural land would free up water that had been used for irrigation and allow it to flow to the Sea. In addition, depending on the baseline inflow assumption and the future inflow scenario, additional land that is currently in agricultural production may be purchased or leased and allowed to be fallow. This process would allow water that would have been used for irrigation to flow to the Sea to compensate for reduced baseline or future inflows. Since no facilities would be constructed on this land, the parcels could be rotated or farmers could be provided subsidies to in lieu of cropping. For all inflow scenarios, this alternative would require two in-Sea modules and two on-land modules. It has been assumed that the two on-land modules would be constructed on 8,819 acres of agricultural land. Additional land use conversion would depend on the inflow scenario. No additional land use conversion would be required for the case where baseline and future inflows remain at 1.3 maf/yr. An additional 125,000 acres of land would need to be converted in the most extreme case where the average future inflow to the Sea is reduced to 0.8 maf/yr. When combined with the 8,819 acres of land for the modules, the total land use would be 133,819 acres for this extreme case.

- **Alternative 5: On-Land Ponds** – On-land solar ponds would be constructed along with on-land terraced salt disposal facilities. Under the assumption that average baseline inflow is 1.3 maf/yr, and future inflow is the same as the baseline inflow, then the number of on-land pond modules required would be six. Twelve modules would be needed if the future inflow is reduced to either 1.0 maf/yr or 0.8 maf/yr.

- **Alternative 6: On-Land Ponds with Land Use Conversion** – On-land solar ponds and terraced salt disposal facilities would be constructed on agricultural lands with land use conversion to provide supplemental water to the Sea. For all inflow scenarios, this alternative would require four on-land modules. It has been assumed that the four on-land modules would be constructed on 17,638 acres of agricultural land. Similar to Alternative 4, depending on the baseline inflow assumption and the future inflow scenario, additional land that is currently in agricultural production may be purchased or leased or subsidies could be provided to farmers to allow it to be fallow to provide additional water to the Sea. AS discussed for alternative this additional land use conversion could range from 0 to 125,000 acres. The amount of land use conversion, including the area for the modules, would vary as shown on Table 2-5.

Three charts have been prepared to illustrate the costs and land requirement for each future inflow scenario. Figures 2-3a and 2-3b illustrate the capital costs and total present value, respectively, of each alternative when the future inflow is equal to the baseline inflow. The charts show how the cost varies for each of the three baseline inflow assumptions. Figure 2-4 illustrates the land requirements associated with each alternative when the future inflow is equal to the baseline inflow. This chart also shows how land area requirements vary between each of the three baseline inflow assumptions. Figures 2-5a and 2-5b and 2-6 provide similar information for the case where the future inflow is equal to 1.0 maf/yr; and Figures 2-7a and 2-7b and 2-8 provide similar information for the case where the future inflow is equal to 0.8 maf/yr.

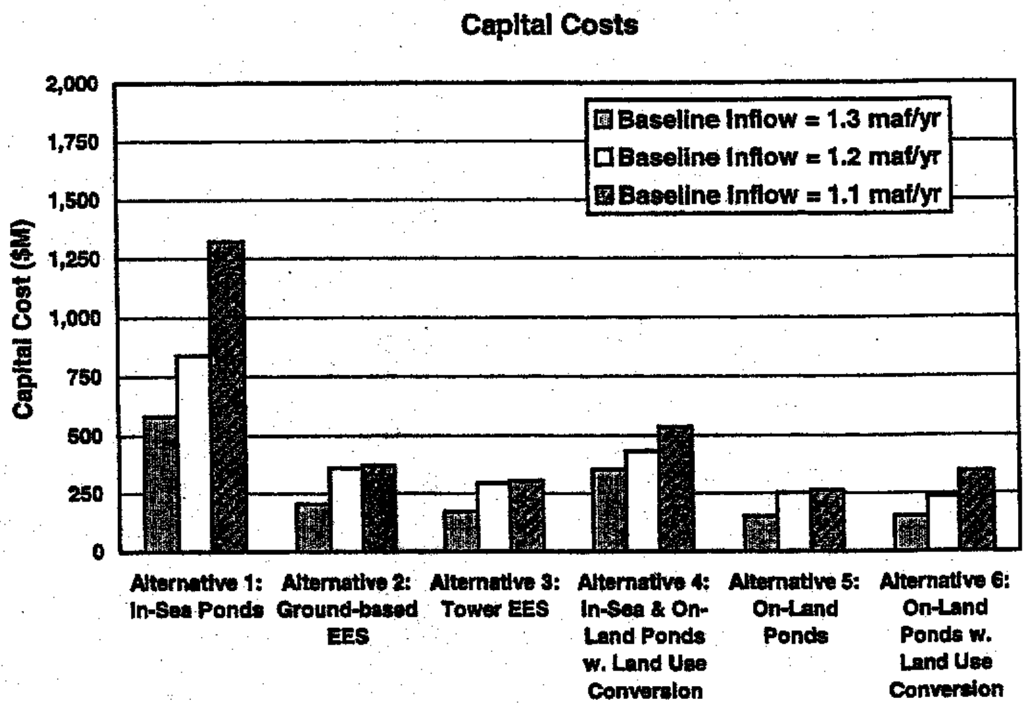

Figure 2-3a. Capital Cost of Alternatives with Future Inflow = Baseline Inflow

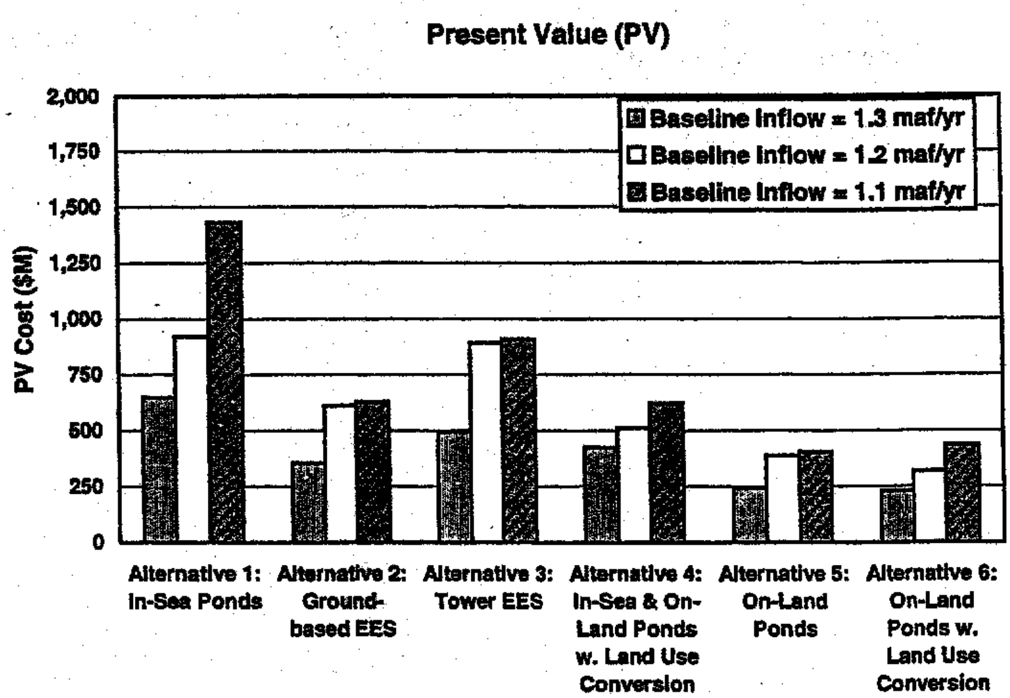

Figure 2-3b. Present Value of Alternatives with Future Inflow = Baseline Inflow

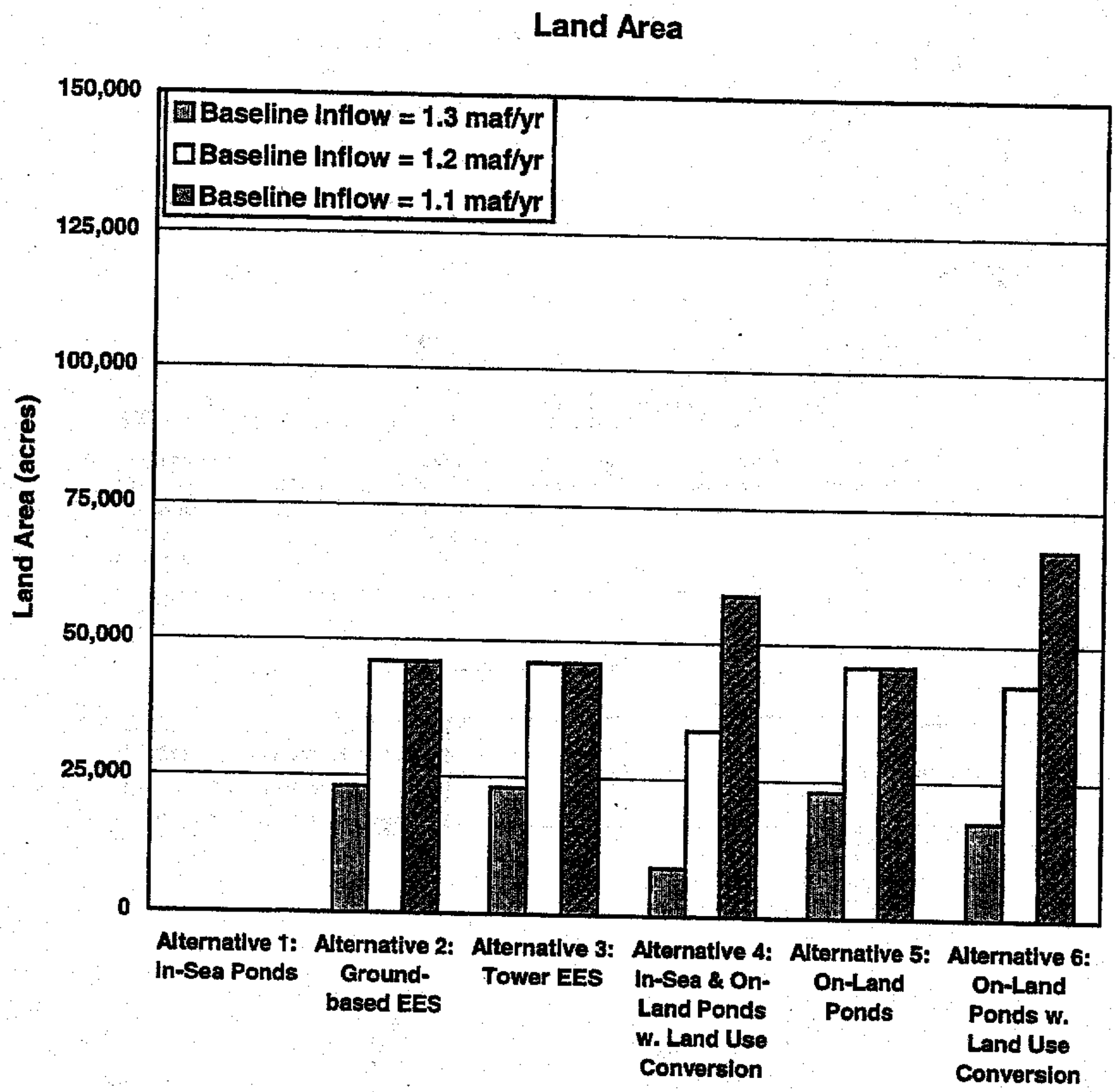

Figure 2-4. Land Area Requirements for Alternatives with Future Inflow = Baseline Inflow

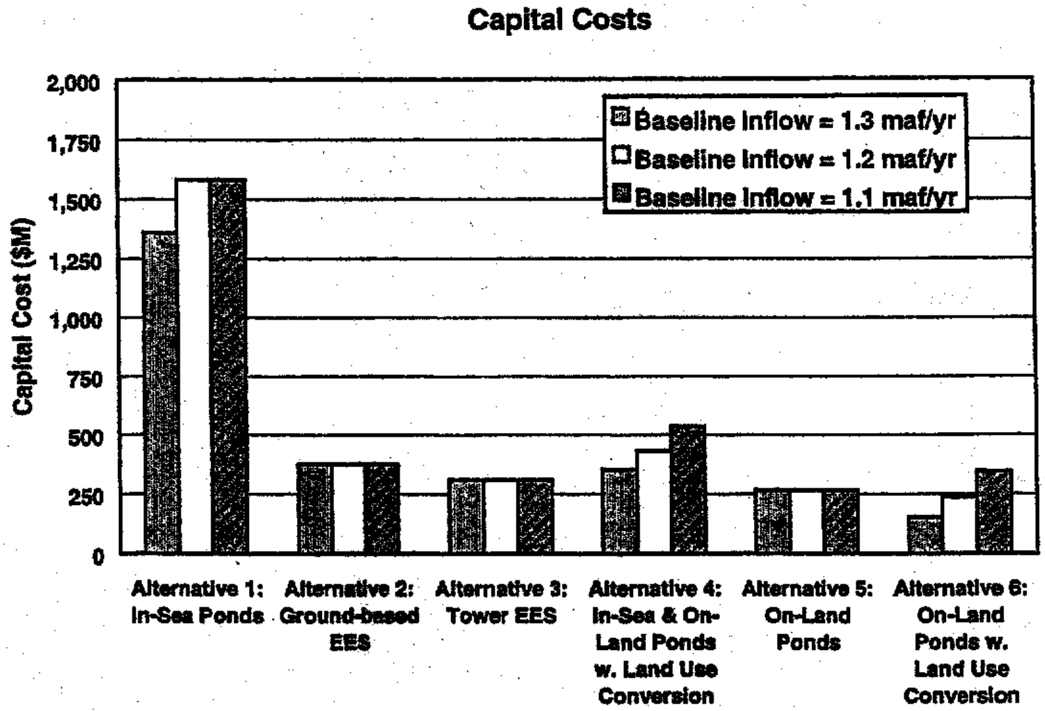

Figure 2-5a. Capital Cost of Alternatives with Future Inflow = 1.0 maf/yr

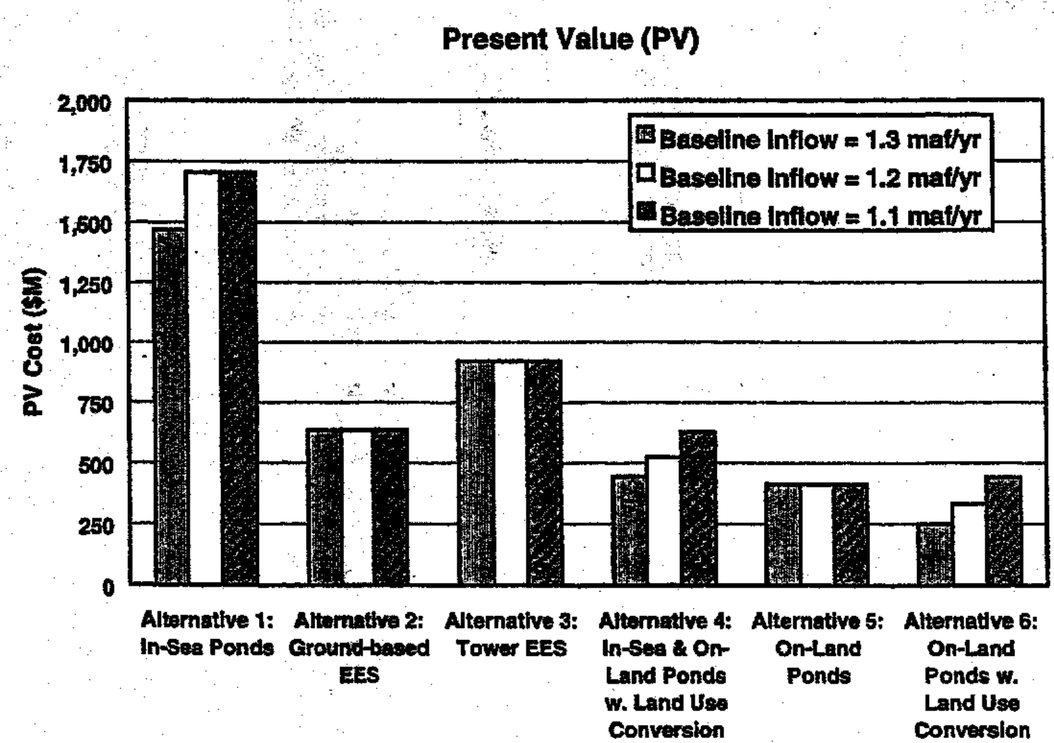

Figure 2-5b. Present Value of Alternatives with Future Inflow = 1.0 maf/yr

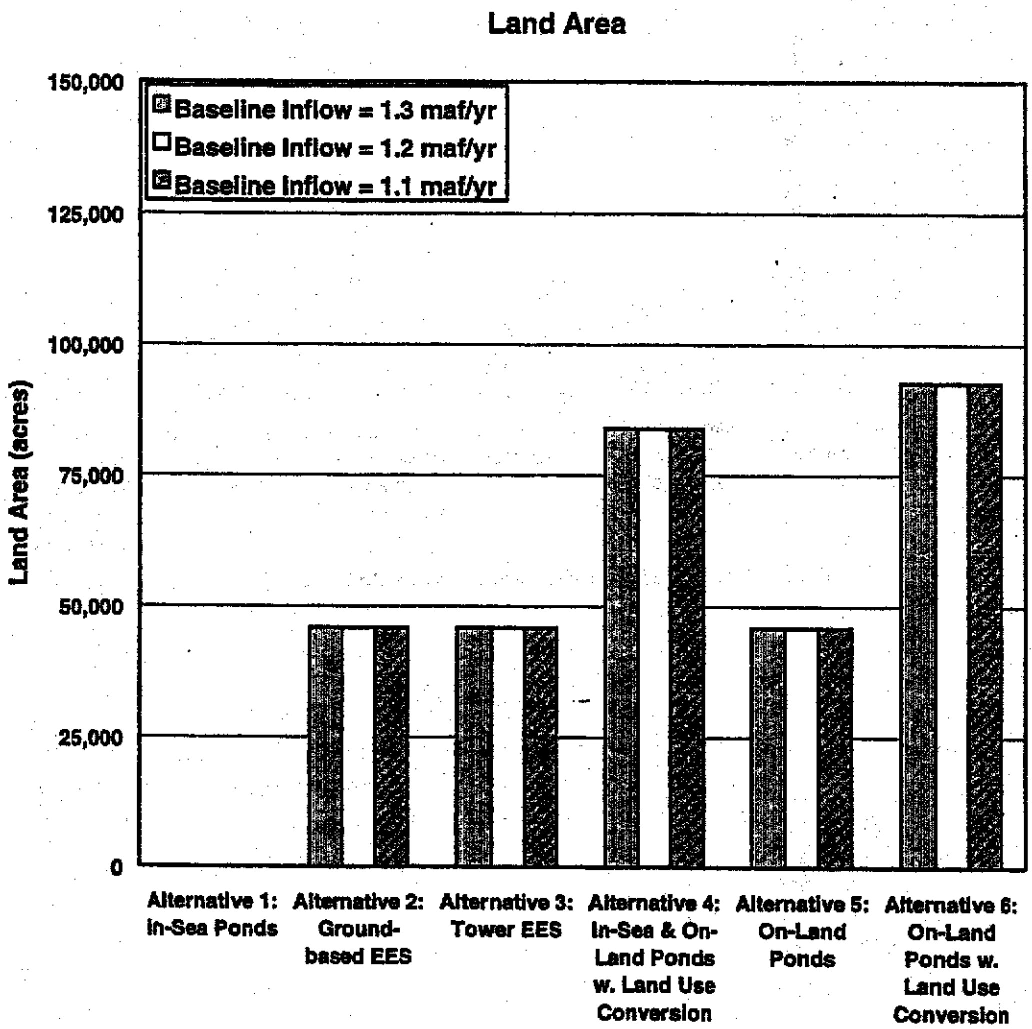

Figure 2-6. Land Area Requirements for Alternatives with Future Inflow = 1.0 maf/yr

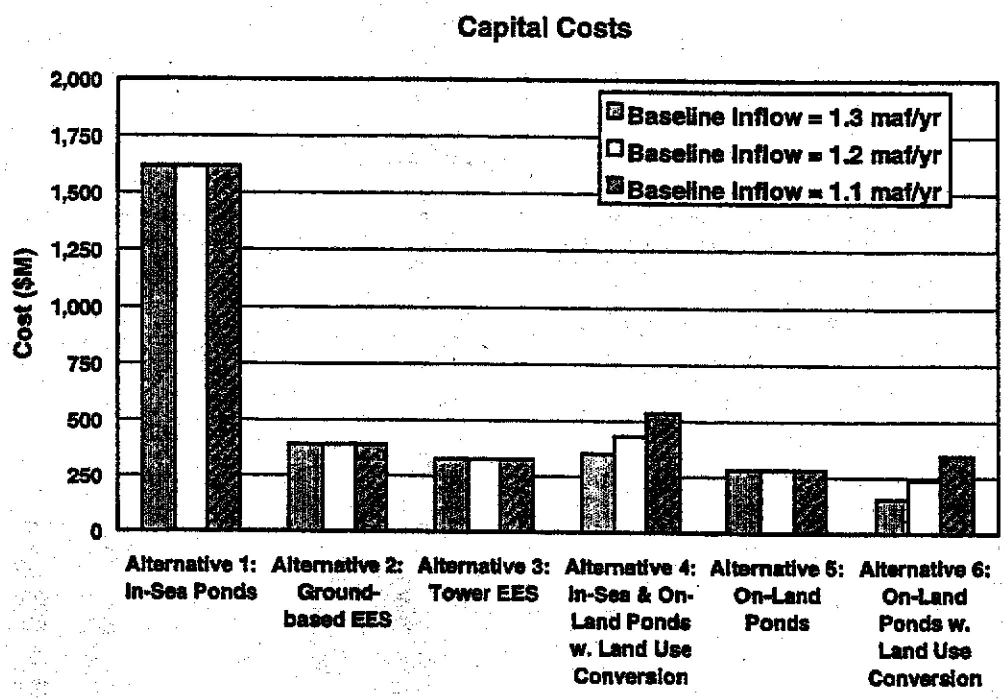

Figure 2-7a. Capital Cost of Alternatives with Future Inflow = 0.8 maf/yr

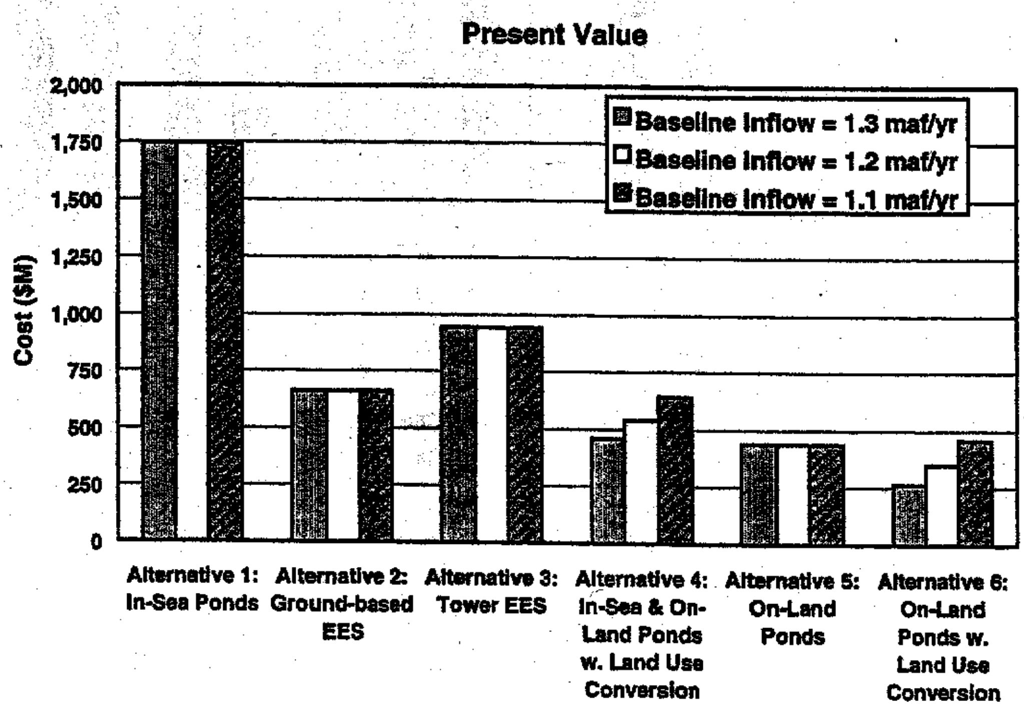

Figure 2-7b. Present Value of Alternatives with Future Inflow = 0.8 maf/yr

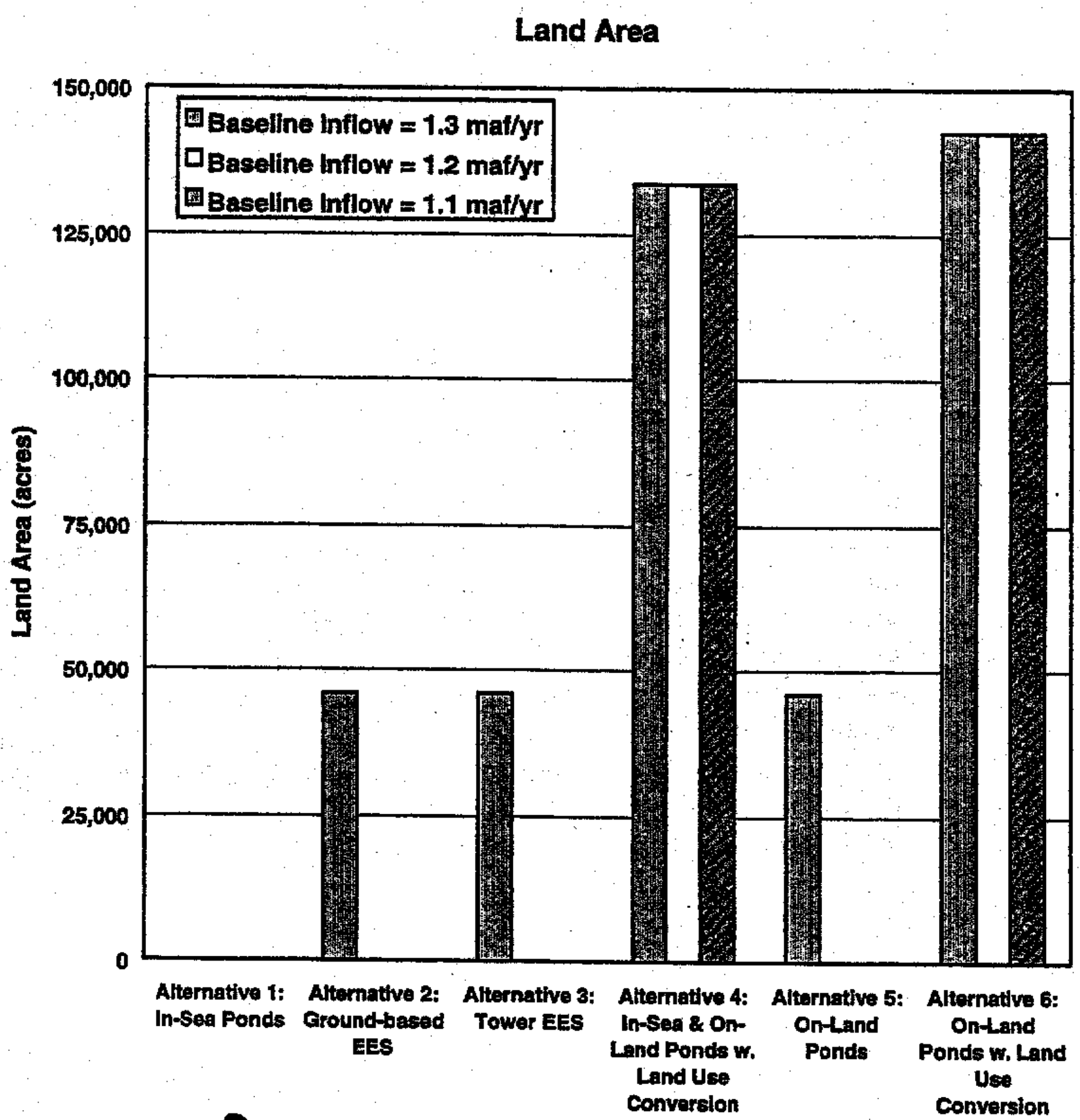

Figure 2-8. Land Area Requirements for Alternatives with Future Inflow = 0.8 maf/yr

Performance of Restoration Alternatives

The six restoration alternatives were evaluated using the Salton Sea Accounting Model discussed in Chapter 3 of this document. Simulations were performed for the three baseline inflow assumptions and the three future inflow scenarios shown in Table 2-5. For each set of average baseline and future inflow conditions a large number of hypothetical sequences of future inflows (stochastic) were modeled for the no project case and for each alternative. The mean simulation results are being reported.

The model results for four combinations of baseline and future inflow conditions have been selected for presentation on the following pages. These combinations were selected to illustrate how the baseline inflows affect the Sea and the performance of the project alternatives and to illustrate the full range of effects of the future inflow scenarios that have been evaluated. For each set of baseline and future inflow conditions, predicted future values of three parameters are shown: salinity, water surface elevation, and quantity of salt removed. The results of the model runs are presented in Figures 2-9a and 2-9b through 2-12a and 2-12b for four different combinations of baseline assumptions and future inflow scenarios. These four combination present the widest perspective on the scope and performance of the six restoration alternatives under the different baseline and reduced future inflows. Figure 2-13 shows the total quantity of salt that would need to be deposited in disposal facilities over a 30-year period of operation for the same four combinations of baseline assumptions and future inflow scenarios.

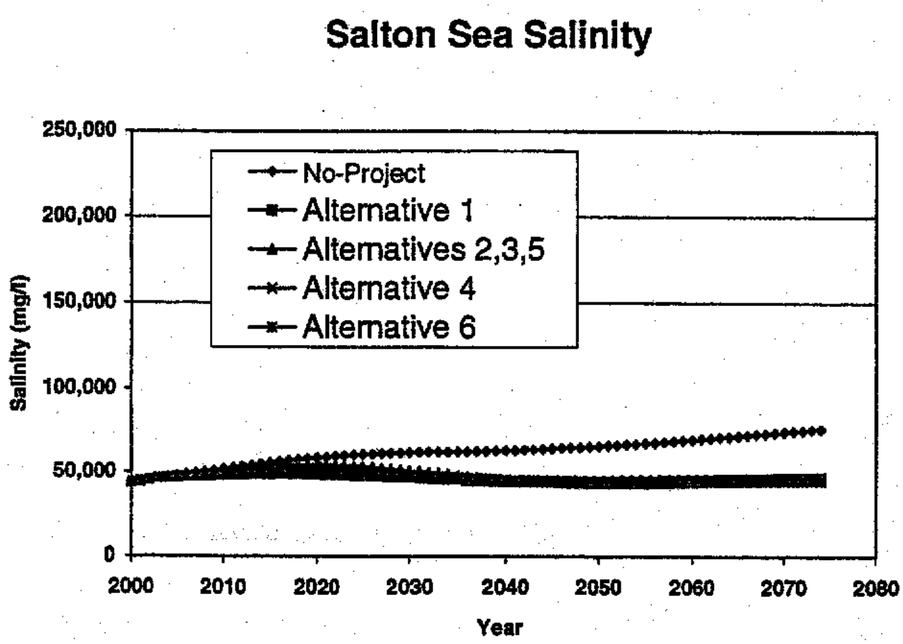

Figure 2-9a. Salinity at Baseline and Future Inflow = 1.3 maf/yr

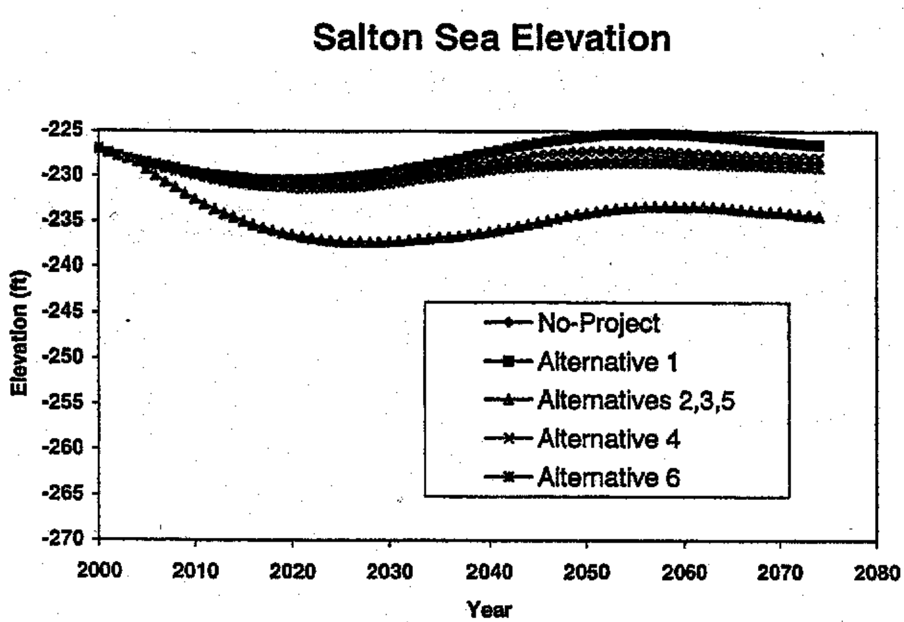

Figure 2-9b. Water Surface Elevation at Baseline and Future Inflow = 1.3 maf/yr

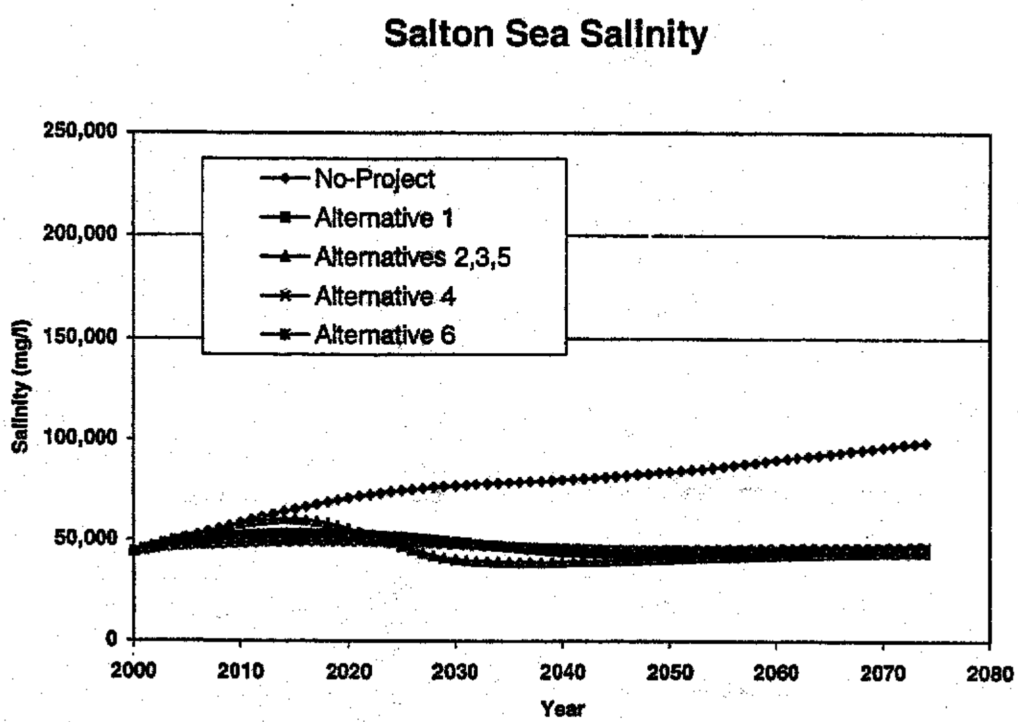

Figure 2-10a. Salinity at Baseline and Future Inflow = 1.2 maf/yr

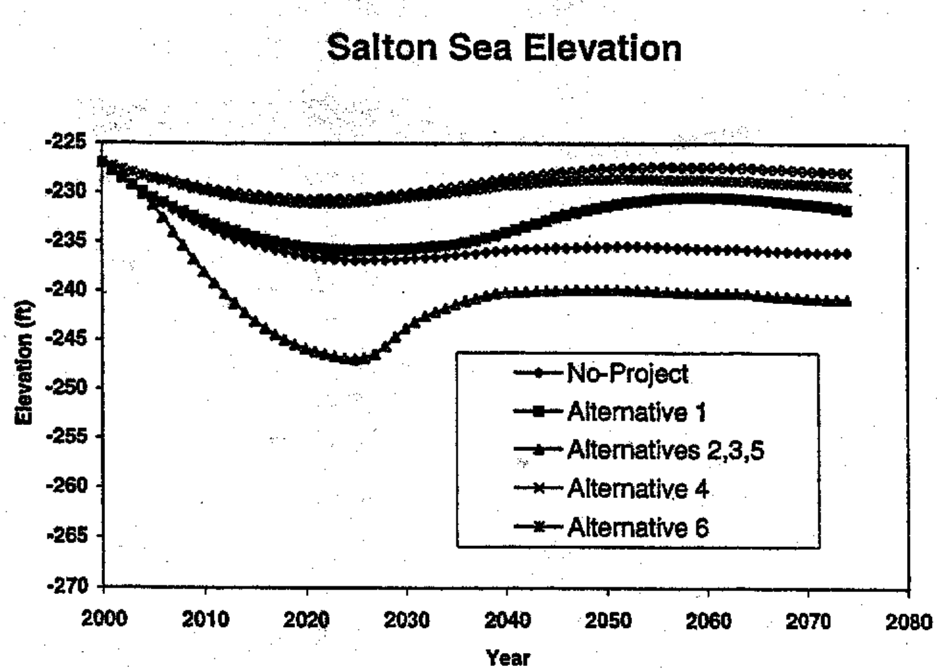

Figure 2-10b. Water Surface Elevation at Baseline and Future Inflow = 1.2 maf/yr

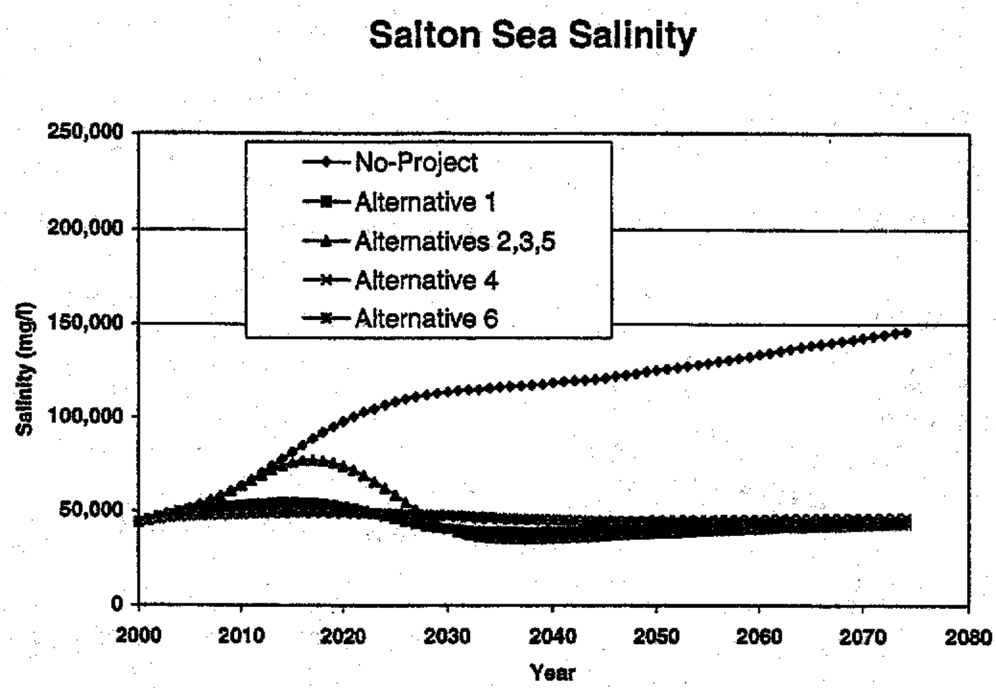

Figure 2-11a. Salinity at Future Inflow = 1.0 maf/yr from Baseline of 1.2 maf/yr

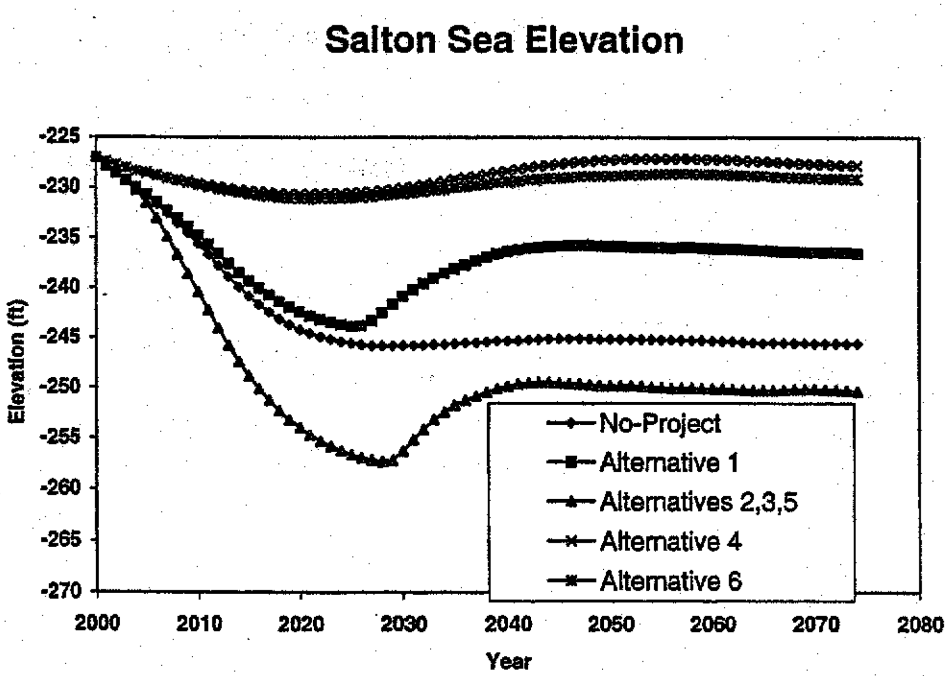

Figure 2-11b. Water Surface Elevation at Future Inflow = 1.0 maf/yr from Baseline of 1.2 maf/yr

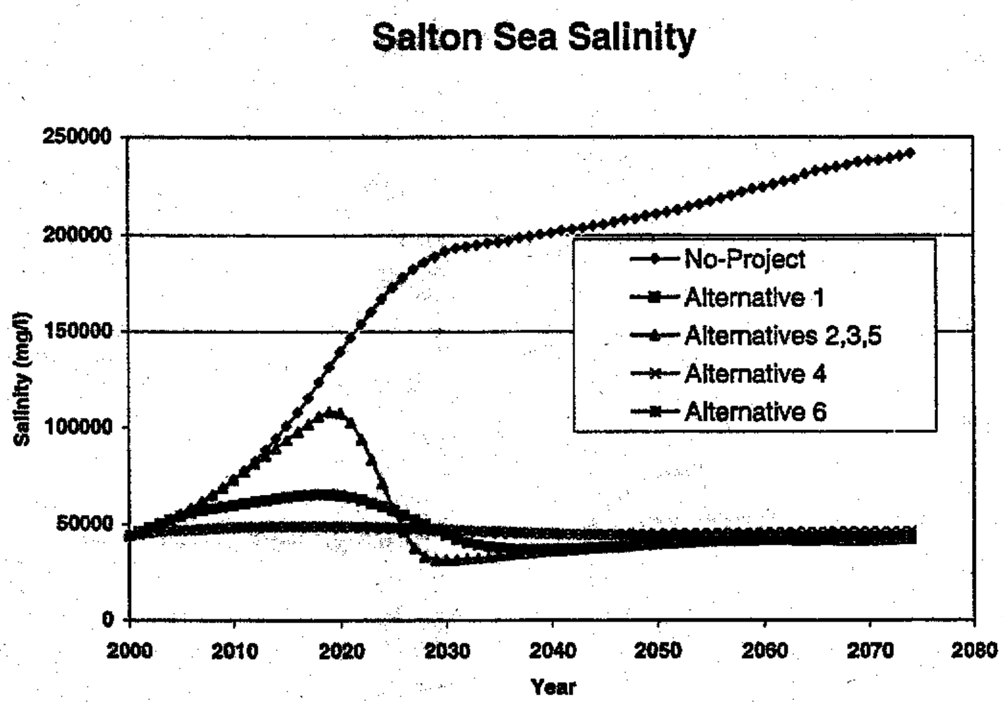

Figure 2-12a. Salinity at Future Inflow = 0.8 maf/yr from Baseline of 1.1 maf/yr

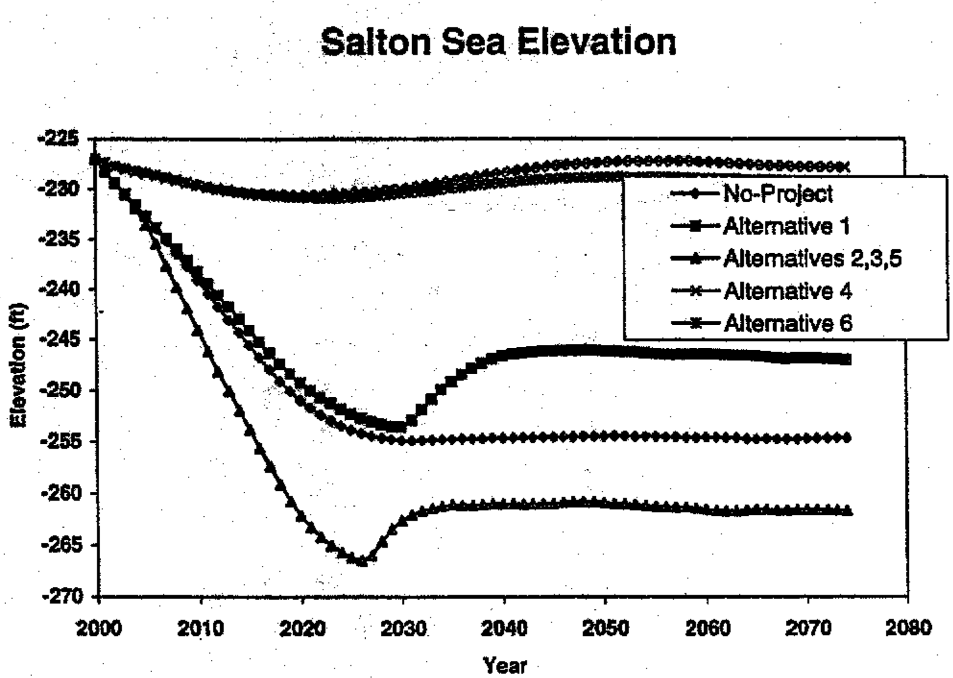

Figure 2-12b. Water Surface Elevation at Future Inflow = 0.8 maf/yr from Baseline of 1.1 maf/yr

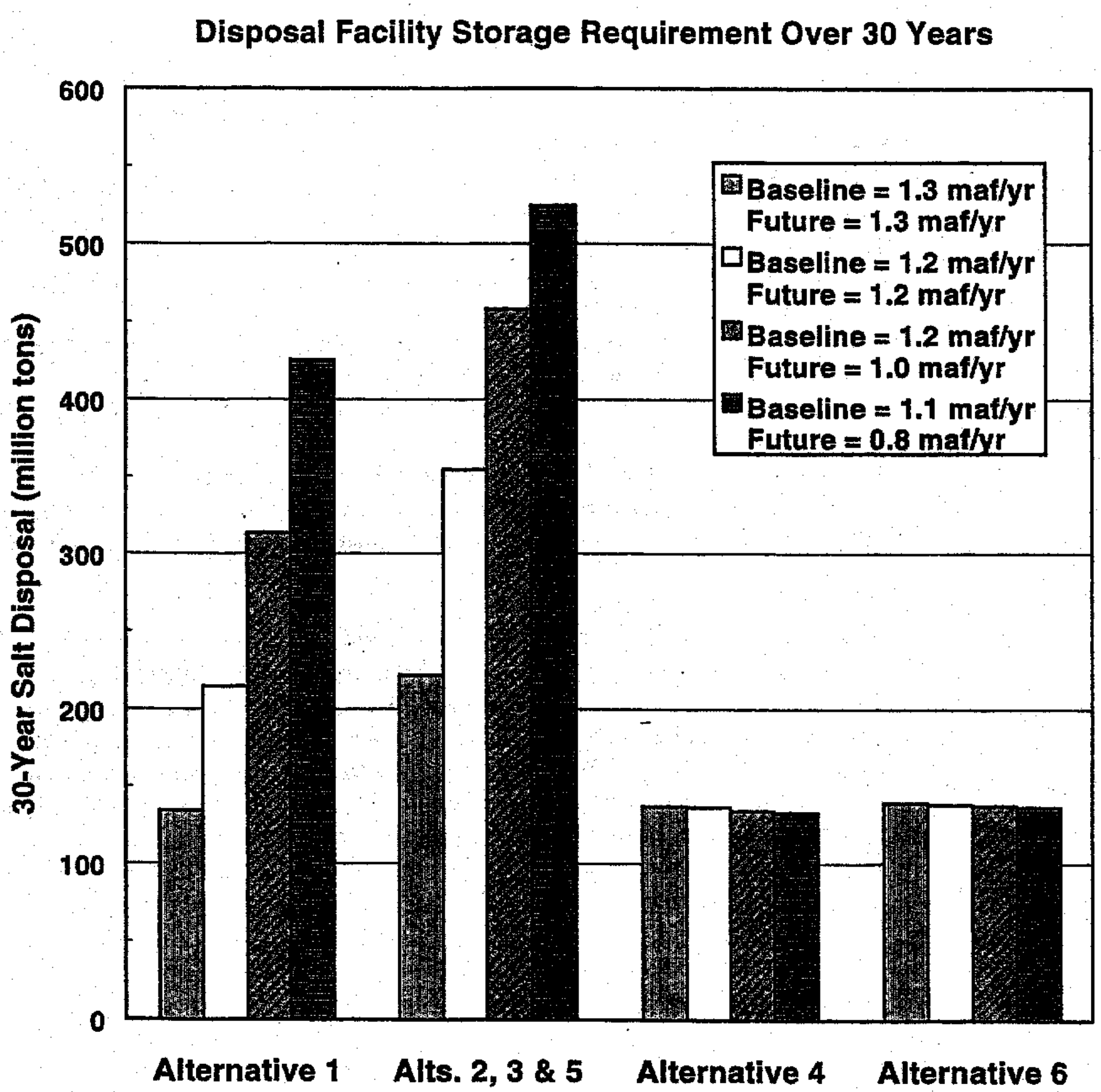

Figure 2-13. Quantity of Salt Disposal Over 30 Years

Discussion of Model Results

The model results for each of the four sets of baseline and future inflow conditions are discussed briefly below:

Baseline and Future Inflow Both Equal 1.3 maf/yr. Under this scenario, average baseline and future inflows would remain similar to the average inflow of the recent past. This combination of inflows provides the best opportunity for maintaining or improving conditions at the Sea. Figure 2-9a shows the projected future values of salinity in the Sea for each of the alternatives for the case where the future inflow is the same as the 1.3 maf/yr baseline inflow. Figure 2-9b shows the projected values of water surface elevation over time for the same inflow conditions as shown in Figure 2-9a. Under these inflow conditions, Alternatives 1, 4 and 6 each require the construction of four salt removal modules and Alternatives 2, 3 and 5 each require six modules. All alternatives are ultimately able to control salinity. Alternatives 1, 4 and 6 are better able to maintain the elevation of the Sea near its present level. Of these alternatives, Alternative 6 would be the least expensive and, therefore, would be the most cost effective.

Baseline and Future Inflow Both Equal 1.2 maf/yr. Under this scenario, average baseline and future inflows would be approximately 100,000 af/yr lower than the average inflow of the recent past. This combination of inflows illustrates how a sudden drop in the average inflow would affect conditions at the Sea. Figures 2-10a and 2-10b show the projected values of salinity and water surface elevation, respectively, for each of the alternatives for the case where the average baseline and future inflow both equal 1.2 maf/yr. Under these inflow conditions, Alternatives 4 and 6 still each require the construction of only four salt removal modules; however, the number of acres of agricultural land to be converted to fallow conditions would be greater than for the 1.3 maf/yr scenario discussed under point 1 above. Alternative 1 would now require six modules as compared to four modules under the conditions of point 1. Alternatives 1, 4 and 6 are still able to control salinity and maintain the elevation of the Sea near its present level. Alternatives 2, 3 and 5 are not as effective in controlling salinity and would each cause a significant decrease in the elevation of the Sea surface. Alternatives 4 and 6 would require the least handling and disposal of salt products. Of these alternatives, Alternative 6 would be the least expensive and, therefore, would be the most cost effective.

Baseline Inflow Equals 1.2 maf/yr and Future Inflow Equals 1.0 maf/yr. Under this scenario, the average baseline inflow would be approximately

100,000 af/yr lower and the average future inflow would be about 300,000 af/yr lower than the average inflow of the recent past. This combination of inflows illustrates how a sudden drop in the average inflow combined with a future reduction would affect conditions at the Sea. Figures 2-11a and 2-11b show the projected values of salinity and water surface elevation, respectively, for this inflow scenario. Under these inflow conditions, only Alternatives 4 and 6 perform satisfactorily in controlling salinity and maintaining water surface elevation. Of these alternatives, Alternative 6 would be the least expensive and, therefore, would be the most cost effective.

Baseline Inflow Equals 1.1 maf/yr and Future Inflow Equals 0.8 maf/yr. Under this scenario, the average baseline inflow would be approximately 200,000 af/yr lower and the average future inflow would be about 500,000 af/yr lower than the average inflow of the recent past. This combination of inflows represents the worst combination of conditions that are being considered at the Sea. Figures 2-12a and 2-12b show the projected values of salinity and water surface elevation, respectively, for each of the alternatives for this inflow scenario. Under these inflow conditions, only Alternatives 4 and 6 perform satisfactorily in controlling salinity and maintaining water surface elevation, while the other alternatives perform even more poorly than for the conditions discussed under point 3 above. Of the two alternatives that do perform well, Alternative 6 remains the least expensive and, therefore, would be the most cost effective.

Conclusions

For all inflow combinations, Alternative 6 would be the most cost effective and would be successful in controlling salinity while maintaining water surface elevation near its current level. needs to drop 3 feet – dikes & lower ht protection

Importance of Land Use Conversion

The charts show clearly that by including land use conversion with Alternatives 4 and 6, they are able to perform satisfactorily over the full range of inflow scenarios. The other alternatives are not effective when either the baseline or future inflows are substantially reduced. With the addition of conversion of some agricultural land to fallow conditions could make all other alternatives more effective.

Alternative 1/In-Sea Ponds. With the proper amount of land use conversion, an in-Sea pond system could be effective in controlling salinity. Four modules would be needed, which would involve building dikes to enclose about 24 square miles of the Sea surface, which represents about 6 percent of its present surface area. The land use conversion would be required to provide water to compensate for reductions of baseline or future inflows. Ultimately about 25,000 acres would need to be converted to fallow conditions for every 100,000 af of future reduction of the average inflow compared to the recent past. If the baseline is lower than the recent past, then the same areas would need to be fallowed immediately while others could be phased in over time. For example, under a baseline inflow assumption of 1.2 maf/yr (100,000 af/yr lower than the recent past) and a future inflow of 1.0 maf/yr (300,000 af/yr lower than the recent past), 25,000 acres would need to be converted immediately and an additional 50,000 acres could be converted to fallow conditions gradually over a ten year period. Since no facilities would be constructed on the fallow land, the land could be purchased outright or rotated by providing subsidies to farmers. The total present value of such an alternative is estimated at $610 million plus whatever costs are involved in land use conversion. The primary advantage of an in-Sea pond system would be that all construction and salt disposal would be accomplished within the Sea. Disadvantages include the higher costs of constructing solar ponds within the Sea and possible environmental issues.

Alternatives 2 and 3/EES. With the proper amount of land use conversion, EES units would perform the same as on-land pond systems, and would be equally effective in controlling salinity. Only four EES modules would be needed, regardless of the baseline and future inflow scenario. The land use conversion required to provide water to compensate for reductions of baseline or future inflows would be the same as the amounts shown on Table 2-5 for Alternative 6 for all inflow scenarios. The total present value of such an alternative is estimated at $254 million if ground-based EES units are used and $348 million if tower system is used, plus whatever costs are involved in land use conversion. Since the land use requirements would be the same as for a solar pond system, the EES units do not offer any particular advantages over a pond system, and they would have higher construction and energy costs.

Alternative 5/On-Land Ponds. Alternative 5 is similar in concept to Alternative 6, except that land use conversion has been included in the Alternative. The addition of land use conversion allows the number of modules to be maintained at four for all inflow scenarios and provides for outstanding performance at all inflows. Comparing Alternatives 5 and 6 illustrates the importance of land use conversion in the success of the project.

The Coachella Valley Water District has agreed to provide information about how the conversion of agricultural land use to fallowing conditions could be accomplished.

Process for Evaluating Restoration Alternatives

The alternatives were evaluated using a numerical scoring process that takes into account performance, environmental, issues and cost. Performance was evaluated with respect to the program goals and objectives within the context of the restoration project framework, all of which are discussed earlier in this chapter. Environmental factors were evaluated on the potential of an alternative to affect conditions at or near the Sea within seven environmental resource categories. Cost was rated on the estimated net present value of the alternatives, where net present value is a factor that combines capital construction costs with the amount of money that would be needed in the present to pay for operation, maintenance, energy, and repairs over 30 years.

Each of the salinity control alternatives was evaluated under the following future inflow conditions: (1) future inflows are the same as baseline inflows and (2) future inflows are reduced to either 1.0 maf/yr or 0.8 maf/yr. Further, each of the alternatives was scored on a scale of 0 to 5 where 0 represented the worst situation (least effective as a performance factor, most environmentally damaging, or most costly) and 5 represented the best situation. The general criteria are provided in Table 2-6. The specific criteria along with more details of the scoring process are provided in Chapter 4 of this document.

Table 2-6. General Scoring Values Used in Alternatives Evaluation.

Score	Performance Evaluation	Environmental Considerations	Cost Evaluation
5	Fully meets or exceeds performance objective	No adverse effects/may be beneficial	Lowest cost alternative
4	Has strong contribution to objective	No adverse effects	20% to 50% more than lowest cost alternative
3	Contributes to objective	Minimal adverse effects or some adverse effects offset by beneficial effects	50% to 100% more than lowest cost alternative
2	Contributes to objective, but with substantial restrictions	Adverse effects/can be mitigated	Two to three times the cost of lowest cost alternative
1	Likely to provide slight contribution to objective, but difficult to subtantiate	Significant but mitigable effects	Three to five times the cost of lowest cost alternative
0	May have adverse effect on objective	Significant effects cannot be mitigated	Greater than five times the cost of lowest cost alternative

Highest Rated Alternatives

Alternatives 5 and 6, on-land ponds with on-land disposal, without and with land use conversion to provide make-up water, respectively, scored the highest for the case where future inflows are the same as baseline inflow conditions. Alternative 6 also scored significantly higher than all other alternatives for reduced future inflow conditions. Alternative 4, which combines in-Sea and on-land ponds, with land use conversion, came in second for reduced inflow conditions. The scoring results are summarized in Table 2-7.

Table 2-7. Summary of Evaluation of Salinity Control Alternatives

EVALUATION FACTORS		Alternative 1: In-Sea Ponds	Alternative 2: Ground-based EES	Alternative 3: Tower EES	Alternative 4: In-Sea & On-Land Ponds w. Land Use Conversion	Alternative 5: On-Land Ponds	Alternative 6: On-Land Ponds w. Land Use Conversion
PERFORMANCE FACTORS							
Future Inflow Same As Baseline	Consider	2.88	3.38	3.38	3.75	3.50	3.88
Future Inflow = 1.0 maf/yr or Less	Consider	3.63	3.38	3.38	3.88	3.63	4.00
ENVIRONMENTAL FACTORS							
Future Inflow Same As Baseline		3.00	2.43	2.29	2.71	3.00	2.86
Future Inflow = 1.0 maf/yr or Less		2.86	2.14	2.00	2.71	2.71	2.71
COST FACTORS							
Future Inflow Same As Baseline		2.00	3.00	2.00	3.00	5.00	5.00
Future Inflow = 1.0 maf/yr or Less		2.00	3.00	2.00	3.00	4.00	5.00
ALL FACTORS -- WEIGHTED AVERAGE							
Future Inflow Same As Baseline		2.47	2.95	2.42	3.12	4.13	4.18
Future Inflow = 1.0 maf/yr or Less		2.62	2.88	2.34	3.15	3.58	4.18

GUIDE TO THIS DOCUMENT

The remainder of this document consists of three major chapters. Chapter 3 describes the methods that were used to evaluate the present and future hydrologic conditions at the Sea, including inflows, salinity, and water elevations under different inflow scenarios, both with and without project alternatives. Chapter 4 describes the possible methods for salinity control and for disposition of salt products and how they could be combined into restoration alternatives. Chapter 4 also provides more detailed information on the alternative evaluation projects. Chapter 5 describes other restoration elements that are not specifically related to salinity control. These elements were described briefly earlier in this Chapter 2.

Chapter 3
HYDROLOGY

Historic and potential future inflows to Salton Sea have been studied in detail by the Bureau of Reclamation, Imperial Irrigation District (IID), and Coachella Valley Water District (CVWD) (Weghorst, 2001). This hydrology work has served as the basis for the development of the Salton Sea Accounting Model which is also being used in the evaluation of effects on the Salton Sea due to other ongoing water agreements and transfer efforts. This model has been used in support of the Salton Sea Restoration Project Alternatives Report. Following is a an overview of historic and predicted future hydrology for the Sea

HISTORY

Historic Inflows

Inflows to the Salton Sea are not constant and have varied from a minimum of 1.19 maf/yr in 1992 to a maximum of 1.50 maf/yr in 1963. Figure 3-1a depicts a history of inflows into the Salton Sea for the years 1950 to 1999 (Weghorst, 2001). Average annual inflows for this same period were 1.34 maf/yr. The historic salt load into the Salton Sea has also been variable. Figure 3-1b presents a history of salt load to the Sea. A minimum load of 3.52 million tons occurred in 1950. A maximum salt load of 6.38 million tons occurred in year 1976. The average annual salt load to the Salton Sea for the period 1950 to 1999 was 5.2 million tons/yr.

Historic Salinity and Elevation

Presently the Salton Sea has an average salinity level of about 44,200 mg/L (Weghorst, 2001). Expectations are that salinity levels within the Sea will continue to increase in the future as a result of evaporation and continuous inflows of salt laden water from agricultural water use by irrigation districts around the Sea and from agricultural and municipal use in Mexico.

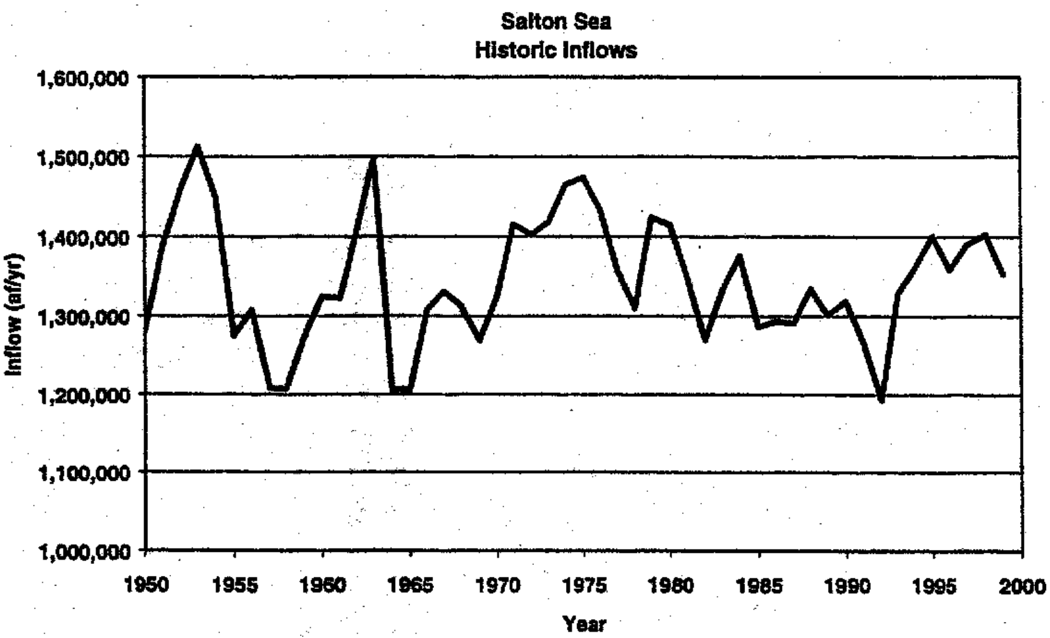

Figure 3-1a. Total Historic Salton Sea Inflows (Source: Weghorst, 2001)

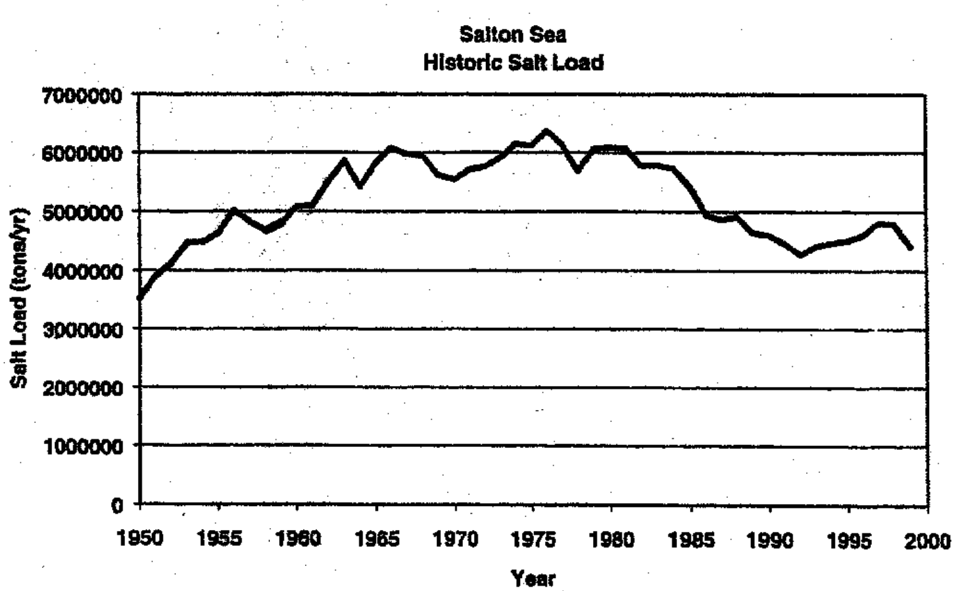

Figure 3-1b. Total Historic Salton Sea Salt Load (Source: Weghorst, 2001)

Imperial Irrigation District (IID) on an annual basis determines average salinity for the Sea from surface samples taken at Bertam Station, Desert Beach, Sandy Beach, and Salton Sea Beach. A historic record exists from 1950 through 2000. Figure 3-2a depicts historic Salton Sea salinity values through time. Beginning in 1992, the rate of salinity increase in the Sea began declining. A similar but more pronounced reduction in salinity occurred between 1972 and 1980. A much more dramatic reduction occurred from 1950 to 1956. Inspection of historic water surface elevations, presented in Figure 3-2b, yields the conclusion that these early salinity changes were both during periods of rising Sea elevations. Rising elevations were a result of increased inflows which provided significant dilution effects. When elevations are increasing, salinity levels are observed to go down or level off. This inverse relationship between salinity and elevation is to be expected since the only way that salinity can increase significantly, over an extended period of time, is when evaporation exceeds inflows. These trends are also observed during the post 1992 period where the trend indicates a leveling off of increases in salinity. However, the leveling of the increase in salinity from 1992 to 1999 is paired with only slight increases in elevation. This trend suggests that solids are precipitating or being biologically reduced from the Sea.

Precipitation of Dissolved Solids

In December 2000, a Science Workshop was held in Riverside, California, to develop a joint opinion of scientists with knowledge in the field of salinity, salt precipitation, and biological reduction of sulfates within natural waters. It was concluded, and presented, in a yet to be published paper that dissolved solids are either being precipitated or biologically reduced within the Salton Sea as dissolved salts are added to Sea waters on an annual basis. It was concluded that, at a minimum, 250,000 tons per year of salts dissolved in inflow waters are being precipitated upon mixing in the Sea. It was also concluded that, at a maximum, 1.4 million tons per year could be precipitating or being biologically reduced. At this higher level, it would be assumed that gypsum is precipitating. If biologic reductions are occurring, then they could be, for example, through actions of sulfate reducing bacteria.

Given the wide range of possibilities that exist between 250,000 and 1.4 million tons per year, the Salton Sea Accounting Model was developed such that this issue was handled as an uncertainty term. When the model is operated in a stochastic mode, a different value for precipitation of dissolved solids is sampled from a uniform probability distribution defined by the above limits of 250,000 and 1.4 million tons per year. The model then reduces the salt load to the Sea on an annual basis by a corresponding amount to that which is sampled from the distribution. This results in model simulations that account for the uncertainty of how dissolved solids are precipitating within the Salton Sea (Weghorst, 2001).

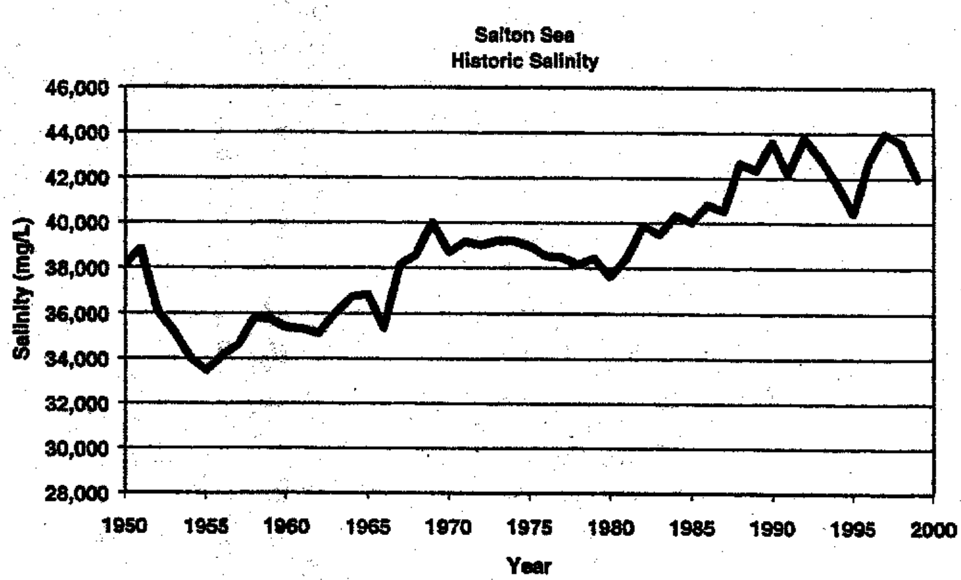

Figure 3-2a. Historic Salinity (Source: Imperial Irrigation District)

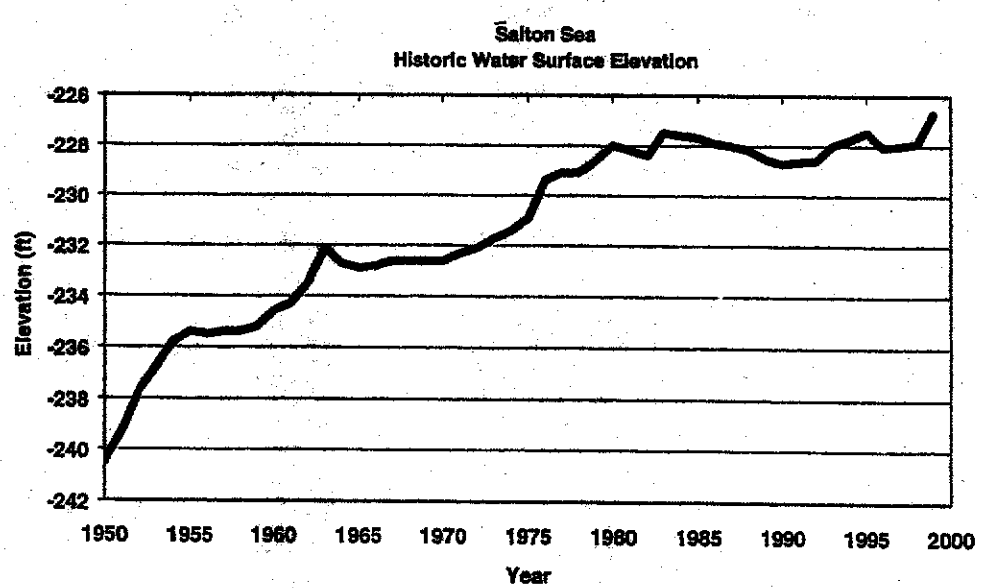

Figure 3-2b. Historic Water Surface Elevations (Source: US Geological Survey)

FUTURE INFLOWS

Future inflows to the Salton Sea are expected to decline. The most likely program that will have an effect on inflows is a transfer of water from IID to San Diego County Water Authority (SDCWA). In addition, an agreement is being finalized to deliver water once used by IID to CVWD. The amount of water that will be transferred to San Diego is between 130,000 af/yr and 200,000 af/yr. The amount of water to be delivered to CVWD is 100,000 af/yr. Implementation of these transfers are to be based upon conservation efforts within the IID service area. The transfers are not expected to occur over night but are expected to follow a predictable schedule for an eventual 130,000 af/yr transfer to SDCWA and 100,000 af/yr to CVWD. The method of conservation for this option is on-farm tail water recovery and reuse. The maximum amount of 200,000 af/yr to SDCWA is based on tail water recovery. For the evaluation of restoration project alternatives, it was assumed that future reductions in inflow down to 1.0 and 0.8 maf/yr would occur at a rate of 20,000 acre-feet less water to the Sea each year. This ramp up would roughly approximate the effects of the Sea by future conservation programs as described above.

There are already other actions in place that that are likely to effect inflows to the Salton Sea. Included in these are a 4.4 maf/yr limited entitlement to Colorado River water for the State of California, pre-exiting conservation agreements, aquifer pumping effects, and activities in Mexico. The effects of these actions defines a baseline inflow to the Sea from which restoration alternatives can be evaluated. However, given the sensitivity pertaining to selecting a specific baseline from which to make these assessments it was decided that restoration alternatives would be assessed against three different baseline. The three different baselines represent the following average annual inflow levels: 1.3 maf/yr, 1.2 maf/yr, 1.1 maf/yr.

The Salton Sea Model operates stochastically and therefore uses a different future sequence of inflows for each simulation. Figure 3-3a presents sample inflow sequences for each of the three baseline conditions. Inflows are shown increasing slightly over time because of a change in water contibribtions from the Coachella Valley. Contributions of both Coachella surface and ground water will increase in the future as water levels in the aquifer rise and as CVWD uses additional Colorado River water delivered to them.

The baseline salt load to the Salton Sea is assumed to be equal to that being forcasted by the water districts and presented in Weghorst, 2001. The average annual salt load used in all simulations is 4.8 Mtons/yr. Figure 3-3b shows a sample sequence of baseline salt load from the model. The baseline salt load is also expected to rise as contributions of both Coachella surface and ground water increase in the future. Baseline salt load will be less then historic because less water will be diverted into the Salton Basin at Imperial Dam in the future. Less water translates into less salt being diverted as well.

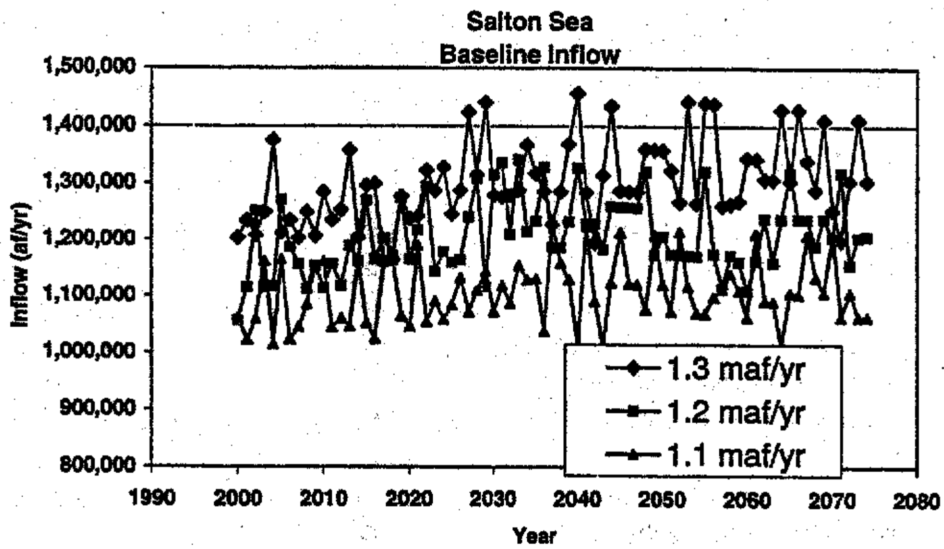

Figure 3-3a. Forcasted Baseline Inflows for Three Different Inflow Assumptions

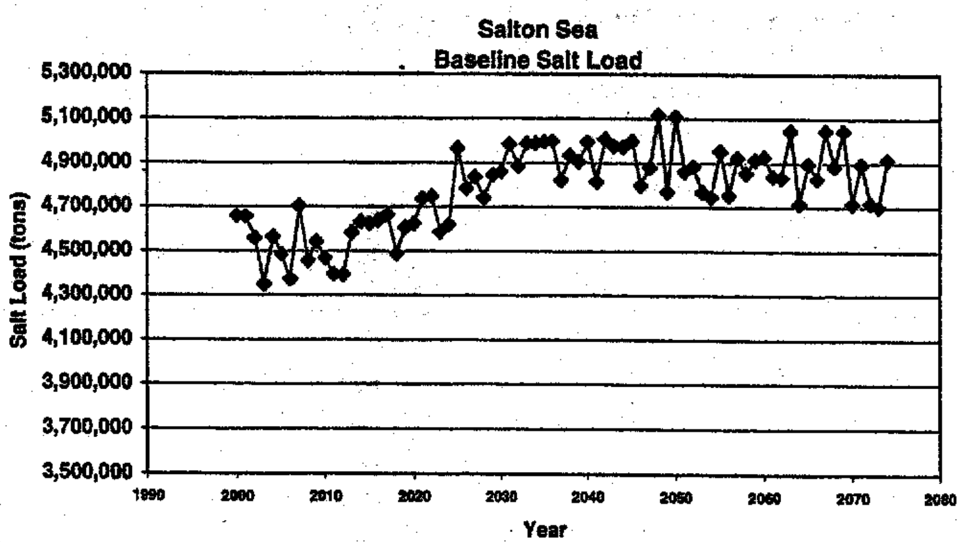

Figure 3-3b. Forcasted Baseline Salt Load

OVERVIEW OF MODEL

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

The Salton Sea Accounting Model (Model) was developed to predict hydrologic response to possible changes in the Sea (Weghorst, 2001). It allows the effective evaluation of historic, present, and future conditions within the Sea. Specifically, the model predicts changes in inflow, elevation, surface area, and salinity. Special operating requirements included the need to simulate:

Future reductions in inflow
Future changes in salt loads into the Sea
Imports of water
Exports of water
In-Sea ponds

The basics of the model involve conservation of mass for both water and dissolved solids (salt). The models maintains separate accounting of each and corresponding calculations of salinity. The model follows the following equations for mass calculations:

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

Salt Content = Previous Salt Content + Salt Load

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

Chapter 4
SALINITY CONTROL

In this chapter, different methods of salinity control or concentrating the salt water from the Salton Sea (Sea) and disposing of it are considered. These methods include solar evaporation pond designs and enhanced evaporation systems, as well as an intake facility, a conveyance system from the Sea to the chosen system, and options to dispose of the salt.

The designs of each system—solar evaporation ponds or enhanced evaporation systems — are designed on a modular system. Each module is designed to remove 1 million tons of total dissolved solids (TDS) per year. This method of design was chosen because of the uncertainty about how much salt will need to be disposed of to achieve the desired results. The changing conditions leading to the uncertainty was discussed in chapter 3.

Various conceptual solar evaporation pond designs and cost level estimates were made to remove 1 or 2 million tons of total dissolved solids (TDS) per year from the Salton Sea. If practical, the designs were to be developed so they could be constructed in units or modules to phase up to a capacity of 10 to 12 million tons per year.

The solar evaporation ponds and conceptual EES systems were developed for on-shore locations near the Sea and for a shallow water in-Sea location. The locations are not site specific, but representative of conditions in the area.

Within the chapter are also specific environmental concerns or potential for wildlife enhancements. The evaluation of the potential environmental effects, however, will be addressed in the revised environmental impact statement/ environmental impact report.

SOLAR EVAPORATION PONDS

Technical Approach

The approach to developing the conceptual design of solar evaporation ponds was to evaluate the pond areas required to concentrate the brine to the crystallization stage based on evaporation and soil seepage characteristics. Much of the approach relies on experience from operating solar evaporation ponds to produce commercial salt. Since the characteristics of salt and bittern produced from Sea water are not fully understood, the pond design may need to be revised as additional information is obtained from the Solar Evaporation Pond Pilot projects being performed by the Salton Sea Authority (Authority).

The salt model is based on material balances within a concentrator pond system. Some of solutions and quantities used in the model are from empirical measurements developed from several existing solar evaporation pond salt operations.

The first material balance forces conservation of liquid volume. It assumes that the total volume input into a solar evaporation pond system must equal the sum of the seepage volume, the volume evaporated, and the output volume. The second material balance forces conservation of salt. It assumes that the total weight of salt input into the pond system must equal the sum of the weight leaving with seepage, the amount deposited in the solar evaporation ponds, and the amount leaving with the output (to the crystalizers). Simultaneous solution of these two balances, plus input of empirically derived quantities and relationships, leads to the proprietary equations used in the model.

The technical approach for the conceptual design included using ten concentrator ponds to concentrate (evaporate) Sea water (brine) before conveying the brine to disposal facility. Calculated seepage and salt production values (See Chapter 3 of the Salt Disposition Appraisal Report) for the desired total dissolved solids (TDS) removals [1- to 10-million tons per year (tons/yr)] from the Sea water were input into the commercial salt model. The following assumptions were used in the salt model:

- Average annual fresh water evaporation from a Class A weather pan is 102.5 inches.
- Average annual rainfall is 2.5 inches.
- Sea brines will evaporate at rates similar to ocean water brines.

- A range of seepage rates likely to be found in the soils surrounding the Sea.
- An input salinity of 44,000 mg/L (approximately 4.4 °Be). (Note: °Be is a term used in the salt industry, which determines the degree of bittern concentration in the brine.)
- A sodium chloride (NaCl) saturation point of 26 °Be (approximately 319,000 mg/L).
- Ocean-based brine phase chemistry, modified by known differences of in-Sea brines.

Three seepage scenarios were modeled to reflect "best-case," "mid-case," and "worst-case" pond leakage, and these scenarios also considered TDS removal from the Sea in 1-million tons/yr modules. Permeabilities of the pond bottoms of $1x10^{-8}$ centimeters per second (cm/s), $1x10^{-7}$ cm/s, and $1x10^{-6}$ cm/s, were assumed for the best-case, mid-case, and worst-case leakage scenarios, respectively. The "best-case" permeability is typical of highly plastic clay soil. The "mid-case" permeability is typical of clay soil and meets the regulatory specification for liners in a municipal solid waste landfill. The "worst-case" permeability is representative of silty clays. Based on some preliminary explorations performed by Reclamation, the soils in the potential solar evaporation pond areas are assumed to approximate the "mid-case" permeability scenario.

The required pond areas for TDS removals of 1-million to 10-million tons/yr are provided in Table 4-1 summarizes three different assumed permeabilities. The best case seepage rate is equivalent to 0.12 inches per year (in./yr) assuming a gradient equal to 1. The mid-case rate is equivalent to 1.24 in./yr, and the worst case is equivalent to 12.4 in./yr for the same gradient.
If the annual quantity of gypsum shown in Table 3–10 in Chapter 3 of the Disposition of Salt Report is deposited at a density of 100 lb/ft^3 in concentrator Ponds 2 through 5, the average thickness of gypsum deposited will range from 0.19 to 0.27 inches per year. The depth of the average annual deposit is dependent on the cumulative concentrator pond area (Ponds 2 through 5), which is dependent on the seepage rate. More concentrator pond area is required to maintain a desired salt removal rate if the seepage is higher. To preserve the desired design life for the solar evaporation pond system, it would be necessary to raise the top of the berms by several inches. The extent of the additional berm height and which specific berms need to be raised can be predicted with more certainty after completion of the solar evaporation pilot project.

The mid-case seepage scenario was used to size the solar evaporation ponds (concentration ponds) and conveyance facilities developed for the conceptual designs. A typical layout of ten ponds was used to provide for concentration gradients within the system. Sea water would be introduced into the first pond and conveyed through the remaining ponds. As the brine is moved from pond to pond, it will become more concentrated with salt due to evaporation. The brine will reach a salt-saturated condition at the outlet of Pond 10.

Table 4-1 Solar Evaporation Pond Area Requirements

Seepage Case	Desired TDS Removal (tons/yr)	Sea Salinity (mg/L)	Calculated Sea Outflow (af/yr)	Required areas (acres)			
				For all Concentrator Ponds	For Concentrator Pond 1	For Concentrator Pond 5	For Concentrator Pond 10
Best	1 million	44,000	16,959	2,683	612	241	78
Mid-case			17,693	2,769	631	249	80
Worst			28,446	4,024	917	362	117
Best	5 million	44,000	84,797	13,415	3,059	1,207	389
Mid-case			88,465	13,845	3,157	1,246	402
Worst			141,104	20,120	4,587	1,811	583
Best	10 million	44,000	169,594	26,830	6,117	2,415	778
Mid-case			176,930	27,690	6,313	2,492	803
Worse			2894,459	40,240	9,175	3,622	1,167

Notes:
1/ If the Sea salinity drops, more acres will be needed to remove the same amount of TDS.
2/ Assumes 1 mg/L = 1.35968209 tons/af = 0.008344167 lb/gal.
3/ Calculated theoretical areas from salt modeling program. Actual areas of individual ponds could vary depending on topography.

The layout of the ponds was typically developed so that pumping is only required into Pond 1 and flow into the subsequent ponds is by gravity. The ponds were laid out to minimize the amount of earthwork required to construct the perimeter berms. For a given area, the minimum perimeter would be a circle. However, a square or rectangular shape is the mininium practical perimeter because it allows common berms to be used to form the sides of adjacent ponds. Rectangular ponds oriented with the longest width parallel to ground contours were typically used to minimize the depth of water and height of berms required for the ponds. It should be noted that the actual lay of the land and other considerations would determine the size, shape, and number of ponds for a specific site.

Conceptual Pond Designs

Five conceptual solar evaporation (concentrator) pond designs are presented below. Three of these designs were sited on-shore and two designs were sited in the Sea. The designs were developed to evaluate the cost impacts of building on flat versus steeper terrain, expanding contiguously versus non-contiguously, and constructing on-shore versus in-Sea.

Once the brine is concentrated sufficiently, it would be conveyed to a disposal impoundment for disposal and/or sale. Conveyance facilities for the solar evaporation ponds are discussed later in this chapter.

Each of the concepts discussed below includes the following features:

- Berm freeboard to prevent wave overtopping.
- Vehicle access provided at berm top.
- A key below the pond berms for a seepage cutoff.
- Small islands and/or inlets in the initial concentrator ponds to serve as wind breaks and nesting and roosting sites for bird life.
- Areas of shallow water and mudflats in the low- and medium-salinity ponds to enhance the potential productivity of brine shrimp and other invertebrates that provide food for birds.

An inlet bubbler or baffle chute can be readily provided, if necessary, to aerate the Sea water as it enters the first concentrator pond to reduce odors and the potential for formation of an anaerobic condition.

Concept A – Solar Evaporation Ponds on Flat Terrain (1-Million tons/yr TDS Removal)

Figure 4-1 presents a conceptual design of concentrator ponds in relatively flat terrain (Concept A) for removing 1-million tons of TDS per year from the Sea. The flat terrain slopes at about 0.2 percent towards the Sea. The ponds are located contiguous to each other to reduce the number and length of berms required.

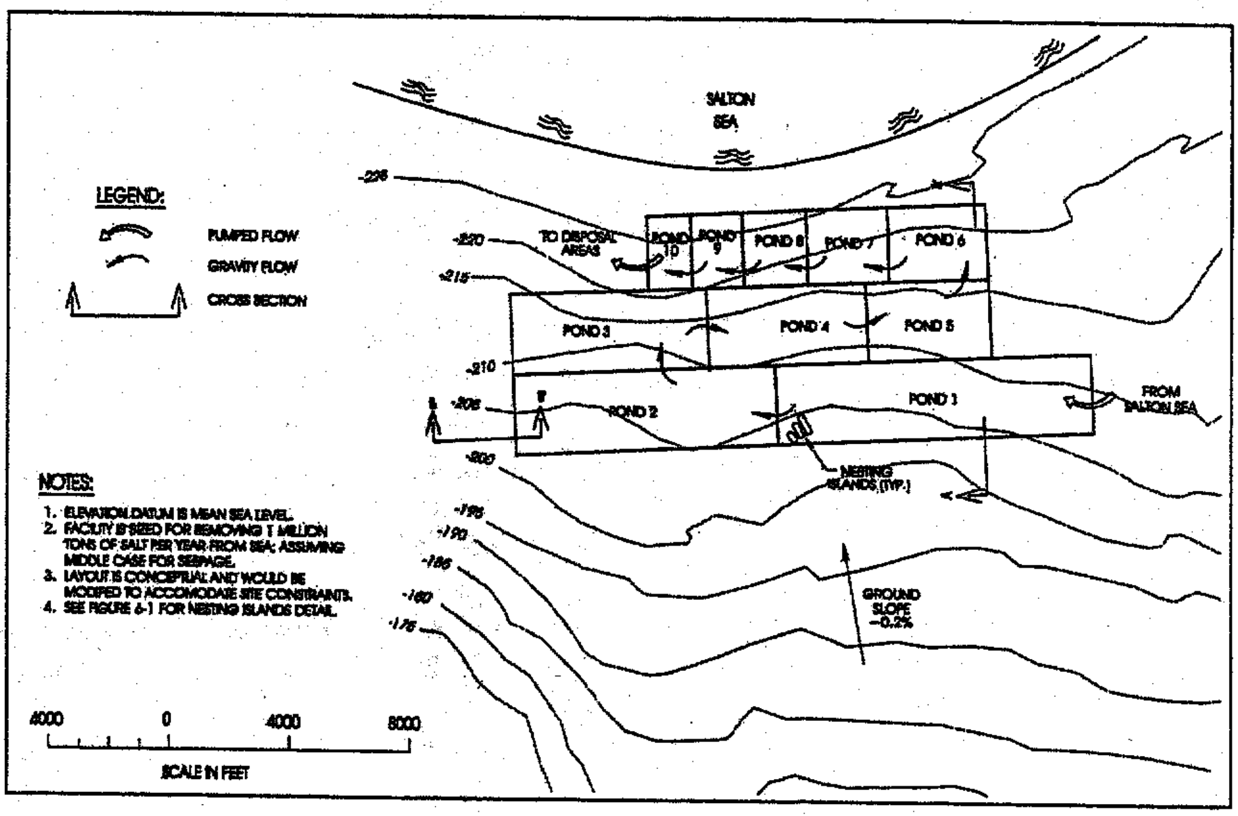

Figure 4-1 – Concept A Layout for Contiguous Concentrator Ponds in Flat Terrain

Figure 4-2 presents Section A-A that illustrates how the contiguous ponds would look in cross-section. The materials for the pond berms would be obtained from within the upslope areas of the ponds to create water depth in those areas. Figure 4-2a presents an artists sketch of the perspective of Concept A concentration ponds.

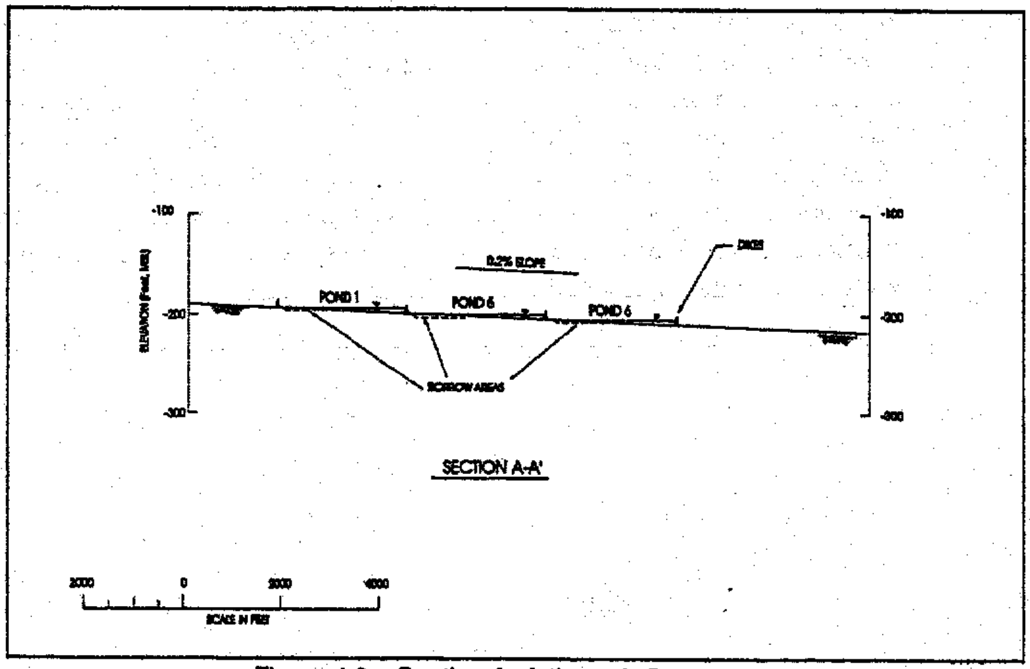

Figure 4-2 – Section A–A through Concept A
Contiguous Concentrator Ponds in Flat Terrain

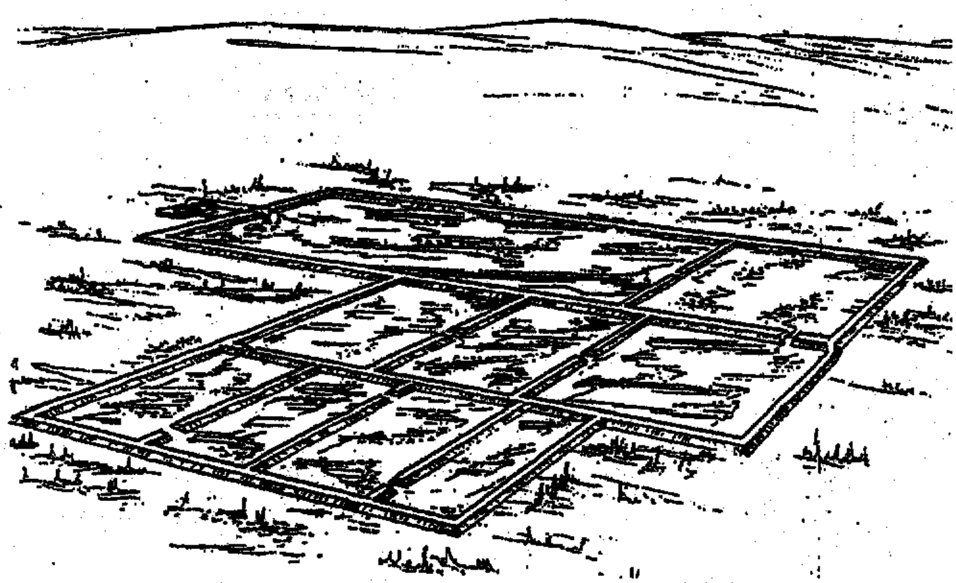

Figure 4-2a. Artists Sketch of Concept A Concentrtion Ponds.

Figure 4-3 presents Section B-B that illustrates a typical cross-section through a concentrator pond berm. The conceptual design of the concentrator pond berms contains side slopes inclined to a ratio of 2½:1 (horizontal:vertical). These might be steepened to ratios of 2:1 as the design is further developed.

The slope of the land dictated the height of this berm; the top of the downslope berm had to be as high as the existing ground at the upslope end of the concentrator pond to provide the required surface area. The berms' design levels were raised by an additional height of 3 feet to prevent wave overtopping. This freeboard height will need to be further evaluated as the design is developed using site-specific wind and fetch and soil information. A top berm width of 12 feet is provided for vehicle access. A key, 2-feet deep and 10-feet wide, is provided below the berm as a seepage cutoff.

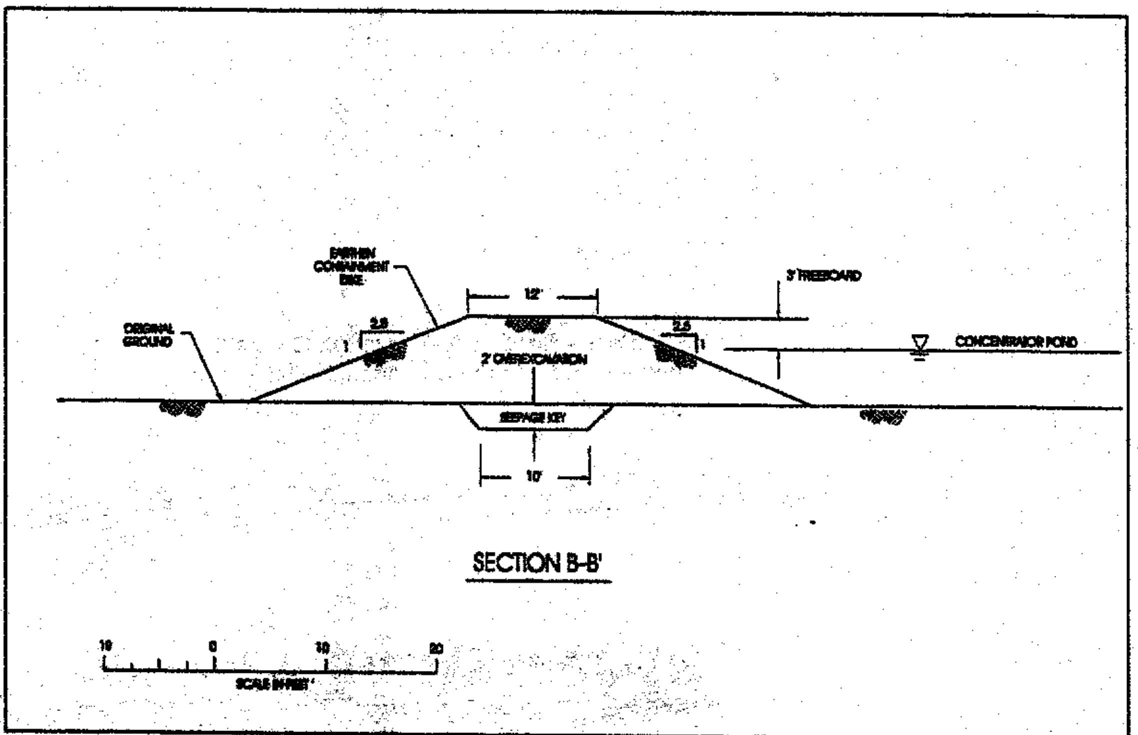

Figure 4-3 – Typical Containment Berm Section Concentrator Ponds

Concept B – Solar Evaporation Ponds on Flat Terrain (Concept A Expanded for 2-Million tons/yr TDS Removal)

Figure 4-4 presents a conceptual design (Concept B) showing the contiguous expansion of the Concept A facility to remove 2-million tons of TDS per year from the Sea. This concept would take advantage of berms that had already been built for Concept A to reduce the amount of earthwork required.

The design and construction of the first phase (module) would be planned to consider any subsequent expansion(s) to take advantage of previously constructed berms.

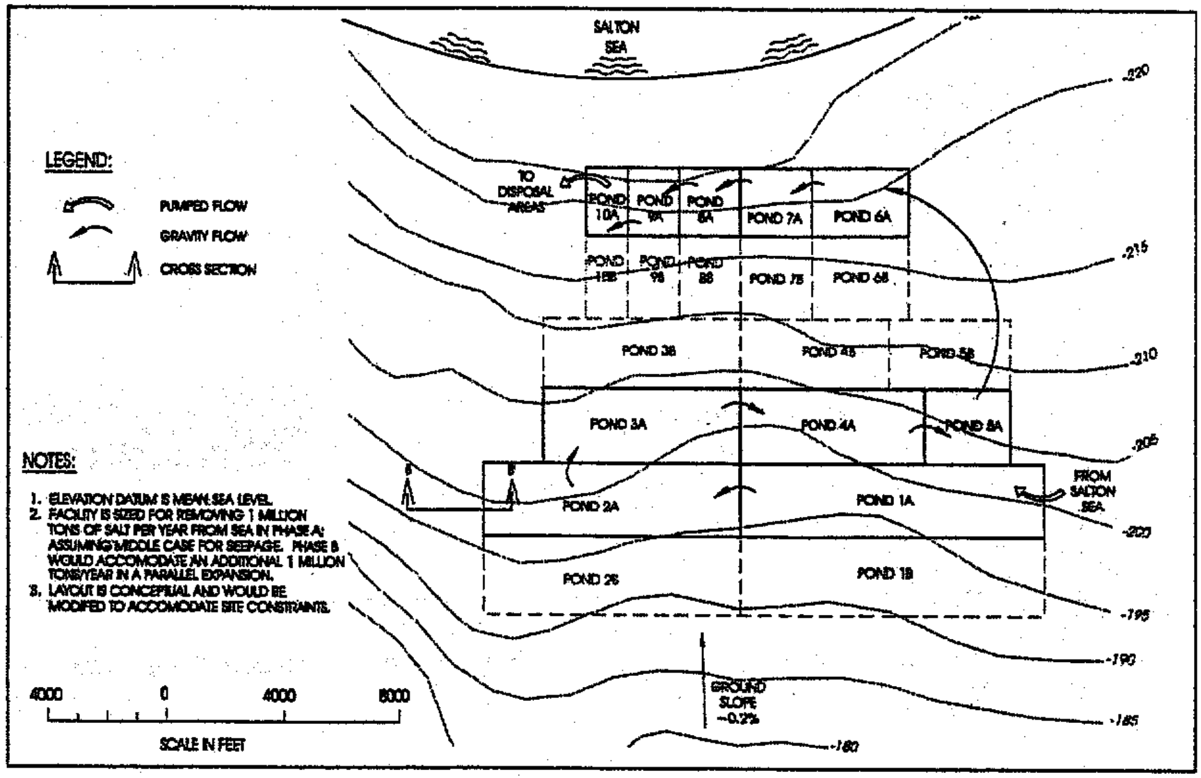

Figure 4-4 – Concept B Layout for Contiguous Concentrator Ponds with Parallel Expansion in Flat Terrain

Concept C – Solar Evaporation Ponds on Steeper Terrain (1-Million tons/yr TDS Removal)

Figure 4-5 presents a conceptual design for concentrator ponds in steeper terrain (Concept C), which considers removing 1-million tons of TDS per year from the Sea. The steeper terrain slopes at about 0.6 percent towards the Sea. This slope is typical of land east and west of the Sea. The berms would have a similar design as discussed above for Concept A. However, significantly higher berms and substantially more earthwork would be required in this terrain to create the required surface area for the concentrator ponds.

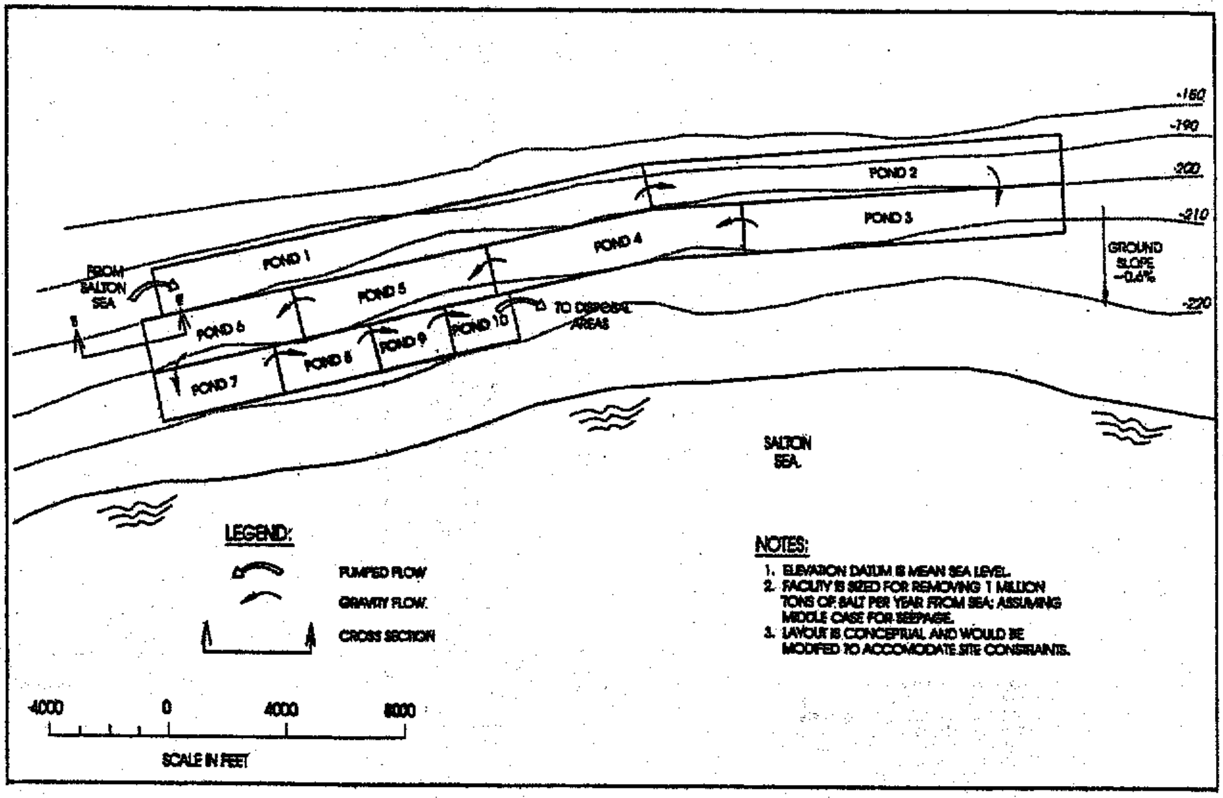

Figure 4-5 – Concept C Layout for Contiguous Concentrator Ponds in Steep Terrain

Concept D – In-Sea Solar Evaporation Ponds in Shallow Water (1 Million tons/yr TDS Removal)

Figure 4-6 presents a conceptual design (Concept D) for a series of concentrator ponds in the Sea that could remove 1-million tons/yr of TDS. The ponds were sized to provide the areas presented earlier in Table 4-1. The ponds would be operated such that the brine level would be slightly lower than the Sea level. This would eliminate seepage of brine through the dike and mitigate the consequences of a possible dike breach by not allowing brine to flow back into the Sea.

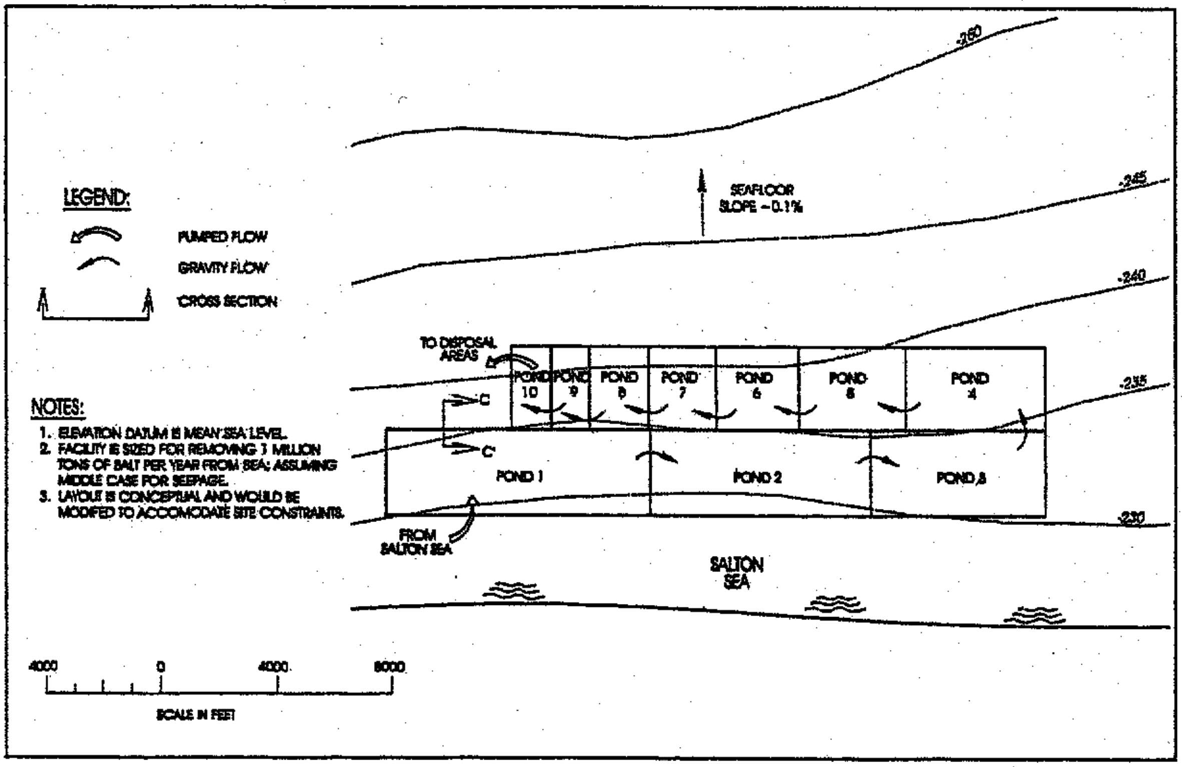

Figure 4-6 –Concept D Layout for Contiguous Concentrator Ponds In-Sea in Shallow Water

The bathymetry of the Sea in Concept D is sloping at approximately 0.10 percent. This is typical of the bathymetry in the southern part of the Sea. The dike closest to the shoreline would be placed in a water depth of about 3 feet. This dike, which would be oriented parallel to the shoreline, would serve as a barrier for drainage water that enters the Sea. It would also provide a conduit between the shoreline and the in-Sea ponds to allow drainage water to flow to the Sea. In addition, it would also ensure that the in-Sea ponds provide the full benefits of surface area reduction of the Sea, even if elevation decreases by 3 feet. This is a significant benefit since one of the main reasons for constructing within the Sea is to reduce the evaporative surface area to help compensate for possible reductions of inflow to the Sea.

Figure 4-7 presents a cross-section through the in-Sea pond dikes. The conceptual design of the in-Sea dike has side slopes inclined at a ratio of 3½:1 (horizontal:vertical). These flatter slopes are required to reduce the seismic vulnerability of the dikes. The side slopes will need to be further evaluated if this design is further developed. The dike design levels were raised 5 feet above the Sea level to prevent wave overtopping. This freeboard height will also need further evaluation. A top width of 30 feet is provided for vehicles to pass on the dike during construction. An overexcavation 5-feet deep was allowed for beneath the entire dike to remove very soft sediments that are believed to be blanketing the Sea floor. These excavated materials are not anticipated to be suitable for reuse and would need to be disposed of in the Sea or elsewhere. The over-excavation would be backfilled with imported fills.

Material for the in-Sea dikes would need to be borrowed from on-shore as discussed in the previous analysis (that Parsons performed in 2000). Special techniques such as gantry conveyors may be required to construct the dikes.

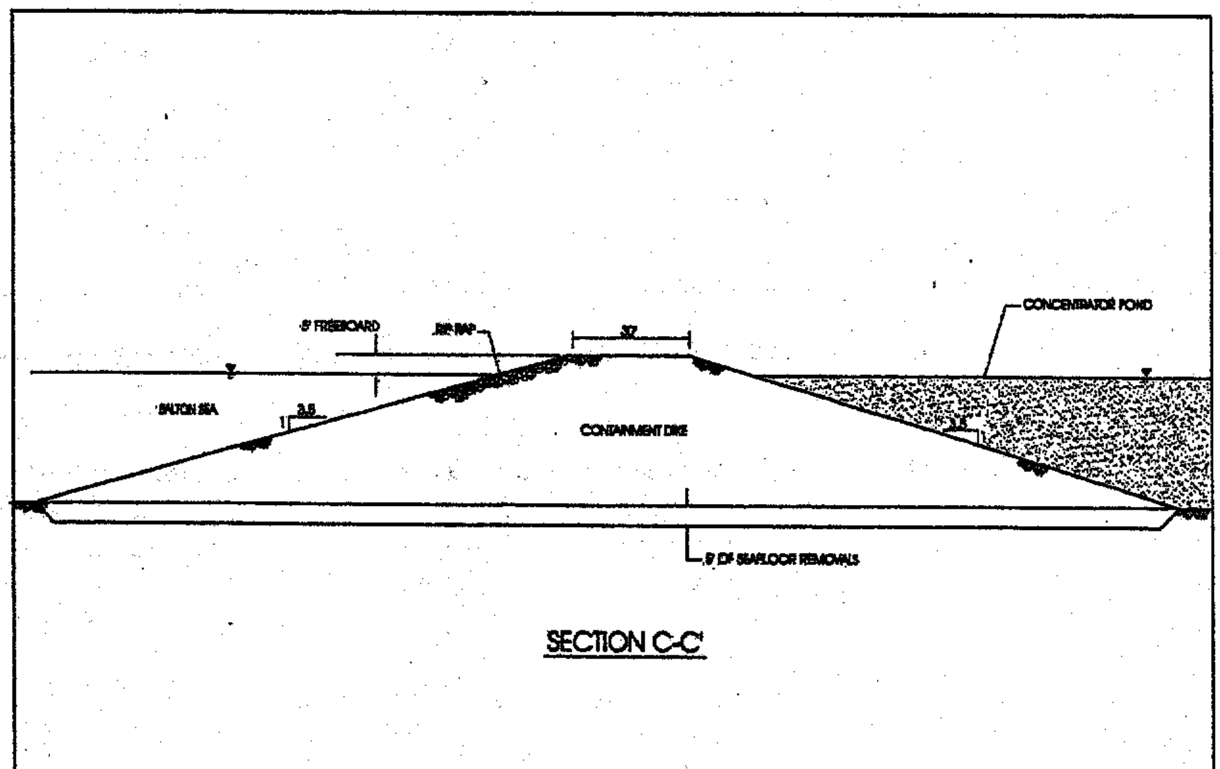

Figure 4-7 – Typical Embankment for In-Sea Containment Dike

Concept E – In-Sea Solar Evaporation Pond Facility in Deeper Water (Concept D Expanded for 2-Million tons/yr TDS Removal)

Figure 4-8 provides a conceptual design (Concept E) for expanding the Concept D facility to concentrate a total of 2-million tons/yr of TDS. This design was formulated to evaluate the expansion of the facility into deeper water. Some of the dikes of the expanded facility were designed to be contiguous to the Concept D dikes. The geometry of the dikes for Concept E is the same as that discussed for Concept D.

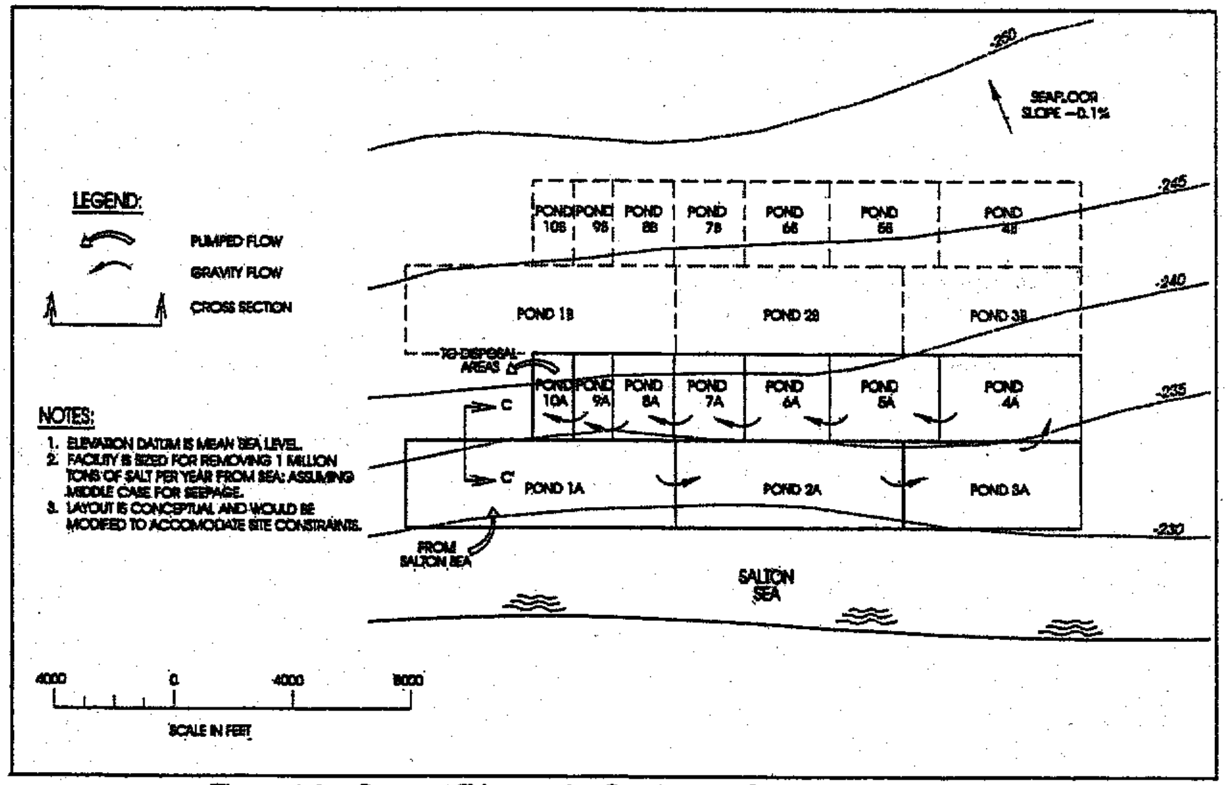

Figure 4-8 – Concept E Layout for Contiguous Concentrator Ponds with Parallel Expansion In-Sea

Operation of Ponds

Operation of the ponds will require low labor and equipment needs assuming no sale of salt products. Staffing for a 1-million tons/yr solar evaporation pond facility can be done with as few as two people on a full-time basis. One person is needed to manage the overall operation. This person must be capable of long- and short-term planning, decision making, budgeting, cost control, use of contractors, general administrative duties, public relations, coordination with agencies, and provide vacation relief for the second person. The second person's main duties would be to move the brines as needed, keep a log of operations, monitor levee and equipment condition, interface with the public, and assist contractors. Secretarial support is not included.

Equipment needs will also be modest. Equipment needs include: two pickup trucks, one four-wheel all terrain vehicle (ATV), a two-person office, a storage shed, and miscellaneous hand tools.

It is anticipated that equipment maintenance will be performed by contractors. Likewise, earthwork maintenance will be performed by local contractors. Periodic flushing of pumps and other conveyance facilities with fresh or low salinity water will be necessary to remove salt deposits. The facilities that convey concentrated brine (rather than Sea water) will be more vulnerable to scale build-up from salt deposition.

Possible Expansion Scenarios

Parallel Expansion

Parallel expansion is defined as adding one or more modules contiguous to an existing facility in a manner similar to that shown in either Concept B or E.

Scaling Factors

An evaluation of building a 1-million tons/yr TDS solar evaporation pond system and expanding contiguously to 2-million tons/yr was performed by formulating concepts B and E. If proper planning and design is performed prior to building the initial module, some cost savings could be achieved compared to building two completely separate 1-million tons/yr facilities. Those savings occur because some of the dikes constructed for the initial module are incorporated into the second module. However, Concept E, contiguous expansion for in-Sea ponds in deeper water, would not be cost-effective.

Further savings can be achieved by building larger conveyance facilities initially. Some of the conveyance facilities can be designed to serve more than one module and an economy of scale can be achieved. However, a larger initial capital outlay would be required.

Operational Changes

Operational changes needed for a parallel expansion are minimal. The same staff with the same training and experience will operate the expanded facility. One person would be added to the staff once the combined facilities reach about 4 million tons of capacity. Another person would also need to be added at about 8 million tons of total capacity.

Series Expansion

Series expansion is defined as adding one or more modules that operates totally independent from existing modules. The added modules may be near, but not contiguous to, existing modules or some distance away.

Scaling Factors

The costs for a series expansion is directly proportional to the desired capacity for the specific concepts evaluated herein. No economy of scale or use of common facilities would occur.

The day-to-day operation and maintenance (O&M) costs would be essentially the same as a parallel expansion although additional storage sheds and office space may be required, depending on the distance between the sites. Series expansion would require a number of small pumps and pipelines. Thus power and other O&M costs are likely to be somewhat greater for a series expansion than for a parallel expansion, because a small number of large pumps and pipes are normally more efficient and less costly to maintain than an equivalent number of small pumps and pipelines.

Operational Changes

The operational changes needed for series expansion are the same as for parallel expansion. The same staff with the same training and experience will operate the expanded facility. One person would be added to the staff once the combined facilities reach about 4-million tons of capacity. One additional person would be added when the total capacity reaches about 8 million tons. However, if the facilities become spread out enough such that travel time becomes a significant factor, an additional person may have to be added to the staff.

Modifications After Initial Construction

Experience Gained from Initial Operations

Once a specific construction site for the ponds is selected, detailed information about that site will be gathered to fine tune the conceptual designs developed and presented herein. Additional evaporation and phase chemistry data will be available from operation of the Pilot Pond Project, and possibly from a larger demonstration pond project, which will result in other refinements. Even with this new data incorporated into the design, changes will need to be made to the ponds after construction to make the system operate more efficiently.

Some of these changes may become evident soon after startup of the system. Others may not be fully apparent or understood for several years after startup. Most of the needed changes will be relatively small. Examples of larger changes that may be needed or desirable include, but are not limited to:

- The ratio of concentrator acres to salt crystallization acres may be found to be incorrect after a period of operation. The solution can range from adding or moving external berms to changing the acreage of either the concentrators or the crystallizers. It could be possible to simply modify the internal levees to accomplish the same result.
- Separate bittern disposal facilities may have to be added to increase the efficiency of the salt crystallization process or if a significant portion of the salt products does not evaporate to dryness.
- An additional pumping station may be needed to move the brine properly.
- Hidden and undiscovered areas of high permeability could be found within the ponds. These areas can significantly affect system performance, and will have to be dealt with if found. For example, additional pond area may have to be added.

Costs to Correct Problems Encountered After Startup

It is difficult to estimate the costs to correct the kinds of problems noted above at this time. However, it would be prudent to budget some contingency funds to deal with post-construction costs.

The following extreme possibilities are based on Concept A for both solar evaporation ponds and disposal impoundments and present a worst case situation:

- The concentrator to crystallizer ratio is currently 4.4:1. If this needed to change to 5.5:1 and it was decided to increase the concentrator area by building new external berms rather than decrease the crystallizer area, the additional cost would be about 26 percent of solar evaporation pond costs.
- If an additional pumping station were needed, the additional cost could be several hundred thousand dollars.

It is not likely that all of the above costs would be incurred. It is also not probable that, after the Pilot Pond data is known, the magnitude of any one problem will be as large as depicted above.

It is not uncommon to establish a reserve for post construction modifications for solar evaporation pond systems of up to 10 percent of the total project costs. The size of the reserve would depend on the quality of the design data at the time of construction. These costs would be incurred over the first 5 to 10 years of operation. This reserve for post-construction modifications is not included in the cost analyses elsewhere in this report.

Cost Sensitivity in Design Assumptions

Topography

The cost of building solar evaporation ponds could increase because of the steeper topography as evidenced by the difference in cost between Concept A and Concept C. Solar evaporation ponds require surface area to evaporate Sea water and concentrated brine. As the topography gets steeper, higher berms are required to create the same surface area. The berm's cross-section increases rapidly as the height increases. To minimize berm heights, the berms should parallel the land contours. However, the result is a less efficient (longer and narrower) pond configuration and longer berms. Higher and longer berms require more earth and thus cost more to construct.

Soil Permeability

Figure 4–9 depicts the relationship between soil permeability and concentrator pond area and inflow to the first concentrator pond (for a 1-million ton TDS solar evaporation pond removal facility). As soil permeability increases, the concentrator pond area required to remove the same TDS increases, and the amount of water that must be conveyed to the first concentrator pond increases.

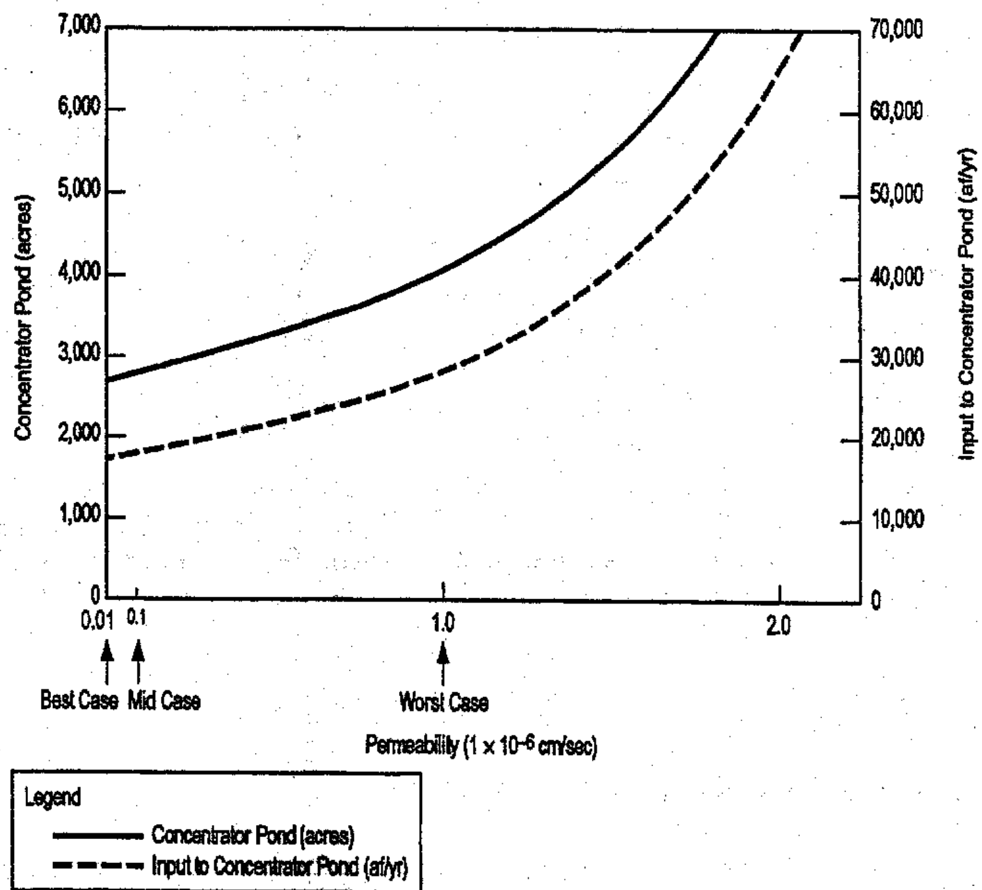

Figure 4–9 – Concentrator Pond Area and Pond Inflow versus Soil Permeability

Between the assumed best-case permeability of 1 x 10^{-8} cm/sec and mid-case permeability of 1 x 10^{-7} cm/sec, the area required increases by about 3 percent and the inflow increases by about 4 percent. However, between the assumed mid-case permeability and the worst-case permeability of 1 x 10^{-6} cm/sec, the area increases by about 45 percent, and the inflow increases by about 61 percent. It is evident that permeability can play a very significant role in the size of the concentrator ponds and in the amount of Sea water that may have to be pumped.

Permeability values were assumed for purposes of this study, because sites have yet to be selected and limited information is available.

The chemical composition of the seepage liquid from any pond will be in equilibrium with (the same as) the liquid in that pond. Thus the composition will range between the composition of Sea water and that of concentrated brine before solid salts form. The seepage liquid will migrate vertically down until it reaches either a more impervious layer or groundwater. At this point, the liquid will also begin to spread horizontally, down gradient. In the Sea basin, down gradient is likely to mean that the seepage liquid will move toward the Sea.

The migration rate of the seepage liquid varies with the permeability assumptions that have been made. The best case seepage rate is equivalent to 0.12 inches per year (in./yr) assuming a gradient equal to 1. The mid-case rate is equivalent to 1.24 in./yr, and the worst case is equivalent to 12.4 in./yr.

Detailed knowledge of soil permeabilities, soil layers, depth to groundwater, and groundwater gradients in the Sea basin are not well known. Therefore, any sites chosen for actual pond construction will have to be further investigated to evaluate the amount of leakage and to determine the fate of the seepage liquid.

Agricultural Lands

Agricultural land in the Imperial Valley generally has the flattest slope of any land near the Sea. Because it costs considerably more to construct solar evaporation ponds on steeper land, agricultural land is more desirable; however, tile drains underlie most of the agricultural lands. These tile drains were installed at a depth of 4 to 5 feet and between 40 and 200 feet apart to reduce and control salt build-up in the soil. The spacing varies with soil type and crop type.

Salt build-up in the soil occurs due to evaporation-transpiration from the Colorado River water used to irrigate the crops grown in the Imperial Valley. Water from the Colorado River has a TDS of 600 to 900 mg/L; thus additional water beyond that needed to grow crops is applied to leach salts out of the plant's root zone to maintain and optimize productivity. This return water, about 35 percent of the total applied water, is collected by the tile drains and conveyed to drainage ditches that flow into the New and Alamo Rivers (and then to the Sea) or directly to the Sea. Most of the drainage ditches flow by gravity into the Sea, but some are pumped into the Sea. The drainage ditches are about 7- to 8-feet deep and are normally located one-half mile apart.

If solar evaporation ponds were constructed on agricultural lands with tile drains, much of the Sea water in the ponds would flow into the tile drains and flow back into the Sea. This would essentially result in little or no TDS removal from the Sea. If agricultural land is used for solar evaporation ponds, measures need to be taken to prevent this from happening. In some cases, the tile drains can be cut or plugged upstream of their outlet to the drainage ditches to prevent the Sea water from getting into the drainage ditches and returning to the Sea. In cases where return water is pumped to the Sea, it may be practical to simply stop operating the pumps.

The permeability of agricultural lands closer to the Sea may be suitable for construction of solar evaporation ponds. Some agricultural lands are broken up to depths of 3 to 4 feet with saber tooth plows periodically to increase permeability. Over time, the permeability of the soil decreases as the fines plug up the voids in the soil. Thus, recently plowed lands may be poorer candidates for solar evaporation ponds than lands plowed several years ago.

Agricultural land near the Sea should be more cost-effective than other lands because it has the flattest slope of any land. However, the history and characteristics of specific parcels of agricultural lands, e.g., soil permeability, the location of tile drains, how often and when the land was plowed with a saber tooth plow, etc., will affect the design and cost-effectiveness of using specific parcels of agricultural lands for solar evaporation ponds. Thus, a site-specific evaluation should be performed to optimize selection of potential agricultural land parcels.

Pond Configuration

The optimal shape for a single pond is circular, because, of all possible shapes, a circular pond has the smallest total berm length for any given surface area. However, square ponds offer the optimal shape to allow common berms to be used to create contiguous ponds. Other shapes will require longer berms and affect the cost of constructing solar evaporation ponds. Generally, the cost of large scale solar evaporation ponds will vary directly with the length of berms required if the slope is relatively uniform and reasonably flat. A pond's shape will not normally affect its ability to evaporate water. However, if ponds are poorly configured, stagnant areas could be created that may result in water quality issues.

Ponds must be sized in a manner that allows brine to concentrate in an efficient manner. The conceptual designs are based on using ten ponds in a solar evaporation pond system; however, 7 to 20 ponds could be used without significantly affecting the efficiency. The critical factor is moving the brine from pond to pond at the appropriate time so operation of the system is optimized.

Construction of non-contiguous ponds was discussed in the Series Expansion section of this chapter. Construction of non-contiguous ponds would significantly increase the total cost because more berms would be needed and longer conveyance facilities would be needed between ponds.

When land is available to reduce cost, consideration should be given to using contiguous pond systems. Non-contiguous ponds within a module should not be constructed unless physical constraints make it necessary.

Solar Ponds Siting Criteria

Potential siting areas for solar evaporation ponds were evaluated with the assistance of the Salton Sea Database Program at the University of Redlands. A siting model analysis was conducted using geographic information system (GIS) software and the criteria identified in Table 4-2. Based on this analysis, areas around the Sea were identified as being most suitable, suitable, or least suitable for siting the ponds. Areas around the Sea that are potentially suitable for siting solar evaporation ponds on land are shown in Figure 4-10. Figure 4-11 presents suitable areas for siting solar evaporation ponds on agricultural land., and Figure 4-12 presents suitable areas for siting solar evaporation ponds within the Salton Sea.

Table 4-2 Siting Criteria for Solar Pond Facilities

	Siting Criteria	Criteria Categories	Site Ranking[a]	Criteria Weighting[b] (%)
On-Land Solar Evaporation Ponds	Slope of Land (%)	< 0.2	1	
		0.2 to 0.5	2	
		> 0.5	3	40
	Area Elevation (ft MSL)	-230 to -180	1	
		-180 to -130	2	
		-130 to -80	3	
		> -80	9	15
	Distance from Sea Shore (miles)	0 to 5	1	
		5 to 10	2	
		10 to 15	3	
		> 15	9	10
	Hydrologic Soil Group[c]	Group D	1	
		Group C	2	
		Group B	3	
		Group A	9	25
	Distance from Urban Areas (miles)	> 1	1	
		1/2 to 1	2	
		< 1/2	3	
		within	9	10
In-Sea Solar Evaporation Ponds	Slope of Seafloor (%)	< 0.1	1	
		0.1 to 0.3	2	
		> 0.3	3	25
	Seafloor Elevation (ft msl)	shoreline to -235	1	
		-235 to -240	2	
		-240 to -245	3	
		< -245	9	50
	Distance from Sea Shore (miles)	0 to 2	1	
		2 to 5	2	
		>5	3	15
	Distance from State Park Beaches, Marinas, or Boat Launches (miles)	> 1	1	
		1/2 to 1	2	
		< 1/2	3	
		within	9	10

Notes:

a. 1=Most Suitable, 2=Suitable, 3=Least Suitable, 9=Excluded.

b. Weightings based primarily on impacts to cost of facility. Weightings sum to 100 for either on-land or in-Sea facility.

c. From USDA Soil Survey Geographic Data Base.

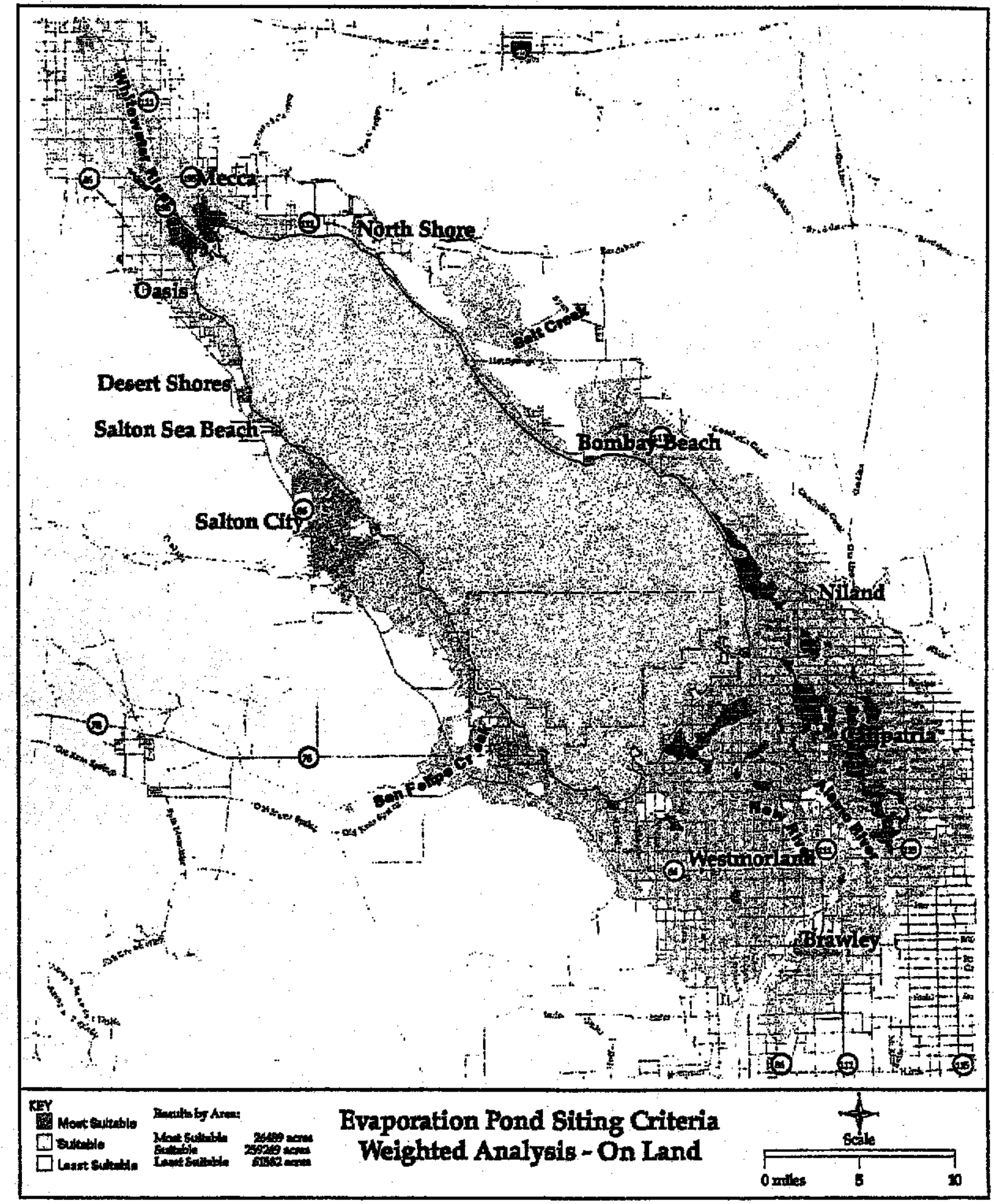

Figure 4-10 Suitable areas for siting solar evaporation ponds on land.

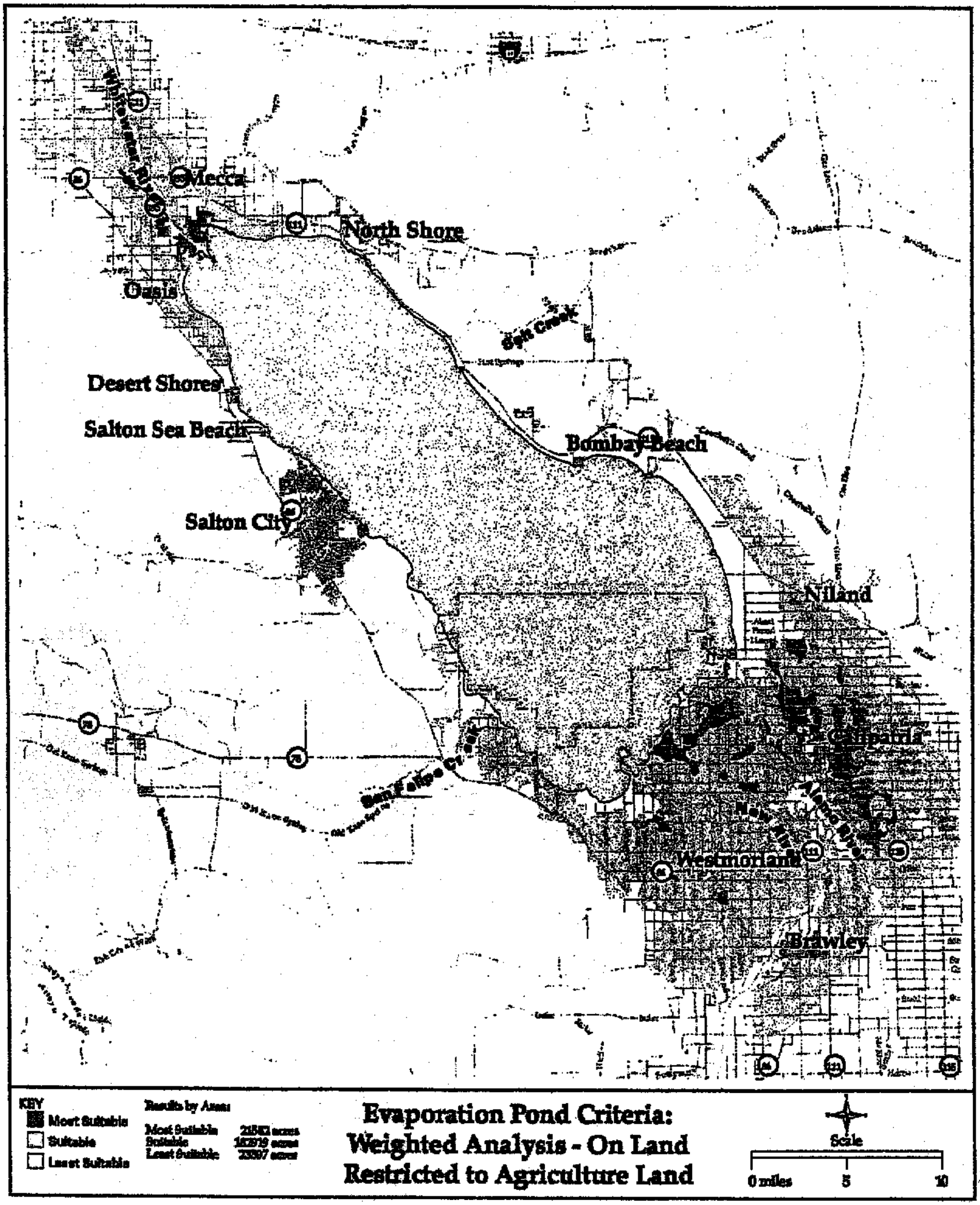

Figure 4- 11 Suitable Areas for Siting Solar Evaporation Ponds on Agricultural Land.

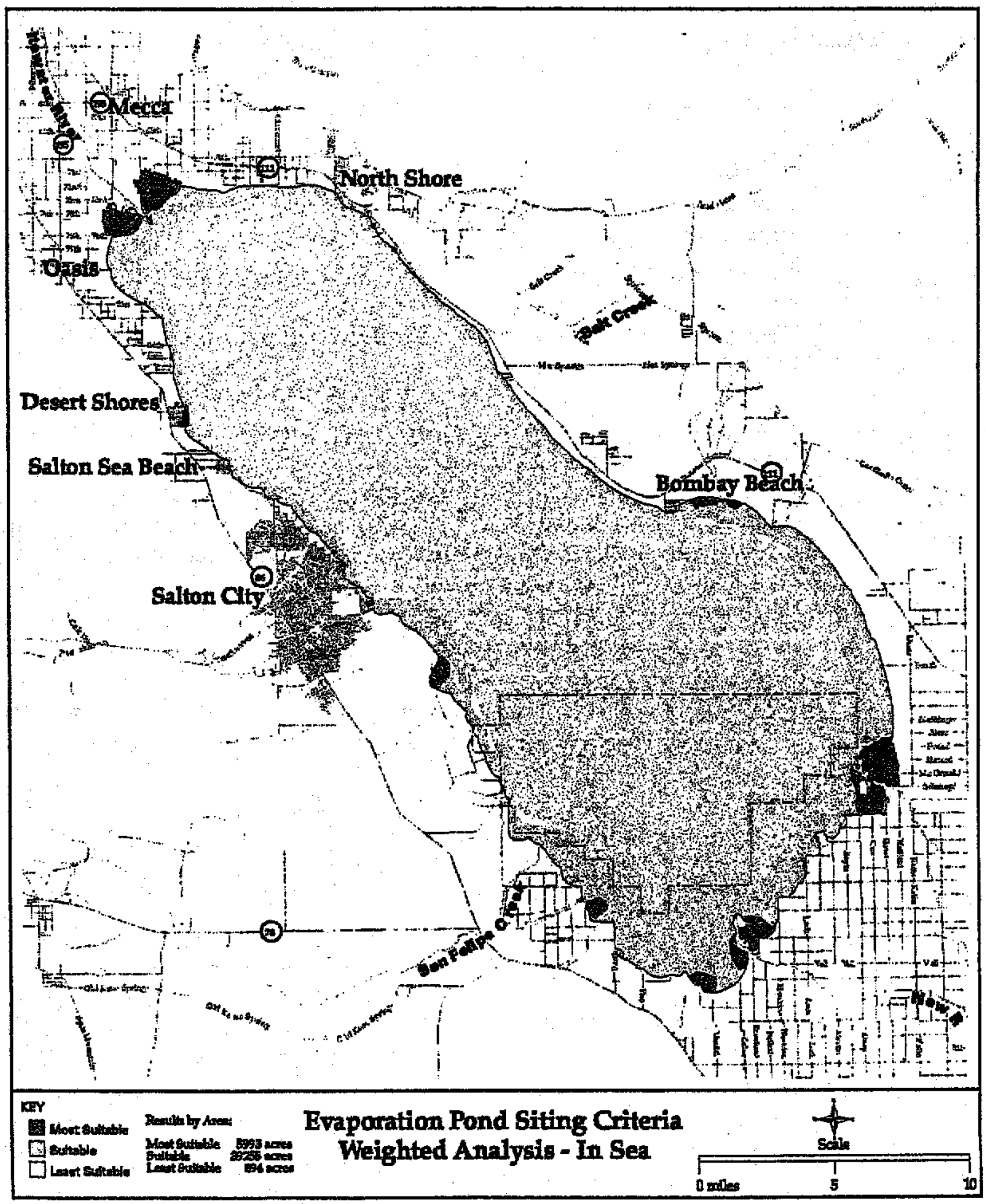

Figure 4-12 Suitable Areas for Siting Solar Evaporation Ponds within the Salton Sea.

Shallow Solar Evaporation Pond Wildlife Features

Wildlife Benefits

The San Francisco Bay Area Wetlands Ecosystem Goals Project in 1999 provided a comprehensive review of the use of salt evaporation ponds by water birds, and developed a set of recommendations for restoring and improving baylands and associated habitats in the San Francisco estuary (EPA 1999). Much of the information from the Goals Project, although specific to the San Francisco estuary, is pertinent to solar evaporation ponds in an inland setting and is included in this report.

Saltwater evaporation ponds and hypersaline lakes across the western United States (U.S.) attract enormous numbers of migratory, wintering, and nesting water birds. (Interior 1999) The actual levels of water bird use of solar evaporation ponds at the Sea will depend, in part, on their overall design and operation. Previous studies have shown that shallow ponds (less than 4-inches deep) with low salinities [less than 60 parts per thousand (ppt)] and slow-moving or wind-mixed water will attract the most species and often the greatest numbers of water birds (Miles et al 2000). Inclusions of roosting islands within the low-salinity and medium-salinity (greater than 60 ppt, but less than 180 ppt) solar evaporation ponds will greatly enhance their use by roosting and nesting shorebirds, gulls, and terns (Barnum 2001).

As currently designed, the Salton Sea solar evaporation pond conceptual alternatives will include ten concentration ponds and the water will be moved from pond to pond via gravity and/or pumps through pipes and/or open channels. In the low-salinity ponds, slow-moving and wind-mixed water will enhance the productivity of macroinvertebrates and important water bird prey species, such as Chironomid midges, alkali flies, brine shrimp, and water boatmen. The medium-salinity ponds (greater than 60 but less than 180 ppt) also will support invertebrates, but only brine shrimp will reproduce in ponds with salinities greater than about 100 ppt. The high-salinity ponds (180 ppt to 300 ppt) will provide habitat for brine shrimp, and the shorelines of these ponds may attract adult alkali flies that have hatched in the low- and medium-salinity ponds. Grebes, gulls, waterfowl, and shorebirds prey on brine shrimp and alkali flies. The high-salinity ponds could receive substantial use by these species (Miles et al 2000, and Barnham, personal communications).

All of these invertebrate species will reproduce in greatest numbers in ponds with moving water, or where there is a predictable wetting and dry cycle of the pond bottom (Barnham, personal communication). Artificial wetlands in the Tulare Lake Basin in Kings County designed with shallow, flowing water and a predictable drawdown cycle provided superabundant invertebrate food for shorebirds such as killdeer, American avocets, and black-necked stilts that nested at extremely high densities on the small levees between the flowing channels. (Hansen 1998; Barnham and Hansen, personal communications). Moving waters of the Salton Sea solar evaporation ponds may be similarly productive for macroinvertebrates and nesting and migratory water birds.

The Sea is a magnet that draws water birds from thousands of miles in the arid southwest (Small 1994). The large expanses of shallow, open water that will be created by the solar evaporation ponds should also attract large numbers of shorebirds, waterfowl, and wading birds. These ponds have the potential to become a regionally important resource for migratory and nesting water birds. More than 380 different bird species, representing more than 60 percent of the species recorded in California, have been observed at the Salton Sea National Wildlife Refuge. A few species such as yellow-footed gulls, gull-billed terns, and black skimmers occur regularly at the Sea, but are extremely rare or absent elsewhere in the state (Small 1994). Due to its large size and proximity to the Gulf of California, the Sea is famous for attracting rare and unusual birds. The Sea is a destination of thousands of birders annually and the solar evaporation ponds could become a major bird viewing area if they were managed for this use.

Potential Adverse Impacts on Wildlife

The primary adverse impacts from operation of the solar evaporation ponds could be the concentration and mobilization of selenium in the food chain, and possible outbreaks of botulism in the warm, shallow waters of the solar evaporation ponds (Barnham personal communication). Both will require further research and monitoring to determine their actual effects on water birds at the proposed Sea solar evaporation ponds.

The adverse effects of selenium on nesting water birds have been well documented in previous studies (Ohlendorf 1999, Skorupa 1989, and Dekker 1998). As discussed in these previous studies, short- and long-term exposure to high concentrations of oxidized selenium can result in direct mortality of adult and juvenile birds, deformities, and mortality of developing embryos, as well as sub-lethal effects including weight loss and behavioral changes.

Selenium is present in measurable concentrations [5.89 parts per billion (ppb) in the Alamo River, 3.24 ppb in the New River, and 2.55 ppb in the Whitewater River] in the water that flows into the Sea. However, selenium is present at low concentrations (1.02 to 1.25 ppb) in the Sea's water column due to dilution, mixing, and possibly fixation via biological activity. The concentration of selenium in bottom sediments is generally two to three times greater than that present in the water column. This suggests that mechanisms for removal of selenium are at work in the Sea. Selenium may be taken up by bacteria and chemically reduced. Selenium may also be incorporated by biological reactions in organic molecules capable of volatilizing to the atmosphere. Some selenium may precipitate with dead plant material (Interior 2000).

The solar evaporation ponds designed to concentrate salts could also concentrate selenium. However, the Sea water delivered to the ponds will contain only trace levels of selenium (about 1 ppb) and the concentrating effects of the evaporation ponds could be minor. Even if selenium concentrates in the brine; however, it may be less bio-available in the high-salinity ponds than it would be in the low-salinity ponds. Studies from other areas, such as Kesterson Reservoir in Merced County, indicate that selenium is taken up by and mobilized into the food chain by bacteria, algae, and emergent vegetation that proliferate in the low-salinity ponds but not in the devegetated, high-salinity ponds (Barnham, personal communications). Lacking abundant primary producers to mobilize selenium in the high-salinity ponds, the brine shrimp there may contain low concentrations of selenium.

The above hypotheses can be tested for Sea water using the pilot solar evaporation ponds to monitor the selenium levels in the water column, primary producers, and macro-invertebrates. When the solar evaporation ponds are operational, samples obtained from low-, medium-, and high-salinity ponds can be analyzed to develop baseline data to forecast the selenium levels. The potential effects of selenium on water birds at the Sea are currently under study by two research teams who will likely include the solar evaporation ponds in their investigations (Barnham, personal communications).

The inlets to the inflow pumps could be situated at a sufficient distance from the outlets of the New and Alamo Rivers and/or a few feet above the bottom sediments to reduce the potential for delivering high-selenium water to the solar evaporation ponds. Water quality at the inlet locations could also be monitored at regular intervals to ensure that it meets state and federal selenium requirements (less than 3 ppb) for use in wetland habitat areas.

Recommended Features to Provide Wildlife Benefits

The following recommendations on enhancing the solar evaporation ponds for water birds have been summarized from the Goals Project (1999), the "Sea White Paper" (2000), and from other published literature and contacts with professional ornithologists. These recommendations reflect the general assumptions from the preceding sections that the solar evaporation ponds will be most attractive for water birds if they are low in salinity, with shallow, slow-moving or wind-mixed and with substantial areas of islands and protected, shoreline roosting habitat. For these reasons, the low- and medium-salinity evaporation ponds (below 100 ppt) could be designed and linked together to increase their attractiveness for water birds. The high-salinity ponds probably would be less attractive to water birds, and fewer design features are recommended.

Low-Salinity Ponds

The low-salinity ponds (less than 60 ppt) are likely to receive the greatest use by water birds, because they will produce the most abundant invertebrate prey. These ponds could be actively enhanced and managed to attract birds by including the following design features:

- A mosaic of islands, mudflats, and open water areas; mudflats are most critical during the spring and fall migration and can be created by drawing down the ponds to appropriate depths.
- Water depths ranging from shallow (less than 3 feet) to very shallow (2 to 10 inches), with 2- to 4-inch depths over much of the pond surface being optimal.
- Areas of deeper water (created by excavating pond bottoms for borrow material) to create nesting and roosting islands (see Figure 4-13); deep water areas (greater than 3-feet deep, and at least 20-feet wide) would serve as an underwater "moat" to reduce predator access to nesting and roosting birds on these islands.

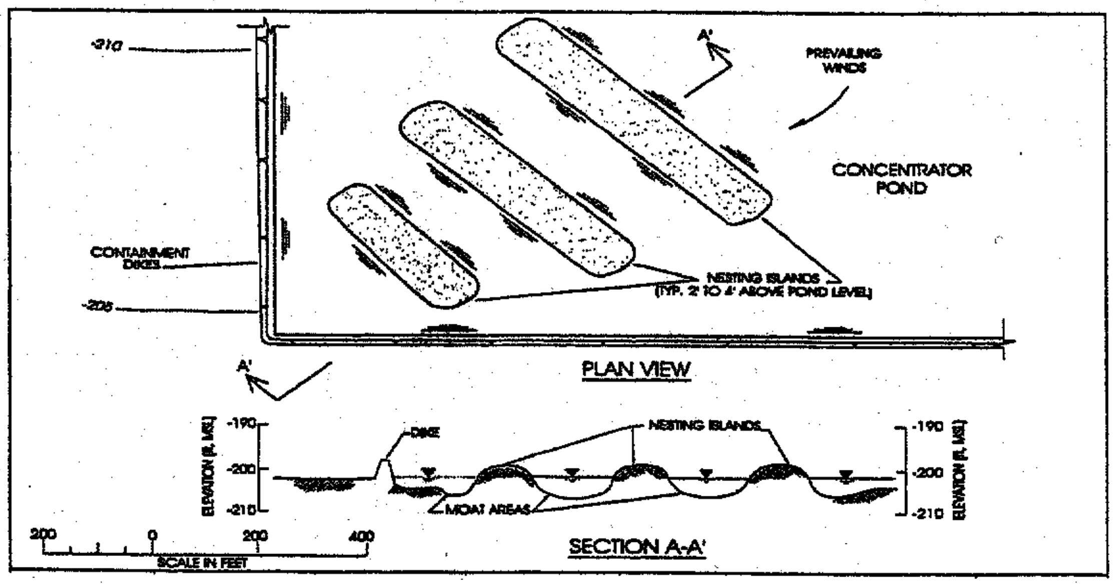

Figure 4-13. Conceptual design for nesting islands.

- Islands can be relatively small (30-yards wide by 100- to 200-yards long) and be designed to serve multiple functions, such as a series of internal windbreaks between the levees. These functions would be best served by a series of three or four windbreaks aligned in parallel fashion with each other, and perpendicular to the prevailing northeast (NE) to southwest (SW) winds in this area.
- The islands should be unvegetated and designed with shallow slopes rising to about 2 feet. The most windward levee should crown at about 3 to 4 feet to ensure that it is not over topped by waves during high winds and so it protects the downward islands from the effects of high waves.
- Either elongated or roughly circular islands would receive high use by terns, gulls, waterfowl, and shorebirds. They should be designed to mimic natural topographic conditions with flat slopes transitioning into mudflats and shallow water areas.

Islands should be located in relatively secluded portions of larger ponds, in areas remote from nearby power lines and other obstructions, and developments. The islands should also be located in close proximity to mudflat areas to reduce commute distances between nesting, roosting, and foraging areas.

Medium-Salinity Ponds

The medium-salinity ponds (60 to 180 ppt) will support invertebrate populations, but those at the lower end of this range (less than 100 ppt) will support the most diverse invertebrate assemblages and will attract the greatest concentrations of water birds. Thus medium-salinity ponds should be designed with the following features in mind:

- Maintain a mosaic of open water and open land with the open water at average depths of 4 to 10 inches.
- Islands can be created for water birds and as internal windbreaks, as discussed for the low-salinity ponds above.

High-Salinity Ponds

High-salinity ponds (greater than 180 ppt) will only support brine shrimp, and the highest salinity ponds (greater than 300 ppt) will provide limited invertebrate food for water birds. These ponds should be designed with the following features in mind:

- Generally maintain only deep (greater than 3 feet) open water.
- Islands, if created as internal windbreaks, will be used only by roosting water birds; foraging will primarily occur if brine shrimp are abundant in the ponds.
- Subdivide the ponds with levee roads, as these areas will be used as roosting habitat for shorebirds, gulls, and terns.

Appraisal Level Earthwork Costs

Appraisal level cost estimates were developed for the earthwork associated with the solar evaporation ponds. The capital costs consist of the earthen berms and conveyances. Conveyance capital and operating costs are discussed in the section on Intake and Conveyance Facilities. Quantities of earthwork required for the concentrator pond berms were estimated for Concepts A through C and are shown in Table 4-3. A cost of $4.10 per cubic yard (cy) was used for excavating, hauling, placing, and compacting the on-shore berm fills. The materials overexcavated for the key below the berms were assumed to be reusable materials; a cost of $3.25/cy was used for excavating, placing, and compacting this material. The total cost (in present day dollars) for the earthwork associated with Concepts A through C is also shown in Table 4-3.

Table 4-3 – Summary of Conceptual Designs of Solar Evaporation Ponds and Appraisal Level Costs (Excluding Conveyance)

Item	Concept A On-Shore Flat Terrain	Concept B On-Shore Flat Terrain	Concept C On-Shore-Steep Terrain	Concept D In-Sea Shallow Water	Concept E In-Sea Deep Water
Facility Capacity (million tons/yr)	1.0	2.0	1.0	1.0	2.0
Concentrator Ponds					
Area (acres) [a]	2,800	5,600	2,800	2,800	5,600
Total Length of Dikes (ft)	99,700	182,900	126,700	99,600	183,500
Average Height of Dikes (ft)	6	7	10	11	15
Average Bottom Width of Dike [b]	44	45	64	104	137
Dike Volume (cy)	660,900	1,294,300	1,862,500	2,588,000	8,661,800
Overexcavation Volume [c]	73,800	135,500	93,900	1,854,200	4,254,500
Earthwork Costs	$3,245,000	$6,321,000	$8,735,000	$48,887,000	$131,639,000
Additional Costs [d]	$5,759,000	$11,364,000	$10,765,000	$44,578,000	$120,039,000
Total Costs	$9,004,000	$17,685,000	$19,500,000	$93,465,000	$251,678,000
Capital Cost ($/ton) [e]	$0.30	$0.29	$0.65	$3.12	$4.19

Notes:
[a] Assumes mid-case for seepage.
[b] Assumes 12-foot top width and 2.5:1 slopes on-shore and 30-foot top width and 3.5:1 slopes in-Sea.
[c] Assumes 2-foot by 10-foot seepage below dikes.
[d] Includes land ($1,000/acre), unlisted items (plus 15 percent), contingencies (plus 25 percent), and noncontract costs (plus 33 percent).
[e] Assumes facility life of 30 years, excludes conveyance costs.

Additional capital costs for the on-shore concentrator ponds were estimated as land ($1,000/acre), unlisted items (plus 15 percent), contingencies (plus 25 percent), and noncontract costs (plus 33 percent). Note that although $1,000 per acre was used as a base cost of land, higher land values were used in developing cost estimates for alternatives that would involve construction on agricultural lands. For the earthwork costs, we assumed that a liner would not be required in the bottom of the ponds. If the ponds are sited in an area where the leakage is estimated to be too high, a liner system may need to be installed. It is estimated that a liner would add approximately $25,000/acre in costs.

Thus, it would generally be considerably less costly to buy more land and build larger solar evaporation ponds.

Appraisal level cost estimates were also developed for the earthwork associated with the in-Sea concepts (Concept D and E). Estimated quantities of the earthwork required are also shown in Table 4-3. A cost of $7.00/cy was used for excavating and hauling (up to 25 miles) fill (dumped below Sea level and compacted above Sea level). The overexcavated materials below the dike were assumed not to be reusable. A cost of $13.00/cy was used for these quantities ($6.00/cy to excavate and dispose and $7.00/cy to replace). The total capital costs (in present day dollars, excluding conveyance) for the in-Sea concentrator ponds are also shown in Table 4-3. Additional capital costs for the in-Sea disposal were unlisted items (plus 15 percent), contingencies (plus 25 percent), and non-contract costs (plus 33 percent). The land was assumed to be available at no cost.

ENHANCED EVAPORATION SYSTEMS

Introduction

Enhanced Evaporation Systems (EESs) increase the evaporation rate over that of normal evaporation evidenced in ponds. EES machines provide such increase or enhancement in a variety of ways, but most systems spray water into the air. Industries all over the world uses EESs to aid in eliminating water from various fluids. The mining industry uses them to save the cost of enlarging existing ponds. Environmental projects use EESs to dry-up existing waste ponds. Other projects use them as Reclamation is considering here, to decrease the volume of holding and salt disposal ponds.

Many of these project managers weigh the cost of EESs against building large ponds or increasing the size of existing ponds. The cost of ponds increases as the slope of the land increases. The cost also increases with the pond size and the loss of use of that land for other purposes. The decision is usually simply a matter of cost.

Basic Theory of EES Technology

Before considering the details of various EES methods, lets look briefly at the theory of how they work. Normal pond evaporation is an interaction of the thin layer of surface water being evaporated and the air contacting it. The rate of evaporation depends on the vapor pressure of the interacting surfaces. This vapor pressure is a function of the temperature of the water, temperature of the air, and the relative humidity of the air. The process is also affected by evaporative properties of the fluid, such as salinity and the air current at the interface. The evaporation rate and the energy requirements are discussed below.

Evaporation Rate

The standard method to estimate normal evaporation is to collect data using a Class A evaporating pan. This is a circular pan, 48 inches in diameter and 10 inches deep. Investigators record the time for the water to evaporate from between 8 and 7 inches deep. Dividing the depth of water evaporated by the time gives the evaporation rate. Appling a correction factor to this rate allows for approximating the rate of evaporation of the body of water in question.

Some investigators have used dyes, black plastic sheets, and other methods to increase evaporation. While some of these may hold promise in aiding our endeavor, little has been done to measure their effect. We will now look at the effect of creating fluid droplets and passing them through the air.

The evaporation process of a water droplet formed by an EES is very similar to that of a pond. The temperature, relative humidity, and fluid property effects are probably similar. The wind, however, affects the falling droplets of water quite differently. The droplet freefalling through the air will fly free with the wind. Its relative velocity to the wind is zero. There are relative velocities caused by the initial spraying and the resulting fall speed to earth. The wind does have a great effect on replacing the high humidity air of the cloud with outside, dry air.

Some researchers also feel that solar energy affects the evaporation much differently than that of a pond. Much more of the energy is probably absorbed by the droplet cloud than the surface of pond. This affords greater energy to facilitate evaporation.

The entire surface of the drops is free to evaporate while the droplets remain in the air. This provides much more surface area, for a given volume, than is allowed on the surface of a pond. The volume of the droplet decreases as the cube of its radius. The initial salt in the droplet remains as the water evaporates, forcing the salinity to increase and the evaporation rate to decrease.

Not all of these droplets remain as individuals. Some of them combine with others as they fall, decreasing the efficiency of the process.

All of the evaporation at such a fast rate raises the humidity of the air in the cloud. The highest humidity is found in the center of the cloud. If one wishes to continue with a fast evaporation rate, then one must supply the cloud with air. This air demand comes from various sources. The first source mentioned above, that of naturally flowing air in currents, was wind. The other comes from air currents caused by the cooling effect of the evaporation process itself and forming a microclimate. These microclimate air currents are quite important to the process.

All of this leads to the fact that the longer the time the droplet remains in the air, the better the evaporation. This is known as hang time.

Energy Requirements

Evaporation rate is not the only parameter that we must consider. Droplet throwing systems use energy to do their work, which can be a major cost of a project. Three modes consume most of the energy in the droplet forming EESs.

The first is pumping used to lift the water from one location to another. Any system that moves water from one location to another, including solar ponds, consumes this energy. Hydraulic design must also account for losses in the pipelines—important because most of these pipelines are long.

The second parameter is the energy to provide the additional pressure head at the nozzles or outlets. This head varies and is dependent on the EES.

The third component may be some form of energy to split or blow the evaporate into the air.

System Descriptions

Normal solar evaporation ponds evaporate water through a series of ponds with salinity increasing in each successive pond. The concentrated brine is sent to the disposal pond after more than 90 percent of the water has evaporated. EESs can use only a disposal facility, or can work together with solar evaporation pond s to reduce the size and/or number of ponds.

Several different EES technologies currently exist. The technologies being considered for the Salton Sea Restoration Project are:

- Line shower system
- Surface spray systems (ground or water surface)
- Spray sticks
- Turbo-enhanced spray systems
- Droplet splitting systems

Tower Line Shower Systems

Line shower systems have been demonstrated to enhance evaporation of the Dead Sea water and are currently being used in mining operations in South Africa. They consist of pipes suspended 60 to 150 feet above the ground that spray water down toward the ground. Air currents caused by the evaporation process suspend the droplets while the droplets evaporate. Droplets not completely evaporated drop to ponds below, along with evaporated salt. (See Figure 4-14). Seismic design of these high towers adds to the capital cost. This becomes critical in earthquake prone areas, such as that at the Salton Sea.

The energy required for such a system is that required to pump the water up to the lines and to spray the water out of the lines at approximately 40 pounds per square inch (psi) pressure.

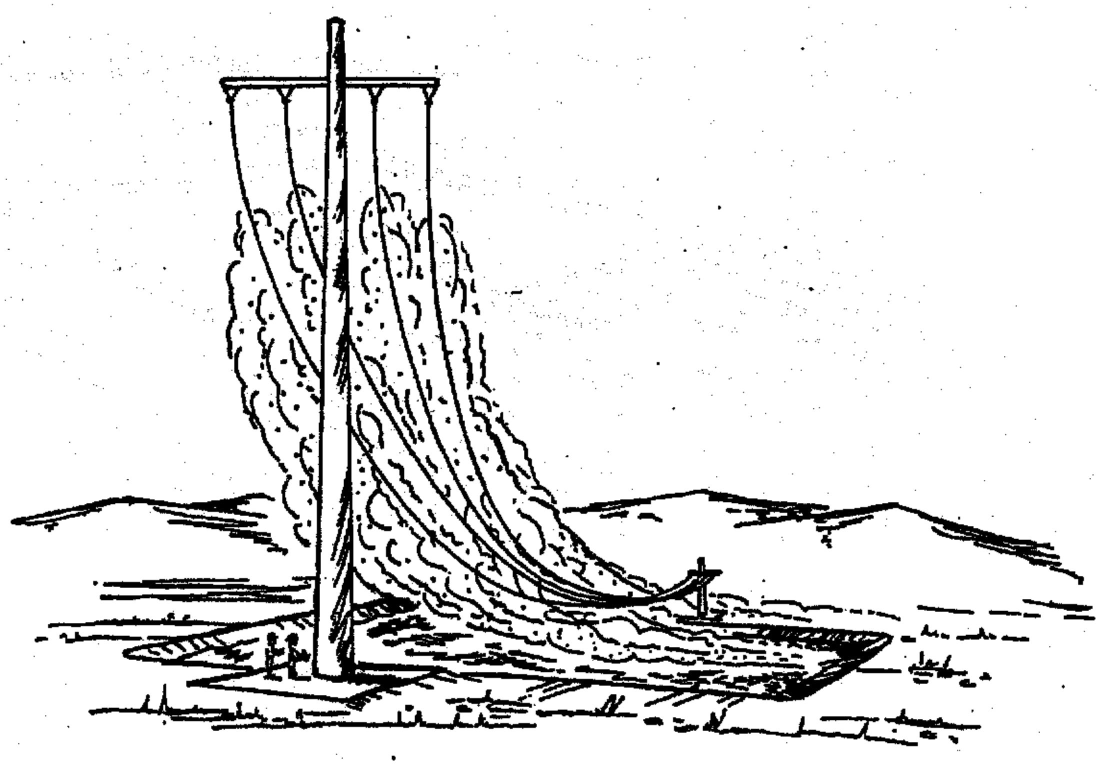

Figure 4-14.—Sketch of a Tower Line Shower System.

Surface Spray Systems

Surface spray systems are similar to the line shower system, but the lines are laid on the ground instead of being suspended in the air. Their nozzles are usually in the shape of a corkscrew. Water squirts through the inside of the corkscrew at high pressure and the stream of water separates as the outside of the stream is sheared away from the stream (see figure 4-15). This eliminates the cost of the towers and possibly some of the energy required to pump the water through them, but at the cost of losing evaporation efficiency. A berm would be constructed around the system to contain sprays and to allow for drainage. A berm could also be built on top of the dikes. Surface spray systems are currently in use in South Africa and Texas.

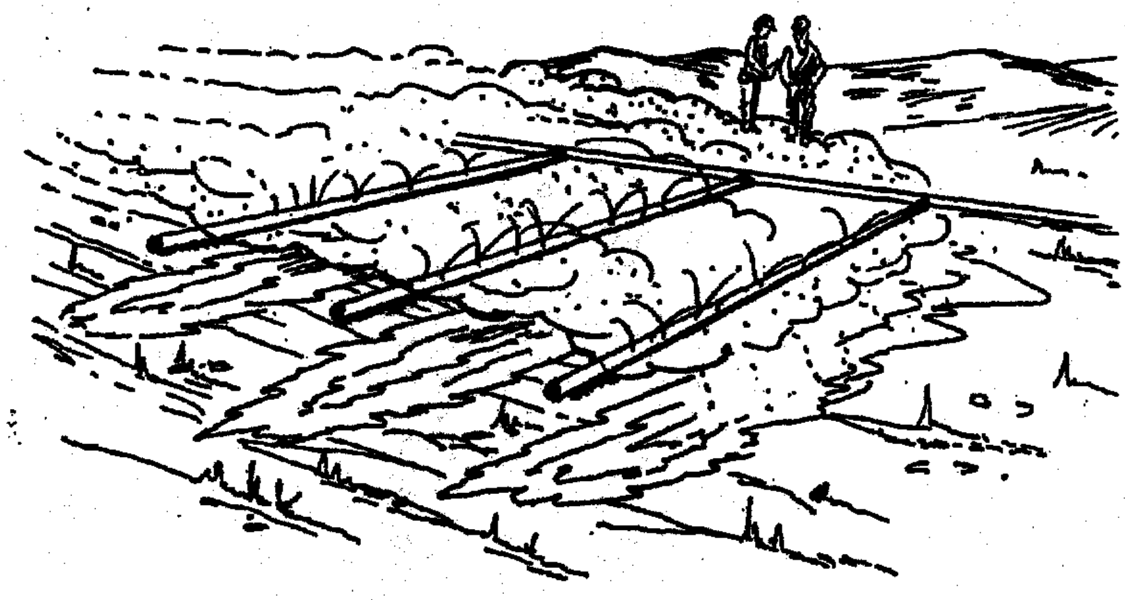

Figure 4-15. Surface Spray System.

Spray Sticks

Spray sticks are similar to the surface spray system but the corkscrew nozzles are placed in a ring-shaped pipe and elevated above the ground tens of feet. This provides for a longer hang time than does the surface spray systems. See figure 4-16 for a sketch of a spray stick.

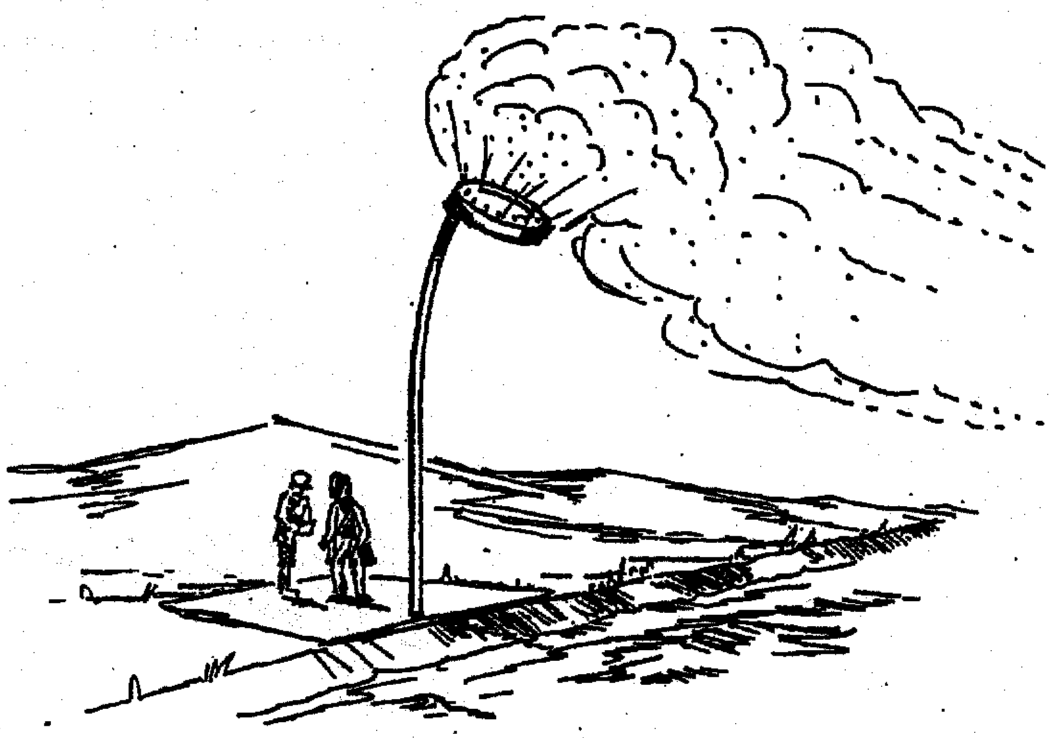

Figure 4-16. Sketch of a Spray Stick System.

Turbo-Enhanced Spray Systems

Turbo-enhanced spray systems make use of the ringed-shaped pipe of the spray sticks but blow air at high velocities through the center of the ring. This blows the sprayed water into the air and provides large volumes of air for the evaporation process (see figure 4-17). These systems require large amounts of energy for the blower. Their energy requirements are many times that of the other EESs. This energy allows their evaporation efficiency to be extremely high. Such systems are expected to evaporate all of the water that passes through them when used in the summer. They are being used extensively in the mining and environmental cleanup industries to evaporate unwanted water.

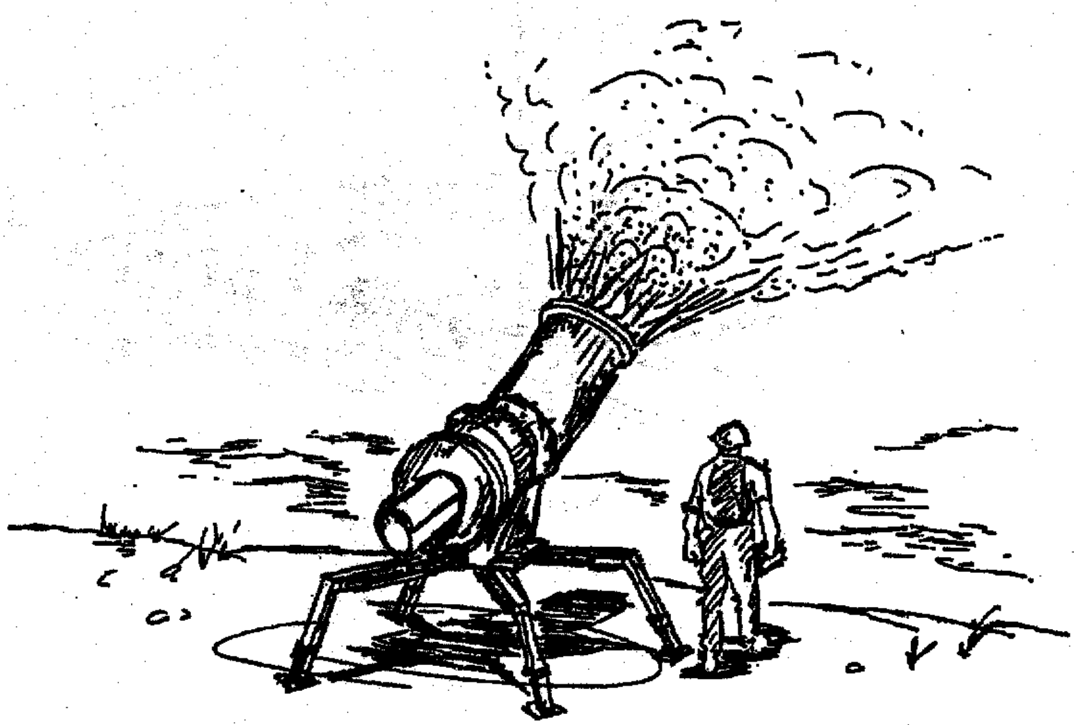

Figure 4-17.—Sketch of a Turbo-Enhanced EES System.

Water Droplet Splitting Systems

Water droplet splitting systems spray water into a water droplet splitter that atomizes the streams of water and propels the droplet cloud vertically. The splitter resembles a fan blade. This machine forms a cloud similar in appearance to the cloud formed by the turbo-enhanced spray machines (see figure 4-18). Their output and energy requirements are also similar, as is their current use, to turbo-enhanced spray systems.

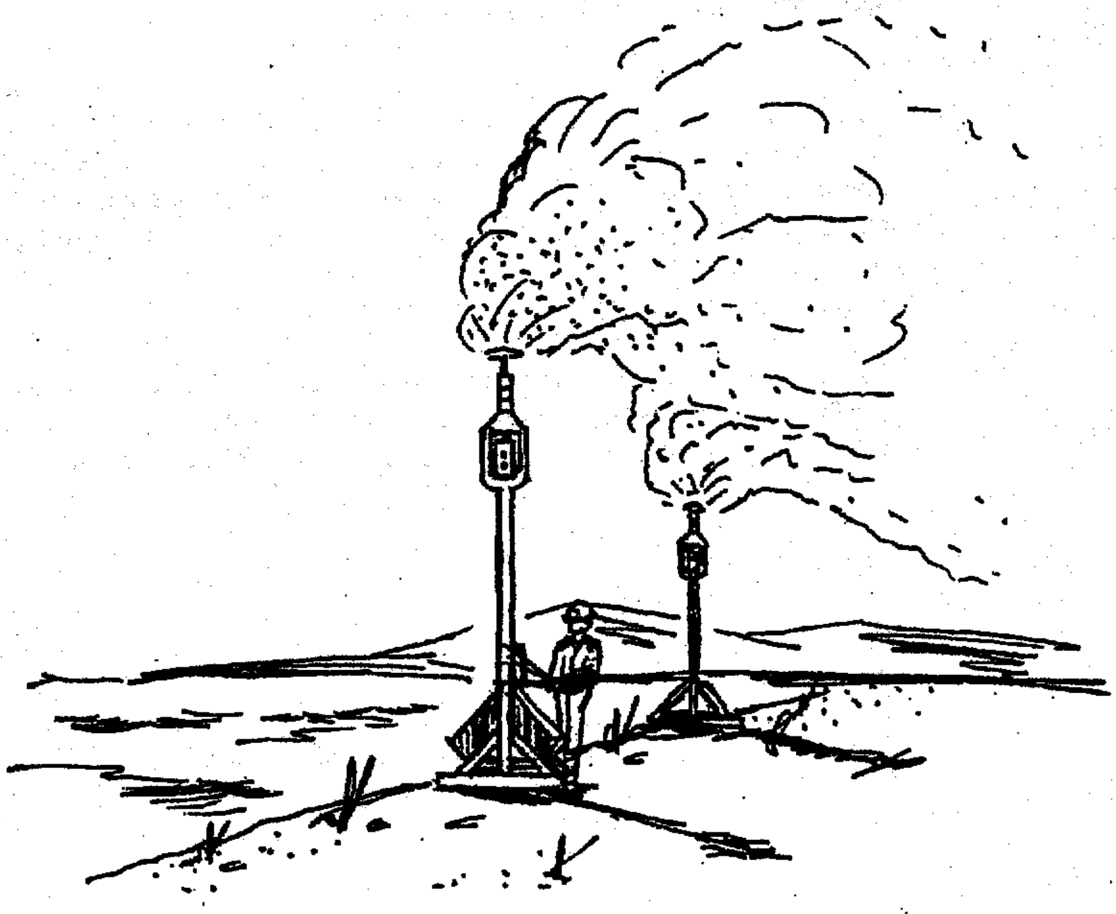

Figure 4-18. Sketch of a droplet splitting system.

EES Unit Efficiency Studies

The studies discussed here do not include the energy required to lift the water from the Sea to the base of the evaporators. Rather this energy would be the same as that used with the ponds and is accounted for there.

Reclamation and the Salton Sea Authority briefly tested the performance of various EESs. Details of the tests are presented in a document by Remmers, 2001. A short disussion of what has been done, what is planned, some results of the testing, and results of minor tests by others is presented in this document.

Ground-Based Turbo-Enhanced Systems

There were two demonstrations of a ground-based turbo-enhanced EES at the Sea. While these demonstrations were done to allow the public to view the machines in operation, operators did note that most of the droplets, at times, completely evaporated. These evaporated droplets were seen on the outside of the main water stream. This information, along with information gained from past EES projects, aids in developing a method of estimating the overall evaporation and energy efficiency of the EES.

These estimates of efficiency rates are far from exact and are being modified as testing continues. Others have hypothesized that the efficiency rate is a linear relationship with the Class A evaporation pans previously discussed.

Other Studies

The current design is based on data collected over the past several years near the Salton Sea Test Base and using the current efficiency equations. These efficiency equations were developed using data from projects in Canada, the U.S., and the demonstrations at the Salton Sea. Combining the efficiency of the EES, the Class A evaporation pan data, and the approximate amortized cost of the system allows designing for the optimum system and operation.

Details of Design for this Alternative

Two types of EESs were used in this conceptual design: a ground-based system and a system that uses towers. The ground-based system uses turbo-enhanced units and the tower system incorporates in-line shower technology. These systems are commonly used to evaporate water and have more data available about their successes. The other systems have merit, depending on the particular application, but are not currently included as part of the Restoration Project.

The following section discusses a placement criteria rating system and the two types of EESs currently under consideration.

EES Siting Criteria

The following is the rating system that was used to create a map, indicating the relative usability of land areas around the EES. Any area scoring zero on any criteria is considered a restricted area to EESs. Distances should be taken considering both existing and planned (on the county's books) uses. Distances taken upwind and downwind should consider various proportions of time the wind blows throughout the year.

EESs are always accompanied by evaporation, disposal, or similar ponds. The rating for an entire pond/EES unit is a function of both the pond rating system and the EES rating system. The siting criteria for EES tower facilities are shown in Table 4-4. The siting criteria for EES ground-based facilities are shown in Table 4-5.

Figure 4-19 presents suitable areas for siting enhanced evaporation system towers.

Figure 4-20 presents suitable areas for siting ground-based enhanced evaporation systems.

Table 4-4. Siting Criteria for Tower EES Facilities

Item	Criteria categories	Site ranking[1/]	Criteria weighting (%)[2/]
	>2	1	
	1 to 2	2	
	0.5 to 1	5	
Distance from urban areas (miles)	< 0.5	9	10
	>1	1	
	0.5 to 1	3	
	0 to 0.5	4	
Distance from agriculture (miles)	within	5	6
	>1	1	
	0.5 to 1	2	
	to 0.5	3	
Distance from highways (miles)	0 to 0.1	9	10
	>0.2	1	
	0.1 to 0.2	2	
Distance from Sea for spray (miles)	0 to 0.1	3	3
	>1	1	
	0.5 to 1	2	
	< 0.5	3	
Distance from wetlands (miles)	within	9	6
	> 2	1	
	0.5 to 2	2	
Seismic zones: Distance from	0.2 to 0.5	3	
Alquist Priolo Zones (miles)	< 0.2	9	15
	-230 to -180	1	
	-180 to -130	2	
	-130 to -80	3	
Area elevation (ft msl)	> -80	9	15
	0 to 5	1	
	5 to 10	2	
Distance from Sea shore for costs	10 to 15	3	
(miles)	> 15	9	10
	Group D	1	
	Group C	2	
	Group B	3	
Hydrologic Soil Group	Group A	9	25

1/ 1= Best, 2= suitable, 3 to 8 = least suitable, 9 = excluded
2/ Assumes buffer zone.

Table 4-5. Siting Criteria for Ground-Based EES Facilities

Item	Criteria categories	Site ranking[1/]	Criteria weighting (%)[2/]
Distance from urban areas (miles)	>2 1 to 2 0.5 to 1 < 0.5	1 2 5 9	15
Distance from agriculture (miles)	>1 0.5 to 1 0 to 0.5 within	1 3 4 5	8
Distance from highways (miles)	>1 0.5 to 1 0.1 to 0.5 0 to 0.1	1 2 3 9	15
Distance from Sea for spray (miles)	>0.2 0.1 to 0.2 0 to 0.1	1 2 3	4
Distance from wetlands (miles)	>1 0.5 to 1 < 0.5 within	1 2 3 9	8
Area elevation (ft msl)	-230 to -180 -180 to -130 -130 to -80 > -80	1 2 3 9	15
Distance from Sea shore for costs (miles)	0 to 5 5 to 10 10 to 15 > 15	1 2 3 9	10
Hydrologic Soil Group	Group D Group C Group B Group A	1 2 3 9	25

1/ 1= Best, 2= suitable, 3 to 8 = least suitable, 9 = excluded
2/ Assumes buffer zone.

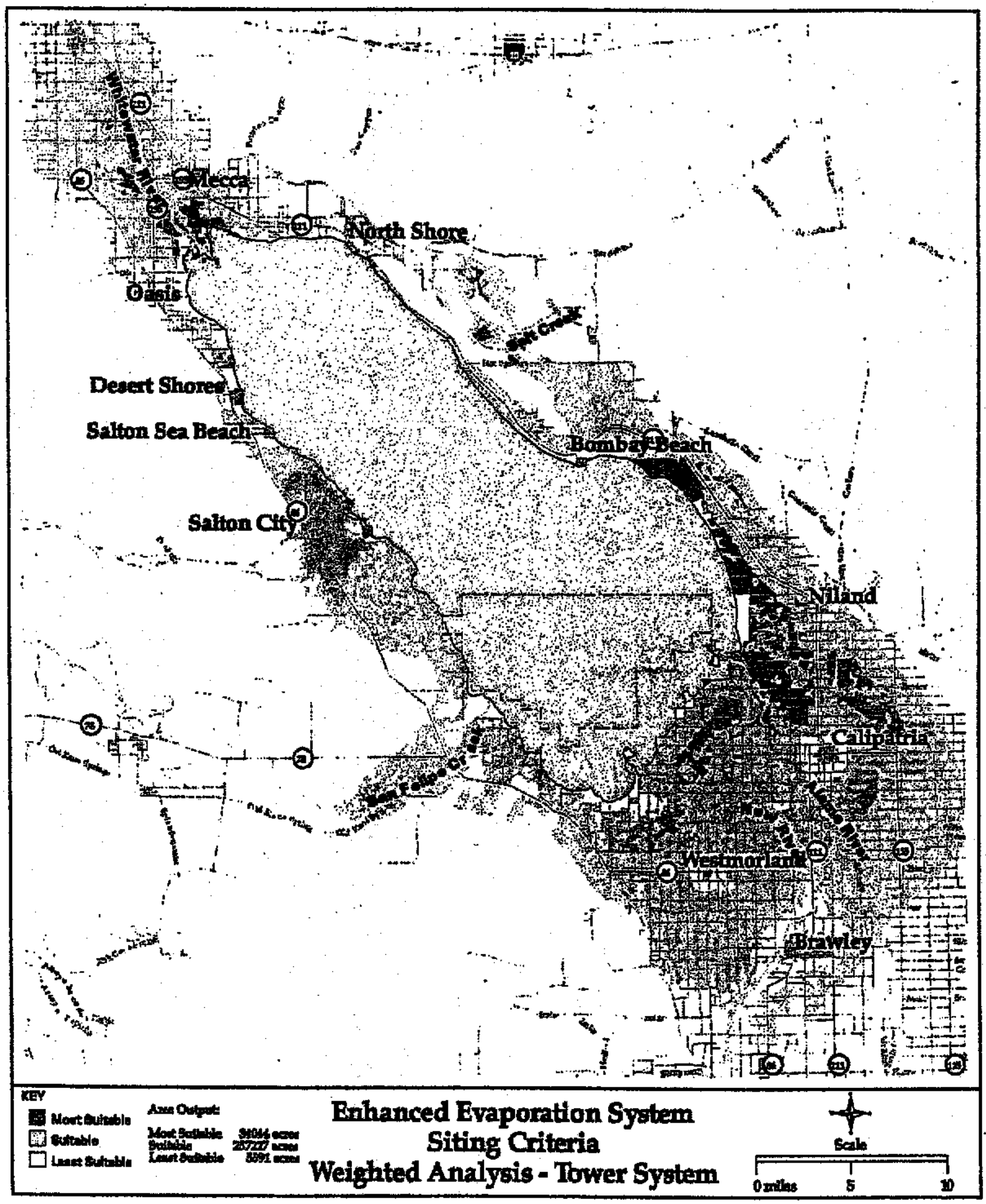

Figure 4-19 Suitable Areas for Siting Enhanced Evaporation System Towers.

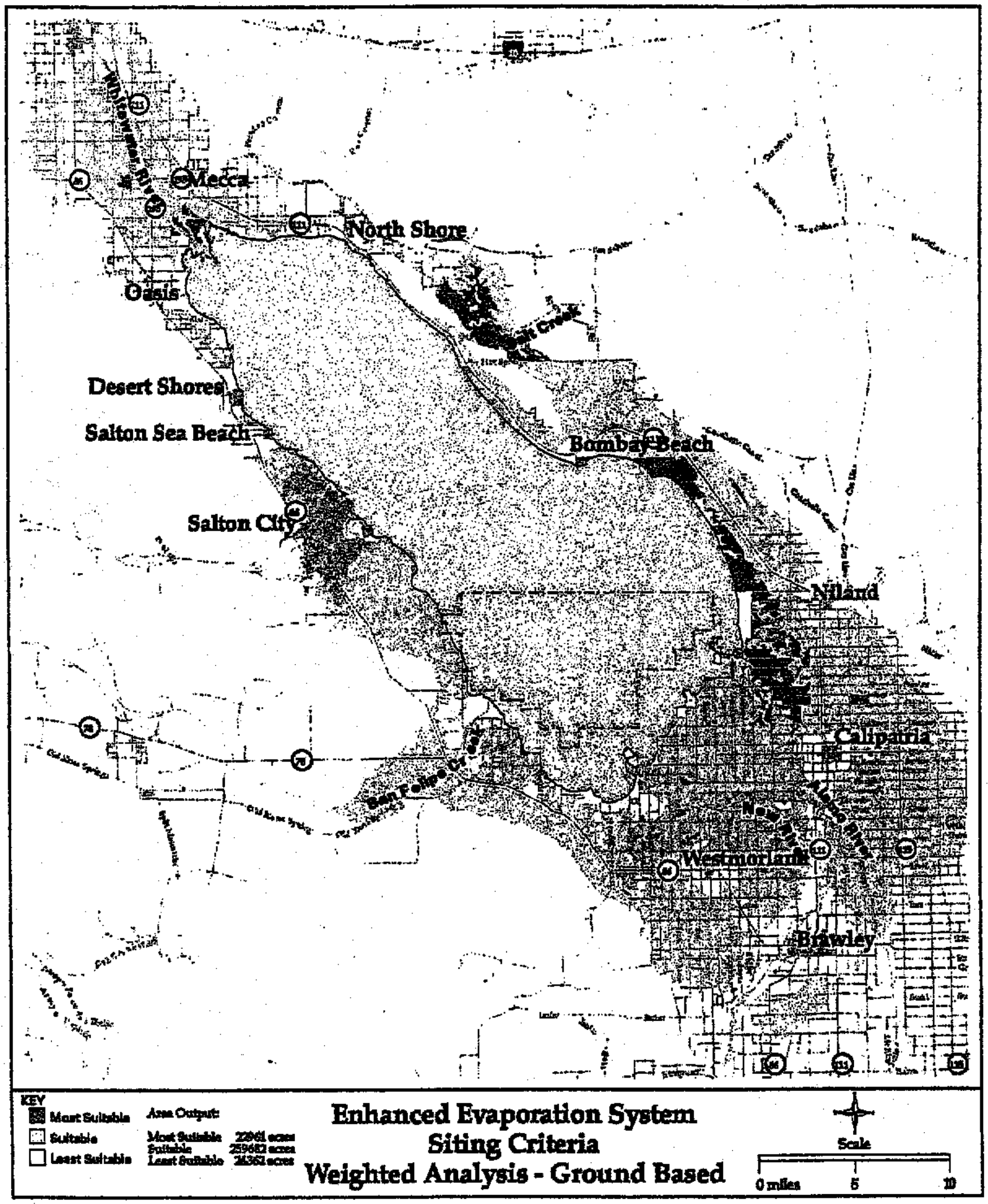

Figure 4-20 Suitable areas for siting ground-based enhanced evaporation systems.

Tower Line Shower Systems

A line shower EES consists of spray water lines suspended high above the ground. The EES is expected to reduce the salinity concentration by providing an outlet from the Sea by increasing evaporation rates through spraying. The facility would have a design life of 30 years.

This option involves constructiong a module(s) on 530 acres, consisting of a line shower EES and pumping effluent to a final disposal pond. Figure 4-21 depicts one module of several that would be needed. This facility has a capacity of 150,000 acre-feet per year.

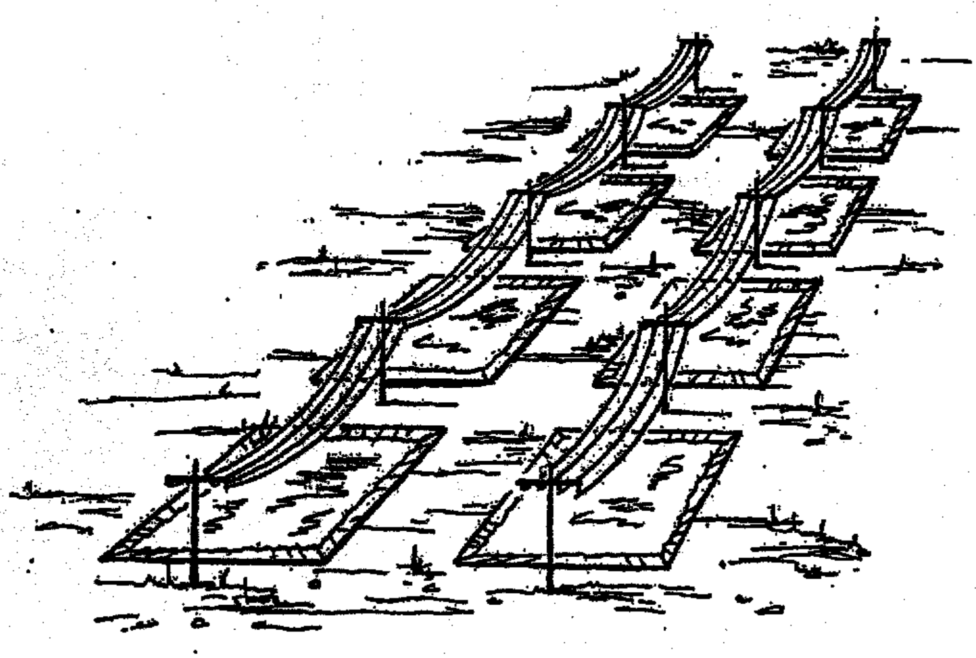

Figure 4-21. A Sketch of One Module of a Tower Line Shower System

The tower line shower EES is designed to operate an average of 18.3 hours per day year-round and shut down if the winds exceed 14 miles per hour. The facility would consist of 210 acres of 80-foot-high EES showers, 210 acres of 130-foot-high showers. The ponds are formed using the natural topography and diking. The salt, about 1 million tons per year, would be disposed of in-place in the final disposal pond.

Sea water would be pumped into the EES line showers with nozzles to allow the sprayed water to evaporate. The concentrated brine that falls to the catchment basins under the showers would then be pumped to the final disposal ponds, where the brine would evaporate to raw salt.

After considering the geology, proximity to the Sea, and low toxicity of the salt, Reclamation feels that the likelihood of need or a liner beyond the naturally occurring clay beds is remote. Costs for ponds shown in this document do not include the cost of lining any of the ponds. Small areas may need to be treated by methods devised for a particular case; these costs are included. The probability of requiring geomembranc lining increases as the ponds get farther from the Sea. A pond constructed in the Sea is not necessarily exempt from needing lining. The ability of the in-situ clay beds to function as pond liners must be evaluated further during high level designs.

The intake structure for the EES would be within the Sea and would include a screened pipe about 42 inches in diameter. The horizontal intake structure would include a trashrack and fish screens. The pipeline leading from the intake to the EES would be buried and would extend from the shoreline to the EES.

Figure 4-22 shows a conceptual layout of a tower line shower EES module.

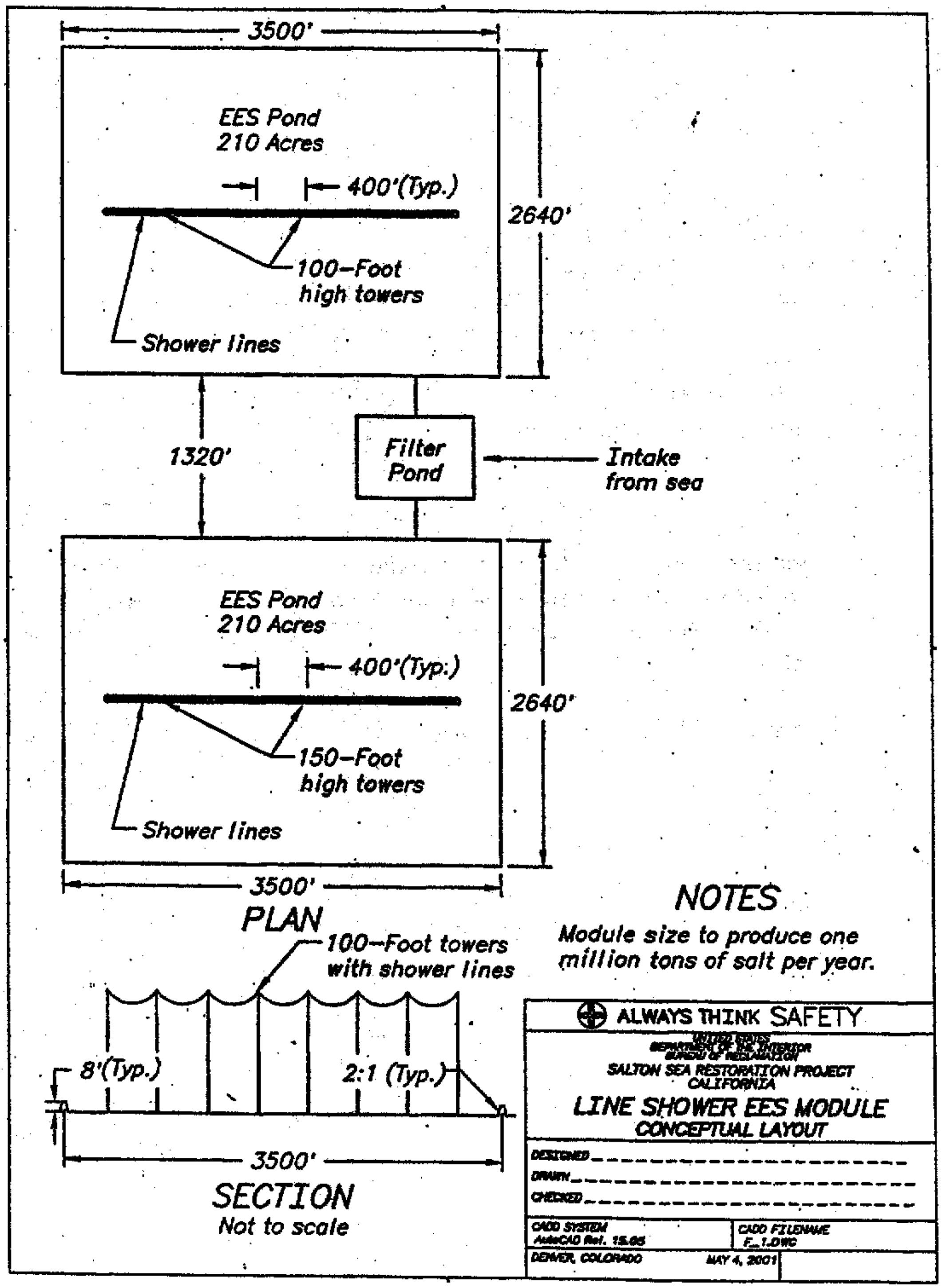

Figure 4-22. Tower Line Shower EES Module, Conceptual Layout.

Ground-Based Turbo-Enhanced Spray Systems

The arrangement of the ground-based turbo-enhanced spray machines can be quite flexible because each machine can act individually. The machines can be placed with other machines in groups or placed individually. They can be placed along the tops of dikes or floated on rafts. Other owners have used all of these arrangements before this project.

This design places the machines as individual units, 180 feet apart. Figure 4-23 depicts the general layout. Operators can point each machine to the optimum angle with the wind. Placing them in groups of four would not allow this. The 180-foot distance is determined by the distance the machines spray water, under calm conditions, so the water would not hit the next machine in its path. This distance also allows for good incoming air movement while minimizing piping and electrical cable costs.

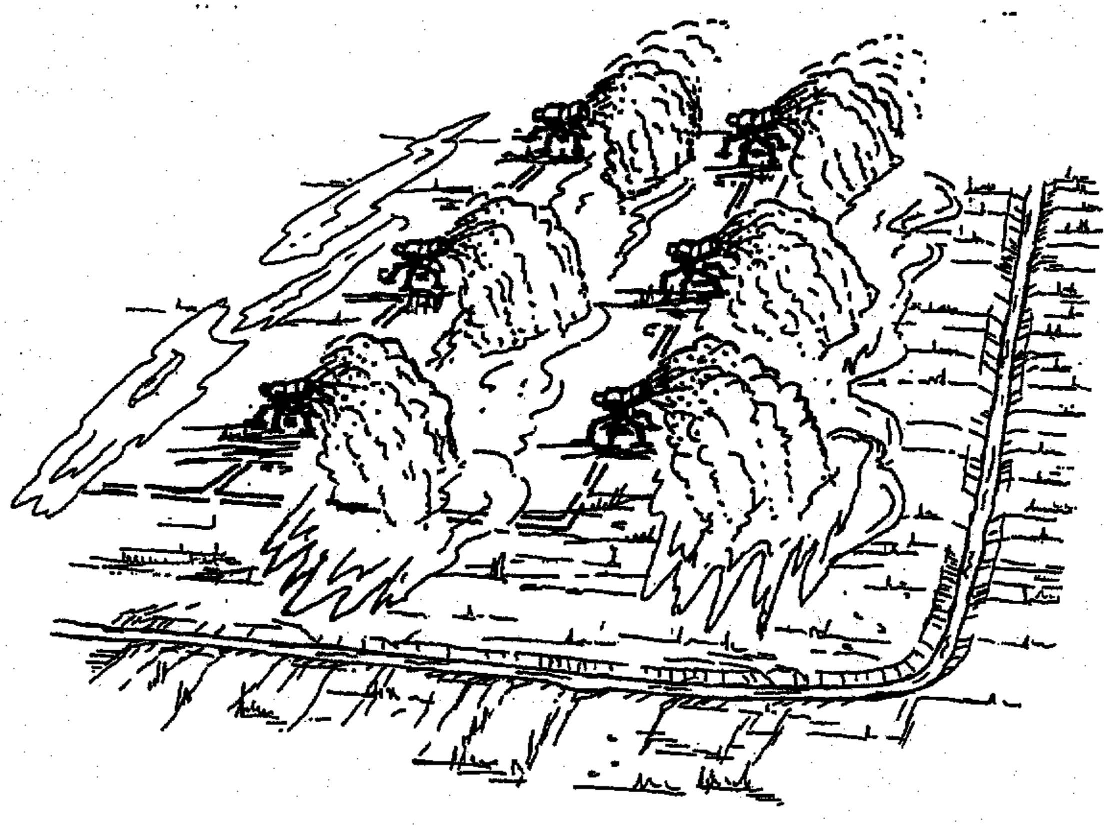

Figure 4-23. Schematic of Turbo-Enhanced EES System.

The design places the 255-acre field of machines uphill from a collection canal or a final disposal pond. Processed water will flow downhill to a canal where it is collected and recirculated through the EESs or pumped to disposal. During times of high evaporation, operators will shut down the blowers on some machines to ensure fluidity of the precipitant. Handling dry salt with moving equipment would be too costly.

The turbo-enhanced design would use 288 machines operating 78 percent of the year. This is the optimum usage based on present worth costs. Each machine will process 66 gpm, at 100 psi, with resulting salinities between 45 percent to more than 90 percent of the water being evaporated on the first pass through the machine. Successive passes through the machine would be required until at least 90 percent of the water is evaporated. Figure 4-24 presents a conceptual layout of turbo-enhanced EES module.

Operators will run the machines a variey of ways, depending on the efficiency of the machines for the real-time meteorologic conditions. The machine's efficiency is expected to vary as a function of the standard pan evaporation rate. The machines are more efficient as the pan evaporation rate increases. The design was based on information gained from various sources. The design air temperature is a composite of temperatures taken at Brawley, south of the Sea, and Mecca, north of the Sea. Their temperatures are usually quite similar. Averages were taken over several years.

Pan evaporation rates were taken from the Three Flags Weather Station, which has a standard evaporation pan rate. IID recently moved the station from the main part of the Test Base to the south end of the Test Base. Their technicians have been collecting this data over the past several years. The last 10 years data was aveaged for this study. Plotting this data came up with a curve that gives the average pan evaporation rate for each day of the year.

Hourly temperature data from the Palm Springs Airport was then analyzed to determine the average diurnal temperature curve. These temperatures vary with the time of the year. Combining this curve with the average high and low temperatures of the Brawley/Mecca data give the average temperature for each hour of the year. These data were then combined with the Three Flags Weather Data to arrive at the average pan evaporation for each hour of the entire year. The total was then checked to ensure the total of these curves matched the average total pan evaporation. These data were then used to determine the optimum average method to run and control the EES machines. As stated before, the operators would operate the machines based on real-time data.

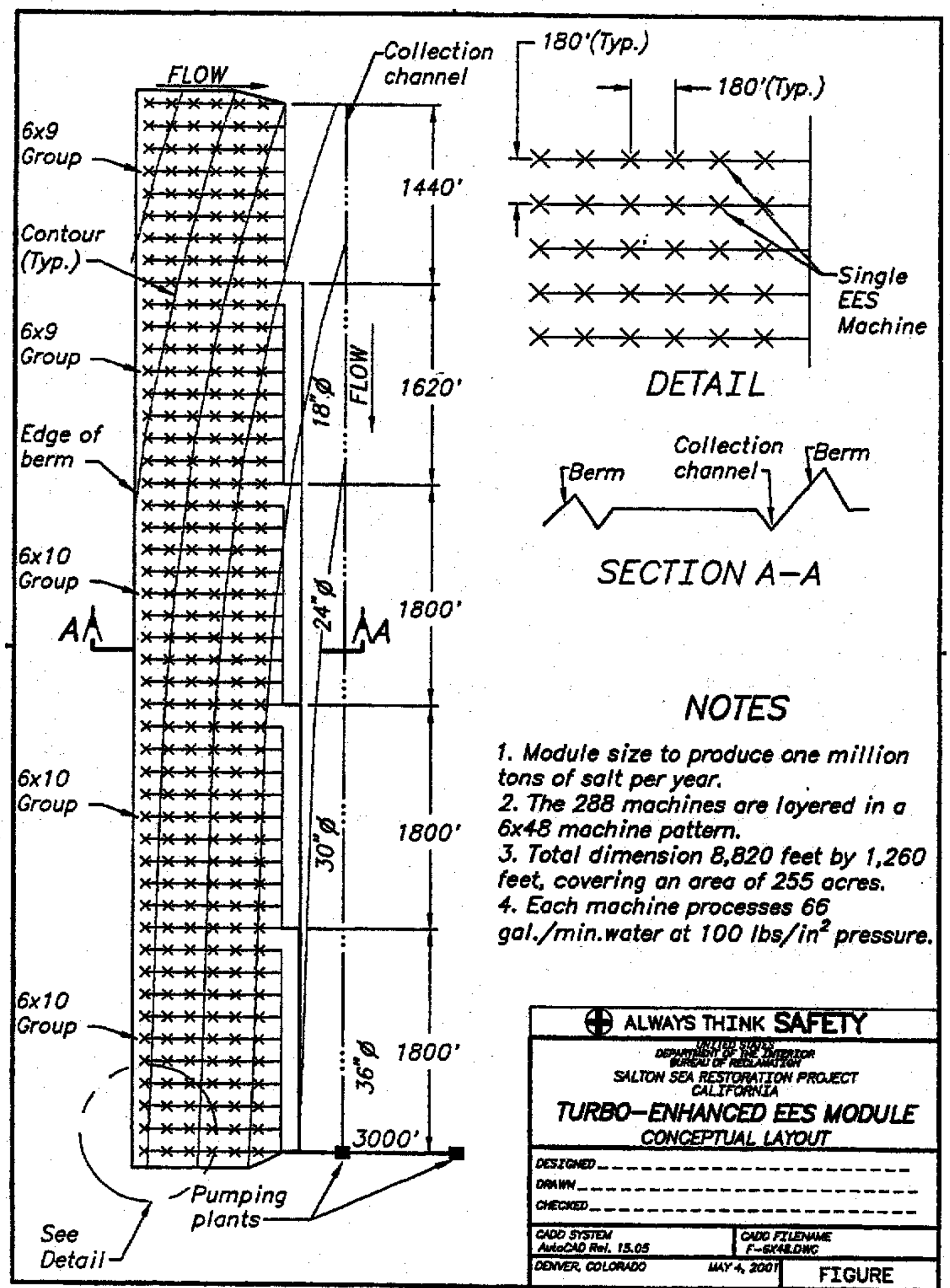

Figure 4-24. Turbo-Enhanced EES Module, Conceptual Layout.

The hourly pan evaporation rate, the cost of the machines, the cost to run the machines, and the required water processed was combined to determine the optimum time to run the machines. The design is based on total present value costs. These runtimes vary throughout the year.

The machines will not be used for about 2 weeks in the coldest time of the year in January. This is when the machines are the least efficient. Operators will begin using the machines in mid- to late-January during the hottest part of the day. They will use them for increasingly longer periods until early to mid-March when they will run for 24 hours a day.

On about the first of May, operators will begin turning some of the machines blowers off during mid-day. They will continue to increase the number they shut down until about mid-June when as many as 10 percent of the machines will run without their blowers for as long as 12 hours a day. This pattern of operations will continue until the about the end of July when the period will begin decreasing from 12 hours per day. Operators will leave the blowers on 24 hours a day on from early to mid-September until November.

Beginning in November, operators will begin turning the machines off during the coldest times of the night. This energy-saving period of the night and day will increase until about mid-January , when machines will be completely shut down.

The operators would also shut down the machines during times of winds exceeding 14 miles per hour.

Environmental Concerns

Residents in the area have three general concerns about EESs, which are humidity, effect of drift on plants and animals, and additional noise. Primary areas of concern expressed by resource agencies wer bird strikes on EES towers and noise.

Humidity

One concern residents in the area have is the increased humidity caused by the EESs; however, the machines would add little to the existing humidity in the basin. Water flow from the Colorado River is more than 3 million acre-feet per year (ac-ft/yr). Most of this water is evaporating or transpiring. The EES modules would only process 16,700 ac-ft/yr, which is less than 1 percent of the water coming into the basin. In addition, Salton Sea will slightly reduce in size, lowering its overall evaporation. The increase in humidity in the basin caused by the EESs is insignificant.

The humidity near the EESs will increase, but this should be mostly contained in a buffer zone that will surround the EES modules or block of modules. The buffer zone ensures that no harm would come to the surrounding area.

Drift Effects on Plants and Animals

Drift of the salt that flies through the air is another concern. Here again the buffer zone addresses this problem. The effect of the salt on plants and animals is not fully understood. One can look at examples elsewhere to help understand this effect. Waves cause ocean water around the world to enter the air. The effect can be seen at the immediate shoreline.

Another location is around the Salton Sea itself. Crops are growing close to the dikes on the southern end of the Sea. It is true, however, that this effect is not nearly as severe as we would find with the EESs.

When trying to hypothesize the salt's effect on plants, remember that this compound is not an herbicide. Minor amounts of salt falling on plants should not be a detriment. The buffer zone should eliminate even this.

Noise

Noise from the EESs is another concern. Slimline Manufacturing Ltd. measured the sound emanating from a Turbo-mist evaporator. The sound reading dropped to 65 db at a distance of 200 feet from the machine. Normal speech registered between 65 and 70 db. Investigators will do more testing on noise during the Pilot Project. Again, the buffer zone comes into play and would attenuate the sound.

Costs

The costs for these two projects have been estimated (preappraisal level) and are presented in table 4-6.

Table 4-6. Estimated costs for EES alternative systems

Costs	Line Shower System (million dollars)	Turbo-Enhanced System (million dollars)
Construction	22.1	17.0
Operation, maintenance, and replacements (per year)	0.9	.41
Energy (per year)	0.3	3.17
Land	0.5	0.20

The energy costs has become a critical component of the total costs. The State of California's energy supply is stressed. This precipitated another look into alternative energy sources. The Project environment is quite compatible with solar energy. While the common photovoltaic systems are far from being economically attractive, solar troughs are on the fringe. A system where solar reflectors in the shape of a trough are used to heat a fluid, which is used to produce electricity, would cost approximately $0.129/kWh. Some California residents are paying $0.125/kWh. Such a system is still not economically attractive in the area of the Project where the rate is closer to $0.070/KWh.

Wind turbines near a sea where birds abound may present environmental challenges. Other alternative energy production methods may soon be attractive, which will be kept in mind in the future.

SALT DISPOSAL OPTIONS

Restoration of the Sea may require disposal of crystallized salt and other solids that could involve a total of 5 million or more tons per year of total dissolved solids. It is likely that crystallizer beds will be used to dispose of most of the salts and other solids. It is presently planned that the salts and other solids will be deposited in a facility where they will crystalize to form a solid layer. Experience with similar facilities is largely related to commercial salt making operations where the crystallized NaCl salts are separated from other salts and products in what is termed a bittern. The bittern in these facilities is removed as a fluid and is not necessarily allowed to evaporate to dryness. Pilot tests are currently being conducted to better define the nature of the solids that will be removed from the Sea, and their disposal requirements. The primary set of disposal facility designs is based on the assuption that the majority of products removed from the Salton Sea will deposit in a solid layer that can be built up over time using terraced berms or dikes. Alternate conceptual designs for disposal facilities that could accommodate a more fluid-like bittern if it is deemed that it will not evaporate to dryness are provided in the Appendix to this report. The potential commercial market for some portion of these products is also being explored.

Review of Salton Sea Data

Information on the major ions in Salton Sea water was determined for TDS of 43,277 mg/L. In turn, the major crystallized salts in Sea water that will precipitate as Sea water evaporates was determined to be 62 percent sodium chloride, 16 percent magnesium sulfate, 7 percent calcium sulfate, and 12 percent sodium sulfate.

In addition to these major constituents, there are minor constituents present at less than 1 percent down to trace amounts. Other constituents may include carbonates; agriculture, and municipal waste components such as ammonia, nitrate, and phosphates; selenium; arsenic; boron; mercury; carbon; silicon; and fluorides, at a total of 3 percent.

An assumed total dissolved solid (TDS) concentration of 44,000 milligrams per liter (mg/L) was used for conceptual design purposes. Thus, the TDS numbers were increased at a ratio from 43,277 to 44,000. The result is shown in Table 4-7.

Table 4-7– Average Concentrations of Major Ions for TDS of 44,000 mg/L

Chemical	Sea Water (mg/L)
Calcium (Ca)	1,023
Magnesium (Mg)	1,407
Sodium (Na)	12,562
Bicarbonate (HCO_3)	250
Sulfate (SO_4)	11,424
Chloride (Cl)	16,605
Unknown	729
Total TDS	44,000

The solids anticipated to be formed as Sea water evaporates are shown in Table 4-8.

Table 4-8 Salt Solids Formed As Sea Water Evaporates

Solids	mg/L	Percent (%)
Calcium Carbonate ($CaCo_3$)	205	0.5
Calcium Sulfate ($CaSO_4$)	3,198	7.3
Sodium Chloride (NaCl)	27,348	62.2
Magnesium Sulfate ($MgSO_4$)	6,976	15.9
Sodium Sulfate (Na_2SO_4)	5,328	12.1
Unknowns/Remainders	945	2.0
Total	44,000	100.0

It is anticipated that the calcium carbonate and gypsum ($CaSO_4$) will be deposited in the concentrator ponds. The remainder of the solids would be deposited in the disposal facility. Until the pilot tests are complete, it is unclear whether $MgSO_4$ and the associated fluid bittern would form.

Table 4-9 summarizes the estimated disposal volumes for TDS removal rates of 1 to 10 million tons per year (tons/yr) for a 30-year design life.

Table 4-9 – Salt Products Volumes and Disposal Requirements for 30-Year Design Life

Desired Salt Removal (tons/yr)	Solids to be Disposed [a] (tons/yr)	Solids in Conc. Ponds[a] (tons/yr)	Annual Disposal Volumes [b] (acre-ftf)	Design Life (years)	Required Disposal Volumes [e] (acre-ft)
1,000,000	922,000	78,000	605	30	18,142
2,000,000	1,844,000	156,000	1,209	30	36,285
3,000,000	2,766,000	234,000	1,814	30	54,427
4,000,000	3,688,000	312,000	2,419	30	72,570
5,000,000	4,610,000	390,000	3,024	30	90,712
6,000,000	5,532,000	468,000	3,628	30	108,855
7,000,000	6,454,000	546,000	4,233	30	126,997
8,000,000	7,376,000	624,000	4,838	30	145,140
9,000,000	8,298,000	702,000	5,443	30	163,282
10,000,000	9,220,000	780,000	6,047	30	181,425

Notes:
[a] Assumes 7.3 percent of TDS will crystallize as gypsum and 0.5% as calcium carbonate in concentrator ponds.
[b] Assumes a density of 70 lb/ft^3.

Technical Approach

The disposal options described herein can be used to dispose of crystallized salt and solid residuals from solar evaporation ponds and/or an EES. They were developed by evaluating the quantities and characteristics of the materials to be disposed of while recognizing the physical constraints and constructability issues posed by potential disposal sites.

Much of the approach relies on experience from operating solar evaporation ponds to produce commercial salt. However, the potential size of the proposed facilities is much larger than most facilities currently operating anywhere in the world. Since the characteristics of salts and solids produced from Sea water are not well known, the disposal options may need to be revised as additional information is obtained from the EES and Solar Evaporation Pond Pilot Studies.

Conceptual Disposal Options

Various impoundments were considered for disposal of the solids. These included impoundments both on-shore and in-Sea. The impoundments for the crystallized salts and other solids can be terraced on top of the deposited solids, as the solids would have some supporting strength. The in-Sea impoundments would need to be constructed as a full section dike to above the Sea level. Substantially more material would be required to construct the in-Sea dikes to accommodate the construction and mitigate seismic instabilities. The most cost-effective disposal of the solids would be the use of crystallizer beds as the final disposal area to avoid rehandling of the solids, unless the salt can be sold commercially. The potential for harvesting and sale of some of the salt products is discussed later in this section. Currently, it seems unlikely that the sale of products will be commercially viable.

The surface area of the disposal ponds was sized to allow for the required evaporation for the expected annual solids deposition. The disposal ponds must also be partitioned into smaller areas to help control the brine concentrations in the disposal area. Partitioning also helps maintain the evaporation surface area and reduce levee erosion when high winds occur. Winds tend to push or pile up the brine against one shoreline and reduce the surface area of brine exposed to evaporation. The surface area required is also dependent on the seepage characteristics of the pond bottom. A pond with a more permeable bottom will require a larger surface area and higher inflows to attain the same crystal deposition rates.

Disposal ponds can be cost effectively located farther from the Sea than the solar evaporation ponds or the EES because the volume of concentrated brine conveyed (by gravity or pumped) to the disposal facility is estimated to be no more than about 13 percent of the volume of Sea water that would be pumped to the initial concentration ponds or an EES. However, it is anticipated that land near the Sea is generally less permeable and may be more suitable for disposal ponds. Land farther from the Sea may need a clay or geomembrane liner to reduce leakage. Further geotechnical investigations are required to determine if a liner would be required for the sites selected for disposal areas.

Conceptual options that use disposal ponds and sale of salt products are examined below. The options were developed for disposal or storage of 30 years of salt at a removal rate of 1 or 2 million tons/yr of TDS from the Sea. A discussion of approaches to increase TDS removal rates and the life beyond 30 years is also included.

On-Shore Impoundments

The on-shore impoundments would consist of earthen berms that enclose the disposal area. The area of the disposal impoundment was sized using experience in sizing salt crystallizer beds in commercial salt making facilities. For the middle case of seepage, 1,023 acres would be required for a 1 million ton per year disposal facility. The disposal area was separated into three internal ponds, with water depths no greater than 5 feet to help control the brine concentrations within the disposal area.

Figure 4–25 presents a conceptual design of a disposal area in relatively flat terrain (Concept A) for disposing of solids from a 1-million tons/yr TDS removal facility. The terrain slopes at about 0.2 percent towards the Sea, which is typical for the topography south and southeast of the Sea. Figure 4-26 presents a conceptual design (Concept B) for expanding this facility to dispose of solids from a 2 million tons/yr facility. Figure 4-27 presents a conceptual design disposal area in steeper terrain (Concept C) for disposing of salt products from a 1 million tons/yr facility. The terrain slopes at about 0.6 percent towards the Sea, which is typical of some of the topography to the east and west of the Sea.

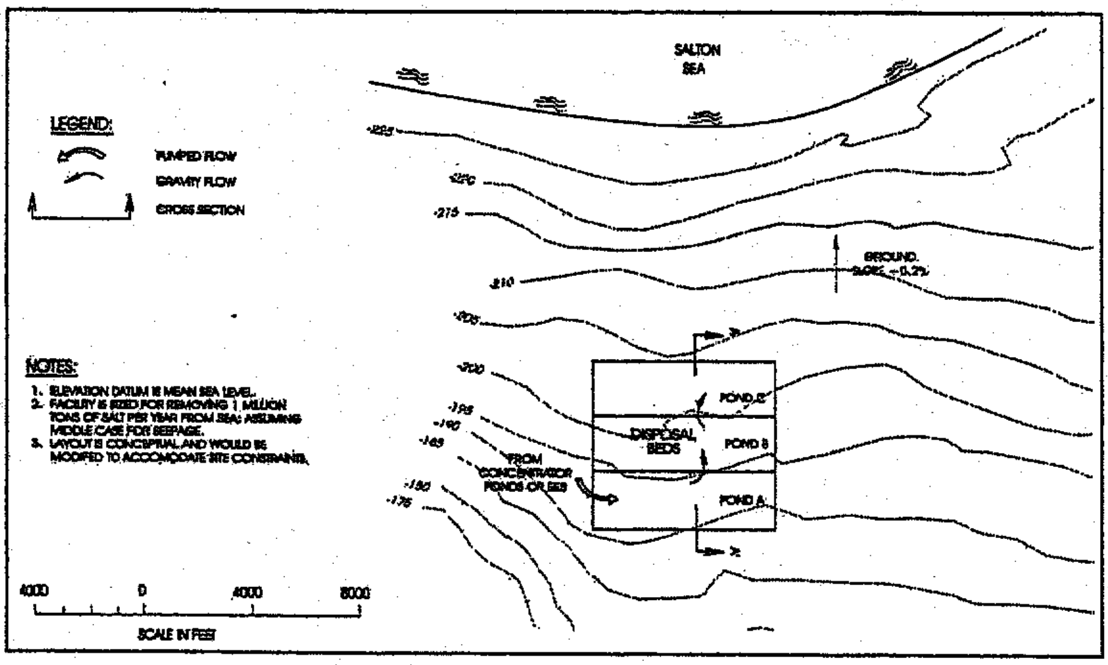

Figure 4–25 – Concept A Layout for Disposal Impoundments in Flat Terrain

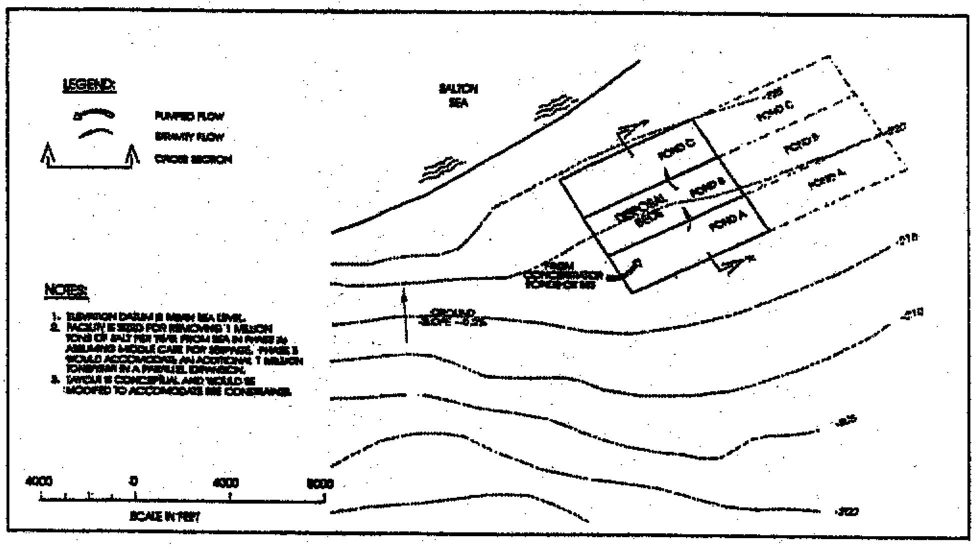

Figure 4–26 – Concept B Layout for Disposal Impoundments with Parallel Expansion in Flat Terrain

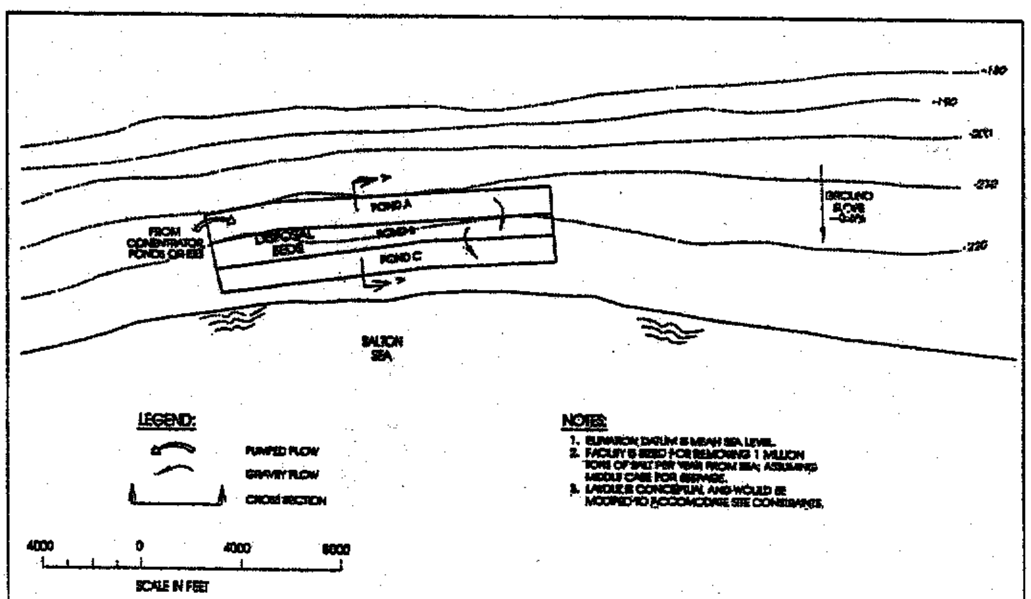

Figure 4–27 – Concept C Layout for Disposal Impoundments in Steep Terrain

Although some concentrated brine will remain in the voids of the deposited solids, it is anticipated the solids will provide some supporting strength. Therefore, it is anticipated that the disposal impoundments can be built using berms in phased lifts that are partly supported on the deposited solids, as shown in Figure 4–28. This is a commonly used technique to construct dams that retain mine tailings. Many of the tailing slimes have strengths that are probably much lower than deposited solids. However, evaluation of the supporting strength of the deposits should be performed as part of the solar evaporation pond pilot studies.

The terraced impoundments would consist of initial earthen berms that enclose the disposal area. Terraced embankments would also be used to separate the disposal area into three internal ponds with water depths no greater than 5 feet to provide for brine concentration gradients.

The conceptual design of terraced berms also has side slopes inclined at 2½:1. These might be steepened to a ratio of 2:1 as the design is further developed. The slope of the land dictated the height of the initial berms, the top of the downslope berm had to be equal to the existing ground elevation at the upslope

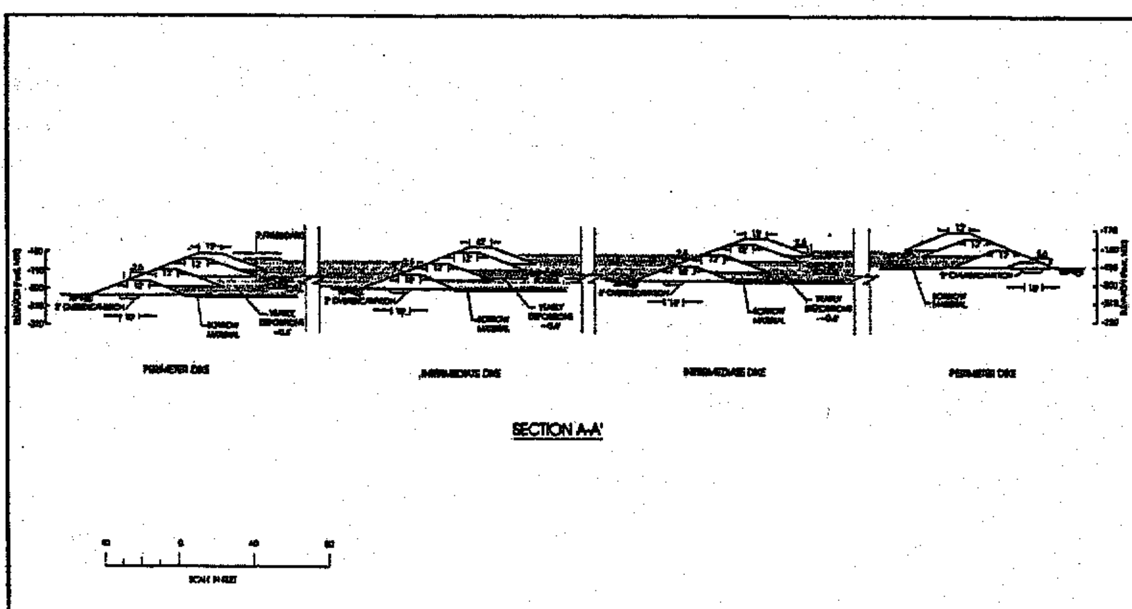

Figure 4-28. Typical Berm and Subsequent Raises On-Shore Disposal Impoundment

end of the disposal area to provide the required flooded area. Water depth in the upslope area would be created by excavating material for the berms from these areas. The design heights of the berms were raised an additional 3 feet to provide freeboard to prevent wave overtopping. This freeboard height will need to be evaluated further during preliminary design using site-specific wind and fetch information. The subsequent berm increases would typically be about 6-feet high. A top width of 12 feet is provided for vehicle access. A key, 2-feet deep and 10-feet wide, is provided below the initial berm as a seepage cutoff.

Material for the initial berms could be obtained from within the disposal areas. However, after solids are deposited, the berm materials would need to be borrowed from outside of the disposal areas (but could be adjacent to or within future disposal areas).

A potential cost saving strategy for the internal levees would be to use the salt deposited in previous years for the levee material. This technique has been used to a very limited extent worldwide, and its success depends on the hydraulic head across the levee and other specific local conditions. This option would have to be investigated and tested once the hydraulic head and salt characteristics are known.

In-Sea Impoundments

The draft Environmental Impact Statement and Environmental Impact Report (EIS/EIR) considered the use of in-Sea impoundments to lower the salinity of the Sea. This concept helped to control the Sea's surface elevation by removing part of the Sea's evaporative surface area. However, a previous study (Parsons 2000; same as previous) indicated numerous issues with this concept, including difficult construction, seismic vulnerability, and berm stability concerns if the bermed area were allowed to dry out (creating large hydraulic gradients across the berm width). Therefore, in this study, in-Sea impoundments are considered viable, when they can be operated with only low hydraulic gradients across the berm width.

Figure 4–29 presents a conceptual design (Concept D) of disposal areas constructed in the Sea for disposal of solids from a 1 million tons/yr of TDS removal facility. To eliminate a head differential across the dikes, the in-Sea impoundment would initially contain Sea water. The Sea water would be displaced by the concentrated brine from the last concentrator pond or the EES. The Sea water would be totally displaced in less than 1 year and the disposal impoundment would then function in a manner similar to the on-shore disposal impoundments.

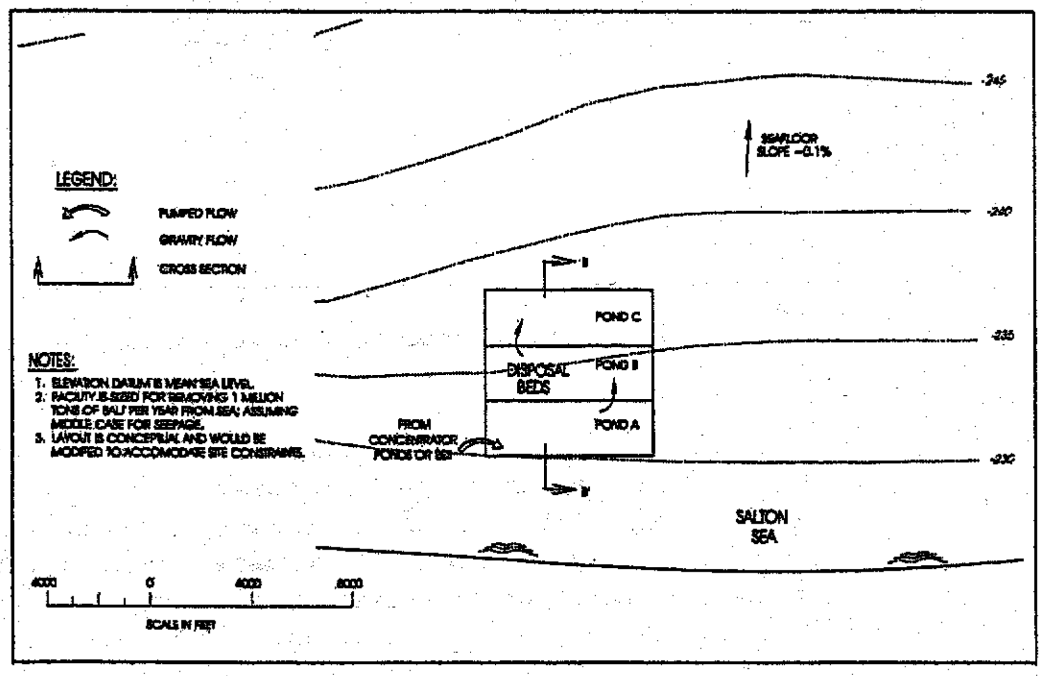

Figure 4–29 – Concept D Layout for In-Sea Disposal Impoundments in Shallow Water

Internal dikes would be used to separate the salt disposal area into three ponds to help control the brine concentrations. Once the solids are deposited to above the Sea's level, the disposal volume would be expanded vertically by constructing the terraced berms as discussed above. Figure 4–30 depicts a cross-section through the in-Sea disposal area. Depending on the level of the concentrator pond or EES feeding into the disposal area, the concentrated brine may need to be eventually pumped into the raised disposal area.

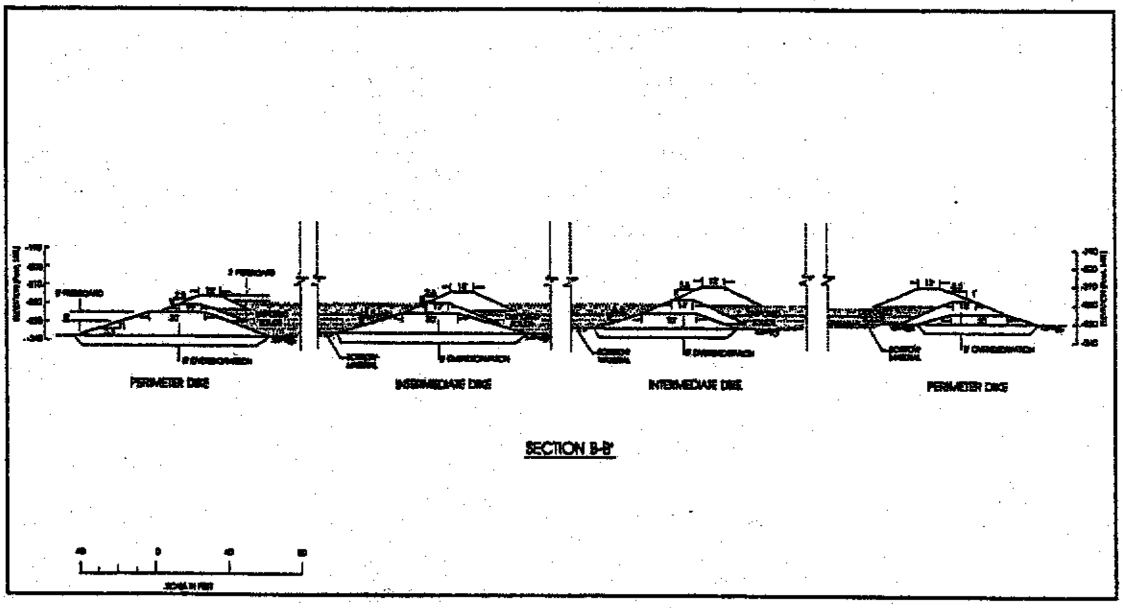

Figure 4–30 – Typical Dike and Subsequent Raises for In-Sea Disposal Impoundment

The bathymetry of the Sea in Concept D is sloping at approximately 0.10 percent. This is typical of the bathymetry in the southern part of the Sea. The conceptual design of the in-Sea dike has side slopes with a ratio of 3½:1. These flatter slopes are required to reduce the seismic vulnerability of the dikes. The side slopes will need to be further evaluated if this design is further developed. The dike design levels were raised 5 feet above the Sea level to prevent wave overtopping. This freeboard height will also need further evaluation. A top width of 30 feet is provided for vehicles to pass on the dike during construction. A 5-foot deep over-excavation was allowed for beneath the entire dike to remove very soft sediments that are believed to be blanketing the Sea floor. These excavated materials are not anticipated to be suitable for reuse and would need to be disposed of in the Sea or elsewhere. The overexcavation would be backfilled with imported fills.

Material for the in-Sea dikes would need to be borrowed from on-shore as discussed in the previous analysis. (Parsons 2000.) Special techniques such as gantry conveyors may be required to construct the dikes. The full height of the in-Sea dikes would need to be constructed at the beginning of the project.

Figure 4–31 provides a conceptual design (Concept E) for expanding the Concept D facility to dispose of a total of 2 million tons/yr of TDS. This design was formulated to evaluate expanding the facility contiguously.

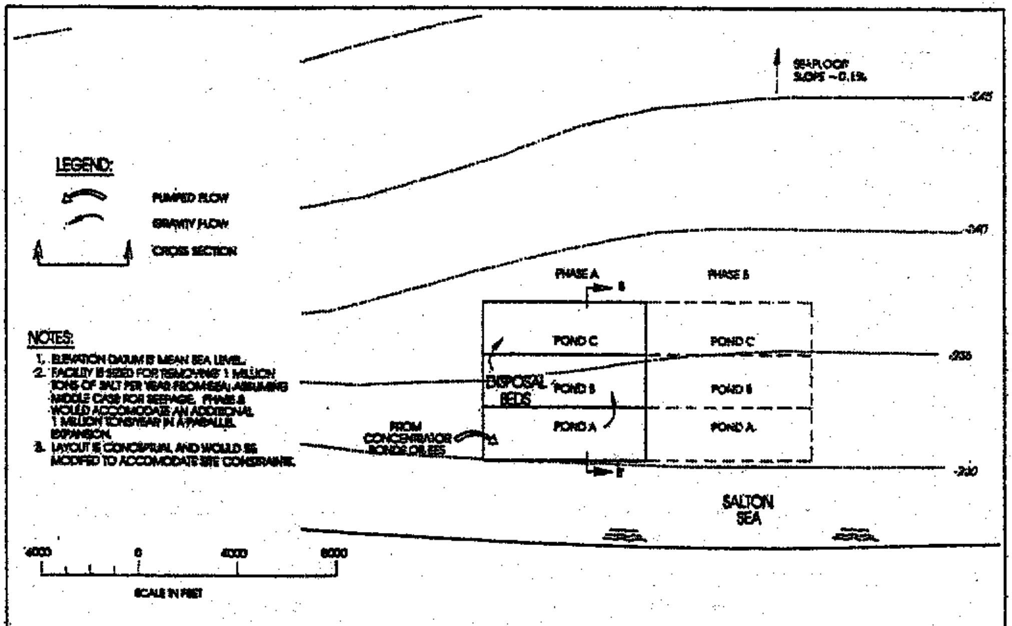

Figure 4–31 – Concept E Layout for In-Sea Disposal Impoundments with Parallel Expansion

Suitable Siting Areas for Disposal Facilities

Potential siting areas for disposal facilities were evaluated with the assistance of the Salton Sea Database Program at the University of Redlands. A siting model analysis was conducted using geographic information system (GIS) software and the criteria identified in Table 4-5. Based on this analysis, areas around and within the Sea were identified as being most suitable, suitable, or least suitable for siting of disposal facilities. Areas around the Salton Sea that are potentially suitable for siting of disposal facilities on land are illustrated in Figure 4-32. Potential siting areas within the Sea are shown in Figure 4-33.

Table 4-10 Siting Criteria for Disposal Facilities

	Siting Criteria	Criteria Categories	Site Ranking[a]	Criteria Weighting[b] (%)
On-Land Disposal Areas	Slope of Land (%)	< 0.2	1	40
		0.2 to 0.5	2	
		> 0.5	3	
	Area Elevation (ft MSL)	-230 to -180	1	15
		-180 to -130	2	
		-130 to -80	3	
		> -80	9	
	Distance from Sea Shore (miles)	0 to 5	1	10
		5 to 10	2	
		10 to 15	3	
		> 15	9	
	Hydrologic Soil Group[c]	Group D	1	25
		Group C	2	
		Group B	3	
		Group A	9	
	Distance from Urban or Wildlife Areas (miles)	> 1	1	10
		1/2 to 1	2	
		< 1/2	3	
		within	9	
In-Sea Disposal Areas	Slope of Seafloor (%)	< 0.1	1	20
		0.1 to 0.3	2	
		> 0.3	3	
	Seafloor Elevation (ft MSL)	shoreline to -235	1	60
		-235 to -240	2	
		-240 to -245	3	
		< -245	9	
	Distance from Sea Shore (miles)	0 to 2	1	10
		2 to 5	2	
		>5	3	
	Distance from State Park Beaches, Marinas, Boat Launches or Wildlife Areas (miles)	> 1	1	10
		1/2 to 1	2	
		< 1/2	3	
		within	9	

Notes:

a. 1=Most Suitable, 2=Suitable, 3=Least Suitable, 9=Excluded.

b. Weightings based primarily on impacts to cost of facility. Weightings sum to 100 for either on-land or in-Sea facility.

c. From USDA Soil Survey Geographic Data Base.

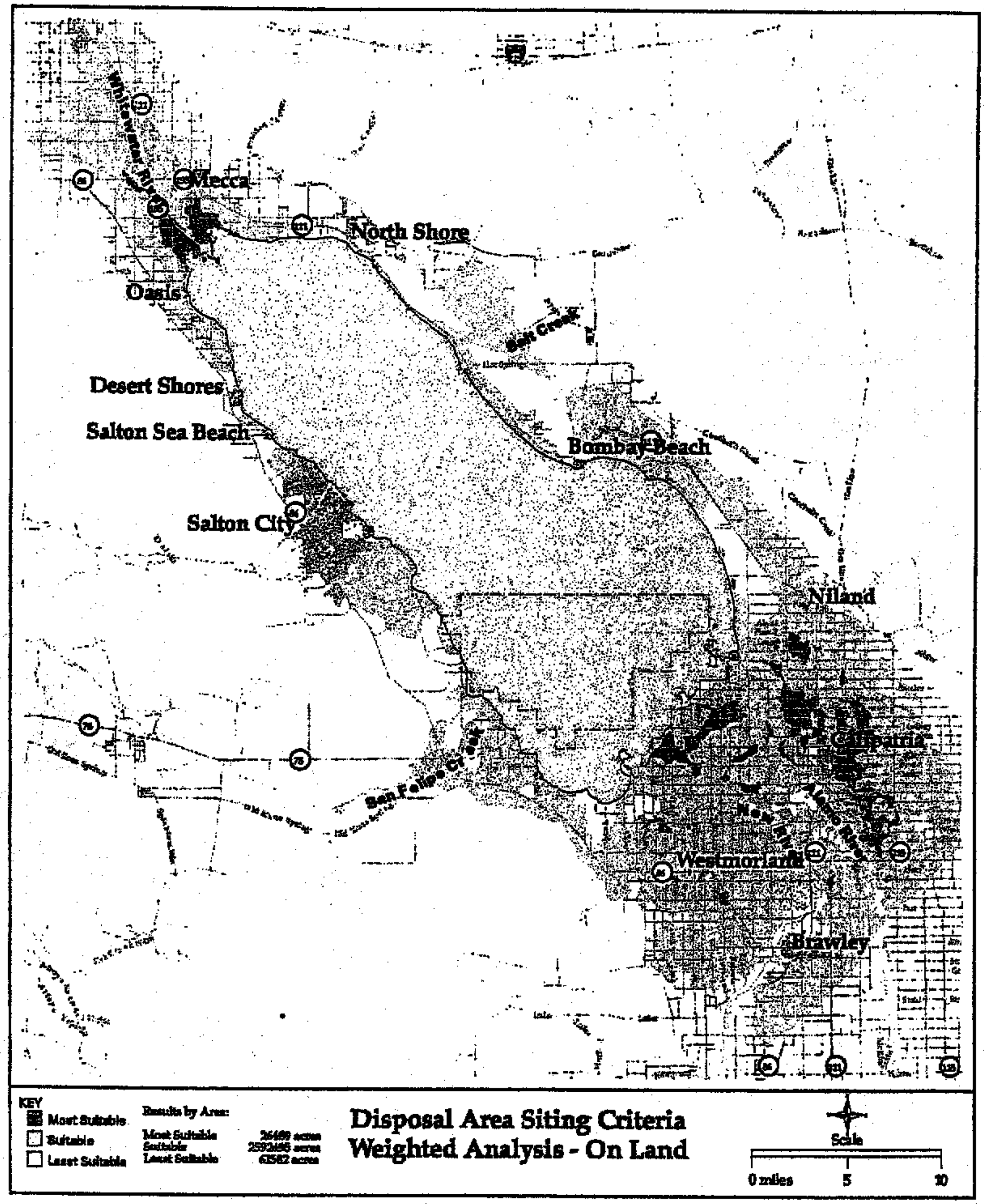

Figure 4-32 Suitable Areas for Siting Salt Disposal Facilities on Land.

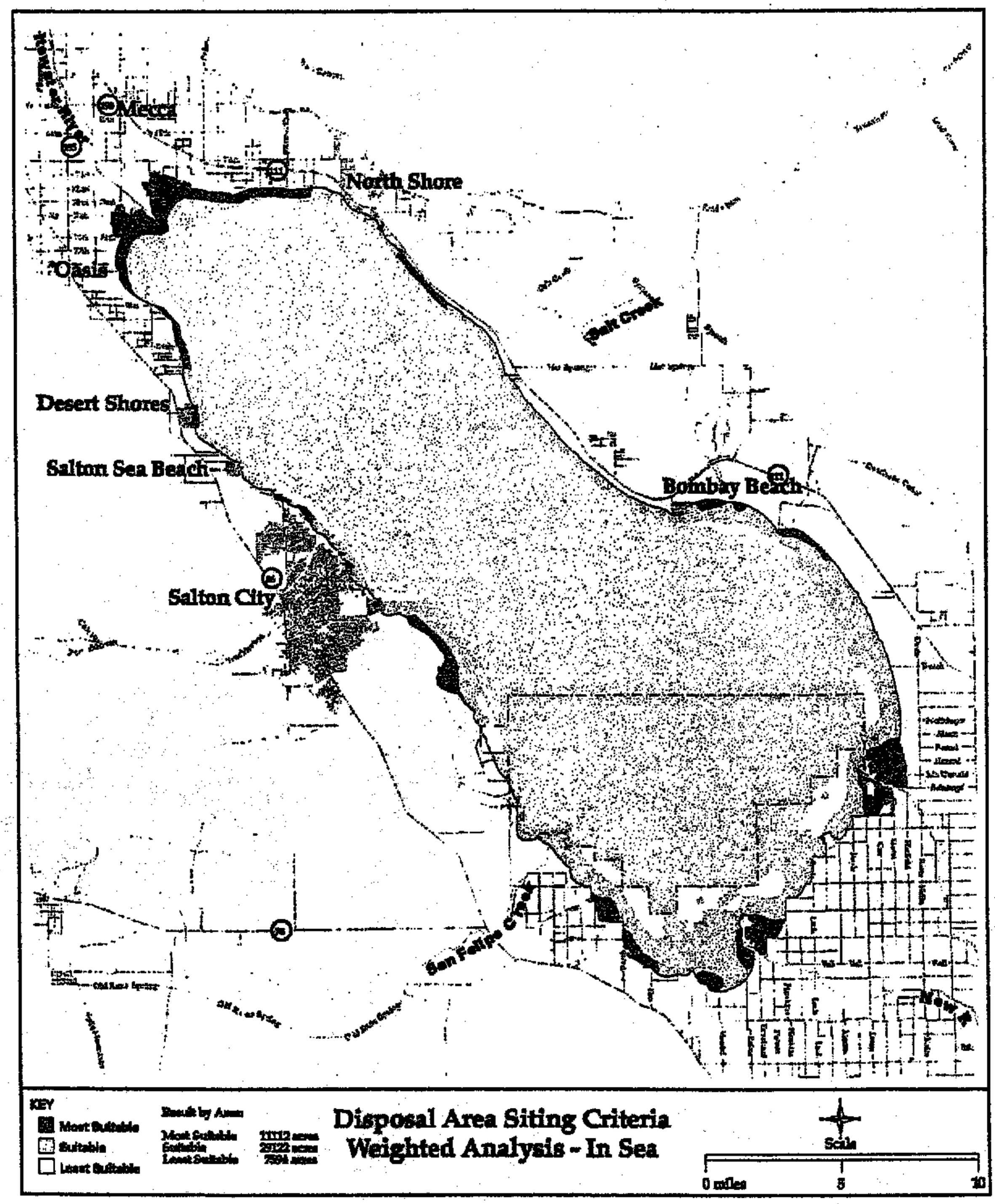

Figure 4-33 Suitable Areas for Siting Salt Disposal Facilities within the Salton Sea.

Appraisal Level Earthwork Costs

Appraisal level cost estimates were developed for the earthwork associated with the above conceptual designs of the disposal facilities. Quantities of the earthwork required for the disposal impoundments were estimated for Concepts A through C and are shown in Table 4-10. The quantity of materials required for the initial berms and subsequent berm raises (which could be phased in) are shown separately in Table 4-10.

For Concepts A through C, a unit cost of $4.10 per cubic yard (/cy) was used for excavating, hauling, placing, and compacting the berm fills. The materials excavated for the key below the berms was assumed to be reusable; a unit cost of $3.25/cy was used for excavating, placing, and compacting this material.

Estimated quantities of the earthwork required for the in-Sea disposal impoundments (Concepts D and E) are shown in Table 4-10. A cost of $7.00/cy was used for excavating and hauling (up to 25 miles) fill (dumped below Sea level and compacted above Sea level). The overexcavated materials below the berm were assumed not to be reusable. The cost of $13.00/cy was used for these quantities ($6.00/cy to excavate and dispose and $7.00/cy to replace).

The earthwork costs assume that a liner would not be required in the bottom of the disposal areas. If the disposal areas are sited in an area where the leakage is estimated to be too high, a liner system may need to be installed. It is estimated that a liner would add about $25,000/acre in costs.

Additional costs for these facilities were estimated as land ($1,000/acre), unlisted items (plus 15 percent), contingencies (plus 25 percent), and non-contract costs (plus 33 percent).

Table 4–11 –Summary of Conceptual Designs for Disposal Areas and Appraisal Level Costs (Excluding Conveyance Facilities)

Item	Concept A (On-Shore – Flat Terrain)	Concept B (On-Shore – Flat Terrain)	Concept C (On-Shore – Steep Terrain)	Concept D (In-Sea – Shallow Water)	Concept E (In-Sea – Deep Water)
Facility Capacity (million ton/yr)	1.0	2.0	1.0	1.0	2.0
Salt Disposal:					
Area (acres) [a]	1,023	2,046	1,023	1,023	2,046
Total Length of Perimeter and Interior Drive	40,100	73,400	60,900	40,100	73,400
Maximum Height of Containment (ft)	24	24	25	23	23
Volume of Initial Dikes (cy)	268,100	443,500	596,600	900,400	1,148,500
Over-excavation Volume (cy) [b]	29,700	42,900	45,100	704,200	1,117,400
Volume of Dike Raises (cy)	933,400	1,263,500	1,405,000	746,900	1,646,600
Earthwork Costs	$5,525,000	$9,910,000	$9,188,000	$24,003,000	$39,372,000
Additional Costs [c]	$6,061,000	$11,083,000	$9,402,000	$21,887,000	$35,902,000
Total Costs	$11,586,000	$20,993,000	$18,590,000	$45,890,000	$75,274,000
Capital Cost ($/ton) [d]	**$0.39**	**$0.35**	**$0.62**	**$1.53**	**$1.25**

Notes:
[a] Assumes mid-case for seepage.
[b] Assumes 2 feet below on-shore berms and 5 feet below In-Sea dikes.
[c] Includes land ($1000/acre, no cost in-Sea), unlisted items (plus 15 percent), contingencies (plus 25 percent), noncontract costs (plus 33 percent).
[d] Assumes facility life of 30 years.

Sale of Salt Products

The sale of salt products continues to be investigated; however, at this point, it does not appear to be practical or commercially viable. The potential salt products that could be recovered and sold include calcium carbonate (calcite), calcium sulfate (gypsum), sodium chloride (common salt), magnesium sulfate, and sodium sulfate. However, no commercial salt facility is known to recover and market calcite and gypsum. Economical recovery and purification of magnesium sulfate and sodium sulfate would be costly and capital intensive.

Sodium chloride (common salt) is sold in a large array of qualities and forms and to a large diversity of industries. Purity and crystal size are the major issues. Salt produced in desert climates tends to be fine rather than coarse and is less valuable. The market is currently fully supplied and price competition is keen. Should Reclamation or the Salton Sea Authority or other governmental agency attempt to market salt and force one or more competitors from the market, lawsuits would likely follow claiming unfair competition.

Operational and design changes would be needed in the systems to consider commercial production. Based upon the fully supplied market and other problems, it appears the sale of salt products is not feasible at this time.

Regulatory Issues Related to Salt Disposal

The lead agencies have evaluated the permitting requirements that may be associated with disposal of salt products at the Salton Sea. Attachment B to this report provides the results of that evaluation. The evaluation included an assessment of salt production and disposal facilities that are of comparable size or scope to those that may be constructed at the Salton Sea, including the large salt disposal facilities at the Great Salt Lake in Utah. One of the principal conclusions of the evaluation was that the proposed project may require permitting through a variety of agencies. Therefore, close coordination with regulatory agencies will be an important part of the final design and permitting process.

INTAKE AND CONVEYANCE FACILITIES

The following discussion on the intake and conveyance facilities refers to intake and conveyance facilities for either the solar evaporation ponds or the EES systems.

Required Flows

The flows into the ponds or the EES systems were estimated as the amount of Sea water required to remove the desired amount of TDS, and increased by the amount of TDS that could possibly return to the Sea by seepage. The seepage liquid will contain TDS in equilibrium with the liquid in that particular pond. To remove the desired amount of TDS, an increased amount of flow must be removed from the Sea to make up for the seepage of TDS. The flows were estimated for the three seepage scenarios and for TDS removal in one-million tons per year (tpy) modules. The estimated flows in each of the ponds are presented in Table 4–12. Also shown is the TDS and specific gravity of the fluids entering each of the ponds.

The seepage liquid will contain TDS in equilibrium with the liquid in that particular pond. To remove the desired amount of TDS, an increased amount of flow must be removed from the Sea to make up for the seepage of TDS.

Table 4-12. Solar Evaporation Pond Flow Requirements.

Seepage case	Desired TDS removal (tons/yr)	Calculated pond seepage (af/yr)	Total required Sea outflow (af/yr)	Required peak pumping capacity (gpm)	Fluid inflows (af/yr)				
					To concentrator pond 1	To concentrator pond 5	To concentrator pond 10	To crystallizer bed	To bittern disposal
Best	1 million	28	16,959	16,825	16,959	6,711	2,570	2,225	456
Mid-case		286	17,693	17,553	17,693	6,948	2,589	2,225	456
Worst		4,163	28,446	28,221	28,446	10,433	2,865	2,225	456
Best	5 million	139	84,797	84,126	84,797	33,554	12,852	11,126	2,281
Mid-case		1,432	88,465	87,765	88,465	34,739	12,946	11,126	2,281
Worst		20,813	142,230	141,104	142,230	52,166	14,325	11,126	2,281
Best	10 million	278	169,594	168,252	169,594	67,107	25,704	22,252	4,562
Mid-case		2,864	176,930	175,530	176,930	69,477	25,892	22,252	4,562
Worst		41,626	284,459	282,208	284,459	104,331	28,649	22,252	4,562
TDS of fluid (mg/L)					44,000	112,000	288,000	319,000	591,000
Specific gravity of fluid					1.031	1.081	1.192	1.211	1.283

Notes:

1/ Calculated assuming a permeability of 1 x 10 –8 centimeters per second (cms) and that crystallizer and bittern ponds will seal and not seep appreciably.

2/ Calculated from salt modeling program. Assumes Class A pan evaporation rate of 102.5 in/yr, annual rainfall of 2.5 in/yr, and bittern removed at 32 *Be.

3/ Assumes 1.6 factors on average pumping requirement for peak pumping requirement.

4/ Calculated from salt modeling program.

A required peak pumping capacity into Pond 1 is also shown in Table 4–1. The value is 60 percent higher than the calculated average flow, and the value was determined by comparing the peak evaporation rate during the year to the average evaporation rate. The peak pumping capacity was used to size the pumping plant required to pump Sea water into Pond 1. This will allow for larger flows to be pumped during the months when evaporation rates are higher. The estimated average flows were used to estimate energy costs for the pumping plant.

Table 4–13 provides a summary of pumping requirements for the conceptual designs that have been developed for the solar evaporation ponds, using the "mid-case" scenario of seepage.

Total required inflows and peak pumping capacities to Pond 1 for the one- and two-million tpy modules are provided. Assumed pumping distance and required lift for Concepts A through E are also provided to obtain an indication of the costs of conveying Sea water to the solar evaporation ponds. These distances and lifts will need to be revised when specific solar evaporation pond sites are evaluated in detail. The required lift includes the topographic lift plus 10 feet to allow for potential aeration. Aeration may be required for mitigation of anticipated anaerobic conditions that could lead to odor problems. It is assumed that apart from this aeration requirement, flow into the in-Sea ponds would be by gravity.

The disposal areas are anticipated to accommodate future disposal by vertical expansion of the containment dikes. Eventually this may require pumping to the disposal areas as they are raised above the elevation of Pond 10. Table 4–13 also provides a summary of the pumping requirements to the disposal areas, assuming the "mid-case" scenario for seepage. The initial and final heads (after 30 years of salt deposition) for pumping to the salt disposal pond from Pond 10 are provided in Table 4–4. It is assumed that the in-Sea salt disposal area will be lower than Concentrator Pond 10 feeding it.

Table 4-13– Solar Evaporation Pond Pumping Requirements (Mid-Case for Seepage)

Item	Concept A (Flat Terrain) [a]	Concept B (Flat Terrain) [a]	Concept B (Flat Terrain) [b]	Concept C (Steep Terrain) [a]	Concept D (Shallow Water)	Concept E (Deep Water)
Facility Capacity (million tpy)	1.0	1.0	2.0	1.0	1.0	2.0
To Concentrator Pond 1:						
Total Required Inflows (af/yr) [c]	17,693	17,693	35,386	17,693	17,693	35,386
Required Peak Pumping Capacity (gpm) [d]	17,553	17,553	35,106	17,553	17,553	35,106
Estimated Specific Gravity of Fluid	1.031	1.031	1.031	1.031	1.031	1.031
Required Lift (ft) [e, f]	38	48	53	50	10	10
Pumped Distance (ft) [e]	6,400	13,200	15,700	5,500	100	100
To Salt Disposal:						
Total Required Inflows (af/yr) [c]	2,225	2,225	4,450	2,225	0	0
Required Peak Pumping Capacity (gpm) [d]	2,207	2,207	4,415	2,207	0	0
Estimated Specific Gravity of Fluid	1.217	1.217	1.217	1.217	1.217	1.217
Years after Initial Filling Pumping Required (yr) [g]	0	8	8	8	N/A	N/A
Initial Pumped Head (ft) [g]	16	1	1	1	N/A	N/A
Maximum Pumped Head (ft) [h]	34	13	13	13	N/A	N/A
Pumped Distance (ft) [e]	8,500	12,000	14,000	100	N/A	N/A
To Bittern Disposal:						
Total Required Inflows (af/yr) [c]	456	456	912	456	0	0
Required Peak Pumping Capacity (gpm) [d]	452	452	905	452	0	0
Estimated Specific Gravity of Fluid	1.283	1.283	1.283	1.283	1.283	1.283
Maximum Pumped Head (ft) [i]	15	15	15	15	N/A	N/A
Pumped Distance[e] (ft)	100	100	100	100	N/A	N/A

Notes:

[a] Facility sized for removing 1 million tons of TDS from the sea, assuming mid-case for seepage.

[b] Concept B includes possible expansion to accommodate the removal of 2 million tpy.

[c] Average required pump inflow to remove specified tons of TDS per year.

[d] Peak pumping capacity is 160 percent of average required pump inflows to account for months with higher evaporative rates.

[e] Layouts are conceptual and would be modified to accommodate site constraints.

[f] Required lift includes topographic lift plus 10 feet to allow for potential aeration.

[g] Pumping to salt disposal not required until salt beds are above Concentrator Pond 10.

[h] The head difference after 30 years of salt deposition.

[i] The required pumped head will increase linearly until the maximum pumped head is reached in Year 30.

Conveyance to Pond 1

The water conveyance systems consist of intake channels, pumping plants, and pipelines. The intake channel must provide flow at the range of water surface elevations that the Sea will experience over the design life of the solar evaporation ponds. Thus, the elevation is dependent on the hydrology of the final scenario selected. The channel is sized for low water velocities to ensure that most of the silt and sand will not reach the pumping plant intake.

If needed, the intake must also allow for the passage of pupfish in the shallow waters at the shoreline. This can be accomplished for minor cost. Costs assume the intake channel is short.

The pumping plant includes the structure, pumps, motors, and piping, trashracks, and fish screens. The trashracks ensure that large debris does not enter the pumping plant and are designed with a through velocity of 2 feet per second (ft/s). After the trashracks filter the water for large debris, fish screens ensure that fish do not enter the pumping plant. The design accomplishes this by using fish screens with a through velocity of 0.5 ft/s and orientating the screens to allow for the fish to swim freely away from the screens.

The pumps are designed to resist scaling and corrosion. The design uses technology that already exists with seawater. The cost of pumping accounts for the increased density of the saline water over that of irrigation water.

The water is delivered from the pumping plant to Pond 1 in a pipeline. Standard methods for computing pipe hydraulics losses for various fluids were used. These pipelines convey the largest flows, and thus they require the largest diameter pipe. The pipelines are economically sized, balancing pipe friction losses against pumping head. The pipeline costs are based on buried polymer lined steel pipe in commercially available sizes. When final designs are prepared, the pipe type must be reevaluated for the lift, discharge, and pipe availability.

Provisions for aeration of the water as it exits the pipeline and enters Pond 1 were provided. Aeration will be provided, if necessary, to prevent anaerobic conditions from forming in Pond 1.

Conveyance to Disposal Areas

The water is conveyed from the evaporation ponds to the disposal area using pumps and pipelines. The pumps will be similar to those discussed above, but they will be smaller and consume less energy. Screens will remove debris from the water prior to entering the pumps. Fish screens are not required.

The flow requirements after most of the evaporation occurs are much lower so smaller pipes are required between the Sea and Pond 1. This allows for use of pipe that is fabricated out of other materials. At these smaller pipe diameters, high density polyethylene (HDPE) and fiberglass become the most economical material to meet the scaling and corrosion problems.

Appraisal Level Costs for Intake and Conveyance

Appraisal level costs were developed for the intake channels, pumping plants, and pipelines to convey Sea water to the solar evaporation ponds or EES systems and from the solar evaporation ponds or EES systems to disposal. The total costs (in present day dollars) for the conveyance costs are shown in Table 4-14. These costs include design, construction, environmental studies, public meetings, geologic exploration, and design data collection. For this study, conveyance costs include delivery of water from the Sea to the solar evaporation ponds and delivery of the salt products (concentrated brine and bittern) to disposal.

Table 4–14 – Summary of Appraisal Level Costs for Intake and Conveyance Facilities
Salton Sea Restoration Project

Conceptual Design		Facility Capacity (Million tpy)	Capital Cost (Million $) [a]	Unit Cost ($/ton) [b]
Concept A	On-Shore-Flat Terrain	1.0	4.1	0.14
Concept B	On-Shore-Flat Terrain	2.0	9.5	0.16
Concept C	On-Shore-Steep Terrain	1.0	3.1	0.10
Concept D	Off-Shore-Shallow Water	1.0	1.0	0.03
Concept E	Off-Shore-Deep Water	2.0	1.9	0.03

Notes:
[a] Includes unlisted items (plus 15 percent), contingencies (plus 25 percent), noncontract items (plus 33 percent).
[b] Assumes pump lifts and conveyance distances as shown in Table 4–4 and facility life of 30 years.

COMBINATION OF SALINITY CONTROL METHODS

The salt removal and disposal modules, along with other restoration elements have been grouped into six alternatives. The alternatives vary by the method of salt removal, solar ponds or EES, and the location, in Sea or on land. The number of salt removal modules required for each alternative will depend on the assumptions used for both baseline and future inflows. The number of modules and the land area requirements associated with each alternative for three different baseline inflow assumptions, combined with three possible future inflows, are shown earlier in Table 2-5.

These alternatives were summarized in chapter 2, and some of that information is repeated here for a complete description. Additional, more detailed information is also presented in this section.

The three baseline assumptions reflect the near-term uncertainties in the quantities of agricultural runoff of water that could be expected to reach the Sea in the coming years. The upper value of 1.3 maf/yr reflects a condition that approximately represents the average inflow over the past few years. The values of 1.2 and 1.1 maf/yr have been used as two possible reduced baseline inflow scenarios. These values were selected because it is believed that they cover the range of possible near-term inflows. Baseline inflows may be lower than in the recent past as a result of a number of factors. For example, reduced flows in the New River may occur if a new water treatment plant in Mexicali comes on-line and causes reduced inflow from across the border. Other factors, such as agreements between water agencies could also affect baseline inflows. The potential IID-San Diego Water Transfer project is not considered to be part of the reduced baseline inflows, but is included in the consideration of possible reduced future inflows.

If baseline inflows are lower than the recent past, it has been assumed that some replacement water could be made available through conversion of some land uses in the Salton Basin. It will be possible for the project to purchase land that is currently in agricultural production and use the land for restoration facilities or allow it to be temporarily fallowed. In either case, water formerly used for irrigation would be freed up and could be allowed to flow to the Sea.

In addition to evaluating three baseline inflow assumptions, three future inflow scenarios have been evaluated. The first scenario assumes that the future conditions are the same as the baseline. The second scenario, assumes that the baseline inflow is reduced by 20,000 af/yr until it reaches 1.0 maf/yr. The third future scenario assumes that the baseline inflow is reduced by 20,000 af/yr until it reaches 0.8 maf/yr. These scenarios recognize that future inflows to the Sea may be reduced by a number of factors, including the potential IID-San Diego Water Transfer Project.

The six alternatives are as follows:

- **Alternative 1: In Sea Ponds** – In-Sea solar ponds with in-Sea terraced salt disposal would be constructed using standard dike construction procedures. As shown on Table 2-5, under the assumption that average baseline inflow is 1.3 maf/yr, and future inflow is the same as the baseline inflow, then the number of modules required would be four. Ten to twelve modules, depending on inflow assumption, would be needed if the inflow is reduced to 1.0 or 0.8 maf/yr.

- **Alternative 2: Ground-based EES** – Ground-based EES turbo-enhanced blower units would be constructed on land, and concentrated brine products would be pumped to an on-land terraced salt disposal facility or facilities. Under the assumption that average baseline inflow is 1.3 maf/yr, and future inflow is the same as the baseline inflow, then the number of EES modules required would be six. Twelve modules would be needed if the future inflow is reduced to either 1.0 maf/yr or 0.8 maf/yr.

- **Alternative 3: Tower EES** – An on-land EES tower configuration would be constructed with in-line showers and an on-land terraced salt disposal facility. The number of modules required would be the same as the requirements for Alternative 2 for all inflow scenarios.

- **Alternative 4: In-Sea and On-Land Ponds with Land Use Conversion** – This alternative would involve the construction of a combination of in-Sea solar ponds with in-Sea terraced salt disposal, and solar ponds constructed on agricultural lands with an on-land terraced salt disposal facility. Construction of facilities on agricultural land would free up water that had been used for irrigation and allow it to flow to the Sea. In addition, depending on the baseline inflow assumption and the future inflow scenario, additional land that is currently in agricultural production may be purchased or leased and allowed to be fallow. This process would allow water that would have been used for irrigation to flow to the Sea to compensate for reduced baseline or future inflows. Since no facilities would be constructed on this land, the parcels could be rotated or farmers could be provided subsidies to in lieu of cropping. For all inflow scenarios, this alternative would require two in-Sea modules and two on-land modules. It has been assumed that the two on-land modules would be constructed on 8,819 acres of agricultural land. Additional land use conversion would depend on the inflow scenario. No additional land use conversion would be required for the case where baseline and future inflows remain at 1.3 maf/yr. An additional 125,000 acres of land would need to be converted in the most extreme case where the average future inflow to the Sea is reduced to 0.8 maf/yr. When combined with the 8,819 acres of land for the modules, the total land use would be 133,819 acres for this extreme case.

- **Alternative 5: On-Land Ponds** – On-land solar ponds would be constructed along with on-land terraced salt disposal facilities. Under the assumption that average baseline inflow is 1.3 maf/yr, and future inflow is the same as the baseline inflow, then the number of on-land pond modules required would be six. Twelve modules would be needed if the future inflow is reduced to either 1.0 maf/yr or 0.8 maf/yr.

- **Alternative 6: On-Land Ponds with Land Use Conversion** – On-land solar ponds and terraced salt disposal facilities would be constructed on agricultural lands with land use conversion to provide supplemental water to the Sea. For all inflow scenarios, this alternative would require four on-land modules. It has been assumed that the four on-land modules would be constructed on 17,638 acres of agricultural land. Similar to Alternative 4, depending on the baseline inflow assumption and the future inflow scenario, additional land that is currently in agricultural production may be purchased or leased or subsidies could be provided to farmers to allow it to be fallow to provide additional water to the Sea. As discussed for this alternative, the additional land use conversion could range from 0 to 125,000 acres. The amount of land use conversion, including the area for the modules, would vary as shown on Table 2-5.

Some charts were presented in chapter 2 to illustrate the costs and land requirement for each future inflow scenario. The charts show how the cost varies for each of the three baseline inflow assumptions. Thirty years is selected as the baseline period for comparing costs for planning purposes. In developing cost estimates for the alternatives, it has been assumed that each alternative would include all of the "Other Restoration Elements" discussed on page 2-25 of this report. Additional information about these alternatives follow in tables 4-15 through 4-20. Table 4-21 shows the annual and total 30-year salt disposal requirements in millions of tons.

Table 4-15. Cost and Land Area of Salton Sea Restoration Alternatives with Baseline = Future Inflow = 1.3 maf/yr

	Salt Removal Options					Disposal		Programs										
	EES		In Sea	Solar Ponds														
	Ground-based EES	Tower EES	In-Sea Ponds (shallow water)	On-Land Ponds (flat terrain)	On-Land Ponds (steep terrain)	In-Sea Terrace	On-Land Terrace	Program Management	Wildlife Disease Control	Created Wetlands	Recreation & Information Programs	Eutrophication Assessments	Fish Recovery	Fishery Management	Economic Development Assistance	Totals	Change in Land Use	Total Cost
Alternative 1: In-Sea Ponds																		
Units			4			5		1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)			0			0										0	0	
In-Sea Area Req'd (sq mi)			18			8										26		
Cost																		
Capital Cost ($M)			978			175		0	1	22	0	0	1	5	0	581	0	581
Total PV ($M)			393			193		6	7	23	10	3	2	11	0	648	0	648
Alternative 2: Ground-based EES																		
Units		6					8	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)		5					13									18	0	
Cost																		
Capital Cost ($M)		136					40	0	1	22	0	0	1	5	0	204	0	204
Total PV ($M)		224					68	6	7	23	10	3	2	11	0	353	0	353
Alternative 3: Tower EES																		
Units	6						8	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)	2						13									15	0	
Cost																		
Capital Cost ($M)	103						40	0	1	22	0	0	1	5	0	171	0	171
Total PV ($M)	365						68	6	7	23	10	3	2	11	0	494	0	494
Alternative 4: In-Sea & On-Land Ponds w. Land Use Conversion																		
Units			2	2		2	3	1	1	1	1	1	1	1	1			
In-Sea Area Req'd (sq mi)			9			3	0									12		
Land Area Req'd (sq mi)				9		0	5									14	14	
Cost																		
Capital Cost ($M)			169	27		70	16	0	1	22	0	0	1	5	0	330	22	352
Total PV ($M)			197	37		77	25	6	7	23	10	3	2	11	3	401	22	423
Alternative 5: On-Land Ponds																		
Units				6			8	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)				26			13									39	0	
Cost																		
Capital Cost ($M)				82			40	0	1	22	0	0	1	5	0	150	0	150
Total PV ($M)				112			68	6	7	23	10	3	2	11	0	242	0	242
Alternative 6: On-Land Ponds w. Land Use Conversion																		
Units				4			5	1	1	1	1	1	1	1	1			
Land Area Req'd (sq mi)				18			8									26	28	
Cost																		
Capital Cost ($M)				54			25	0	1	22	0	0	1	5	0	108	44	152
Total PV ($M)				75			42	6	7	23	10	3	2	11	5	184	44	228

Table 4-16. Cost and Land Area of Salton Sea Restoration Alternatives with Baseline = Future Inflow = 1.2 maf/yr

	Salt Removal Options: EES		Salt Removal Options: In Sea	Salt Removal Options: Solar Ponds		Disposal		Programs										
	Ground-based EES	Tower EES	In-Sea Ponds (shallow water)	On-Land Ponds (flat terrain)	On-Land Ponds (steep terrain)	In-Sea Terrace	On-Land Terrace	Program Management	Wildlife Disease Control	Created Wetlands	Recreation & Information Programs	Eutrophication Assessments	Fish Recovery	Fishery Management	Economic Development Assistance	Totals	Change in Land Use	Total Cost
Alternative 1: In-Sea Ponds																		
Units			6			7		1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)	0	0	0			0										0	0	
In-Sea Area Req'd (sq mi)			26			11										37		
Cost																		
Capital Cost ($M)			567			244		0	1	22	0	0	1	5	0	840	0	840
Total PV ($M)			590			270		6	7	23	10	3	2	11	0	922	0	922
Alternative 2: Ground-based EES																		
Units		12					12	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)		10					19									29	0	
Cost																		
Capital Cost ($M)		271					60	0	1	22	0	0	1	5	0	360	0	360
Total PV ($M)		448					101	6	7	23	10	3	2	11	0	611	0	611
Alternative 3: Tower EES																		
Units	12						12	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)	5						19									24	0	
Cost																		
Capital Cost ($M)	205						60	0	1	22	0	0	1	5	0	294	0	294
Total PV ($M)	730						101	6	7	23	10	3	2	11	0	893	0	893
Alternative 4: In-Sea & On-Land Ponds w. Land Use Conversion																		
Units			2	2		2	3	1	1	1	1	1	1	1	1			
In-Sea Area Req'd (sq mi)			9			3	0									12		
Land Area Req'd (sq mi)				9		0	5									14	53	
Cost																		
Capital Cost ($M)			189	27		70	15	0	1	22	0	0	1	5	0	330	101	431
Total PV ($M)			197	37		77	25	6	7	23	10	3	2	11	10	408	101	510
Alternative 5: On-Land Ponds																		
Units				12			12	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)				53			19									72	0	
Cost																		
Capital Cost ($M)				163			60	0	1	22	0	0	1	5	0	252	0	252
Total PV ($M)				224			101	6	7	23	10	3	2	11	0	388	0	388
Alternative 6: On-Land Ponds w. Land Use Conversion																		
Units				4			5	1	1	1	1	1	1	1	1			
Land Area Req'd (sq mi)				18			8									26	67	
Cost																		
Capital Cost ($M)				54			25	0	1	22	0	0	1	5	0	108	128	236
Total PV ($M)				75			42	6	7	23	10	3	2	11	12	191	128	319

Table 4-17. Cost and Land Area of Salton Sea Restoration Alternatives with Baseline = Future Inflow = 1.1 maf/yr

	Salt Removal Options					Disposal		Programs										
	EES		In Sea	Solar Ponds														
	Ground-based EES	Tower EES	In-Sea Ponds (shallow water)	On-Land Ponds (flat terrain)	On-Land Ponds (steep terrain)	In-Sea Terrace	On-Land Terrace	Program Management	Wildlife Disease Control	Created Wetlands	Recreation & Information Programs	Eutrophication Assessments	Fish Recovery	Fishery Management	Economic Development Assistance	Totals	Change in Land Use	Total Cost
Alternative 1: In-Sea Ponds																		
Units			10			10		1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)			0			0										0	0	
In-Sea Area Req'd (sq mi)			44			16										60		
Cost																		
Capital Cost ($M)			945			349		0	1	22	0	0	1	5	0	1,323	0	1,323
Total PV ($M)			983			386		6	7	23	10	3	2	11	0	1,431	0	1,431
Alternative 2: Ground-based EES																		
Units		12					14	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)		10					22									32	0	
Cost																		
Capital Cost ($M)		271					70	0	1	22	0	0	1	5	0	370	0	370
Total PV ($M)		448					118	6	7	23	10	3	2	11	0	628	0	628
Alternative 3: Tower EES																		
Units	12						14	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)	5						22									27	0	
Cost																		
Capital Cost ($M)	205						70	0	1	22	0	0	1	5	0	304	0	304
Total PV ($M)	730						118	6	7	23	10	3	2	11	0	910	0	910
Alternative 4: In-Sea & On-Land Ponds w. Land Use Conversion																		
Units			2	2		2	3	1	1	1	1	1	1	1	1			
In-Sea Area Req'd (sq mi)			9			3	0									12		
Land Area Req'd (sq mi)				9		0	5									14	92	
Cost																		
Capital Cost ($M)			189	27		70	15	0	1	22	0	0	1	5	0	330	206	535
Total PV ($M)			197	37		77	25	6	7	23	10	3	2	11	17	415	206	621
Alternative 5: On-Land Ponds																		
Units				12			14	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)				53			22									75	0	
Cost																		
Capital Cost ($M)				163			70	0	1	22	0	0	1	5	0	262	0	262
Total PV ($M)				224			118	6	7	23	10	3	2	11	0	405	0	405
Alternative 6: On-Land Ponds w. Land Use Conversion																		
Units				4			5	1	1	1	1	1	1	1	1			
Land Area Req'd (sq mi)				18			8									26	106	
Cost																		
Capital Cost ($M)				54			25	0	1	22	0	0	1	5	0	108	237	345
Total PV ($M)				75			42	6	7	23	10	3	2	11	19	199	237	435

Table 4-18. Cost and Land Area of Salton Sea Restoration Alternatives with Baseline Inflow = 1.3 maf/yr and Future Inflow = 1.0 MAF/yr

	Salt Removal Options					Disposal		Programs											
	EES		In Sea	Solar Ponds														
	Ground-based EES	Tower EES	In-Sea Ponds (shallow water)	On-Land Ponds (flat terrain)	On-Land Ponds (steep terrain)	In-Sea Terrace	On-Land Terrace	Program Management	Wildlife Disease Control	Created Wetlands	Recreation & Information Programs	Eutrophication Assessments	Fish Recovery	Fishery Management	Economic Development Assistance	Totals	Change in Land Use	Total Cost
Alternative 1: In-Sea Ponds																		
Units			10			11		1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)																	0	
In-Sea Area Req'd (sq mi)			44			18										61		
Cost																		
Capital Cost ($M)			945			384		0	1	22	0	0	1	5	0	1,357	0	1,357
Total PV ($M)			983			425		6	7	23	10	3	2	11	0	1,469	0	1,469
Alternative 2: Ground-based EES																		
Units		12					15	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)		10					24									34	0	
Cost																		
Capital Cost ($M)		271					75	0	1	22	0	0	1	5	0	375	0	375
Total PV ($M)		448					127	6	7	23	10	3	2	11	0	636	0	636
Alternative 3: Tower EES																		
Units	12						15	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)	5						24									29	0	
Cost																		
Capital Cost ($M)	205						75	0	1	22	0	0	1	5	0	309	0	309
Total PV ($M)	730						127	6	7	23	10	3	2	11	0	918	0	918
Alternative 4: In-Sea & On-Land Ponds w. Land Use Conversion																		
Units			2	2		2	3	1	1	1	1	1	1	1	1			
In-Sea Area Req'd (sq mi)			9			3	0									12		
Land Area Req'd (sq mi)				9		0	5									14	131	
Cost																		
Capital Cost ($M)			189	27		70	15	0	1	22	0	0	1	5	0	330	22	352
Total PV ($M)			197	37		77	25	6	7	23	10	3	2	11	24	423	22	445
Alternative 5: On-Land Ponds																		
Units				12			15	1	1	1	1	1	1	1	0			
Land Area Req'd (sq mi)				53			24									77	0	
Cost																		
Capital Cost ($M)				163			75	0	1	22	0	0	1	5	0	267	0	267
Total PV ($M)				224			127	6	7	23	10	3	2	11	0	413	0	413
Alternative 6: On-Land Ponds w. Land Use Conversion																		
Units				4			5	1	1	1	1	1	1	1	1			
Land Area Req'd (sq mi)				18			8									26	145	
Cost																		
Capital Cost ($M)				54			25	0	1	22	0	0	1	5	0	108	44	152
Total PV ($M)				75			42	6	7	23	10	3	2	11	27	206	44	250

Table 4-19. Cost and Land Area of Salton Sea Restoration Alternatives with Baseline Inflow = 1.2 or 1.1 maf/yr and Future Inflow = 1.0 MAF/yr

	Salt Removal Options					Disposal		Programs									Change in		Total	
	EES		In Sea	Solar Ponds													Land Use		Cost	
	Ground-based EES	Tower EES	In-Sea Ponds (shallow water)	On-Land Ponds (flat terrain)	On-Land Ponds (steep terrain)	In-Sea Terrace	On-Land Terrace	Program Management	Wildlife Disease Control	Created Wetlands	Recreation & Information Programs	Eutrophication Assessments	Fish Recovery	Fishery Management	Economic Development Assistance	Totals	Baseline = 1.2 ac-ft/yr	Baseline = 1.1 ac-ft/yr	Baseline = 1.2 ac-ft/yr	Baseline = 1.1 ac-ft/yr
Alternative 1: In-Sea Ponds																				
Units			12			12		1	1	1	1	1	1	1	0					
Land Area Req'd (sq mi)																	0	0		
In-Sea Area Req'd (sq mi)			53			19										72				
Cost																				
Capital Cost ($M)			1,134			419		0	1	22	0	0	1	5	0	1,581	0	0	1,581	1,581
Total PV ($M)			1,179			463		6	7	23	10	3	2	11	0	1,704	0	0	1,704	1,704
Alternative 2: Ground-based EES																				
Units		12					15	1	1	1	1	1	1	1	0					
Land Area Req'd (sq mi)		10					24									34	0	0		
Cost																				
Capital Cost ($M)		271					75	0	1	22	0	0	1	5	0	375	0	0	375	375
Total PV ($M)		448					127	6	7	23	10	3	2	11	0	636	0	0	636	636
Alternative 3: Tower EES																				
Units	12						15	1	1	1	1	1	1	1	0					
Land Area Req'd (sq mi)	5						24									29	0	0		
Cost																				
Capital Cost ($M)	205						75	0	1	22	0	0	1	5	0	309	0	0	309	309
Total PV ($M)	730						127	6	7	23	10	3	2	11	0	918	0	0	918	918
Alternative 4: In-Sea & On-Land Ponds w. Land Use Conversion																				
Units			2	2		2	3	1	1	1	1	1	1	1	1					
In-Sea Area Req'd (sq mi)			9			3	0									12				
Land Area Req'd (sq mi)				9		0	5									14	131	131		
Cost																				
Capital Cost ($M)			189	27		70	15	0	1	22	0	0	1	5	0	330	101	206	431	535
Total PV ($M)			197	37		77	25	6	7	23	10	3	2	11	24	423	101	206	524	629
Alternative 5: On-Land Ponds																				
Units				12			15	1	1	1	1	1	1	1	0					
Land Area Req'd (sq mi)				53			24									77	0	0		
Cost																				
Capital Cost ($M)				163			75	0	1	22	0	0	1	5	0	267	0	0	267	267
Total PV ($M)				224			127	6	7	23	10	3	2	11	0	413	0	0	413	413
Alternative 6: On-Land Ponds w. Land Use Conversion																				
Units				4			5	1	1	1	1	1	1	1	1					
Land Area Req'd (sq mi)				18			8									26	145	145		
Cost																				
Capital Cost ($M)				54			25	0	1	22	0	0	1	5	0	108	128	237	236	345
Total PV ($M)				75			42	6	7	23	10	3	2	11	27	206	128	237	334	443

Table 4-20. Cost and Land Area of Salton Sea Restoration Alternatives with Future Inflow = 0.8 MAF/yr for All Baseline Inflow Assumptions

	Salt Removal Options					Disposal		Programs									Cost of Change in Land Use			Total Cost		
	EES		In Sea	Solar Ponds																		
	Ground-based EES	Tower EES	In-Sea Ponds (shallow water)	On-Land Ponds (flat terrain)	On-Land Ponds (steep terrain)	In-Sea Terrace	On-Land Terrace	Program Management	Wildlife Disease Control	Created Wetlands	Recreation & Information Programs	Eutrophication Assessments	Fish Recovery	Fishery Management	Economic Development Assistance	Totals	Baseline = 1.3 ac-ft/yr	Baseline = 1.2 ac-ft/yr	Baseline = 1.1 ac-ft/yr	Baseline = 1.3 ac-ft/yr	Baseline = 1.2 ac-ft/yr	Baseline = 1.1 ac-ft/yr
Alternative 1: In-Sea Ponds																						
Units			12			13		1	1	1	1	1	1	1	0							
Land Area Req'd (sq mi)	0	0	0			0										0	0	0	0			
In-Sea Area Req'd (sq mi)			53			21										73						
Cost																						
Capital Cost ($M)			1,134			454		0	1	22	0	0	1	5	0	1,616	0	0	0	1,616	1,616	1,616
Total PV ($M)			1,179			502		6	7	23	10	3	2	11	0	1,743	0	0	0	1,743	1,743	1,743
Alternative 2: Ground-based EES																						
Units		12					18	1	1	1	1	1	1	1	0							
Land Area Req'd (sq mi)		10					29									39	0	0	0			
Cost																						
Capital Cost ($M)		271					90	0	1	22	0	0	1	5	0	390	0	0	0	390	390	390
Total PV ($M)		448					152	6	7	23	10	3	2	11	0	662	0	0	0	662	662	662
Alternative 3: Tower EES																						
Units	12						18	1	1	1	1	1	1	1	0							
Land Area Req'd (sq mi)	5						29									34	0	0	0			
Cost																						
Capital Cost ($M)	205						90	0	1	22	0	0	1	5	0	324	0	0	0	324	324	324
Total PV ($M)	730						152	6	7	23	10	3	2	11	0	944	0	0	0	944	944	944
Alternative 4: In-Sea & On-Land Ponds w. Land Use Conversion																						
Units			2	2		2	3	1	1	1	1	1	1	1	1							
In-Sea Area Req'd (sq mi)			9			3	0									12						
Land Area Req'd (sq mi)				9		0	5									14	209	209	209			
Cost																						
Capital Cost ($M)			189	27		70	15	0	1	22	0	0	1	5	0	330	22	101	206	352	431	535
Total PV ($M)			197	37		77	25	6	7	23	10	3	2	11	39	437	22	101	206	459	539	643
Alternative 5: On-Land Ponds																						
Units				12			18	1	1	1	1	1	1	1	0							
Land Area Req'd (sq mi)				53			29									81	0	0	0			
Cost																						
Capital Cost ($M)				163			90	0	1	22	0	0	1	5	0	282	0	0	0	282	282	282
Total PV ($M)				224			152	6	7	23	10	3	2	11	0	439	0	0	0	439	439	439
Alternative 6: On-Land Ponds w. Land Use Conversion																						
Units				4			5	1	1	1	1	1	1	1	1							
Land Area Req'd (sq mi)				18			8									26	223	223	223			
Cost																						
Capital Cost ($M)				54			25	0	1	22	0	0	1	5	0	108	44	128	237	152	236	346
Total PV ($M)				75			42	6	7	23	10	3	2	11	41	220	44	128	237	264	348	457

Table 4-21. Salt Removal from Salton Sea–Salton Sea Alternatives

Present Level Inflow Condition = 1,300,000 af/yr

	Future Inflow					
	1,300,000		1,000,000		800,000	
	30 Year Salt Removal		30 Year Salt Removal		30 Year Salt Removal	
Alternative #	Total (Mtons)	Average (Mtons/yr)	Total (Mtons)	Average (Mtons/yr)	Total (Mtons)	Average (Mtons/yr)
1	133.8	4.5	323.7	10.8	386.7	12.9
2	221.5	7.4	457.2	15.2	524.4	17.5
3	221.5	7.4	457.2	15.2	524.4	17.5
4	136.6	4.6	134.7	4.5	131.8	4.4
5	221.5	7.4	457.2	15.2	524.4	17.5
6	139.1	4.6	137.3	4.6	136.6	4.6

Present Level Inflow Condition = 1,200,000 af/yr

	Future Inflow					
	1,200,000		1,000,000		800,000	
	30 Year Salt Removal		30 Year Salt Removal		30 Year Salt Removal	
Alternative #	Total (Mtons)	Average (Mtons/yr)	Total (Mtons)	Average (Mtons/yr)	Total (Mtons)	Average (Mtons/yr)
1	214.4	7.1	313.0	10.4	417.4	13.9
2	354.4	11.8	458.2	15.3	523.0	17.4
3	354.4	11.8	458.2	15.3	523.0	17.4
4	136.1	4.5	133.8	4.5	133.3	4.4
5	354.4	11.8	458.2	15.3	523.0	17.4
6	138.0	4.6	137.3	4.6	136.4	4.5

Present Level Inflow Condition = 1,100,000 af/yr

	Future Inflow					
	1,100,000		1,000,000		800,000	
	30 Year Salt Removal		30 Year Salt Removal		30 Year Salt Removal	
Alternative #	Total (Mtons)	Average (Mtons/yr)	Total (Mtons)	Average (Mtons/yr)	Total (Mtons)	Average (Mtons/yr)
1	275.1	9.2	318.0	10.6	425.5	14.2
2	411.9	13.7	460.4	15.3	524.3	17.5
3	411.9	13.7	460.4	15.3	524.3	17.5
4	135.2	4.5	134.2	4.5	132.4	4.4
5	411.9	13.7	460.4	15.3	524.3	17.5
6	137.6	4.6	137.0	4.6	136.2	4.5

EVALUATION OF SALINITY CONTROL METHODS

All salinity control alternatives under consideration were evaluated using four performance factors, seven environmental factors, and one cost factor. The performance factors are similar to the first four project goals described in Chapter 2. The fifth project goal of 'enhancing the Sea to provide economic development opportunities' was not used separately in this evaluation because the relevant objectives for this goal would be satisfied if the objectives of the third and fourth goals are met. Performance factors were further evaluated using specific objectives that ensure the attainment of a given performance factor or goal. The performance factors, including objectives, and the environmental and cost factors are listed below:

Performance Factors and Objectives

1. Maintain the Sea as repository for agricultural drainage.
   a. Maintain Salton Sea elevations at or below current levels.
   b. Maintain accessibility to the Sea for agricultural drainage water.

2. Provide a safe, productive environment at the Sea for resident and migratory birds and endangered species.
   a. Control salinity to maintain forage and invertebrate foodbase for birds.
   b. Protect/provide quality roosting and nesting habitat for waterbirds.
   c. Maintain/provide a broad array of avian habitats.

3. Restore recreation uses.
   a. Stabilize Salton Sea water surface elevation.
   b. Maintain salinity at or below existing levels.

4. Maintain viable sport fishery.
   a. Maintain or reduce salinity at or below current levels.

Environmental Factors

1. Surface water and groundwater resources.
2. Air quality and noise.
3. Aquatic resources.
4. Avian resources.
5. Public health and environmental hazards.
6. Socioeconomics, utilities, and public services.
7. Cultural, paleontological and Native American resources.

Cost Factor

1. Total present value (PV).

Each of the salinity control alternatives was evaluated under two inflow conditions: (1) existing inflow condition and (2) reduced inflow condition. The reduced inflow condition represented an average annual inflow that was reduced by 300,000 acre-feet. Further, each of the alternatives was scored on a scale of 0 to 5 where 0 represented the worst situation (least effective as a performance factor, most environmentally damaging, or most costly) and 5 represented the best situation.

Results of Scoring Process

The alternative evaluation was accomplished by a project team of engineers and environmental scientists, with input to the process from representatives of several agencies. The team's evaluation of each of the performance, environmental, and cost factors and scores given to each of the alternatives are presented in Tables 4-22 and 4-23.

Alternatives 5 and 6, on-land ponds with on-land disposal, without and with land use conversion to provide make-up water, respectively, scored the highest for the case where future inflows are the same as baseline inflow conditions. Alternative 6 also scored significantly higher than all other alternatives for reduced future inflow conditions. Alternative 4, which combines in-Sea and on-land ponds, with land use conversion, came in second for reduced inflow conditions.

Table 4-22. Evaluation of Salinity Control Alternatives with Baesline and Future Inflow = 1.3 maf/yr

	Alternative 1: In-Sea Ponds	Alternative 2: Ground-based EES	Alternative 3: Tower EES	Alternative 4: In-Sea & On-Land Ponds w. Land Use Conversion	Alternative 5: On-Land Ponds	Alternative 6: On-Land Ponds w. Land Use Conversion	Wt.
PERFORMANCE FACTORS							
Maintain Agricultural Drainage Repository							
Maintain Salton Sea elevations at or below current levels	0.0	5.0	5.0	5.0	5.0	5.0	
Maintain accessibility to the Sea for agricultural drainage water	1.0	5.0	5.0	2.0	3.0	3.0	
Provide a Safe, Productive Environment at the Sea for Resident & Migratory Birds & Endangered Species							
Control salinity to maintain forage and invertebrate foodbase for birds	4.0	3.0	3.0	4.0	3.0	4.0	
Protect/provide quality roosting and nesting habitat for waterbirds	4.0	2.0	2.0	4.0	4.0	4.0	
Maintain/provide a broad array of avian habitats	3.0	2.0	2.0	4.0	4.0	4.0	
Restore Recreational Uses							
Stabilize Salton Sea water surface elevation	3.0	3.0	3.0	3.0	2.0	3.0	
Maintain salinity at or below existing levels	4.0	4.0	4.0	4.0	4.0	4.0	
Maintain Viable Sports Fishery							
Maintain or reduce salinity at or below current levels	4.0	3.0	3.0	4.0	3.0	4.0	
Average Performance Score	2.88	3.38	3.38	3.75	3.50	3.88	1
ENVIRONMENTAL FACTORS							
Surface Water and Groundwater Resources	3.0	3.0	3.0	2.0	2.0	2.0	
Air Quality and Noise	3.0	2.0	2.0	3.0	3.0	3.0	
Aquatic Resources	2.0	4.0	4.0	3.0	4.0	4.0	
Avian Resources	3.0	2.0	1.0	3.0	2.0	2.0	
Public Health and Environmental Hazards	4.0	3.0	3.0	4.0	4.0	4.0	
Socioeconomics, Utilities and Public Services	4.0	1.0	1.0	2.0	4.0	3.0	
Cultural, Paleontological and Native American Resources	2.0	2.0	2.0	2.0	2.0	2.0	
Average Environmental Score	3.00	2.43	2.29	2.71	3.00	2.86	1
COST FACTOR							
Total PV	2.00	3.00	2.00	3.00	5.00	5.00	
Cost Score	2.00	3.00	2.00	3.00	5.00	5.00	2
Weighted Average -- All Factors	2.47	2.95	2.42	3.12	4.13	4.18	

Table 4-23. Evaluation of Salinity Control Alternatives with Future Inflow = 1.0 maf/yr or Lower

	Alternative 1: In-Sea Ponds	Alternative 2: Ground-based EES	Alternative 3: Tower EES	Alternative 4: In-Sea & On-Land Ponds w. Land Use Conversion	Alternative 5: On-Land Ponds	Alternative 6: On-Land Ponds w. Land Use Conversion	Wt.
PERFORMANCE FACTORS							
Maintain Agricultural Drainage Repository							
Maintain Salton Sea elevations at or below current levels	5.0	5.0	5.0	5.0	5.0	5.0	
Maintain accessibility to the Sea for agricultural drainage water	1.0	5.0	5.0	2.0	3.0	3.0	
Provide a Safe, Productive Environment at the Sea for Resident & Migratory Birds & Endangered Species							
Control salinity to maintain forage and invertebrate foodbase for birds	4.0	4.0	4.0	4.0	4.0	4.0	
Protect/provide quality roosting and nesting habitat for waterbirds	4.0	2.0	2.0	4.0	4.0	4.0	
Maintain/provide a broad array of avian habitats	3.0	2.0	2.0	4.0	4.0	4.0	
Restore Recreational Uses							
Stabilize Salton Sea water surface elevation	4.0	1.0	1.0	4.0	1.0	4.0	
Maintain salinity at or below existing levels	4.0	4.0	4.0	4.0	4.0	4.0	
Maintain Viable Sports Fishery							
Maintain or reduce salinity at or below current levels	4.0	4.0	4.0	4.0	4.0	4.0	
Average Performance Score	3.63	3.38	3.38	3.88	3.63	4.00	1
ENVIRONMENTAL FACTORS							
Surface Water and Groundwater Resources	3.0	3.0	3.0	2.0	2.0	2.0	
Air Quality and Noise	3.0	2.0	2.0	3.0	3.0	3.0	
Aquatic Resources	1.0	2.0	2.0	3.0	2.0	4.0	
Avian Resources	3.0	2.0	1.0	3.0	2.0	2.0	
Public Health and Environmental Hazards	4.0	3.0	3.0	4.0	4.0	4.0	
Socioeconomics, Utilities and Public Services	4.0	1.0	1.0	2.0	4.0	2.0	
Cultural, Paleontological and Native American Resources	2.0	2.0	2.0	2.0	2.0	2.0	
Average Environmental Score	2.86	2.14	2.00	2.71	2.71	2.71	1
COST FACTOR							
Total PV	2.00	3.00	2.00	3.00	4.00	5.00	
Cost Score	2.00	3.00	2.00	3.00	4.00	5.00	2
Weighted Average – All Factors	2.62	2.88	2.34	3.15	3.58	4.18	

Performance Factors

Maintain the Sea as Repository for Agricultural Drainage

The continuation of the Salton Sea as a repository for agricultural drainage is a fundamental component of the Salton Sea Restoration Project. Specific objectives that will be used to ensure that agricultural uses are maintained include: (1) maintenance of the Salton Sea elevations at or below current levels and (2) maintenance of accessibility to the Sea for agricultural drainage water. Project alternatives would be able to meet these objectives with varying effectiveness. For example, construction of in-Sea ponds may reduce the surface area of the main body of the Sea resulting in increased Sea elevation and potential coastal flooding and damage to beach-front properties. Similarly, construction of in-Sea ponds at the southern end of the Sea may impede the accessibility of drainage water to the main body of the Sea without construction of costly diversion facilities. Even if final design features could be incorporated to avoid such problems, at this stage of the analysis, all potential issues are being considered in scoring the alternatives. The following scoring factors were considered in the evaluation of the goal of maintaining the Sea as an agricultural drainage repository with separate scores given for each of the two performance objectives:

Score	Description
5	Fully meets or exceeds the two performance objectives of: (1) maintaining the Sea elevation and (2) accessibility to the Sea for agricultural drainage water.
4	Has strong contribution to each of the two objectives mentioned above.
3	Contributes to the each of the two objectives mentioned above.
2	Contributes to the each of the two objectives mentioned above, but with substantial restrictions.
1	Likely to provide slight contribution to each of the two objectives mentioned above, but difficult to substantiate.
0	May have adverse effect on each of the two objectives mentioned above.

All alternatives under consideration were expected to meet the two objectives of maintaining the Sea elevation and accessibility to the Sea for agricultural drainage water, but with varying effectiveness. All alternatives except Alternative 1, with in-Sea pond with in-Sea disposal, would allow the Sea elevation to be maintained without any adverse effects. These are given a score of 5. Alternative 1, on the other hand, reduces the surface area of the Sea substantially and, therefore, creates a potential for increase in Sea elevation in the main body of the Sea resulting in coastal flooding and possible damage to beach-front properties. This alternative is, therefore, given a score of 0.

Alternatives 2 and 3, with ground-based EES units, would have no effect on accessibility to the Sea for agricultural drainage water and are given a score of 5. On the other hand, Alternatives 1 and 4, with in-Sea ponds, are likely to impede the accessibility and/or increase the cost of maintaining the accessibility through construction of diversion facilities to the main body of the Sea. These alternatives are, therefore, given a score of 1 and 2, respectively. Alternatives 5 and 6 would contribute to the objective without any restrictions or adverse effects and are given a score of 3.

The issues affecting the goal of maintaining the Sea as an agricultural drainage repository were considered to be similar for continuation of existing inflows and for reduced inflow conditions. Therefore, all alternatives for reduced inflow conditions, except Alternative 1, were given the same score as for continuation of existing inflows. Alternative 1 with reduced inflow conditions, is not likely to result in increased elevation of the Sea or damage to beach-front properties and is, therefore, given a score of 5 instead of 0 for the continuation of existing inflows.

Provide a Safe, Productive Environment at the Sea for Resident and Migratory Birds and Endangered Species

A number of avian and fish species are highly dependent on a healthy Salton Sea ecosystem. These species include threatened and endangered species (including both avian and fish species), federal species of management concern, and trust species of migratory birds. Providing a safe, productive environment for resident and migratory birds and endangered species is a major goal of the Salton Sea Restoration Project. Specific performance objectives that will be used to ensure the attainment of this goal include: (1) control of salinity to maintain forage and invertebrate foodbase for birds, (2) protection and provision of quality roosting and nesting habitat for waterbirds, and (3) maintenance and provision of a broad array of avian habitats. Project alternatives would be able to meet these objectives with varying effectiveness. For example, the EES system is likely to be less effective because it would result in greater loss of desert habitat and would affect a larger number of avian species from loss of foraging and nesting habitat compared to the in-Sea ponds. Migratory birds may also be affected by the EES towers because the birds could strike them at night or the towers could interfere with their migratory paths. A concern was raised that mist and light associated with the EES towers could confuse the birds during their flight. Even if the final design features and the location of the EES or on-land ponds could avoid some of these problems, at this stage of the analysis, all potential issues are being considered in scoring the alternatives. The following scoring factors were considered in the evaluation of the goal of providing a safe, productive environment at the Sea for resident and migratory birds and endangered species with separate scores given to each of the three performance objectives mentioned above:

Score	Description
5	Fully meets or exceeds the three performance objectives mentioned above.
4	Has strong contribution to each of the three objectives mentioned above.
3	Contributes to each of the three objectives mentioned above.
2	Contributes to each of the three objectives mentioned above, but with substantial restrictions.
1	Likely to provide slight contribution to each of the three objectives mentioned above, but difficult to substantiate.
0	May have adverse effect on each of the three objectives mentioned above.

All alternatives under consideration are expected to meet the three objectives, but with varying effectiveness. The objective of controlling salinity to maintain forage and invertebrate foodbase for birds with minimum adverse effects is likely to be more effectively met by Alternatives 1, 4, and 6 because they would minimize the loss of foraging and nesting habitat. These alternatives, are given a score of 4. Alternatives 2, 3, and 5 would also meet the objective but not as effectively as Alternatives 1, 4, and 6 and are, therefore, given a score of 3.

Neither Alternative 2, with ground-based EES nor Alternative 3, with tower EES, would be as effective as the other four alternatives in meeting the two objectives of (1) protecting and providing quality roosting and nesting habitat for waterbirds and (2) maintaining a broad array of avian habitats. As a result, Alternatives 2 and 3 were given a lower score of 2 compared to a score of 4 given to other alternatives.

The issues affecting the goal of providing a safe, productive environment at the Sea for resident and migratory birds and endangered species were somewhat different for continuation of existing inflows and for reduced inflow conditions. No differentiation among the alternatives could be made in meeting the performance objective of controlling salinity to maintain forage and invertebrate foodbase for birds. Therefore, all alternatives were given a score of 4. For the other two objectives, the scores were similar to those given for the continuation of existing inflow conditions.

Restore Recreation Uses

Recreational use of the Salton Sea was greater and more varied in the past than it is today. Visitors in the past used the area for camping, picnicking, and participating in numerous water sports, such as boat racing, water skiing, and swimming. Restoration of recreational uses enjoyed by the visitors in the past is one of the primary goals of the Salton Sea Restoration Project. Specific objectives that will be used to assist in restoring recreational uses include: (1) stabilization of Salton Sea water surface elevation and (2) maintenance of salinity at or below existing levels. Over the years, increasing surface elevations have flooded recreational facilities along the shoreline. In addition, increase in salinity of the Sea and increasing public perceptions of potential health risks have led to a decrease in visitation and particularly water/body contact recreational uses. Project alternatives would be able to restore recreational uses by meeting the two objectives mentioned above with varying effectiveness. For example, the ground-based EES and on-land pond and disposal system are less likely to meet the objective of stabilizing Salton Sea water surface elevation than other alternatives under consideration. The following scoring factors were considered in the evaluation of the goal of restoring the recreational uses with separate scores given to each of the two performance objectives mentioned above:

Score	Description
5	Fully meets or exceeds the two performance objectives mentioned above.
4	Has strong contribution to each of the two objectives mentioned above.
3	Contributes to each of the two objectives mentioned above.
2	Contributes to each of the two objectives mentioned above, but with substantial restrictions.
1	Likely to provide slight contribution to each of the two objectives mentioned above, but difficult to substantiate.
0	May have adverse effect on each of the two objectives mentioned above.

All alternatives under consideration are expected to meet the two objectives, but with varying effectiveness. The objective of stabilizing Salton Sea water surface elevation is equally likely to be met by all alternatives except Alternative 5 which requires transfer of larger quantities of water compared to other alternatives. Therefore, Alternative 5 has been given a score of 2 instead of a higher score of 3 as given to all other alternatives. The objective of maintaining salinity at or below existing levels is equally likely to be met by all alternatives under consideration. Therefore, all alternatives are given a score of 4.

The issues affecting the goal of restoring recreational uses were somewhat different for continuation of existing inflows and for reduced inflow conditions. The objective of stabilizing water surface elevation of the Salton Sea is more difficult to be met by Alternatives 2, 3, and 5, which require transfer of a larger quantity of water from the Sea, than Alternatives 1 and 4 with in-Sea ponds or Alternative 6 with on-land pond but with land use conversion to provide make-up water. Therefore, Alternatives 2, 3, and 5 are given a score of only 1 whereas Alternatives 1, 4, and 6 are given a score of 4. Even with reduced inflow conditions, the objective of maintaining salinity at or below existing levels could be equally met by all alternatives. Therefore, no differentiation has been made and all alternatives have been given a score of 4.

Maintain Viable Sport Fishery

The Salton Sea became widely known for its sport fishery following the successful introduction by the California Department of Fish and Game of several species from the Gulf of California and elsewhere. Tilapia, corvina, sargo and bairdiella (croaker) are the four main sport fish inhabiting the Salton Sea. Increasing salinity levels are adversely affecting fish reproduction. Maintaining viable sport fishery has been recognized as one of the primary goals of the Salton Sea Restoration Project. The performance objective that will be used to assist in maintaining viable sport fishery is to maintain or reduce salinity at or below current levels within the Sea. This would provide benefits to several species within the sport fishery by improving conditions for reproduction. The following scoring factors were considered in the evaluation of the goal of maintaining viable sport fishery:

Score	Description
5	Fully meets or exceeds performance objective of maintaining or reducing salinity at or below current levels.
4	Has strong contribution to performance objective mentioned above.
3	Contributes to performance objective mentioned above.
2	Contributes to performance objective mentioned above, but with substantial restrictions.
1	Likely to provide slight contribution to performance objective mentioned above, but difficult to substantiate.
0	May have adverse effect on performance objective mentioned above.

All alternatives under consideration are expected to meet the performance objective, but with varying effectiveness. Alternatives 1and 4, which include in-Sea ponds and Alternative 6 which provides for the replacement of water taken for on-land transfer, are considered better able to maintain or reduce salinity at or below current levels. Therefore, they are given a score of 4. On the other hand, Alternatives 2 and 3, which include ground-based EES and Alternative 5, which includes on-land pond and disposal, would be able to maintain the salinity in the Sea at current levels but would not be as effective in reducing salinity. Therefore, they are given a score of 3.

With the reduced inflow conditions, all alternatives are considered to be equally effective in controlling salinity and are given a score of 4.

Environmental Factors

Surface Water and Groundwater Resources

Surface water and/or groundwater resources in the vicinity of the Salton Sea may be affected by project alternatives. Examples of project effects that would be considered adverse would include alteration of drainage patterns in a manner that could cause flooding, or seepage of saline water into freshwater aquifers. It is not expected that any alternatives would necessarily cause such problems. However at this stage of the analysis, all potential issues are being considered, even if final design features could be incorporated to avoid such problems. The following scoring factors were considered in the evaluation of surface water and groundwater issues.

Score	Description
5	No adverse effects on surface water or groundwater resources are anticipated; there may be some beneficial results of the project.
4	No adverse effects to surface water and groundwater resources are anticipated.
3	Minimal adverse effects to surface water and groundwater resources are anticipated; or some adverse consequences may occur that would be offset by beneficial effects.
2	Adverse effects to surface water or groundwater resources are anticipated; however, it is expected that they can be mitigated.
1	Significant adverse effects to surface water or groundwater resources are anticipated; however, it is expected that they can be mitigated.
0	Significant adverse effects to surface water or groundwater resources are anticipated, that cannot be mitigated.

By helping to control salinity and nutrient levels, all alternatives are considered to have a beneficial effects on the water quality in the Sea. Alternatives that include in-Sea ponds or EES units have the potential to have some local water quality problems that can be mitigated. Therefore, these alternatives were given scores of 3. Alternatives that include on-land ponds have the potential for seepage issues, and were given scores of 2. The issues affecting water resources were considered to be similar for continuation of existing inflows and for reduced inflow conditions. Therefore, the scoring factors for surface water and groundwater issues for any alternative were scored the same for both inflow conditions.

Air Quality and Noise

Air quality and noise in the vicinity of the Salton Sea may be affected by project alternatives. An example of project effects that would be considered adverse to air quality would include salt drifts expected from the tower EES alternative and generation of dust on lands exposed by alternatives that reduce inflow to the Sea. Construction activity would result in temporary increase in noise in the vicinity of facility construction sites. It is not expected that all alternatives would necessarily cause such problems. However at this stage of the analysis, all potential issues are being considered, even if final design features could be incorporated to avoid such problems. The following scoring factors were considered in the evaluation of air quality and noise.

Score	Description
5	No adverse effects on air quality and noise are anticipated; there may be some beneficial results of the project.
4	No continuous/ permanent adverse effects to air quality and noise are anticipated.
3	Minimal adverse effects to air quality and noise are anticipated; or some adverse consequences may occur that would be offset by beneficial effects.
2	Adverse effects to air quality and noise are anticipated; however, it is expected that they can be mitigated.
1	Significant adverse effects to air quality and noise are anticipated; however, it is expected that they can be mitigated.
0	Significant adverse effects to air quality and noise are anticipated, that cannot be mitigated.

The alternatives that include in-Sea and on-land ponds would have minimal adverse effects on air quality and noise. Therefore, these alternatives were given scores of 3. Alternatives that include ground-based EES and the tower EES have the potential for salt drift and temporary noise from construction equipment, and were given scores of 2. Changes in water inflow to the Sea are likely to effect air quality because a drop in lake elevation could cause greater exposure of land to dust generation. Long-term air quality benefits would result from stabilization of the water elevation and development of land along the shoreline.

Aquatic Resources

Aquatic resources of the Salton Sea may be affected by project alternatives. An example of project effects that would be considered adverse to aquatic resources includes habitat loss from in-Sea ponds and reduction in water level of the Sea even from land-based salinity control facilities. It is not expected that all alternatives would necessarily cause such problems. However at this stage of the analysis, all potential issues are being considered, even if final design features could be incorporated to avoid such problems. The following scoring factors were considered in the evaluation of aquatic resources.

Score	Description
5	No adverse effects on aquatic resources are anticipated; there may be some beneficial results of the project.
4	No adverse effects to aquatic resources are anticipated.
3	Minimal adverse effects to aquatic resources are anticipated; or some adverse consequences may occur that would be offset by beneficial effects.
2	Adverse effects to aquatic resources are anticipated; however, it is expected that they can be mitigated.
1	Significant adverse effects to aquatic resources are anticipated; however, it is expected that they can be mitigated.
0	Significant adverse effects to aquatic resources are anticipated, that cannot be mitigated.

By helping to control salinity, all land-based alternatives are considered to have lower adverse effects and some beneficial effects on the aquatic resources in the Sea. Therefore, these alternatives were given scores of 4. The alternative that includes in-Sea ponds and salt disposal facilities is expected to cause habitat loss for aquatic resources, and was given a score of 2, whereas the alternative with in-Sea pond and on-land disposal facilities was given a score of 3. The reduced water inflow to the Sea would also have greater impacts on aquatic life than the continuation of existing inflows. This variation was also considered in determining the scores mentioned above.

Avian Resources

Avian resources (resident and migratory birds) of the Salton Sea may be affected by project alternatives. Project effects that would be considered adverse to avian resources would vary with the extent of restoration of the Salton Sea. Adverse or beneficial effects may also result from blowing mist from the tower EES or reduction of avian disease from improvements in water quality. At this stage of the analysis, all potential issues are being considered, even if final design features could be incorporated to avoid most of the problems. The following scoring factors were considered in the evaluation of avian resources.

Score	Description
5	No adverse effects on avian resources are anticipated; there may be some beneficial results of the project.
4	No adverse effects to Avian resources are anticipated.
3	Minimal adverse effects to avian resources are anticipated; or some adverse consequences may occur that would be offset by beneficial effects.
2	Adverse effects to avian resources are anticipated; however, it is expected that they can be mitigated.
1	Significant adverse effects to avian resources are anticipated; however, it is expected that they can be mitigated.
0	Significant adverse effects to avian resources are anticipated, that cannot be mitigated.

The in-Sea alternatives are considered to have less adverse and some beneficial effects on avian resources and were given scores of 3. Alternatives that include on-land ponds provide were given scores of 2 because of the possible formation of contaminants in ponds that could potentially affect resident and migratory birds. The tower EES alternative was given a score of 1 because of the concern for blowing mist and the 150-foot height of the towers. A reduction in water inflow would also adversely affect habitat for avian resources. Changes in inflow were, therefore, included in determining the scores mentioned above.

Public Health and Environmental Hazards

Public Health in the vicinity of the Salton Sea may be affected by project alternatives. An example of project effects that would be considered adverse to public health includes air borne dust during facility construction and salt from the spray systems. Other issues could be related to the changes in the contaminant levels in the Sea and their exposure to the visitors to the Salton Sea. At this stage of the analysis, all potential issues are being considered, even if final design features could be incorporated to avoid such problems. The following scoring factors were considered in the evaluation of public health and environmental hazards.

Score	Description
5	No adverse effects to public health and no environmental hazards are anticipated; there may be some beneficial results of the project.
4	No adverse effects to public health and no environmental hazards are anticipated.
3	Minimal adverse effects to public health and minimal environmental hazards are anticipated; or some adverse consequences may occur that would be offset by beneficial effects.
2	Adverse effects to public health and adverse environmental hazards are anticipated; however, it is expected that they can be mitigated.
1	Significant adverse effects to public health and significant environmental hazards are anticipated; however, it is expected that they can be mitigated.
0	Significant adverse effects to public health and significant environmental hazards are anticipated, that cannot be mitigated.

By helping to control salinity and contaminants in the Salton Sea, all alternatives except those that include enhanced evaporation systems (EES) are considered to have a beneficial effect on public health and lesser environmental hazards for persons living in the vicinity of the Sea or visiting the Sea for recreational activities. Therefore, these alternatives were given scores of 4. The alternatives of ground-based EES and the tower EES could have relatively greater adverse effects on public health and are given scores of 3. However, even these effects are likely to be offset by the beneficial effects of reduced salinity and contaminants. Changes in water inflow to the Sea were also expected to affect public health and environmental hazards both in regards to air quality and changes in contaminant levels and were included in determining the scores mentioned above.

Socioeconomics, Utilities, and Public Services

Socioeconomics, utilities and public services in the vicinity of the Salton Sea may be affected by project alternatives. Some alternatives have a better chance of enhancing the health of the Salton Sea ecosystem than others. Alternatives, which enhance the bird life, sport fishing and the surrounding natural beauty of the area without any adverse effects, would create attractive environment for people to visit and settle at the Sea and, in turn, provide a foundation for socioeconomic development opportunities. Examples of project effects that would be considered adverse to socioeconomic environment include varying energy costs and land requirements for development of facilities. At this stage of the analysis, all potential issues are being considered, even if final design features could be incorporated to avoid some of the problems. The following scoring factors were considered in the evaluation of avian resources.

Score	Description
5	No adverse effects on socioeconomics, utilities and public services are anticipated; there may be some beneficial results of the project.
4	No adverse effects to socioeconomics, utilities and public services are anticipated.
3	Minimal adverse effects to socioeconomics, utilities and public services are anticipated; or some adverse consequences may occur that would be offset by beneficial effects.
2	Adverse effects to socioeconomics, utilities and public services are anticipated; however, it is expected that they can be mitigated.
1	Significant adverse effects to socioeconomics, utilities and public services are anticipated; however, it is expected that they can be mitigated.
0	Significant adverse effects to socioeconomics, utilities and public services are anticipated, that cannot be mitigated.

All alternatives would result in beneficial socioeconomic effects to the residents in the vicinity of the Salton Sea. For example, potential increase in local property and sales tax revenues would benefit all communities in the vicinity of the Salton Sea. However, different alternatives have varying land and energy requirement and the scores given to them were based on these factors. In-Sea alternatives, which required the least amount of land, and alternatives which needed less energy were given scores of 3 or 4. The alternatives with in-Sea ponds and on-land disposal facilities received an score of 2. Finally, the alternatives that include ground-based EES and the tower EES have both large land requirements and high energy costs. These were given a score of 1. The issues affecting water resources were considered to be similar for continuation of existing inflows and for reduced inflow conditions. Therefore, the scoring factors for socioeconomics, utilities and public services issues for any alternative were rated the same for both inflow conditions.

Cultural, Paleontological and Native American Resources

Cultural, paleontological and Native American resources on the Sea-bed and in the vicinity of the Salton Sea may be affected by project alternatives. Effects on these resources may occur from construction activities, dredging, and from archaeological sites becoming inundated or exposed by changes in elevation of the Salton Sea. It is not expected that all alternatives would necessarily cause such impacts. However at this stage of the analysis, all potential issues are being considered, even if final design features and other mitigation measures could avoid most of the impacts. The following scoring factors were considered in the evaluation of cultural, paleontological and Native American issues.

Score	Description
5	No adverse effects on cultural, paleontological and Native American resources are anticipated; there may be some beneficial results of the project.
4	No adverse effects on cultural, paleontological and Native American resources are anticipated.
3	Minimal adverse effects to cultural, paleontological and Native American resources are anticipated; or some adverse consequences may occur that would be offset by beneficial effects.
2	Adverse effects to cultural, paleontological and Native American resources are anticipated; however, it is expected that they can be mitigated.
1	Significant adverse effects to cultural, paleontological and Native American resources are anticipated; however, it is expected that they can be mitigated.

0 Significant adverse effects to cultural, paleontological and Native American resources are anticipated, that cannot be mitigated.

Impacts to cultural, paleontological and Native American resources are expected from all alternatives under consideration. However, these impacts can be mitigated by achieving compliance with applicable federal, state and local historic preservation laws and regulations. Therefore, all alternatives have been given a score of 2. Reduced inflow conditions may expose more archaeological sites currently under water. However, the same mitigation measures could be applied to the newly exposed sites. As a result, scores given to the cultural, paleontological and Native American resources would not change with changes in the elevation of the Salton Sea.

Cost Factor

Total Present Value

The cost of restoration of the Salton Sea was evaluated using the total present value (PV) of construction and operations of the alternatives under consideration. The total PV includes the capital cost of construction, annual cost of operations, maintenance and replacement (OM&R), and annual cost of energy expressed in current dollars. Costs used in evaluation are comparative costs and are meant only to compare the relative differences in costs among the alternatives. The following scoring factors were considered in evaluating the total present value cost of the alternatives:

Score	Description
5	Lowest cost alternative.
4	20 percent to 50 percent more than lowest cost alternative.
3	50 percent to 100 percent more than lowest cost alternative.
2	Two to three times the cost of lowest cost alternative.
1	Three to five times the cost of lowest cost alternative.
0	Greater than five times the cost of lowest cost alternative.

With the continuation of existing inflow conditions, Alternatives 5, with on-land ponds and disposal, was estimated to be the lowest cost among all the alternatives under consideration. Therefore, it was given a score of 5. Alternative 6, with on-land pond and disposal with land use conversion, was estimated to be within 20 percent above the lowest cost alternative. Therefore, it was also given a score of 5. Alternative 3, with tower EES and on-land disposal, was estimated to be 45 percent more than the lowest cost alternative. It was, therefore, given a score of 4. Alternative 2, with ground-based EES with on-land disposal, was estimated to be about 75 percent above the lowest cost alternative, and was given a score of 3. Alternative 4, with in-Sea and on-land ponds and disposal with land use conversion, is estimated to have a total PV cost that would be more than two times the cost of the lowest cost alternative, and was given a score of 2. Finally, Alternative 1, with in-Sea ponds with in-Sea disposal, was estimated to have a total PV cost that would be the highest cost of all the alternatives under consideration and more than three times the lowest cost alternative. It was given a score of 1.

With reduced inflow conditions, the total PV cost of all alternatives was higher when compared to the same alternatives under the existing inflow conditions. For example, the total PV cost of Alternative 6, with on-land pond and disposal with land use conversion under the reduced inflow conditions, was estimated to be about 50 percent higher than the same alternative under the existing inflow conditions. The primary reason for the estimated cost difference lies in the cost of purchasing extra agriculture land for land use conversion to provide make-up water. Still, Alternative 6 was found to be the lowest cost alternative, when compared with other alternatives under the reduced inflow conditions. It was, therefore, given a score of 5. Alternatives 4 and 5, were estimated to be more than two times the PV cost of Alternative 6. Therefore, they were given a score of 2. The remaining three alternatives (Alternatives 1, 2, and 3) had a total PV cost of more than 3 times the cost of the lowest cost alternative and were given a score of 1.

Chapter 5
OTHER RESTORATION ELEMENTS

The following actions are possible restoration elements that could be included with any alternative. They are designed to address the project's multiple goals and objectives, when combined with one of the salinity control measures. These other restoration elements are designed to help stem further degradation of the Sea and may be supplemented by later actions developed under the adaptive management efforts of the Salton Sea Restoration Project. The other restoration elements consist of the following possible actions:

- Wildlife disease control
- Created wetlands
- Recreation and public information
- Eutrophication assessment
- Shoreline clean up
- Fishery management
- Economic development assistance

For planning purposes, it has been assumed that each of these elements will be included in each of the alternatives, except for the economic development assistance program. The economic development assistance program would be included in any alternative that would involve conversion of land currently in agricultural production to another use. As discussed below, two alternatives include conversion of agricultural land to other uses, and therefore, include economic development assistance.

WILDLIFE DISEASE CONTROL

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

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

Efforts to combat disease at the Salton Sea in the past have been largely crisis responses to die-offs with the primary burden being shouldered by the U.S. Fish and Wildlife Service (FWS) with support from the California Department of Fish and Game (CDFG). An initiative of the Salton Sea Restoration Project to augment FWS surveillance efforts has enhanced the early detection of disease, which is a critical first step in minimizing losses. That initiative is collaborative with the Sonny Bono Salton Sea National Wildlife Refuge and is structured by the conditions of the Memorandum of Understanding (MOU) established for that purpose. The Salton Sea Authority (SSA), on behalf of the Restoration Project, developed an additional MOU with the U.S. Geological Survey's National Wildlife Health Center (NWHC). That MOU provides essential technical assistance, such as disease diagnostic support and disease control guidance.

Objective

These efforts and activities are important first steps but are not sufficient to address disease impacts of the Restoration Project Goal, which is to:

> "Provide a safe, productive environment for resident and migratory birds and endangered species."

An integrated approach that provides a continual interface between environmental monitoring, disease surveillance and response, and scientific investigations of disease ecology is needed. Wildlife rehabilitation must also be provided because of the avian botulism problem affecting pelicans at the Salton Sea. Therefore, the goal for the long-term disease control effort is to

> "Provide an integrated approach to wildlife disease (including fish and birds) at the Salton Sea in a manner that enhances opportunities for wildlife

managers to minimize disease events and associated losses. This approach would

- Methodically monitor environmental conditions
- Quickly detect, diagnose, and respond to disease events
- Collect and rehabilitate afflicted wildlife
- Develop a sound understanding of disease ecology at the Sea"

Approach

Disease is an outcome rather than a cause. The basic model for considering diseases has three primary factors:

- Susceptible hosts
- Agents capable of causing illness or death
- Environmental factors that facilitate or cause host-agent interactions in a manner that results in disease

Disease prevention and control is generally oriented at determining the relationship between those three primary factors to determine what intervention will be most effective and cost efficient (Figure 5-1). However, these straightforward concepts are often complicated by interactions that can affect any of the primary factors. These interactions must be understood to effectively intervene in disease control. Thus, effective disease prevention and control generally requires a multi-functional, integrated approach.

Success in combating disease will largely depend on the cumulative capabilities and knowledge gained from a balanced, fully integrated approach. Each program component (Table 5-1) provides unique contributions; but individually, none of those components can accomplish what is needed. An integrated program will minimize disease losses, be cost-effective and efficient by minimizing duplication of efforts by multiple organizations, and facilitate methodical, timely evaluations to guide Restoration Project efforts. The stewardship roles of the multiple agencies with responsibilities for species and habitat management within the Salton Sea ecosystem must be considered when such a program is organized and implemented.

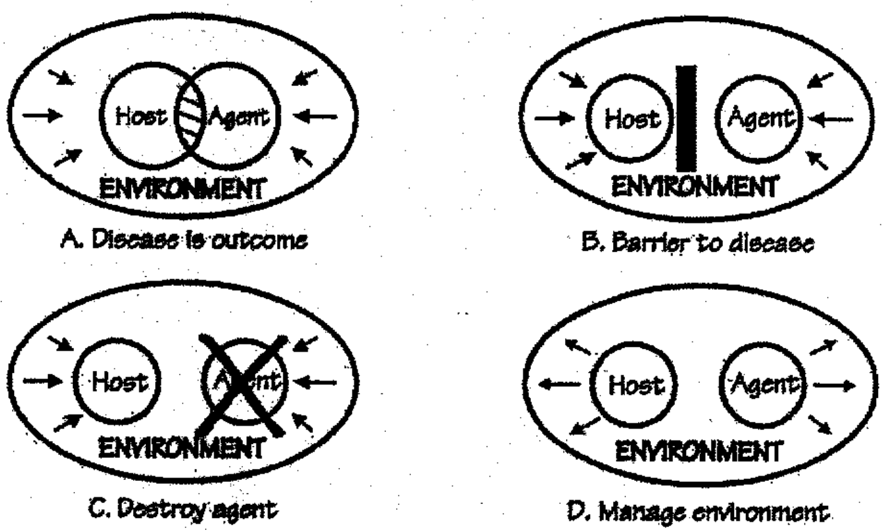

Figure 5-1. Susceptible hosts, agents capable of causing disease and environment are the basic factors generally involved in disease events. (A) disease (hatched area) is an outcome of environmental conditions that facilitate host-agent interactions in a manner that causes disease. Disease prevention and control generally focuses on (B) making the host immune to the disease agent by the use of various barriers (i.e., vaccines); (C) destroying the disease agent (i.e., disinfectants); or (D) environmental management that minimizes the potential for host-agent interactions.

Table 5-1. Program components for long-term disease prevention and control at the Salton Sea.

Component	Basic Requirements	Primary Contributions
Disease surveillance	Methodical, timely on-Sea monitoring	Early detection of problems; important initial step for combating disease.
Diagnostic Services	Team of specialists in appropriate scientific disciplines; specialized facilities	Timely and accurate evaluations of causes of mortality events
Field response	Work force and equipment for carcass clean-up and disposal; disease specialists for guidance	Disease control to minimize losses.
Wildlife rehabilitation	Work force, equipment and facilities for bird retrieval, handling, and housing; specialists for clinical treatment	Recovery of substantial numbers of birds that would otherwise die; endangered species are involved.
Focused investigations	Scientists with appropriate expertise, facilities, equipment, and support base	New information, enhanced understanding and capabilities for addressing diseases of concern
Environmental management	Capabilities to alter environmental conditions and evaluate results through measurements and other means	Application of technical knowledge to address disease problems

Program Components

Disease Surveillance

Early detection of wildlife mortality events is a critical first step to minimize losses. Methodical, onsite observations at appropriate locations and within scheduled intervals facilitate early detection, when wildlife managers can intervene to minimize losses. The size of the Sea, weather, and other factors requires multiple methods to accomplish this labor-intensive activity.

Diagnostic Services

Observing sick or dead wildlife is rarely sufficient to determine the disease agent. The spread of disease may result from improper judgments about the disease because different approaches are often needed to contain different types of diseases. Disease diagnostic laboratories provide the types of evaluations needed. Because the disease can spread rapidly, the laboratory must promptly receive appropriate specimens and promptly respond back to those at the Salton Sea.

Field Response

Disease specialists can provide timely, initial evaluations leading to organization of disease control efforts before they receive a preliminary or final diagnosis from the diagnostic laboratory. Management agencies with responsibilities for the species involved bear the major burden for the highly labor intensive disease control effort. When major disease events erupt, the field response can last weeks to months and involve large numbers of people with major equipment needs.

Wildlife Rehabilitation

Avian botulism is a major disease problem affecting pelicans and other fish eating birds at the Salton Sea. When sick birds are collected early in the disease process, many can be successfully treated and returned to the wild. Large numbers of pelicans are retrieved from the Salton Sea and many of those birds have been successfully rehabilitated. This success is due to early detection of outbreaks, timely collection of sick birds, veterinary and other clinical care provided, special facilities built at the Refuge to handle those birds, and the collaboration established with private sector wildlife rehabilitation programs. The U.S. Fish and Wildlife Service is pursuing further development of this component of the program.

Focused Investigations

Research on the ecology of the various diseases present at the Salton Sea, monitoring environmental factors for disease risk assessments, development of enhanced capabilities for disease control, and other solution oriented investigations are among the activities associated with this program component. Findings from the other program components guide the focused investigations that need to be undertaken (Figure 5-2).

Environmental Management

The insights gained from the collective findings of the other components of the long-term disease prevention and control program are applied in the environmental evaluations, adaptive management, and other Restoration Project goal-oriented activities. This component of the long-term disease program includes ecosystem modeling and evaluates management actions on reducing losses from disease and minimizing the probability for disease outbreaks (Figure 5-3).

Program Coordination

The Salton Sea Science Office will serve as the coordinating body for the Restoration Project long-term disease prevention and control effort. Much coordination and inter-organization collaboration will be required for program success (Figure 5-3). Various external committees and advisory groups composed of natural resource agencies and disease specialists will assist the Science Office in that task. A disease prevention and control plan with 5- and 10-year benchmarks and an Annual Work Plan that integrates the disease program components will be key planning and guidance documents. A common-use Science Office field facility will facilitate program coordination.

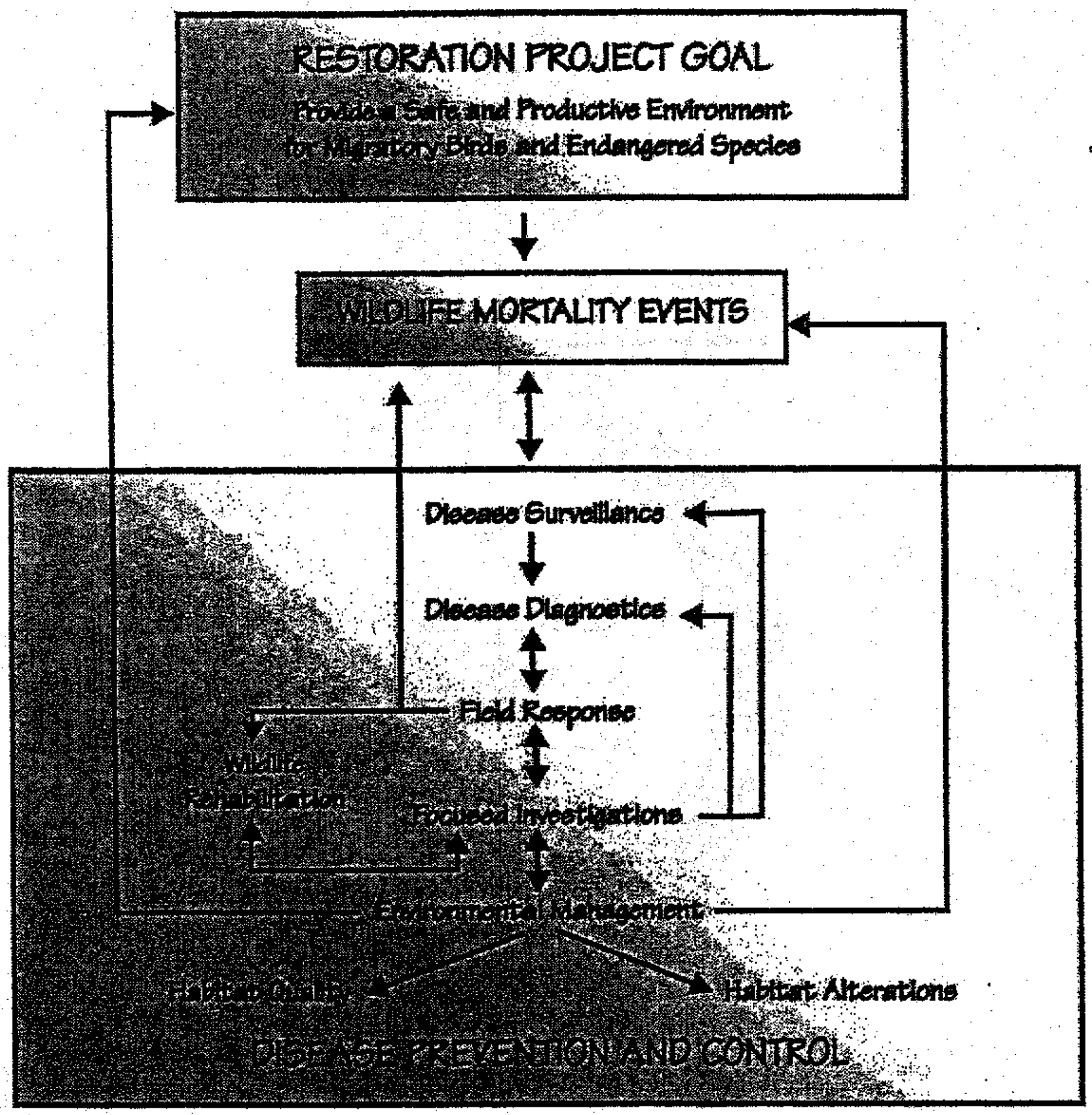

Figure 5-2. Functional relations between components of a long-term disease prevention and control strategy and between that strategy and Salton Sea Restoration Project goals.

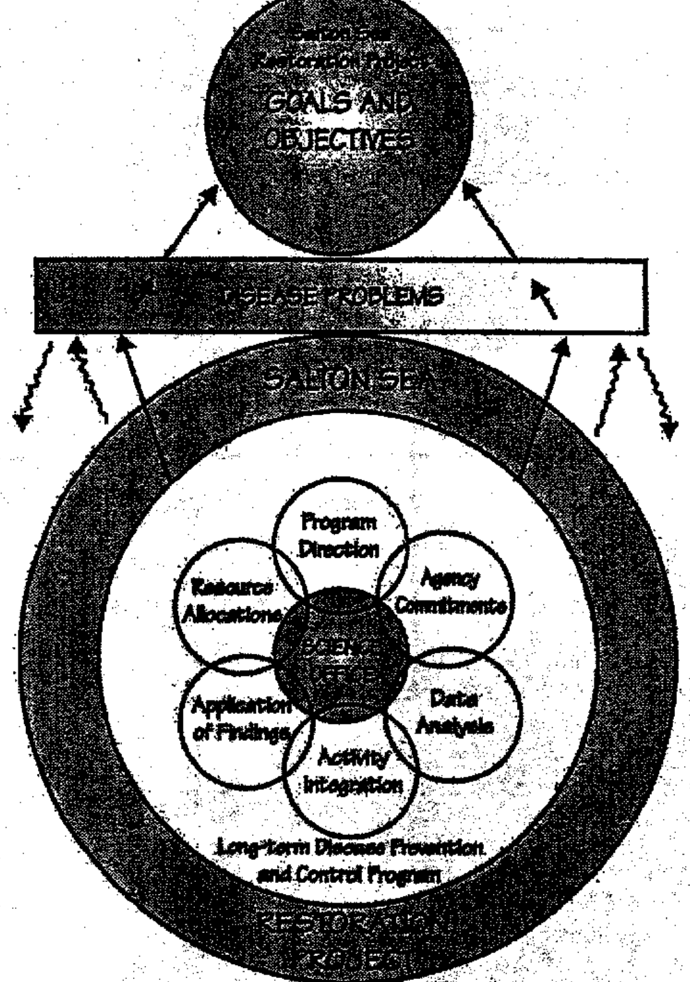

Figure 5-3. Inter-organization collaboration and coordination needed to overcome (→) disease problems and achieve Restoration Project goals and objectives. Lack of collaboration and coordination (⇝) will result in disease being a major barrier obstructing goal achievement.

Priorities

Avian botulism is the disease of highest priority for the Salton Sea Restoration Project. It is important that wildlife managers understand the ecology of avian botulism at the Salton Sea if they are to manage the Sea in a manner that minimizes the potential for avian botulism outbreaks. Wetland development, modification of existing wetland areas, and fluctuating water levels are all situations likely to occur and have been associated with avian botulism. The Project will need to address these factors along with changes in water chemistry. Therefore, wildlife managers must know how to address those and other conditions to minimize the potential for avian botulism outbreaks.

Type C avian botulism has been present at the Salton Sea since at least 1917. The spores of Clostridium botulinum are widely distributed throughout this environment and depend on certain environmental conditions and co-factors for their germination and processes leading to disease events. However, the Salton Sea is unique in having an aberrant expression of type C botulism involving pelicans and perhaps some other fish-eating birds. Different biological processes are involved in classical outbreaks of type C botulism than are involved for this disease in fish-eating birds.

In addition, type E toxin has also been detected in sediments of the Sea. Far less is known about the ecology of type E than type C botulism. An added dimension is that type E is a human pathogen. Thus, avian botulism presents a complex situation and is directly related to environmental conditions at the Sea. Unless the ecology of this disease in its various forms is adequately understood, efforts to provide a safe and productive environment for birds could result in the opposite outcome. Also, actions taken to address other goals of the Restoration Project could result in increasing problems associated with avian botulism.

The second highest priority relative to avian disease is resolving the continual attrition of eared grebes and ruddy ducks (Oxyura jamaicensis). The Salton Sea is an important wintering area for both species, and both are experiencing substantial losses. Avian cholera is responsible for some of that loss, but in general, the true magnitude of losses, their causes, and periodicity of mortality are poorly understood.

Another high priority is the need to determine the natural history of Newcastle disease at the Salton Sea. Outbreaks appear to be confined to double-crested cormorants nesting on Mullet Island. Snag-nesting cormorants at other locations at the Sea have not been diagnosed with Newcastle disease. Mullet Island is the only island at the Sea for ground-nesting birds and has been used by species other than cormorants, including brown pelicans attempting to colonize the island. Hazards posed for other species are unknown, despite their susceptibility to Newcastle disease virus. Also, if water levels recede too much at the Sea, Mullet Island will be lost as a breeding area because predators will use the resulting land bridge. New islands could be developed to provide replacement breeding habitat. However, if Newcastle disease is likely to be a problem on new islands, that approach becomes highly questionable.

Understanding the ecology of Newcastle disease at the Sea is important for informed risk assessment to guide management actions.

The remaining avian disease problems currently identified at the Salton Sea, while in need of study, have lower priority. As wildlife managers learn about managing the Sea in a manner that minimizes losses associated with the three high priority situations, greater attention should be given to salmonellosis. In the interim, surveillance should be maintained to determine whether salmonellosis outbreaks remain sporadic. If frequency increases, this disease will need to be given greater attention because it is a human pathogen. Similarly, it is important to maintain adequate disease surveillance to quickly detect new disease problems and any increased occurrence of existing diseases.

Discussion

The Salton Sea Restoration Project is addressing a major ecosystem health problem. Wildlife mortality is an important index to evaluate the success or failure of the Restoration Project. However, the Restoration Project cannot, and should not, replace the functional and wildlife stewardship roles of the agencies with statutory responsibilities at the Salton Sea. Therefore, unless those agencies also place high priority on combating wildlife mortality at the Sea through the investment of their resources, significant progress in minimizing losses from disease will not occur until the Restoration Project has advanced well beyond the initial phases of the restoration effort.

The natural resources agencies currently shoulder most of the costs associated with response to disease outbreaks, which usually involve reactive actions. Those needed and effective actions do not resolve the causes resulting in the outbreaks of disease. However, there is great value in integrating those activities with a broader approach toward disease control. The information gained and applied from past efforts will provide greater capability to combat disease from a preventive, as well as a response mode. The Science Office needs Restoration project funding of $500,000 annually as part of its annual funds to provide the enhanced effort just noted. In addition, a one-time appropriation of $1 million is needed to construct and provide equipment for a common use field facility as identified within the Strategic Science Plan (Science Subcommittee, 1999). That facility will provide physical support needed for the long-term disease prevention and control program.

CREATED WETLANDS

Reduced annual inflows to Salton Sea would threaten the important snag habitat currently used by wildlife in the northern portion of the Sea. This area provides the largest expanse of snag habitat at the Sea. Various wetlands projects have been and are being considered by different groups to preserve or enhance the habitat values in the northern area or in other areas around the Sea. Any pilot or demonstration wetlands actually constructed would provide valuable information in determining which, if any, created wetlands projects to pursue. Two wetland projects that are currently under consideration by other organizations and one project that has already been constructed are briefly discussed in this section. In addition, the proposed North Wetland Project that would be part of the restoration project is also described

Programs by Other Agencies

Whitewater River Delta Wetlands Habitat

The Coachella Valley Water District is considering a project that consists of installing a 6-foot tall vinyl sheet pile wall at the existing 6-foot depth contour. The wall would tie into the existing shoreline on each side of the Whitewater River Delta to enclose a total of about 1,000 acres. Two alternatives for the project were studied.

Alternative No. 1 consists of constructing a single reach of vinyl sheet pile from one side of the Whitewater River Delta to the other, crossing the Whitewater River channel (coincident with the Coachella Valley Stormwater Channel in this area) several hundred feet from shore. This would allow for capture of all freshwater discharges from the channel and adjacent drains and would result in a wetlands habitat. As the level of the Sea drops, any excess fresh water would spill over the 6-foot tall sheet pile wall. This alternative will also capture all sediment from the channel behind the sheet pile wall. Thus, periodic dredging of the accumulated sediment may be required.

Alternative No. 2 consists of constructing two reaches of vinyl sheet pile. One reach would extend from the west bank of the Channel to the existing west shoreline. The second reach would extend from the east bank of the channel to the existing east shoreline. Each reach would follow the existing 6-foot deep contour and would enclose approximately 500 acres for an approximate total of 1,000 acres of wetlands habitat.

Two shallow low-flow diversion channels would be constructed from the channel to each wetlands habitat. This would allow for the capture of all freshwater discharges from the channel and adjacent drains. As the level of the Sea drops, any excess freshwater would spill over the sheet pile. This alternative allows design floods and the sediment they generate to be carried to the Salton Sea without destroying the sheet pile walls.

Creating a wetlands habitat at the mouth of the channel at the Salton Sea could establish a freshwater/brackish water shallow wetlands and a deep water aquatic habitat area that would substantially enhance wildlife species habitat values. Freshwater inflows would promote establishment of nearshore wetlands habitats by increasing the areal extent and biomass of emergent and submerged hydrophytes. The nearshore wetlands and shallows would promote a net increase in bioproductivity of food web components including invertebrates and fish that constitute the prey base for resident and migratory birds.

The nearshore shallows would function as a fish breeding nursery and refugia for juveniles. Movement of fish from the shallows into the deepwater aquatic habitat would provide foraging opportunities for pelicans, cormorants, and black skimmers. Nesting, roosting, foraging, and escape cover habitats for waterbird and riparian associated bird species would be enhanced with new fringe wetland and riparian habitat types. The nearshore shallows will also provide additional breeding habitat and refugia for desert pupfish.

North Shore Wetlands Protection and Restoration Project

The Torres Martinez Desert Cahuilla Indians are also proposing a North Shore Wetlands Protection and Restoration Project, which would involve one to three pilot wetlands protection and/or restoration projects on the north shore of the Salton Sea. The project would be designed to determine the best approach to a permanent wetland protection/ restoration program. It would complement the Tribe's long-term goals for their reservation and the wetlands area. In addition, the project would benefit and assist the overall Salton Sea Restoration Project and all of its associated economic benefits.

This wetlands project has identified three primary goals:

- Protect and restore the wetland habitats along the north shore of the Salton Sea that are critical to a variety of wildlife

- Protect and enhance water quality conditions within the north wetlands

- Develop and test pilot wetlands project(s) that will provide important information to support and potentially guide other restoration strategies for the overall Salton Sea program

However, no specific plans for the development of wetlands have yet been identified. The emphasis of their proposal is on a study, which would determine the feasibility of such a project.

New River Water Quality Improvement Project

The Citizens Congressional Task Force on the New River is responsible for the development of the Brawley Constructed Wetlands Demonstration Project. The purpose of the Brawley Constructed Wetlands Demonstration Project is to study how wetlands can improve the quality of agricultural drain water, New River stream flows and, ultimately, inflows to the Salton Sea. To achieve this end, two demonstration wetlands are proposed for construction in Imperial County near Brawley, California: the 7-acre Brawley Site and the 68-acre Imperial Site. The 68-acre Imperial site has been constructed and extends about 1 mile along the river. In Brawley, a few miles downstream, a much smaller but similar site of 7 acres will treat water diverted directly from the New River. These sites will serve to demonstrate the effectiveness of using constructed wetlands through a 3-year monitoring program to treat constituents of concern in the water column, sediment, and biota.

Additional projects under construction by the Task Force are the New River Aeration structure near Calexico, CA. This demonstration structure will determine feasibility of additional structures to improve dissolved oxygen near the border. Also under design are sediment control structures for use in IID drains to control sediment loads before they enter into the New and Alamo Rivers.

North Wetland Habitat

As part of the restoration project, the north wetland habitat would be a created wetland designed to preserve snag habitat currently used by wildlife in the northern portion of the Sea. This area provides the largest expanse of snag habitat at the Sea along with low island habitat. The north wetland habitat area would be constructed to preserve these existing values in the area as well as allow adaptive management of a freshwater/Salton Sea water interface to enhance habitat values. Dikes would be constructed at the -230 foot contour on both sides of the Whitewater River Delta, leaving the mouth of the Whitewater River free to flow in to the Sea. As currently envisioned, the created ponds would have up to 3 feet of water depth. The western dike system would begin west of the mouth of the Whitewater River and continue approximately 2 miles west along the -230 foot contour to the Avenue 76 drain. The eastern dike system would begin east of the mouth of the Whitewater River and continue approximately 3 miles east along the-230 foot contour. The distance from shoreline would range between approximately 100 feet to a maximum distance of 1,800 feet. The total area within the two diked areas would total about 1,000 acres. See figures 5-4 and 5-5 for the expected dike location and for a cross section of a typical dike section.

The two habitat areas would be constructed using 10-foot long sheet piling which would be driven into the Sea bed about 6 feet. Sheet piling forms a Z-shaped dike when completed. Construction would be accomplished from barges or with specialized equipment. During construction, occasional piles of rock would be placed against the sheet piling to provide roosting and nesting opportunities and provide rock substrate for benthic invertebrates. Water from the Whitewater River would be pumped or gravity fed into the two areas in a manner which allows for gravity flow through the system. Water within the two areas would be at a slightly higher elevation then that of the Sea, allowing for gravity flow back into the Sea via outflow structures. Maximum capacity for diversion would be approximately 100 cfs into each area. Pumping facilities would be constructed to supplement the outflow structures to allow maximum flexibility of water elevation and water quality management. Water quality would be monitored before and after construction.

Once the existing habitat values have been protected, the north habitat areas would be used to test management techniques to enhance threatened habitat values within the Salton Sea. Interior dikes, upland management, and adaptive management of sub-units would be developed as appropriate in the future. These interior features would be developed as goals for the entire Sea as part of the long-term management plan. Any future construction or management may require additional compliance actions before implementation. Knowledge gained through the management of the north wetland habitat would be applied to other areas along the shoreline of the Sea, as appropriate.

This project could possibly be combined with or coordinated with the other two wetland projects discussed above which would be located in the same general area. The two other potential projects in the area are the proposals by

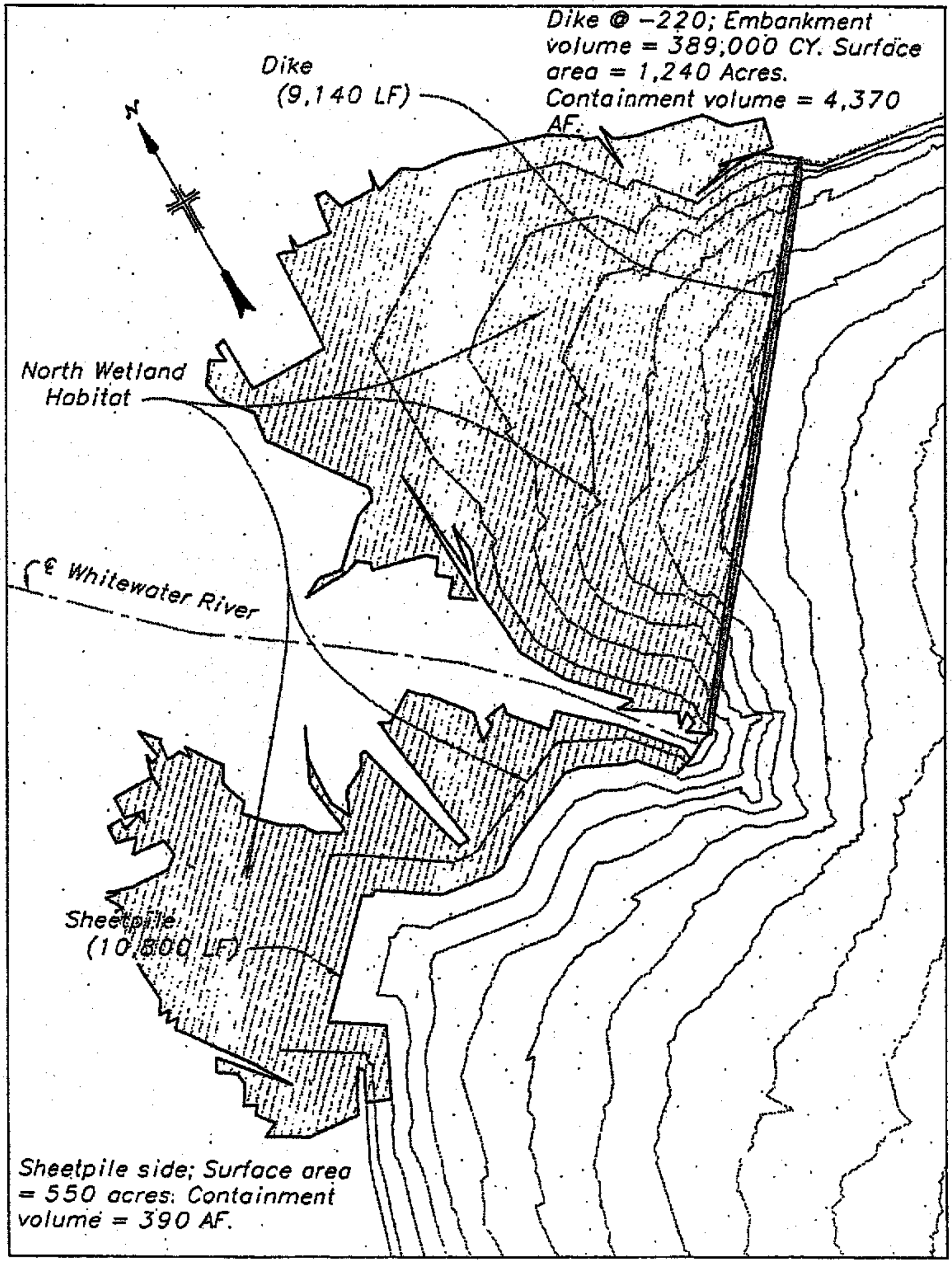

Figure 5-4. Proposed location of dike in the north wetlands area.

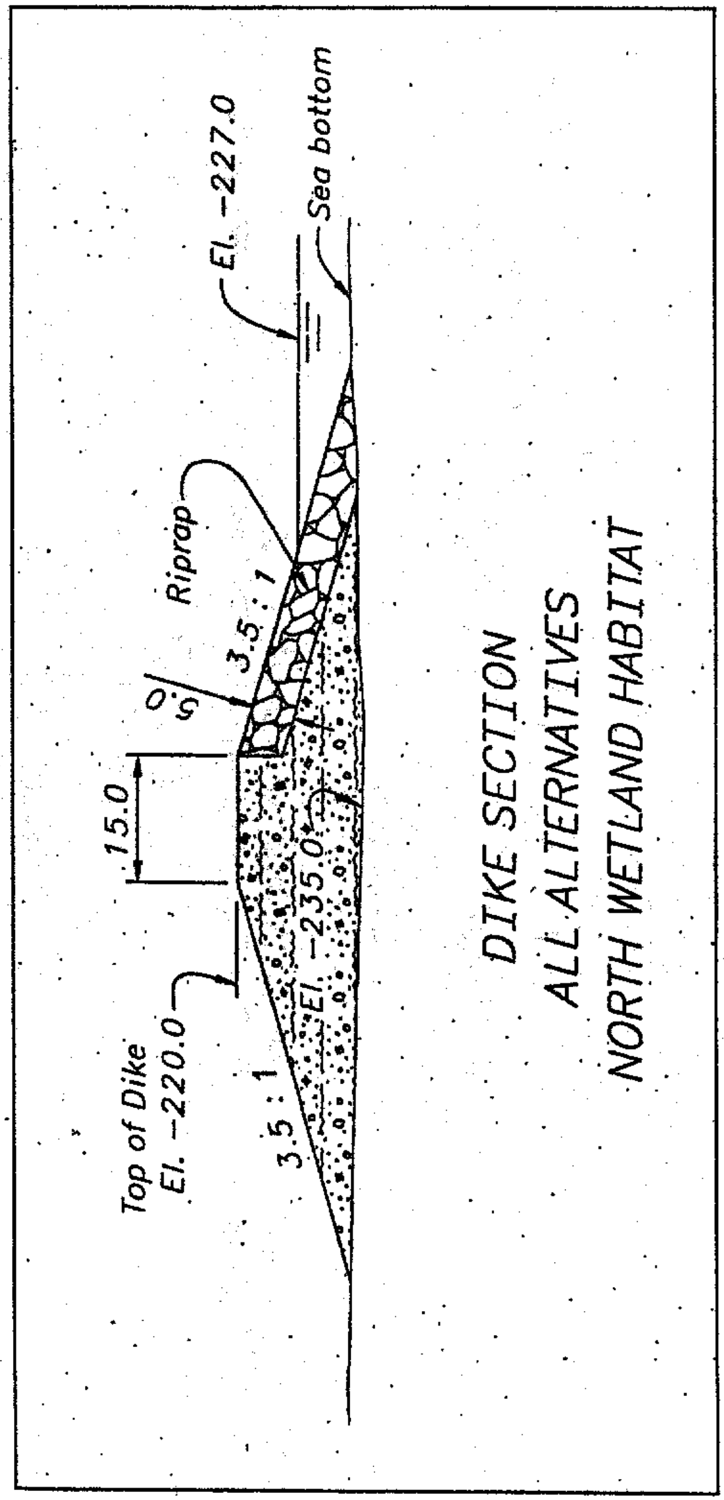

Figure 5-5. Typical dike section for north wetland habitat.

the Coachella Valley Water District and the Torres Martinez Desert Cahuilla Indians.

The cost for construction of the north wetland habitat is estimated at $22 million. The annual cost for operating and maintaining the wetland is estimated at $60,000 per year. The total estimated present value of the north wetland habitat is $22.7 million.

RECREATION AND PUBLIC INFORMATION

Although the Salton Sea continues to draw visitors, recreational use in the past was higher and more varied than it is today. In addition to fishing, past use included camping, picnicking, and participating in numerous water sports, such as boat racing, water skiing, and swimming. These different recreational opportunities at the Sea attracted many visitors to the region. Over the years, increasing surface water elevations flooded recreational facilities along the shoreline. In addition, decreasing water quality, increasing public perceptions of potential health risks, and aging of recreational facilities at the Sea led to visitor decline.

Today, the Sea remains extremely popular for bird watching, camping, and fishing. Although opportunities are plentiful for boating, swimming, and water skiing, their use has markedly declined since the early 1960s. Existing recreational facilities at the Sea include the State Recreation Area, operated by the California Department of Parks and Recreation, and a number of smaller facilities, such as boat ramps that are operated under county, local government, and private ownership. Improvements to existing recreational facilities are currenly being planned at a number of locations, including a significant upgrade at the State Recreation Area. In addition to improvements planned by other organizations, the restoration project includes a recreational enhancements program. Selected recreational areas around the Sea are shown on Figure 5-6.

The Salton Sea Restoration Project presents a unique opportunity to develop an education and public information program to benefit students, teachers, and the general public. Currently, the Salton Sea Authority is working to develop stand-alone units on the Salton Sea that can be offered to teachers, and to assess effective ways to develop curricula that use the Sea. For the students and the general public, history can come alive as they view the landscape and see the evidence of an ancient shoreline. Science could become an adventure as

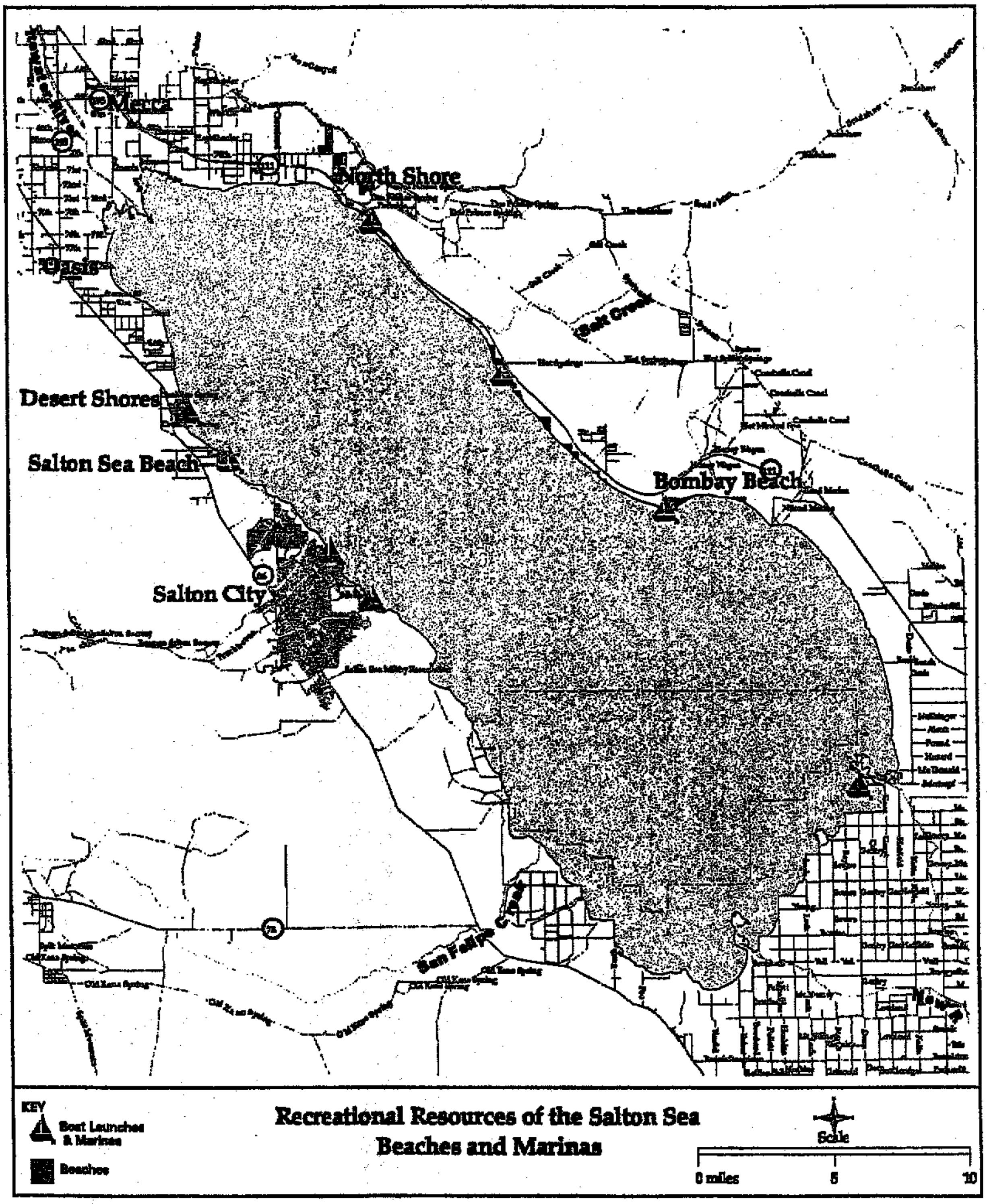

Figure 5-6. Location of Selected Recreational Facilities around the Salton Sea.

students conduct experiments on salinity. The opportunities for learning are many and varied. Establishment of a multi-agency visitor center, with hosted or non-hosted interpretive-oriented facilities, such as wildlife viewing facilities, natural history, and historically focused interpretive elements, can be provided by the State park staff. Information about the concepts and features of salt harvesting and other restoration activities can also be an important first step toward developing other public information programs.

Programs by Other Agencies

As of March 2001, the California Department of Parks and Recreation had received funding approval for 11 projects at the Salton Sea State Recreational Area. These projects are expected to be encumbered by mid-2002 and in-place before the end of 2002. Table 5-2 provides an overview of the 11 funded projects. The total authorized funding for these projects is about $2.2 million.

Table 5-2 Funded Improvements Planned for the State Recreational Area

No.	Category	Project Description	Funding
1	Roads	Chip, sand, and seal asphalt overlay roads at the Headquarters Area	$85,000
2	Roads	Redesign main parking area and hookup campground; remove/replace asphalt, redesign traffic flow, soften presentation	$265,000
3	Varner Harbor Boat Ramp	Stabilize shoreline, add promenade and small picnic area, repair boat ramp (funded by the Department of Boating and Waterways).	$400,000
4	Varner Harbor Jetty	Redesign fishing jetty, new ramadas, new lights, and concrete overlay; repair handicapped-access parking area; and install handicapped-access fishing areas	$350,000
5	Infrastructure	Rehabilitate pump stations/lift stations at Mecca Beach, sewer system tanks, and tight-lines	$85,000
6	Infrastructure	Rehabilitate electrical system at entrance station, lift station, and campground office	$45,000
7	Infrastructure	Rehabilitate drinking water system throughout Salton Sea State Recreational Area	$200,000
8	Infrastructure	New roofing for Residence 1	$16,000
9	Dredge	Dredge Varner Harbor boat channel 100' x 350' x 10' deep, remove barnacle bar	$100,000
10	Office/Visitor Center	Rehabilitate Visitor Center/install interpretive plaza	$600,000
11	Kayak Trail	Install an 18-mile kayak trail that will include put in/haul out areas, and two boat-in campgrounds plus interpretive material (funded by the Department of Boating and Waterways, aquatic trails program).	$100,000

In addition to the funded items listed in table 5-2, the following additional improvements are in the preliminary planning stage:

1. Remove/replace restrooms at Mecca Beach Campground
2. Remove/replace restrooms at Headquarters Campground
3. Remove/replace Visitor Center restroom
4. Install restroom for Hookup Campground
5. Continue dredging Varner Harbor
6. Redesign Varner Harbor/rehabilitate jetties
7. Install new group day use area at Headquarters Campground
8. Rehabilitate Mecca Beach Campground
9. Rehabilitate Headquarters Campground
10. Rehabilitate Hookup Campground
11. Rehabilitate "strip beaches"
12. Install boat basin at Mecca Beach Campground
13. Rehabilitate dump station/boat wash area
14. Additional infrastructure projects for rehabilitation of various electrical, water, sewage, and other systems

These projects are in line to be funded, but funds have not yet been committed. The projects listed above should, therefore, be considered tentative, for possible construction in the next 3 to 5 or more years. The total cost of all 14 items listed above would be about $10 million.

In addition to the State projects described above, local groups are considering several other projects. Two community groups are working on separate projects on the west side of the Sea, both in Imperial County. One seeks funding to dredge Johnson's Landing. It is estimated that such a project would cost about $350,000. If approved, this project could be funded in 2002 or 2003. The other project would involve installation of boat launching facilities in Desert Shores and the construction of a recreational vehicle park. This project has some additional levels of approval required, but could also be funded by

2002 or 2003. Another project, planned by Imperial County, would involve an upgrade to the boat launch area at Red Hill Marina. This project has been approved and will be funded by the Department of Boating and Waterways. A fourth project that is in the early planning stage would involve rehabilitation of the North Shore Yacht Club.

Recreational Enhancements Program

The five main goals of the Salton Sea Restoration Project include restoration of recreational uses at the Sea. One of the objectives for achieving this goal is to "maintain and improve access to the Sea for a variety of recreational activities and enhance the shoreline condition to encourage use." Several components of the restoration project would partially address this objective. For example, salinity control or reduction measures could make the Sea more attractive to boaters, and the shoreline maintenance program discussed later in this chapter would improve accessibility. The recreational enhancements program discussed here also directly addresses the recreation goal.

Under the recreational enhancements program, a sinking fund on the order of $10 million would be established to provide improvements to recreational facilities over a predetermined period. For example, if a 10-year period were established, such a fund would provide $1 million per year to support local recreational improvements. The recreational enhancements program would be implemented over a period of years to respond to the evolving need for recreational improvements. During the implementation period, it is likely that some elevation changes at the Sea might occur. These changes may occur as a result of project actions or outside factors that affect inflows to the Sea. Therefore, it will be necessary to implement recreational improvements at the appropriate Sea elevations or range of elevations that can be expected in the future.

Each year the joint leads (Reclamation and the Authority) would work with representatives of the California Department of Parks and Recreation, and possibly other agencies such as the CDFG and FWS to determine the best uses for the funds allocated for a given year. The joint leads would also make recommendations as to how, what, and who would continue to oversee any new facilities over the long term. The following potential actions or facilities are among the items likely to be included in the recreational enhancements program:

- A visitor center or interpretive boards at restoration facilities such as solar ponds or enhanced evaporation system sites
- Linkages to existing facilities such as interpretive displays established at the State Recreation Area that provide information about the restoration project
- Support for improvements to access areas or creation of new access points associated with restoration facilities
- Upgrades to public use areas such as piers or other waterfront areas, particularly in areas associated with or adjacent to restoration facilities
- Public outreach material such as literature or videos to promote recreational opportunities at the Sea

These components are addressed briefly in the following paragraphs.

Visitor Center and Interpretive Displays

A visitor center is proposed if either a solar pond system or an enhanced evaporation system is implemented as part of the restoration project. Each of these systems would have unique features that could be of significant interest to the public. The visitor center could be a hosted or non-hosted facility that would provide information about the concepts and features of salt harvesting and how it would enhance the habitat at the sea. Additional information could be provided about the unique habitats that would likely be created at the solar ponds themselves. It would include public viewing areas of the facilities and possibly designated trails. Interpretive displays may also be placed in other areas around the Sea, possibly at observation points where restoration facilities could be viewed from afar. Interpretive Plaza presentation, which are un-hosted, outdoor, and open style, have worked well at other places. A regional, multi-agency visitor center that presents the Salton Sink as a unit can also be considered. An artistic rendering of an interpretive plaza is shown in Figure 5-7.

Graphic to be supplied

Figure 5-7. Artistic Rendering of Interpretive Plaza.

Linkages to Existing Facilities

Linkages with project facilities could be provided to and from existing recreational areas to increase usage of the web of activities at the Sea. For example, interpretive displays could be established at the State Recreation Area that would provide information about the restoration project. If salinity control facilities are constructed, these displays could provide information about salt harvesting and provide directions to the visitor center discussed in the previous paragraph. If fishery management measures are implemented, displays about such a program could also be provided.

Improvements to Public Access Facilities

There are several public access points around the Salton Sea that are in need of repair, including waterfront areas, piers, and boat ramps. The main concerns are safety and usability, because some of these facilities are in need of major rehabilitation. Some of the ramps have cracks and holes, several should be widened, and some should be replaced entirely. Some minor dredging may be required to provide access from most of the boat ramps to the water. Dredging could also expand the usage of boat ramps over a wider range of elevations. Breakwaters or jetties may need to be constructed to block the movement of sand in front of the ramps. Some channelization may be required to provide deeper water access for the boats where the seabed is too flat. The boat ramps around the Sea are operated and maintained by State and local interests. The joint leads would work in conjunction with local agencies to determine on a case-by-case basis if financial support could be provided to assist with facility repairs or upgrades. Generally, the joint leads would focus on public access areas near or connected with restoration facilities.

Upgrades to Existing Waterfront or Other Public Use Areas

Public shoreline access for fishing and other uses will be evaluated. Existing docking structures, piers, or other waterfront access areas may be improved. In addition, the joint leads would work with the local communities to review the possibilities of developing other waterfront access areas for fishing and other public uses. However, the joint leads would primarily focus on areas that are near or could be developed in conjunction with restoration facilities. Creation of hiking trails will also be considered. There is a good possibility of linking trails at the Sea and providing hiking access from the Coachella Valley all around the Sea. Construction of a kayak trail and expanding it into a paddle route all the way around the Salton Sea is another possibility worth considering. Specific measures will be reviewed over the implementation period for the recreational enhancements program.

Public Recreational Outreach

The program may include public outreach material such as literature or videos to inform the public about restoration activities at the Sea. In addition, the possibility of creating or promoting events similar to the annual bird festival will be considered. Such events could include boat racing, regattas, and fishing derbies. The joint leads could support such events, but would generally not be sponsors, unless they were directly related to restoration. Specific means of public outreach will be reviewed and, if appropriate, recommended by the joint leads.

EUTROPHICATION ASSESSMENT

Eutrophication of the Salton Sea has been recognized as one of the major factors severely affecting its beneficial uses, including recreation and fish and wildlife resources. Eutrophication is defined as "the loading of inorganic and organic dissolved and particulate matter to lakes and reservoirs at rates sufficient to increase the potential for high biological production." Some of the effects of eutrophication include high algal biomass, high fish productivity, low clarity, frequent very low dissolved oxygen concentrations, massive fish kills, and noxious odors. External loading of nutrients, particularly phosphorus, to the Salton Sea from agricultural discharges and from municipal and industrial effluent is responsible for the eutrophication of the Salton Sea.

The Alamo, New, and Whitewater Rivers and other drains discharge varying amounts of nutrients from agricultural, municipal, and industrial sources to the Sea. The Sea is abundantly supplied with mineral nutrients, mainly compounds of nitrogen and phosphorus, which encourage excessive growth of phytoplankton. Although phytoplankton are essential to the Sea's ecology, phytoplankton blooms discolor the water and, upon death and decomposition, often deplete the water's oxygen content locally and produce unpleasant odors. The additional loss of oxygen in areas with already low oxygen has been cited as a contributing factor in fish kills in the Sea (California Regional Water Quality Control Board, 1990). In addition, these conditions reduce the Sea's aesthetic appeal and have contributed to the reduction of water contact recreation (Salton Sea Alternative Evaluation Final Draft Report, Sep.1997).

Fertilizers are used to promote growth on farmland. They make their way into the Salton Sea with the tributaries and drain water. Because of these fertilizers, the Salton Sea is so nutrient-rich that great portions of the Sea experience algal blooms. The Sea turns green, or brown, and sometimes small portions even show a reddish color when algal species bloom. However, the alga quickly die after the bloom. When they die, they pull oxygen from the water of the Sea to the extent that not enough oxygen remains to sustain the fish, and large-scale fish die-offs follow within a day or so.

Sources of Nutrient Loading

Eutrophication or nutrient loading of the Salton Sea is principally a function of nutrient inflow, particularly in the form of phosphorus (P). Possible sources of phosphorus to the Sea include external loading from in-flowing tributaries and agricultural drains, ground water and precipitation, and internal loading from the sediments. These are discussed briefly below:

Tributaries and Agricultural Drains

The major tributaries to the Salton Sea are the New, Alamo, and Whitewater Rivers. These rivers currently account for about 46, 32, and 6 percent of the inflow to the Salton Sea. Imperial Valley agricultural drains discharging directly to the Sea account for 8 percent of the inflow (Setmire et al 2001). Thus the tributary loading and agricultural drains supply the majority of nutrients to the Sea. Data collected in 1968-69 and in 1999 indicate that annual loading from the tributaries has increased over time. In the Alamo River, total phosphorus concentrations and loads increased by about 120 percent from 1968-69 to 1999 and ortho phosphate increased about 85 percent. In the New River, total phosphorus loads increased by about 80 percent and ortho phosphate loads increased by 230 percent. The total phosphorus load discharged by the tributaries to the Salton Sea has doubled since 1968-69 and is estimated to be 1.3 million kilograms per year (kg/yr) in 1999 (Setmire et al 2001). Municipal and industrial waste discharges to the New and Alamo Rivers were estimated to contribute approximately 179,000 kg/yr of ortho phosphate in the early 1960s. Advances in sewage treatment technology have reduced phosphorus loading from sewage treatment plants but data available for 2000 are insufficient to evaluate changes.

Agricultural drains that discharge directly to the Sea account for about 8 percent of the inflow. If it is assumed that the total phosphorus concentration in these drains is similar to the Alamo River, direct drains may supply about 99,000 kg/yr to the Sea.

Groundwater and Precipitation

Groundwater accounts for less than 5 percent of the inflow with most of it coming from the Coachella Valley. Concentrations of total phosphorus in groundwater are usually very low; and, therefore, phosphorus loading to the Sea is expected to be insignificant. Only about 4 inches of precipitation falls on the Sea per year. Phosphorus concentrations in precipitation are also usually very low; and, therefore, phosphorus loading from precipitation is also thought to be insignificant.

Internal Sediment Release

Sediments can function as a reservoir, or temporary resting place for certain elements such as phosphorus, which can be released back into the water column with changing environmental conditions. Depletion of dissolved oxygen in the overlying water, which typically occurs in the Sea, produces a reducing environment that can result in remobilization of phosphorus from the bottom sediments. This process termed "internal loading" is calculated in $mg/m^2/day$. Estimates of the net internal phosphorus loading from column studies using sediments from the Salton Sea range from -5 $mg/m^2/day$ for deep-water sediments to -10$mg/m^2/day$ for shallow water sediments. These internal loading estimates indicate the potential for a tremendous negative flux or a sink for phosphorus in the sediments at certain times of the year rather than a source of phosphorus. The continuous high phosphorus loading, diffusive fluxes, and the lack of increased near-bottom phosphorus concentrations indicate that there is a significant phosphorus loss to the sediments.

Total Phosphorus Loading

Currently, the total phosphorus loading to the Salton Sea is estimated to be about 1.385 million kg/yr. Apportioning this load over the 365-square mile surface of the Salton Sea gives an areal loading of 4.02 $mg/m^2/day$ (Setmire et al 2001).

Possible Solutions to Reduce Eutrophication

Based on the above discussion that phosphorus is the limiting nutrient in the Salton Sea, and external loading is significantly larger than internal loading, it appears that reducing the external phosphorus loading may reduce eutrophication problems in the Salton Sea. A workshop sponsored by the Salton Sea Authority, the Salton Sea Science Office, and the U.S. Bureau of Reclamation and convened at the University of California at Riverside, September 7-8, 2000, identified a number of possible solutions to reduce eutrophication of the Sea. These include alum treatment, addition of polymers to increase the settling rate of fine particles in the tributaries, reduction of loading to tributaries, limiting total maximum daily loads, wetland treatment, and fishery management. These are discussed in the following sections.

Alum and/or Polymer Treatment

Alum or aluminum sulfate has been added to lakes and reservoirs since the 1950s to control algal blooms by reducing phosphorus loading. When added to water, the aluminum forms aluminum hydroxide which is a colloidal, amorphous flocculent with high phosphorus adsortion properties. Typically, alum is added directly to lakes to adsorb the phosphorus and form a barrier on the sediments, limiting internal phosphorus loading. The sheer size of the Salton Sea makes such alum treatment impractical. However, alum can be added to the tributaries to tie-up phosphorus before the water enters the Salton Sea. Alum addition to the New and Alamo Rivers at their outlets to the Salton Sea could remove significant loads of phosphorus and decrease the eutrophication of the Sea. A significant amount of phosphorus is associated with fine suspended particles in the tributaries to the Salton Sea. These fine particles likely have a high percent of the phosphorus adsorbed to their surfaces. Various polymers have been added to the river water to increase the settling rate of fine particles. Therefore, another way to reduce the phosphorus loading to the Sea may be to increase the settling rate of fine particles by adding specific polymers in the tributaries to the Sea.

A proposal to test and evaluate the efficiency of sediment and phosphorus removal from tributaries to the Salton Sea has been approved for funding by the State Water Resources Control Board. The project will investigate the feasibility of instream removal methods of phosphorus using alum and polymers. Information derived from this project will be used to aid in the design of a full implementation project for sediment control in the Imperial Valley and alum/polymer injection on both the New and Alamo Rivers.

Reduction of Loading to Tributaries

Nutrient loading to tributaries is from three major components: (1) agricultural discharge, (2) treatment plant effluent, and (3) municipal and industrial effluent from Mexicali. To be effective in reducing eutrophication in the Sea, participation of the farmers in the Imperial Valley would have to be sought in phosphorus reduction efforts. Reducing the use of fertilizers, reducing the total acreage of land used for farming, increasing land left fallow on an annual basis, and other best management practices to reduce phosphorus originating from agricultural fields, feed lots, and fish farms can contribute significantly to the reduction of phosphorus loading to the tributaries and eventually to the Salton Sea.

Municipal wastewaters that drain into the Sea from the towns and cities in the watershed add phosphates into the Sea. Although most human waste travels to treatment plants before discharge to the tributaries, phosphates from this waste make their way into the Sea. Tertiary treatment of all municipal effluent in the watershed would significantly reduce the levels of phosphate in the waters discharged to the Sea.

Total Maximum Daily Loads

The Environmental Protection Agency is requiring states to enforce a provision in the Clean Water Act designed to set water quality standards based on the total quality of water in a stream or lake, rather than on individual contaminants. If a stream or lake is classified impaired, then the state must identify all sources of impairment. The total maximum daily loads (TMDLs) are standards allocated among all sources of identified impairment, and each source must cut back its contribution to the impairment to meet the standard. The process of establishing standards is just getting underway, but it has the potential to require significant changes in the amount of nutrients, the degree of salinity, and other factors.

The Salton Sea Transboundary Watershed has been recognized by the California Regional Water Quality Control Board as the Region's priority watershed as it contains the most severely impaired surface waters of the Region. The Regional Board has begun to develop and implement TMDLs for the Imperial Valley and the New River at the International Boundary. Implementation of the TMDLs over the entire watershed, including the sediments at the Sea bottom, would contribute to the removal of some of the phosphorus from the system.

Wetland Treatment

Wetland treatment to remove various contaminants from water is gaining in popularity worldwide. However, wetlands constructed along tributaries or in deltas of the rivers are not expected to significantly change the eutrophication of the Salton Sea. Wetlands are effective at removing nitrogen, but not so effective at removing phosphorus.

Fishery Management

Fish harvesting, a possible component of fishery management, is being considered as a means to remove phosphorus from the Salton Sea. Tilapia play a significant role in tying up and removing phosphorus. If about 50 percent of tilapia are harvested each year, it could remove about 10 percent of the external loading of phosphorus from the Sea. If this were the only solution, it would have minimal impact on eutorphication. However, coupled with other possible solutions, it could prove to be helpful.

Continuing Eutrophication Assessments

The joint leads will continue to pursue solutions to eutrophication in the Salton Sea, sponsor additional investigations through the Salton Sea Science Office, and coordinate with other agencies to find other possible solutions. Additional work on alum/polymer treatment is being carried out to better understand if alum/polymer treatment could be feasible. Fishery management, which may reduce phosphorus loading, is being considered as a part of the Restoration Project, as discussed later in this chapter. In addition, the joint leads will coordinate with the California Regional Water Quality Control Board and other agencies on the implementation of TMDL measures.

FISH RECOVERY SYSTEMS

The Salton Sea is home to a very large fish population, which in turn sustains a large population of migratory birds. The continuing increase of salt concentrations in the Sea is predicted to have a significant negative impact to the existing ecosystem. In addition, due to frequent eutrophic conditions in the Sea and the very hot climate, the water becomes oxygen depleted through algae blooms, which in turn cause large-scale fish die-offs. Fish die-offs have occurred during the winter as a result of cold water temperatures. Currently the dead fish are allowed to remain floating on the Sea and eventually end up on the shoreline. The public has expressed significant concern with these events because of the negative visual impacts, access problems along the beaches, and odors. It has been estimated that up 10,000,000 pounds of fish can result in one die-off event. However, typical die-offs range in the order of 100,000 fish, or 150,000 to 200,000 pounds based on 1.5 to 2 pounds per fish.

Shoreline cleanup to improve aesthetics and reduce odors and nutrient load should be a part of any alternative to restore the Salton Sea. A comprehensive fish recovery system and cleanup program should consist of removing dead fish on the water surface and along the shoreline. Removing the dead fish would reduce noxious odors and nutrient load within the Sea, creating a healthier environment for the public and the fishery.

Currently, some shoreline cleanup occurs at public access locations, such as the Salton Sea Recreation Area; Sonny Bono Salton Sea National Wildlife Refuge; Bombay, Salton Sea, and Mecca Beaches; Desert Shores; Salton City; and Niland Marina. This work is very labor intensive and only results in a fraction of the total dead fish mass being removed. Many of the fish float to inaccessible areas of the shoreline and many probably sink to the Sea bottom.

One method of increasing shoreline clean up efficiency is to use conventional beach cleaning equipment (Figure 5-8). Generally, these machines are mechanical rakes operated by one person from the seat of a towing tractor or truck. It can provide safe, fast, and efficient cleaning. Typical elements of a rake include:

1. **The moldboard** levels uneven areas in loose material.
2. **Spring tines** mounted on a belt-covered bar flight conveyor rake debris from the surface toward
3. an adjustable **deflector** plate. As a result, refuse is deposited on
4. the elevating portion of the **conveyor** to
5. the hydraulically raised and tripped **hopper**.

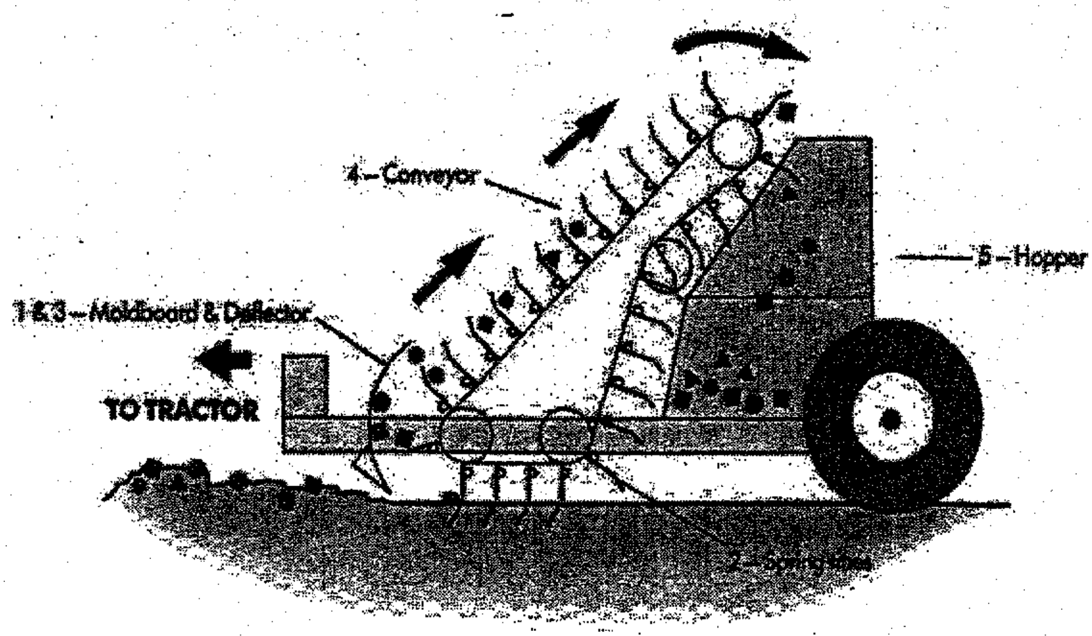

Figure 5-8. Schematic Representation of Beach Cleaning Equipment.

This beach cleaning system has a conveyor system that rakes the beach. It would pick up dead fish and bones, then load them into a hopper for transfer to a container truck that ultimately would transport the fish for disposal. The surface rake has hundreds of tines mounted in offset rows that rake through the sand, removing broken glass, plastic, cigarette butts, pop-tops, straws, cans, stones 1/2-inch to 4 inches in diameter, seaweed, fish, and small pieces of wood. This system may not operate as efficiently on shoreline areas with hard pan or stiff soils. The hopper capacity is 1-1/2 cubic yards.

This process would minimize labor and speed up fish removal on the accessible segments of the shoreline. The estimated capital cost for a tractor/truck and rake is $175,000. Annual operating costs could range from $50,000 to $75,000 depending on labor and fuel costs. These costs do not include storage or transportation of the equipment or disposal of the dead fish. An archeological survey would need to be conducted before on-land cleanup can commence.

The Salton Sea shoreline is approximately 130 miles long, depending on the Sea elevation. Assuming that a large fish die-off occurs, it is estimated that 10 to 15 percent of the shoreline may be affected. The current and wind directions immediately following the fish die-off will dictate which shorelines and beachs will be affected. Clean up efforts should be focused on populated and recreational areas such as Salton Sea Recreation Area; Sonny Bono Salton Sea National Wildlife Refuge; Bombay, Salton Sea, and Mecca Beaches; Desert Shores; Salton City; and Niland Marina. It is recommended that three beach cleaning systems be provided to clean up as much as 13 to 20 miles of shoreline at several locations simultaneously.

FISHERY MANAGEMENT

Fishery management would be a collaborative effort between the lead agencies, other agencies charged with resource management, such as the California Department of Fish and Game and possibly private or commercial interests. Two elements of fishery management at the Sea are being investigated at the Salton Sea:

- Fish hatchery
- Fish population control

As part of an interim measure to ensure the continuance of a sportfishery and a forage base for piscivorous birds, a Salton Sea sportfish rearing and stocking program will need to be implemented upon the determination that survival of the early life stages of these fish has been terminated due to increasing salinity levels, prior to the implementation of a restoration program. A brood stock of all 4 species of Salton Sea sportfish will be maintained in a hatching and rearing facility for future use in producing large numbers of fish for a put-and-grow fishery and as food for fish-eating birds. Fish population control is designed to help control biomass and nutrients in the Sea. If a decision is made to proceed with fishery management, a detailed fishery management plan will be prepared that will include detailed design alternatives for the fishery hatchery and specific strategies for fish population control.

Fish Hatchery

The salinity control measures discussed in chapter 4 are designed to halt the current trend toward increasing salinity in the Sea, and to ultimately reduce salinity. However, it is possible that salinity control cannot be implemented in manner that will be timely enough to preserve the current fish populations in the Sea. Therefore, a fish hatchery is proposed to preserve the current fish stock (four sportfish species) at the Sea, which has adapted over many (20-25) generations, to the highly saline conditions.

Currently, the salt concentration in the Sea is about 25 percent greater than that of the Pacific Ocean. The fish hatchery would be designed to preserve the genetic character of the current fish population that has, at least as of this writing, thrived under the high salinity conditions at the Sea. If the genetic stocks are not maintained, it may be difficult to re-establish these fish stocks in the Sea. After salinity control measures are implemented, the salinity of the Sea would most likely be greater than that of ocean water for many years; this would inhibit the survival of the earliest life stages of these fish. However, the scientific literature demonstrates that the more advanced life stages can survive and grow in higher salinities. Maintaining a fish hatchery and a fish stocking program will serve as an interim measure in the continuance of a sportfishery that will ultimately preserve the food base for fish-eating birds, such as pelicans and cormorants.

Development of the fish hatchery will initially focus on preservation of the genetic stock of the four major sport fish in the Salton Sea: orange-mouth corvina, bairdiella, sargo, and tilapia. Monitoring of the fish populations will be conducted by the California Department of Fish and Game to determine when the earliest life stages of any of these species will be adversely affected by elevated salinities. The monitoring program will determine when and for what species to focus a sportfish-rearing program.

The fish hatchery would be constructed and operated similar to other freshwater and saltwater (e.g. the White Seabass Rearing Program at Hubbs Sea World Research Institute) hatcheries in California. The photograph (Figure 5-9) shows the Mojave River State Hatchery in Victorville, CA. It is estimated that the hatchery would occupy from one to five acres at the southern end of the Sea, possibly on Federal or State land already designated for wildlife usage.

Figure 5-9. Mojave River State Fish Hatchery, Victorville, California

Fish Population Control

Fish population control of tilapia is being investigated as a means of reducing the internal nutrient load and fish densities within the Salton Sea. Nutrient rich inflows to the Sea facilitate high biomass production. Eutrophication can generate anaerobic conditions, which release hydrogen sulfide gas, reducing esthetics and recreational use. Nutrient loading also may encourage the growth of phytoplankton species that are toxic to fish. Reducing fish population densities and nutrients would provide a healthier environment for the current fishery.

Fishery population control may involve fish harvesting or selected management of the life cyles of the tilapia population. Fish lifecycle management could, for example involve disturbance of tilapia spawning areas. Fish harvesting could involve commercially catching fish, then grinding them to make fertilizer or fishmeal. The operation would basically consist of netting fish using fishing boats, offloading the fish onto dump trucks at the pier by a mobile crane, and hauling the fish to a tub grinder to make fishmeal. The fishmeal would typically be transported by conveyor to a silo and stored. A commercial truck would take the fishmeal to an off-site processing plant. The dump trucks would be washed down at a wash rack.

In order to determine the practicality and sustainability of a commercial fish harvesting operation for tilapia, the lead agencies would first need to seek permission from the California Department of Fish and Game, through the California Fish and Game Commission, for an experimental commercial fishery. This commercial fishery would have to be closely monitored by the

Department for total catch (tilapia) and bi-catch (other species), in relation to some initial quotas that would need to be established. The lead agencies would contract the services and could possibly provide subsidies, if harvesting were not fully commercial viable. Since it is anticipated that fish harvesting will be a private contract or venture. Any capital costs anticipated with the Salton Sea fish harvesting project would actually occur under other items such as shoreline cleanup, where facilities are shared between the fish harvesting and fish recovery activities.

Efforts to develop a fishery management plan have involved continued scientific investigations of the fish populations in the Salton Sea. These efforts have involved investigations of the number and diversity of fish in the Sea, their life cycle characteristcs, and the nature of their diseases. In addition, preliminary testing of fish for use as pet food or other products has also been conducted. These efforts have involved netting several hundred pounds of fish and testing it for pet food and fish meal applications.

Because of the large volume of nutrients existing and deposited into the Salton Sea each year, fish harvesting represents only a partial solution to reduce nutrients. Ongoing efforts by the California Water Quality Control Board, Region 7, to establish Total Maximum Daily Loads (TMDLs) for reduction of silts in the Salton Sea and its tributaries, could potentially reduce nutrient inflows and provide the rest of the solution for the current eutrophic conditions. Region 7 has developed a Watershed Management Initiative "integrated plan" to develop and implement 16 TMDL thresholds to reduce silt, pesticide, selenium, nutrients, and bacteria in the waterways of the Salton Sea watershed. The TMDLs silt thresholds are scheduled for development in 2002.

Fishery Management Costs

The costs of the fishery management would likely be shared among a number of agencies, including the proponents and the California Department of Fish and Game. For planning purposes, the construction cost of a fish hatchery has been assumed to be $5 million and the annual operation, maintenance, energy, and repair costs have been assumed to be $500 thousand per year. The total present value is, therefore, estimated at $11 million.

ECONOMIC DEVELOPMENT ASSISTANCE

Some Salton Sea Restoration alternatives under consideration call for the use of agricultural land for development of salt removal and salt disposal facilities (ponds). The conversion of irrigated agricultural land for this purpose is considered particularly useful for the project if average annual inflow of water to the Sea is reduced by 300,000 acre-feet because of transfer agreements with the San Diego County Water Authority (SDCWA) and the Coachella Valley Water District (CVWD). The excess irrigation water available from the converted lands can be utilized to replace the reduced inflow and to maintain the water elevation of the Sea. The water not utilized for irrigation and directly diverted to the Sea would have lower salinity and would, therefore, also contribute to the project goal of salinity reduction. Alternative 4, which includes the construction of both in-Sea and on-land ponds for salt removal and disposal would require about 51 square miles (32,640 acres) of agricultural land conversion. Alternative 6, on the other hand, calls for construction of ponds on land only. The conversion of agricultural land, therefore, is anticipated to be significantly larger than Alternative 4 requirements, amounting to about 114 square miles or 72,960 acres.

Conversion of irrigated agricultural land would result in loss of income for the landowners (farmers) unless they are properly compensated for the loss of their land and livelihood. An Economic Development Assistance program may be established to provide needed assistance to the farmers of the land taken by the project. However, if the project actions reduce the amount of irrigation water available, farmers can change their cropping patterns by fallowing the lands, by planting crops that require no or little irrigation water (dry crops), or by adopting water conservation measures. This may reduce the impacts to some extent but would not eliminate them. In all cases, farm profits would be affected. The extent of the impact would depend on the change in the water used, the cost of producing the new crops, the prices received for the new crops, and the cost of implementing water conservation measures.

The loss of irrigated cropland would not only affect the landowners/farmers directly through the loss of farm income, but would also impact indirectly all those businesses and individuals who benefit from the continued farm operations. These include farm workers, farm machinery and equipment dealers, and service industries and businesses, which provide services, such as food/beverage, fuel/automotive, recreational supplies, retail items, and entertainment.

Development Research Associates, in 1969, conducted an economic benefits study of the Salton Sea area for the State Water Resources Control Board. In calculating the local income effects at the Salton Sea, they concluded that the communities surrounding the Sea had a weak economic base in that the only industries in the area were retail. There was no manufacturing or wholesaling to keep the dollars spent in the local area within the local economy. Of every dollar spent at the Sea, the largest percentage leaked out of the local economy in payment for goods and services, which must be imported. However, whatever income accrues to local entrepreneurs and wage earners does create additional income for the local economy. They calculated the incremental portion of local income generated by the initial investment of one dollar in the local economy to be $.07 in 1969 increasing to $.14 by 1980. This means that every dollar of initial income or investment would generate an incremental $.14. This multiplier effect, though small, does have a positive effect on the local economy. On the contrary, loss of initial income, such as that represented by the loss of agricultural income accruing to farmers and farm workers, would result in a greater than (1.14 times) the initial loss to the local economy.

The loss of income from decreased farming activity would be compensated to a large extent by the benefits derived from the restoration of the Salton Sea. Decreased salinity and improvement in overall water quality would have a positive impact upon the sport fishery and other recreational pursuits. These positive impacts would further translate to increasing visitation to the Sea and encouragement and support of businesses in the surrounding area. Increased attractiveness of the Sea and related economic activity would result in increased local population, income, employment, retail sales, property values and the like, in the communities surrounding the Sea. As a result, while some farmers and related businesses may be adversely affected by the loss of irrigated farmlands, the overall benefits of the project may have a positive effect on the communities surrounding the Salton Sea.

A complete analysis of the economic impacts of land use conversion and the economic benefits of the restoration project has been initiated, but is not yet complete. For preliminary planning purposes and for comparing costs of alternatives, some preliminary estimates have been included for the economic development assistance program. It is expected that the next version of this document will include the results of the economic analysis and an updated estimate of the costs associated with economic development assistance. The values included in this document assume that assistance would be provided in proportion the amount of land use conversion involved in a particular alternative. The numbers that have been included can only be considered as rough preliminary estimates.

Chapter 6
LONG-TERM MANAGEMENT

The long-term management plan will describe the process to implement and maintain the restoration project. The Salton Sea Authority (the Authority) and the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) will jointly implement the plan. The plan will describe the project operational and maintenance responsibilities, scientific research and monitoring responsibilities, and resource sustainability and management. The plan's concept is that management is adaptable, given the recognized unknowns at the Salton Sea ecosystem. The long-term management program will have operational flexibility to respond to monitoring and research findings and varying resource conditions. The plan will include the following components:

- Long-term operation and maintenance (O&M) plan that describes O&M requirements, including the potential opportunities to modify the restoration actions to improve their effectiveness in meeting Project goals

- Strategic Science Plan that (1) describes scientific investigations of ecological conditions and relationships that either exist or will develop in the Sea and (2) monitors the effectiveness of the actions implemented

- Resource management plan that will outline the program for overall management of the biological resources at the Sea.

Each of these components is briefly discussed below.

OPERATION AND MAINTENANCE PLAN

The Salton Sea Restoration Project is expected to involve management actions that will include (1) construction of salinity control facilities, such as solar ponds and/or an enhanced evaporation system (EES) and (2) implementation of management actions that will improve conditions at the Sea. The operation and maintenance (O&M) component of the long-term management plan will describe how the various elements of the project will continue to function after the initial construction phase is complete. As additional phases are completed, those components will be added to the O&M plan. The O&M plan will provide specifications for how restoration facilities will be operated and maintained throughout their design life.

The O&M plan will include a continuous improvement program that will involve monitoring the efficiency of restoration actions and provide a mechanism for adjusting operations or upgrading facilities to improve their operations. In addition to standard O&M upgrades, the performance of the restoration effort, itself, will need to be continually reassessed. As part of a continuous improvement process, both restoration actions and management strategies may need to be modified or adapted as new information and a better scientific understanding of the Sea evolve over time. Physical, biological, and economic conditions will be considered in any proposed modification to project operation or implementation of any additional restoration measures.

The O&M plan will be designed to guide continued evaluation and adjustments, when needed, of the restoration effort and to better meet the purpose and need of the project. For example, the capacity of salinity control measures may need to be increased or decreased in response to future changes in salinity within the Sea. The O&M plan will specify how the performance of facilities such as solar ponds or EES units would be monitored so that recommendations for facility modifications could be developed.

Throughout the operational life of restoration facilities, consultation will be maintained with agencies that may be affected by those facilities, including the Federal agencies, such as U.S. FWS, and California agencies, such as CDFG. In addition, consultation will continue with affected local governments, tribal organizations, and the public, including representatives of academic institutions and other scientific organizations, environmental groups, and the recreation industry. The O&M plan will define opportunities for information exchange and involvement by all parties.

The O&M plan will define operating criteria and also define conditions needed to modify those criteria. Updates to O&M procedures will involve consulation with scientists and engineers, as well as stakeholders and other interested parties. The lead agencies will work with these groups to refine the program goals and policies, if it becomes apparent that such changes would be beneficial. Through this process, the O&M plan will be updated as necessary and integrated into the overall long-term management plan, which will be based upon final restoration decisions and congressional authorizations.

In addition to the O&M component, the long-term management plan will provide guidelines for implementing the various components of the restoration project (including construction, mitigation, monitoring, and new investigations). An additional critical role of the long-term management plan will be to guide the continued implementation of restoration actions and the coordinatation of the selected actions with actions by other agencies that may affect the goals of this program, either positively or negatively.

Finally, as the management program develops, adaptive management principles will be applied by the lead agencies. These principles will ensure that results of management decisions made under present conditions are monitored and adjusted to continue to meet future requirements. Adaptive management provides a scientifically based method for adjusting restoration actions in the future to make certain that these actions continue to be effective in attaining defined project goals.

STRATEGIC SCIENCE PLAN

The Strategic Science Plan has already been drafted. The plan defines the generic, long-term science approach, activities, and needs and recommends a Science Office be developed to effectively manage the scientific effort into the future. The plan describes the proposed scientific staff and outlines monitoring and research activities. The plan was designed in direct response to the needs of the lead agencies for the restoration project. An external multi-disciplinary panel of highly qualified scientists provided input in the form of a draft document that served as the foundation for the Strategic Science Plan. The continuing science program will be an integral part of future planning and evaluation of the restoration project.

A process will be developed to ensure funding for the Science Office, to coordinate and communicate management agency needs to scientists, to develop recommendations for management decisions, and to transfer scientific evaluations and new scientific information to the management agencies. Independent, external review processes will be critical to the science effort. An on-Sea common-use field station and a coordinated database have been identified as highly desirable components of the science effort. It is critical to the process that the science staff is both independent of the management work group and yet highly interactive with, and responsive to, their needs.

Critical roles for the science staff will be to:

- Facilitate the development of a conceptual model of the Salton Sea ecosystem
- Provide a common frame of reference for scientists, stakeholders, and the interested public
- Guide long-term monitoring and focused investigations
- Be intimately involved in the design and evaluation of adaptive management activities

The conceptual model will be an early priority of the science staff and will be a working tool, emphasizing processes rather than details. As information is developed and relationships are defined, quantitative models of the relationships defined in the conceptual model will be developed for predicting ecosystem responses to specific restoration actions.

The continuing science program will include the following components:

- Conceptual modeling to guide both long-term monitoring and focused studies toward goals and objectives identified for the project
- Monitoring to evaluate the success of restoration actions and to collect long-term data from which quantitative models could be validated
- Quantitative modeling to generate hypotheses about these processes and ecosystem functions, that focused investigations then will explore
- Focused investigations to fill in key information gaps, to support monitoring by identifying important measures that were not initially recognized, and to help in validating quantitative models
- Technical assistance to address time-responsive short-term needs, such as consultations, data synthesis and evaluation, and other scientific evaluations to guide management response and actions
- Data management to help integrate data among monitoring, focused investigations, modeling, and management
- Design input relative to adaptive management actions to support timely evaluations for monitoring such actions and to identify corrective actions, if needed

"Adaptive management" frequently is cited as an effective approach to managing natural systems; however, the term is widely misunderstood, and rarely is it undertaken. Under adaptive management, scientists work closely with managers to define desired outcomes, to design necessary scientific evaluations, to monitor progress, and evaluate outcomes. Restoration managers will then be able to use the results of such investigations to make needed adjustments to the operation of solar ponds or other restoration systems.

RESOURCE MANAGEMENT PLAN

The biological resources of the Salton Sea ecosystem are under the statutory authorities of the U.S. Fish and Wildlife Service (migratory birds and endangered species) and the California Department of Fish and Game (resident wildlife and fisheries). On-site stewardship for those species is vested in the Department of the Interior and State of California land management agency lands and water where those species are found. Fish and wildlife on tribal lands are managed in accordance with tribal regulations and within the scope of any applicable federal and state regulations. The shared interests and responsibilities that are inherent in the stewardship of these biological resources results in situation specific, collaborative management by the government agencies and tribes.

Actions associated with the Restoration Project could affect achievement of biological resources goals and objectives of agencies and tribes with lands and waters that are part of the Salton Sea ecosystem and the actions of those parties could affect achievement of Restoration project goals and objectives. The long-term management plan provides a vehicle for the restoration of the Salton Sea that engages the Restoration Project and the natural resources stewardship agencies and tribal community in a manner that facilitates the long-term sustainability of those resources. It is expected that the foundation for the long-term management plan will be built upon formal interagency and organizational agreements that are developed to address general needs and that the primary goal will be the long-term sustainability of the biological resources of the Salton Sea ecosystem and the overall recreational values of the area. An interagency/ organization forum that is part of the long-term management plan will serve as a venue to address the balance that must be maintained between the protection of biological resources, recreatonal opportunities and economic benefits that ae inherent aspects of the Restoration Project.

Biological resource management at the Salton Sea must also involve the larger community of Stakeholder groups, including the general public, in addition to embracing a coordinated effort among the biological resources stewardship agencies and the tribal community. Key components associated with that approach include:

- A formal means of communication between the operational managers of facilities such as the State Recreation Area and the Sonny Bono Salton Sea National Wildlife Refuge Complex and operators of restoration facilities
- A mechanism for coordinating the continuing resource management efforts
- An opportunity for steering continuous improvements in resource management and for obtaining funding for such effort
- A form means for community stakeholder and public involvement in the development of long-term management goals.

Once a restoration project is approved, the Authority and Reclamation will coordinate with representatives of the other agencies and the public to develop the specific features of the resource management plan and the organizations and individuals who will participate in the process.

REFERENCES

Barnham, Doug. Wildlife Biologist, Salton Sea Scientific Committee, Telephone Conversations February 1 and 6, 2001.

Barnham and Hansen, Personal Communications.

Hansen, Rob. 1998. Wildlife Biologist, Tulare Lake Drainage District. Tour of Bird Mitigation Ponds in Tulare Lake Basin, May 1998.

Miles, A.K., J.Y. Takekawa, D.H. Schoellhamer, C.T. Lu, C.T., W.G. Duffy, and M.K. Saiki, *Science Support for Wetland Restoration in the Napa-Sonoma Salt Ponds*, San Francisco Bay Estuary 1999 Progress Report, (Unpublished Progress Report), U.S. Geological Survey, Davis, CA, 2000.

Miles, et al, 2000, and Barnham, Personal Communications.

Ohlendorf, H.J., 1999. Goals Project 1999; *Bioaccumulation and Effects of Elevated Selenium in Wildlife*, in: L.W. Jacobs (ed). Selenium in Agriculture and the Environment, American Society of Agronomy and Soil Science Society of America. Madison, WI; 1989.

Pelizza, Charlie, 2001. Refuge Biologist, Salton Sea National Wildlife Refuge, Telephone conversation February 21, 2001.

Rosen, M.N., 1971. *Botulism* in Infectious and Parasitic Diseases of Wild Birds, ed. J. W. Davis et al., Iowa State University Press, Ames, Iowa, 1971.

Skorupa, J.P., *Selenium Poisoning of Fish and Wildlife in Nature: Twelve Real-World Examples*, in: Environmental Chemistry of Selenium, Marcel Dekker, Inc., 1998.

Small, A., 1994. *California Birds: Their Status and Distribution*, Ibis Publishing Co., Vista, California.

Technical Committee on Evaporation Ponds, 1999. *Final Report: Evaporation Ponds*, San Joaquin Valley Drainage Implementation Program, Sacramento, California.

U.S. Department of the Interior, Bureau of Reclamation, 2000.Draft Sea Restoration Project Environmental Impact Statement/Environmental Impact Report, January 2000.

U.S. Environmental Protection Agency, 1999. *Goals Project, Baylands Ecosystem Habitat Goals Project,* San Francisco, California, 1999. This report contained habitat recommendations, which was prepared by the San Francisco Wetlands Ecosystems Goals Project.

Attachment A
Conceptual Disposal Options with Separated Bittern

The primary conceptual disposal facility designs presented in Chapter 4 of the report are based on the assumption that the majority of salt products to be removed from the Sea could be disposed in crystallizer beds. The alternative designs presented in this appendix will apply if significant quantities of bittern products are produced that will not form solid products in the crystallizer beds. The alternative conceptual designs were formulated to accommodate a fluid-like bittern, if the ongoing pilot studies indicate that the bittern does not evaporate to dryness. Like the primary designs, these designs also included impoundments on-land and in-Sea. The impoundments for the crystallized salts incorporated the berms terraced on top of the deposited salts, as the salt crystals would have some supporting strength. However, the impoundments for the bittern will need to have a significant cross section to contain the fluid-like substance. The in-Sea impoundments would also need to be constructed as a full section dike to above the Sea level. Substantially more material would be required to construct the in-Sea dikes to accommodate the construction and mitigate seismic instabilities.

The surface area of the disposal ponds was sized to allow for the required evaporation for the expected annual salt deposition. The alternative conceptual designs developed for the salt crystallizer beds was similar to the conceptual design described above for the disposal ponds that assume the bittern evaporates to dryness.

On-Land Impoundments

The on-land impoundments would consist of earthen berms that enclose the disposal area. The area of the salt disposal impoundment was sized for the areas estimated for the crystallizer beds in the salt modeling program. The required bittern area was estimated to be two-thirds of the crystallizer area, based on experience with operating commercial salt-making facilities.

Figure A–1 presents a conceptual design of contiguous salt and bittern disposal areas in relatively flat terrain (Alternative Concept A) for disposing of salt products from a 1-million tons/yr TDS removal facility. Figure A–2 presents a conceptual design (Alternative Concept B) for expanding this facility to dispose of salt and bittern from a 2 million tons/yr facility. Figure A–3 presents a conceptual design of contiguous salt and bittern disposal areas in steeper terrain (Alternative Concept C) for disposing of salt products from a 1 million tons/yr facility.

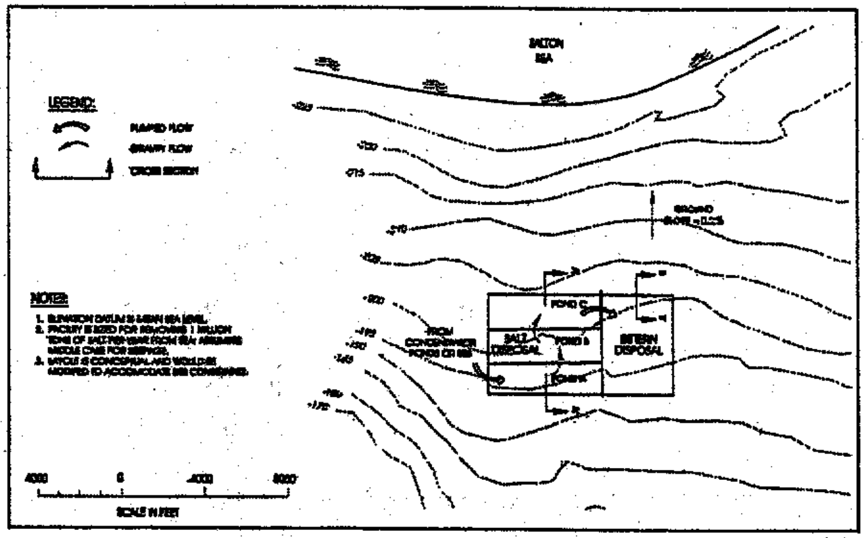

Figure A–1 – Alternative Concept A Layout for Contiguous Disposal Impoundments in Flat Terrain

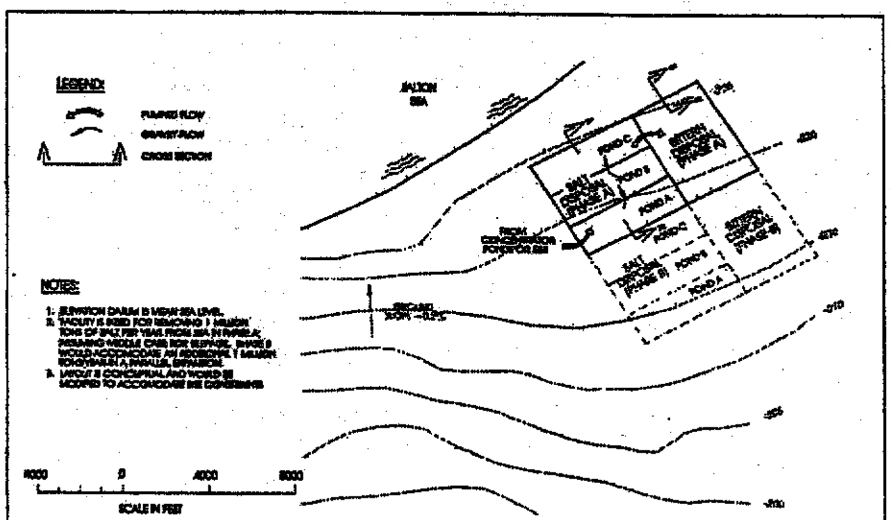

Figure A–2 – Alternative Concept B Layout for Contiguous Disposal Impoundments with Parallel Expansion in Flat Terrain

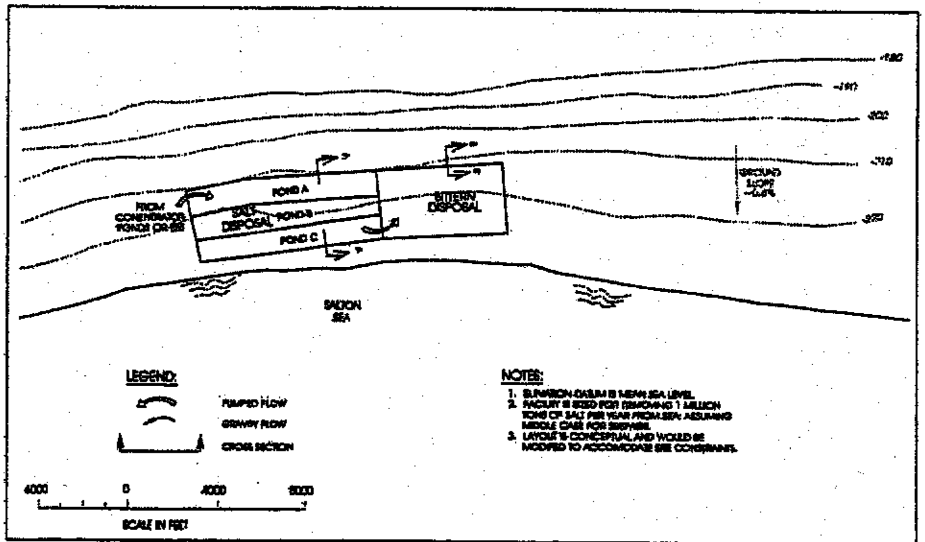

Figure A–3 – Alternative Concept C Layout for Contiguous Disposal Impoundments in Steep Terrain

Figure A–4 presents a cross-section through the bittern disposal berms. Substantially more material is required for a berm to resist the hydrostatic pressures if the bittern does not evaporate to dryness. As shown in this figure, the berms could be constructed in phases with subsequent height increases to allow for the continued disposal of bittern.

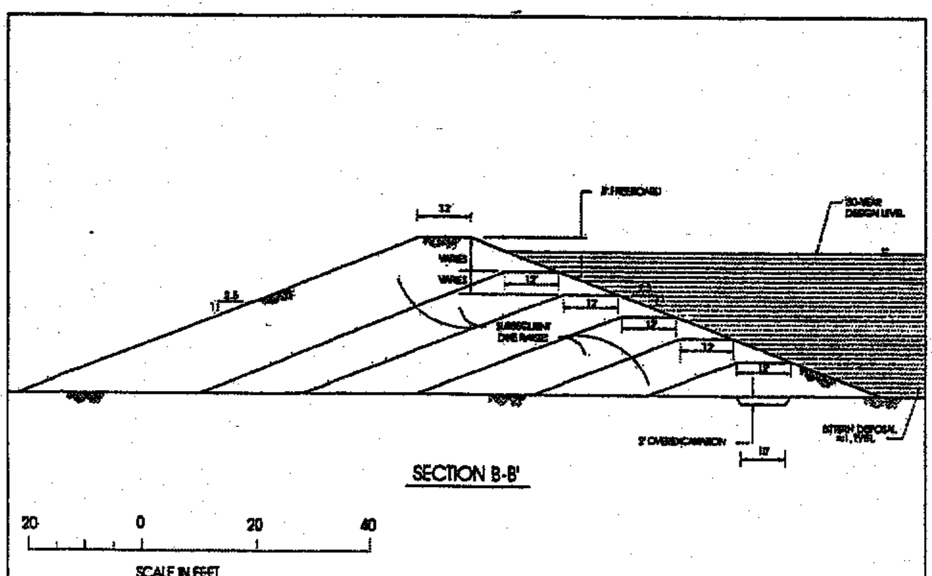

Figure A–4 – Typical Berm and Subsequent Raises for On-land Bittern Disposal Impoundment

Material for the initial berms could be obtained from within the disposal areas. However, after salt and bittern is deposited, the berm materials would need to be obtained from outside of the disposal areas (but could be adjacent to or within future disposal areas).

The salt will be deposited in crystallizer beds as solid crystals and the bittern withdrawn in the alternative conceptual designs. The berms surrounding the salt crystallizer beds would be constructed as described earlier for the combined salt and bittern disposal facility,as shown in Figure A–5.

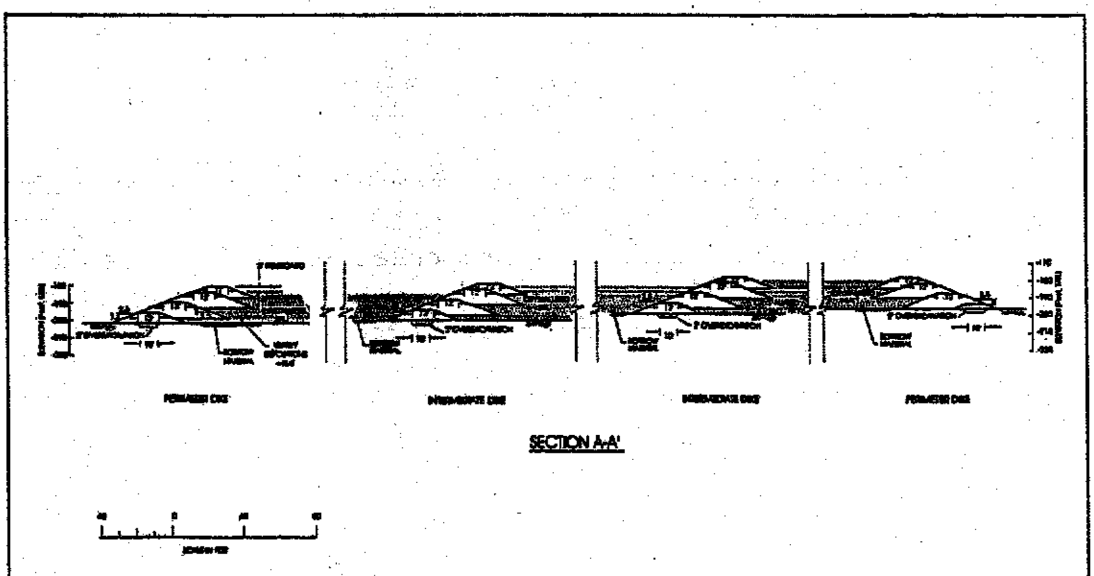

Figure A–5 – Typical Berm and Subsequent Raises On-land Salt Disposal Impoundment

Figure A-6 presents an artists perspective of Concept A, salt and bittern disposal.

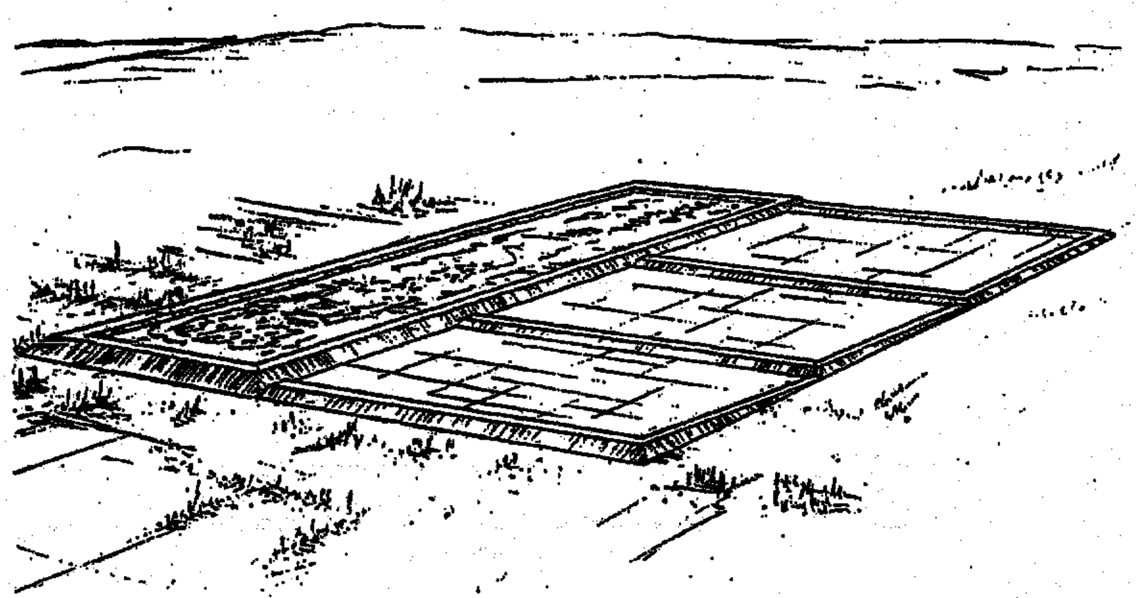

Figure A–6 —Artists Perspective of Alternative Concept A, Salt and Bittern Disposal

In-Sea Impoundments

In-Sea impoundments were also developed for the alterntive conceptual designs which separated the bittern from the crystallized salts. Figure A–7 presents a conceptual design (Alternative Concept D) of salt and bittern disposal areas constructed in the Sea for disposal of salt products from a 1 million tons/yr of TDS removal facility. The salt disposal areas were sized to provide the surface area for the required evaporative losses. To eliminate a head differential across the dikes, the in-Sea impoundment would initially contain Sea water. The Sea water would be displaced by concentrated brine from Concentrator Pond 10 or the EES. The Sea water would be totally displaced in less than 6 months and the salt disposal impoundment would then function in a manner similar to the on-land salt disposal impoundments. The design assumes that there would be no leakage from the ponds because the head differential between the ponds and the Sea would be negligible.

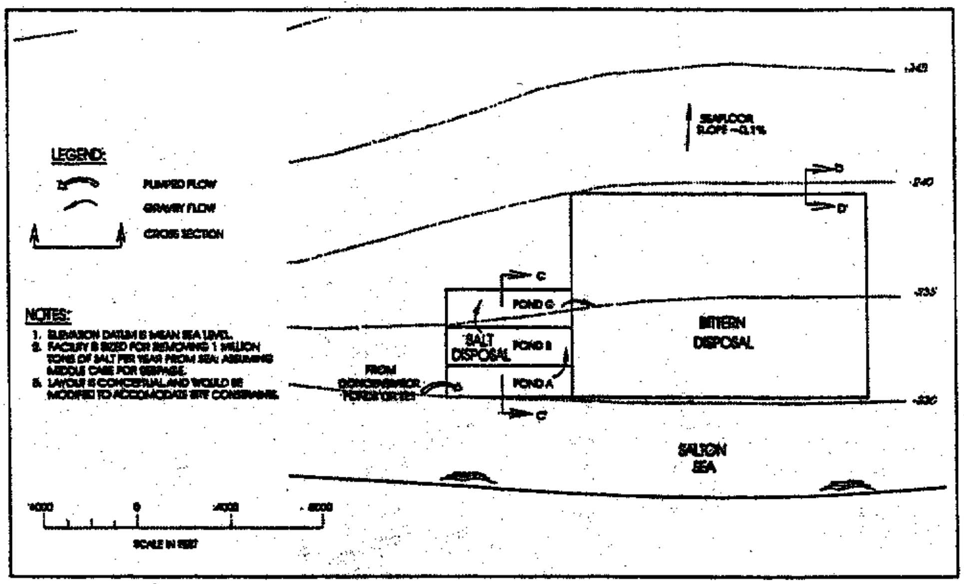

Figure A–7 – Alternative Concept D Layout for In-Sea Disposal Impoundments in Shallow Water

Internal dikes would be used to separate the salt disposal area into three ponds to help control the brine concentrations. Since the disposal area would be constructed in shallow water, the required surface areas do not provide the volume required for 30 years of salt disposal. Once the crystallized salt is deposited to above the Sea's level, the disposal volume would be expanded vertically by constructing the terraced berms as discussed above. Figure A–8 depicts a cross-section through the in-Sea salt disposal area. Depending on the level of the concentrator pond or EES feeding into the salt disposal area, the concentrated brine may need to be eventually pumped into the raised salt disposal area.

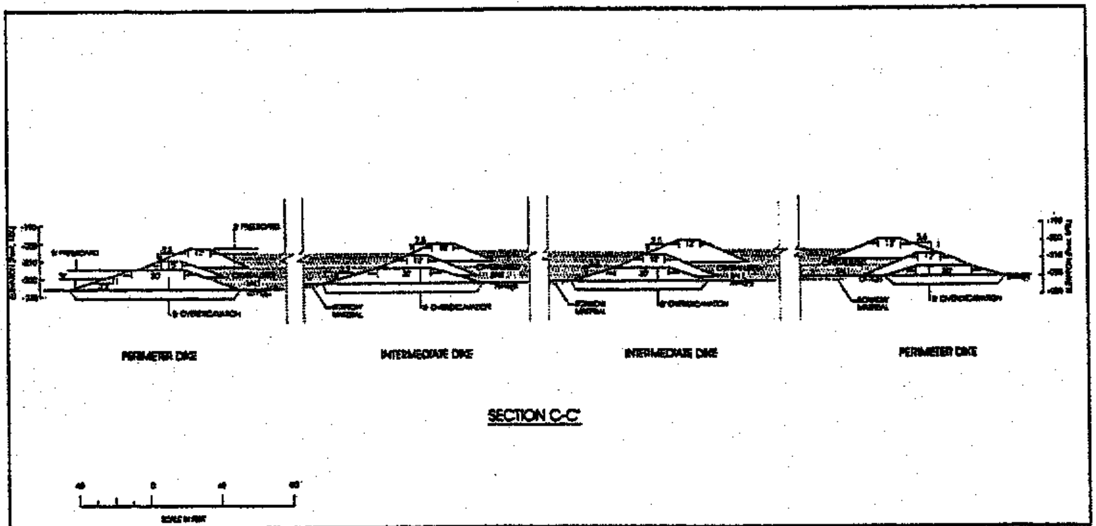

Figure A–8– Typical Dike and Subsequent Raises for In-Sea Disposal Impoundment

The bittern disposal area for Alternative Concept D was sized to provide the anticipated bittern volume to be disposed of over 30 years for a 1-million tons/yr TDS removal facility. The impounded area would initially contain only Sea water. Bittern would be deposited into this area below the lighter density Sea water. The bittern would partially replace the volume lost by evaporation within the impoundment. Sea water would be conveyed into the bittern disposal pond to maintain the fluid level within the impoundment slightly lower than the adjacent Sea level so that seepage of bittern through the dike would not occur. This would also mitigate the consequences of a possible dike breach by not allowing bittern to flow into the Sea. Furthermore, it would also allow more water to be pumped (and TDS to be removed) from the Sea.

The bathymetry of the Sea in Alternative Concept D is sloping at approximately 0.10 percent. This is typical of the bathymetry in the southern part of the Sea. Figure A-9 presents a cross-section through the in-Sea disposal dikes. The alternative conceptual designs use similar dike geometries as those discussed for the design combining the salt disposal with bittern.

Figure A–10 provides a conceptual design (Alternative Concept E) for expanding the Concept D facility to dispose of a total of 2 million tons/yr of TDS. This design was formulated to evaluate expanding the facility into deeper water.

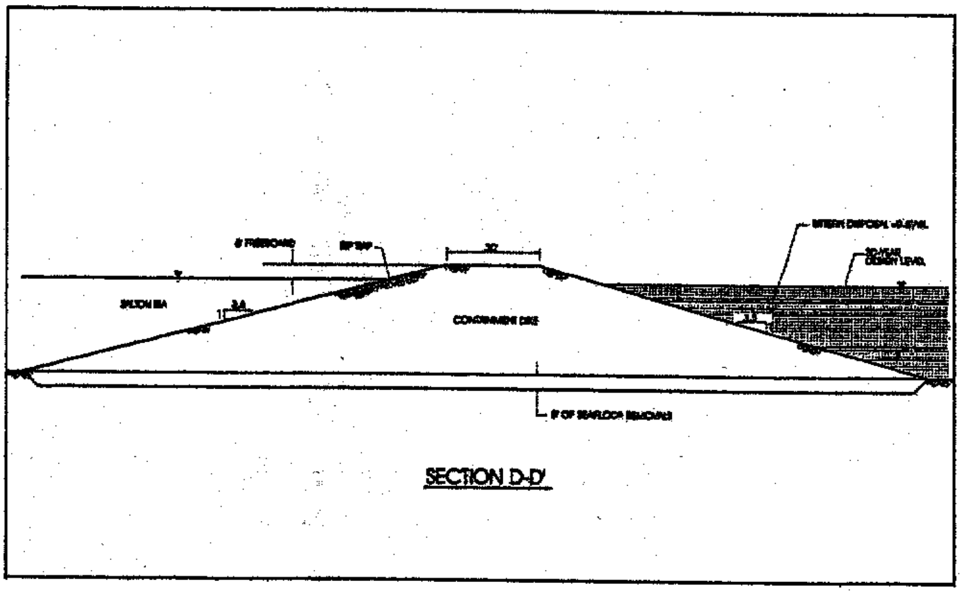

Figure A–9 – Typical Embankment for In-Sea Containment Dike

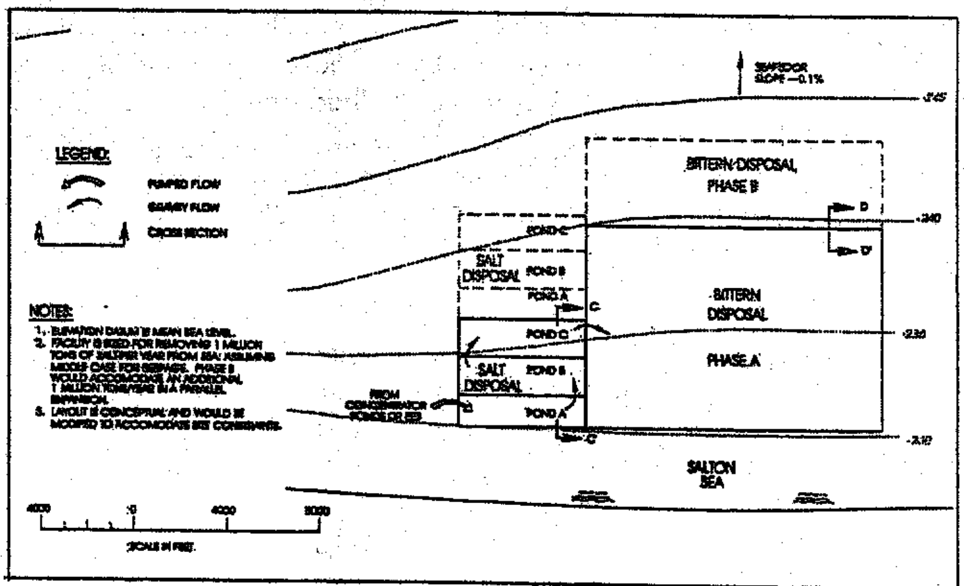

Figure A–10 – Alternative Concept E Layout for
In-Sea Disposal Impoundments with Parallel Expansion

EES Bittern Disposal

Using EES's can reduce the surface area of the bittern pond by 50 percent. Using them reduces the surface area required for evaporation. The EES's need to evaporate only 50 percent of the water leaving the crystallizing beds. The volume needed for storage of salts remains the same as that required for normal evaporation. While the line showers may accomplish the required enhanced evaporation, only enhancement using the turbo-enhanced EES is presented here.

Seven turbo-enhanced EES machines will evaporate the desired amount of water from the bittern. Figure A-11 is an artists rendition of this system. The machines will crystallize the bittern in one pass through the machine and deposit it an average of 180 feet from the machines. These machines will likely be quite different than those used to evaporate virgin Salton Sea water. The nozzles may be larger, the pumping head less, and the velocity of the air blowing through the evaporator tube less than the standard evaporator. These modifications are likely to reduce cost considerably, and designers did not use them in the design they present here. The Pilot Test should incorporate testing bittern enhanced evaporation. Figure A-12 shows a conceptual layout.

In this scheme, the machines will advance in a line. The machines will start atop a dike and eventually set atop salt that they previously deposited. Operators can use several passes or other paths with terraced dike construction. The cost estimate includes all necessary piping and machine movement for any path.

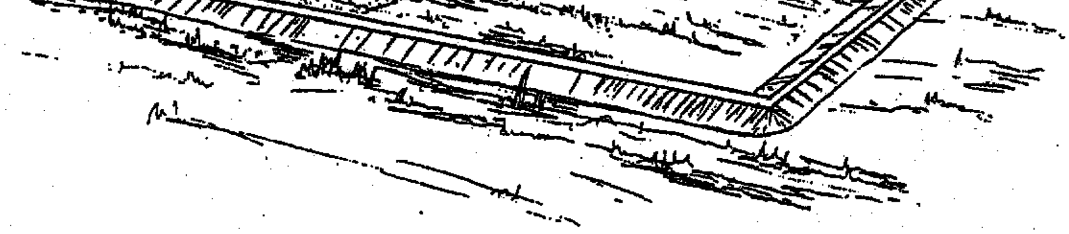

Figure A-11. Sketch of turbo-enhanced bittern disposal system.

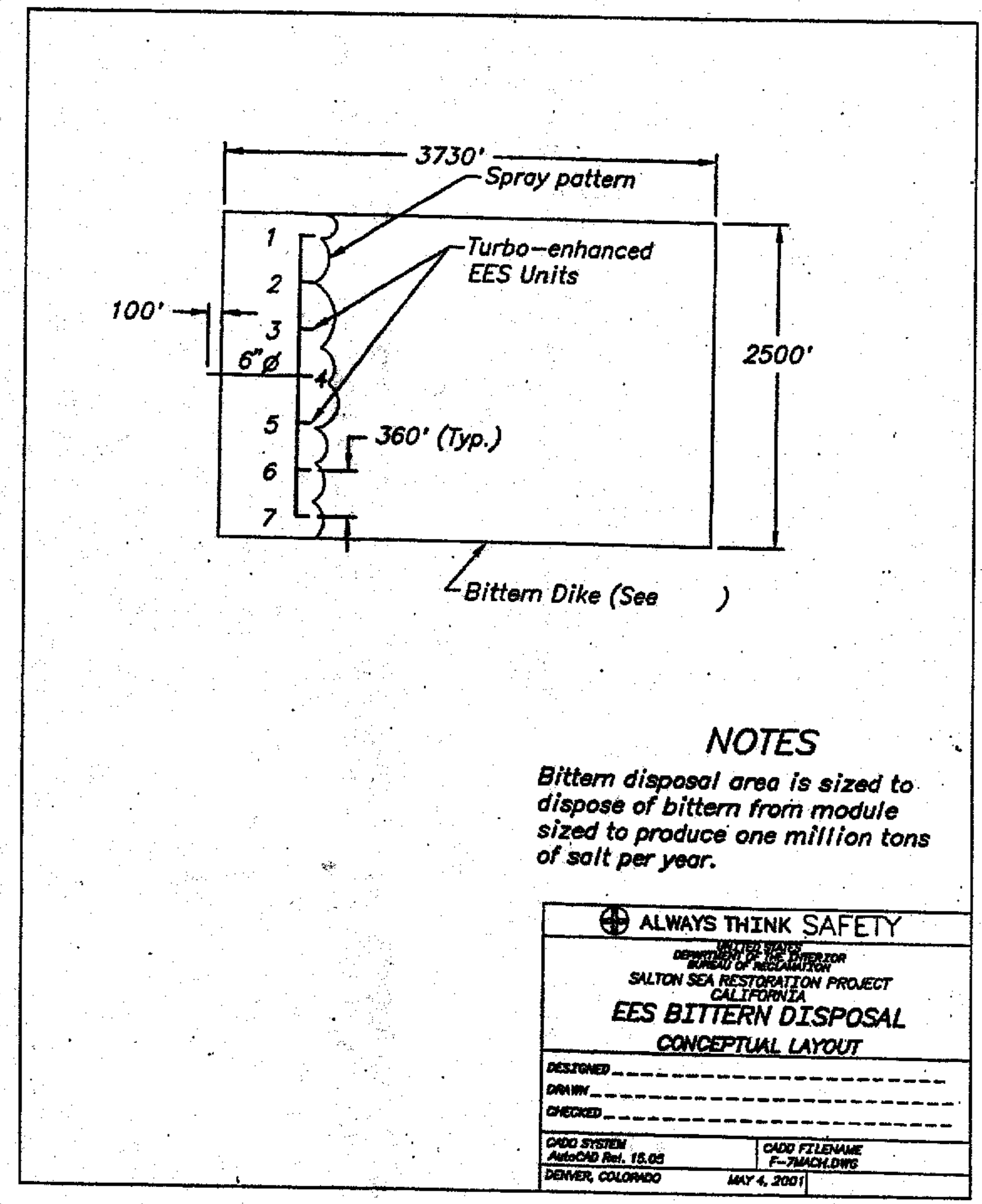

Figure A-12. EES bittern disposal conceptual layout.

An alternative scheme would be to set the EES units atop a dike and remove. less water than would be in the previous scheme. Because a 10 percent safety factor was used, the proposed pond would be large enough to accommodate the required evaporation. Piping costs would be less than above.

Costs of the EES bittern system are shown in the following tabulation.

Item	Construction Cost Estimate ($ million)	OM&R ($ M/yr)	Energy Cost ($million/yr)	Construction Cost Estimate Present Worth ($ million)	OM&R Present Worth ($ million)	Energy Cost Present Worth ($ million)	Total Present Worth ($ million)
EES and Conveyance	0.6	0.0	0.1	0.6	0.1	0.8	1.5
Dikes w/EES	10.7	0.0	0.0	10.7	0.0	0.0	10.7
Total				11.3	0.1	0.8	12.2
Dikes w/o EES	21.3	0.0	0.0				

EES Salt Bittern Disposal

One method of disposing both sodium-chloride and bittern in one area is to use EES. Figure A-13 shows an artists rendition of such a system. The dike would be constructed in two phases. Both disposal areas are the same size, which is

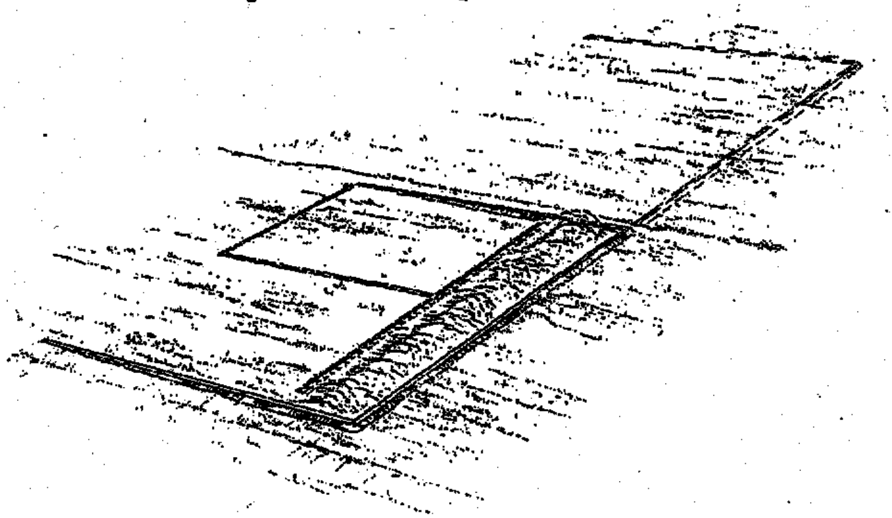

Figure A-13.– An artists rendition of an EES salt bittern disposal system based on 33 EES units operating abreast of each other. They would begin depositing crystallized salts at the downhill end of the area. After filling the area to a depth three feet less than the dike height, operators would move the machines further uphill. This process will continue over 15 years until the Phase 1 disposal area is full. Operators would then move all of the machines to the newly constructed Phase 2 disposal area and begin the process over again. Figure A-14 shows an EES salt bittern disposal conceptual layout.

Both of these disposal areas are designed to accommodate precipitation and include drainage ditches to channel the water around the areas. The total width and length of the 30-year storage area are based on the optimum configuration for the given slope and storage requirements.

Some testing of the EES machines would need to be done to ensure that the machines will operate effectively. Experimenters in the future will probably find the economical optimum time to use these machines is prior to what this module design uses. This design is very conservative and the costs should allow for such changes. Determining such optimum timing will be done during final design.

The design uses dikes constructed to their final height during at the time of construction. The dikes have a top width of 15 feet and side slopes of 2.5:1. The same unit prices were used as for other dikes in this document that are constructed on land. Costs of the EES salt bittern disposal system are shown in the following tabulation.

Item	Construction Cost Estimate Present Worth ($ million)	OM&R Present Worth ($ million)	Energy Cost Present Worth ($ million)	Total Present Worth ($ million)
Dike I	6	–	–	6
Dike II	2	–	–	2
EES	3	1	5	9
Total present value	11	1	5	17

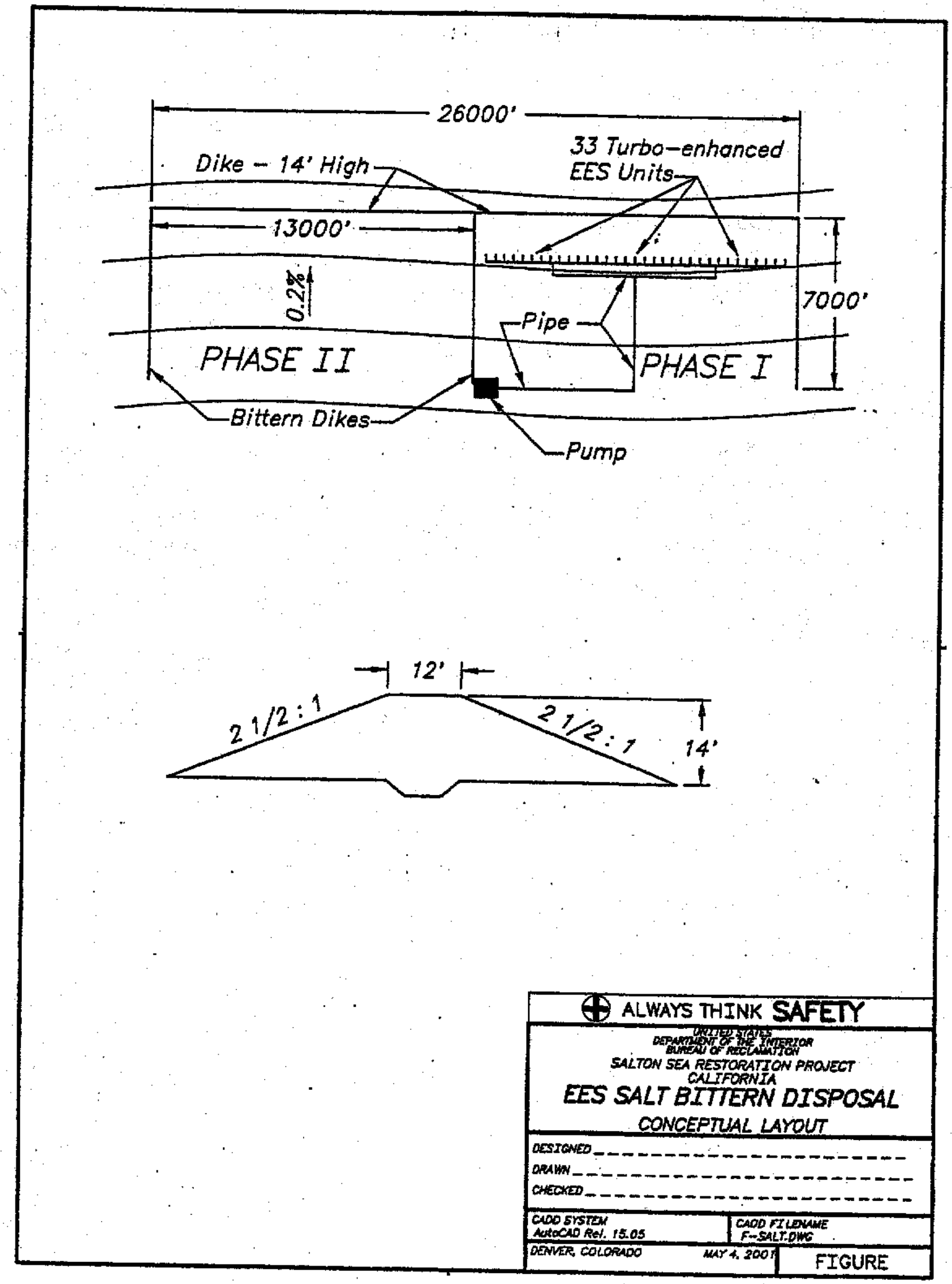

Figure A-14. EES Salt Bittern Disposal Conceptual Layout.

Appraisal Level Earthwork Costs

Appraisal level cost estimates were developed for the earthwork associated with the alternative conceptual designs of the disposal facilities. Quantities of the earthwork required for the terraced berm salt and bittern disposal impoundments were estimated for Alternative Concepts A through C and are shown in Table A–1. The quantity of materials required for the initial berms and subsequent berm raises (which could be phased in) are shown separately in Table A–1. The total earthwork costs (in present day dollars) for the salt and bittern disposal is also shown in Table A–1. The cost estimates were developed using the unit costs discussed above for the conceptual designs which combine disposal of the salts with the bittern.

Estimated quantities of the earthwork required for the in-Sea disposal impoundments (Alternative Concepts D and E) are also shown in Table A–1. Again, the costs were developed using the unit costs discussed for the conceptual designs which combine disposal of the salts with the bittern.

Table A–1 –Summary of Alternative Conceptual Designs for Disposal Areas and Appraisal Level Costs (Excluding Conveyance Facilities)

Item	Concept A (On-land – Flat Terrain)	Concept B (On-land – Flat Terrain)	Concept C (On-land – Steep Terrain)	Concept D (In-Sea – Shallow Water)	Concept E (In-Sea – Deep Water)
Facility Capacity (million ton/yr)	1.0	2.0	1.0	1.0	2.0
Salt Disposal:					
Area (acres) [a]	640	1,280	640	640	1,280
Total Length of Perimeter and Interior Drive	31,700	58,200	40,600	31,700	58,200
Maximum Height of Containment (ft)	24	24	25	22	22
Volume of Initial Dikes (cy)	171,100	223,600	381,800	562,900	1,841,600
Over-excavation Volume (cy) [b]	23,500	32,600	30,000	505,600	937,000
Volume of Dike Raises (cy)	770,300	1,098,600	951,700	671,300	385,500
Earthwork Costs	$4,330,000	$7,952,000	$6,121,000	$17,719,000	$39,828,000
Additional Costs [c]	$4,588,000	$8,532,000	$6,222,000	$16,158,000	$36,318,000
Total Costs	$8,918,000	$16,484,000	$12,343,000	$33,877,000	$76,146,000
Capital Cost ($/ton) [d]	$0.30	$0.27	$0.41	$1.13	$1.27
Bittern Disposal:					
Area (acres) [a]	427	853	427	2,737	3,878
Total Length of Perimeter Dikes (ft)	17,600	31,600	17,900	44,100	64,600
Maximum Height of Dikes (ft)	42	40	44	15	20
Maximum Bottom Width of Dike (ft) [e]	220	210	230	135	170
Total Volume (cy)	2,411,500	4,394,700	2,492,600	1,143,000	2,540,700
Volume of Initial Dikes (cy)	203,900	182,900	325,200	1,143,000	2,540,700
Overexcavation Volume (cy) [b]	13,000	21,200	13,300	816,600	1,284,200
Volume of Dike Raises (cy)	2,207,600	4,211,800	2,167,400	0	0
Earthwork Costs	$10,922,000	$19,896,000	$11,289,000	$22,539,000	$40,943,000
Additional Costs[c]	$10,387,000	$18,996,000	$10,721,000	$20,552,000	$37,335,000
Total Costs	$21,309,000	$38,892,000	$22,010,000	$43,091,000	$78,278,000
Capital Cost ($/ton) [d]	$0.71	$0.65	$0.73	$1.44	$1.30
Total Capital Cost ($/ton) [d]	**$1.01**	**$0.92**	**$1.51**	**$2.57**	**$2.57**

Notes:

[a] Assumes mid-case for seepage.

[b] Assumes 2 feet below on-land berms and 5 feet below in-Sea dikes.

[c] Includes land ($1000/acre, no cost in-Sea), unlisted items (plus 15 percent), contingencies (plus 25 percent), noncontract costs (plus 33 percent).

[d] Assumes facility life of 30 years.

[e] Assumes 12-foot top width and a ratio of 2.5:1 for slopes on-land, and 30-foot top width and a ratio of 3.5:1 for slopes in-Sea.

Attachment B
Regulatory Issues Related to Salt Disposal and Management

INTRODUCTION

This attachment provides the results of a preliminary evaluation of the permitting issues that may arise in construction of salt disposal facilities for the Salton Sea Restoration Project. The evaluation was performed by the URS Corporation under contract with the Salton Sea Authority.

Project Background

The Salton Sea (Sea) is currently considered a sink, since water drains to the sea without an outlet. As a result, the salinity of the Sea has been increasing over time. The proposed restoration project involves removal of water from the Sea in an effort to reduce the salinity of the water body. The removed water would be placed in a series of concentrator ponds, where it would evaporate to produce a highly saline brine, which would then be conveyed to drying or disposal beds for final disposition of the solids within the water.

This report discusses potential permitting requirements associated with disposal of the crystalline salts and other solids resulting from the evaporation process. Likely precipitates deposited in the disposal facilities would include the following:

- Chalk (Calcium Carbonate, $CaCO_3$)
- Gypsum (Calcium Sulfate, $CaSO_4$)
- Salt (Sodium Chloride, NaCl)
- Magnesium Sulfate and Sodium Sulfate ($MgS0_4$ and Na_2S0_4)

For the purpose of this study, we have assumed that the remaining salts and bittern would be classified as a non-hazardous material with respect to California Code of Regulations (CCR) Title 22. We also understand that groundwater in the southern portion of the Salton Sea may be considered degraded and unsuitable for agricultural, domestic, or municipal beneficial uses.

Estimated Quantity of Material to be Managed

The total estimated quantity of total dissolved solids (TDS) that would need to be removed from the Salton Sea each year to maintain the current salinity level without reducing inflow into the Sea is estimated to be approximately 5.2 million tons. This would amount to approximately 3,400 acre-feet of disposal volume annually; using an in place density of 70 pounds per cubic foot (pcf) for the deposited solids.

Inflows to the Sea may be reduced due to water transfers that are currently being negotiated. With reduced sea inflows, the total estimated quantity of TDS that would need to be removed to maintain the current salinity is estimated to be approximately 16.8 million tons per year. This would amount to approximately 11,000 acre-feet of disposal volume annually.

Comparable Landforms

Landforms comparable to that which would be created by the disposed solids for the restoration project include similar salt and bittern management facilities at other locations, municipal solid waste landfills and tailings dams. A minerals mining operation on the west side of the Great Salt Lake in Utah results in volumes of salt and bittern similar to that expected by the Salton Sea Restoration project. Since the beginning of this operation 10 years ago, approximately 20,000 acres of evaporation beds have accumulated approximately 4 feet of salt. Figure 1 presents an aerial photo of these beds. A more detailed description of this facility is presented below.

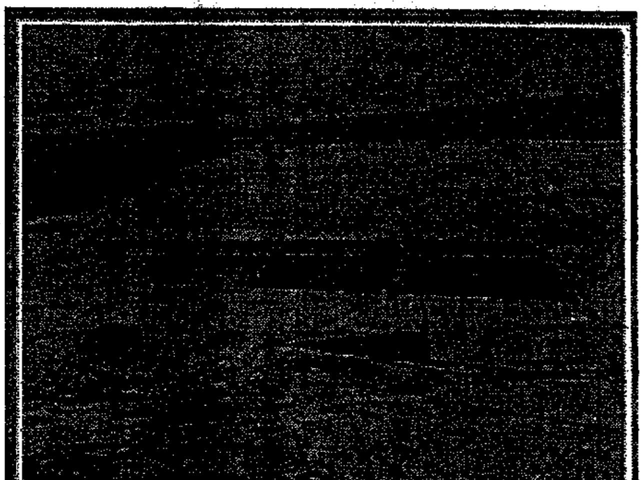

Figure 1: Aerial Photograph of Great Salt Lake Minerals Corp. Landfills

Landfills in California are required to be permitted by the California Integrated Waste Management Board (CIWMB) and the Regional Water Quality Control Board (RWQCB), along with other regulatory agencies and are considered a discharge of waste to land. One of the largest landfills is the Fresh Kills Landfill, located along the western shore of Staten Island in New York. The Fresh Kills landfill covers over 2200 acres with waste piles greater than 200 feet in height. During operation, maximum daily tonnage of refuse accepted was as much as 29,000 tons per day (1986-1987).

Several large landfills also exist in southern California. The Puente Hills landfill, operated by the Los Angeles Sanitary District covers approximately 622 acres. El Sobrante landfill in Riverside County currently has over 7 million tons disposed of in the landfill. An expansion for an ultimate disposal of 108 tons has recently been approved.

Regulatory Overview

The proposed project may require permitting through a variety of agencies. The most rigorous permits and the focus of this document are those regulated by the RWQCB and the CIWMB. Though the US Fish and Wildlife Service and the California Department of Fish and Game will also likely have regulatory requirements related to the restoration project, it is believed that the restoration of the Sea will be perceived very positively by these wildlife resource agencies and therefore, the regulatory requirements regarding habitat and wildlife issues are not expected to be burdensome and are not addressed further in this document.

Due to the unique nature of this project, regulatory requirements for this facility are ambiguous and unclear. This document presents regulatory permitting requirements and analysis with a technical focus. We have laid out the possible permit requirements and resulting implications to design and operation of the disposal beds. This analysis should not be construed as a legal interpretation, and due to the ambiguity in the regulations as they relate to this unique facility, URS recommends that the lead agencies obtain an opinion from legal counsel related to this issue.

Relevant Regulatory Definitions

The discharge of liquids and solids to land in California falls under the regulations of the RWQCB. If the discharge is considered as a disposal of solid waste to land, then the requirements of the CIWMB are also applicable. These regulations include numerous definitions that are important in evaluating the regulatory requirements related to a proposed project. The following definitions from the California Water Code (CWC) and portions of CCR Title 27 administered by the RWQCB are important in developing an understanding of the regulatory framework related to the Salton Sea Restoration Project:

- "Waste" includes sewage and any and all other waste substances, liquid, solid, gaseous, or radioactive, associated with human habitation, or of human and animal origin, or from producing, manufacturing, or processing operation, including waste placed within containers of whatever prior to, and for purposes of, disposal.
- "Non-hazardous Waste" means all putrescible and non-putrescible solid, semi-solid and liquid wastes, including garbage, trash, refuse, paper, rubbish, ashes, industrial wastes, demolition and construction wastes, abandoned vehicles and parts thereof, discarded home and industrial appliances, manure, vegetable or animal solid and semi-solid wastes and other discarded wastes (whether of solid or semi-solid consistency); provided that such wastes do not contain wastes which must be managed as hazardous wastes, or wastes which contain soluble pollutants in concentrations which exceed applicable water quality objectives, or could cause degradation of waters of the state (i.e., designated waste).
- "Waters of the state" means any surface water or groundwater, including saline waters, within the boundaries of the state.
- "Designated waste" means either of the following: (a) Hazardous waste that has been granted a variance from hazardous waste management requirements pursuant to Section 25143 of the Health and Safety Code. (b) Nonhazardous waste that consists of, or contains, pollutants that, under ambient environmental conditions at a waste management unit, could be released in concentrations exceeding applicable water quality objectives or that could reasonably be expected to affect beneficial uses of the waters of the state as contained in the appropriate state water quality control plan. "Waste pile" means a waste management unit at which only noncontainerized, bulk, dry solid waste is discharged and piled for treatment or storage on an engineered liner system that prevents the waste from contacting the underlying surface. The term does not include a Unit of similar construction which is used for waste disposal (such a Unit would be a landfill).
- "Mining waste" means all solid, semisolid, and liquid waste materials from the extraction, beneficiation, and processing of ores and minerals. Mining

waste includes, but is not limited to, soil, waste rock, and overburden as defined in Section 2732 of the PRC and tailings, slag and other processed waste materials, including cemetitious materials that are managed at the cement manufacturing facility where the materials were generated. Group A mining wastes are wastes that must be managed as hazardous waste pursuant to CCR Title 22, provided that the RWQCB finds that such mining wastes pose a significant threat to water quality. Group B mining wastes are wastes that consist of or contain hazardous wastes, that qualify for a variance under CCR Title 22, provided that the RWQCB finds that such mining wastes pose a low risk to water quality or wastes that consist of or contain nonhazardous soluble pollutants of concentrations which exceed water quality objectives for, or could cause degradation of waters of the state. Group C mining wastes are wastes from which any discharge would be in compliance with the applicable water quality control plan, including water quality objectives other than turbidity.

- "Surface impoundment" means a waste management unit which is a natural topographic depression, excavation, or diked area, which is designed to contain liquid wastes or wastes containing free liquids, and which is not an injection well.
- "Tailings pond" means an excavated or diked area which is intended to contain liquid and solid wastes from mining and milling operations.
- "Landfill" means a waste management unit at which waste is discharged in or on land for disposal. It does not include surface impoundment, waste pile, land treatment unit, injection well, or soil amendments.

The following definitions pertain to the Public Resources Code (PRC) and portions of CCR Title 27 administered by the CIWMB:

- "Solid waste" means all putrescible and nonputrescible solid, semisolid, and liquid wastes, including garbage, trash, refuse, paper, rubbish, ashes, industrial wastes, demolition and construction wastes, abandoned vehicles and parts thereof, discarded home and industrial appliances, dewatered, treated, or chemically fixed sewage sludge which is not hazardous waste, manure, vegetable or animal solid and semisolid wastes, and other discarded solid and semisolid wastes.
- "Solid waste landfill" means a disposal facility that accepts solid waste for land disposal, but does not include a facility which receives only wastes generated by the facility owner or operator in the extraction, beneficiation, or processing of ores and minerals, or a cemetery which disposes onsite only the grass clippings, floral wastes, or soil resulting from activities on the grounds of that cemetery.

- "Disposal facility" or "facility" means any facility or location where disposal of solid waste occurs.

SALT AND BITTERN MANAGEMENT AT OTHER SITES

Based on a review of other salt production/management facilities, regulatory requirements tend to vary dramatically based on the project location, potential impact to the groundwater, and history of the facility. For the purposes of this study, we contacted the following facilities: Great Salt Lake, Searles Dry Lake, Western Salt in San Diego, Cargill Salt in San Francisco and salt mining operations at the Dead Sea. We received no response from the salt operations at the Dead Sea. Both Cargill Salt and Western Salt opted not to participate in this study and provided no information about their facilities. A summary of the requirements at the Great Salt Lake and Searles Dry Lake are presented below.

Great Salt Lake

Mr. David Butts provided information regarding the salt and bittern management practices at the Great Salt Lake in Utah. Mr. Butts has retired from being the manager of a commercial salt producing facility at the Great Salt Lake.

The site, operated by the Great Salt Lake Minerals Corporation, currently operates in two locations, located on the eastern and western shores of the Great Salt Lake. The operation removes saline water from the lake, further concentrates the brine through evaporation, and extracts materials such as potassium sulfate or magnesium chloride from the resulting brine. Due to the small market for the sale of salt, sodium chloride is typically considered an unused by-product of the operation. Approximately 20 million tons of sodium chloride is crystallized each year (10 millions tons from each of the two facilities). Sodium chloride is diluted with water from the Bear River and redeposited into the Great Salt Lake on the eastern operation. Water for dilution is not available on the western operation, therefore, the remaining salts are retained by a dike approximately 40 miles in length. Approximately four feet of salt is currently retained behind the dike.

The facility on the eastern shore of the Great Salt Lake has been operating since the 1960s. The facility is located near a bird refuge. No permitting was required for the existing facility. In the late 1980s and early 1990s, the facility tried to expand, however, due to environmental restrictions associated with taking land near or in the bird refuge, a site on the western side of the lake was selected. None of the salt storage areas are lined. The facilities were regulated by the State of Utah.

Searles Dry Lake

Mr. James Fairchild and Mr. Larry Trowsdale of North American Chemical provided information related to the Searles Dry Lake facility.

Searles Dry Lake facility is located in Trona, California and has been in operation since 1917. It currently processes 100,000 to 200,000 tons of salt per year. The Searles Dry Lake operation is currently owned and operated by North American Chemical Company. The main products from this facility include, but are not limited to, sodium carbonate and borax. Although some salt produced at the facility is sold, the majority is not. General operating procedures at the facility include pumping of water from the Searles Dry Lake into the processing facility where profitable minerals are extracted. Then the remaining brine is returned to the Searles Dry Lake by percolation or through injection wells. Approximately 20,000 gallons per minute are returned to the lake (half of which is by infiltration, and half by injection).

Alternatively, water from the Searles Dry Lake is placed in solar concentration ponds where the saturation of salts can be increased through evaporation and recovery of profitable minerals can be maximized. The remaining salts from the evaporation ponds are excavated with standard earthmoving equipment and stockpiled on-site. Based on discussion with the facility operator, the existing stockpiles are up to 25 feet in height and are estimated to include 5 to 10 million tons of salt. The stockpiles are located in an area that may be considered part of the historic dry lake; the stockpiles are located on existing natural salt-deposits and during heavy rainfall, lake level rises to above the base of the stockpiles.

Waste Discharge Requirements (WDRs) have been issued for the effluent released from the processing facility back into the Searles Dry Lake by the RWQCB (Lahontan Region, Region 6). No WDRs have been issued for the salt stockpiles. Injection well permits have been issued in accordance with EPA regulations (Underground Injection Control, UIC). The CIWMB has not been involved in the stockpiling and injection operations at the facility. Other regulatory challenges for the facility relate to migratory birds.

POSSIBLE PERMITS AND APPROVALS FOR SALT AND BITTERN MANAGEMENT AT THE SALTON SEA RESTORATION PROJECT

Regional Water Quality Control Board

The RWQCB has authority to regulate waste discharges per the CWC. Regulations promulgated by the RWQCB include the CCR Titles 23 (hazardous waste) and 27 (non-hazardous waste).

Possible Permit Approvals Required

The Salton Sea has been designated by the Federal Government as an agricultural drainage sink (executive order signed March 10, 1924 and 1928). All lands below the -220 feet Mean Sea Level (MSL) contour were withdrawn from all forms of entry. More recently, in 1968, the State designated the Salton Sea as an area for collection of agricultural drainage, seepage, leaching and control waters. The RWQCB has acknowledged this primary purpose for the Sea in its 1994 Basin Plan. Therefore, if the proposed evaporation ponds are at or below the -220 feet MSL contour, the RWQCB may not have or exert jurisdiction over the discharge. However if the ponds are located above the --220 feet MSL contour, the brine discharge would fall under the jurisdiction of the RWQCB.

Per the CWC and CCR Title 27, discharges of waste to land must be permitted with Waste Discharge Requirements (WDRs) issued by the RWQCB. WDRs typically include the design operation requirements for the facility including liner systems, vadose and groundwater monitoring requirements. WDRs may be waived by a regional board for a specific discharge or type of discharge pursuant to Section 13269 of the CWC if the waiver is deemed not against the public interest. Waivers for specific types of discharges may not exceed five years in duration, but may be renewed by a regional board.

Furthermore, if a waste can be discharged directly or indirectly to water of the state under effluent or concentration limits that implement applicable water quality control plans, the discharge is not subject to SWRCB-promulgated provisions of Title 27. WDRs for such a discharge would still be required, unless a waiver is granted, as discussed above.

Applicability of Requirements to Salt/Bittern Management

Several permitting strategies are available within the regulatory provisions related to the discharge of sea water and bittern to land. During the preparation of this document, URS has initiated a dialogue with the RWQCB and we recommend that further discussions with the RWQCB regarding permit requirements be continued.

Based on these preliminary discussions, it appears that the most direct method to avoid a lengthy permit process would be to sponsor legislation exempting the Salton Sea Restoration project from the regulatory requirements. The RWQCB indicated that they would support this type of legislation and that similar legislation was enacted to streamline a wetlands restoration project in the same area. It would be expected that little opposition would result if the legislation would be crafted carefully enough as to not develop loopholes for other projects. Reasonable language could include extending the -220 contour that delineates the federally designated drainage sink to a higher elevation along the southern portion of the Salton Sea. This approach would require support from the senator and legislative representative for the region.

In the event that a legislative change is not obtained, the Colorado River Basin Region of the RWQCB (Region 7), would be required to classify the facility and issue WDRs in accordance with requirements in Title 27. Requirements promulgated by the RWQCB and WDRs will depend on the classification of the salt and bittern and of the disposal facility and the compliance of the waste discharge with the water quality control plan for the region.

The existing water quality control plan for the Colorado River Basin, dated 1994, includes a discussion of the increasing salinity of the Salton Sea. The RWQCB states in this basin plan that it will support the lead agencies in their efforts to improve water quality in the Salton Sea.

The groundwater objective within the existing water quality control plan is to minimize the quantities of contaminants reaching any groundwater basin. The existing water quality control plan prohibits discharges of water softener regeneration brines, other mineralized wastes, and toxic wastes to disposal facilities which ultimately discharge in areas where such wastes can perculate to groundwaters useable for domestic and municipal purposes. However, if total dissolved solids (TDS) in underlying groundwater exceeds 3,000 mg/l, the water is not considered suitable or potentially suitable for municipal or domestic water supply. Existing groundwater conditions should be verified in the proposed pond areas to confirm that the groundwater is unsuitable for domestic or municipal beneficial uses.

As discussed earlier, classification of the proposed salt and bittern disposal facility will involve interpretation of the regulations. The brine solution will be deposited into the disposal beds in a liquid form. Therefore, several disposal facility classifications, such as a Class II landfill or waste pile and a Class III landfill would not be appropriate as these types of facilities cannot accept liquid wastes. Table 1 summarizes categories of disposal facilities and their applicability to the proposed salt and bittern disposal. As shown in this table, the proposed facility could be classified as one of the following:

- Class B Mining Facility
- Class C Mining Facility
- Class II Surface Impoundment
- Wastewater discharge

Typical liner requirements for these facilities are shown in Table 1. We believe that it would be reasonable to expect that the RWQCB would classify the facility and discharge as either wastewater or a Class C mining facility which would result in less severe regulatory requirements than the other options.

In order to obtain a WDR for a discharge, the discharger must submit a Report of Waste Discharge (ROWD) to the RWQCB. The ROWD includes information regarding the facility such as waste characteristics, geologic and climatologic characteristics of the Unit and surrounding region, installed features, operation plan for waste containment, precipitation and drainage controls, and closure and post-closure maintenance plans. Submittal requirements for ROWDs can be found in 27 CCR §21710, 21750, and 21760

California Integrated Waste Management Board

According to PRC 43101, the state water board and regional water boards shall be the sole agencies regulating the disposal and classification of solid waste for the purpose of protecting the waters of the state and the CIWMB and Local Enforcement Agencies (LEAs) shall regulate all other aspects of solid waste disposal within the scope of their appropriate regulatory authority. The CIWMB has jurisdiction under California Public Resources Code (PRC), Division 30 to regulate disposal of solid waste to protect public health and safety and the environment. Applicable regulations are presented in 27 CCR. The CIWMB does not regulate disposal of hazardous materials. Enforcement activities related to disposal of hazardous materials are performed by the Department of Toxic Substances Control (DTSC).

Possible Permit/Approvals Required

Per the PRC and CCR Title 27, disposal of solid waste requires a Solid Waste Facilities Permit (SWFP). A SWFP includes conditions considered necessary to specify a design and operation for which the operator/applicant has demonstrated the ability to control the adverse environmental effects of the facility. In the event that a SWFP is required, the permit would be issued by the CIWMB and the permit requirements would be enforced by the County of Imperial, Department of Health Services, Division of Environmental Health, which would act as the LEA for the project.

Potential requirements resulting from issuance of a SWFP for the proposed facility include the following:

- Security
- Recordkeeping
- Signage
- Health and Safety
- Waste Material Handling and Placement
- Stockpiling
- Daily Cover
- Various Controls (such as dust, vector, nuisance, litter, etc.)

Applicability of Requirements to Salt/Bittern Management

According to definitions in the PRC, the proposed facility would not classify as a solid waste landfill (which excludes a facility which receives only wastes generated by the facility owner or operator in the extraction, beneficiation, or processing of ores and minerals).

In the event that the facility is classified as a surface impoundment or mining facility, the CIWMB would not be involved in permitting of the facility.

Air Pollution Control District

Air pollution control permits are issued to control emission of air contaminants, like nitrogen (NO_x), carbon monoxide (CO), fine particulate matter (PM_{10}), oxides of sulfur (SO_x) or toxics to within Federal and State standards. The salt and bittern are not expected to emit air pollution, including dust. Based on discussions with operators of similar facilities, dust control does not appear to be a significant design concern. In fact, operations at Searles Dry Lake include placement of salt on unpaved roads to control dust.

No air permits will likely be needed for salt and bittern management other than possibly those typically required for large earthmoving projects only if construction of the berms for the evaporation beds would trigger dust control requirements. Such permits would be obtained through the Imperial County Air Pollution Control District (ICAPCD). Air pollution control permitting will likely be associated with dust and emissions from earthmoving equipment associated with construction of berms. Permit requirements would likely include dust control measures such as use of water on soils that may emit dust and maintenance of equipment to limit emissions. A minor processing fee is required to obtain a permit.

Design Implications and Costs

The conceptual designs of the disposal facilities is for bermed impoundments (onshore) or diked impoundments (if built within the Sea). No liners are currently planned for the impoundments. Our preliminary evaluation indicates that permitting requirements will not significantly impact the presently conceived designs, or resulting construction costs.

We also believe that groundwater monitoring and financial assurance provisions in the regulations will not be required by the RWQCB. Unfortunately, this will not be confirmed until the RWQCB reviews a ROWD that provides an engineering and scientific basis that demonstrates that these provisions would not be required due to site specific conditions.

In summary, we recommend that the lead agencies use a two-pronged approach to address the regulatory requirements for the salt and bittern management facility. The first strategy would be to work with a legislative representative to sponsor legislation that would exempt this project from the CCR Title 27 requirements. Concurrently, the lead agencies should develop an ongoing dialogue with the RWQCB to assess if it would be possible to reach an understanding that the facilities could be regulated without expensive liners and monitoring systems.

Table 1 - 27 CCR Waste Disposal Facility Classifications

Facility Type	Typical Liner Requirements	Leachate Collection and Removal Systems	Siting Requirement	Applicability
Class II landfill	Single clay liner (unless underlain by a substatial thickness of natural geologic materials with low permeability)	Blanket Ttype Required	200-foot setback from holocene fault	27 CCR 20200(d) any waste that contains liquid in excess of the moisture-holding capacity of the waste in the class II landfill, or which contains liquid in excess of the moisture-holding capacity as a result of waste management operations, compaction, or settlement shall only be discharged to a surface impoundment
Class II waste pile	Single or double liner (see 21410)	Blanket Ttype may be Required	200-foot setback from holocene fault	27 CCR 20200(d) wastes containing free liquids shall not be discharged at class II waste pile.
Class III landfill	Single composite liner (exceptions may apply)	Blanket or Dendritic if Liner Required	May not be sited on holocene fault	27 CCR 20200(d) liquids or semi-solid waste, other than dewatered sewage and waste treatment sludge, shall not be discharged to class III landfills. Exceptions may be granted by the RWQCB if the discharger can demonstrate that such discharge will not exceed the moisture-holding capacity of the landfill.
Mining Waste - Group B	Double Liner (natural features capable of containing waste and leachate may satisfy primary containment requirements	Blanket Type Required	May not be sited on a holocene fault	
Mining Waste - Group C	No liners required	Not Required	May not be sited on a halocene fault unless displacement will not allow escape of wastes or cause irreparable damage to containment structures.	
Wastewater		N/A		Title 27 requirements not applicable if discharge complies with applicable water quality control plan, discharge is not considered hazardous waste, and WDRS have been issued or waived by the appropriate RWQCB.
Class II Surface Impoundment	Double Liner (natural features capable of containing waste and leachate may satisfy primary containment requirements	Blanket Type Required		

1. All new landfills, waste piles, and surface impoundments shall be sited, constructed, and operated to ensure that wastes will be a minimum of 5 feet above the highest anticipated elevation off underlying groundwater.