CHAPTER V

Alternatives Eliminated

Chapter V

ALTERNATIVES ELIMINATED

This chapter describes alternative plans that have been proposed to address Salton Sea problems but that were eliminated from further consideration during the screening process. Plans in this chapter did not satisfy elimination criteria described in Chapter III. Reasons for their elimination are presented in this chapter.

5.0 INTRODUCTION

Alternatives described in this chapter were dismissed from further consideration because they failed to satisfy one or more of the basic elimination criteria described in Chapter III. The elimination criteria consisted of the following four components:

1. Reaching a target salinity level of 35 to 40 ppt;
2. Reaching a target elevation range of -230 to -235 feet msl;
3. The utilization of proven technology; and
4. A $10 million threshold in annual OME&R costs.

Of the 54 alternatives that were considered during the evaluation process, 49 were eliminated from further consideration. Each of those alternatives are described in this chapter along with the applicable reasons for elimination. Although additional information might be available for some of the alternatives, only enough information was provided in this chapter to allow for determining that the alternative did not meet at least one of the elimination criterion. If costs were given, those costs were indexed to January 1996 using techniques presented in Chapter IV. For the most part, information describing the alternative came directly from the original sources.

5.1 ELIMINATION SUMMARY

Table 13 depicts various categories of alternatives with individual titles of proposals listed under each category. Following the title of individual alternatives, in italics, is a number corresponding to the reason(s) why an individual alternative did not meet one or more of the elimination criteria.

SALTON SEA ALTERNATIVES

Table 13 - Elimination Summary

DIKED IMPOUNDMENTS

6. 30 mi^2 with pumping *(4)*
7. 30 mi^2 max pump *(4)*
13. 190 mi^2 - Plastic Curtain *(3)*
14. Various Sized Impoundments - Plastic Curtain *(3)*

PUMP-OUT

8. Onshore Evaporation Ponds *(4)*
9. Enhanced Evap/Solar Pond/Power *(4)*
10. Dry Lake Bed (Palen, Clark, or Ford) *(4)*
11. Pipe to Pacific Ocean/Camp Pendleton *(4)*
12. Navigable Waterway/Mexicali Seaport *(4)*
15. Canal/Dam to Base of Chocolate Mts *(1)*
16. Diked Impoundment to Gulf of CA *(4)*
17. Frontier Aquadyne Enhanced Evaporation *(3,4)*
18. Solar Still Desalt/Colo River Replenish *(3)*
19. SNAP Technology *(3)*
20. Aquaculture/Evaporation Ponds *(1,2)*
21. Pump to Gulf of CA (415K AF) *(4)*
22. Pump to Laguna Salada/Gulf of CA (415K AF) *(4)*
23. Pumped Storage Canal to Gulf of CA *(4)*
24. Solar Membrane Distillation *(3)*
25. Disposal of Reject Stream to Yuma *(1,2)*

COMBINATION

26. Impound/EvapPond/Pipe to Gulf of CA/YDP *(4)*
27. Impound/Power Generation/Wetlands *(4)*
28. Freshwater Shore/Pumped Storage/Wetlands *(4)*
29. Solar Power/Pumped Storage/Wetlands with Laguna Salada Disposal *(4)*

REMOVAL OF INFLOW SALT

30. Move Yuma Desalting Plant to Sea *(2,4)*
31. Poplar Tree Constructed Wetlands *(1,2)*
32. Special Pre-Treatment Reservoirs *(1,2,3)*
33. U.S. Filter-New River Desalting *(1,2,4)*
34. Groundwater Pump for Selenium Mgmt *(1,2)*

WATER IMPORTS

35. Freshwater Blending - Calexico *(2)*
36. Replenish - Colorado River Surplus *(2)*

OTHER

37. Venturi Air Pump *(1,2)*
38. Foraminifera Studies (Research) *(1,2,3)*
39. Potential Use Study Ponds (Research) *(1,2,3)*
40. Injection Well Salt Disposal *(4)*
41. Air Diffusion/Ultraviolet Ozone System *(1,2)*
42. Surface Aeration *(1,2)*
43. Gravel Berm *(1,2)*
44. Sea Water Filtration *(1,2)*
45. Enzyme-Activated Removal *(1,2)*
46. Power/Freshwater Cogeneration *(1,2)*
47. Water Conservation *(1)*
48. Drainage Water Reuse or Blending *(1)*
49. Pulsed Plasma *(3)*
50. Hydropower/Filtration System Resort *(3,4)*
51. Slow Sand Reverse Osmosis Filtration *(1,2,4)*
52. Electrochemical Extraction *(2,3)*
53. Mexican Cleanup of New River *(1)*
54. Land Speed Racetrack *(1,2)*

Note: Numbers in italics following an alternative's title indicate which elimination criteria were applicable in dismissing the proposal from further consideration as follows:
(1) Salinity 35-40 ppt *(2)* Elevation -230 to -235 ft msl *(3)* Unproven Technology *(4)* OME&R > $10 M

Alternative 6	Diked Impoundment 30 Square Mile With Pumping

HISTORY

This alternative was included in the Reclamation and RAC report, *Salton Sea Project, California, Federal-State Feasibility Report* (1974). It was identified as Plan B in that report.

PROPOSAL DESCRIPTION

This plan would be comprised of three distinct parts. First, a 30-mi^2 diked impoundment would be constructed in the southeastern end of the Salton Sea. The dike would be a continuous, 22-mile earthen dike built on the Sea floor, with the shoreward side approximately 1/4 mile offshore. The dike would be connected to shore at two locations by causeways and would be available for recreational uses, such as fishing and sightseeing. One inlet structure would control the flow of water into the impoundment.

The second part of the plan would include a pumping facility to remove 95 ft^3/s (65,000 AF per year) of concentrated salt water from the impoundment in the Sea through a pipeline to Palen Dry Lake, northeast of the Sea. An earthen dam would be constructed at Palen Dry Lake to form a brine disposal pond.

To prevent decreasing the Sea's water level by the removal of saltwater, freshwater in the same amount would be obtained from a well field in the East Mesa and conveyed via the East Highline Canal and the existing drainage system to the Sea.

EVALUATION OF ALTERNATIVE

This alternative is problematic for a number of reasons. East Mesa groundwater between the Coachella Canal and East Highline Canal is relatively poor in quality, and the yield of wells would be relatively low because of relatively low aquifer hydraulic conductivity (*Colorado River Recharge Study, Imperial County, California,* Reclamation, December 14, 1989). Furthermore, a lower water table due to pumping would induce leakage from the unlined East Highline Canal and All-American Canal which are in hydraulic connection to the water table. In time, the induced leakage would equal well field pumping. Pumping East Mesa groundwater east of the sand dunes would have little direct impact on United States water because the Coachella Canal is lined, and water in the All-American Canal is not hydraulically connected to the water table. However, significant pumping east of the dunes would decrease or reverse the All-American Canal seepage-induced groundwater gradient to Mexico. This would raise a significant issue with Mexico.

O&M COSTS

Operational costs consist primarily of annual power cost but also include adjustments to the passive dike structure inlet controls. Automation could reduce the daily operational requirements. Maintenance costs would include grading the dike surface; weed control; painting exposed metal surfaces; annual refurbishment of the pumping plant, pipeline, and surge tanks; and periodic grading of the access roadway along the pipeline right-of-way. Using an O&M cost of $38,000 per mile of dike per year would result in a yearly cost of $836,000. Dredging costs of $38,000 from the 1974 report indexed to 1996 dollars would be $121,000. The operational cost of facilities associated with Palen Dry Lake and the East Mesa well field, not including pumping energy costs, was $615,000 in the 1974 report. Indexing this cost to 1996 dollars was calculated to be $1.96 million per year. Pumping costs would be $13.3 million per year as follows:

95 ft^3/s = 65,000 AF/yr = 40,300 gal/min
50 mi of pipeline, 60-inches in diameter
Static head = 1,800 feet
Friction head = 200 feet
Total head = 2,000 feet

Hydraulic horsepower = (40,300 gal/min) (2,000 ft) / (3,960) (0.70 efficiency) = 29,080 HP

29,080 HP * 0.746 kW/HP * 24 hrs/day * 365 days/yr * $0.07 kWh = $13.303 million per year.

After about 40 years, the operation costs would be reduced to practically zero because the salinity target level could be maintained by the 30-mi^2 impoundment. Pumping would then cease, and there would be no power cost. The total O&M costs would be projected at $16.22 million per year until year 41 when the costs would be $332,000 per year.

COST		(1973 $)	(1996$)
Construction		$104,600,000	$440,200,000
Annual O&M	(yrs 1-40)	719,000	2,917,000
	(yrs 41+)	104,000	332,000
Pumping (Power)	(yrs 1-40)	1,766,000	13,303,000
	(yrs 41+)	0	0

CONSTRUCTION COSTS

This alternative built today would be similar to the 1974 report except that all embankment material would consist of onshore borrow. The dredged embankment material quantity listed in the 1974 report was replaced by onshore borrow and reduced to reflect the change in side slope placement from 4 to 1 to 2.5 to 1. An adjustment was made to the height and volume of the dike used in the 1974 report when the Sea was approximately 5 feet lower in elevation. The cost for constructing the 22-mile dike, using the end dump method with a revised volume of 22.1 million yd^3 at $11.98 per yd^3, would be $264.8 million. The pumping plant, pipeline, and earthen dam at Palen Dry Lake required to remove 95 ft^3/s of water, would cost $126 million (1973 dollars indexed to 1996). The development and delivery of the East Mesa well field water would cost $49.4 million (1973 dollars indexed to 1996). The total cost for the three components of this alternative was calculated to be $440.2 million.

REASON FOR ELIMINATION

The proposal did not meet the requirement that O&M costs not exceed $10 million annually. For this reason, the alternative did not warrant further consideration.

Alternative 7	Diked Impoundment 30 Square Mile (Maximum Pumping)

HISTORY

This alternative was proposed in the Reclamation and RAC report, *Salton Sea Project, California, Federal-State Feasibility Report* (1974). It was identified as Plan C in that report.

PROPOSAL DESCRIPTION

This plan would be comprised of three distinct parts. First, a 30-mi^2 diked impoundment would be constructed in the southeastern end of the Salton Sea. The dike would be a continuous, 22-mile earthen dike built on the Sea floor, with the shoreward side approximately 1/4 mile offshore. The dike would be connected to shore at two locations by causeways and would be available for recreational uses, such as fishing and sightseeing. One inlet structure would control the flow of water into the impoundment.

The second part of the plan would include a pumping facility to remove 195 ft^3/s (135,000 AF per year) of concentrated salt water from the impoundment in the Sea through a pipeline to Palen Dry Lake, northeast of the Sea. An earthen dam would be constructed at Palen Dry Lake to form a brine disposal pond.

To prevent decreasing the Sea's water level by the removal of saltwater, freshwater in the same amount would be obtained from a well field in the East Mesa and conveyed via the East Highline Canal and the existing drainage system to the Sea.

EVALUATION OF ALTERNATIVE

The use of East Mesa water is problematic for a number of reasons. East Mesa groundwater between the Coachella Canal and East Highline Canal is relatively poor in quality, and the yield of wells would be relatively low because of relatively low aquifer hydraulic conductivity (*Colorado River Recharge Study, Imperial County, California,* Reclamation, December 14, 1989). Furthermore, a lower water table due to pumping would induce leakage from the unlined East Highline Canal and All-American Canal which are in hydraulic connection to the water table. In time, the induced leakage would equal well field pumping. Pumping East Mesa groundwater east of the sand dunes would have little direct impact on United States water because the Coachella Canal is lined, and water in the All-American Canal is not hydraulically connected to the water table. However, significant pumping east of the dunes would decrease or reverse the All-American Canal seepage-induced groundwater gradient to Mexico. This would create a significant issue with Mexico.

O&M COSTS

Operational costs of the pumping plant would include annual power costs; periodic refurbishing of the pumps, controls, and pipelines; and adjustments to the passive dike structure inlet controls. Automation could reduce the daily maintenance. Maintenance costs would include grading the dike surface; weed control; painting exposed metal surfaces; annual refurbishment of the pumping plant, pipeline, and surge tanks; and periodic grading of the access roadway along the pipeline right-of-way. Using an O&M cost of $38,000 per year per mile of dike would result in a yearly cost of $836,000. Dredging costs of $38,000 from the 1974 report, indexed to 1996, would be $121,000. The operational cost of facilities associated with Palen Dry Lake and the East Mesa well field, not including pumping energy costs, was $937,000 in the 1974 report. This cost, indexed to 1996 dollars, would be $2.984 million per year. Pumping costs would be $28.93 million per year as follows:

195 ft^3/s = 135,000 AF/yr = 83,475 gal/min
50 miles of pipeline, 84 inches in diameter
Static head = 1,800 feet
Friction head = 300 feet
Total head = 2,100 feet

Hydraulic horsepower = (83,475 gal/min) (2,100 feet) / (3,960) (0.70 efficiency) = 63,240 HP

63,240 HP * 0.746 kW/HP * 24 hrs/day * 365 days/yr * $0.07 kWh = $28.928 million per year.

In year 26, the operational costs would be reduced to practically zero as equilibrium between inflow and evaporation would have occurred. Pumping would cease, and there would be no power cost. The total O&M costs would be $32.87 million per year until year 26 when the costs would be $332,000 per year.

COST		(1973 $)	(1996 $)
Construction		$140,700,000	$555,300,000
Annual O&M	(yrs 1-25)	1,041,000	3,941,000
	(yrs 26+)	104,000	332,000
Pumping (Power)	(yrs 1-25)	3,667,000	28,928,000
	(yrs 26+)	0	0

CONSTRUCTION COSTS

This alternative built today would be similar to the 1974 report except that all embankment material would consist of onshore borrow. The dredged embankment material quantity listed in the 1974 report was replaced by onshore borrow and reduced to reflect the change in side slope placement, from 4 to 1 to 2.5 to 1. An adjustment was made to the height and volume of the dike used in the 1974 report when the Sea was approximately 5 feet lower in elevation. The cost for constructing the 22-mile dike, using the end dump method with a revised volume of 22.1 million yd^3 at \$11.98 per yd^3, would be \$264.8 million. The pumping plant, pipeline, and earthen dam at Palen Dry Lake required to remove 195 ft^3/s of water would cost \$207.4 million (1973 dollars indexed to 1996). The development and delivery of the East Mesa well field water would cost \$83.1 million (1973 dollars indexed to 1996). The total cost for the three components of this alternative would be \$555.3 million.

REASON FOR ELIMINATION

The proposal did not meet the requirement that O&M costs not exceed \$10 million annually. For this reason, the alternative did not warrant further consideration.

PUMP-OUT OPTIONS

INTRODUCTION

A number of alternatives, which would involve pumping water out of the Sea as the principal means of reducing salinity, were proposed. Pump-out alternatives would reduce salt concentrations through the creation of a surrogate outlet by pumping water from the Sea to a receiving body of water. This receiving body of water would be the Gulf of California, Laguna Salada, a desert dry lakebed, the Pacific Ocean, or some other water sink, such as a deep groundwater aquifer.

Salts would be exported to the receiving water through the outflow, rather than remaining in the Sea and increase in concentration as water evaporates from the surface. Since water in the Sea has a higher salt burden than inflow from the Alamo River, New River, and other inflow sources, the salt load in the Sea would decline over time, thereby reducing salinity concentrations.

In addition to salts being exported from the Sea with a pump-out alternative, the Sea's total water volume would be reduced. This would create a Sea shrinking in size. A smaller Sea would have two implications. First, a smaller water volume means that remaining salt would be more concentrated and salinity reductions would happen more slowly than if water volume in the Sea remained constant. Second, a smaller Sea would place shoreline development further from the water. In order to mitigate these undesirable effects, some alternatives included two-way pumping—pumping out to a receiving water body and pumping fresher water back into the Sea.

Suggested rates of pump-out range from 150,000 AF per year to about 400,000 AF per year. Pump-out rates were directly correlated to the rate of salinity decrease in the Sea—the higher the pump-out rate, the faster the salinity reduction in the Sea. Once the Sea reached a target salinity, pumping volumes could be reduced to maintain the target level.

Costs for pump-out alternatives would be closely linked with the location of the receiving water body and the amount of water pumped out each year. Return pumping to control water surface elevations in the Sea also would have a drastic impact on estimated cost. With respect to the pump-out alternatives, the annual pumping costs, including efficiencies and losses and electrical costs for pumping Sea water, were presented in dollar figures. The annual cost of energy would include energy losses due to efficiencies of the equipment.

All pump-out alternatives would require an inlet structure, one or more pumps, and conveyance facilities consisting of a pipeline, a canal, or a combination pipeline/canal. Some of the alternatives eliminated would require earth embankment dams to contain water in the receiving area; others would include opportunities for energy recovery.

While water in the Sea would become less saline until it reaches an equilibrium level, the receiving water body would become more concentrated. This would not be a problem for the ocean or Gulf of California, but it could be an issue for a dry lake or some other repository. For the solar pond concept, this actually would be an advantage since solar ponds could not operate until salinity concentrations approach saturated levels.

The reliance on mechanical and electrical equipment for moving water would make pump-out alternatives more susceptible to unscheduled down time, more dependent upon O&M procedures, and require higher operating budgets as compared to diked impoundments within the Sea.

Alternative 8	Pump-out Onshore Evaporation Ponds (Site Unidentified)

HISTORY

First examined in the Reclamation and RAC report, *Salton Sea Project, California, Federal-State Reconnaissance Report* (1969) and in the final report (1974), this alternative was also included in the Aerospace Corporation report, *Salinity Control Study, Salton Sea Project, Report No. ATR-71 (S990)-5* (1971).

PROPOSAL DESCRIPTION

This alternative would involve pumping Sea water into evaporation ponds located onshore where the water would be evaporated, leaving behind saline residue. Saline water would be removed from the Sea until the desired salinity was reached. At this point, pump-out would continue at a lower rate so that salts removed by pump-out each year would equal the annual inflow of salts. Eventually, the evaporation ponds would fill with salts, and disposal would be necessary. The southeastern shore of the Sea, between Bombay Beach and Red Hill, would be a potential location for onshore evaporation ponds.

In the initial stages of this proposal, a total of 400,000 AF of water would be pumped each year. To evaporate this quantity of water would require nearly 70,200 acres, calculated as follows: (400,000 AF per year / 5.7 feet per year).

EVALUATION OF ALTERNATIVE

This alternative would require the construction of about 70,200 acres of evaporation ponds near the shore of the Sea and a pump/pipe system to transfer the water from the Sea to the evaporation ponds. The evaporation ponds would require lining to protect the surrounding groundwater environment.

Implementation of this alternative would achieve the target salinity levels in less than 10 years; therefore, for purposes of this evaluation, it was assumed that evaporation pond capacity would be adjusted to stabilize the elevation of the Sea.

OME&R COSTS

OME&R costs for this alternative would include the cost of pumping water from the Sea to the evaporation ponds and the cost of replacing the liner systems within the evaporation ponds.

Pumping costs for 400,000 AF were based on an assumed elevation head of 50 feet and a friction head loss of 35 feet for a total of 85 feet. The annual cost to pump 400,000 AF per year was calculated to be $3.9 million (see Table 14).

Assuming a 10-year life for the lining under the evaporation ponds and providing an evaporation capacity of 100,000 AF (100,000 AF / 5.7 AF per year = 17,500 acres), replacement costs would total about $122.53 million every 10 years (17,500 acres * $7,000 per acre for placement of liner). When spread over 10 years, the costs for replacing the liner system for 17,500 acres would be slightly over $12 million per year.

Based on the pumping costs and liner replacement costs, the annual OME&R costs for this alternative would be $16 million per year.

CONSTRUCTION COSTS

Construction costs were not calculated since the annual OME&R costs would exceed $10 million per year.

REASON FOR ELIMINATION

OME&R costs would exceed the annual $10 million threshold; therefore, no further consideration of this alternative was warranted.

Table 14
Alternative 8
400,000 AF to Evaporation Ponds

Flow AF	Flow ft³/s	Flow gal/min	Elevation head	Friction head	Total head	hp
400,000	550	246,933.33	50	35	85	7,571.91

kW	kWh/yr	Electric cost	Replace cost	Annual replace cost	Annual O&M	Total OME&R
5,648.64	49,482,126.18	3,463,748.83	1,855,117.85	185,511.78	218,071	3,867,331.61

hp = (gal/min * total head) / (3,960 * efficiency)

kW = hp * 0.746

kW/yr = kW * 24 hrs/day * 365 days/yr

Electric cost = kW/yr * $0.07/kWh

Replacement cost = $245 per hp

Annual O&M costs = $28.80 per hp

Alternative 9 **Pump-out**
Enhanced Evaporation/Solar Pond/Power Generation

HISTORY

First proposed by Ormat Turbines (Yavne, Israel) in *A Study of the Feasibility of a Solar Salt Pond Generating Facility in the State of California, U.S.A.* (1980), an updated proposal was submitted by Ormat Technical Services, Inc. (610 East Glendale Avenue, Sparks, Nevada 89431) in the *Salton Sea Project, Preliminary Study* (March 1989). This alternative was included in Meyer Resources, Inc. (Davis, California) in the *Summary Analysis of Authorities and Responsibilities Associated with the Salton Sea* (1988); Imperial Irrigation District (Imperial, California) and the County of Imperial (El Centro, California) in the *Salton Sea Mitigation Plan Phase I* (1988); and Coachella Valley Water District (Coachella, California) (undated). All of the proposals used technology first proposed by Ormat in 1980.

PROPOSAL DESCRIPTION

The proposed project would be a combination of three basic technologies: the Enhanced Evaporation System (EES), a lined solar pond system, and a power plant (see Illustration 6). Sea water would be pumped to a spray system, located 20 to 100 feet above the solar pond surface, where it would then be sprayed in droplets over the solar pond. The nozzles on the spray system could be adjusted to produce droplets of the desired size, thereby increasing the rate of evaporation and lessening the drift of the spray, as required (see Illustration 7).

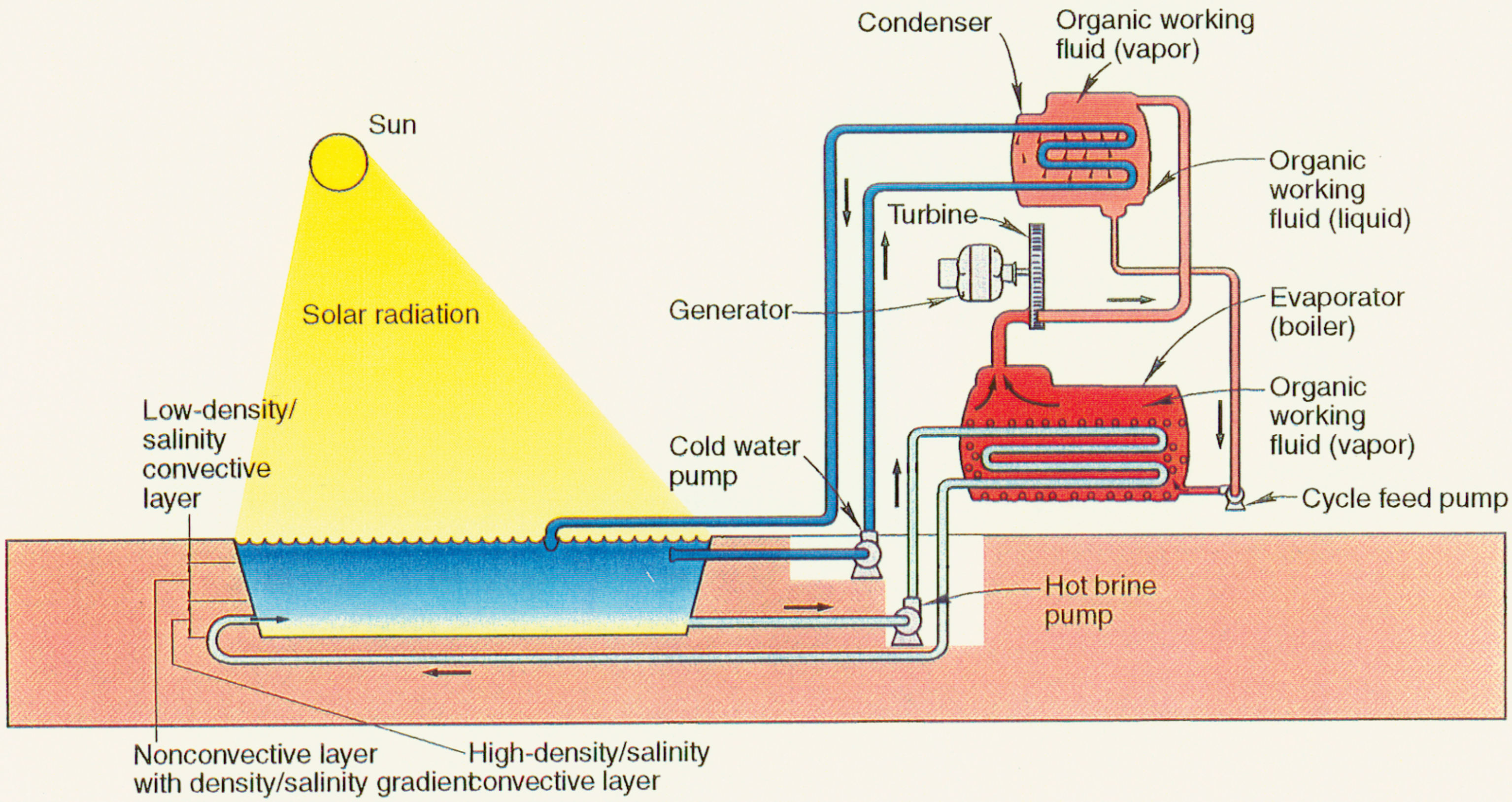
The project would be built in modules, each of which would consist of smaller duplicated subsystems. One module would evaporate 25,000 AF per year and would occupy a maximum area of 2.0 by 1.2 miles. Total electric generating capacity for each module would be 4 MW (36,000 megawatt hours per year (MWh/yr)).

Each "basic module" would include the following features:

- 612 acres of EES
- 4 (and up to 8) 1.0 MW Ormat Energy Converters
- 4 (and up to 8) 40-acre solar ponds
- A 75-acre crystallization pond
- 1 deep injection well (optional).

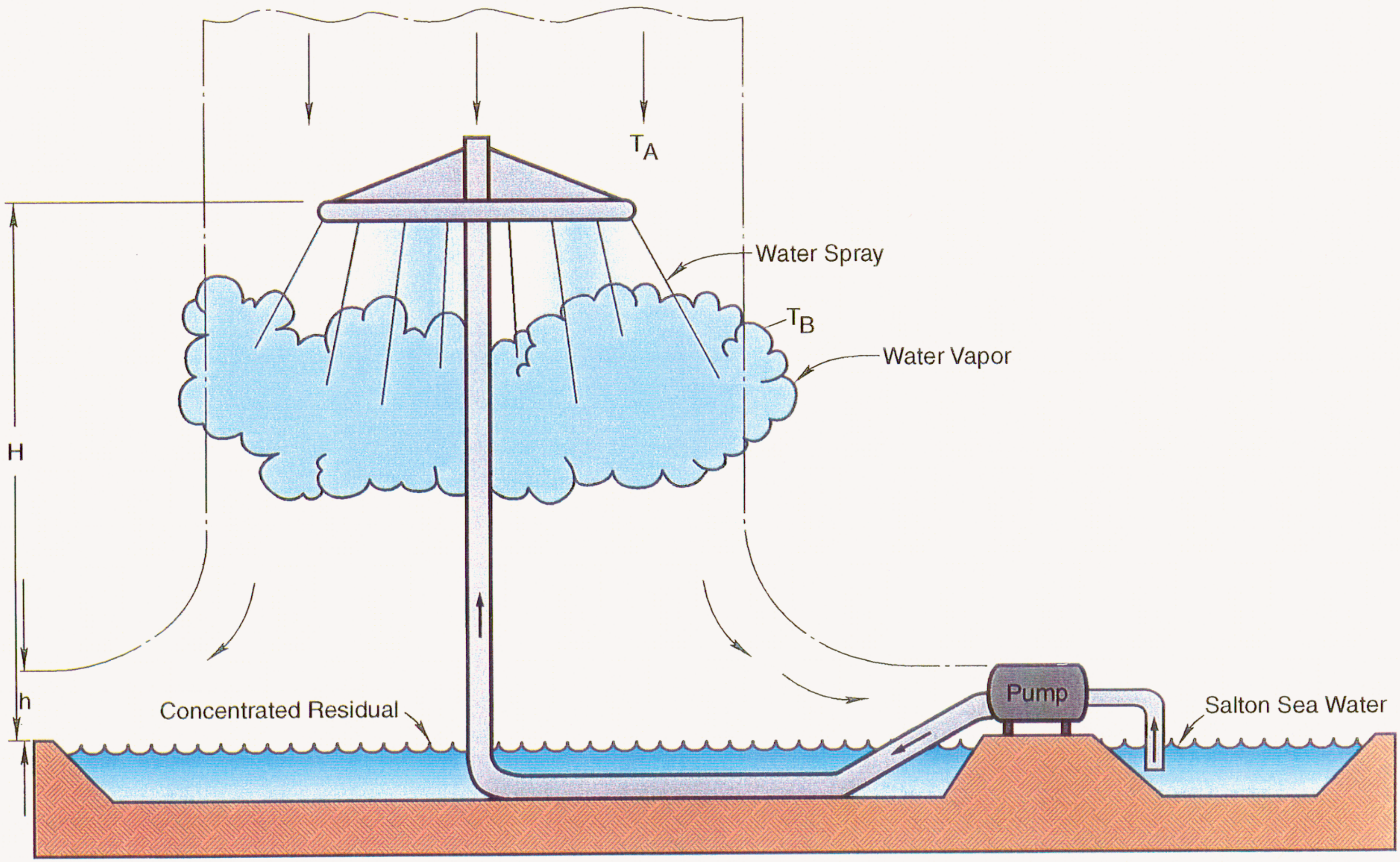
Four of these modules would be needed for the original 100,000 AF per year project, while nine of the "basic modules" could evaporate 225,000 AF per year of Sea water with a total capacity of either 36 MW (144,000 MWh/yr) or 72 MW (288,000 MWh/yr).

THE SOLAR POND POWER PLANT



In a solar pond power plant, the pond collects and stores solar energy. Hot brine from the lower bottom layer evaporates organic fluid which, in turn, expands in a turbine, producing mechanical work that is subsequently converted into electricity. A condenser cools the fluid.

Alternative No. 9
Illustration No. 6



Alternative No. 9
Illustration No. 7

These modules could be constructed in one area or spread out in different site locations around the Sea. This project would be modular by nature, which would enable a shorter construction period than a single large project, lower component costs, and lower on-site construction costs. In addition, the vendor stated that it would give operating unit redundancy, enabling the combined system performance to maintain a high capacity factor with a high level of confidence.

EVALUATION OF ALTERNATIVE

Pumping 250,000 AF per year from the Sea would reduce salinities to target within a reasonable time—probably about 10 years.

Production of energy by solar ponds has been demonstrated to work, but commercialization has not progressed in the United States because, in general, production costs are higher than alternative energy production methods. Ormat's costs, using estimated developed in 1980 and 1989, indicated energy production costs of $0.10 to $0.20 per kWh, assuming 20-year amortization of capital investment at 7 percent interest (Ormat, 1989; and Ormat Turbines, Ltd., *A Study of the Feasibility of a Solar Salt Pond Generating Facility in the State of California, U.S.A.*, November 1980, p. 14-9).

OME&R COSTS

OME&R costs for a nine-module project would be $29.2 million per year. Pumping costs would represent about $4.2 million of this figure, with lines replacement adding $4.9 million and subsidy for power production adding $10.8 million. The remainder of the OME&R costs were indexed from costs provided in the Ormat proposal.

Calculations for pumping costs are as follows:

225,000 AF per year = 138,400 gal/min.
Static head = 150 feet
Friction head = 35 feet
Total head = 185 feet.

Hydraulic horsepower = (138,400 gal/min) (185 feet) / (3,960) (0.70 efficiency) = 9,240 HP
9,240 HP * 0.746 kW/HP * 24 hours/day * 365 days/year * $0.07 kWh = $4.227 million per year.

ORMAT, 1989		
COST (1996 $)	**4 modules**	**9 modules**
Construction	$186 million	$418.5 million
Annual OME&R	$6 million	$13.5 million

Assuming a 10-year life for the lining under the solar pond and EES system, replacement costs would total over $48.6 million every 10 years as follows:

612 acres for EES + 160 acres for solar ponds = 772 acres.

Further, 772 acres per unit * 9 units * $7,000 per acre for placement of liner.

When spread over 10 years, the costs for replacing the liner system in all of the EES facilities and solar ponds would be $4.9 million per year.

With production costs of $0.10 to $0.20 per kWh and retail energy available for about $0.07 per kWh, solar pond energy production would have to be heavily subsidized. With a 36-MW facility and subsidy of $0.07 per kWh (assuming a cost of $0.14 and sale at $0.07 per kWh), the annual subsidy would amount to over $10.8 million per year as follows:

36,000 kW * 12 hrs/day * 365 days/year * $0.07 per kWh.

CONSTRUCTION COSTS

Construction costs for this proposal would be $46.5 million (1989 cost indexed to 1996 dollars) per "basic module" for a minimum total of $186 million for four modules and $418.5 million for nine modules. Other considerations not calculated include the disposal costs for evaporated salts from the EES beds (lagoons) and periodic adjustment of the EES.

REASON FOR ELIMINATION

OME&R costs would exceed the $10 million annual threshold. Therefore, this alternative did not warrant further consideration.

Alternative 10	Pump-out Dry Lake Bed Evaporation (Palen, Clark, or Ford Lakes)

HISTORY

This alternative was one of a number of alternatives included in an appraisal study by Reclamation and the RAC, 1969. There was very little detail contained in the source material because it was recognized early on that costs and environmental implications made the proposal much less attractive than other proposals. It was necessary, therefore, to extrapolate information from other pumping proposals in order to determine viability.

PROPOSAL DESCRIPTION

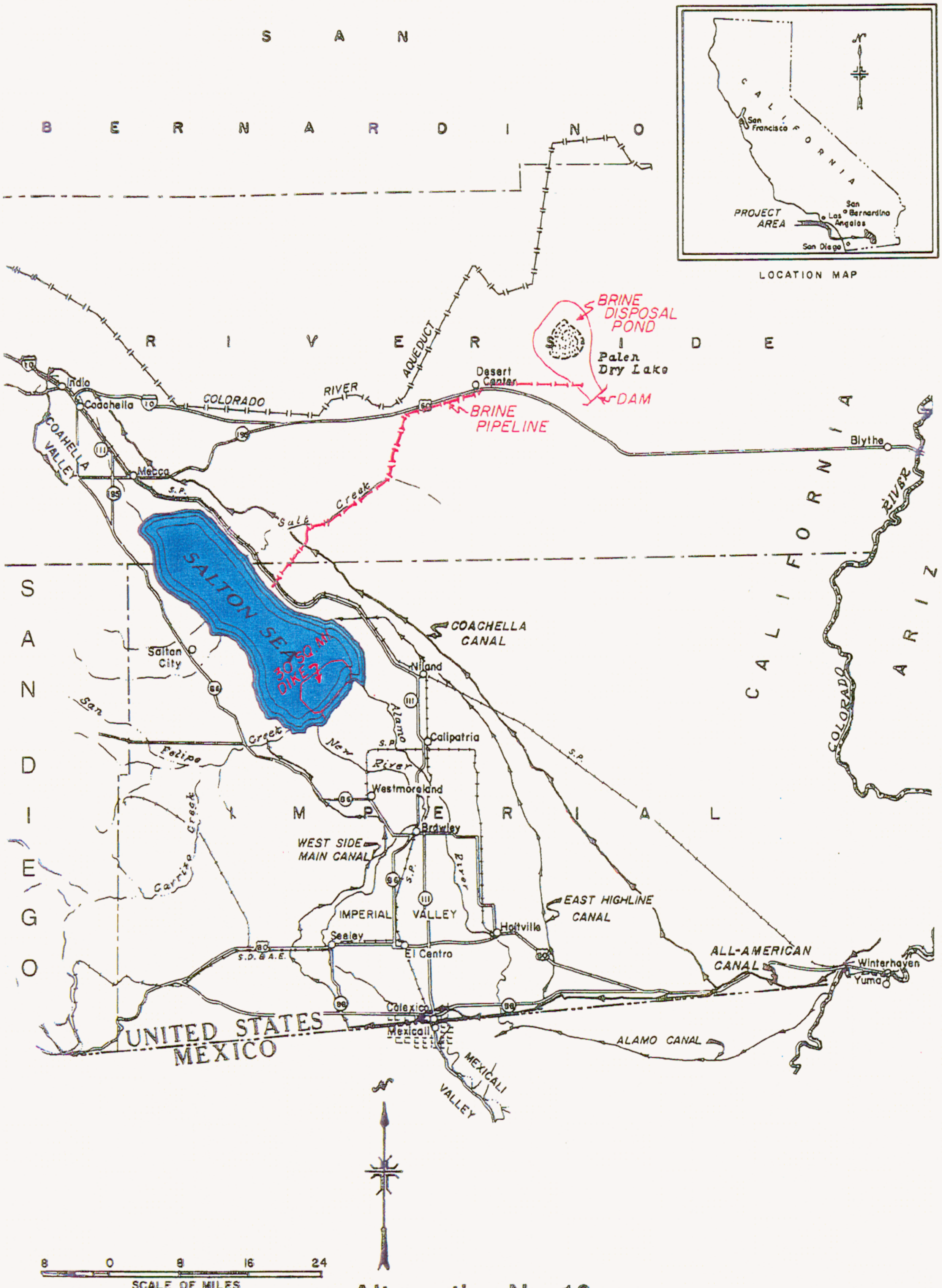
Water would be pumped from the Sea through a pipeline to one of three potential dry lake bed sites—Palen Lake or Ford Dry Lakes east of the Sea or Clark Lake west of the Sea (see Illustrations 8 and 9). For the purposes of this analysis, Palen Dry Lake was assumed to be the proposal evaporation site (Ford Dry Lake would have similar pumping requirements and a longer pipeline; Clark Dry Lake would have a shorter pipeline but would not have the capacity of the other two dry lakes).

An earthen dam would be constructed around Palen Dry Lake to form a sump to retain Sea water and its associated salt, thereby essentially acting as an evaporation pond and storage area for the salts removed from the Sea water.

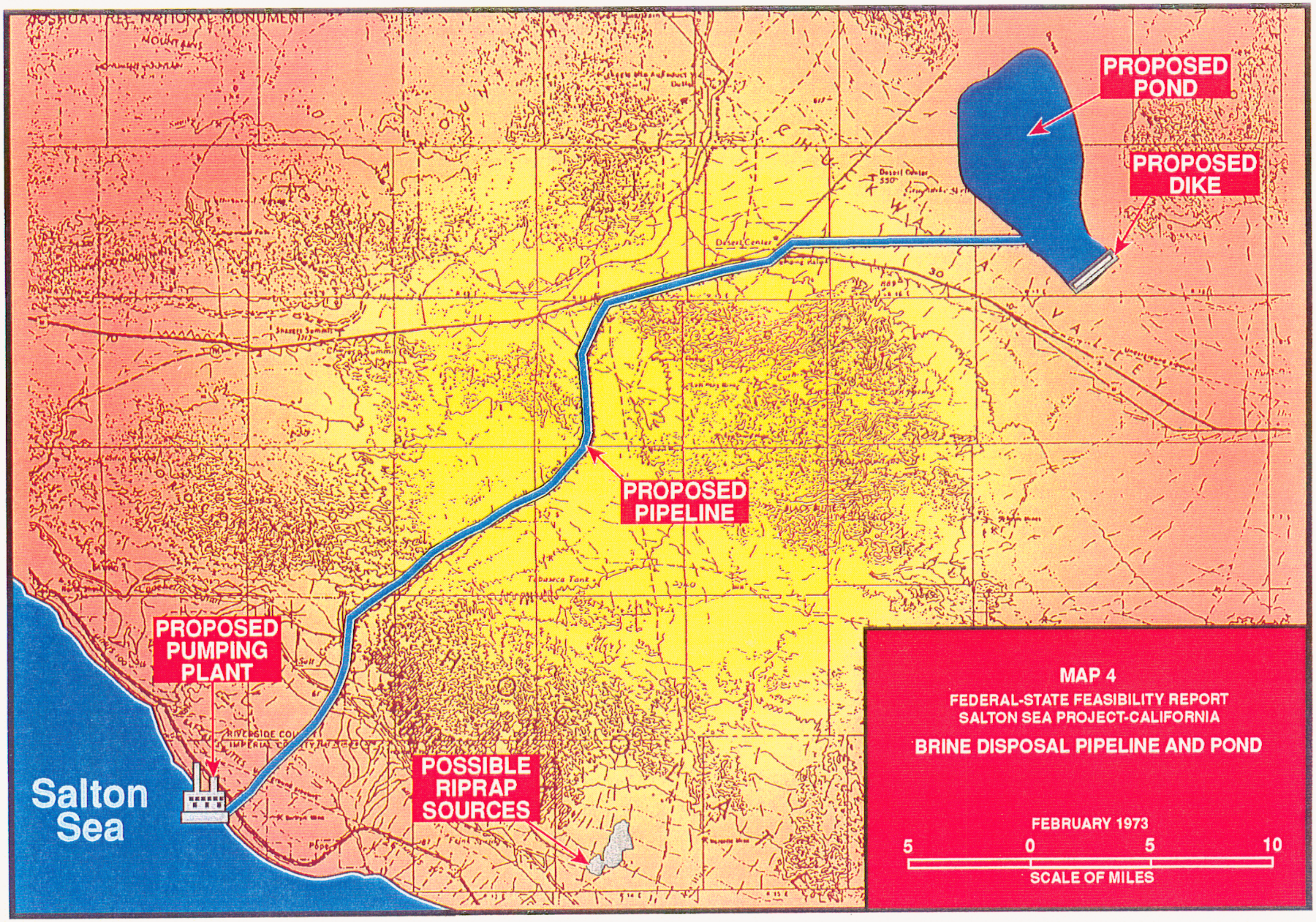
EVALUATION OF ALTERNATIVE

Initial pumping quantities could be between 200,000 and 400,000 AF per year, depending upon the acceptable time period to reach target salinity. The more water pumped, the faster the Sea would reach the salinity target. For the purposes of this analysis, a pumping rate of 200,000 AF per year was assumed. The Sea is at -235 feet msl. Palen Dry Lake is at 1,560 msl. This equated to a vertical lift of 1,795 feet. Without replenishment of the Sea water with freshwater (in addition to existing inflow), the Sea's elevation would decrease. The level of decreased elevation would depend on the amount of water pumped from the Sea every year.

Major components of the proposal included as many as six pumping plants lifting the water 1,795 feet, about 50 miles of pipeline, and an earthen dam around Palen Dry Lake.



Alternative No. 10
Illustration No. 8



Alternative No. 10
Illustration No. 9

OME&R COSTS

The major cost to operate this proposal would be energy costs. In order to pump 200,000 AF per year, the pumping system would require a capacity of about 275 ft^3/s. With a power requirement of 0.0846 kW to lift 1 ft^3/s by 1 foot, a total of 41,880 kW of pumping capacity would have to be installed to lift 275 ft^3/s 1,795 feet. Friction losses over the length of the pipeline would total about 320 feet of head. This would bring the total pumping head to 2,115 feet. Assuming 24-hour operation 365 days per year, pumping efficiency of 70 percent, and an energy cost of $0.07 a kWh, the annual pumping cost would be about $43,279,000 as follows:

275 ft^3/s = 200,000 AF/yr = 124,000 gal/min

124,000 gal/min * 2,115 ft / 3,960 * 0.70 = 94,610 HP

94,610 HP * 0.746 kW/HP = 70,579 kW

70,579 kW * (24 hrs) (365 days) * $0.07 = $43,279,256 per year.

Other operational costs would probably boost total OME&R costs to over $50 million per year. No attempt was made to determine the potential for energy recovery.

CONSTRUCTION COSTS

Construction costs were not calculated since the OME&R costs would exceed $10 million annually.

REASON FOR ELIMINATION

This proposal exceeded the $10 million annual limitation for OME&R costs. Therefore, this alternative did not warrant further consideration.

Alternative 11 **Pump-out**
Pipeline to Pacific Ocean (Camp Pendleton Area)
(pump-out only / pump-out and replenish)

HISTORY

While the concept of water transfer between the Sea and the ocean has been considered in the past, this specific proposal was provided by Mr. Kenneth A. Munro of Riverside, California, in response to public notification of the workshops held in August and September 1995 and in a letter dated May 24, 1994.

PROPOSAL DESCRIPTION

Under this proposal an artificial outlet to the Sea would be provided by pumping water from the Sea over the Laguna Mountains to the Pacific Ocean.

Suggestions that accompanied the proposal included use of State Highway 78 right-of-way for conveyance alignment to minimize construction cost (see Illustration 10), energy recovery, and location of the ocean discharge on the south boundary of Camp Pendleton, a Marine base at Oceanside, California.

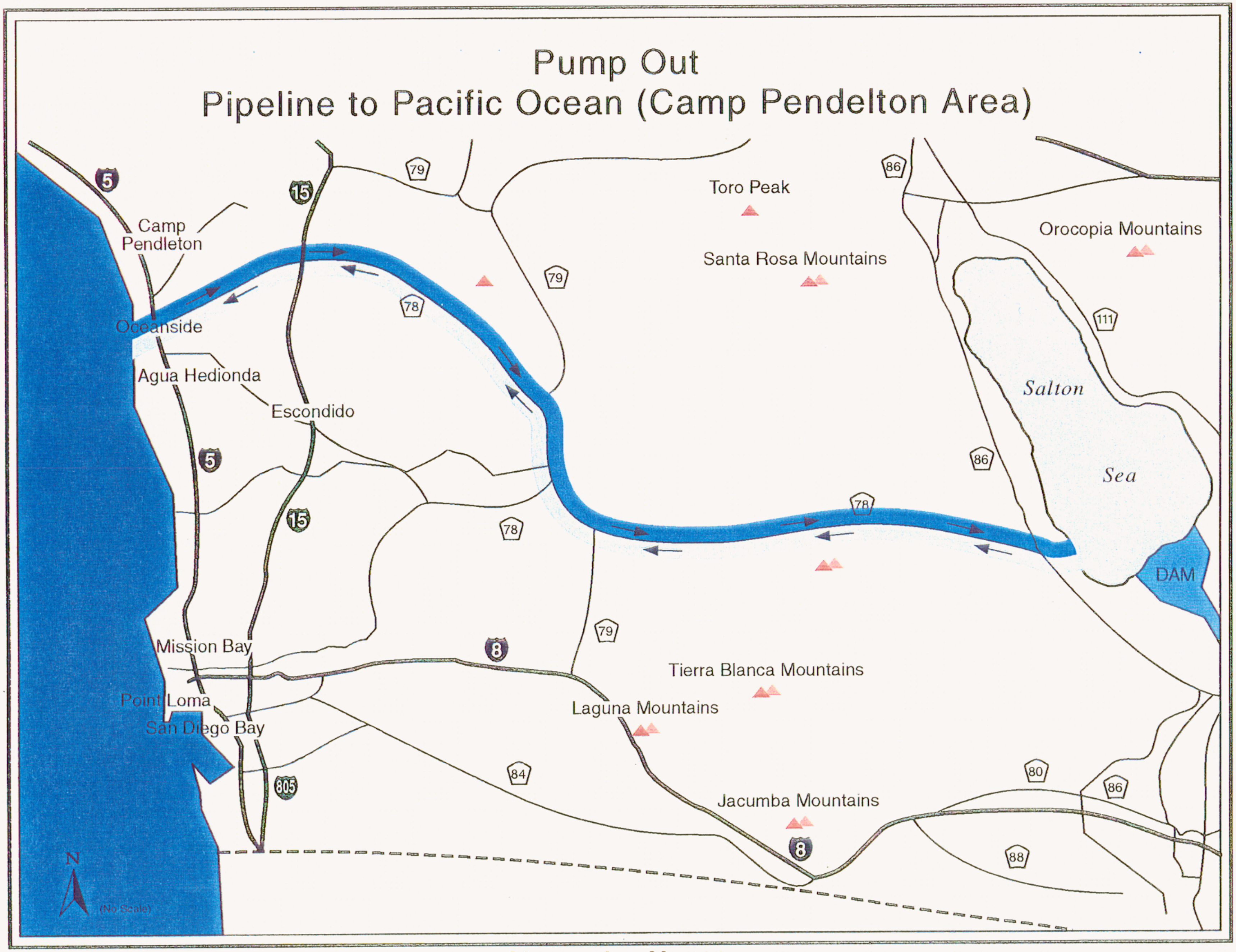
EVALUATION OF ALTERNATIVE

Proposal details—such as pipe sizes, conveyance type, conveyance alignment, intake and outlet location—have not been developed, but making reasonable assumptions allowed for appropriate calculations of costs.

Like all pump-out proposals, salinity in the Sea would initially increase because a reduction in Sea volume would concentrate remaining salt. Eventually, salinity would decline to a stable level as determined by the quantity of water pumped. A one-way pumping volume of 200,000 AF per year was assumed for the purpose of calculating costs. One-way pumping would eventually reduce salinity to target levels, but elevation could not be managed. In order to manage elevation, water would have to be imported from some source, presumably the ocean.

OME&R COSTS

Pumping costs were calculated by assuming a static pumping head of 4,000 feet, an energy cost of $0.07/ kWh, and energy recovery of the dynamic head plus one quarter of the static head. With a flow rate of 275 ft^3/s, 4,000 feet of head, and continuous pumping, 815,205,600 kWh of energy would be required. Energy recovery would reduce the power requirement to 611,400,000 kWh. Annual energy costs would be $42.8 million. Since energy costs would



Alternative No. 11
Illustration No. 10

exceed the $10 million elimination criterion, no attempt was made to calculate other operation costs. It should be noted, however, that pumping plants and energy recovery systems would add substantially to operational costs.

CONSTRUCTION COSTS

Construction costs even without two-way pumping would almost certainly be in the $300 to $400 million range, based on costs calculated for pumping to the Laguna Salada (Reclamation, 1991). While existing highway right-of-way was suggested as a possible alignment, it was questionable whether right-of-way widths would allow construction of a pipeline of the size required for this project. Even if highway right-of-way were available for pipeline construction, unacceptable traffic disruption could force the alignment away from highways.

REASON FOR ELIMINATION

This proposal exceeded the $10 million annual cost limitation for OME&R costs. In addition, without some sort of replenishment, elevations would not be controlled. Therefore, the alternative did not warrant further consideration.

Alternative 12 — **Pump-out**
Navigable Waterway/Mexicali Seaport
(pump-out and replenish)

HISTORY

This project was documented in Meyer Resources, Inc., *Problems and Potential Solutions at Salton Sea* (December 1988) and *Summary Analysis of Authorities and Responsibilities Associated with the Salton Sea* (December 1988), and the proposal was mentioned in the Dangermond and Associates report, *Strategies for the Restoration and Enhancement of the Salton Sea* (July 1994). It was also discussed in the Coachella Valley Water District report, *The Salton Sea* (undated).

PROPOSAL DESCRIPTION

None of the references provided any detailed information on a seaport or navigable waterway between the Gulf and Sea. Only the concept was presented.

No attempt was made to complete even preliminary designs for this alternative. Costs were estimated using gross calculations and extrapolations from existing locks.

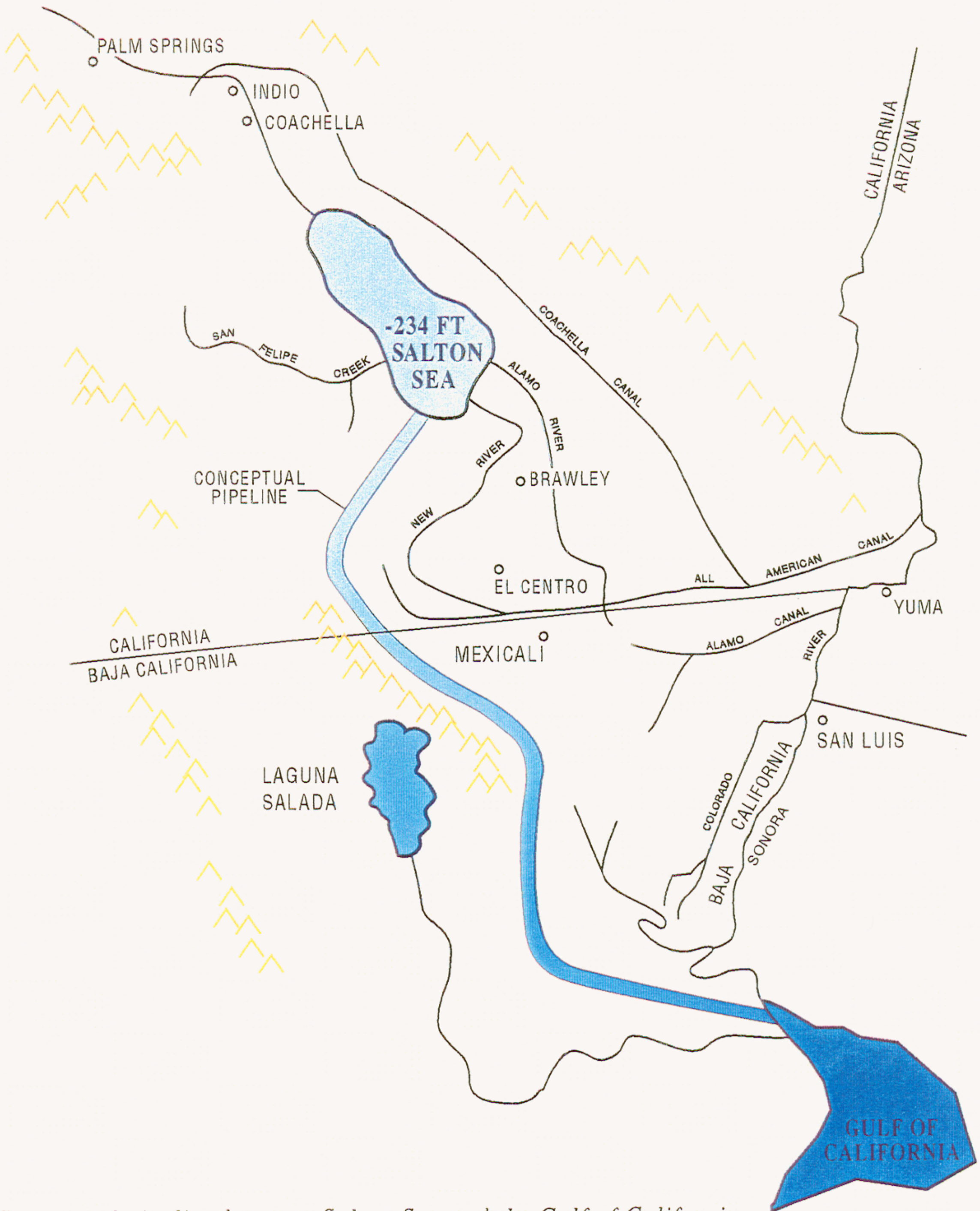
EVALUATION OF ALTERNATIVE

The idea of a channel between the Gulf of California and the Sea to allow recreational or commercial boat traffic to reach a marina on the Sea (see Illustration 11) has been around for a number of years. With passage of the North America Free Trade Agreement, discussion shifted toward an inland seaport near Mexicali. Boat or ship passage between the Gulf and the Sea would require a channel with locks that would maintain the water surface elevation difference between the two bodies of water, while a port at Mexicali would be built at sea level. For a navigable channel to the Sea, water could flow by gravity from the Gulf to the Sea, but it would have to be pumped in the opposite direction. The Laguna Salada has also been suggested as a possible location for the ocean end of a channel to the Sea.

In terms of providing an outlet to the Sea, this proposal was similar to other proposals to pump water to the Gulf or Laguna Salada. In the case of an inland seaport at Mexicali, the conveyance distance would be shortened by the distance from the port to the Gulf. As with all proposals to transport Sea water to the Gulf or other locations in Mexico, this proposal would have international implications. However, the port feature of this proposal would make Mexican involvement much more significant.

CONCEPTUAL PIPELINE

BETWEEN SALTON SEA AND
THE GULF OF CALIFORNIA



Conceptual pipeline between Salton Sea and the Gulf of California.

C596.DRW (3-15-1992)

Alternative No. 12

Illustration No. 11

OME&R COSTS

In order to provide salinity benefits to the Sea, at least 200,000 AF of water would have to be transferred from the Sea to the ocean. The water could be transferred by pumping into a series of locks or it could be pumped directly to the ocean, inland seaport, or Laguna Salada. Pumping costs would be similar among variations of this proposal.

Pumping costs were calculated by assuming a pumping head of 300 feet, a pumping rate of 275 ft^3/s (or 200,000 AF per year), and power costs of $0.07 per kWh. Friction losses over the length of the pipeline would be about 220 feet of head. This would bring the total pumping head to 715 feet. Annual pumping costs were calculated to be about $14,513,000 as follows:

275 ft^3/s = 200,000 AF/yr = 124,000 gal/min

124,000 gal/min * 715 ft /3,960 * 0.70 = 31,726 HP

31,726 HP * 0.746 kW/HP = 23,667 kW

70,579 kW * (24 hrs) (365 days) * $0.07 = $14,512,604 per year.

The annual replacement costs for equipment and pumps was estimated to be $780,000, and the annual maintenance cost was estimated to be $891,000. Total combined OME&R costs amount to $15.4 million.

O&M costs would include personnel, equipment, and supplies. Replacement of pumps and other equipment would also have to be considered. Without a design, estimating these costs was problematic, but a comparison was made with lock operation on the Mississippi River. Operation costs for each lock on the Mississippi River vary, but $20 million per year might be considered a conservative estimate (personal communication with Corps of Engineers personnel, St. Louis, Missouri). Of course, locks on the Mississippi River and the lock system considered here were quite different—in traffic type and volume, design, and maintenance priorities. However, it would not be unreasonable to assume that the operating cost of the entire Gulf/Sea system would equal the cost of one of the Mississippi River locks. Therefore, it was estimated that a system to support navigation would have an annual OME&R cost in excess of $20 million.

Costs could be offset by fees charged to boats and ships using the channel. There is no information, however, with which to estimate what those fees might be and how much revenue might be generated.

CONSTRUCTION COSTS

Construction costs were not estimated because the annual OME&R costs exceeded the $10 million ceiling.

REASON FOR ELIMINATION

This proposal exceeded the $10 million annual threshold for OME&R costs. Therefore, the alternative did not warrant further consideration.

Alternative 13	Diked Impoundment 190 Square Miles Plastic Curtain - Divide Sea in Half

HISTORY

The use of a plastic material for separating the Sea into sections with different salinity concentrations was proposed by Mr. Gerald Martin in a paper titled Salton Sea Barrier Curtain Project dated August 1995. A fax detailing the technical proposal was received by Reclamation on March 5, 1996. The technical proposal was prepared by GSE Lining Technology in July 1995. It was also examined in the Reclamation and TAC report, *A Value Engineering Evaluation of Salton Sea Alternative Dike Structures* (August 1995).

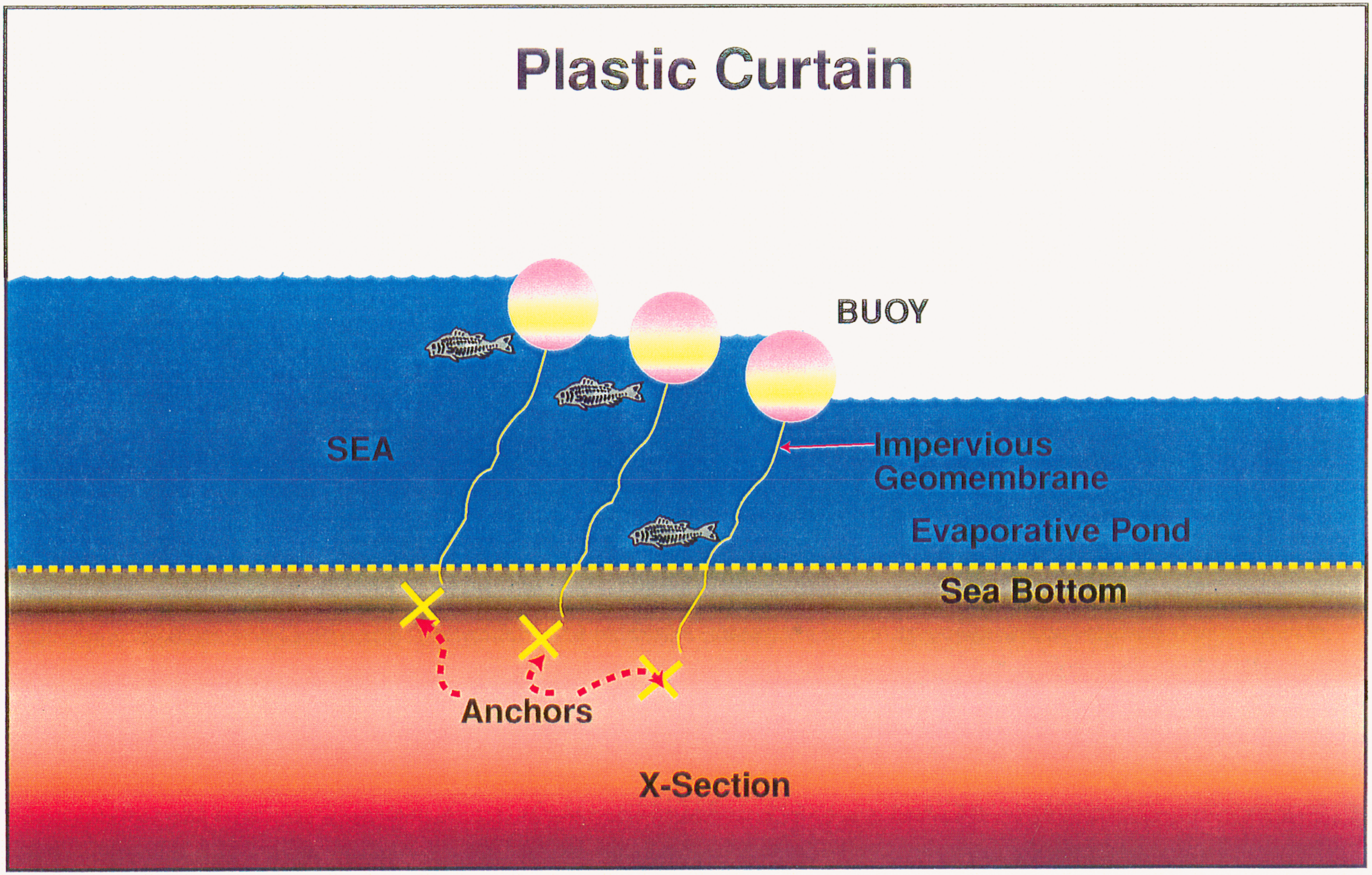
PROPOSAL DESCRIPTION

This proposal contemplated the separation of the Sea into an evaporation section and a fresher section, but, instead of using earth dikes, a high-density polyethylene dam or curtain would be used (see Illustration 12). Although a plastic curtain could be used anywhere in the Sea and in any configuration considered for earth dikes, this proposal specifically considered a dam that would be placed across the Sea to divide the Sea in half. The barrier would be located near the narrowest part of the Sea—just north of Bombay Beach—and would be placed to protrude 6 to 12 inches above the water surface to discourage water splashing over the top as a result of wave action (see Illustration 13). The barrier would be weighted on the bottom by a cement-filled tube, which would make it 95 percent water-tight. There would be several one-way gates to permit water to flow from the south end of the Sea to the north end.

EVALUATION OF ALTERNATIVE

The material was reportedly guaranteed for 20 years against deterioration from sunlight and anything found in the Sea except, of course, power boats and prop damage. It was unknown, however, if this had been verified under the conditions it would be subjected to at the Sea.

A system of three curtains was considered necessary in order to ensure reliability, limit the mixing effect caused by wave action over the tops of the suspension floats, and provide protection in case of a liner tear (Reclamation and TAC, 1995). If a rigid support system were installed to improve curtain stability to wind and wave action, this level of redundancy may be unnecessary and the material cost for curtains would decrease. However, material strength would be severely compromised by support structures necessary for inlet weirs, gates, and other flow control measures across the barrier (personal communication with lining systems distributors and installers, 1995).



Alternative No. 13
Illustration No. 12