*Chapter 6*

# Water Treatment Alternatives

## Reverse Osmosis Desalting Plant With Pump-Out / Pump-In

The proposed project would be a combination of two basic proven technologies as shown in figure 15, a reverse osmosis desalting plant with pump-in to the Sea and a pump-out system to one of the locations discussed under the pump-out alternative in chapter 5. The pump-out system would be put into operation first, and the desalting plant/pump-in system would be put into operation years later, after the elevation criteria has been reached, because the desalting plant is only needed to maintain the salinity and elevation once the target elevation has been reached.

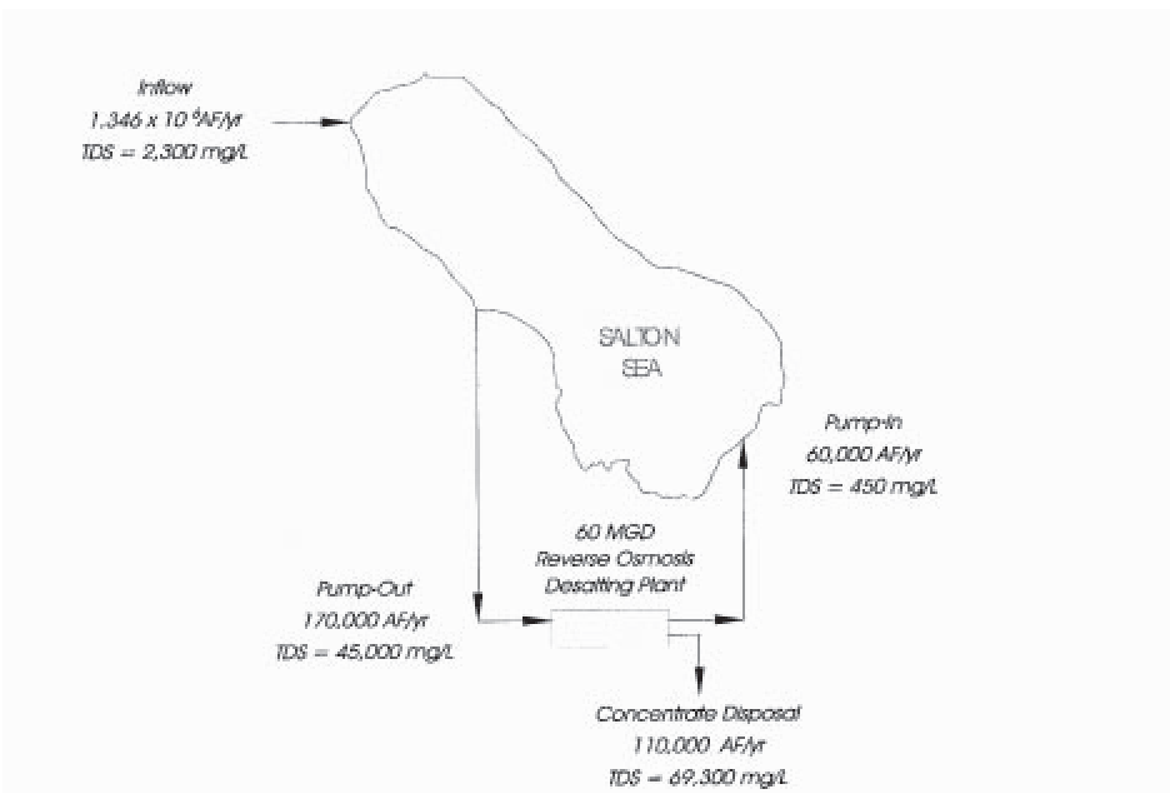



*Figure 15.—Reverse osmosis desalting plant with pump-in/pump-out.*

### *Analyses*

A conceptual design study was accomplished extrapolating the performance and cost data for a similar seawater reverse osmosis plant in the Arabian Gulf having a feed water with TDS of 45 ppt (Shields et al., 1996). The desalting plant would have a feed water flow rate from the Salton Sea of 170,000 acre-feet per year and an average TDS of 45 ppt. Because of the high TDS, the recovery ratio is not likely to exceed 35 percent. On this basis, the desalting plant would provide a freshwater pump-in rate back to the Salton Sea of 60,000 acre-feet per year at a TDS of approximately 0.45 ppt and a concentrate reject flow of 110,000 acre-feet per year at a TDS of 69.3 ppt. The costs and size of plant may possibly be reduced further by blending the product waterflow to match the higher TDS of other pump-in alternatives, but this was not included in this initial study. For the alternative that was studied, the pump-out system for the concentrate flow would have to be designed for a flow rate of 110,000 acre-feet per year.

A summary of the assumptions and results of this conceptual design study are as follows:

**Assumptions**

| | |
|---|---|
| Desalting plant capacity | 60 million gallons per day |
| Availability | 90 percent |
| Feed water TDS | 45 ppt |
| Product TDS | 0.45 ppt |
| Recovery ratio | 35 percent |
| Intake | Open Sea |
| Energy costs | $0.0725 per kilowatthour |
| Energy per 1,000 gallons | 27.8 kWh per 1,000 gallons |
| Energy cost per 1,000 gallons | $2.03 per 1,000 gallons |
| Average labor cost | $25 per hour weighted average (management, supervisors, and staff) |
| Capital amortization | 20 years at 8-percent interest |

1998 dollars

Capital cost of Salton Sea seawater plant estimated to be 50 percent higher than Arabian Gulf plant because the pretreatment system is expected to require removal of considerably more contaminants at the Salton Sea

**Results**

| | |
|---|---|
| Total construction capital cost | $435 million |

Labor — The estimated staffing required for the 60-million-gallon-per-day plant is as follows:

| | |
|---|---|
| Managers | 1 |
| Supervisors | 3 |
| Operators | 20 |
| Mechanics | 11 |
| Lab technicians | 2 |
| Office workers | 2 |

| | |
|---|---|
| Total workforce | 39 staff days per day |
| Total annual O&M cost | |
| Energy cost | $39.90 million per year |
| Labor | $2.85 million per year |
| Consumables, maintenance, and membrane replacement | $13.65 million per year |
| Total | $56.4 million per year |
| Product water produced per year | $1.97 \times 10^{10}$ gallons per year (about 60,000 acre-feet per year) |
| Total water cost | |
| Cost per 1,000 gallons | $5.11 per 1,000 gallons |
| Cost per acre-foot | $1,665 per acre-foot |

## *Pilot Plant*

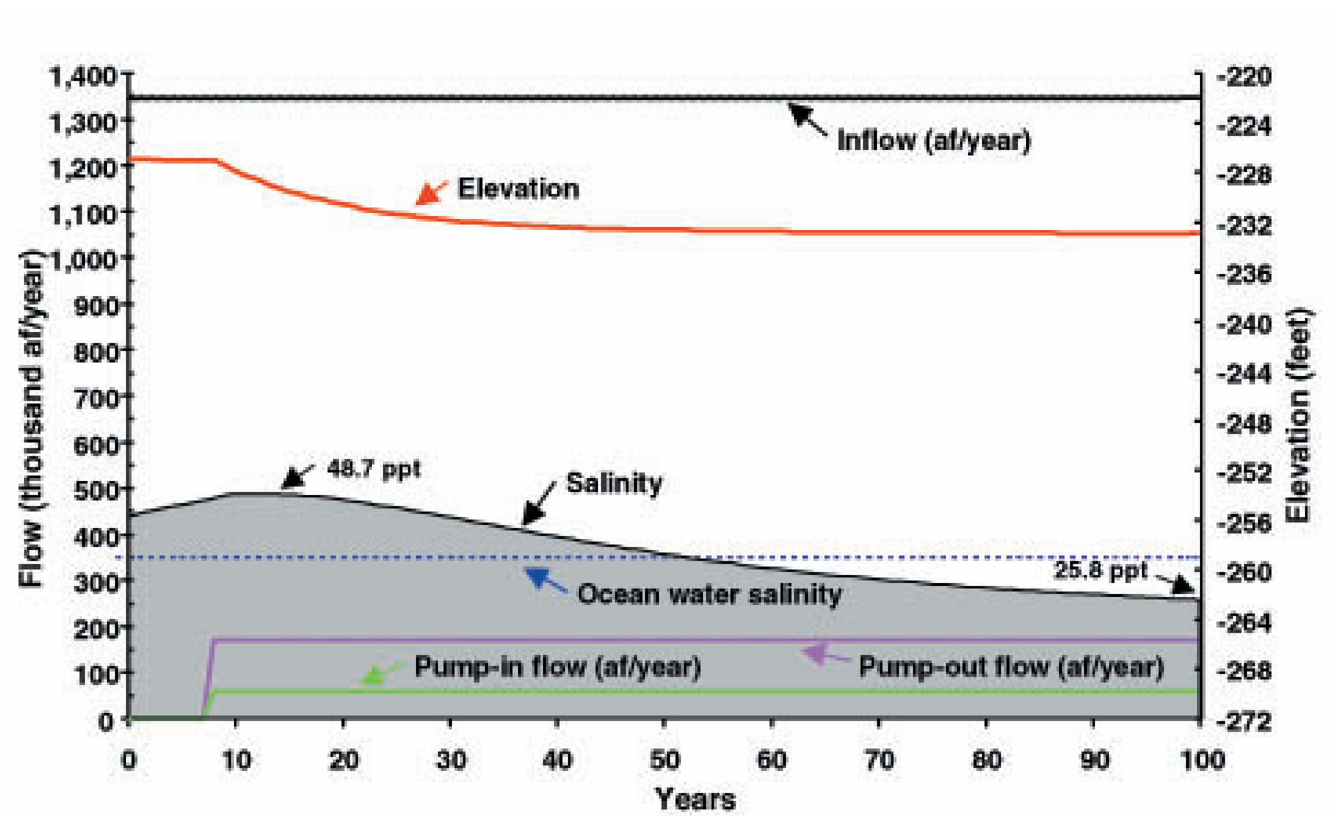
This alternative would require that a desalting pilot plant be built and tested with a number of pretreatment systems and reverse osmosis membranes be tested to determine the most cost-effective way to desalt the Salton Sea water and whether or not this alternative is cost effective when compared to the other pump-in alternatives. The possible pretreatment systems that could be tested are a conventional pretreatment system, a membrane bioreactor system, a membrane pretreatment system consisting of a microfiltration or ultrafiltration system, a slow sand system, and/or combinations of each.

It is estimated that the capacity of the pilot plant would be 6 to 24 gallons per minute; the cost of the desalting system would be approximately $300,000; the lease of four pretreatment systems would be approximately $50,000 each, for a total of $200,000; other miscellaneous components would be approximately $50,000; and the labor would be approximately $400,000 over a 2-year period. Adding contingencies, the estimated cost would be about $1.2 million for the pilot plant.

It is estimated that it would take 1 year to design and build the pilot plant and 1 to 2 years to test it. This could be done without compromising the schedule of the overall Salton Sea project because the pump-out phase could be built first and the desalting plant/pump-in phase could be put into operation years later, after the elevation criteria has been reached.

### *Salinity and Elevation of the Sea*

The Salton Sea computer model was run for this alternative, and the results are shown in figure 16 for this 60,000-acre-foot-per-year pump-in rate and 170,000-acre-foot-per-year pump-out rate. This alternative represents No. 24 on table 2. An explanation of the graph is found in chapter 9.



### Conclusion

As shown herein, this alternative uses proven technologies and satisfies the salinity target and elevation target criteria.

## Solar Salt Gradient Pond / MED Desalting Plant With Pump-In / Pump-Out

The solar salt gradient pond/multiple effect distillation (MED) desalting plant proposal was included as a part of alternative 9 which included both a power system and a desalting system with a solar pond in the September 1997 report. It used technologies first proposed by Ormat Turbines (Yavne, Israel) in 1980 and was updated numerous times from 1980 to 1989 by and for numerous agencies, including Ormat Technical Services, Inc. (Sparks, Nevada); Meyer Resources, Inc. (Davis, California); Imperial Irrigation District (Imperial, California); County of Imperial (El Centro, California); and the Coachella Valley Water District (Coachella, California).

Based on a more recent report published in November 1991, Ormat Turbines, Ltd., has since concluded that low efficiency electric powerplants, such as the organic rankine powerplant, will not compete with conventional high temperature, high efficiency powerplants driven by fossil fuels unless fuel costs should increase. Therefore, the powerplant would not be cost effective when compared to grid power available locally at $0.0725 per kilowatthour, so is not a proven technology for this application. However, in the same report, they conclude that a solar salt gradient pond with an enhanced evaporation system (EES) may be cost effective for use with an MED desalting plant and have proposed a solar salt pond desalting plant to be built near Elait, Israel. This plant has yet to be built but is still being considered.

As a result, the Salton Sea studies were updated again in August 1998, assuming just a desalting system in combination with a solar pond and a pump-in/pump-out system.

### Proposal Description

The proposed project includes a combination of several proven technologies as shown in figure 17, an MED desalting system with pump-in to the Sea, a solar salt gradient pond system that provides heat and cooling water to the desalting system, and a pump-out system to one of the locations discussed under the pump-out alternatives in chapter 5. An enhanced evaporation system (EES) would be used for initial filling of the solar pond. The

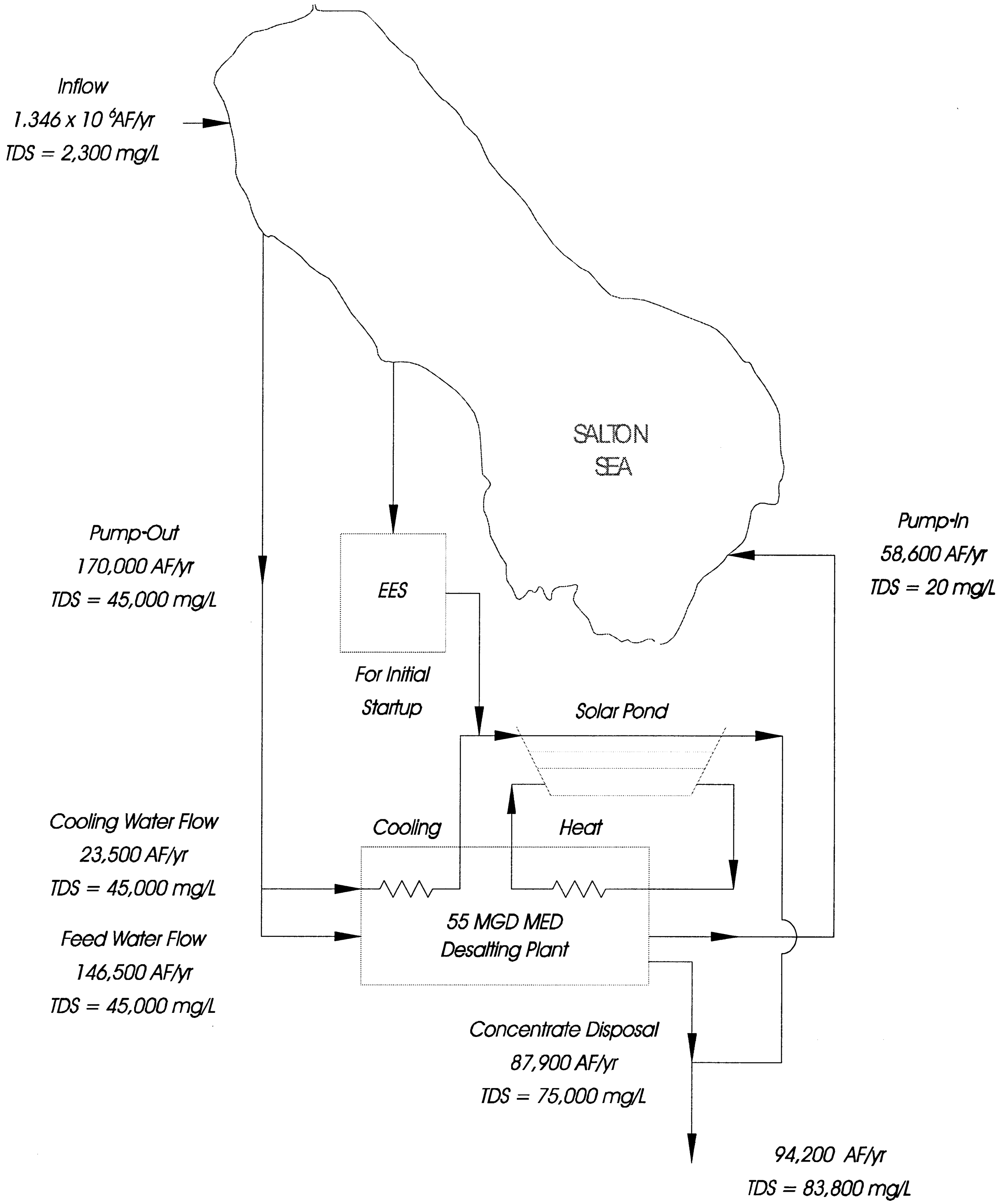



*Figure 17.—Solar salt gradient pond/MED desalting plant with pump-in/pump-out.*

pump-out system would be put into operation first, and the desalting plant/pump-in system would be put into operation years later, after the elevation criteria has been reached, because the desalting plant is only needed to maintain the salinity and elevation once the target elevation has been reached.

The use of a solar salt gradient pond is a proven technology, as a large 60-acre solar pond has been operated successfully in Israel over a number of years, and a 1-acre solar pond has been operated successfully by the University of Texas at El Paso with the Bureau of Reclamation for more than 10 years. Both have also operated solar ponds successfully with desalting plants and powerplants.

The Ormat EES is also a proven technology, which has been used in a commercial saltworks in Israel and would be used to expedite the initial filling of the solar pond lower heat storage zone. Once the desalting plant is operating, the EES is no longer required for the solar pond because the main flash chamber of the desalting plant can produce the required makeup brine for the solar pond. The EES pond can be designed to be converted to a solar pond once it is no longer needed for the initial filling. The EES technology can also be used alone with other pump-out options to reduce the volume of brine before it is pumped, so the size and cost of the pipeline would be less, or it can be installed to reduce the size of evaporation ponds if used at the final disposal site for the pump-out alternatives. It is reported that the EES

### *Analyses*

A conceptual design study was accomplished extrapolating the performance and cost data (Ormat 1991) for a similar solar salt gradient pond and MED sea water desalting system that has been proposed to be built in Israel.

It was assumed that the Salton Sea desalting plant would have a feed water flow rate from the Salton Sea of 170,000 acre-feet per year and an average TDS of 45 ppt. Approximately 23,500 acre-feet per year will be needed for the desalting plant cooling waterflow and for flushing the surface of the solar pond, leaving a desalting plant feed water flow of 146,500 acre-feet per year. Because of the high TDS, the recovery ratio is not likely to exceed 40 percent. On this basis, the desalting plant would provide a product water pump-in rate back to the Salton Sea of 58,600 acre-feet per year at a TDS of approximately 0.020 ppt and a concentrate reject flow of 87,900 acre-feet per year at a TDS of 75 ppt. The water for flushing the surface of the solar pond would be added to this flow, giving a total flow of 94,200 acre-feet per year at a TDS of 83.8 ppt for pump-out to the site selected under the pump-out alternatives.

A summary of the assumptions and results of this conceptual design study are as follows:

| | |
|---|---|
| Desalting plant capacity | 55 million gallons per day |
| Availability | 95 percent |
| Feedwater TDS | 45 ppt |
| Product TDS | 0.020 ppt |
| Recovery ratio | 40 percent |
| Intake | Open Sea |
| Solar pond surface area | 3,403 acres (5.3 $mi^2$) |
| Number of solar ponds | 120 "U"-shaped ponds |
| Solar pond liners | 2 clay and plastic liners |
| Enhanced evaporation system pond area | 23.5 acres |
| Energy costs | $0.0725 per kWh |
| Energy per 1,000 gallons | 5.56 kWh per 1,000 gallons |
| Total energy costs | $7.7 x $10^6$ per yr |
| Other O&M costs | $17.8 x $10^6$ per yr |
| Total O&M costs | $25.5 x $10^6$ per yr |
| Total capital construction cost | $551 x $10^6$ |
| 1998 dollars (assuming no change since November 1991 report) | |
| Contingencies | 20 to 30 percent (economy of scale) |
| Capital amortization | 20 years at 8-percent interest |
| Total water cost | |
| Cost per 1,000 gallons | $4.27 per 1,000 gallons |
| Cost per acre-foot | $1,391 per acre-foot |

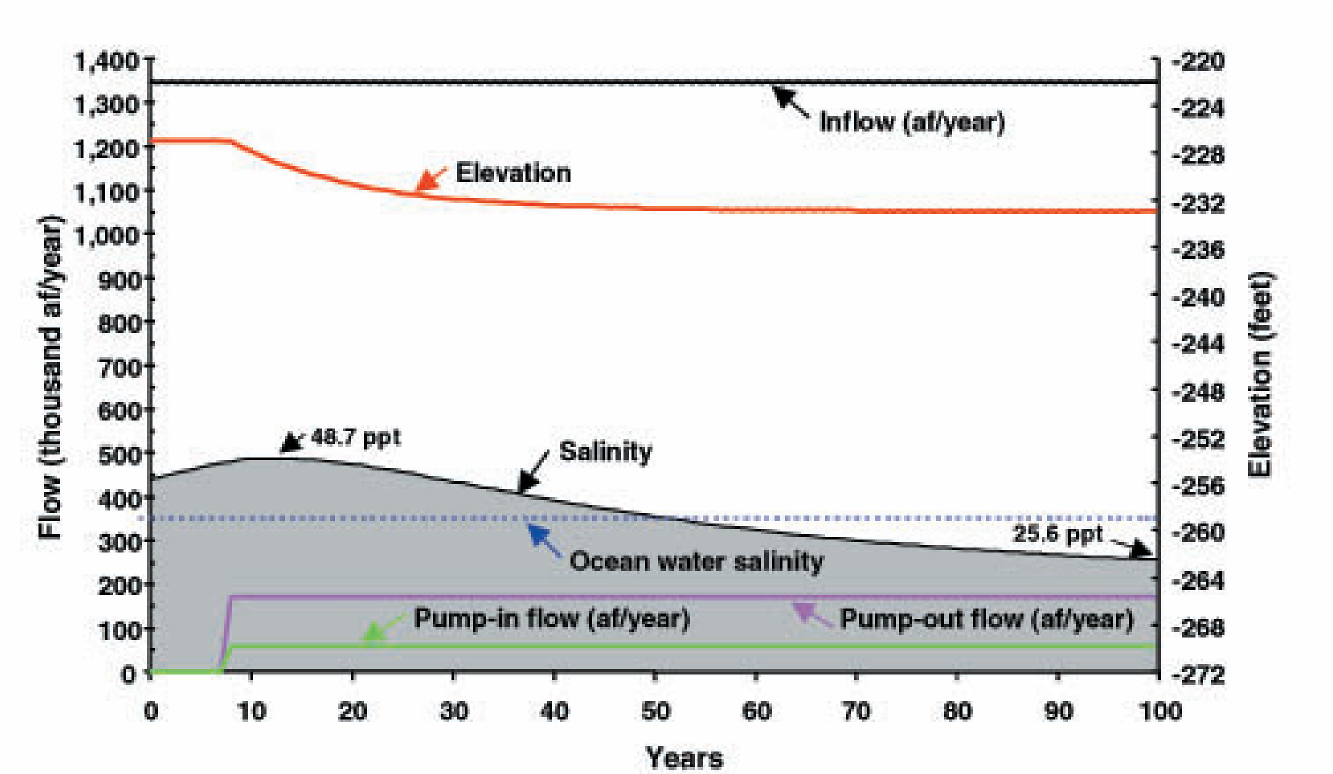
### *Pilot Plant*

As mentioned, the use of a solar salt gradient pond with a desalting plant is a proven technology by Ormat Turbines, Inc., in Israel and at the Bureau of Reclamation solar pond test facility in El Paso, Texas, on a small scale. However, a large pilot plant would have to be designed and built over a 2-year period of time, then tested for a 2-year period of time to determine the required pretreatment, performance, and cost using Salton Sea water before it would be known whether a full-scale solar pond desalination plant would be cost effective compared to a conventional reverse osmosis desalting plant for the Salton Sea.

To be able to scale up to a 55-million-gallon-per-day production plant, it is estimated that the capacity of the pilot plant would have to be 1 million gallons per day with 62 acres of solar ponds and a small enhanced evaporation system. On this basis, it is estimated that the cost of the pilot plant would be approximately $12 million, and the labor over a 2-year test period of time would be approximately $600,000. Adding contingencies, the estimated pilot plant cost would be approximately $15 million.

### *Salinity and the Elevation of the Sea*

The Salton Sea computer model was run for this alternative, and the results are shown in figure 18 for this 58,600-acre-foot-per-year pump-in rate and 170,000-acre-foot-per-year pump-out rate. This alternative represents No. 25 on table 2. An explanation of the graph is found in chapter 9.




### *Conclusion*

As shown herein, this alternative uses proven technologies and satisfies the salinity target and elevation target criteria.