Chapter 4. Future Conditions

Water Supply Overview

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

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

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

Risk-Based Future Inflows

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

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

- Economic conditions
- Competing water demands
- Water market conditions

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

Inflows from Mexico

Figure 4.1 presents total inflow distributions of the full range of possibilities in average annual future inflows to the Salton Sea from Mexico. Two lines are presented on **Figure 4.1**: the first represents average annual conditions for the period 2003 to 2077, and the second shows average conditions for the period 2018 to 2077. These distributions are based on the assumption that future possible inflows from Mexico can be represented by a triangular distribution as follows:

> *Highest Possible:* Same as flows coming from Mexico during the period 1963 to 1978 when Lake Powell was filling.

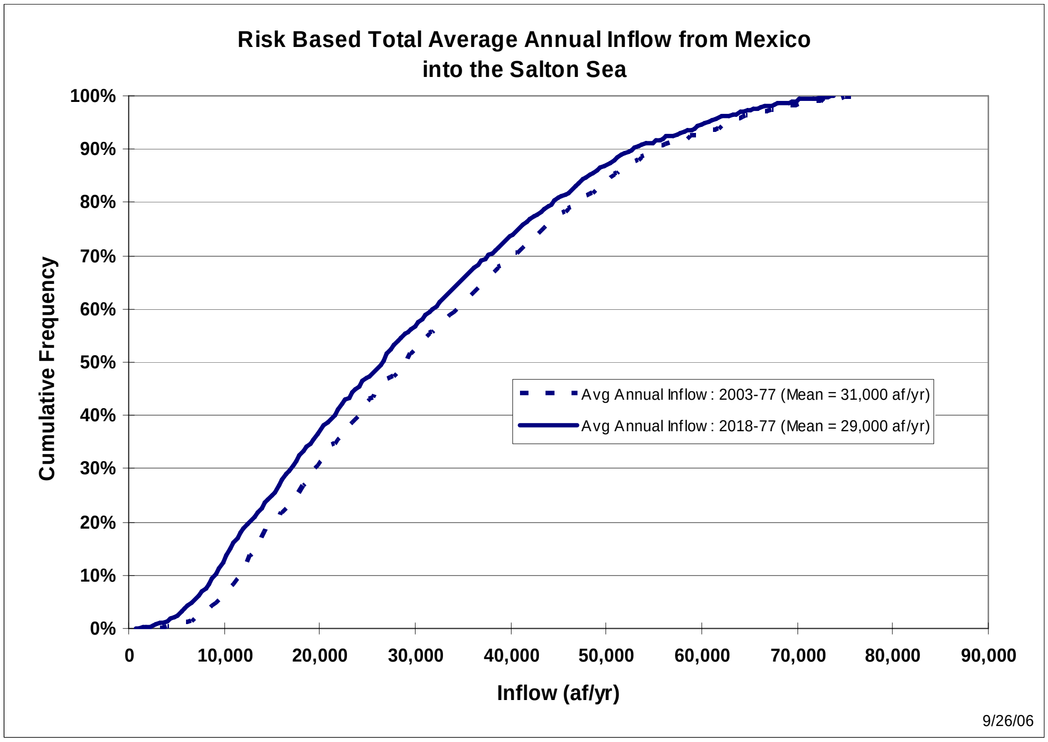

Figure 4.1 Risk-based possibility distribution of total inflows from Mexico.

Most Likely: A 60 percent reduction from those flows coming from Mexico during the period 1963 to 1978 when Lake Powell was filling.

Lowest Possible: Zero flows crossing from Mexico and into the Salton Sea.

The curves presented in **Figure 4.1** represent the cumulative frequency of average annual inflows resulting form the stochastic sampling of 1,500 different futures from this triangular distribution. The range in average annual inflows from Mexico for the period 2018 to 2077 can be described statistically as follows:

5 Percent of All Futures: Inflows will be less than or equal to 6,700 acre-feet per year

Mean of All Futures: Inflows will be 29,000 acre-feet per year

95 Percent of All Futures: Inflows will be less than or equal to 60,000 acre-feet per year

Inflows from Imperial Irrigation District

Figure 4.2 presents total inflow distributions of the full range of possibilities in average annual future inflow to the Salton Sea from IID. Two lines are presented

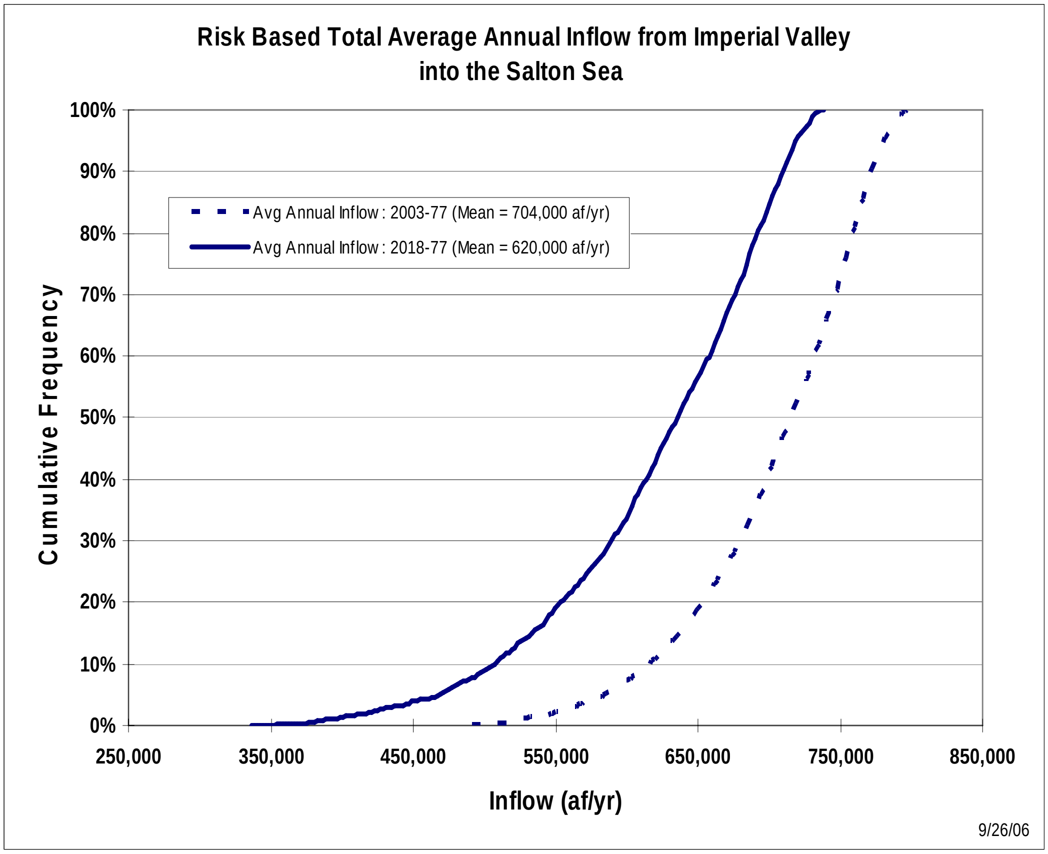

Figure 4.2 Risk-based possibility distribution of total inflows from Imperial Valley.

on **Figure 4.2**: the first represents average annual conditions for the period 2003 to 2077 and the second shows average conditions for the period 2018 to 2077. These distributions are based on the assumption that future possible inflows from IID can be represented by a triangular distribution of possible inflows from IID as follows:

> *Highest Possible:* Zero additional reductions in inflows from IID beyond those identified for the IID and San Diego Transfer
>
> *Most Likely:* Zero additional reductions in inflows from IID beyond those identified for the IID and San Diego Transfer
>
> *Lowest Possible:* A 100-percent reduction in tailwater discharges from IID to the Salton Sea.

The assignment of the lowest possible inflows is further defined by a uniform distribution representing the full range of uncertainty in estimates of IID tailwater quantities. IID tailwater has been identified as ranging from a minimum of 426,000-acre-feet per year to 716,000 acre-feet per year (Reclamation, 2003).

The curves presented in **Figure 4.2** represent the cumulative frequency of average annual inflows resulting from the stochastic sampling of 1,500 different futures from this compound triangular and uniform distribution. The range in average annual inflows from IID for the period 2018 to 2077 can be described statistically as follows:

> *5 Percent of All Futures:* Inflows will be less than or equal to 468,000 acre-feet per year
>
> *Mean of All Futures:* Inflows will be 620,000 acre-feet per year
>
> *95 Percent of All Futures:* Inflows will be less than or equal to 719,000 acre-feet per year

Inflows from Coachella Valley Water District

Figure 4.3 presents total inflow distributions of the full range of possibilities in average annual future inflow to the Salton Sea from Coachella Valley Water District. Two lines are presented on **Figure 4.3**: the first represents average annual conditions for the period 2003 to 2077, and the second shows average conditions for the period 2018 to 2077. These distributions are based on the assumption that future possible inflows from CVWD can be represented by a triangular distribution as follows:

> *Highest Possible:* That the Coachella Valley Water Management Program's (with project) predictions for future inflows to the Salton Sea will occur without change.
>
> *Most Likely:* That the Coachella Valley Water Management Program's (with project) predictions for future inflows to the Salton Sea will occur without change.
>
> *Lowest Possible:* That the CVWD without project will occur without change.

The flows for CVWD with and without project are presented in IID, 2002.

The curves presented in **Figure 4.3** represent the cumulative frequency of average annual inflows resulting form the stochastic sampling of 1,500 different futures from this triangular distribution. The range in average annual inflows from CVWD for the period 2018 to 2077 can be described statistically as follows:

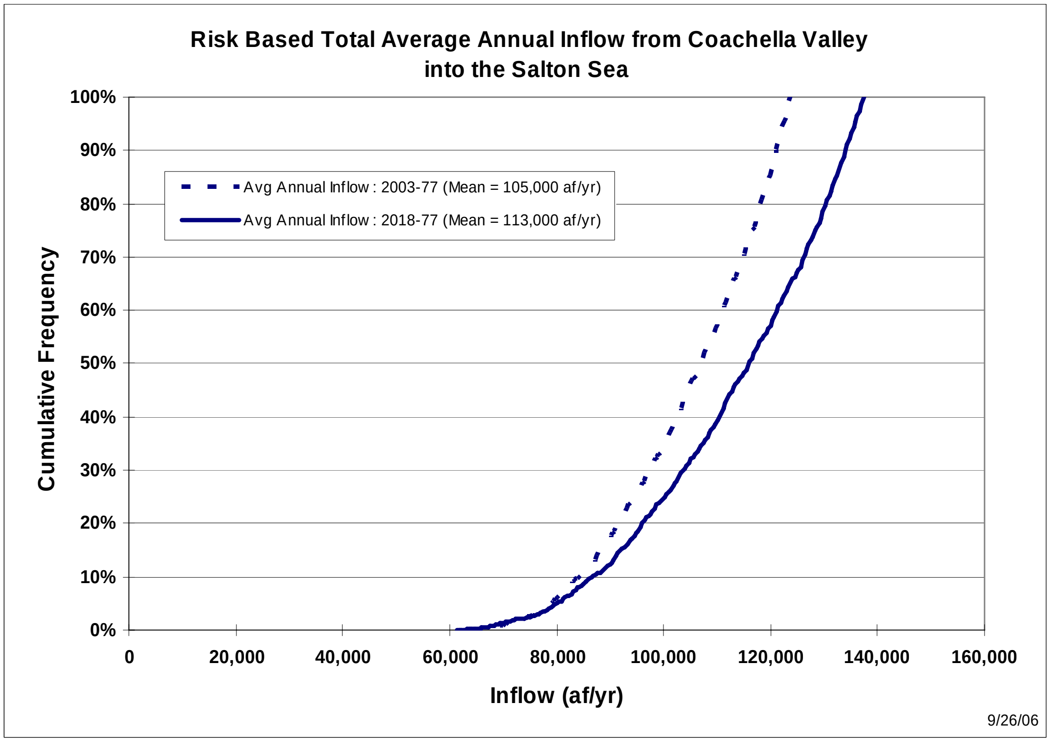

Figure 4.3 Risk-based possibility distribution of total inflows from Coachella Valley.

5 Percent of All Futures: Inflows will be less than or equal to 80,000 acre-feet per year

Mean of All Futures: Inflows will be 113,000 acre-feet per year

95 Percent of All Futures: Inflows will be less than or equal to 136,000 acre-feet per year

Total Future Inflows

In the risk-based approach to future inflows to the Salton Sea, possibility distributions for Mexico, IID, and CVWD were sampled 1,500 times and combined with estimates of tributary and direct precipitation estimates for a 75-year future period. **Figure 4.4** shows the total inflow possibility distribution for average annual future inflow to the Salton Sea from all sources. Two lines are presented on **Figure 4.4**: the first (dashed line) represents average annual inflow conditions for the period 2003 to 2077, and the second (solid line) shows average annual inflow conditions for the period 2018 to 2077.

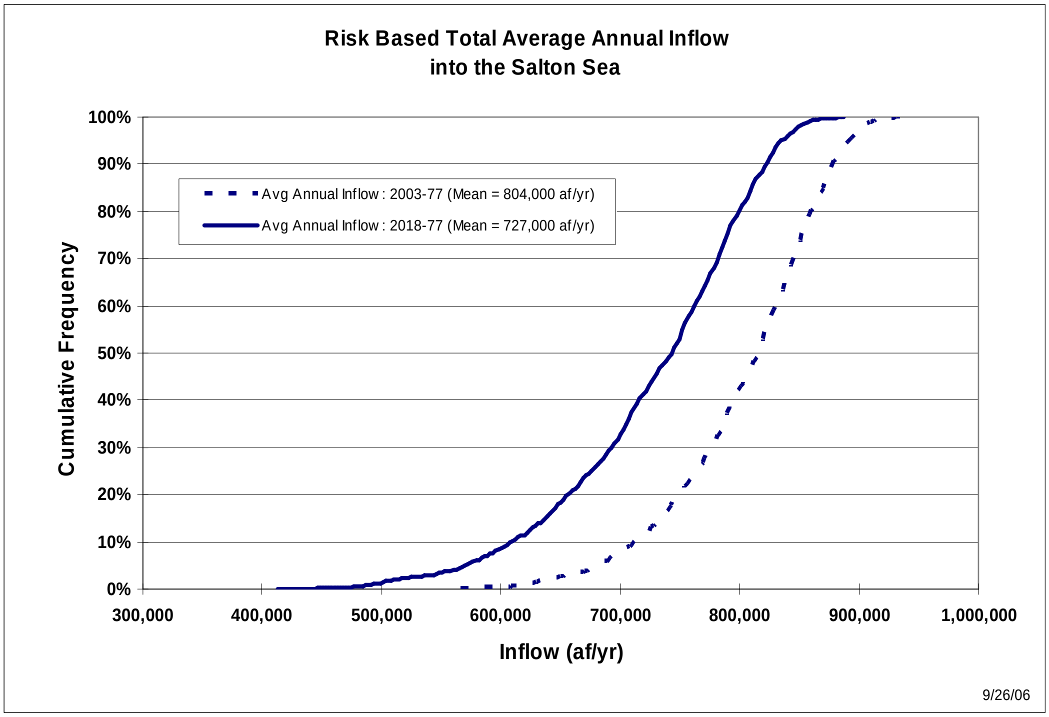

Figure 4.4 Risk-based possibility distribution of total inflows from all sources.

The curves presented in **Figure 4.4** represent the cumulative frequency of average annual inflows resulting from the random sampling of 1,500 different futures from each source possibility distribution. The range in average annual inflows from all sources for the period 2018 to 2077 can be described statistically as follows:

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

Total stochastic risk-based inflows through time are presented in **Figure 4.5**. This chart is a hydrograph of the potential uncertainty in inflow to the Salton Sea. The data presented provide an understanding of the total inflow risk and uncertainty that might occur in the future to any restoration alternative.

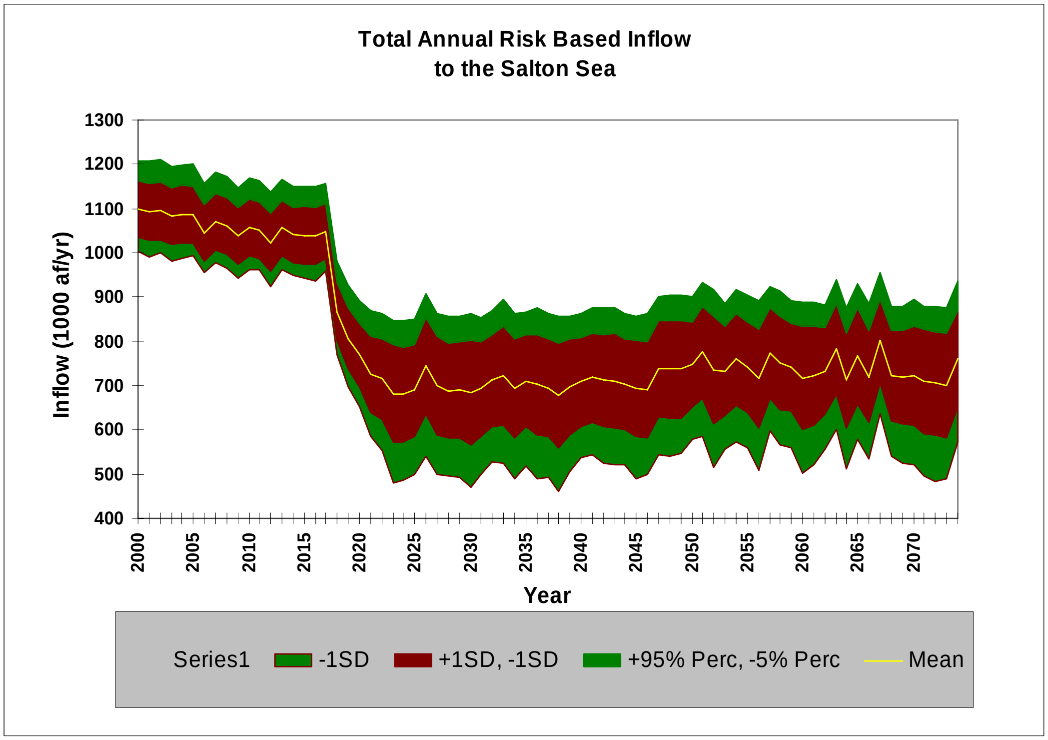

Figure 4.5 Total annual future risk-based inflow to the Salton Sea.

Climate Change Effects on Evaporation

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

The ranges in uncertainty of these increases in evaporation were incorporated into the SSAM. SSAM was used to predict future conditions relative to each restoration alternative. Within SSAM, increases in evaporation rates due to climate change were conservatively applied by assuming that evaporation would change linearly from no change in the present to a maximum increase by the year 2074. The maximum impacts of climate change were represented in SSAM by increases in evaporation based on an uniform distribution from 9 to 13 inches. **Figure 4.6** presents a hydrograph of the full range in uncertainty in net evaporation through time.

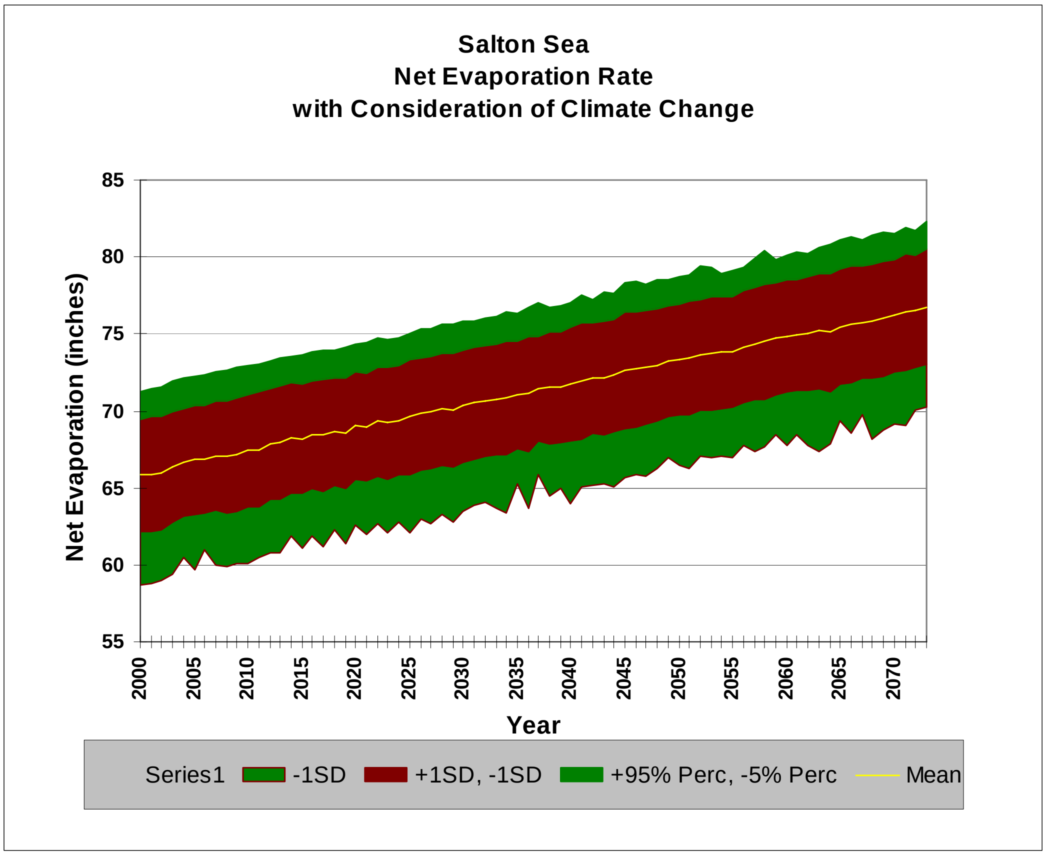

Figure 4.6 Future net evaporate rate with climate change considered.

Salton Sea Accounting Model Overview

Assessment of the future of potential Salton Sea restoration projects is dependent on the ability to predict the hydrologic response of the Sea to changing conditions. Predicting hydrologic response to these possible changes requires a predictive computer model of the Salton Sea. The Salton Sea Accounting Model was developed for this purpose and used in evaluation of the QSA and previous Salton Sea restoration studies. The development of SSAM was a joint effort of Reclamation, IID, and CVWD. The districts developed the historic and QSA water and salt budgets. Reclamation developed the model application.

SSAM is a spreadsheet model that resides inside Microsoft Excel 2003 and uses a risk and uncertainty package produced by Palisades called @Risk. SSAM incorporates the ability to perform stochastic and deterministic simulations of Salton Sea conditions. These stochastic capabilities provide for analysis of the variability of hydrologic parameters, such as Sea inflow. The model operates on an annual time step.

The objectives behind the development of SSAM were to provide a tool that would allow the effective evaluation of historic, present, and future conditions within the Salton Sea. Specifically, the model was developed to provide predictions of changes in elevation, surface area, exposed shoreline surface areas, and salinity based on changes in inflow.

SSAM Modes of Operation

SSAM incorporates the ability to perform stochastic and deterministic simulations of the Salton Sea. 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 as in the QSA water budget. During stochastic simulations of the Salton Sea, random samples are taken from the Mexico, IID, and CVWD inflow possibility distributions described above. Corresponding salt load and dissolved solids precipitation distribution samplings are also made. Dissolved solids precipitation is described below. In addition, net term evaporation is sampled in paired fashion to corresponding inflow data from IID. In this mode, the model is typically executed 1,500 times and statistics related to model results are compiled. These statistics include for each year: mean values, mean values plus one standard deviation, mean values minus one standard deviation, 5 percentiles, and 95 percentiles. The data are to be interpreted as follows:

> *95 Percentile*: 95 percent of all model traces resulted in values less than or equal to the indicated values
>
> *5 Percentile*: 5 percent of all model traces resulted in values less than or equal to the indicated values
>
> *Mean*: Mean of all traces
>
> *-1 Standard Deviation*: Values representing one standard deviation below the mean
>
> *+1 Standard Deviation*: Values representing one standard deviation above the mean

Bathymetric Modeling

In 1995, Reclamation conducted an extensive survey of the Salton Sea (Reclamation, 1997). The survey was to develop underwater topography and to compute area/elevation/capacity relationships for the Sea. This survey did not incorporate existing levees around the shoreline of the Salton Sea. As a result, the bathymetric model of the Salton Sea and corresponding area/elevation/capacity data that were developed were not accurate at higher elevations. In the summer of 1999, Reclamation updated this survey data to reflect the influences of the existing levees on the area/elevation/capacity relationships. Updating was accomplished through the digitization of the Salton Sea shoreline from digital orthophoto quadrangles. Levees were identified along this shoreline and assigned an elevation of -220 feet. The two resulting elevation data (shoreline and levees) were merged into the 1995 survey data. New area/elevation/capacity data were then computed using Reclamation's reservoir survey software. This information was then used to develop bathymetric models and area/elevation/capacity relationships for each of the alternatives. This information was incorporated into SSAM to interpolate elevations and surface areas for each year of model operation.

The bathymetric models of each alternative were also used to develop depth-of-water estimates on a 2500 square foot grids basis. These depth-of-water grids were computed for each alternative at all future water surface elevations. These grids were important in the development of habitat areas as described in Chapter 5.

Evaporation as a Function of Salinity

As salinity increases in the Salton Sea, it is expected that evaporation rate suppression will occur. **Figure 4.7** shows how evaporation is expected to be affected as salinity (as measured as total dissolved solids) increases in any future restoration alterative. This relationship of "E/Ep" represents a "brine factor" that is the ratio of salt-water evaporation to fresh water evaporation. The curve shown is derived from the application of two equations. The first is used to derive specific gravity as a function of salinity and the second to derive the "brine factor" as a function of specific gravity. These equations were developed based on research conducted at the Salton Sea Test Base Salinity Control Research Project and the Agrarian Research / Salton Sea Authority's Bombay Beach Solar Pond Pilot Project. These relationships were incorporated into the SSAM for the purpose of adjusting evaporation as salinity increases. Within the model, the "E/Ep" factor is not allowed to go below 0.65.

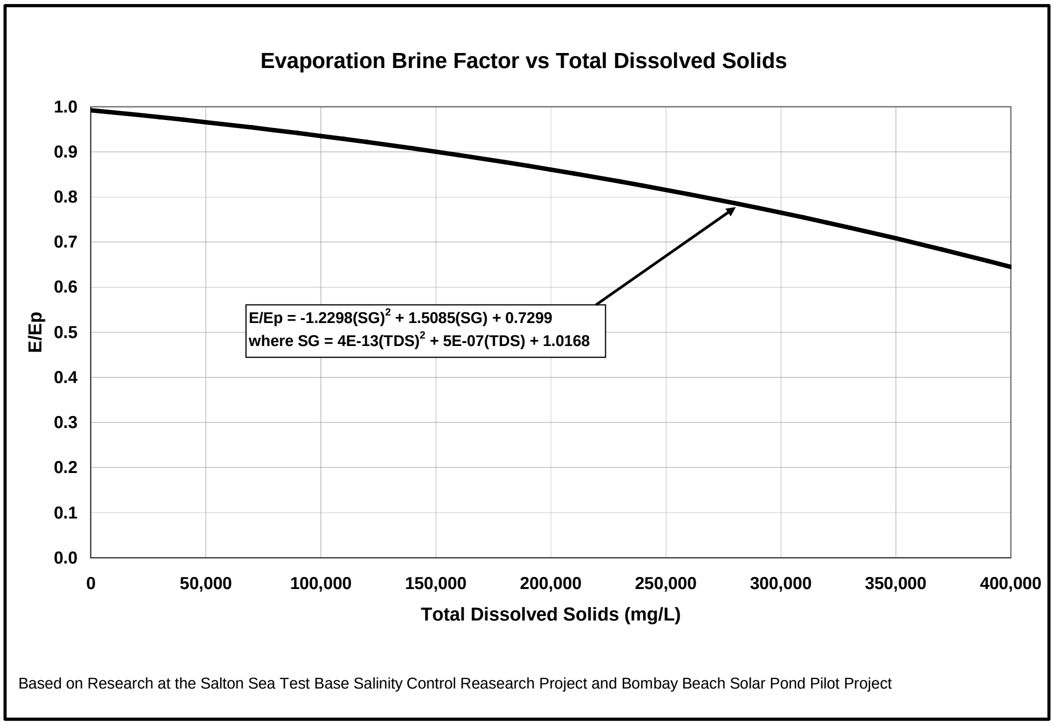

Figure 4.7 Evaporation suppression as a function of salinity.

Assumptions Modeled Related to Project Completion

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

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

Precipitation of Dissolved Solids

In December 2000, a science workshop was held in Riverside, California, to develop a joint opinion of scientists with knowledge in the field of salinity, salt precipitation, and biological reduction of sulfates within natural waters. It was concluded that dissolved solids are either being precipitated or biologically reduced within the Salton Sea as dissolved salts are added to Sea waters on an annual basis. It was concluded that, at a minimum, 0.7 million 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, 1.2 million tons per year are either being precipitated and/or biologically reduced. 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 0.7 and 1.2 million tons per year, the Salton Sea Accounting Model was developed such that this issue was handled as an uncertainty term. When SSAM is operated in a stochastic mode, a different value for precipitation of dissolved solids is sampled from a uniform probability distribution defined by the limits of 0.7 and 1.2 million tons per year. SSAM 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 precipitated or reduced within the Salton Sea.

Alternatives Modeling Results

Each alternative was simulated using the stochastic capabilities of SSAM. Each model was executed 1,500 times while sampling from the risk-based inflow distributions as described above. The results from each iteration were saved and analyzed statistically to develop graphical and tabular representations of model results. SSAM model results include water surface elevation, water surface area, salinity, and exposed lake playa for all marine lakes and residual brine pools. A discussion of model results for these parameters follows.

Water Surface Elevations

Hydrographs of mean future water surface elevations (not including brine pools) for each restoration alternative are shown in **Figure 4.8,** which depicts elevations through time for years 2025 to 2074. These elevations are based on mean future risk-based inflows. Three elevation curves are shown for the Concentric Lakes Alternative; each curve represents one of three concentric lakes that would be constructed. The fourth and innermost concentric lake proposed by the Imperial Group would not be required under the risk-based inflows used in this study.

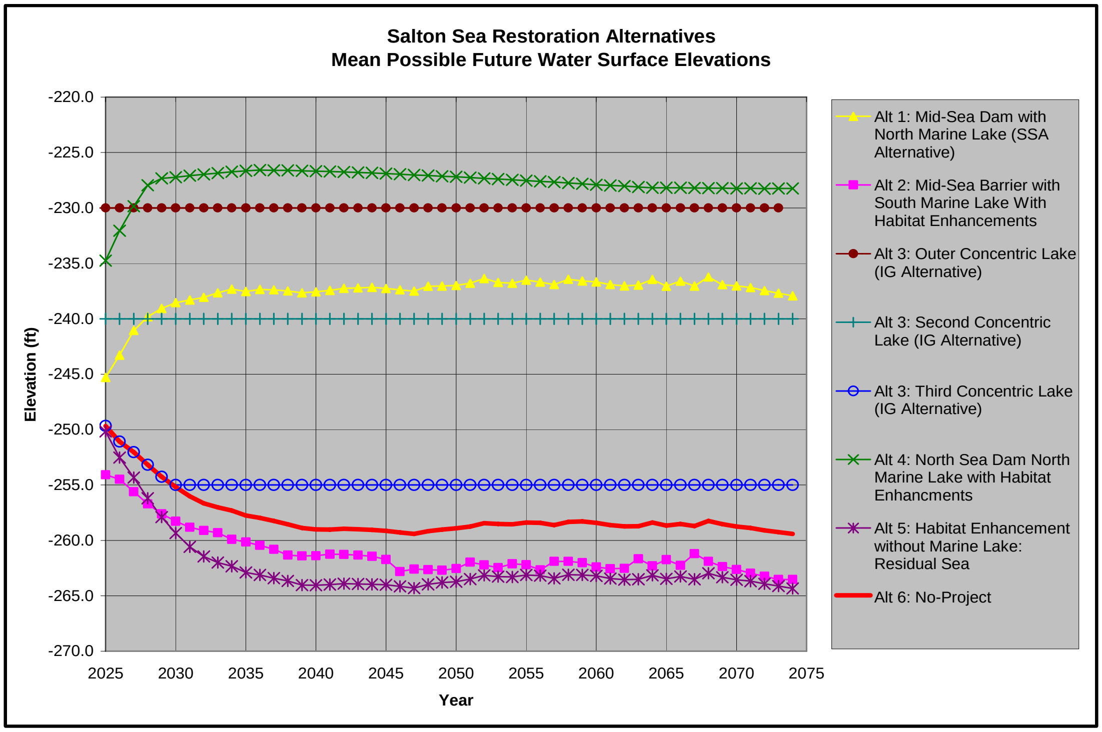

Figure 4.8 Mean future water surface elevations for restoration alternatives.

Stochastic simulation water surface elevation results for years 2006, 2023, 2040, and 2074 are provided in **Table 4.1**. The data are to be interpreted as follows:

> *95 Percentile*: 95 percent of all model traces resulted in values less than or equal to the indicated values
>
> *5 Percentile*: 5 percent of all model traces resulted in values less than or equal to the indicated values
>
> *Mean*: Mean of all traces
>
> *-1 Standard Deviation*: Values representing one standard deviation below the mean
>
> *+1 Standard Deviation*: Values representing one standard deviation above the mean

Table 4.1 Stochastic alternatives water surface elevations for years 2006, 2023, 2040, and 2074

Alternative Description	2006					2023					2040					2074				
	5 Perc	-1 SD	Mean	+1 SD	95 Perc	5 Perc	-1 SD	Mean	+1 SD	95 Perc	5 Perc	-1 SD	Mean	+1 SD	95 Perc	5 Perc	-1 SD	Mean	+1 SD	95 Perc
Alt. No. 1: Mid-Sea Dam with North Marine Lake											-247.2	-242.0	-237.6	-233.2	-234.2	-247.4	-242.2	-237.9	-233.6	-234.5
Alt. No. 2: Mid-Sea Barrier with South Marine Lake											-269.2	-266.3	-261.4	-256.4	-254.0	-270.3	-267.9	-263.5	-259.2	-256.4
Alt. No. 3: Concentric Lakes Outer (1st) Concentric Lake	-230.0	-230.0	-230.0	-229.8	-229.1	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0	-230.0
2nd Concentric Lake						-240.0	-240.0	-240.0	-240.0	-240.0	-240.0	-240.0	-240.0	-240.0	-240.0	-240.0	-240.0	-240.0	-240.0	-240.0
3rd Concentric Lake											-255.0	-255.0	-255.0	-255.0	-255.0	-255.0	-255.0	-255.0	-255.0	-255.0
4th Concentric Lake																				
Alt. No. 4: North Sea Dam with Marine Lake											-227.1	-227.0	-226.7	-226.4	-226.1	-228.7	-228.6	-228.3	-227.9	-227.6
Alt. No. 5: Habitat Enhancement without Marine Lake											-270.7	-267.3	-264.0	-260.8	-260.2	-271.4	-268.0	-264.3	-260.7	-260.2
Alt. No. 6: No-Project	-232.2	-231.7	-230.7	-229.8	-229.1	-249.3	-248.1	-246.3	-244.6	-243.6	-264.5	-262.3	-259.0	-255.7	-254.2	-264.8	-262.4	-259.4	-256.4	-255.3

Water Surface Areas

Hydrographs of mean future water surface areas (not including brine pools) for each restoration alternative are shown in **Figure 4.9,** which depicts areas through time for years 2025 to 2074. These areas are based on mean future risk-based inflows. Three surface area curves are shown for the Concentric Lakes Alternative; each curve represents one of three concentric lakes that would be constructed.

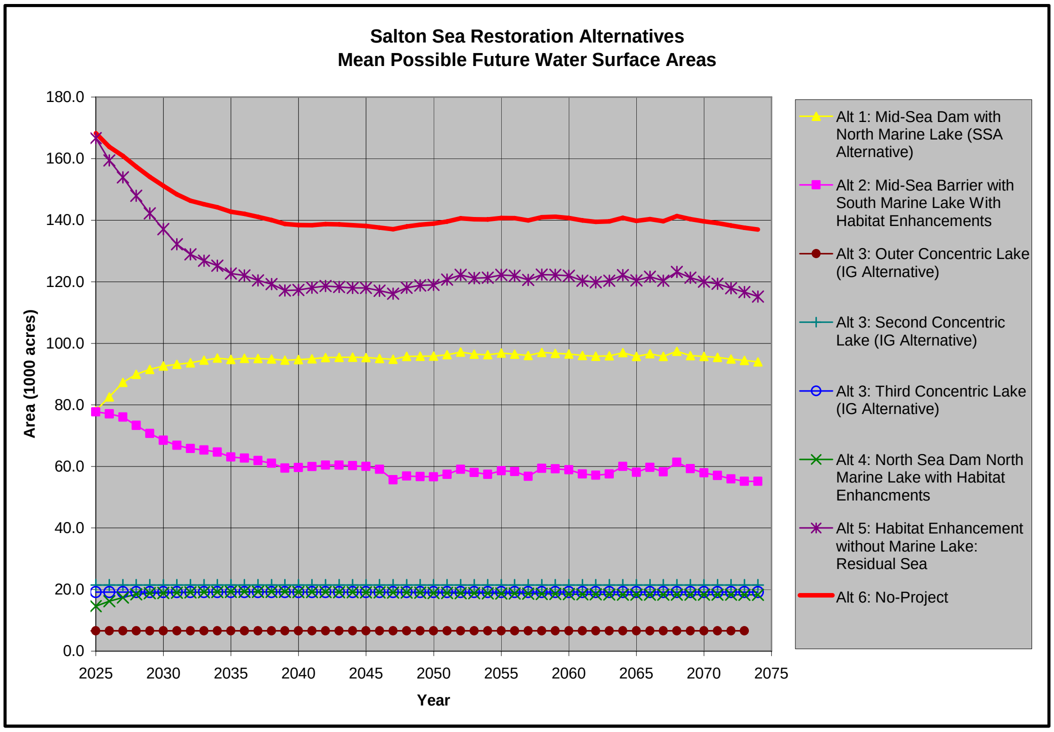

Figure 4.9 Mean future water surface areas for restoration alternatives.

Stochastic simulation water surface areas results for years 2006, 2023, 2040, and 2074 are provided in **Table 4.2.**

Table 4.2 Stochastic alternatives water surface areas for years 2006, 2023, 2040, and 2074

Alternative Description	2006					2023					2040					2074				
	5 Perc	-1 SD	Mean	+1 SD	95 Perc	5 Perc	-1 SD	Mean	+1 SD	95 Perc	5 Perc	-1 SD	Mean	+1 SD	95 Perc	5 Perc	-1 SD	Mean	+1 SD	95 Perc
Alt. No. 1: Mid-Sea Dam with North Marine Lake											73.3	86.1	94.7	103.4	101.5	72.9	85.5	94.0	102.4	101.0
Alt. No. 2: Mid-Sea Barrier with South Marine Lake											36.0	45.4	59.7	74.0	78.1	32.5	42.3	55.2	68.1	73.1
Alt. No. 3: Concentric Lakes Outer (1st) Concentric Lake	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
2nd Concentric Lake						21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4	21.4
3rd Concentric Lake											19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
4th Concentric Lake																				
Total Concentric Lakes	6.6	6.6	6.6	6.6	6.6	28.0	28.0	28.0	28.0	28.0	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3
Alt. No. 4: North Sea Dam with Marine Lake											19.0	19.1	19.2	19.4	19.6	18.1	18.1	18.3	18.5	18.7
Alt. No. 5: Habitat Enhancement without Marine Lake											74.9	98.1	117.4	136.7	135.2	66.7	92.9	115.2	137.5	135.2
Alt. No. 6: No-Project	224.2	225.0	227.0	229.0	230.2	169.0	173.0	179.5	186.1	190.4	117.8	126.0	138.4	150.9	154.6	116.4	124.7	137.0	149.3	151.2

Salinities

Hydrographs of mean future salinity in the marine lakes for each restoration alternative are shown in **Figure 4.10**, which depicts salinity through time for years 2025 to 2074. These salinity results are based on mean future risk-based inflows. Three curves are shown in **Figure 4.10** for the Concentric Lakes Alternative; each curve represents one of three concentric lakes that would be constructed.

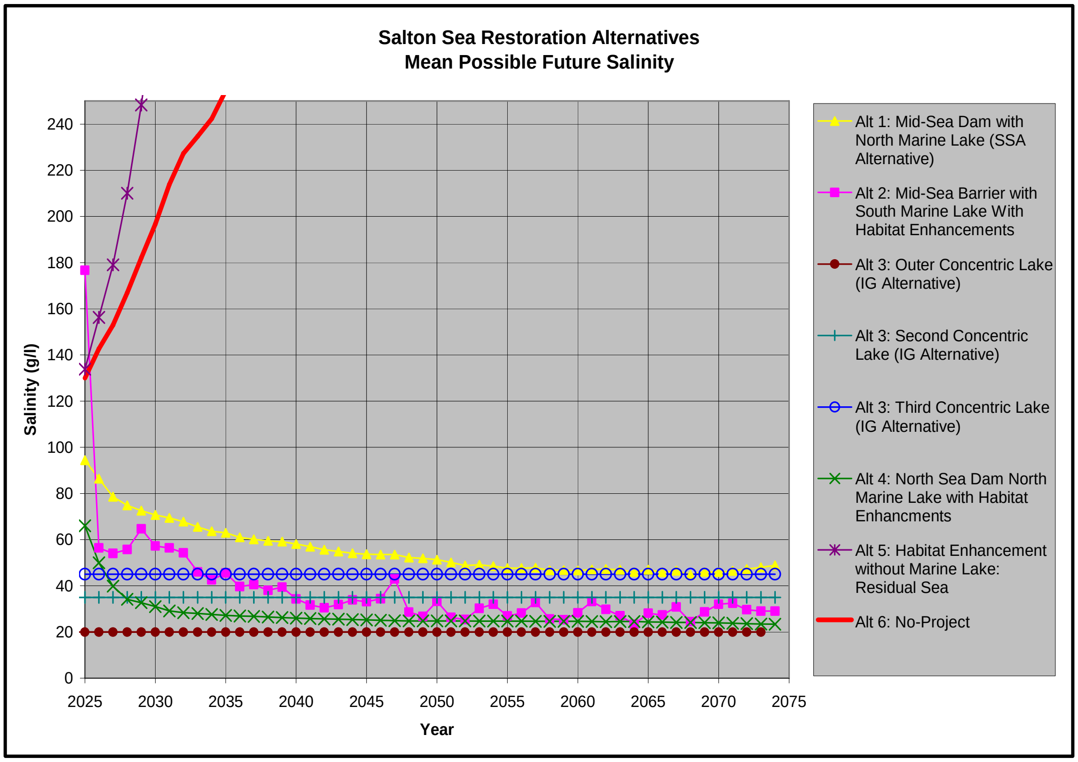

Figure 4.10   Mean future salinity for restoration alternatives.

Stochastic simulation salinity results for years 2006, 2023, 2040, and 2074 are provided in **Table 4.3.**

Table 4.3 Stochastic alternatives salinity for years 2006, 2023, 2040, and 2074

Alternative Description	2006					2023					2040					2074				
	5 Perc	-1 SD	Mean	+1 SD	95 Perc	5 Perc	-1 SD	Mean	+1 SD	95 Perc	5 Perc	-1 SD	Mean	+1 SD	95 Perc	5 Perc	-1 SD	Mean	+1 SD	95 Perc
Alt. No. 1: Mid-Sea Dam with North Marine Lake											36.6	39.1	58.1	77.1	89.9	33.7	29.1	48.8	68.6	85.3
Alt. No. 2: Mid-Sea Barrier with South Marine Lake											9.8	15.1	34.3	53.6	48.3	7.6	5.0	29.0	51.9	44.5
Alt. No. 3: Concentric Lakes Outer (1st) Concentric Lake	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
2nd Concentric Lake						35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
3rd Concentric Lake											45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
4th Concentric Lake																				
Alt. No. 4: North Sea Dam with Marine Lake											19.2	22.8	26.0	29.2	29.5	5.0	12.5	23.3	34.2	34.0
Alt. No. 5: Habitat Enhancement without Marine Lake											250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0
Alt. No. 6: No-Project	48.7	49.8	51.4	52.9	53.9	93.2	97.6	107.1	116.6	123.4	180.7	123.3	250.0	250.0	250.0	223.1	189.1	250.0	250.0	250.0

Exposed Lake Playa and Air Quality Mitigation Water Requirements

SSAM also makes predictions of exposed lake playa surface areas in the future. For all alternatives, the exposed playa areas are determined from a baseline Sea elevation of -228 feet. Total exposed lake playa surface areas predicted by SSAM are presented in **Table 4.4**. The data presented are based on mean future stochastic model results for year 2040. On the basis of these predicted areas, SSAM estimates and takes into account AQM water and brine requirements. General AQM requirements are discussed in Chapter 3. The approach taken in this study adheres to the current DWR Salton Sea Ecosystem Restoration Program approach to AQM. DWR's approach identifies the need to make 1 acre-foot per acre of inflow water available for AQM purposes using water-efficient vegetation. In addition, DWR identifies the need to allocate 0.2 acre-foot per acre of brine water for AQM purposes. Exposed acres to be mitigated with water-efficient vegetation and other methods are also listed in **Table 4.4**.

Table 4.4   Exposed lake playa surface areas

Alternative	Exposed Lake Playa Surface Areas (acres)	Exposed Lake Playa Mitigated with Water-efficient Vegetation[1] (acres)	Exposed Lake Playa Mitigated with Other Methods[2] (acres)
Alternative No. 1: Mid-Sea Dam with North Marine Lake	103,800	51,900	20,760
Alternative No. 2: Mid-Sea Barrier with South Marine Lake	73,600	36,800	14,720
Alternative No. 3: Concentric Lakes	65,000	32,500	13,000
Alternative No. 4: North-Sea Dam with Marine Lake	91,800	45,900	18,360
Alternative No. 5: Habitat Enhancement Without Marine Lake	81,200	40,600	16,240
Alternative No. 6: No-Project	92,200	46,100	18,440

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

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

Water Surfaces and Depths in 2040

SSAM simulation results for mean future water surface elevations in the year 2040 were used to develop GIS-based maps for each alternative. These maps accurately depict the extent of mean future water surface elevations and depths of marine lake water. **Figures 3.2, 3.3, 3.4, and 3.5** are mean future water depth maps for the Salton Sea Authority Alternative (Alternative No.1), the Mid-Sea Barrier with South Marine Lake Alternative (Alternative No. 2), the Concentric Lakes Dikes Alternative (Alternative No. 3), and the North-Sea Dam with Marine Lake Alternative (Alternative No. 4). There is no marine lake associated with the

Habitat Enhancement Without Marine Lake Alternative No. 5 or the No-Project Alternative No. 6. **Figure 3.6** shows the extent of the residual brine pool for Alternative No. 5. **Figure 3.7** depicts the extent of the residual brine pool of the No-Project Alternative (Alternative No. 6).

To create these maps, SSAM results for water surface elevation were used in the application of “cell based” modeling techniques built into ARC/INFO GRID GIS software. Grids were developed of each alternative that define depth of water at half-foot intervals throughout the range of water surface elevations that would occur in the future under each alternative.

Maximum year 2040 mean future depths for each alternative are presented in **Table 4.5.**

Table 4.5 Maximum mean future water depths for restoration alternatives marine lakes

Alternative	Maximum Depth (feet)
Salton Sea Authority Alternative (Alternative No. 1)	43.5
Mid-Sea Barrier with South Marine Lake Alternative (Alternative No. 2)	15.5
Concentric Lakes Dikes Alternative (Alternative No. 3)	6.0
North-Sea Dam with Marine Lake Alternative (Alternative No. 4)	33.0
Habitat Enhancement Without Marine Lake Alternative (Alternative No. 5)	No marine lake
No-Project Alternative Residual Sea (Alternative No. 7)	No marine lake

Viability of Alternatives Relative to Future Inflows

Without a guaranteed water supply, each of the alternatives would be subject to the risk-based inflows discussed above. The performance of each alternative under the range of future possible inflow helps to describe the viability of the alternatives. **Figure 4.10** presents future salinities of the marine lakes associated with each alternative under mean possible future inflows. A salinity of 60,000 mg/L has been identified as the threshold beyond which it will not be possible to maintain a fishery. This section includes a discussion of the viability of each alternative relative to future inflows. Viability is presented in terms of risk as defined by the following:

- ***Fatal*:** Nothing can be done to alleviate the problems and issues associated with variability in inflows.

- ***High Risk***: Problems are extreme and cannot be dealt with through changes in project feature operating criteria but instead would require relocating project structural elements.

- ***Serious Risk***: Problems threaten project performance but can be dealt with by making significant changes in project feature operating criteria.

- ***Moderate Risk***: Problems are evident that may require changes in project feature operating criteria.

- ***Low Risk***: Problems are not likely to occur.

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

The mean possible future inflow to the Salton Sea is expected to be 727,000 acre-feet per year. As shown in **Figure 4.10**, in year 2040, under Alternative No. 1 the mean future salinity would be 58,000 mg/L, which is very close to the 60,000 mg/L salinity threshold for a sustainable fishery. After construction is completed in 2024, salinity in the marine lake would not fall below 60,000 mg/L until year 2038. Not until after this time would a fishery be potentially viable. The early start features described in the discussion of SHC in Chapter 3 would be necessary to maintain a viable fishery prior to 2038.

Figure 4.10 depicts salinity conditions under mean possible inflow conditions. Alternative No. 1 was modeled assuming an operating water surface elevation of -238 feet so that salinity in the lake could be maintained below 60,000 mg/L in year 2040. The SSA desires to operate the lake at elevation -230 feet. From **Figure 4.10**, it can be seen that a salinity of 45,000 mg/L would not be reached until year 2055. Thus, if 45,000 mg/L were the target salinity, the SSA would not be able to slowly increase the operating elevation of the lake to -230 feet until after 2055. This salinity sensitivity to inflows and operating water surface elevation indicates that the viability of this alternative would be at **serious risk** relative to future inflows. This classification indicates that problems can be dealt with by making significant changes in project operating criteria, which in this instance would be lake water surface elevation. If future inflow conditions are significantly above mean possible estimates, then the operating elevation of the marine lake could be higher (and much sooner) and potentially at a level consistent with the SSA's target of -230 feet. Under lower-than-mean possible future inflow conditions, the operating surface elevation criteria for the marine lake would need to be reduced below the -238 feet simulated at mean possible future conditions.

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

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

Under the risk-based inflow approach described above, it is expected that Alternative No. 2 salinity would be 34,000 mg/L by the year 2040. Salinity in the marine lake would decrease only slightly beyond year 2040. By the year 2074, salinity would be 29,000 mg/L. Other stochastic model simulation results (not shown in **Figure 4.10**) for Alternative No. 2 indicate that salinities in the south marine lake would be highly variable, ranging from 5,000 to 52,000 mg/L. Thus, large variability would exist for inflows significantly below mean future levels. As a result of this potentially negative variability in salinity, the viability of this alternative would be at **serious risk** relative to future inflows. Problems could be dealt with by accepting a variable salinity operating criteria for lower inflow conditions.

Alternative No. 3: Concentric Lakes

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

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

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

Alternative No. 5: Habitat Enhancement Without Marine Lake

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

Alternative No. 6: No-Project

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