Restoration of the Salton Sea

Volume 1: Evaluation of the Alternatives

Appendix 1F: Rationale for a Smaller “Marine Lake” at the Salton Sea

RATIONALE FOR A SMALLER "MARINE LAKE" AT THE SALTON SEA

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There are several factors to consider when designing mitigation habitat at the Salton Sea. First, the most critical habitat that is being lost with a salinizing sea is the marine fishery. Saline shallow-water habitat and freshwater marshes will be relatively easy to construct and should be considered second priority to a marine-salinity lake that supports fish.

Secondly, it is important to size the lake such that all possible future inflows can be accommodated while maintaining the water quality and elevation of the lake. A lake with a near-constant elevation is desirable because island and snag habitat, nesting sites, and resting areas can be constructed and protected. In addition, shoreline development of recreation facilities is more attractive with a stable shoreline.

There have been discussions on the size of the lake, with inflows ranging from 400,000 AF/yr to 900,000 AF/yr. It is my opinion that we should design a smaller lake, one that can be supported by an annual inflow of 200,000 to 300,000 AF. There are two good reasons for this: a small lake can be adaptively managed, and minimum required inflows can be assured.

The Salton Sea, or a constructed impoundment within the sea, has no water rights and thus the minimum inflow that can be assured must be based on the minimum drainage requirements for the Imperial and Coachella Valley irrigation projects. The minimum required drainage needed to control salinity in the root zone of the agricultural fields will produce between 200,000 and 300,000 AF/yr. This is the only volume that can be assured, and is the volume of drainage needed to maintain the productivity of the agricultural lands. Tailwater contributes very little to salt leaching, and thus, cannot be considered as potential flows to maintain a marine lake. It could be legally argued that a project designed for 200,000 AF/yr inflow has a "water right" to this amount because the irrigation projects MUST discharge this volume of water to be sustainable. Representatives from Imperial Irrigation District have said that 200,000 AF of drainage water is the lowest possible discharge achievable for the project.

The current inflow to the Salton Sea is approximately 1.3 MAF/yr and most of this inflow comes from the Imperial Irrigation District (IID). IID imports

~3.1 MAF/yr of Colorado River water, and another 0.3 MAF is distributed in the Coachella Valley. (Because of the QSA, these volumes will change somewhat and the following calculations should be refined with new flows.) The exact amount of irrigation water that actually enters the soil and goes to evapotranspiration (plant growth and surface evaporation) and subsurface drainage has been debated. As a first approximation, I will assume that 2.1 MAF/yr enters the soils of the Imperial and Coachella Valleys. Assuming an average salinity of 1,000 mg/L in the delivery water (Colorado River), and a minimum leaching fraction of 10%, the assured drainage water volume and quality in the distant future would be 210,000 AF with a salinity of 10,000 mg/L. [The leaching fraction (LF) is the ratio of volume of subsurface drainage water/volume of water that enters the soil. If the irrigation project could achieve a LF of 10%, the average root zone salinity would be low enough to grow crops classified as "moderately sensitive" to salinity. A higher leaching fraction would be required to grow salt "sensitive" crops such as beans, carrots, onions, and citrus. A higher leaching fraction would produce more drainage water with a lower salinity.] Based on this, the marine lake should be designed to function with an annual inflow of 210,000 AF. The maximum salinity of this inflow would be 10,000 mg/L. It is likely that higher flows and lower salinities will be available for many years to come, which will allow for these additional flows to be used to mitigate exposed sea floor for dust. The project must be designed to handle higher flows (flood flows), which entails diversions around the main inflow to the lake.

Assuming an annual inflow of 210,000 AF with a salinity of 10,000 mg/L, and an average evaporation rate from the lake of 5.5 feet/yr, the lake must have a surface area of 27,000 acres. Salt balance requires that 60,000 AF/y of the lake water be discharged to the salt repository. This will maintain the salinity of the lake at 35,000 mg/L. If the inflow had a lower salinity, inflows and discharge would be adjusted to maintain 35,000 mg/L in the lake.

For example, if the lake is size at 27,000 acres but the inflow has a salinity of 2,400 mg/L (current Alamo River salinity), the required inflow volume would be 161,000 AF/yr and 11,000 AF of lake water (salinity = 35,000 mg/L) would be discharged to the brine pool. The water balance is: 161,000 AF inflow = 150,000 AF evaporation + 11,000 AF brine pool discharge
Salt balance: total salt in = salt out: 161,000 AF x 2.4 g/L = 11,000 AF x 35 g/L (rounded).

If the lake has a mean depth of 13 feet (4 meters), the volume of the lake would be 351,000 AF. At an inflow of 210,000 AF, the residence time would be 1.7 years. At an inflow of 161,000 AF, the residence time would be 2.2 years. These residence times are somewhat shorter than the current Salton Sea which averages 5.6 years (7.3 MAF/1.3 MAF).

A shallower, smaller lake is preferred due to the potential problem of persistent stratification in a deep lake. Persistent stratification could lead to the accumulation of hydrogen sulfide and ammonia below the thermocline. When the lake mixes in the winter, the H2S and NH3 would likely kill all fish, barnacles, pileworms, Trichocorixa (water boatmen), and gammarus (shrimp) in the lake. There is also the potential of downwind impact of a large H2S outgassing from the lake.

A lake with an average depth of 4 m will not have persistent stratification, although short periods of stratification that lead to low oxygen in the hypolimnion would still occur and this condition would serve to sequester selenium in the sediments.

A smaller, shallower lake will be slightly colder than the existing sea during the winter, so Tilapia will likely be extirpated from the newly formed lake. Most marine fish are more tolerant of low temperatures, which will allow the marine species to once again dominate.

For the next few decades, the flows to the Salton Sea will be greatly in excess of 210,000 AF. Under these conditions, excess flow must be diverted around the marine lake and discharged directly to the salt repository or brine pool, on the backside of the dam and downstream of the marine lake. The excess flow could be used to control dust, reclaim exposed sea floor sediments, and provide shallow-water habitat.

Along with changes to inflow, there will be changes in water chemistry (salinity, nutrient concentration, selenium concentration, and suspended solids content) that need to be considered.

The advantage of a smaller lake is that the loading of nutrients, selenium, and sediment can be more easily controlled. Initially, when the lake is first constructed and available flows are high (~1.3 MAF/yr), the bulk of the water will be diverted around the marine lake. This will keep the nutrient and Se loading at a level similar to the current Salton Sea. As the lake freshens from 46 g/L to 35 g/L total salinity, the ammonium levels will drop, hydrogen sulfide production will decrease because of lower sulfate concentrations, and fish kills will decrease. Ammonium concentrations are likely to drop for two reasons: first, there will be a dilution due to the flow-through operation of the impoundment, and second, it has been hypothesized that the nitrifying microbes that convert ammonium to nitrate are salt sensitive and the freshening of the sea will allow nitrification to resume.

Phosphorus (P) loading will decrease due to water conservation in the irrigation projects. Water conservation within the irrigation projects will be accomplished by reducing tailwater flows and canal spillage. The ratio of tailwater to subsurface drainage water will decrease resulting in an increase in salinity, selenium, and nitrate concentrations, and a decrease in phosphorus concentrations.

In general, there is very little P in subsurface drainage water and the bulk of the P in the rivers comes from tailwater discharge. Nitrogen, as nitrate, will increase assuming the main source of nitrate is subsurface drainage. However, denitrification reactions in the Salton Sea will keep nitrate from accumulating.

Thus, as flows decrease over time, water treatment to remove Se can be phased-in. Under the worst-case condition, and assuming an average Se concentration of 4 ppb in the Colorado River, the drainage water could average 40 ppb, if maximum water conservation was achieved and the leaching fraction averaged 10%. Water containing this concentration of Se would require treatment before discharge to the marine lake, although it will be decades before this may be needed.

Phosphorus and sediment loading will naturally decrease as tailwater is reduced and there is on-farm management of “fertigation” or “water-run fertilization.” Nutrient removal from the inflow water may not be needed in the distant future but treatment, or on-farm management, should be instituted to improve water quality in the newly formed lake. The smaller size of the lake makes treatment possible. Because the marine lake will require a relatively small volume of inflow, waters containing unusually high concentrations of Se and/or P could be isolated and diverted directly to the saline repository.

The lake could be built at either the south or north end (or both ends) of the existing sea. Two smaller lakes (total area 27,000 acres) could be built to maximize the delta habitat at both the north and south ends of the current sea.