

Salton Sea Water Balance

As inflows from the rivers and irrigation drains that have largely sustained the Salton Sea continue to decline due to QSA water transfers and other factors, the Salton Sea will shrink until inflows stabilize with the outflows (primarily evaporation loss) to reach an equilibrium. The new equilibrium level is likely to be 20 feet or more below the current surface elevation exposing tens of thousands of acres of potentially emissive playa. The rate of Water Import needed to build and sustain a desired level in the Salton Sea to cover much of that playa is determined by the water balance in the Salton Sea impacted by the following variables and volume balance equations (to be exact water mass balance is more correct, but the density of water varies only slightly within the ambient temperature range, so volume balance is a reasonable approximation for level calculations):

$V_{SS}$  = Volume of Salton Sea

$\Delta V_{SS}$  = Change in Volume of Salton Sea

$I_{RD}$  = Inflow to Salton Sea from all Rivers and irrigation Drains

$I_P$  = Inflow to Salton Sea from Precipitation to surface

$I_{GW}$  = Inflow to Salton Sea from Groundwater flows

$I_{MW}$  = Inflow to Salton Sea from QSA Mitigation Water flows

$I_{WI}$  = Inflow to Salton Sea from Water Import

$I_{SER}$  = Return flow to Salton Sea from Salt Extraction Revenue technologies

$O_{SE}$  = Outflow from Salton Sea to Salt Extraction Revenue technologies

$O_E$  = Outflow from Salton Sea to Evaporation

$O_{SP}$  = Outflow from Salton Sea to Seepage

$$\Delta V_{SS} = (I_{RD} + I_P + I_{GW} + I_{MW} + I_{WI} + I_{SER}) - (O_{SE} + O_E + O_{SP})$$

By the time Water Import conveyance infrastructure can be agreed upon, permitted, and constructed, the Salton Sea will almost certainly be many feet lower than its current elevation. To raise the level of the Salton Sea up to a target surface elevation that covers dust emitting playa the volume of the Sea will need to increase:

$$\Delta V_{SS} > 0$$

$$(I_{RD} + I_P + I_{GW} + I_{MW} + I_{WI} + I_{SER}) - (O_{SE} + O_E + O_{SP}) > 0$$

Or rearranging for net inflows to exceed net outflows:

$$I_{RD} + I_P + I_{GW} + I_{MW} + I_{WI} + I_{SER} > O_{SE} + O_E + O_{SP}$$

Since the rate of outflow to Salt Extraction Revenue generating technologies, and any return flows from same, will be largely determined by the salt balance and the other variables are controlled by natural processes, the rate of Water Import is the key controllable variable for Salton Sea elevation building:

$$I_{WI} > (O_{SE} + O_E + O_{SP}) - (I_{RD} + I_P + I_{GW} + I_{MW} + I_{SER})$$

Once a target elevation is achieved, the Volume of the Salton Sea should be held constant, primarily by controlling the Water Import flow:

$$\Delta V_{SS} = 0$$

$$I_{WI} = (O_{SE} + O_E + O_{SP}) - (I_{RD} + I_P + I_{GW} + I_{MW} + I_{SER})$$

### Salton Sea Salt Balance

The Salton Sea has varied in Salinity throughout its existence in historical time. This is evidenced by salinity data and studies going back many decades. Salinity variation is evident throughout prior incarnations as Ancient Lake Cahuilla based on alternate use of freshwater fish traps and Native American salt trails to the area and by the New Liverpool and Standard Salt Company operations in the Salton Sink prior the 1905 flooding.

The Salton Sea has been receiving approximately four million metric tons of mixed salts annually, drained from farm fields to the north and south and originating mostly from salts carried down the Colorado River from both natural and human sources upstream. The salt content of the Salton Sea is mostly sodium chloride, but is highly elevated in sulfate due to agricultural practices, and also moderately elevated in magnesium, a change from the very pure sodium chloride once harvested from the dry lakebed prior to 1905. Farm drainage also loads the Salton Sea with nutrients and biological materials, but the most critical issue challenging the aquatic ecosystem in the Salton Sea is excess salt.

Any Water Import scheme to the Salton Sea from a natural source would carry with it additional salt that would need to be managed if sustaining aquatic life in the Salton Sea is a goal and requirement. If the goal is simply dust mitigation, then salinity management may not be required. However, precipitated salts will accumulate once the Salton Sea reaches the saturation point for the various components. If salinity management to sustain an aquatic ecosystem, or just to limit salt accumulation, is required, the salinity in the Salton Sea will be impacted by the following variables and mass balance equations:

$MS_{SS}$  = Mass of Salt in the Salton Sea

$S_{SS}$  = Salinity of Salton Sea, averaged throughout the volume expressed as density of TDS (not NaCl only)

$\Delta MS_{SS}$  = Change in Mass of Salt in the Salton Sea

$S_{RD}$  = Salinity of Inflows to Salton Sea from all Rivers and irrigation Drains averaged by relative flow

$S_P$  = Salinity of Inflow to Salton Sea from Precipitation, near zero so eliminate

$S_{GW}$  = Salinity of Inflow to Salton Sea from Groundwater flows

$S_{MW}$  = Salinity of Inflow to Salton Sea from QSA Mitigation Water flows

$S_{WI}$  = Salinity of Inflow to Salton Sea from Water Import

$S_{SE}$  = Salinity of Outflow from Salton Sea to Salt Extraction Revenue technologies

$S_{SER}$  = Salinity of return flow to Salton Sea from Salt Extraction Revenue technologies, if any

$S_E$  = Salinity of Outflow from Salton Sea to Evaporation, near zero so eliminate

$S_{SP}$  = Salinity of Outflow from Salton Sea to Seepage

$MS_P$  = Mass of Salt precipitating out of the Salton Sea annually

$$MS_{SS} = V_{SS} \times S_{SS}$$

$$S_{SS} = \frac{MS_{SS}}{V_{SS}}$$

$$\Delta MS_{SS} = (I_{RD} \times S_{RD} + I_{GW} \times S_{GW} + I_{MW} \times S_{MW} + I_{WI} \times S_{WI} + I_{SER} \times S_{SER}) - (O_{SE} \times S_{SE} + O_{SP} \times S_{SP}) - MS_P$$

Assuming a well-mixed Salton Sea, true after major wind events, but can be moderately stratified and vary slightly by location at other times, the salinity of outflow to salt extraction and to seepage would be the same as the Sea's average salinity. Salinity data from the Bureau of Reclamation over time show only slight variability in salinity by sampling depth and location supporting the assumption.

$$\Delta MS_{SS} = (I_{RD} \times S_{RD} + I_{GW} \times S_{GW} + I_{MW} \times S_{MW} + I_{WI} \times S_{WI} + I_{SER} \times S_{SER}) - (O_{SE} \times S_{SS} + O_{SP} \times S_{SS}) - MS_P$$

The salinity of the Salton Sea already far exceeds that optimal for an aquatic ecosystem able to support fish and fish eating birds. The optimal salinity range identified by the Salton Sea Management Program for aquatic habitat is 30 g/liter to 40 g/liter. The Salton Sea salinity now exceeds 60 g/liter and is expected to rise rapidly. By the time Water Import conveyance infrastructure can be constructed, the Salton Sea will almost certainly be much higher in salinity. Initially a reduction in salinity would be needed if aquatic habitat is a goal within the Salton Sea, hence:

$$\Delta MS_{SS} < 0$$

$$(I_{RD} \times S_{RD} + I_{GW} \times S_{GW} + I_{MW} \times S_{MW} + I_{WI} \times S_{WI} + I_{SER} \times S_{SER}) - (O_{SE} \times S_{SS} + O_{SP} \times S_{SS}) - MS_P < 0$$

$$O_{SE} \times S_{SS} > (I_{RD} \times S_{RD} + I_{GW} \times S_{GW} + I_{MW} \times S_{MW} + I_{WI} \times S_{WI} + I_{SER} \times S_{SER}) - (O_{SP} \times S_{SS}) - MS_P$$

When target salinity is reached, Salt Extraction would be scaled back to balance with salt inflow:

$$O_{SE} \times S_{SS} = (I_{RD} \times S_{RD} + I_{GW} \times S_{GW} + I_{MW} \times S_{MW} + I_{WI} \times S_{WI} + I_{SER} \times S_{SER}) - (O_{SP} \times S_{SS}) - MS_P$$

$$O_{SE} = \frac{(I_{RD} \times S_{RD} + I_{GW} \times S_{GW} + I_{MW} \times S_{MW} + I_{WI} \times S_{WI} + I_{SER} \times S_{SER})}{S_{SS}} - O_{SP} - MS_P$$