Salton Sea Water Recycling Project

Response to Request for Salton Sea Restoration Concepts
Offered by Sephton Water Technology, Inc.

Brief Overview and Benefit of Concept

The Salton Sea Water Recycling (Project) is a concept for restoration of the Salton Sea as a functioning fish and bird ecosystem, as a destination for recreation on land and water, and as healthy place for people to live, work, and thrive. The concept is centered on recycling both water and excess salts directly from the Salton Sea and putting them to beneficial use for restoration of aquatic habitat and recreation and for mitigation of PM10 dust from exposed areas of the Salton Sea lakebed (playa). The Salton Sea Water Recycling Project will use established water treatment technologies that have been adapted for use at the Salton Sea by several years of pilot testing under California State and Federal grants to recover pure water and purified commercial grade salt from highly saline Salton Sea water.

Long Term Salton Sea Water Quality Restoration

Pure water will be supplied by channels and/or pipelines to aquatic habitat and recreational areas to be blended with Salton Sea water in situ, or with concentrated salt water containing nutrients originating from the Salton Sea, to create and sustain large areas of aquatic ecosystem for decades to come. Over the long term, the removal of millions of tons of salt from the Salton Sea each year and the return of pure water to the aquatic ecosystem will drive down the salinity of the Salton Sea to roughly 35 g/liter, similar to the Pacific Ocean. Once that long term salinity target is reached, the amount of water recycling and salt extraction can be reduced to that sufficient to remove the three to four million tons per year of salt in the brackish inflows to the Salton Sea. That will sustain a marine ecosystem and recreational uses in the central Salton Sea indefinitely.

Mid Term Localized Water Quality Restoration

Removing enough salt to bring the central Salton Sea down to marine salinity will be a roughly three decade long process. Collapse of the Salton Sea's fishery and aquatic ecosystem in general is already well underway for the last few years. Restoring portions of the aquatic ecosystem in a shorter timeframe will be accomplished by delivering pure water reclaimed from the Salton Sea to shoreline aquatic habitat and blending it with Salton Sea water and/or brine concentrate where appropriate to achieve and sustain a target salinity. Already planned aquatic habitat projects like the New River centered Species Conservation Habitat, a possible Alamo River Habitat complex, a North Lake Project, a Desert Shores Channels Project, and possibly a restarted Red Hill Bay Project can benefit from this pure water supply with saline water outflow back to the Salton Sea.

Mid Term Water Quality Restoration in Sections of Salton Sea Shoreline

A more flexible and cost effective solution to restoring thousands of acres of managed salinity habitat along selected areas of shoreline will use commercially available floating silt curtains, used for river and lake construction projects to contain silt, to instead curtain off impoundments of lower marine salinity along the shoreline from the hypersaline body of the Salton Sea. The marine salinity will be maintained by blending of pure water recycled from the Salton Sea with Salton Sea water in situ. The floating salinity curtains will be periodically relocated and re-anchored with the shore contour as the Salton Sea shoreline recedes. These marine salinity impoundments will support a restored community of benthic and pelagic invertebrates, from algae to pile worms. The invertebrates will in turn support fish species that were until recently abundant in the Salton Sea. The restored fish population will enable the return of pelicans, cormorants, osprey, black skimmers, terns and other fish eating birds to the Salton Sea.

Mid Term Restoration for Shoreline Communities, Shoreline Lakes

The restoration of shoreline near where people live is equally important, if not more so. The West Shores communities of Salton City, Vista del Mar, Salton Sea Beach, and Desert Shores have been damaged by a retreating shoreline and drying salt encrusted former boat channels next to homes. The east side communities of North Shore and Bombay Beach have been similarly impacted by the receding Salton Sea shoreline and worsening water quality. The quality of life, vitality of the community, and value of property can be greatly enhanced by building earthen berms with a rock face up to ¼ mile out from the historic pre-QSA shoreline and filling between the historic shoreline and the berms with pure water recycled from the Salton Sea blended with filtered mixed salt brine to marine salinity to control reeds and mosquitos. These restored community shoreline lakes will be restocked with fish and serve as a magnet for fishing and water sport recreation that formerly enabled these communities to thrive and will do so again on a smaller scale.

Recycled Water Delivery

Getting pure recycled Salton Sea water to where it’s needed to support managed pond habitat, floating habitat, and shoreline lakes at communities will be a project in itself. Salton Sea water will be recycled at a few optimal locations to access local renewable energy resources and minimize shoreline community impact. From those locations, a pipeline will be built incrementally along the Salton Sea shoreline upslope of the projects that need the water. Gated outflow lateral channels and/or pipes will deliver pure water where needed to habitat and shoreline restoration projects. At full build out, this will result in a perimeter pipeline encircling most of the Salton Sea shoreline to deliver pure recycled water at any location where it’s needed.

Dust Control with Salt Crust from Brine Concentrate

Residual mixed salts will be recovered at or near saturation suitable for use to rapidly form salt crust as an accepted Best Available Control Measure (BACM) for PM10 dust mitigation on exposed playa. In the early years of the Project, while the Salton Sea is hypersaline, up to six million tons of salt will be removed from the Salton Sea annually. All of the mixed salt and some of the purified salt will be available for use in PM10 dust mitigation. This will be delivered in HDPE pipelines as brine concentrate to shallow salt evaporation ponds created on highly emissive areas of Salton Sea playa by raising earth berms of up to four feet to create evaporation pond cells then, flowing the brine concentrate into the cells to dry and build a thick enough salt crust to indefinitely resist erosion by windblown sand and occasional rain. This is one PM10 dust BACM demonstrated at Owens Dry Lake and other locations, with the improvement that use of brine concentrate from the Salton Sea water recycling process will accelerate creation of salt crust and reduce the amount of water lost to evaporation.

Brine Concentrate Delivery

The locations where Salton Sea water will recycled will also produce a stream of concentrated Salton Sea brine containing a mixture of salts and small organic molecules not removed by coarse filtration. This mixed brine stream will be 5% to 10% by volume of the hypersaline Salton Sea water drawn in by the water recycling systems. It will need to be delivered to high emissivity areas of Salton Sea playa as those areas become exposed. The mixed salt brine will fill salt crust evaporation ponds to eliminate PM10 dust from those sections of exposed playa. Since the mixed salt brine will contain organic matter and low concentrations of some contaminants present in Salton Sea water, some pure salt brine may be used over a dried, mixed salt crust to dry and cap the crust with pure crystallized salt. The brine delivery, mixed or purified, will use parallel, but much smaller, pipelines to the Perimeter Pipeline delivering pure recycled Salton Sea water along the shoreline. Use of HDPE plastic pipe will be durable and will resist corrosion from the very high salinity. Most of the high emissivity playa is likely to be exposed at the southern half of the Salton Sea where there is a shallow slope and a lot of fine sediment on the lakebed. This will reduce the cost of pumping this brine through long pipelines.

Dust Control with Tree Windbreaks and Vegetation

While salt crust is a suitable BACM to eliminate PM10 dust in the many unpopulated areas of the Salton Sea, the shorelines where people live will do better with a more attractive solution. In the shoreline communities, pure water recycled from the Salton Sea will be used to plant and sustain native trees such as honey mesquite and palo verde as well as the shoreline shrubs like iodine bush favored by public agencies. Stands of native trees in and around these near treeless shoreline communities will moderate hot dry weather and will support of variety of terrestrial wildlife and birds. Rows of appropriately spaced trees native trees like mesquite have been shown to provide effective windbreaks [1] to mitigate dust from both the desert and the exposed playa. While rows of salt cedar (tamarisk) have been extensively used in the region as windbreaks to protect farms, project sites, and railroads from blowing sand and dust, mesquite are not invasive, have a somewhat lower water demand [2, 3, 4], and survive well in the desert climate. Whether planted in rows or stands, native trees will also benefit the aesthetics of the shoreline communities improving both quality of life and public health.

Pure Salt Recovery to Offset Costs

Recycling hypersaline Salton Sea water to recover pure water to restore the ecosystem, control dust, and support recreation is an expensive undertaking. The largest challenge is the vast amount of salt in the Salton Sea, on the order of 440 million metric tons in 2022 and increasing by three to four million metric tons every year. The salt in the Salton Sea is mostly sodium chloride. Before the most recent filling, the mostly dry Salton Sea basin was a prized source of commercial salt from the late 1800's to 1905. Two commercial salt companies harvested some of the purest, highest quality, salt in the U.S. from the lakebed and shipped it out for sale by wagon and by rail. That salt dissolved into Colorado River water after 1905. In the last century the quality of the salt dissolved in the Salton Sea has been degraded by agricultural drainage and some industrial waste. The sodium chloride in the Salton Sea is now mixed with a substantial portion of sulfate from agricultural drainage, significant amounts of magnesium, and a modest amount of calcium, potassium, and bicarbonate, plus trace amounts of a wide range of elements. Fertilizer runoff stimulates a massive growth of microorganisms that decay to release a wide range of organic molecules. Fortunately, in the last couple of decades new filtration technologies like microfiltration and ultrafiltration have proven methods to separate micro-particles and microorganisms from saltwater and nanofiltration technology can separate ions of various sizes and charges. These technologies combined with distillation make it feasible to recover purified sodium chloride of commercial quality similar to what was harvested from the dry lakebed in the late 1800's. New more energy efficient distillation technology makes recovery of high purity water also feasible in a combined pure water recycling and pure salt recovery process. The market value of the purified salt at $220 per metric ton (USGS bulk FOB 2021 data) is sufficient to fully offset the cost of recycling the water from the Salton Sea. In this combined process, the hypersaline nature of the current Salton Sea is actually a benefit because more pure salt can be recovered and sold per volume of Seawater recycled.

Water Recycling Technical Concept Background

The concept originated with an unsolicited proposal made to the Salton Sea Authority by Sephton Water Technology founder Dr. Hugo H. Sephton and three colleagues with deep experience in the water treatment industry, Ferris Standiford, Phil Hammond, and Dieter Emmermann. The 2001 concept was to return the Salton Sea to marine salinity over a couple of decades by drawing out high salinity Salton Sea water and returning very low salinity distilled Salton Sea water using geothermal and/or solar heat. All of the four original proponents have since passed away, but successors have continued the work at the Salton Sea refining and improving on the existing distillation technology to adapt it to the water quality, water supply, and economic challenges of the local region.

Locally water is in limited supply, but available at a very low price to users with water rights. The quality of water supplies, other than the Colorado River and a limited number of potable quality wells, is low with high salinity in most unused water sources (see Figure1).

Local Surface Water Resources, Cost, & Salinity

Source	Quantity (MAF)	Cost (per Acre Foot)	Salinity (g/lit TDS)	Authority
Colorado River Import	2.4 – 3.2 annual flow	$20 - $85	0.07-0.09	IID
Agricultural Drain Flows	1 – 0.7 annual flow	None set	0.3 – 0.4	IID
Salton Sea	5.3 declining	None set	75 rising	None
Ground Water	14.4 stable	None set	1.8 - 10	IC, IID, and Landowner

- Conclusion: The Salton Sea is the best local surface water resource for salt. There is no major local customer likely to pay the cost of distilling Salton Sea water for sale with raw Colorado River water rates as low as $20 per acre foot. There are potential customers in adjacent regions, but that would require water trading and/or conveyance and should alleviate, not exacerbate the decline of the Salton Sea. The Salton Sea ecosystem is already damaged by rapidly rising salinity. While counterintuitive, it makes sense to give desalinated water back to the environment. That will support revegetation, planting of trees, and restoration of critical aquatic wildlife habitat with pure water supply.

Figure 1. Local Water Resources, Imperial Valley

Any water treatment strategy to remove salt from water in the region has to address the challenge that the only currently used regional repository for excess salt is the Salton Sea, defined in the 1920’s by Presidential decree as an agricultural sump. However accumulation of salt in the Sea is the largest single factor in the decline of the Salton Sea as a fish and bird ecosystem and is therefore one of the most critical problems to be solved.

One regional advantage is the abundance of solar, wind, and geothermal energy resources. Given California’s aggressive climate change reduction strategy, making use of these local renewable resources would be more acceptable than use of fossil fuels, or the mostly fossil fuel based local grid electricity supply from the Imperial Irrigation District (IID).

The goals of adapting existing water treatment technology to solve the local challenges at the Salton Sea therefore focused on reducing the cost of purified water, utilizing local renewable energy resources, increasing the energy efficiency, and eliminating any brine discharge to surface waters.

Water treatment systems run more cost effectively 24/7 than intermittently. Most large scale water treatment plants, including both conventional potable water plants and desalination plants, are designed to run around the clock. This best amortizes capital costs and supports a steady schedule of equipment maintenance and replacement. Because both wind and solar are intermittent energy sources and also vary seasonally, they are difficult energy sources to cost effectively apply to water treatment systems unless a very reliable and affordable energy storage system is available. Several energy storage technologies are in development, but do not yet provide established commercial low cost 24 hour delivery from wind and solar resources. Geothermal energy, on the other hand, is a continuous 24/7 energy source for both electricity and heat and has a well-developed four decade history in the Imperial Valley adjacent to the Salton Sea. Therefore geothermal energy was chosen as the preferred renewable energy resource for water treatment technology development in the Salton Sea region.

The CalEnergy Region 1, Units 1&2 geothermal power plant location is closest to the Salton Sea at 600 feet from the shore and was therefore chosen as the optimal location for a Salton Sea water treatment technology pilot project. The original project sponsor, the Salton Sea Authority, contracted and filed a 2002 CEQA Mitigated Negative Declaration for what was then called the Vertical Tube Evaporation Pilot Project. Project funding was expected to be a mix of State, from the California Department of Water Resources, with Federal funding, from the U.S. Bureau of Reclamation. Reclamation's January 2003 Salton Sea Study, Status Report described the Vertical Tube Evaporation technology as a salinity control restoration option for the Salton Sea with an estimated cost of $1.2 to $1.5 billion in 2003 net present value to return the Salton Sea to marine salinity [Reference 1, pg. 3, pgs. 13-20]. The signing of the Quantification Settlement Agreement (QSA) in 2003 dropped the original Vertical Tube Evaporation Pilot Project from consideration by the Salton Sea Authority because it was clear that the reduced agricultural drain inflows would not be able to sustain the elevation of the Salton Sea and therefore salinity control alone became a low priority compared to a receding shoreline and PM10 dust from exposed playa.

The U.S. Bureau of Reclamation offered to consider a proposal from Sephton Water Technology, Inc. for a scaled down Vertical Tube Evaporation Pilot Project, which was funded in 2004. A reduced scale pilot plant was assembled, mostly from existing equipment, at the CalEnergy Region 1, Units 1&2 geothermal power plant in 2005, began operation in 2006 and started distilling Salton Sea water with heat from low pressure geothermal steam in 2007 (Figure 2). Additional project funding was provided by the California Department of Water Resources in 2008 to expand the plant equipment and continue testing.

The Vertical Tube Evaporation (VTE) process was initially developed to optimize the cost and energy efficiency of using non-commercial atmospheric pressure geothermal steam that has been vented from triple flash process geothermal power plants operating on the southeast shore of the Salton Sea for more than 40 years (see photo in Figure 3). This is the lowest cost 24/7 renewable heat resource for distillation in the region. A Multi-Effect Distillation (MED) process was tested with two effects run at temperature and brine concentration conditions matching those of an

MED process with many more effects. The MED concept was developed in the late 1800's for sugar processing and is currently used in the Middle-East and other areas of the world for thermally efficient distillation of seawater. MED reuses heat from evaporation multiple times over in successive effects, each a few degrees cooler than the one before, essentially recycling heat to produce more distilled water.

Figure 2. Vertical Tube Evaporator Pilot Plant at CalEnergy Region 1, Units 1&2 geothermal power plant

A distillation process was selected over the more popular Reverse Osmosis (RO) process because conventional commercial RO systems are inefficient with hypersaline source water like the Salton Sea compared with distillation that can operate efficiently with highly concentrated saltwater if mineral scaling can be controlled. The VTE process developed at the Salton Sea made use of a Dispersed Seeded Slurry scale control method originally developed and patented by Dr. Hugo Sephton, now in the public domain.

Results from the Vertical Tube Evaporation Pilot Project were reported to the granting agencies [5], and later presented as a paper at the 2017 International Desalination Association World Congress in Sao Paulo [6]. A 15 effect MED system could produce 14 kg of distilled Salton Sea water from 1 kg of non-commercial geothermal steam with a recovery rate of 86% of the Salton

Sea water converted to distilled water. The quality of the water distilled from the Salton Sea is high, meeting standards for a wide range of uses when appropriately re-mineralized or blended.

Sample ID	A-Slurry	B-Seawater	I1-Dist. VTE1 E 15	I2-Dist. VTE2 E 15	J1-Dist. VTE1 E 7	J2-Dist. VTE2 E 7
McCampbell Lab ID	1107530-001	1107530-002	1107530-015	1107530-016	1107530-017	1107530-018
Sample Date	07/02/11	07/04/11	7/2/2011	7/2/2011	7/3/2011	7/3/2011
Sample Time	17:00	23:58	22:10	22:10	3:55	3:55
Sample Source	Slurry Tank	Feed Tank A	Distillate Tank 2	Distillate Tank 1	Distillate Tank 2	Distillate Tank 1
Effect	0	0	15	15	7	7
On site lab Conductivity (mS/cm @ 25C)	72.8	60.2				
On site lab pH (at 25C)	8.02	7.92				
Analytical lab TSS (mg/liter)	10,900	2.1				
Analytical lab TDS (mg/liter)	62,700	49,300	<10	<10	37	<10
Sodium (mg/Liter)	14,000	14,000	<0.5	<0.5	<0.5	0.690
Potassium (mg/Liter)	400	300	<0.5	<0.5	<0.5	<0.5
Calcium (mg/Liter)	770.0	820.0	<0.5	<0.5	<0.5	<0.5
Magnesium (mg/Liter)	2,100	1,600	<0.05	<0.05	0	0
Lithium (mg/Liter)	6.60	4.90	<0.05	<0.05	<0.05	<0.05
Strontium (mg/Liter)	30.0	24.0	<0.05	<0.05	<0.05	<0.05
Arsenic (mg/Liter)	0.031	0.025	<0.0005	<0.0005	<0.0005	<0.0005
Boron (mg/Liter)	18.0	14.0	0.002	<0.0016	0.021	0.015
Barium (mg/Liter)	<0.1	0.11	<0.005	<0.005	<0.005	<0.005
Silica (mg/Liter)	19.0	18.0	<0.11	<0.11	<0.11	<0.11
Chloride (mg/Liter)	29,000	20,000	0.32	0.18	0.51	0.33
Fluoride (mg/Liter)						
Bromide (mg/Liter)	24.0	19.0	<0.1	<0.1	<0.1	<0.1
Sulfate (mg/Liter)	15,000	11,000	0.22	0.39	0.30	0.95
Phosphate (mg/Liter)						
Total Alkalinity (mg/Liter)	338.0	262.0	<1.0	<1.0	<1.0	<1.0
Carbonate (mg/Liter)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bicarbonate (mg/Liter)	338.0	262.0	<1.0	<1.0	<1.0	<1.0

Table 1. Salton Sea water chemistry compared to Salton Sea distillate from VTE Pilot in 2011 testing

Figure 3. Non-Commercial geothermal steam vented at CalEnergy Region 1 power plants

Eliminating brine discharge to surface waters is a challenge faced by most desalination technologies in environmentally sensitive areas. Ocean discharge is hard to get approval for in California. It took a six year process for the Carlsbad desalination plant to obtain ocean discharge approval from the Coastal Commission and other agencies. Inland sites typically face even greater discharge challenges.

After recycling 86% of raw Salton Sea water as pure distilled water 14% of the original volume was six fold concentrated brine. Sephton Water Technology proposed a project to the U.S. Bureau of Reclamation to develop a process to discharge that brine thousands of feet underground into the geothermal aquifer as a means to help replenish that aquifer, which is already saturated with salt. The project was funded by Reclamation. Geochemist, Dr. William Bourcier from Lawrence Livermore National Lab analyzed the compatibility of Salton Sea chemistry with the geothermal aquifer chemistry at the CalEnergy plants and consulted with CalEnergy staff. The conclusion reached was that nearly all of the sulfate and magnesium present at substantial concentration in Salton Sea water, and a few low concentration constituents would have to be removed from the brine concentrate to avoid plugging geothermal wells when injected. Dr. Bourcier worked with colleagues Larry Lein, principal of Membrane Development Specialists, Richard Simonis, and Sephton Water Technology, Inc. to first develop a process at bench scale and then pilot test it at the Salton Sea. The process developed is diagrammed in Figure 4.

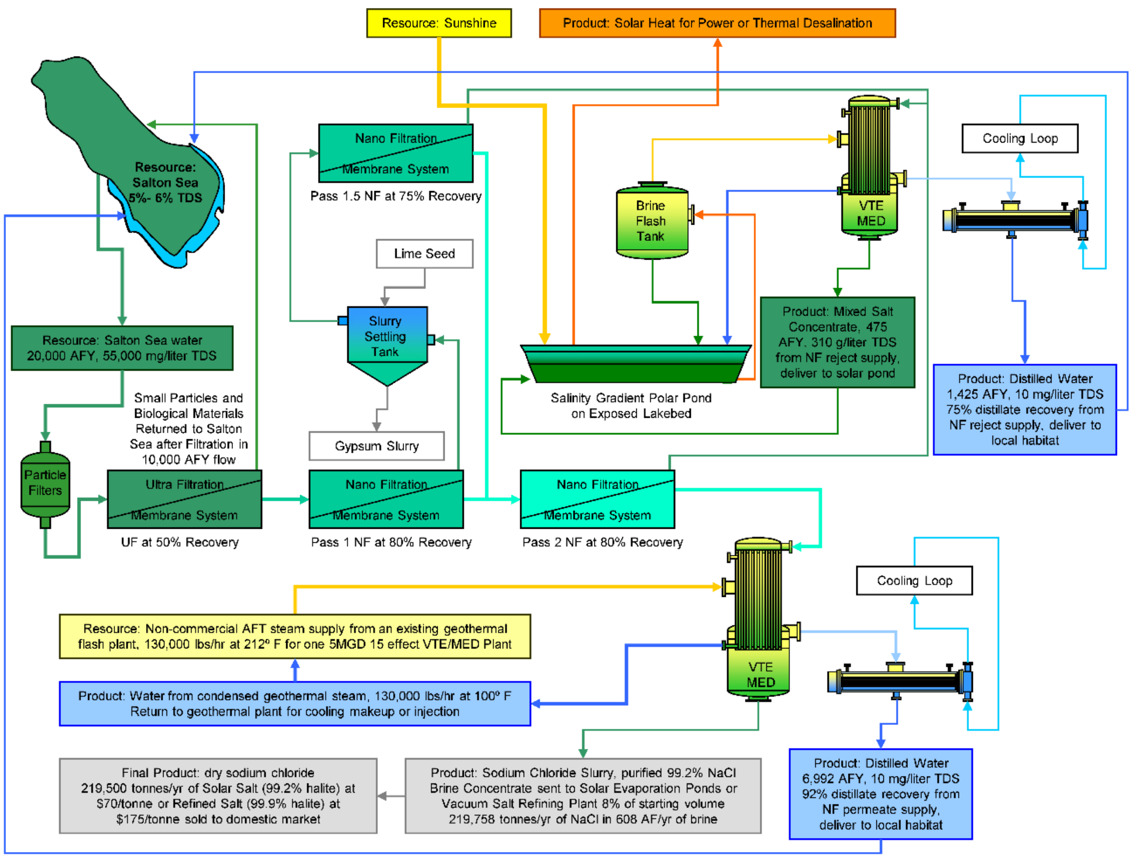

Figure 4. Salt Separation Process Developed at the Salton Sea

Adjustment of Salton Sea water pH from 8 to 6.5 followed by particle filtration, ultrafiltration, and two passes of nanofiltration removed all bicarbonate and organic material, and reduced sulfate and magnesium by 99.9%. The saltwater product (permeate) was then concentrated in the VTE Pilot Plant recovering 92% of the volume as distilled water. The remaining 8% of brine concentrate after distillation met the standards required by CalEnergy for injection into the geothermal aquifer (see analysis in Figure 5). This process was further optimized with a step to seed rejected high sulfate brine with lime to precipitate gypsum, then recycle the liquid, to yield 95% recovery by volume of the Salton Sea water. The results of this work were reported to Reclamation [5] and later presented as a paper at the 2019 International Desalination Association World Congress in Dubai [7].

It was noted that the brine concentrate from permeate was 99% sodium chloride. When dried in the sun the salt from the VTE concentrated permeate was analyzed by X-ray diffraction as 99.3% sodium chloride and by mass spectroscopy as 99.2% sodium chloride meeting the standard for commercial solar salt. Serendipitously, the process developed to enable injection of brine concentrate into the geothermal aquifer, made it feasible to recycle most of the salt content in Salton Sea water as commercial salt. This offers an opportunity to do a modern version what was done in the Salton Sea basin in the late 1800's, to brine mine salt for sale to the Western U.S.

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14737 (1-18) July 2, 2010

Bill Bourcier
LLNL
Salton Sea Mineral Recovery

Report of Analysis

Lab Number: 14737 - 18

Descriptor: VTE1-N 4-22-10 17:54
NF 2nd Pass Permeate in VTE1 1:12 conc

Analyte	mg/kg
Sodium	63900
Potassium	1030
Calcium	177
Magnesium	5.90
Lithium	16.8
Strontium	2.98
Iron	<0.258
Boron	87.6
Silica*	17.0
Chloride	93500
Fluoride	<0.202
Bromide	87.1
Sulfate	306
Total Alkalinity to pH 4.5 (as HCO3-)**	257
Ammonia	<1.14
Nitrate	15.4
TDS (Calculated)	159000
Lab pH (units)	8.39

*Analyzed by inductively coupled plasma emmission spectrometry. Lower than expected spike recovery was observed indicating possible signal supression.

**Total alkalinity from titration to a pH 4.5 endpoint, expressed as HCO_3^-.

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Figure 5. Salt Separation Result after Filtration and 12 Fold Brine Concentration

Water Source

The primary water source for the Salton Sea Water Recycling Project will be the Salton Sea itself. No one public agency, nor any private entity, has established ownership or complete jurisdiction over this water resource. Nevertheless, it can be seen as a public resource, or as a public liability. The Salton Sea Water Recycling Project aims to gradually recover and recycle the water in the Salton Sea for the public benefit, thus converting the Salton Sea from a liability into a valuable water and salt resource.

Salton Sea Water Intake

The volume of the Salton Sea is a little under five million acre feet and shrinking, but it's sustained by more than 800,000 acre feet per year of inflow currently, and while that is likely to decline, the remainder will be sufficient to sustain the public benefits proposed and the outflow from the beneficial reuse projects will return to the Salton Sea to be recycled again.

Hypersaline water will be drawn directly from the Salton Sea using submerged fish screens (such as the one pictured in Figure 6) with a screen opening of 0.1" and an approach velocity of less than 0.4 feet per second at the screen surface, less than what fish can readily swim away from.

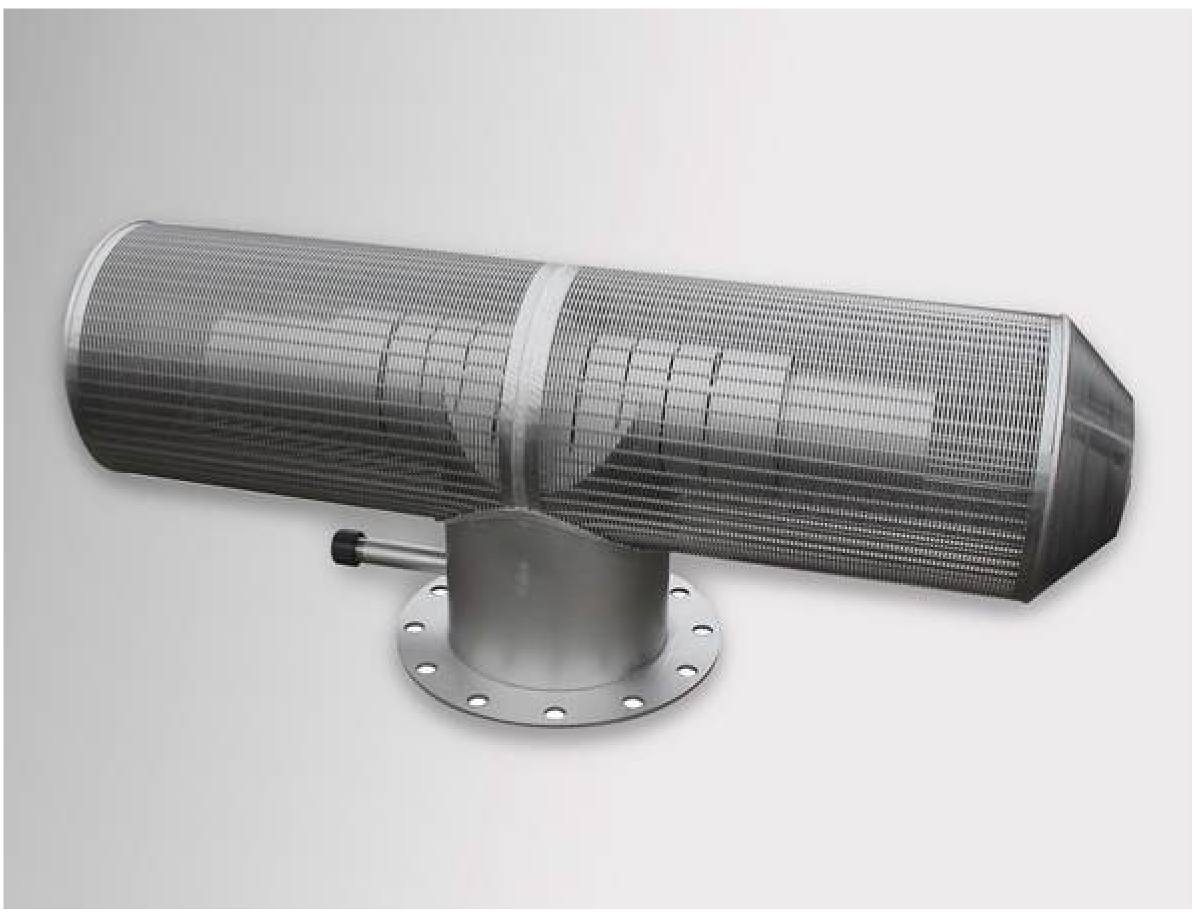

Figure 6. Submerged fish screen to eliminate impingement of fish in the Salton Sea

There will be several onshore water recycling facilities, each designed for a 20 million gallon per day (MGD) capacity. Relocatable seawater intake pump stations will be placed offshore near each water recycling facility, far enough out to sustain more than three feet of operating depth factoring in the decline of the Sea's elevation. From each relocatable seawater intake pump station, screened Salton Sea water will be pumped through 48" HDPE pressure pipe on the lakebed at 18,000 gpm using a lift pump (Goulds VIT or equivalent, see appendices O and P for specs and costing). The Salton Sea water will be delivered to each onshore facility where it will be recycled to yield the three products illustrated in Figure 7:

1. High quality distilled water
2. Purified sodium chloride brine
3. Mixed salt brine

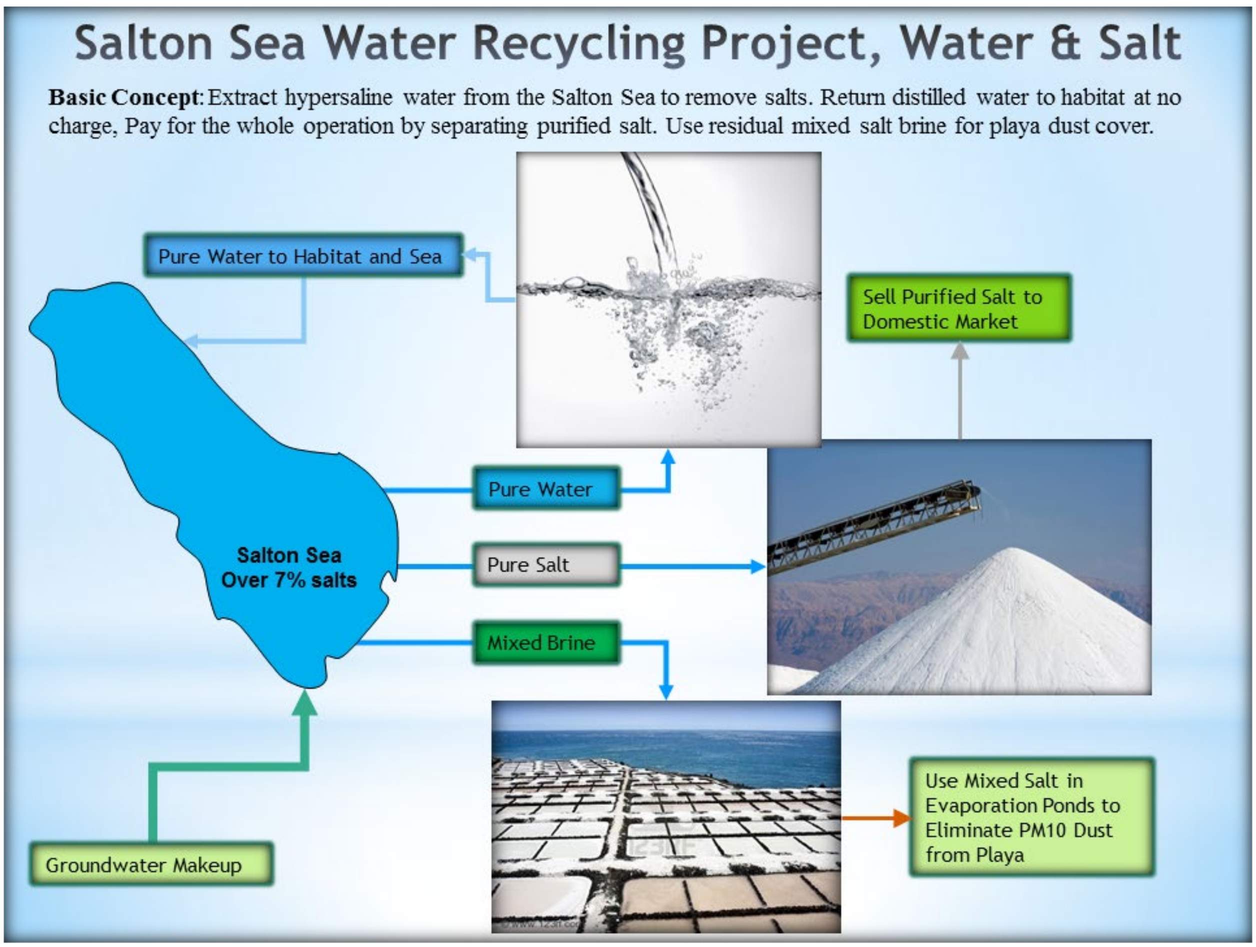

Figure 7. Salton Sea Water Recycling Project, Basic Water and Salt Recycling Concept

Each integrated onshore water recycling facility will include four types of water and salt treatment facilities. First a set of four Filtration and Salt Separation Plants each with 6 MGD permeate output, second a single Vertical Tube Evaporator Multi-Effect Distillation Plant with 20 MGD distilled water output, third solar evaporation ponds built on adjacent exposed playa for the dual purpose of evaporating and harvesting solar salt and for eliminating PM10 dust from that section of exposed playa, and fourth Vacuum Salt Refining Plants that will produce table grade salt for food processing and industrial uses.

Recycling Facility Type 1

Filtration and Salt Separation Plants using particle filters and ultrafiltration (UF) membranes to remove particles and biological materials, followed by nano-filtration (NF) membranes to separate larger more highly charged ions from sodium and chloride ions. The Salt Separation Plants will be built in 6 million gallon per day (MGD) modules. These Plants will be similar in construction to a Reverse Osmosis (RO) desalination plant with stacks of membrane housings, pumps, and other filtration equipment in a building or container. However the NF membranes used have a pore size ten-fold larger than RO membranes making it feasible to treat hypersaline water from the Salton Sea. They will placed on the Southeastern shore of the Salton Sea adjacent to other Project facilities. Four of the 6 MGD plants will be built per year, adjacent to one of the 20 MGD VTE-MED plants to feed their 99% pure sodium chloride permeate product to the VTE-MED process for salt concentration and distilled water recovery.

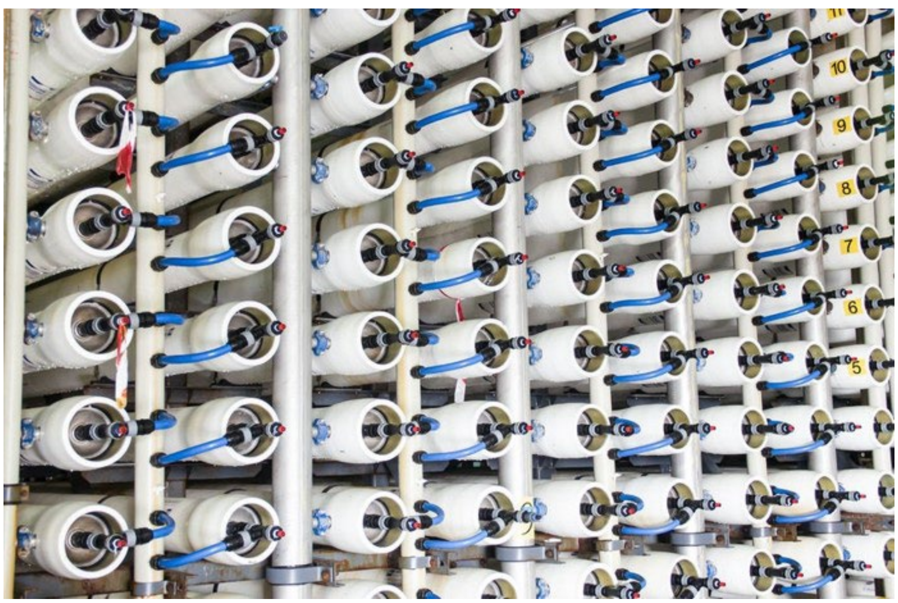

Figure 8. Array of Pressure Vessels Typical for NF Plant, Facility type 1

Recycling Facility Type 2

Vertical Tube Evaporator (VTE) Multi-Effect Distillation (MED) Plants will be driven by geothermal heat purchased as steam from local geothermal developers to separate pure water from filtered saltwater from the Salton Sea by distillation.

The first VTE-MED plant can be built to use available non-commercial geothermal steam. It will have 15 effects and a distilled water output capacity of 5 MGD to match currently available non-commercial atmospheric pressure geothermal steam resources of up to 120,000 lbs per hour from existing geothermal plants on the Southeast shore of the Salton Sea. By purchasing existing unused geothermal steam, the development cycle can be accelerated to demonstrate the fully renewable energy based Salton Sea water recycling technology initially at modest commercial scale. The distilled water output will be 5,000 acre feet per year. One local public benefit use for that pure water, re-blended with saltwater, would be to fully support the water needs of a rejuvenated Red Hill Bay Shallow Water Habitat Restoration Project. A single VTE-MED plant with 5 MGD capacity, such as that pictured in Figure 9, paired with a single 6 MGD Filtration and Salt Separation Plant would be more than sufficient to sustain an aquatic habitat project at Red Hill Bay with optimal water quality at targeted salinity and very low selenium content under 1 part per billion (ppb). No polluted water from the Alamo River would be required.

Figure 9. VTE-MED Facility, 15 Effect 5 MGD, for Non-Commercial geothermal steam, Facility type 2.

Larger VTE-MED Plants with up to 60 effects for very high thermal energy efficiency will designed to use low to medium pressure steam purchased from local geothermal developers at up to 200°C (394°F) with a design output of 20 MGD. These high efficiency VTE-MED plants can be built in linear arrays of 60 effects total, or four of the plants pictured in Figure 9 combined. Alternatively, the 20 MGD plants can composed of twelve cylindrical vacuum vessels containing five effects each in a vertical stack for a total of 60 effects enabling very high thermal efficiency from purchased geothermal steam with a more compact and attractive visual and a lower operating cost as pumping is reduced by cascading brine in vertical stacks.

Operation of high thermal efficiency MED plants with up to 60 effects at the unusually high top brine temperature of up to 200°C is made possible by the ion separation process developed by Sephton Water Technology and a team of consultants at the Salton Sea. The saltwater fed to the VTE-MED plants will 99% sodium chloride, minimizing the risk of mineral scaling at high temperatures and high brine concentration factors. Additionally, the recent availability of novel high temperature polymer composite evaporator tubes with thermal conductivity similar to metal tubes, but with the very high resistance to scaling, fouling, and corrosion of plastics helps to make this performance improvement possible [11]. These evaporator tubes have been developed by Technoform Kunststoffprofile GmbH in Germany. Seven 20 MGD VTE-MED plants will be built at the Salton Sea at a pace of one per year adjacent to new geothermal power plants that will supply both heat from geothermal steam and power for pumping. Contracts to buy all the heat and power from the new geothermal plants over a 30 year plant life will enable the Salton Sea geothermal industry to expand to meet this new demand. This will also be highly compatible with lithium recovery from geothermal brine because geothermal plants optimized for the lithium process will often have excess low to moderate pressure geothermal steam available that's not ideal for power production. Selling the excess steam for Salton Sea distillation will benefit the economics of the geothermal lithium operation.

After the first 30 years of operation the Salton Sea will have reached marine salinity. At that point only four of the seven 20 MGD VTE-MED plants at the Salton Sea will be needed to remove excess salts entering the Salton Sea from agricultural drainage. Three of the seven 20 MGD VTE-MED plants can be decommissioned and the remaining four plants refurbished and re-equipped for the next 30 years of operation at a rate of one plant per year.

Recycling Facility Type 3

Solar Salt Evaporation Ponds will take 99% purified sodium chloride brine concentrated to near saturation in the VTE-MED plants and crystallize the salt in shallow ponds built on exposed Salton Sea playa. The crystallized salt will be harvested, washed, dried, and sorted by traditional methods. Similar ponds are in use in coastal areas all over the world, including Sand Diego Bay and the Sea of Cortez. These evaporation ponds will be built out gradually as needed covering 1,200 acres at peak operation of exposed playa at the Salton Sea

Figure 10. Solar Salt Evaporation Ponds, Facility type 3

Recycling Facility Type 4

Vacuum Salt Refining Plants will take 99% purified sodium chloride brine concentrated to saturation in the 20 MGD VTE-MED plants and crystallize the salt in small VTE-MED evaporators driven by low temperature geothermal steam, removing remaining impurities by crystallization and drawing off the liquor, to achieve the 99.9% purity of refined salt used for food processing and a range of chemical process industries The refined salt crystals will be dewatered by centrifugation and fluid bed hot air drying, then milled and sorted for sale. Twenty one of these plants will be built in 250 metric ton per day production units and located near VTE-MED plants that supply the concentrated brine and near geothermal plants that will be paid to supply geothermal steam to heat the vacuum evaporation and drying process and to supply electric power.

Figure 11. Vacuum Salt Refining Plant in Europe, Facility type 4

Recycled Water and Brine Distribution

The great majority of the production of recycled water and brine from the Salton Sea will take place at the Southeast corner of the Salton Sea because that's where the geothermal resource is located. While electrical power purchased from geothermal plants can be carried by transmission lines to other locations, transporting flashed geothermal steam requires large pressure pipes. The existing geothermal plants typically do not move flashed steam more than a half mile from separators to turbines. The cost of going much further than that would become prohibitive. Distillation and salt drying components of the Salton Sea water and salt recycling process will need to be located near existing and new geothermal power plants, which are located where the geothermal aquifer resource is, on the Southeast shore of the Salton Sea.

The projects that can and probably will use the water, and in some cases the brine, from the Salton Sea Water Recycling Project will be located all around the shoreline of the Salton Sea, therefore a pure water and brine distribution system is needed. Construction of a Perimeter Pipeline around much of the shoreline of the Salton Sea upslope of all current, planned, and here proposed local restoration and mitigation projects that have a need for water. This will allow the amount of water needed to be diverted from the pipeline by an automated valve or gate and flow down to each project by gravity.

The amount of pure water available for delivery to projects around the Salton Sea will be 148,978 acre-feet per year (AFY). The flow rate in the pipeline would be (148,978

AFY)(325,851 gal/acre-foot)/(365 days/yr)/(24 hrs/day)/(60 min/her) = 92,360 gpm. If evenly divided between an East side and West side pipeline, that’s 46,180 gpm. For pure water a delivery pipeline of 63” (or 1600 mm) made from HDPE pipe SDR 17 with heated tool butt welding to join pipe sections in the field would be sufficient. The estimated cost of the 57 mile East Side Perimeter Pipeline is $135 million and the cost estimate for the 44 mile West Side Perimeter Pipeline is $104 million (see Appendix I for cost basis). The pipe size can be reduced along the route as water is diverted to projects to substantially reduce capital costs. The construction cost could be bond funded by the State or other public entity with bond payments and operation and maintenance cost paid from revenues received from sale of purified salt.

The amount of mixed salt brine available for delivery to PM10 dust control brine crust evaporation ponds, and where useful to habitat projects needing saltwater blend, will peak at 3,108,431 metric tons per year then decline in mass as the salinity of the Salton Sea starts to go down. The volume flow will peak at 9,016 acre-feet per year (AFY). The flow rate in the pipeline would be (9,016 AFY)(325,851 gal/acre-foot)/(365 days/yr)/(24 hrs/day)/(60 min/her) = 5,590 gpm. If evenly divided between East side and West side, that’s 2,795 gpm. For mixed salt brine a delivery pipeline of 24” made from HDPE pipe DR 18 would be more than sufficient. The pipe size can be reduced along the route as brine is diverted to salt crust evaporation ponds and only has to encircle the southern half of the Salton Sea, which is likely to have most of the emissive playa and has very little human habitation nearby.

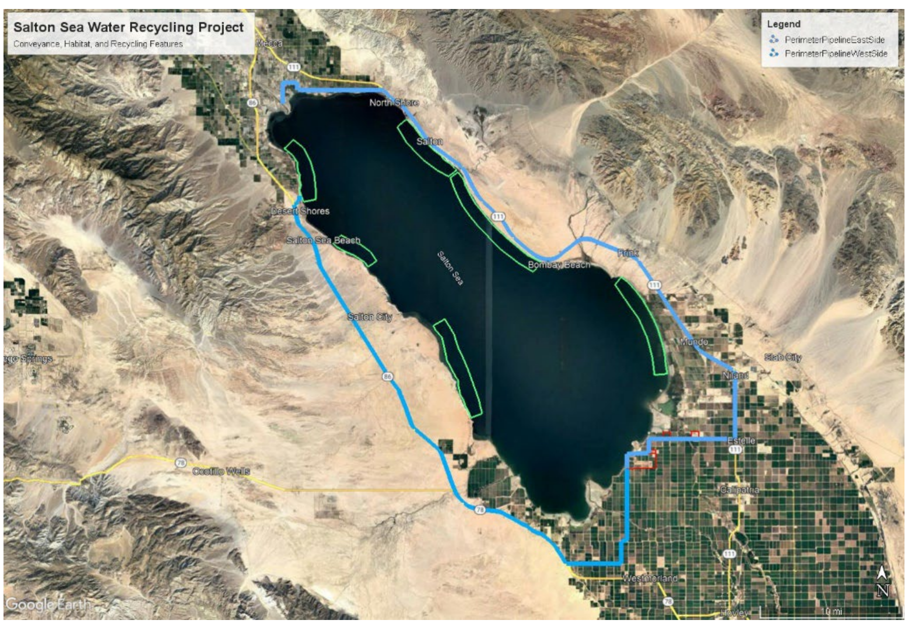

Figure 12. Perimeter Pipe Route with In Sea Habitat

Figure 12 shows a proposed route for the Perimeter Pipeline in blue. Actual routing will have to be adjusted based on where right of way can be secured. One option is to use County road right of ways to bury pipes adjacent to the roads from the geothermal plant areas southwest to the highway, then use the State Highway 86 right of way to convey pure water and brine north and west in pipes buried adjacent to the Highway to the West Shores communities. In the opposite direction, County road right of ways can be used from the geothermal area east to State Highway 111, then follow the 111 Highway north and west along the east side of the Salton Sea.

Water Supply Requirement

There are two broad categories of water supply requirements for the Salton Sea Water Recycling Project. First is the long term water supply requirement to sustain the Salton Sea and gradually restore it to marine salinity. The second category is the mid-term and long term water supply requirement for each individual habitat project, recreational feature, and for each dust control concept and project.

To address the long term water supply requirements for restoration of the Salton Sea itself to meet salinity and other water quality standards needed to sustain an ecosystem capable of supporting anything more than halophilic algae and bacteria, it's clearly necessary to analyze the hydrology of the Sea and the mass balance of salts, which are the primary driver for the collapse of the fish and bird ecosystem that is apparently underway now. The Salsa 2 hydrology model developed under contract for public agencies is not available to the public. Even it were (the author had temporary access several years ago) the Salsa 2 model is configured to only estimate the impacts of a narrow range of habitat restoration concepts that were under consideration by public agencies at the time it was developed. It is not a general tool for hydrology analysis of new concepts for Salton Sea restoration. Therefore it was necessary to create a simpler spreadsheet based Salton Sea hydrology analysis tool to estimate the impacts, benefits, and water supply requirements of the concepts proposed by this Salton Sea Water Recycling Project. This tool includes volumetric hydrology balance equations for all known Salton Sea inflows and Project inflows and known outflows due to surface evaporation, seepage, and Project outflows. Similarly it was necessary to include mass balance equations for inputs of salts to the Salton Sea system from rivers and agricultural drains, existing salts in the Sea, and calculate output of salts from Project salt extraction and from precipitation. The theory behind these calculations is described in the document in Appendix A. The actual calculations are in the spreadsheet and charts that comprise Appendix B. Data to populate the spreadsheet was obtained from reports by local public water agencies and published literature. Project impact data sources were from published experimental results extrapolated to a larger scale. The data sources are noted in Appendix B.

The main inflows to the Salton Sea are from the rivers and agricultural drains. These are shown in Figure 13 by the dark blue line for inflows calculated if there had been no inflow reduction due to the QSA water transfers, and by the red line showing the influence of QSA water transfers and mitigation water deliveries up to a few years ago. There are much smaller inflows from rain and groundwater seepage, which are estimated in the calculation, but are not shown in Figure 13.

A proposed groundwater recovery inflow of up to 50,000 AFY is shown in Figure 13 as the light green line. This is a proposed new water source for the Salton Sea, but it is not required to achieve the salinity reduction in the Salton Sea or to support any of the proposed habitat, recreational, or dust control projects. The extra inflow is useful to help manage a steady elevation after a new inflow versus outflow equilibrium is reached a few decades out from now. The groundwater would be recovered by wellfields on the southeast side of the Salton Sea accessing brackish groundwater available from the East Mesa area and north to Iris Wash that can be recovered from shallow depth and delivered to the Salton Sea through the Iris Wash and the Z Drain. That aquifer area is estimated to hold roughly one million acre feet of brackish groundwater [8]. The 50,000 AFY extraction rate is based on the limits to recharge of that aquifer by IID underruns estimated from historical data and by using the abandoned unlined section of the Coachella Canal as a recharge basin when underruns are available.

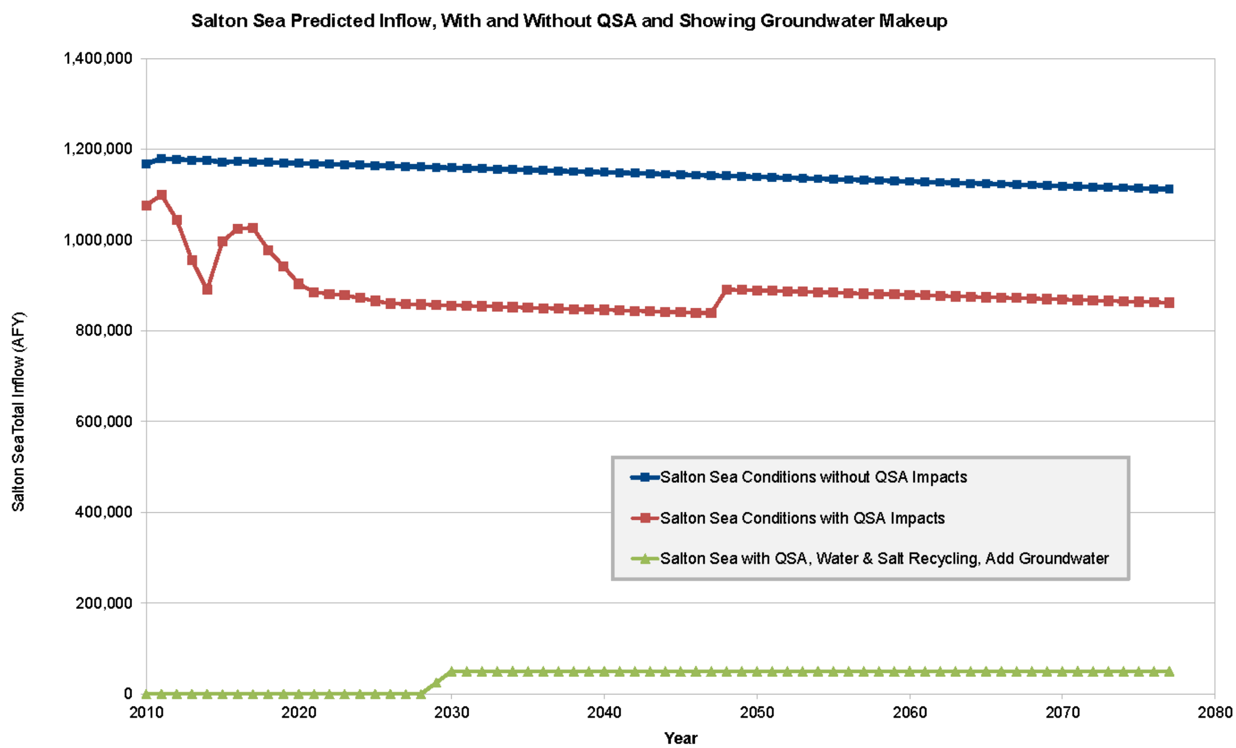

Figure 13. Predicted Salton Sea Inflows, Baseline Scenarios and Groundwater Make-up

Cost estimates for the wellfield development are included as a tab in Appendix D based on cost estimates in the 2009 IID Draft Integrated Regional Water Management Plan Appendix N pg. 26 for similar brackish water wellfield development in the same region.

The largest outflow from the Salton Sea is by surface evaporation to the air. Evaporation from a water body varies with a range of factors including temperature, wind speed, humidity, and solar radiation, but the evaporation rate is directly proportional to surface area. As the elevation of the Salton Sea declines in a shallow basin, the surface area also declines. The reduction in surface area will reduce the amount of water lost to evaporation. If inflows stabilize, the Salton Sea will reach a new equilibrium when the smaller surface area reduces evaporation loss to balance inflows. Figure 14 shows a prediction of Salton Sea surface area under several scenarios. The dark blue line shows surface area declining gradually if there were no QSA water transfers. The red line shows surface area with QSA water transfers, but no restoration project. The light blue line shows surface area with a Salton Sea Water Recycling Project without groundwater inflow and the light green line shows surface area stabilizing at a higher acreage if roughly 50,000 AFY of brackish groundwater is delivered to the Sea. With or without a Project a new equilibrium is predicted around the year 2050.

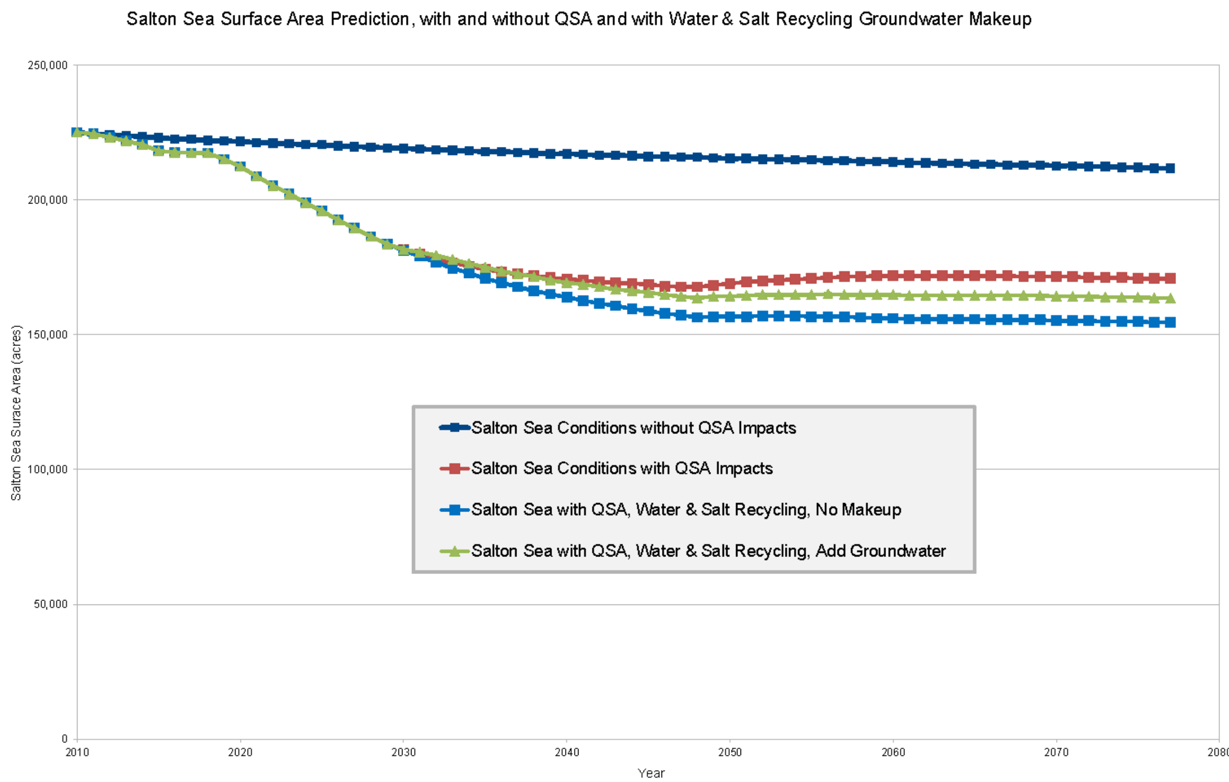

Figure 14. Predicted Salton Sea Surface Area, Project versus Baseline Scenarios

The most significant impact of this rebalancing of inflows and outflows, caused mostly by QSA water transfers, is on the elevation of the Salton Sea. Figure 15 shows a prediction of Salton Sea elevation by the hydrology model used for this proposal. The dark blue line shows elevation declining gradually if there were no QSA water transfers. The red line shows rapid elevation decline with the QSA water transfers, absent a restoration project. The light blue line shows elevation with a Salton Sea Water Recycling Project without groundwater inflow and the light green line shows the elevation stabilizing few feet higher if brackish groundwater is delivered to the Sea. Unfortunately the Salton Sea Water Recycling Project cannot return 100% of the water drawn from the Salton Sea because some of it goes with the 5% mixed salt flow to form salt crust for dust mitigation letting that water evaporate and some stays with the purified salt slurry and has to be driven off by salt drying. One benefit of the Project is the removal of millions of tons of salt from the Salton Sea each year that will drive down salinity over time until the once thriving aquatic ecosystem can be restored and sustained. If a larger source of water import could be identified, then there would be an opportunity to balance the Salton Sea surface elevation several feet higher.

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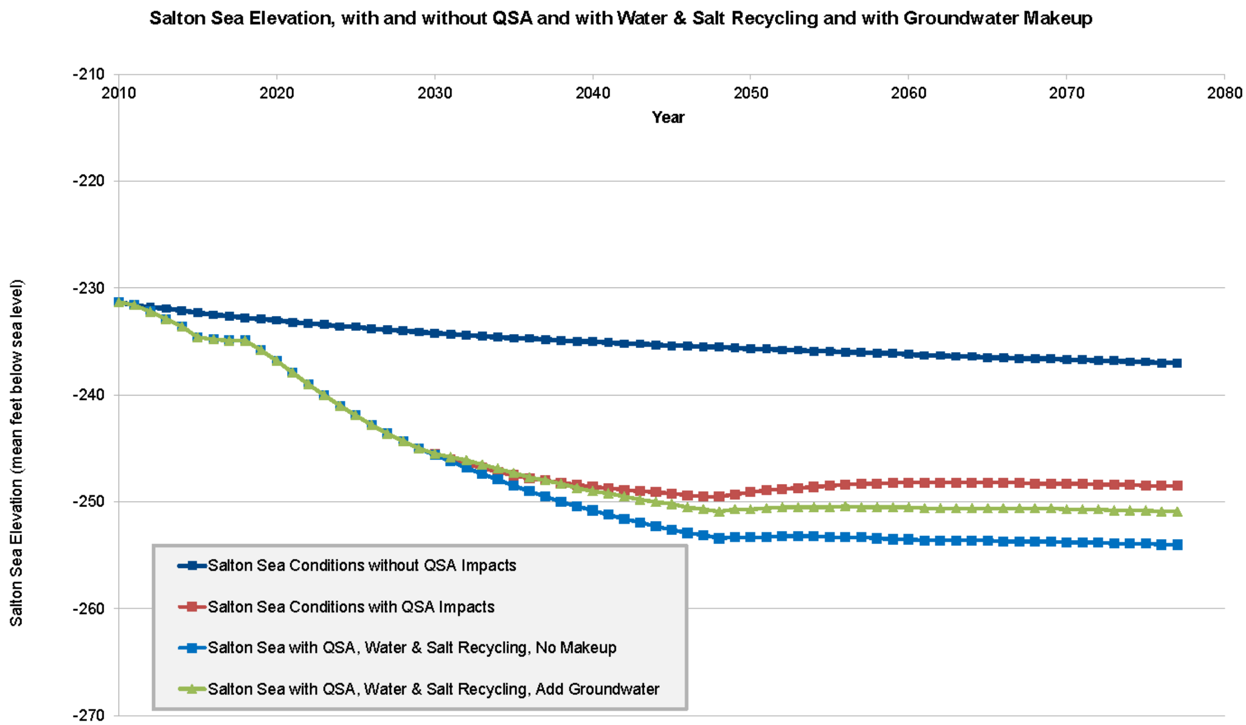

Figure 15. Predicted Salton Sea surface Elevation, Project versus Baseline Scenarios

There are several consequences to the decline in elevation of the Salton Sea. One is the recession of shoreline thousands of feet away from the communities built to take advantage of it like Salton Sea Beach, Bombay Beach and several others. Another consequence is the concentrating effect of shrinking the volume of the Sea causing salts and any contaminants to concentrate in the water since the Salton Sea is a terminal lake. Perhaps the most problematic consequence is the exposure of tens of thousands of acres of playa composed in many locations of fine sediments that blow in the wind as PM10 dust capable of causing increases in asthma, bronchitis, and lung cancer. Also of concern is some areas of toxic components in those sediments laid down by a century of industrial agriculture and by other industries on both side of the U.S./Mexico border.

Figure 16 shows a hydrology model prediction of the acres of playa exposed year by year at the Salton Sea. The dark blue line shows playa exposing gradually in the absence of QSA water transfers. The red line shows rapid exposure of tens of thousands of acres of playa with the QSA water transfers, absent a restoration project. The light blue line shows playa exposure going to zero in 2057 with a Salton Sea Water Recycling Project without groundwater inflow. Playa exposure will go to zero because all of the exposed playa will be covered with salt crust by 2057. The light green line shows playa exposure going to zero three years later if brackish groundwater is delivered to the Sea because the extra groundwater will dilute the salt in the Sea reducing the amount of mixed salt recovered to form salt crust. If only part of the exposed playa is found to be emissive and salt crust is targeted to those areas, then full PM10 dust elimination from Salton Sea playa could be achieved many years earlier.

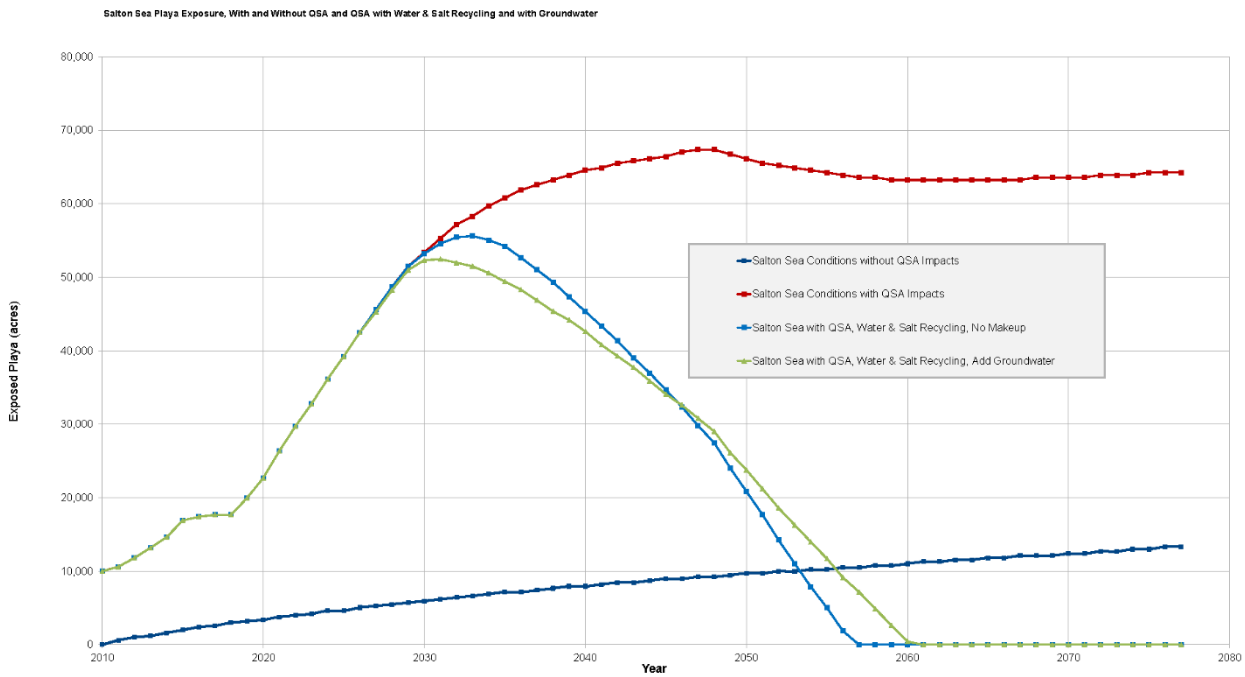

Figure 16. Predicted Salton Sea Playa Exposure, Project versus Baseline Scenarios

Long term water supply can also control PM10 dust in a targeted way by implementing the existing and highly effective local strategy of using rows of trees to block windblown sand and dust from encroaching on farms, railroads, and project sites. Examples include the main railroad through the Coachella Valley paralleling Interstate 10 and the railroad through the Glamis desert area protected by rows of salt cedar (aka tamarisk). A tall stand of salt cedar are used at Three Flags Ranch ten miles south of Salton City to protect a large citrus farm from windblown sand and dust from the adjacent desert to the west. Similar rows of trees are used by farms in the Imperial Valley. Going back to the Second World War, the old Navy Test Base south of Salton City used salt cedar planted in raised berms to protect the central area of the Base from encroachment by the sand dunes around it. These trees still survive after decades of neglect on a limited amount of groundwater available below the Base area. While rows of salt cedar make highly effective windbreaks for dust control, they are considered invasive and are often removed by public agencies. Fortunately native mesquite are also effective as windbreaks [Reference 1] and will support a community of native birds and animals. Studies in Arizona [References 2, 3] showed an evapotranspiration rate for desert mesquite of 28.6 inches per year. This is a somewhat lower water requirement than salt cedar [Reference 4]. Honey mesquite put down taproots us deep as 100 feet. Planting using a deep tube irrigation system enables them to survive on groundwater once mature if irrigation is interrupted. The water requirement for a stand of mesquite is estimated at 2.4 AFY per acre of trees. The water requirement for a single row of mesquite windbreak with ten feet between trees is estimated at 6.4 AFY per mile of windbreak. Please see Appendix E for calculations. This is a modest water requirement in the context of this Salton Sea Water Recycling Project. Many miles of mesquite windbreak can be readily supported in multiple rows to protect all of the communities along the Salton Sea shoreline. Rows of mesquite strategically placed as windbreaks between shoreline communities and sources of PM10 dust from both the Salton Sea playa and the desert can mitigate health impacts on local communities near the Salton Sea shoreline.

Figure 17. Salton City Dust Windbreaks, 40 miles of Mesquite Tree Lines in Rows of Three

An example of shoreline community PM10 dust protection with mesquite windbreaks is shown in Figure 17 where Salton City is shielded from both desert and off road recreation area dust on the west, where the prevailing wind comes from, and is shielded from Salton Sea playa dust on the east when the wind reverses. A total of 40 miles of mesquite windbreaks in three parallel rows shields both sides. Windbreaks protecting Salton City and Vista del Mar could be planted in triple rows with a separation of up to 50 meters between rows to direct wind upward and cut the wind speed to reduce the loading of sand. A total of about 40 miles of tree line in triple rows 20 feet wide each would need to be irrigated by delivering water to the root of each tree through a vertical gravity fed pipe to stimulate deep taproot development. The annual fresh water requirement would be (6.03 AFY/mile)(40 Miles)= 242.1 AF a small fraction of the thousands of acre feet this Project will supply each year.

Figure 18 shows a more extensive example where triple row tree line windbreaks are extended south from Salton City along the shoreline to protect the Salton Sea playa from sand dunes already spreading onto the playa causing saltation that breaks free PM10 dust from the playa surface when windblown sand strikes the surface of the finer sediments on the playa. This larger shoreline PM10 dust protection would employ a total of 225 miles of mesquite windbreaks in multiple rows to protect the West Shore playa from saltation. The water requirement would be (6.03 AFY/mile)(225 Miles)= 1,357 AFY, or about 1% of the annual water output of the Project.

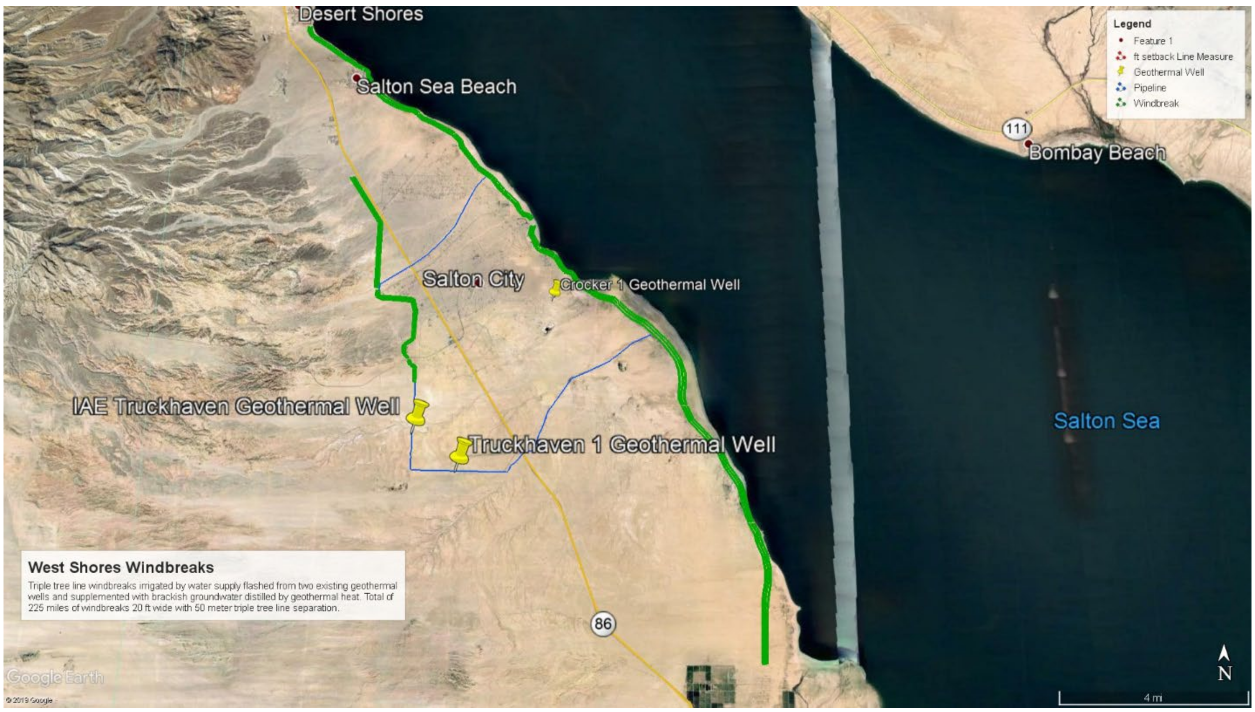

Figure 18. West Shores Dust Windbreaks, 225 miles of Mesquite Tree Lines in Rows of Three

The water supply requirement for the Shoreline Lakes component of this Project is estimated based on the need to use fresh water to blend with salt water and the need to offset loss of water in the Lakes to surface evaporation, seepage through the berms and bottom, and outflow needed to circulate and keep the water in the Lakes from stagnating. Estimates have been made for the larger component of this concept called the West Shore Lakes. It includes two small recreational lakes on the shoreline of Desert Shores and Salton Sea Beach, and a larger recreational lake on the shoreline of Salton City with connecting boat and fish channels between them. The total water surface area for all three West Shore Lakes and channels is 1,226 acres. A 60% freshwater blend ratio to achieve 35 ppt salinity early in the Project timeframe will require 5,175 AFY of pure distilled water supply from the Salton Sea Water Recycling Project and 3,450 AFY of Salton Sea water, see Appendix H (West Shore Lakes Water Estimate tab) for info.

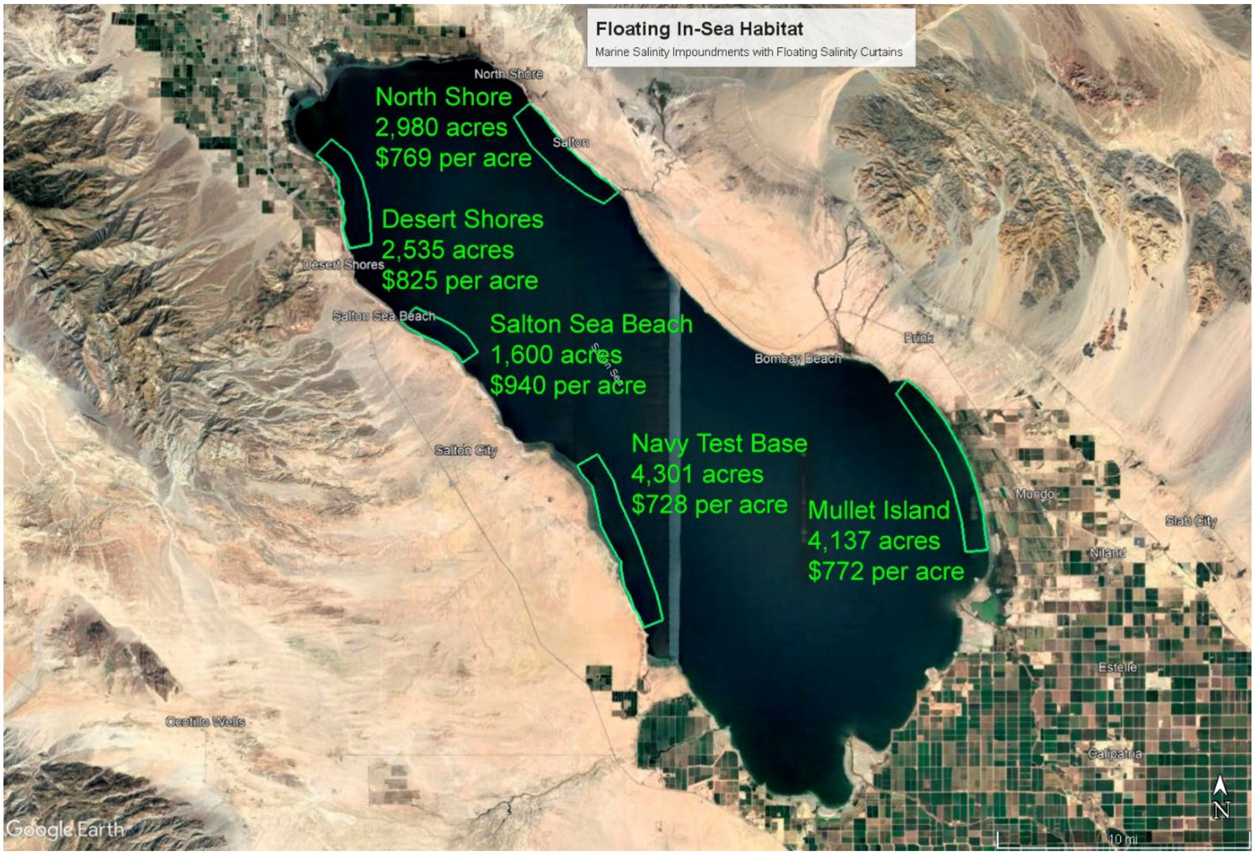

Figure 19. Floating In-Sea Habitat Impoundments. Roughly 15,000 acres total at $728 to $940 per acre

The water supply requirement for managed salinity impoundments in the Salton Sea itself separated from the hypersaline Sea by floating salinity curtains is directly based on surface evaporation from those impoundments. A 1978 study [9] of Salton Sea surface evaporation, from when the Sea was close to marine salinity, estimated 68 inches per year of surface evaporation. The evaporation rate is much higher in summer than in winter, but the average is sufficient for annual water supply estimates. That gives (68 in.)/(12 in./ft.)= 5.7 AFY of evaporation from each acre of in Sea habitat. Since habitat is important and thousands of acres are needed, the intent is to direct any pure recycled Salton Sea water not needed for other projects to the in Sea managed salinity habitat impoundments. After full buildout of the Salton Sea Water Recycling Project infrastructure and deducting the water requirements noted above, this could leave 126,484 AFY of pure distilled water available, which would sustain up to 22,190 acres of in Sea habitat.

Figure 19 shows in light green proposed locations for roughly 15,000 acres of Floating In-Sea Habitat (FISH) impoundments around the Salton Sea shoreline with area and estimated cost per acre to build and maintain for 20 years. The cost basis for the estimate is in Appendix J. It assumes cost per linear foot of floating salinity curtain based on the purchase price a few years ago for a prototype test rig that was floated in the Salton Sea for several months (Figure 20) and assuming wood pilings to anchor the curtain that would be re-driven annually as the Sea recedes.

Figure 20. Floating In-Sea Habitat prototype test rig from 2017

If other projects need water supply, such as the Red Hill Bay Shallow Water Habitat Restoration Project, North Lake, or the Species Conservation Habitat, then that supply would be deducted from the amount estimated above.

Salinity (freshwater or saltwater)

All of the aquatic habitat and recreational features proposed will be designed to operate between 20 parts per thousand (ppt) and 40 ppt total dissolved solids (TDS). This is the same range prescribed by the State of California's Salton Sea Management Program. That range of salinity is suitable to sustain a marine fishery like that that thrived in the Salton Sea prior the turn of the 21st Century. The 20 ppt to 40 ppt range of salinity will suppress the growth of reeds that bio-accumulate selenium and reintroduce it to sensitive species and is also thought to help to suppress the growth of mosquito larvae. To the extent feasible, 35 ppt TDS will be targeted, by aquatic features of this Project, equivalent to the Pacific Ocean.

The Shoreline Lakes recreational and aquatic habitat features will achieve target 35 ppt TDS by blending pure distilled water from the Perimeter Pipeline with Salton Sea water pumped up to the lakes or by blending with brine concentrate flowing by gravity down to the Shoreline Lakes from a parallel Perimeter Brine Pipeline..

The Floating In-Sea Habitat impoundments will achieve target 35 ppt TDS by blending pure distilled water from the Perimeter Pipeline with Salton Sea water in situ using variable inflow vortex blend devices to mix fresh and saltwater at the edge of each managed salinity impoundment where the freshwater enters and also to oxygenate the inflow.

Over a roughly three decade restoration period, the body of the Salton Sea remaining when the reduced Sea reaches an equilibrium between inflow, evaporation loss, and seepage will be reduced to a target 35 ppt TDS by removal of salt and return of lower salinity water by outflow from the Shoreline Lakes, floating salinity curtain impoundments, and any other projects supplied with water like Red Hill Bay, the North Lake, or the Species Conservation Habitat.

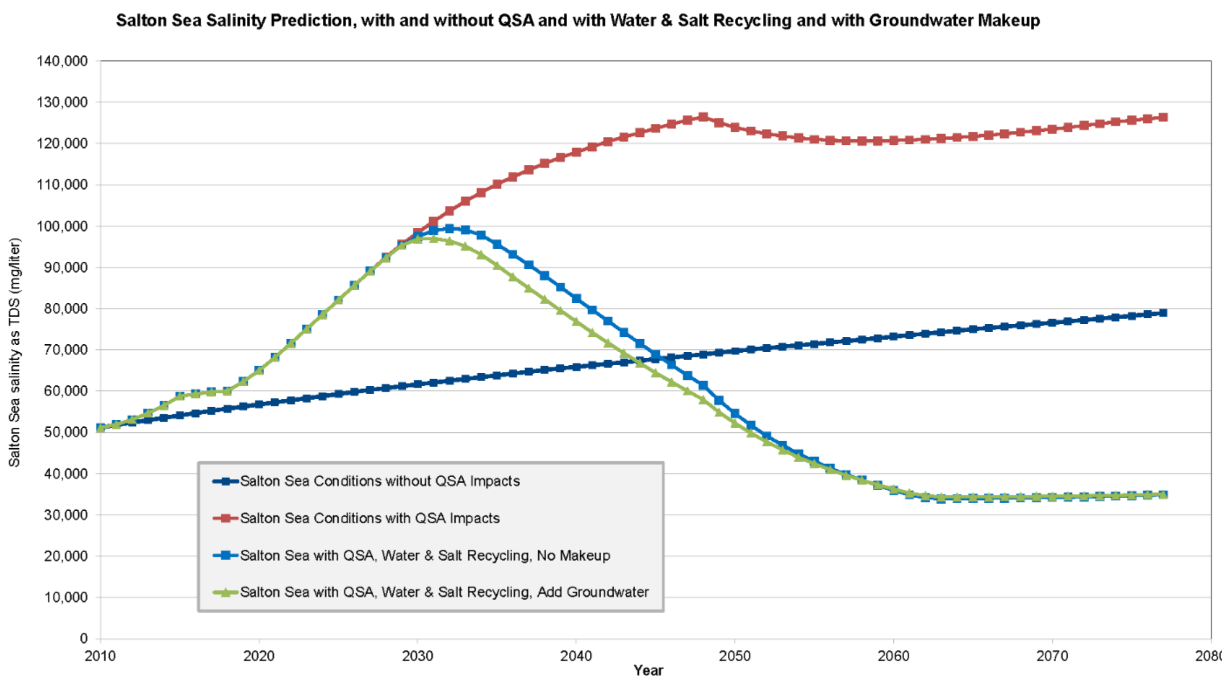

Figure 21. Predicted Salton Sea Salinity with Water Recycling Project versus Baseline Scenarios

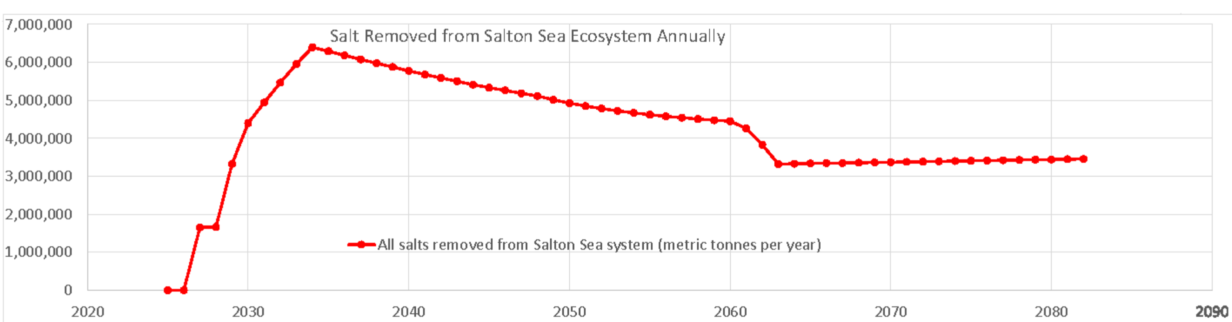

Figure 22. Salt Removed from the Salton Sea Annually with this Water Recycling Project

Figure 21 shows a predictive hydrologic and salt balance model of Salton Sea salinity comparing this Project with groundwater make-up flow up to 50,000 AFY (light green line) and without groundwater make-up (light blue line). The two Project outcomes are compared with two baseline scenarios, one if there had been no QSA water transfers (dark blue line), and the other baseline with current QSA water transfers (red line). The model uses basic hydrology volume balance equations assuming no new water transfers and mass balance equations for total salts as TDS. See Appendix A for formulas and Appendix B for calculations. Figure 22 shows the amount of salts removed from the Salton Sea annually by the Project. Both Salton Sea Water Recycling Project scenarios start to turn around rising salinity as soon as recycling facilities start to come online in 2028 making a difference by 2030. The salt removal pushes salinity down to 35 ppt TDS around 2060, then maintains salinity at that level from 2060 onward. Salinity would go below 50 ppt TDS by about 2050 at which point the fish population could begin to recover in the whole remaining Salton Sea.

Recreational Opportunities or Features

Recreational features in the mid-term, starting several years out and continuing, include Shoreline Lakes and stands of native trees in and around the communities that are closest to the Salton Sea. These communities include Salton City, Vista del Mar, Salton Sea Beach and Desert Shores on west side of the Salton Sea plus Bombay Beach and North Shore on the east side of the Salton Sea. All of these communities are impacted by the receding shoreline.

The health impact of PM10 dust from exposed playa under specific wind conditions relates to increasing complaints in the last few years of asthma and nosebleeds from some of these shoreline communities, and other nearby communities. Although systematic collection of health data is inadequate to fully quantify the impact, even the impression of health risk causes local residents to stay indoors and avoid outdoor recreation. Over time that impression will also cause recreational visitors to stay away from the area.

The appearance of the shoreline communities is mostly devoid of trees with sparse desert shrub vegetation. For example an existing park in Desert Shores has for many years looked like a few pieces of playground equipment dropped in a desert. The direct sun with no shade makes the play equipment too hot to touch for half the year. The lack of trees and vegetation makes the existing recreational opportunities in shoreline communities uninviting. The short supply and high cost of freshwater in these shoreline communities is the key reason for the barren appearance. Other desert communities in the region like Brawley and El Centro are much better supplied and support trees and residential vegetation. This can be reversed with better water supply for public amenities where it makes the most difference.

The key feature that caused all these shoreline communities to be built in the first place was the Salton Sea shore. These towns were designed in the mid 20th Century to be beachfront communities and had all the amenities that went with that from beach clubs to boat launches to golf courses. Now that the Salton Sea shoreline is receding rapidly away from these communities, most of these amenities are non-functional or have been bulldozed by the water agencies that now own most of the shoreline. There are no functional manmade boat ramps in any of the shoreline communities anymore. Much of the beach is now off limits to local residents with no trespassing signs posted by public agencies along most former areas of shoreline access in these communities.

The status quo for recreation in most of the shoreline communities with respect to health, appearance, availability of amenities, and access to the shoreline is all one of decline and destruction. Only Bombay Beach has partly overcome that with an eclectic art community drawn to the desolate appearance and abandoned buildings, but even that is running on borrowed time and on borrowed land.

Essential to reversing the loss and restoring recreation to the shoreline communities is to provide quality long term affordable water supply in the places where it will make the most difference. Long term affordable water supply will support planting and sustaining native vegetation, particularly native trees like mesquite and palo verde that provide shade, reduce wind speed at ground level, and provide habitat. Trees planted in and around public parks and streets will provide shade and create a more walkable community. Stands of native trees and shrubs planted on the outskirts of the shoreline communities will hold down dust, moderate wind, and provide habitat for birds and a range of terrestrial species. Recreationally, stands of trees with foot paths will provide public areas to walk, run, and bike improving both health and quality of life.

A key recreational feature of this Project are the Shoreline Lakes. Figure 23 shows the main example of this concept. It includes three recreational lakes at three of the four West Shores Communities, Desert Shores, Salton Sea Beach, and Salton City. The Lakes will be created by building berms from the community shoreline out into the Salton Sea. These lakes will connect with existing, but now disconnected and drying, boat channels already built within each community and surrounded by houses thereby restoring boat access. The West Shores Lakes will be supplied with a blend of raw Salton Sea water pumped in and pure distilled Salton Sea water supplied by the Project through the Perimeter Pipeline. The salinity target will be 35 ppt. The water quality will be greatly improved by dilution with pure distilled water. A connecting channel will join each recreational lake allowing small boats and fish to move between the lakes.

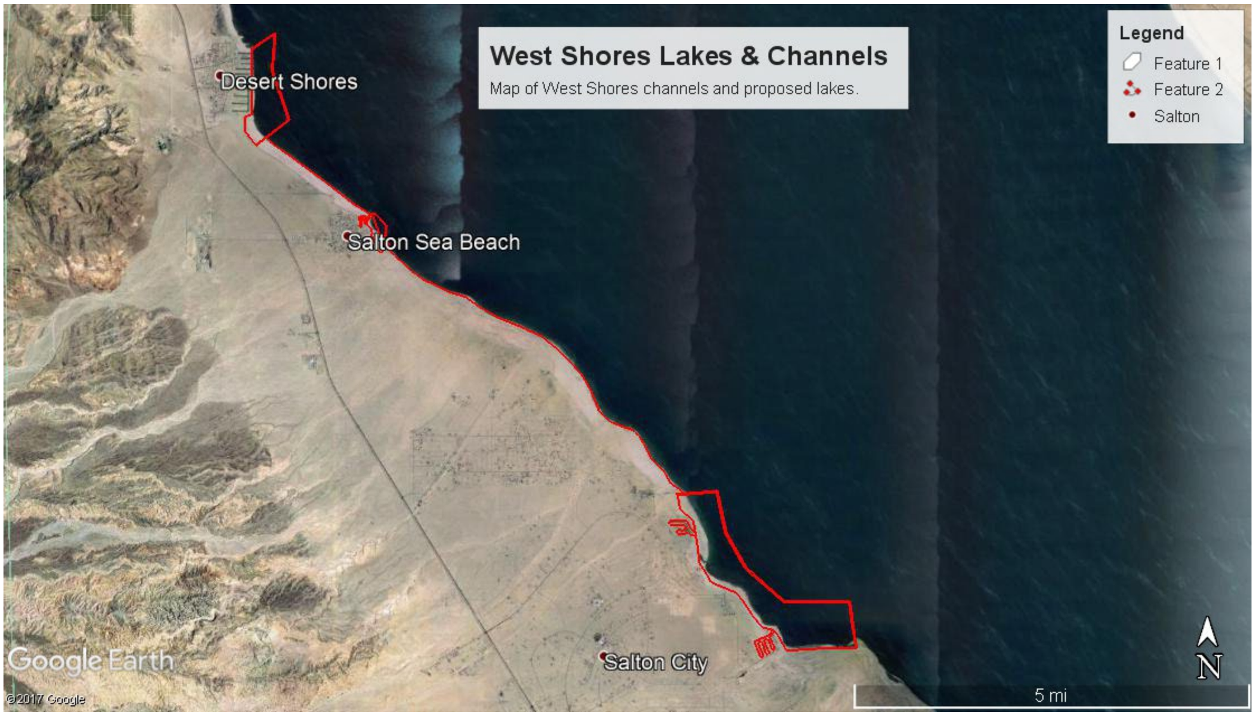

Figure 23. West Shores Lakes Overall Project Map

Figure 24. Desert Shores Lake Local Project Map

The 267 acre Desert Shores Lake will restore the original -227 feet below mean sea level shoreline elevation the community was designed for. It will be 30 feet deep at the furthest point off shore. The lake will support wildlife from fish, to shorebirds, to diving birds. It will rejoin saltwater with all ten former boat channels enabling boat access for both residents and the visiting public. The land under the Desert Shores Lake is mostly owned by the Torres Martinez Band of Desert Cahuilla Indians and by the Hoffman Family. Figure 20 shows a berm map outline of the Lake.

Figure 25 shows the Salton Sea Beach Lake berm outline crossed by the path of the connecting channel between the three lakes. This Lake will also restore the -227 foot shoreline with a small 48 acre, maximum 15 foot depth lake that will reconnect to two former channels now out of use and owned by IID. The public is now prohibited from any shoreline access in the Salton Sea Beach community because it's all IID property, but a land purchase may be negotiable to restore public access.

Figure 25. Salton Sea Beach Lake Local Project Map

Figure 26 shows the substantially larger Salton City Lake berm and water edge outline map. It too will restore the -227 shoreline elevation the community was built around with an 830 acre lake at a maximum depth of 25 feet at the berm opposite the shoreline. Two sets of drying boat channel housing areas, the Pelican Keys at the north side of Salton City, and the Riviera Keys at the south side, will be reconnected by the Lake in between.

Figure 26. Salton City Lake Local Project Map

Like the two smaller connected lakes to the water will be returned to a 35 ppt target salinity, quality will be improved by dilution with pure distilled water blended with Salton Sea water, and fish and birds will repopulate the Salton City Lake with wildlife. Boat ramp access will be restored at Johnson's Landing at the north edge of Lake, which is the only surviving shoreline business in any of these communities offering a popular local restaurant and bar with a trailer park and a nearby motel. There are multiple property owners along the Salton City shoreline, although IID is the largest and has posted no trespassing signs along much of the shoreline. Agreements or land purchase will have to be worked out with both public and private land owners of the areas that will be restored as a Lake.

The timing of when these all these recreational features can start to be implemented is largely a function of the availability of new water supply recycled from the Salton Sea by this Project.

Engineering Feasibility

Please see Appendix G for more information on the engineering feasibility of the core technology solutions proposed.

Land Use and Ownership

A land ownership map of the entire Salton Sea (Figure 27) is provided as Appendix N.

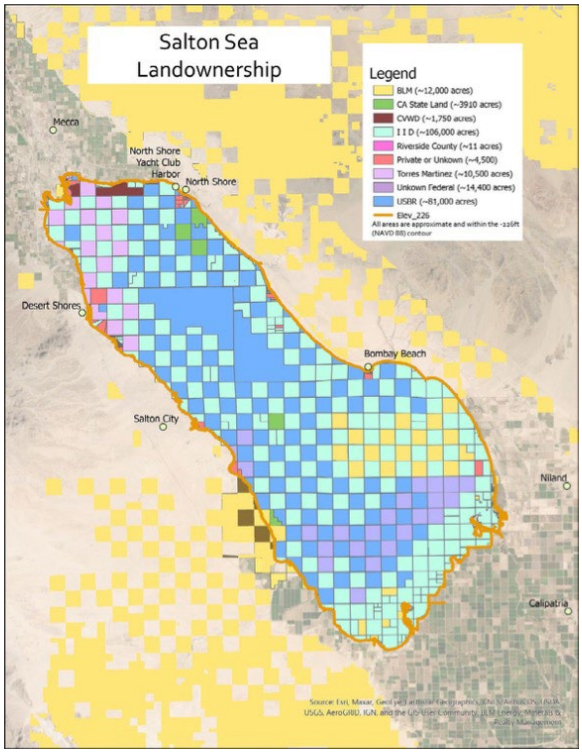

Figure 27. Land Ownership Map (Courtesy of the SSMP)

Multiple land owners will be impacted by this Project. There will be a need for extensive right of way negotiations and some plots may need to be purchased.

Impacts to Water and Wildlife

The Salton Sea Water Recycling Project will restore thousands of acres of deep, shallow, and shoreline aquatic habitat in the mid-term, several years from project start, by using floating salinity curtains to section off managed salinity impoundments near the shoreline and return water in these impoundments to marine salinity targeted at 35 ppt with oxygenation of the inflow and using pure distilled Salton Sea water to blend with the hypersaline Salton Sea water in situ, thus diluting excess nutrients and any contaminants in the water column. Salinity of these shoreline impoundments will be managed between 20 ppt and 40 ppt.

In addition the Salton Sea Water Recycling Project will restore dozens of acres of prime recreational aquatic areas near shoreline communities that will also support fish and birds. This will be accomplished by blending pure distilled Salton Sea water delivered to these communities with either Salton Sea brine concentrate or hypersaline Salton Sea water pumped up from the Sea to a target salinity of 35 ppt to be maintained in Shoreline Lakes designed to enable water access to the public for swimming, boating, and fishing.

Providing fresh water supply to already planned, but stalled habitat projects, for example the Red Hill Bay Shallow Water Habitat Restoration Project, will provide hundreds of additional acres of aquatic habitat if local agencies and landowners allow it.

The introduction and irrigation of native trees near shoreline communities will also support birds and terrestrial wildlife as well as improving the quality of life for residents.

Project Development Schedule

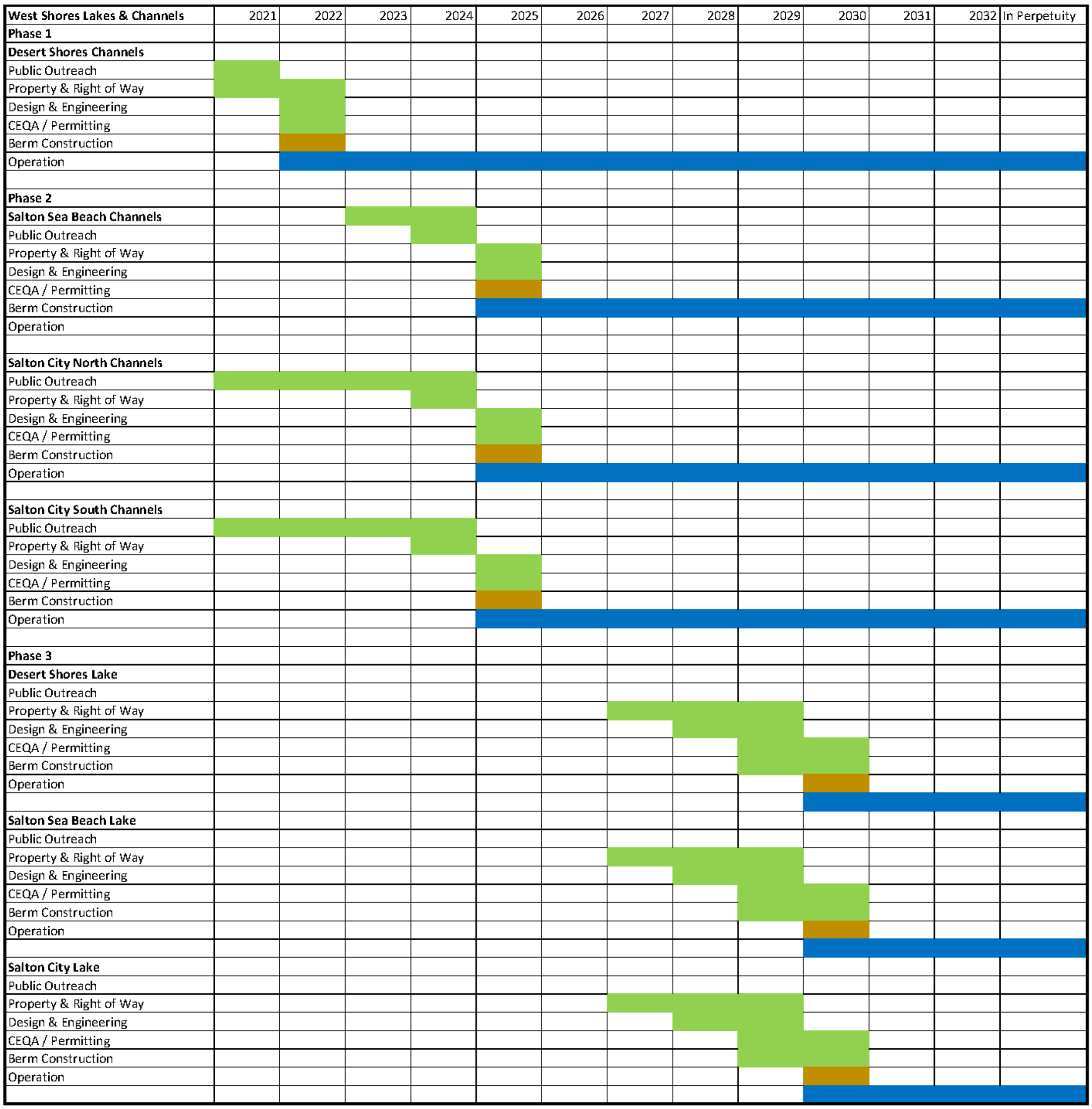

Figure 28. West Shores Lakes Proposed Gantt Chart

The West Shores Lakes concept is connected to work on restoring the much smaller channels in three of the four West Shores communities that is already underway. The Desert Shores Channels Restoration Project was proposed to Imperial County more than five years ago and has been in active discussion with community residents, local non-profits, and State and local agencies since then. Discussion has been underway with residents of the two Salton City channels for nearly as long. Water supply is the biggest impediment to getting any of the projects implemented. Figure 28 shows a proposed schedule to implement the channel projects and later join them with the Shoreline Lakes projects. This will depend mostly on water availability.

Please see Appendix C for a spreadsheet detailing the proposed schedule of design, permitting, and implementation for the Salton Sea Water Recycling and salt recovery operations that could be implemented by a private entity along with the cost and revenue projections year by year with a projected start in 2025 allowing for a three year decision making and organizing process by State, Federal, and local agencies. Other Project features can commence design, permitting, and implementation to coordinate with the expected dates that sufficient fresh water supplies, and brine concentrate supplies for salt crust dust control, would become available from the Salton Sea Water Recycling and salt recovery operations.

Cost and Revenue

Please see Appendix C for a spreadsheet detailing the cost and revenue projections for the Salton Sea Water Recycling and salt recovery operation. These operations are projected to produce a profit after initial construction sufficient to pay off construction loans and operating costs that will provide hundreds of millions in annual net revenue after cost to pay for other Project features like dust control, habitat restoration, recreational amenities and access, and could even pay the long term operation and maintenance costs of the Salton Sea Management Programs 10 Year Plan Projects. This type of water treatment and salt harvesting operation is probably more efficiently run by one or more private entities in a partnership with the State and Federal Government agencies responsible for a long term Salton Sea restoration program. A share of profits can be paid to Government entities to pay for the operation and maintenance of Salton Sea projects and the recycled Salton Sea water could be supplied to restoration projects at zero cost to the public. In exchange, the private entities would be given a long term license to harvest salt and other minerals present in excess quantities from the Salton Sea.

Appendix C has an analysis of USGS information on the domestic salt market and the price of salt over the last 30 years. Appendices O and P have cost information on fish screened saltwater intakes in the Salton Sea.

Cost Basis of Water and Salt Treatment Facilities

Estimates of the production capacity, capital costs, operating costs, and revenues for each type of water and salt treatment facility planned for the Project are included in the following Figures.

20 MGD 60 Effect VTE-MED	**Amount**	**Unit**
Plant capital cost	**$49,849,315**	each plant
Amortizaton period	30	years
Interest rate	8.3%	per year
Plant life capital cost	$135,451,773.55	
Annualized capital cost	**$4,515,059.12**	
Performance Ratio	56	lbs/1,000 BTU
Distillate capacity	20,000,000	gpd
Distillate capacity	75,708	m^3/day
Concentration factor	12.00	
Brine Capacity	1,666,667	gpd
Recovery ratio	92%	
Plant availability	95%	
Plant spec cost	$2.49	
Plant Operating Costs		
Electrical requirement	1,579	KW
Electrical rate	$0.085	per kWh
Electrical cost	$1,117,126.38	per year
Thermal requirement	120,000	lbs/hr
Thermal rate (geothermal)	$0.0045	per lb/hr
Thermal cost (geothermal)	$4,493,880.00	per year
Thermal requirement	100,068,000	BTU/hr
Thermal requirement	29,327	kW_t
Thermal rate (solar)	$0.0100	kWh_t
Thermal cost (solar)	$2,440,595.92	per year
Annual Energy Cost	**$3,557,722.30**	
Operation & maintenance	$3,723,000.00	per year
Chemicals	$438,000.00	per year
Maintenance Supplies	$146,000.00	per year
Annual O&M Cost	**$7,864,722.30**	
Annualized Plant Cost	**$12,379,781.42**	
Distillate cost	**$1.79**	per 1,000 gal
Distillate cost	**$0.47**	per m^3
Distillate cost	**$581.69**	per acre-ft
Amortized Capital Cost	**$0.17**	per m^3
Annual Distillate Output	21,283	AFY
Enthalpy of Evaporation	834	Btu/lb
Thermal Use per m3	**9.30**	kWh_t/m^3
Electrical Use per m^3	0.50	kWh/m^3

20 MGD 60 Effect VTE-MED	**Capital Cost**
Evaporator 60 effects	$26,869,168
Deaerator	$35,360
Foundation	$37,926
Excavation	$13,333
Chemical feed system	$20,000
Pumps and Motors	$925,495
Steam ejector system	$50,000
Piping and valves	$1,200,000
Electrical gear & cables	$1,000,000
Instrumentation	$400,000
Computer control sytem	$50,000
Misc. bolts, nuts, gaskets	$40,000
Subtotal Construction Equipment & Materials	**$30,641,282**
Freight in (1.5% of materials)	$459,619
Insurance (0.5% of materials)	$153,206
Mobilization	$167,000
Installation & site fabrication	$734,000
Subtotal Construction Contract	**$1,513,826**
Contractor markup (15% of above)	$4,823,266
Total Construction Contract	**$36,978,374**
Materials inspection (1.5% of materials)	$459,619
Construction management (5% of contract)	$1,848,919
Design & engineering (8% of contact)	$2,958,270
Total Plant Costs	**$42,245,182**
Interest during construction (8% of total)	$3,379,615
Contingencies (10% of total)	$4,224,518
Total Plant Construction Project	**$49,849,315**

Figure 29. Cost Basis for 20 MGD 60 Effect VTE-MED Plants

Salt Separation Plant		Cost to Feed 5 MGD VTE		Capacity Factor to 30 MGD	Cost to Feed 30 MGD VTE		Capacity Factor to 1 MGD	Cost to Feed 1 MGD Pond VTE	
Plant capital cost		$16,500,000	each	6.35	$104,828,781	each	0.16	$2,612,360	each
Amortizaton period		30	years		30	years		30	years
Interest rate		6.0%	per year		6.0%	per year		6.0%	per year
Plant life capital cost		$35,613,301			$226,260,543			$5,638,470	
Annualized capital cost		**$1,187,110.04**			**$7,542,018.10**			**$187,949.02**	
Permeate capacity		6,316,128	gpd	6.35	40,128,000	gpd	0.16	1,000,000	gpd
Feed Capacity		8,421,504	gpd		53,504,000	gpd		1,333,333	gpd
Reject capacity		2,105,376	gpd		13,376,000	gpd		333,333	gpd
Recovery ratio		75%			75%			75%	
Plant availability		95%			95%			95%	
Plant spec cost		$2.61	$/gpd		$2.61	$/gpd		$2.61	$/gpd
Plant Operating Costs									
Replacements & Supplies	$0.0791	$658,270.20	per year	6.35	$4,182,161.38	per year	0.16	$104,220.53	per year
Manpower		$412,000.00	per year	6.35	$2,617,542.90	per year	0.16	$65,229.84	per year
Maintenance Supplies		$46,107.73	per year	6.35	$292,934.40	per year	0.16	$7,300.00	per year
Annual O&M Cost		**$1,894,484.93**			**$12,036,154.34**			**$299,944.04**	
Plant Energy Costs									
Electrical requirement	1.1	26,400	kWh/day	6.35	167,726	kWh/day	0.16	4,180	kWh/day
Electrical rate		$0.085	per kWh		$0.085	per kWh		$0.085	per kWh
Electrical cost		$778,107.00	per year		$4,943,515.66	per year		$123,193.67	per year
Annualized Plant Cost		**$3,081,594.97**			**$19,578,172.44**			**$487,893.05**	
Permeate cost		**$1.41**	per 1,000 gal		**$1.41**	per 1,000 gal		**$1.41**	per 1,000 gal
Permeate cost		**$458.49**	per acre-ft		**$458.49**	per acre-ft		**$458.49**	per acre-ft
NaCl in Permeate		19,180	mg/liter		19,180	mg/liter		19,180	mg/liter
Annual Permeate Output		6,721.17	AFY		42,701.36	AFY		1,064.13	AFY
Annual NaCl output		159,011	Metric Tons		1,010,237	Metric Tons		25,175	Metric Tons
NaCl Cost in Brine		$19.38	per metric ton		$19.38	per metric ton		$19.38	per metric ton
Mixed Salts in Reject		58,700	mg/liter		58,700	mg/liter		58,700	mg/liter
Annual Reject Output		2,240.39	AFY		14,233.79	AFY		354.71	AFY
Annual Mixed Salt output		162,216	Metric Tons		1,030,603	Metric Tons		25,683	Metric Tons
Electrical Use per MG		4,179.78	kWh/MG		4,179.78	kWh/MG		4,179.78	kWh/MG

Figure 30. Cost Basis for Salt Separation Plants, 6 MGD unit basis scaled to 1 MGD and 30 MGD

Solar Salt Evaporation Pond Sizing and Costs		
Pond Bottom Area	10.0	In acres
Pond Bottom Area	435,600.0	square feet
Pond Inside Edge	660.000	feet
Berm Height	4.0	feet
Berm Top Width	10.0	feet
Berm Slope X:1	2.0	W:H ratio
Berm Base Width	26.000	feet
Berm Cross Section	72.000	square feet
Berm Corner Volume	69.333	cubic yards
Berm Side Volume	1,760.000	cubic yards
Total Berm Volume	7,317.333	cubic yards
Dirt Fill Unit Cost	$4.00	cubic yard
Berm Fill Cost	$29,269.33	total
EDPM Liner roll width	30.0	feet
EDPM Liner roll length	100.0	feet
EDPM Liner roll cost	$2,580.00	each
Number of Rolls	146	
Cost of Liner 45 mil	$376,680.00	
PVC Liner roll width	48.0	feet
PVC Liner roll length	102.0	feet
PVC Liner roll cost	$2,399.04	each
Number of Rolls	89	
Cost of Liner 20 mil	$213,514.56	
Canal Bottom Width	3.0	feet
Canal Length	660.0	feet
Canal Bottom Area	1,980.0	square feet
Canal Inside Edge	1,980.000	feet
Berm Height	4.0	feet
Berm Top Width	2.0	feet
Berm Slope X:1	1.0	W:H ratio
Berm Base Width	10.000	feet
Berm Cross Section	24.000	square feet
Berm Corner Volume	8.889	cubic yards
Berm Side Volume	1,760.000	cubic yards
Total Berm Volume	7,075.556	cubic yards
Dirt Fill Unit Cost	$4.00	cubic yard
Berm Fill Cost	$28,302.22	total
Salt Fill Labor Cost per Pond	$5,000.00	each unit
Capital Cost per pond	$276,086.12	
Capital Cost per acre	$27,608.61	
Maintenance Cost per acre	$10.00	per year
Maintenance Cost per pond	$100.00	per year
Harvest cost per acre	$1,200.00	per year
Harvest Cost per pond	$12,000.00	per year
Annual operating cost per pond	$17,100.00	per year
Annual operating cost per acre	$1,710.00	per year
Density of saturated NaCl at 49.93 deg C	1,189,200	mg/liter
Density of NaCl brine	300,000.00	mg/liter
Mass percent NaCl brine	25.23%	
Cubic meters per acre foot	1,233	
Liters per acre foot	1,233,489	
Pond brine capacity	30.0	acre feet
Saturated salt capacity per pond	44,005.962	metric tons
Saturated salt capacity per acre	4,400.596	metric tons

Figure 31. Cost Basis of 10 acre Solar Salt Evaporation Pond

Description	Cost	Unit
Salt Refinery total capital cost	**$2,185,910**	
Vacuum Crystallizing Plant	$1,400,000	each plant
Amortizaton period	30	years
Interest rate	6.0%	per year
Plant life capital cost	$3,021,735	
Annualized capital cost	**$100,724.49**	
Dewatering Centrifuge	$2,790	each unit
Pusher Centrifuge	$83,120	each unit
Amortizaton period	15	years
Interest rate	6.0%	per year
Unit life capital cost	$130,492	
Annualized capital cost	**$8,699.49**	
Drying, Sorting, Packing Plant	$700,000	each plant
Amortizaton period	15	years
Interest rate	6.0%	per year
Plant life capital cost	$1,063,260	
Annualized capital cost	**$70,883.97**	
Salt Capacity	250	tonne/day
Input salt concentration		
Crystallizing Plant Capacity		
Crystallizing Plant Slurry Density	15%	by weight
Brine Slurry Capacity	374,244	gpd
Water Recovery ratio	75%	
Plant availability	95%	
Plant spec cost	$2,800.00	$/tonne/day
Plant Operating Costs		
Vacuum Crystallizing Plant parts	$168,000.00	per year
Dewatering Centrifuge parts	$10,309.20	per year
Drying, Sorting, Packing parts	$84,000.00	per year
Replacements & Supplies	$262,309.20	per year
Manpower	$1,750,000.00	per year
Operating Supplies	$866,875.00	per year
Annual O&M Cost	**$3,644,867.57**	
Plant Energy Costs		
Evaporator Thermal Requirement	54,013.23	kWh_t/day
Drying Thermal Requirement	34,890.00	kWh_t/day
Thermal Rate	$0.0128	$/$kWh_t$
Thermal Cost	$393,859.53	per year
VTE electrical requirement	2,895.42	kWh_e/day
Centrifuge electrical requirement	2,040.00	kWh_e/day
Dry/Sort electrical requirement	7,680.00	kWh_e/day
Electrical rate	$0.085	per kWh_e
Electrical cost	$371,823.84	per year
Annual Energy Cost	**$765,683.37**	
Annualized Plant Cost	**$4,590,858.89**	
Salt cost (refinery only)	**$52.96**	per tonne
Salt Price (2015 Domestic)	**$182.00**	per tonne
Net	$129.04	per tonne
Refinery Annual Ouput	86,688	Metric tons
Refinery Annual net	$11,186,266.11	
Total Salt Supply to All Plants	15,747	tonne/day
Number of Salt Refineries	63	
Electrical Use per Tonne	50.46	kWh_e/tonne
Thermal Use per Tonne	355.61	kWh_t/tonne

Figure 32. Cost Basis of 250 tonne/day Vacuum Salt Refinery

Business Plan

The Salton Sea Water Recycling Project will be owned and operated as a public/private partnership between private stakeholders, the State of California and possibly other public agencies.

Sephton Water Technology, Inc.is leading the early phase planning, design, and technology development for this Project in collaboration with Membrane Development Specialists, Leading Edge Technologies, LLC, Process Engineering LLC, JFMPE, and individual experts contributing expertise. Sephton Water Technology, Inc. is a California corporation with more than fifteen years of experience developing the suite of technologies proposed for this Project and essential to overcoming some of the unique water quality challenges at the Salton Sea. Sephton Water Technology has well over a decade of operational experience purifying Salton Sea water and salt with geothermal heat. The Company is the only entity with recent and extensive experience in the unique challenges of extracting Salton Sea water and salts to restore environmental water quality and offset the costs with purified salts and solar energy. Sephton Water Technology has forged working relationships with engineering, contracting, and geothermal development firms at the Salton Sea in that carrying out that work including Berkshire Hathaway Energy Renewables over many years and Controlled Thermal Resources for a shorter time.

Sephton Water Technology, Inc. is a small company. If the Project proposed were to move forward past planning and development into final design and construction, it would be appropriate to partner with a larger firm that has the staff and deep pocket financial resources to execute a large project like the restoration of the Salton Sea. Local geothermal developer would be a good choice. The managers, engineers, operators, and maintenance crews of local geothermal companies are capable of taking on the salt recovery, geothermal energy development, and water treatment aspects of this Project. These functions are designed to be revenue generating and profitable so they are appropriate for private companies to undertake. Some of the local geothermal developers are well funded by parent companies or business partners as well.

CalEnergy Operating Company is a subsidiary of Berkshire Hathaway Energy Renewables, in turn a subsidiary of Berkshire Hathaway. Much of the salt recovery and water treatment technology proposed for this Project was developed at one of their plants under a cooperation agreement with Sephton Water Technology, Inc.

Controlled Thermal Resources is a new geothermal developer owned by an Australian billionaire The company is now designing the largest geothermal plant at the Salton Sea. Controlled Thermal Resources has a major investment from General Motors for geothermal lithium development.

Energy Source owns and operates the newest geothermal plant at the Salton Sea built and is ready to construct a lithium recovery plant adjacent to their geothermal plant.

Ormat Nevada, Inc. owns local geothermal power plants south of the Salton Sea and is developing a well field to the west of the Salton Sea. Ormat is a subsidiary of a large international firm, Ormat Technologies, Inc., which operates in 30 countries around the world in power and originally in turbines.

Any of these geothermal developers could be well suited to take on the lead role among the private firms working on the revenue generating aspects of the Project.

Government Entities, Water Conveyance

Conveyance of recycled water will be contracted with a State or Federal Government agency. The U.S. Department of the Interior, Bureau of Reclamation is the appropriate Federal agency. The appropriate State agency is the California Department of Water Resources. Either agency has the engineering, management, and operations staff capable of conducting environmental review, securing permits, and designing and operating conveyance infrastructure around the Salton Sea and either can contract with U.S. engineering and construction contractors to build the canals, pipelines, power infrastructure needed. The infrastructure designed, built, and bond funded by a State or Federal agency will be owned and operated by that agency, unless the agency decides to pass operation control and/or ownership to a different public agency.

The design, permitting, and construction of conveyance and power infrastructure will be financed with public bond funds raised by the State of California, or other suitable entity. The lead private entity of the Project will contract to pay the State or Federal agency to supply water and brine concentrate to the Salton Sea. The State or Federal agency will responsible for delivering power for pumping. The conveyance infrastructure will be owned and operated by the public agency. This conveyance will run for the duration of the QSA water transfers, with an option to renew.

Revenue Basis: Marketable Products from the Project

This Salton Sea Water Recycling Project is conceived as a public benefit business enterprise supporting public health and the environment, but also able to benefit private investors making it possible to raise equity capital to get the water and salt recycling work started. The private entities that comprise the Project will implement energy and cost efficient processes to desalinate high salinity water resources from the Salton Sea while converting the concentrated salts to useful products. The products from implementation of the concept will be pure distilled water, purified sodium chloride sold as solar salt (99.0% purity) and as refined salt (99.9% purity). Other minerals will also be products if cost competitive separation processes and markets are proven. The pure water and salt produced will be sourced from the Salton Sea.

The water and salt recycling aspect of the concept will produce a rising quantity of solar salt for sale, sourced from purified brine concentrated in the 20 MGD VTE-MED plants, all dried and crystallized in dust elimination ponds at the periphery of the Salton Sea. The rate of solar salt production is shown in Figure 33 by the dark grey plot. The 99% purity solar salt product had a market value of $120 per metric ton FOB in the 2021 U.S. domestic market according to USGS mineral market data (Appendix C) with a gradually rising demand over the last three decades.

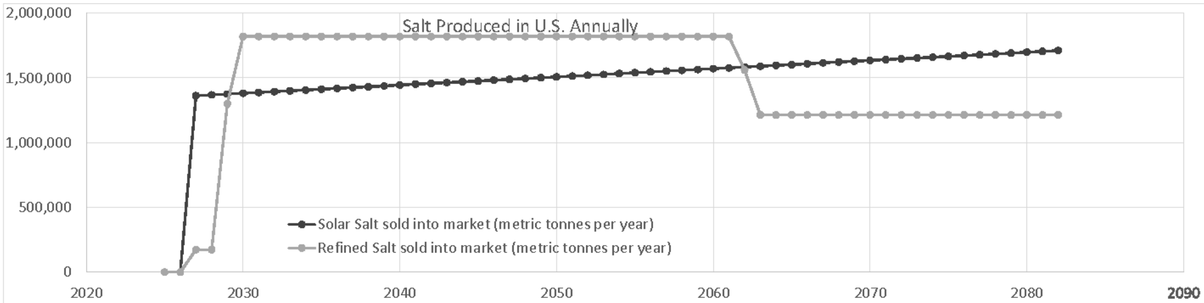

Figure 33. Solar Salt (dark grey) and Refined Salt (light grey) Production, Concept A

Vacuum process refined salt will be produced for sale at the required 99.9% purity by vacuum crystallization of 99.0% purified brine concentrate sourced from the salt separation and VTE-MED process using Salton Sea water as feed. The rate of vacuum refined salt production is shown in Figure 33 by the light grey plot. The vacuum refined salt product had a market value of $215 per metric ton FOB in the 2020 U.S. domestic market according to USGS data (Appendix C). Production projections are limited to 30% of the gradually rising market demand trend-line to avoid flooding the regional salt market. To the extent feasible, the Project will work to build partnerships with local and regional industries that can use purified salt in manufacturing to reduce the price impact on the domestic market and boost the regional economy. Examples of partnerships may include food processing, leather tanning, and the chloralkali chemical process, as well as other industrial processes.

Sephton Water Technology is already starting work with a company developing processes to use waste salt from agricultural drain and other saltwater desalination for storage of heat at solar thermal power plants to continue to produce power at night [10].

Target Market, Salt

The Project will serve the bulk solar salt and refined salt market in the Western United States. This market is mature but has grown in the last few years due to high demand and supply shortages in other parts of the Nation.

As shown in Figure 34, domestic production reported by the USGS of all salt grades rose from 35 to 40 million metric tons from 1991 to 2019 with apparent domestic consumption rising from 40 to 50 million metric tons over the same time period, the difference being made up by salt imports. The U.S. has consistently been a net salt importer from 1991 through the present, with imports at 23% in the most recent USGS report covering 2020. Salt exports have been consistently low throughout that time frame.

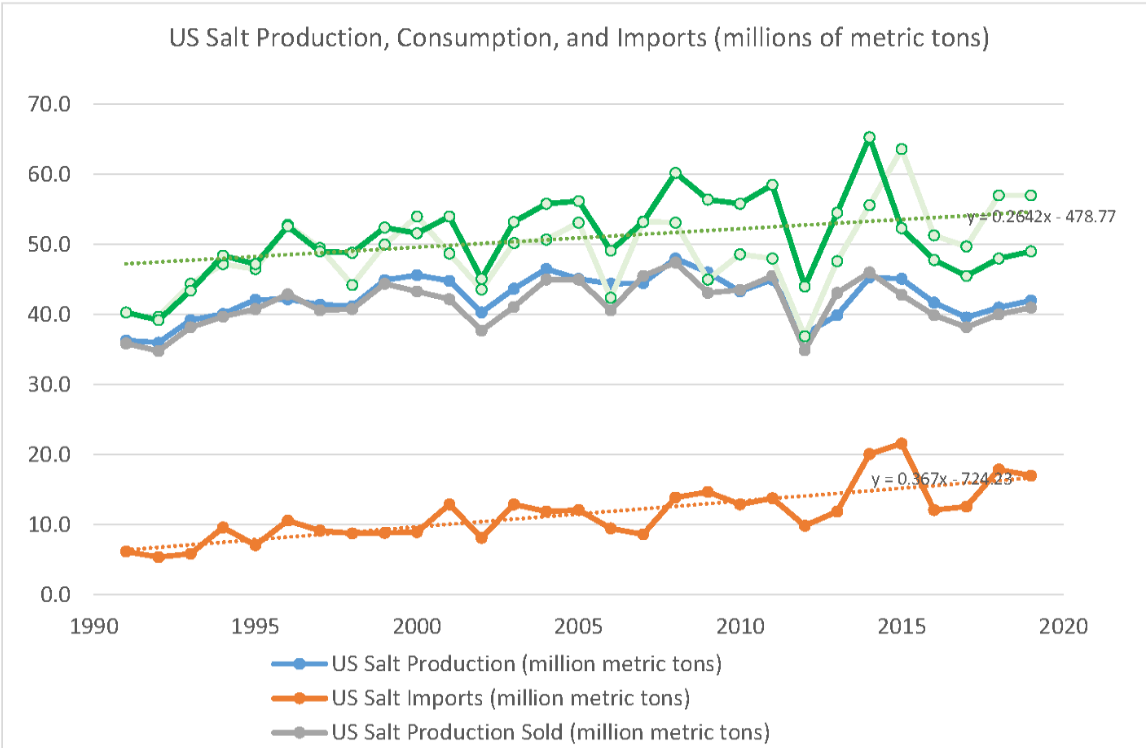

Figure 34. Comparison of Domestic Salt Consumption, Production, Imports, and Exports 1991-2020

Market volatility in recent years has been caused by unusually cold winters in the Eastern U.S. depleting supplies of road de-icing salt that are typically supplied by mined rock with reduced demand in subsequent warmer winters. Municipalities typically purchase road salt with long term contracts to stabilize prices, but unusual weather has destabilized that market recently. Higher grades of salt may be purchased by municipalities when road salt supplies are depleted.

Solar salt and vacuum pan refined salt have made up 7% to 11% each of the total salt used domestically from 1991 to 2020 according to USGS data. The solar salt and vacuum pan refined salt are used in a wide range of industries from food processing, to water softening, to chemical manufacturing. Figure 35 compares domestic consumption of solar salt and vacuum pan refined salt to overall domestic salt consumption. The domestic demand volatility of these two higher grade salt products is less than the overall salt market with a modest impact on the higher grade consumption from overall salt market demand fluctuations and only a slight rising trend in domestic demand for solar salt and refined salt from 1991 to the present.

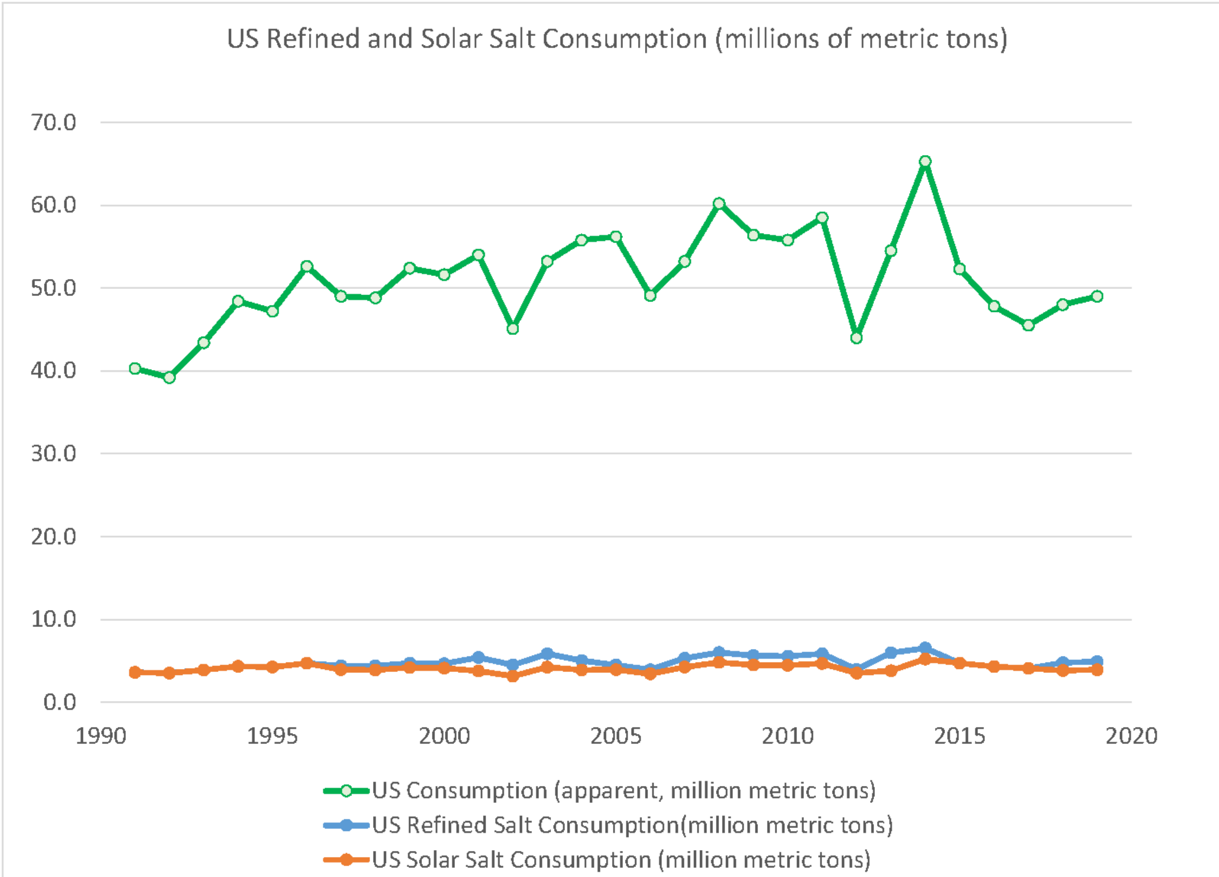

Figure 35. Comparison of Refined and Solar Salt to the Overall Domestic Salt Market 1991-2020

Figure 36 compares the prices of rock salt, vacuum pan refined salt, and solar salt from 1991 to 2020 based on USGS domestic salt market data. At recent market pricing, only the two higher grades of salt are economic to produce and ship using the desalination and extraction process proposed at the Salton Sea. The price of all three salt grades shown has a rising trend in spite of price fluctuation over one or more years. The price rise trend is faster for the higher priced salt grades. The rising price of refined salt exceeds the average rate of inflation.

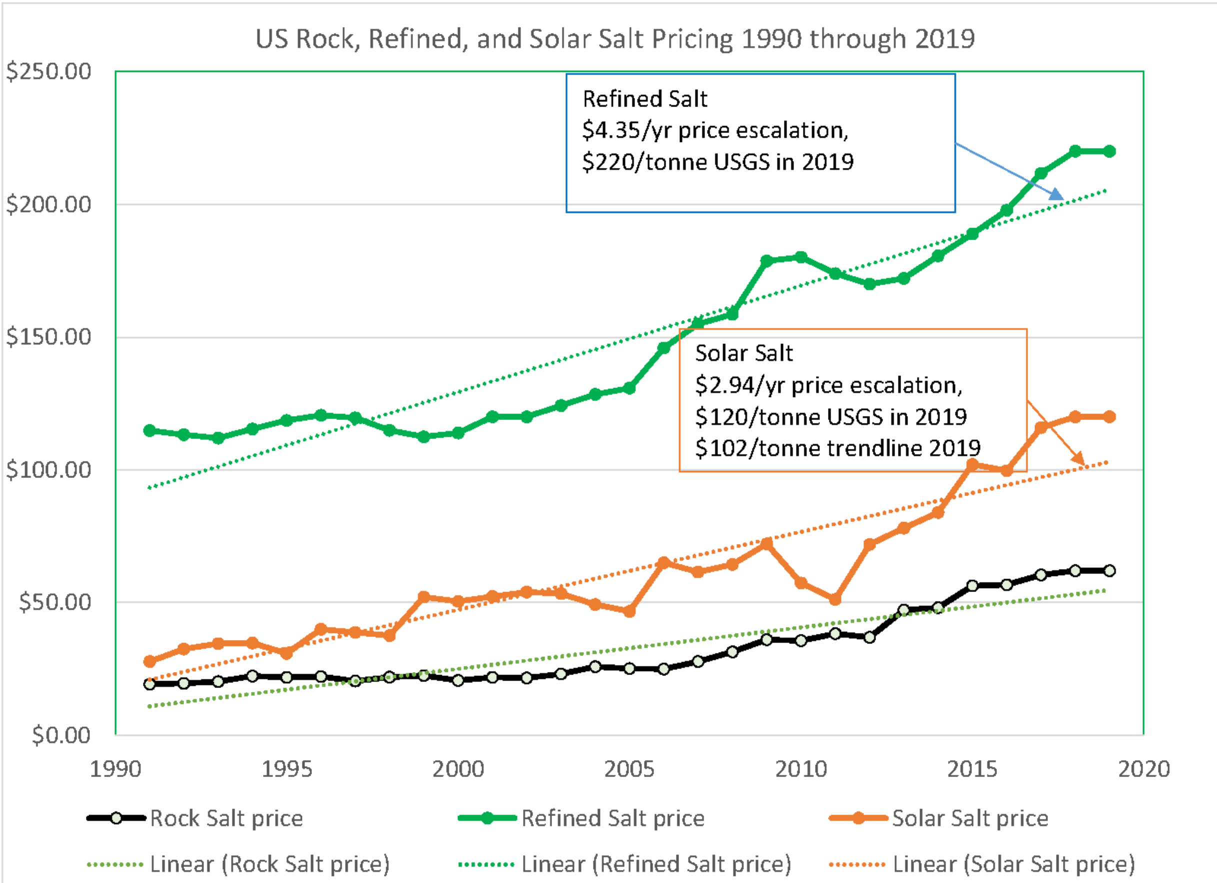

Figure 36. Comparison of Refined and Solar Salt to the Overall Domestic Salt Market 1991-2020

The trend line price rise of $4.35 per year with a 2020 trend line starting price of $205 is used in the project revenue estimates for sales of vacuum pan refined salt calculated in the Appendix D spreadsheets. For solar salt, the trend line price rise of $2.94 per year with a 2020 trend line starting price of $102 is used in the Project revenue estimates in Appendix D.

After limited sales to the local agricultural and water softening market, the Project will ship the majority of the two salt products to regional markets over an existing Southern Pacific rail link connecting the production area to Los Angeles and Phoenix and on to the Nation. Rail loading facilities exist within ten miles of the proposed plants, but one or more dedicated rail spurs may be more cost effective if large quantities of dry salt are produced in a centralized location near a large geothermal plant.

Marketing and Sales, Salt

Higher grade refined salt and solar salt are marketed to consumers and industry for a very wide range of uses. Sea salt from various sources and other specialty salts are successfully marketed at premium prices, often disconnected from the actual production cost and quality. An example is Himalayan Sea Salt, a relatively impure mined product sold for food and bathing at a premium price with a pink color and a good story. While the Project private entities' product purity will be high and the environmental story is a good one, the marketing effort to consumers will have to be carefully crafted as the Salton Sea has a negative reputation as a polluted body of water among the small percentage of people in Southern California who even know it exists. The Salton Sea mermaid will be the marketing mascot with her slogan “Salty is Sexy”.

As production increases, the focus of sales and marketing will have to shift to the larger industrial market serving a wide range of uses including chemical production, pulp and paper production, leather tanning, textile treatment and dye processes, and drilling fluids for oil, gas, and geothermal exploitation. The Project private entities can competitively sell some industrial products locally for use in agriculture and geothermal drilling fluids. Selling large amounts of product into the broader U.S. industrial market would put the Project private entities in direct competition with the major domestic salt producers Morton (now owned by K&S), Cargill, and Compass Minerals. A strategic alliance can be sought to supply product to one of those competitors at a price sufficient to sustain profitability and growth. Such an alliance would leverage the extensive marketing, branding, and distribution networks already established by each company. While Cargill, Morton, and Compass Minerals have extensive domestic production capability, none has a production operation in Southern California. The one significant solar grade salt manufacturer in Sothern California, South Bay Salt Works, competes directly with Morton’s branded products in consumer solar salt sales for water softening by substantially undercutting the price. Regional price competition is an option if neither Cargill nor Morton will form an alliance, but it is a problematic strategy.

An alternate sales strategy is to bring a major salt using industry to the Imperial Valley where land, labor, and energy are relatively cheap by U.S. standards. Existing rail and highway routes provide access to the Southwestern U.S. and to industry in Northwestern Mexico. Such industries could include leather tanning, food processing and packing, or chemical production. Several of the other raw materials are locally produced and shipped out. With such industries as local customers, the Project private entities would be well positioned as the lowest cost supplier of salt products.

The Competition, Salt

Three large vertically integrated companies dominate the salt production industry in the U.S. Morton Salt (now owned by the German firm K&S) is an established brand that owns salt mines, evaporation ponds, and salt refining operations and controls product distribution to industries and store shelves. Cargill owns the Diamond Crystal and several other brands and purchased the well known Leslie Salt in 1978. Cargill operates the largest California salt production facilities in San Francisco Bay producing 500,000 tons of salt annually from 12,000 acres of evaporation ponds. Cargill also operates salt mining and production facilities around the country. Compass Minerals operates salt evaporation ponds at the Great Salt Lake, mines salt, and operates vacuum refining plants in Canada, the Midwest and the Great Lakes. United Salt Corporation operates salt mining, refining, and evaporation plants in Texas, New Mexico, and Virginia. The South Bay Salt Works near Chula Vista, California is the geographically closest competitor. This small operation has existed since the late 1800's and produces a steady 75,000 tons of salt annually from 1,000 acres of land designated as a historic site. Several small U.S. producers compete in niche markets including Real Salt in Utah.

The largest salt production competitor is Exportadora de Sal, owned 51/49 by the Mexican Government and Mitsubishi. This seawater evaporation facility is in Mexico's Baja State at Guerrero Negro about 375 miles to the south on the Pacific coast. It is the world's largest salt works, producing several grades of salt totaling nearly 7.5 million tons annually for export around the world and for sale in Mexico and to the United States. The production site is environmentally sensitive for grey whales and birds. Expansion plans in the late 1990's were halted by environmental opposition in Mexico. This provides a regional market opportunity for environmentally beneficial salt production at the Salton Sea. Salt produced in the Mexicali Valley under the Concept B, All Mexican Canal option could be effectively marketed by the Mexican government through Exportadora de Sal to salt importing countries around the world with shipment by sea from Baja California ports.

Competitive Advantage, salt

Traditional solar salt production by evaporating ocean water requires large areas of flat land. Coastal land in Southern California is in very high demand and is extremely costly making expanded coastal solar salt production uneconomic in the region. All major existing California salt operations are in environmentally sensitive areas also restricting expansion. The three fold environmental benefits of the concept, suppression of a the public health risk from Salton Sea playa dust, clean water for habitat, and salinity management of the Salton Sea ecosystem, may serve to grant access to an expanding publicly owned land resource as the Sea recedes at very low cost.

Plan for Funding of Proposed Project

The Salton Sea Water Recycling Project will sell stock to raise funds for project planning. The more costly design, permitting, and construction work, and early operations will be funded with loans from banks and other financial institutions and/or from private investors. Revenues from the sale of power, salt, water, and any other products will be used to pay off the loans and construction bonds needed to design, permit, construct and operate the salt extraction, salt purification, water treatment, and playa covering infrastructure at the Salton Sea. These borrowed funds plus revenues will also be used to pay for the conveyance of recycled water to the Salton Sea to complete a restoration.

The early planning phase of the project will be funded by equity investment in the Project. Late planning and engineering design phases of the project will be funded from loans raised for the design, permitting, construction, and early operation phases.

The Project will be responsible for the operation and maintenance of all plant and equipment, pipes, pumps, electrical generation, buildings, vehicles, tools, and personnel directly related to salt and saltwater extraction from the Salton Sea, salt purification, distillation, salt evaporation ponds, and related infrastructure that deals with water and salt drawn from the Salton Sea. The O&M budget varies substantially from year to year as water and salt treatment facilities are commissioned or decommissioned. The project O&M costs by facility type and in total are included in the Annual Cost & Revenue tab of the spreadsheet in Appendix D from 2025 through 2077.

Business Cost and Revenue Estimates and Private Funding Plan for Salton Sea Restoration

The concept will be funded by construction loans sought on the private capital market. An interest rate of 8% per annum on bank loans and private loan capital is assumed for this analysis. Revenues will come from sales of purified salt with possible future revenues from other minerals in the Salton Sea.

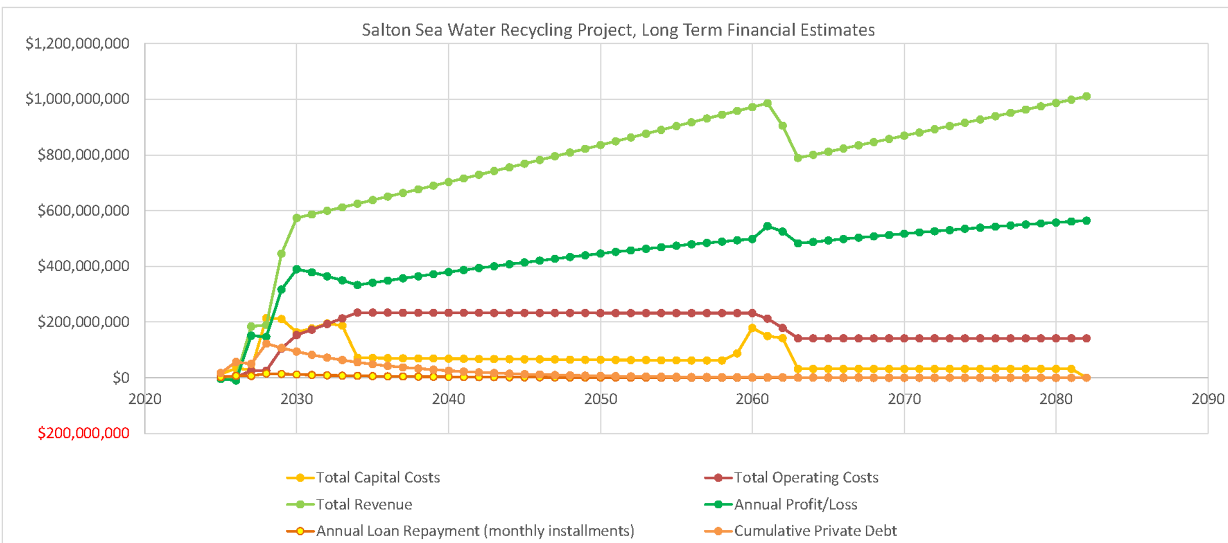

Figure 37. Capital Costs, Operating Costs, Revenue, Profit/Loss, and Loan Repayment

Figure 37 shows the capital and operating costs, construction loan repayment, revenue, and profit/loss yearly throughout the life of the Project. The derivation of these estimates is detailed in Appendix D. The Project private entities will operate at a loss for the first few years through a long and complex planning, contracting, design, and permitting process. Profitability is estimated to start in year three when salt production begins to come online. The Project private entitie is estimated to earn a steadily rising profit for the duration of the QSA water transfers to reward early investors. Profitable operation is likely thereafter, but predicting conditions 60 years hence at the close of the QSA contracts is uncertain at best.

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