Vertical Tube Evaporation Multi-Effect Distillation at the Salton Sea

Sephton Water Technology, Inc.

Etiwanda Generating Plant SCE, Mohave Desert 1982

Coolwater Coalgas, Texaco, Mohave Desert 1986

Modesto Energy Plant, Modesto, CA 1989

CalEnergy Geothermal Plant, Salton Sea 2022

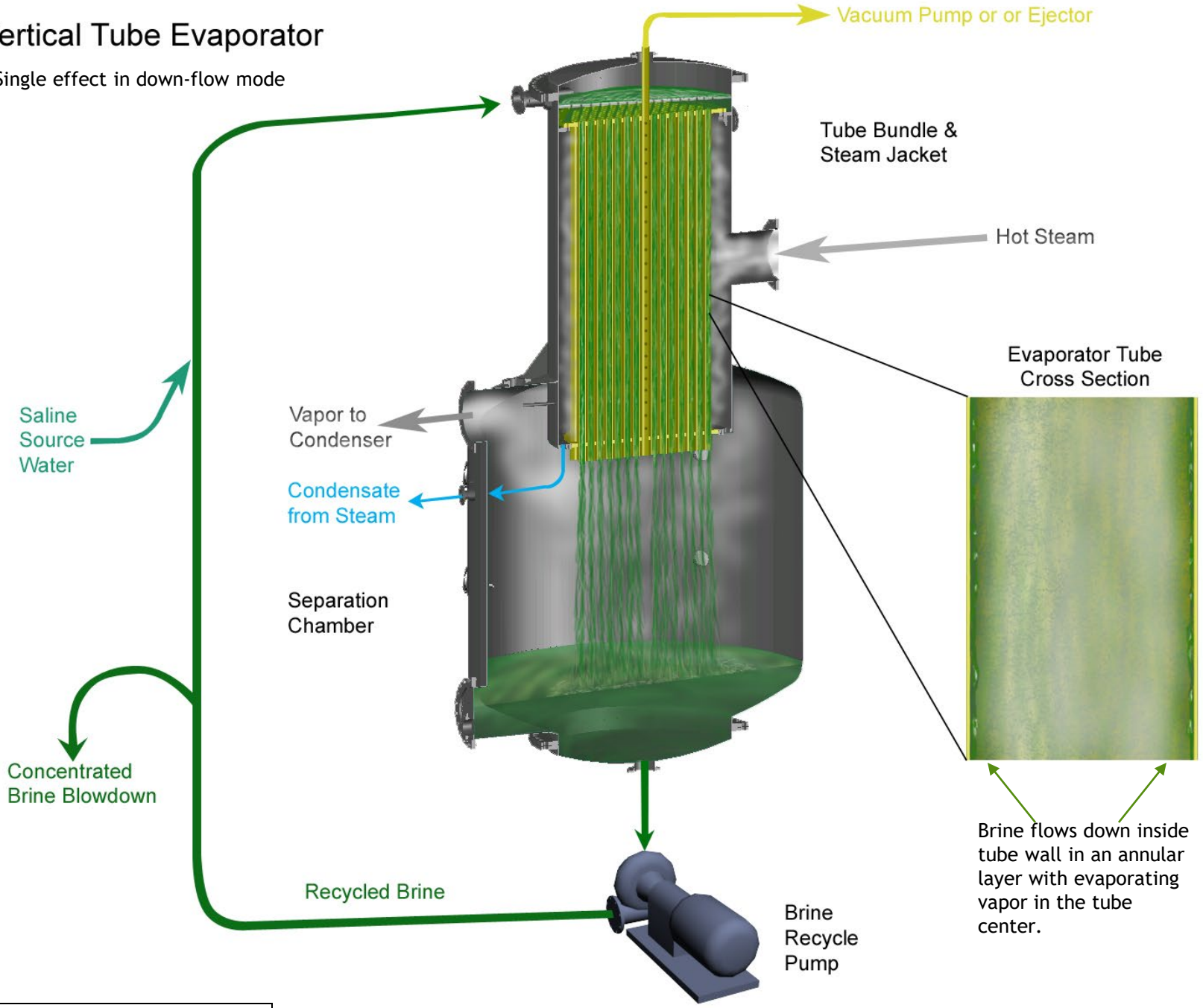
The Environmental Challenge Brought Us to the Salton Sea

A Key Local Resource is Geothermal Heat for Distillation

Non-commercial AFT steam released at BHE Renewables Region 1 Geothermal Plant.
This is enough steam to distill 9 million gallons per day of Salton Sea water.

Vertical Tube Evaporator

Single effect in down-flow mode

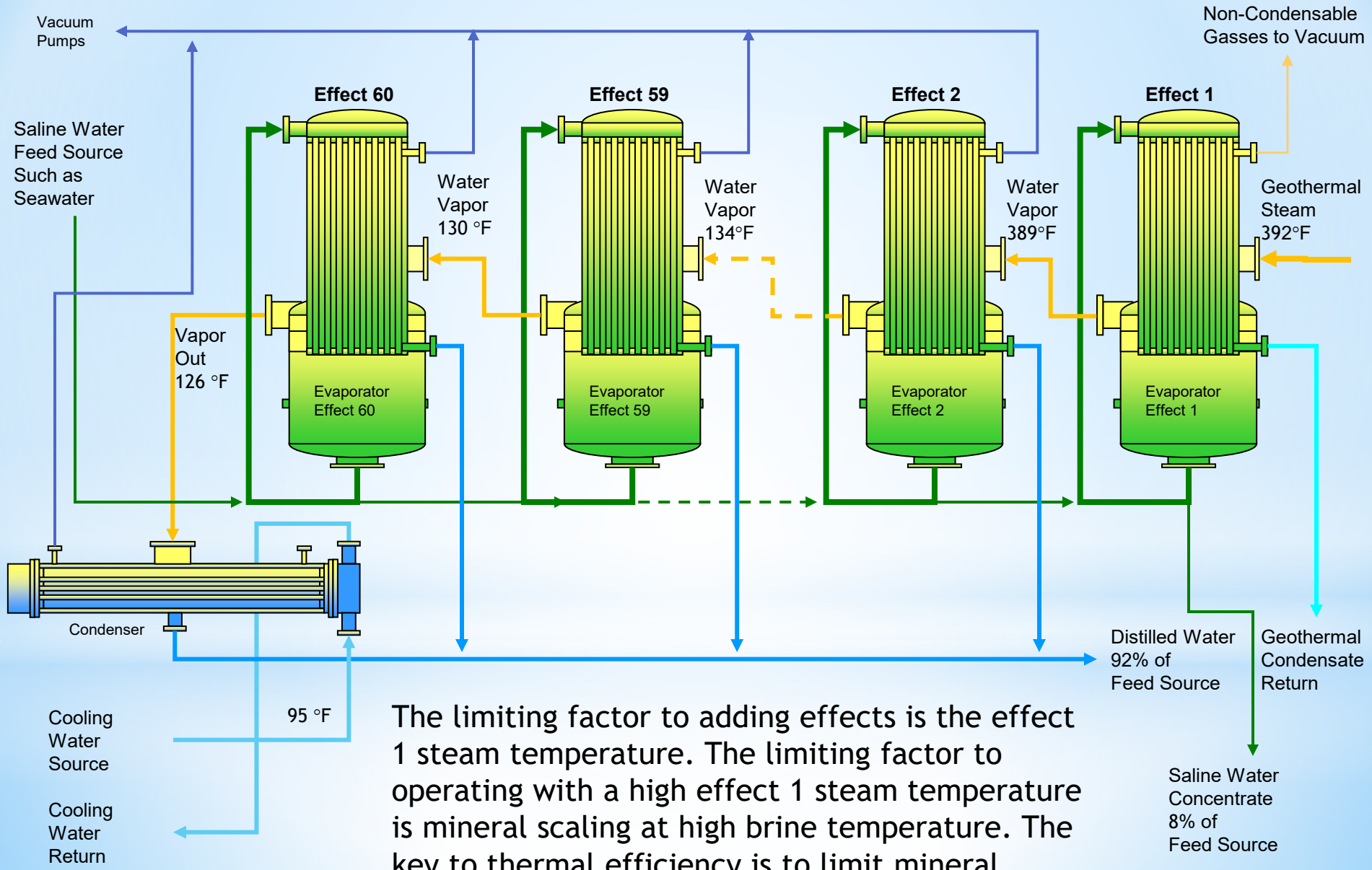


VTE Demonstration Plant at CalEnergy Units 1&2

* VTE Demonstration Plant connected to Geothermal Plant and VTE Pilot Plant
* Capacity 21,000 gpd if supplied with up to 7,500 lbs/hr of steam
* Frame structure designed for Seismic Zone 4 with magnitude 7 earthquakes likely

High Efficiency 60 Effect VTE-MED Plant Schematic

Reverse Feed Operation with 60 Effects and Prime Geothermal Steam as the Heat Source



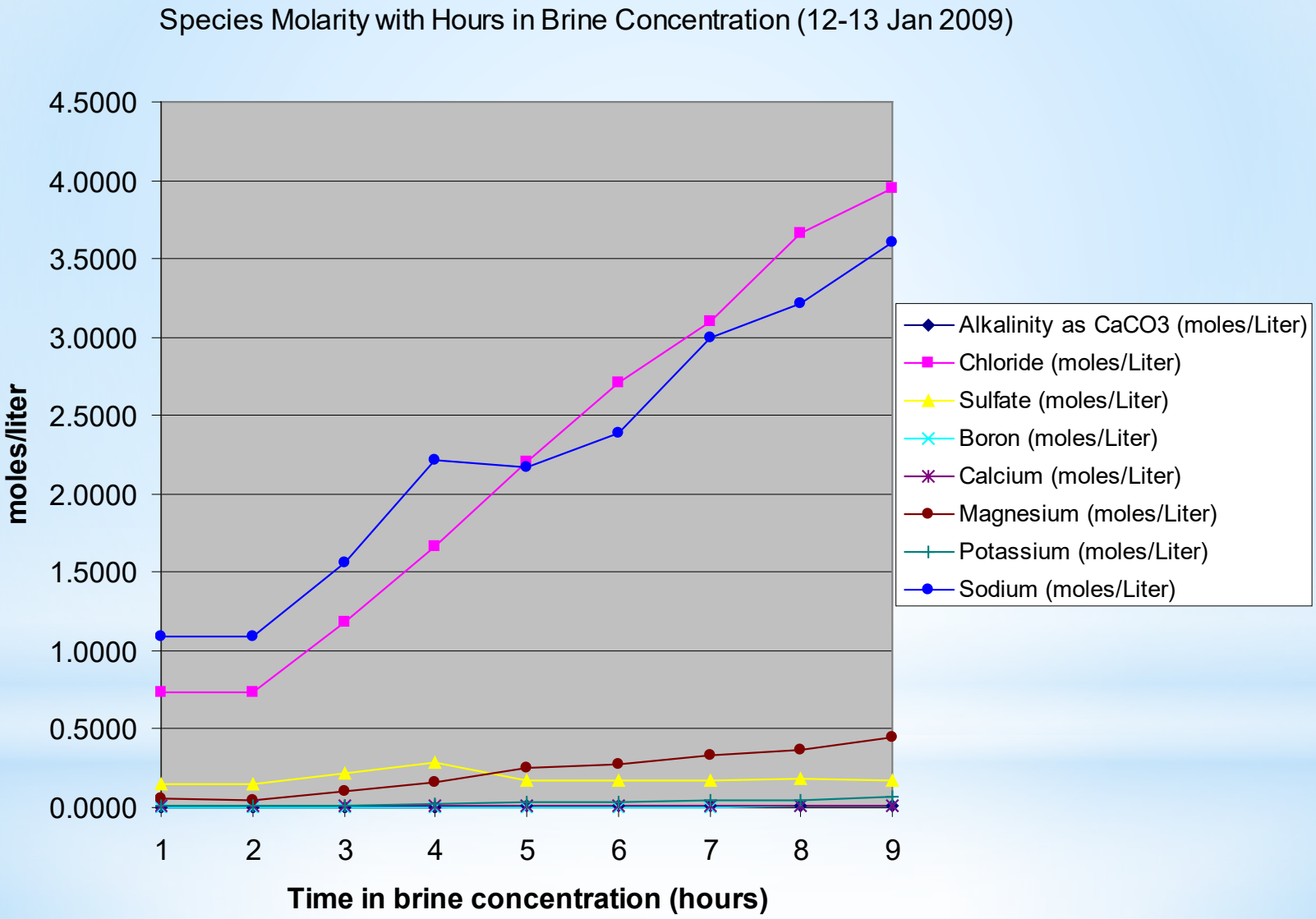
The limiting factor to adding effects is the effect 1 steam temperature. The limiting factor to operating with a high effect 1 steam temperature is mineral scaling at high brine temperature. The key to thermal efficiency is to limit mineral scaling.

Vertical Tube Evaporator Multi-Effect Distillation Plant

Could be located adjacent to geothermal plants

VTE-MED Pilot Testing Results at BHER Units 1&2

VTE 2 Pilot Project Chemistry Data Concentrating Salton Sea Water 2009

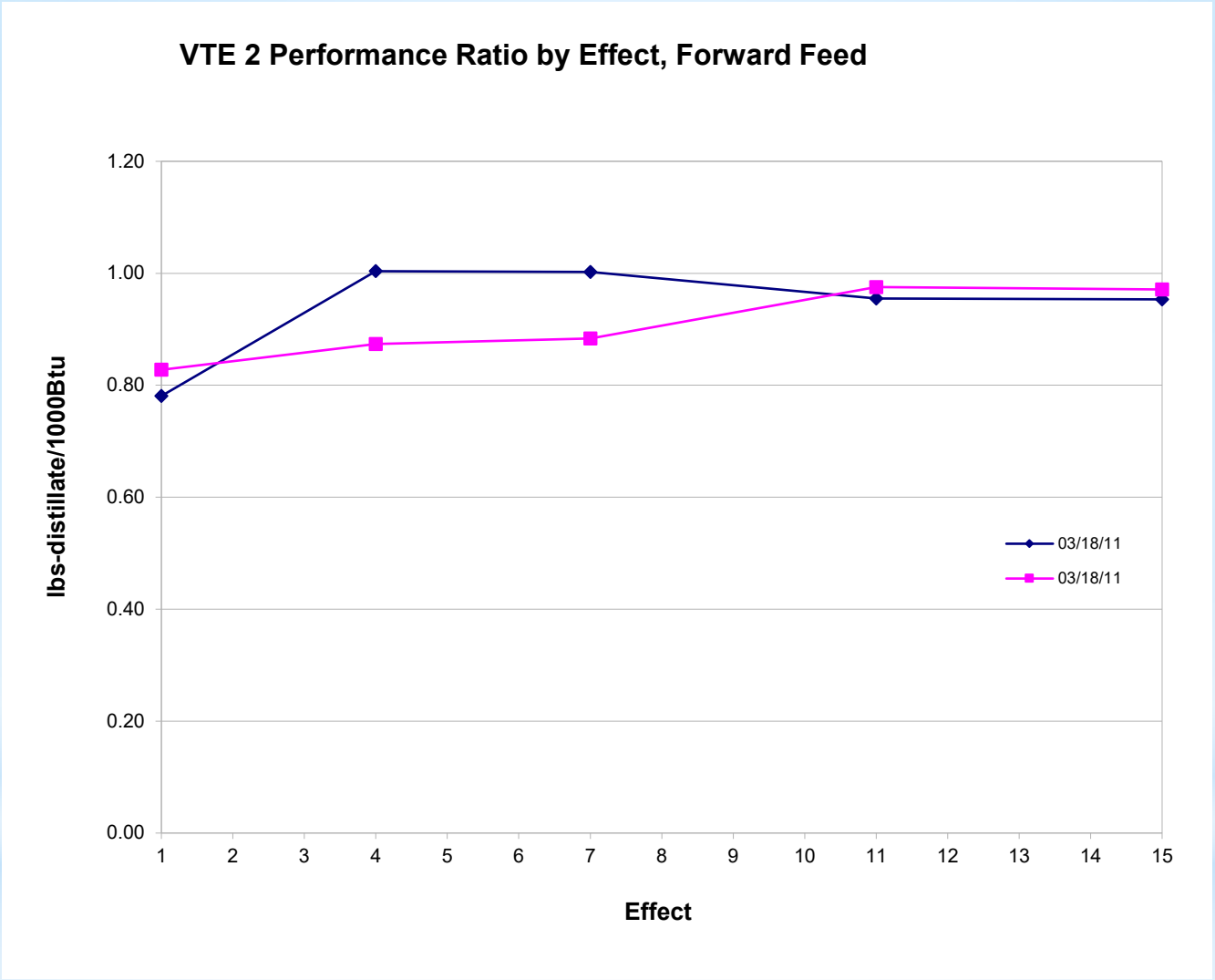


VTE Pilot Project Distillate Quality from Salton Sea Water 2011

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

VTE Pilot Project Thermal Performance Data (17-18 Mar 2011)

Thermal Performance Ratio at each Effect Condition in VTE 2 (forward feed)



VTE Pilot Project Performance for 15 Effects

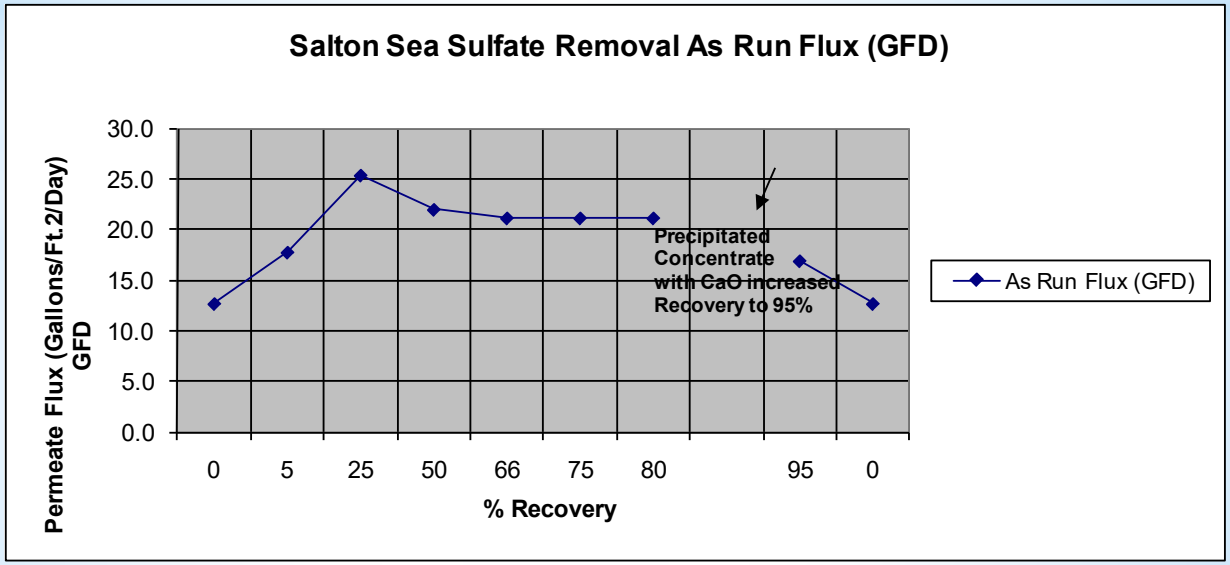
Salton Seawater Distillation using Heat from AFT Geothermal Steam at 212°F, Forward Feed

Interpolated Effect	Steam Enthalpy (Btu/lb)	Condensate Rate (lb/hr)	Distillate Rate (lb/hr)	Heat Rate (Btu/hr)	Performance Ratio (lb/1000Btu)	Gained Output Ratio (lb water/lb steam)	
VTE 2							
1	970.2	395.910	308.431	384,093	0.80	0.78	
2	976.3	348.075	283.455	339,234	0.85	0.83	
3	982.4	300.240	258.479	294,374	0.89	0.88	
4	988.6	252.404	233.503	249,515	0.94	0.93	
5	992.1	248.439	230.999	246,456	0.94	0.93	
6	995.7	244.475	228.495	243,398	0.94	0.94	
7	999.3	240.510	225.990	240,340	0.94	0.94	
8	1,002.4	238.627	226.355	239,169	0.95	0.95	
9	1,005.4	236.744	226.720	237,998	0.95	0.96	
10	1,008.5	234.861	227.085	236,828	0.96	0.97	
11	1,011.5	232.978	227.450	235,657	0.97	0.98	
12	1,014.3	215.036	210.267	217,958	0.96	0.98	
13	1,017.1	197.094	193.083	200,259	0.96	0.98	
14	1,019.9	179.151	175.899	182,559	0.96	0.98	
15	1,022.7	161.209	158.715	164,860	0.96	0.98	
15 Effect Sum		248.4	3,414.9	384,093	14.0	14.0	
Distillate Output	for Steam Rate	120,000	1,680,917	116,418,000	4,841,236	4.8	MGD
Brine Output					968,247	1.0	MGD

High Efficiency VTE-MED Pre-Treatment

Under a 2009 grant from Reclamation we developed an Ultra-Filtration (UF) and two pass Nano-filtration (NF) ion separation pre-treatment process aimed at removing magnesium, calcium, and sulfate from Salton Sea brine concentrate. The goal was geothermal injection for brine disposal, but it had the serendipitous benefit of converting Salton Sea water to a 99% sodium chloride brine, which has very little tendency to form scale at elevated temperatures and can be pushed to high concentration for high distillate recovery. Some of the 2009-2010 pilot test data are shown below.

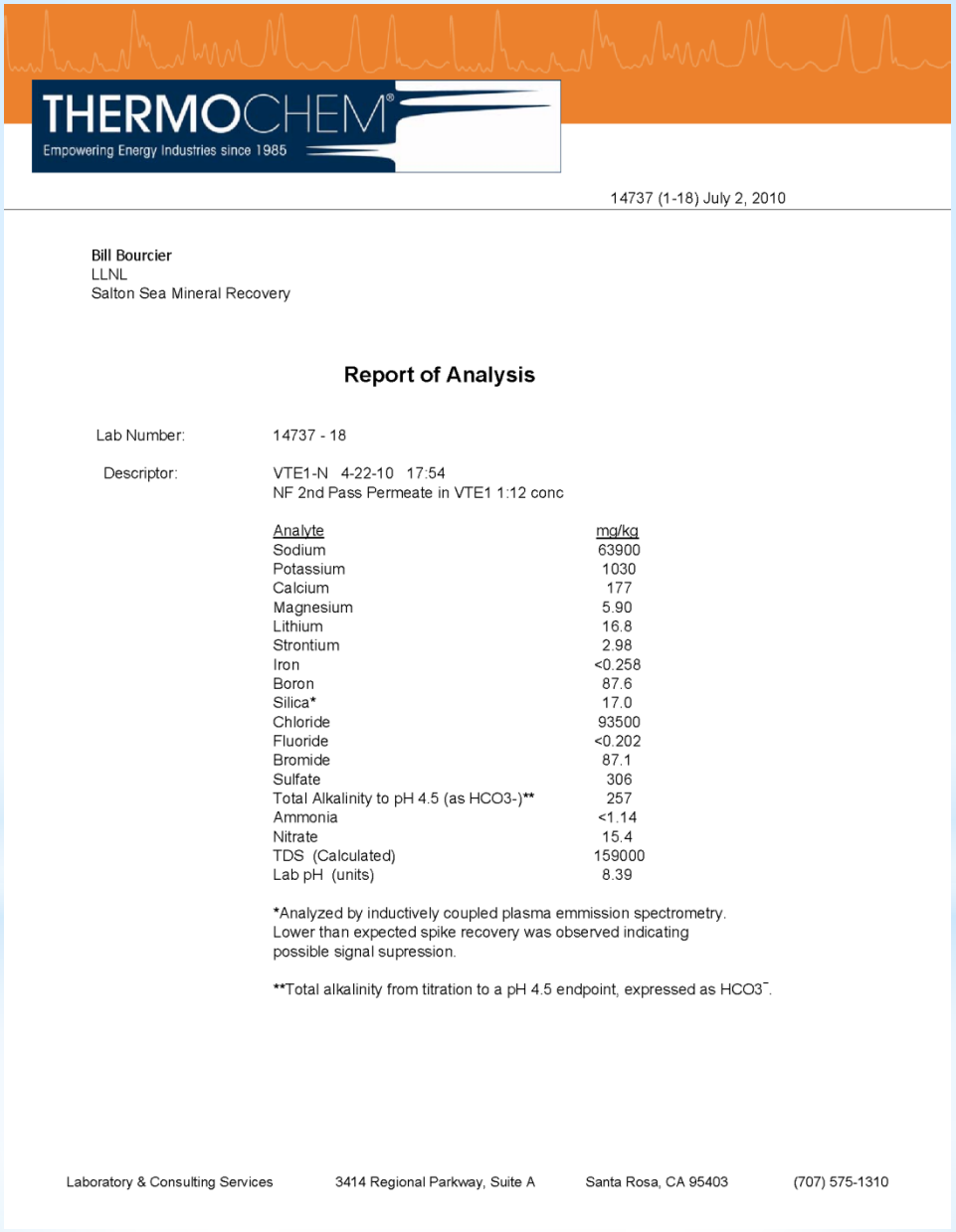
DESCRIPTION			FEED					CONCENTRATE				PERMEATE				REJECTION
Test Recovery %	Date	Time	Temp (°C)	pH	Cond. (µS/cm)	Ca&Mg (mg/L)	Sulfate (mg/L)	pH	Cond. (µS/cm)	Ca&Mg (mg/L)	Sulfate (mg/L)	pH	Cond. (µS/cm)	Ca&Mg (mg/L)	Sulfate (mg/L)	Sulfate
NF 1st Pass 50%	5-Dec-09	12:15	32	8.2	59,600			8.3	60,000			8.1	52,000		1,600	
NF 1st Pass 50%	5-Dec-09	14:48	24	8.3	59,500		14,000	8.3	63,300		21,600	7.9	46,200		720	99.00%
NF 2nd Pass 50%	10-Jan-10	11:00		7.3	61,300	12,840	18,125	7.3	66,700		26,250	7.0	43,400		25	99.97%
NF 2nd Pass 50%	10-Jan-10	14:40	28.5	7.0	60,100		20,000	7.1	65,700		29,375	6.8	45,700	83	24	99.98%
NF 2nd Pass 50%	11-Jan-10	10:30	26.5	7.0	60,500		10,625	7.0	66,600		18,850	6.5	43,000		29	99.95%
NF 2nd Pass 50%	11-Jan-10	15:30		6.9	60,500		10,000	7.0	66,600		17,500	6.6	41,400		27	99.95%
NF 2nd Pass 50%	12-Jan-10	14:00		7.6	38,700	171	32	7.7	42,900		86	7.2	32,400		1	99.79%
NF 2nd Pass 75%	19-Jan-10	12:20		6.9	54,100		8,589	7.1	74,100		31,875	6.8	43,200		17	99.98%



VTE Project data 2010

Salton Seawater, Salt Separation Results

Analysis of treated VTE concentrated Salton Seawater showing 99% sodium chloride brine



THERMOCHEM®
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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 $HCO3^-$.

Laboratory & Consulting Services 3414 Regional Parkway, Suite A Santa Rosa, CA 95403 (707) 575-1310

Sodium 63,900 mg/liter

Chloride 93,500 mg/liter

TDS 159,000 mg/liter

(Na+Cl)/TDS = 0.9899

99% purity NaCl is commercial grade solar salt and can be refined to 99.9% pure food grade

Source: VTE Project data 2010

Next: Commercial Demonstration Project

Basic Concept: Hypersaline Salton Sea water is desalinated to provide water for aquatic environment and agriculture and purified salt for revenue. Solar thermal heat and power separate Salton Sea water into distilled water, purified salt, and a small volume of mixed salt brine.

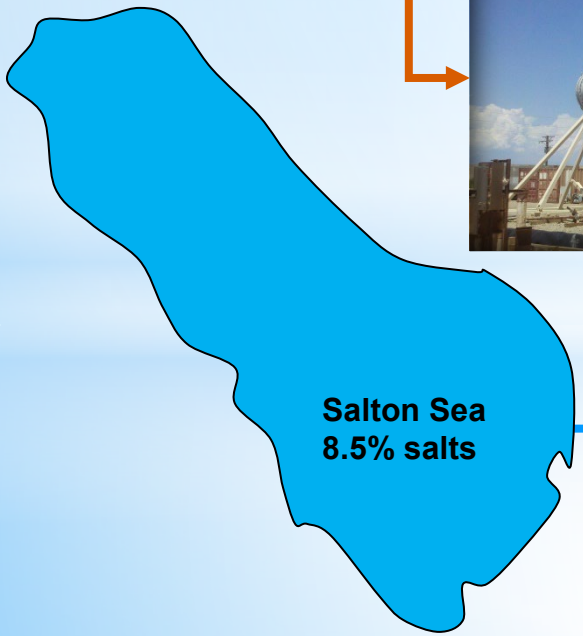
Clean Water to the Environment

Solar Thermal Heat & Power

Water

Salt

Brine

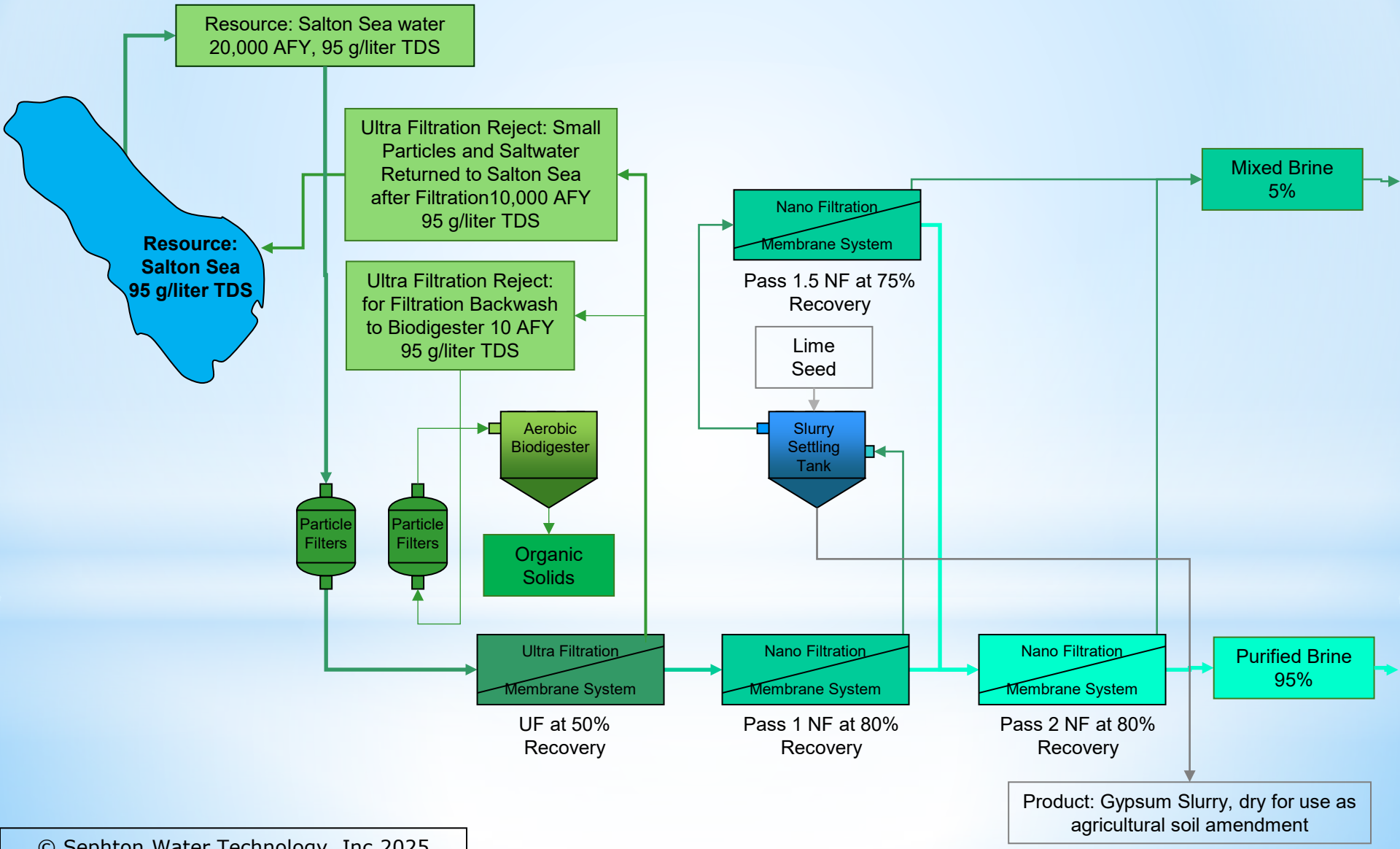


Energy from Brine

Sell Purified Salt

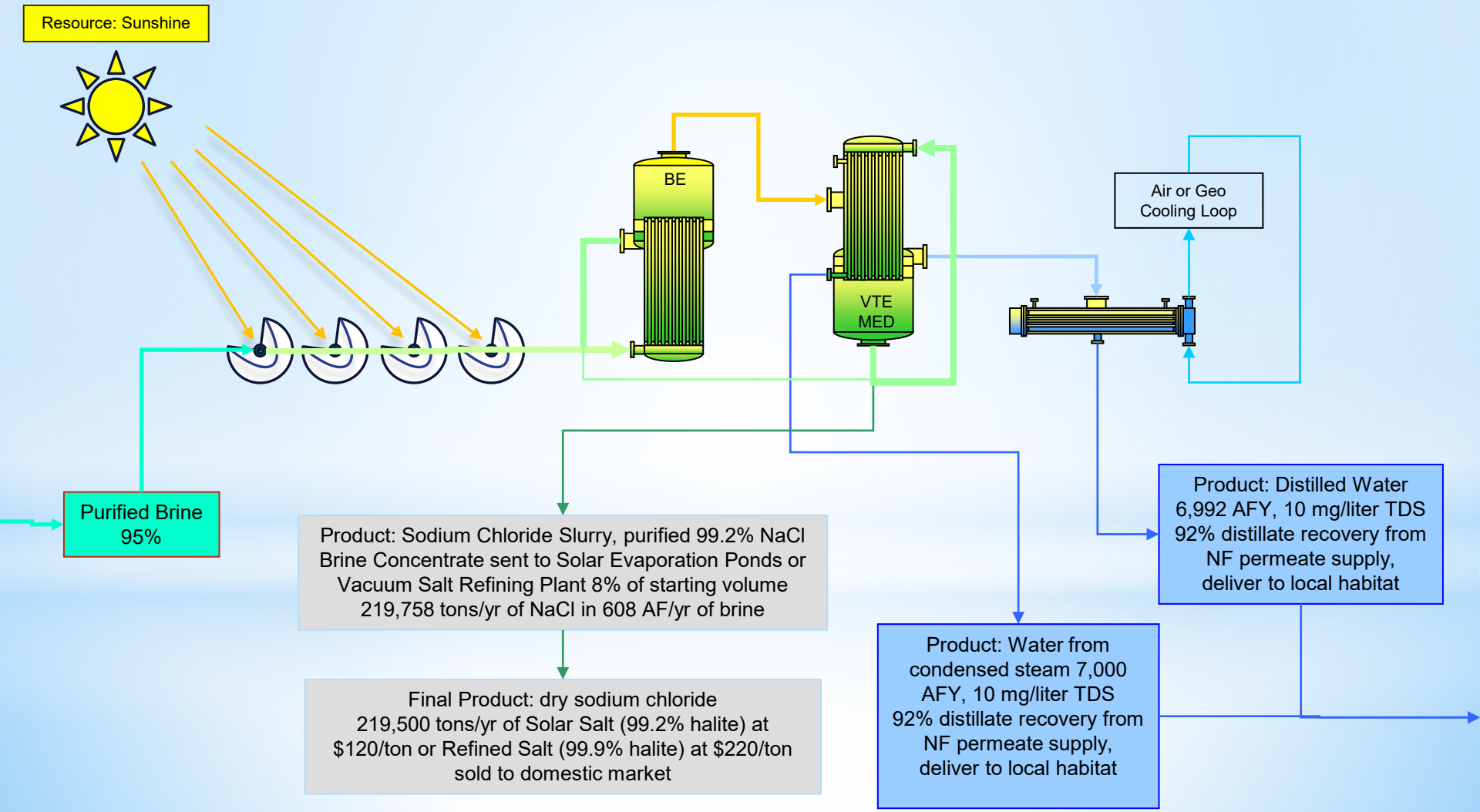
Commercial Demonstration Plant Process, Step 1
Extract Salton Sea Water, Filter and Digest Biomass
Separate Sodium Chloride and Gypsum from Mixed Salts

(flows show commercial scale in acre feet per year)



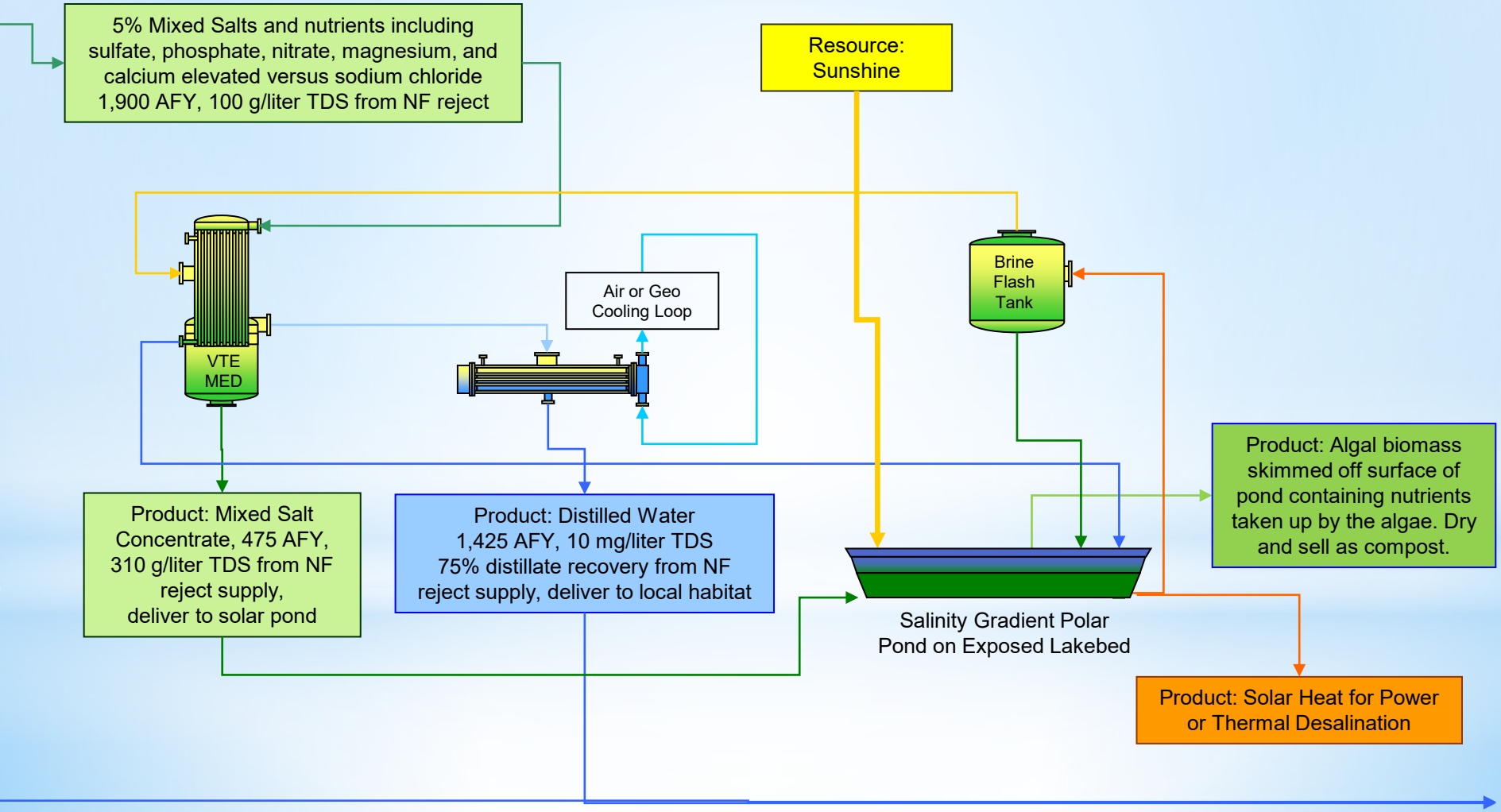
Commercial Demonstration Plant Process, Step 2
Recover 92% of Inflow as Distilled Water and Recover Purified Sodium Chloride

(flows show commercial scale in acre feet per year)



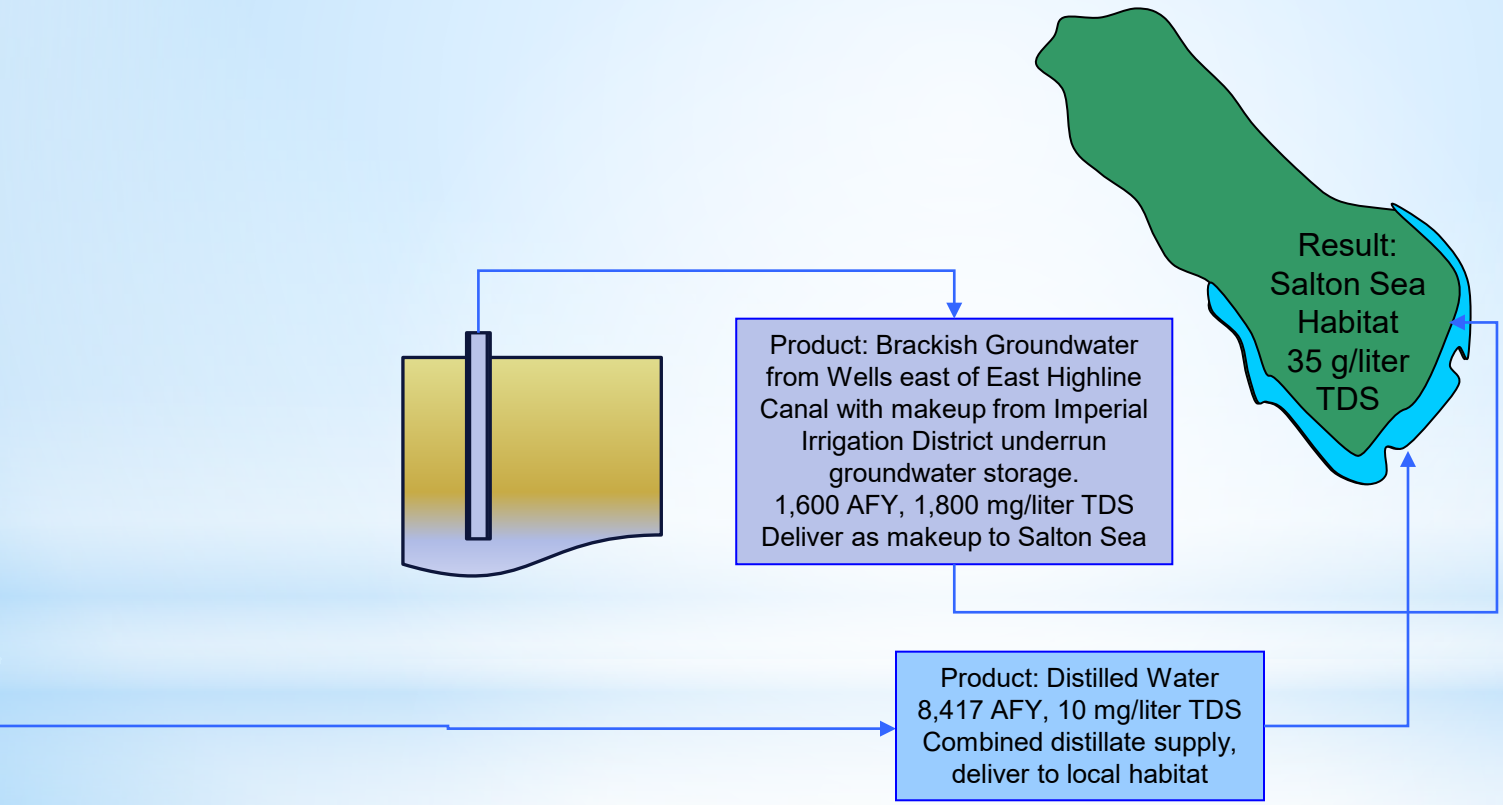
Commercial Demonstration Plant Process, Step 3
Recover 75% of 5% Mixed Salt as Distilled Water
Use Mixed Salts to Collect and Store Solar Heat
Recover Excess Nutrients to Produce Compost

(flows show commercial scale in acre feet per year)



Commercial Demonstration Plant Process, Step 4
Return 95% of Water to Salton Sea Habitat as Pure Distilled Water
Make-up 5% Loss With Brackish Groundwater on Site

(flows show commercial scale in acre feet per year)



Let the Problem Pay for a Solution

Extract Purified Salt and Excess Nutrients from the Salton Sea and Sell at a Profit.

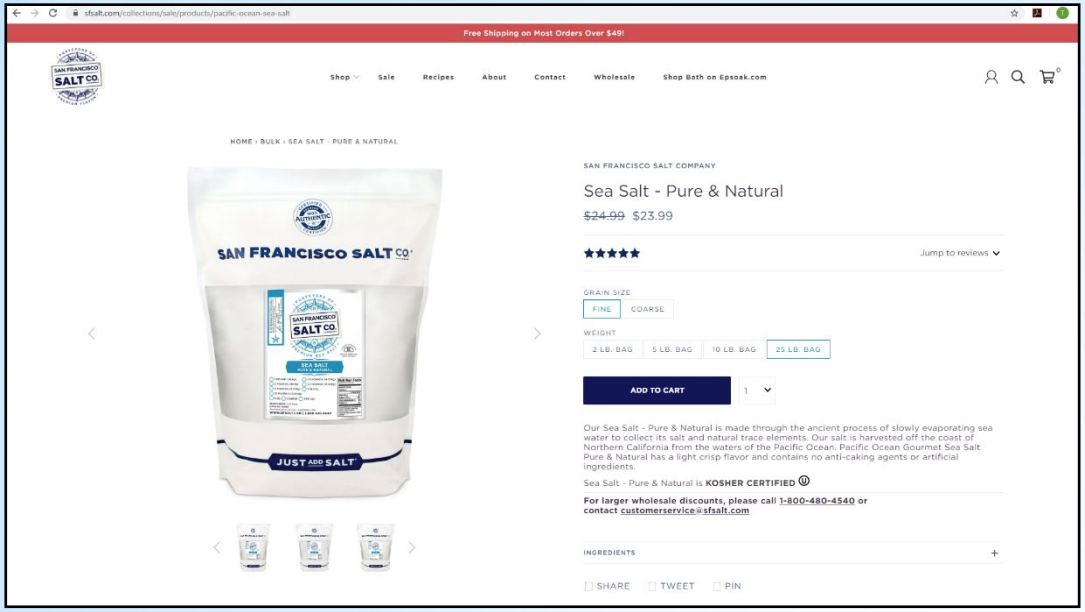
- A large commercial scale Salton Sea salt business needs to be proven at a small scale to provide confidence to deep pocket investors to secure private investment or construction loans.
- A very small amount of purified Salton Sea salt was produced during 2009-2010 pilot testing, by serendipity. The test results prove it can be done. Subsequently we came up with the high efficiency VTE-MED technology. Purified salt can be produced at a small commercial scale to yield a profit now while optimizing the technology and developing marketing leads for a large commercial scale operation in the future.
- Other companies are successful at online retail marketing of specialty salt products at very high markup over bulk salt prices. We have a unique environmental protection story to tell.

SaltWorks – Americas Sea Salt Company

San Francisco Salt Company

Revenue Potential Based on Other Salt Sellers Online Prices

Revenue possible from selling salt while running demo, using online retail sales model



Description	Value	Unit
BE/VTE 3 distillate production	85,787	GPD
BE/VTE 3 concentrate production	7,799	GPD
Salt content of source water	7.50%	
UF/NF salinity reduction	50.00%	
Purified NaCl Content of feed	3.750%	
kg per gallon of water	3.79	
kg per metric ton	1,000.00	
BE/VTE 3 NaCl production	13.30090313	tonne per day
San Francisco Salt Co. online retail example		
Price of generic packaged sea salt	$23.99	bag
Pounds per bag	25.00	lb
Pounds per metric ton	2,204.62	lb/tonne
Daily revenue from salt	$28,138.77	
Packages per day	1,173	
Daily personnel cost	$1,200.00	
Daily cost of materials	$2,346.94	
Daily cost of energy	$1,655.35	
Daily Net Income	$22,936.48	
Annual Net Income	**$5,963,485.92**	
America's Sea Salt Co. online retail example		
Price of packaged flake sea salt	$18.50	bag
Pounds per bag	25.00	lb
Pounds per metric ton	2,204.62	lb/tonne
Daily revenue from salt	$21,699.34	
Packages per day	1,173	
Daily personnel cost	$1,200.00	
Daily cost of materials	$2,346.94	
Daily cost of energy	$1,655.35	
Daily Net Income	$16,497.06	
Annual Net Income	**$4,289,234.96**	

Source: VTE Project 2022

Demonstration Scale Profitable Salt Marketing Concept

Salt Product Marketing and Labelling Concepts

The salt marketing campaign and product packaging will feature a mermaid logo making a psychological connection to the sea, to a concept of quality, and to the mystical benefits that many consumers think they get from gourmet salt products like the premium products offered by the San Francisco Salt Company and from SaltWorks / America's Sea Salt Company. There will also be an ecological benefit story other salt producers cannot offer due to the clean water returned for aquatic habitat restoration. Salton Sea Mermaid concept courtesy of Jasmyn Phillips.

Projected Annual Net Income from Salt Production and Sale

Revenue based on online retail, less operating costs, and investment or grant capital cost

		Year 1	Year 2	Year 3
Revenue	Revenue from Sale of Packaged Vacuum Refined Salt	$1,432,156.67	$5,728,626.66	$5,728,626.66
	Revenue from Sale of Purified Water	$0.00	$0.00	$0.00
	Total Revenue	$1,432,156.67	$5,728,626.66	$5,728,626.66
		$0.00	$0.00	$0.00
Expenses	Equipment Procurement Costs	$3,521,788.73	$0.00	$0.00
	Equipment Replacement and Spare Parts	$110,466.69	$206,259.25	$206,259.25
	Salaries	$480,000.00	$480,000.00	$480,000.00
	Wages	$734,976.00	$728,640.00	$728,640.00
	Benefits	$242,995.20	$241,728.00	$241,728.00
	Professional Services	$24,000.00	$48,000.00	$48,000.00
	Site Security costs	$24,000.00	$24,000.00	$24,000.00
	Utilities	$43,730.96	$85,061.93	$85,061.93
	Fuel	$118,816.60	$351,949.81	$351,949.81
	Salt Packaging Materials	$206,530.58	$619,591.74	$619,591.74
	Salt Product Transportation	$348.00	$1,392.00	$1,392.00
	Water Product Transportation	$10.93	$43.72	$43.72
	Salt Sales & Marketing	$129,000.00	$120,000.00	$120,000.00
	Travel Costs	$6,000.00	$1,200.00	$1,200.00
	Liability Insurance	$5,000.00	$5,000.00	$5,000.00
	Total Expenses	$5,514,449.11	$2,755,541.44	$2,755,541.44
		$0.00	$0.00	$0.00
Gains	Cost Reimbursement from Investment or Grant Funding	$5,132,103.60	$0.00	$0.00
		$0.00	$0.00	$0.00
Losses	Expenses Unreimbursable from Investment or Grants	$9,785.42	$0.00	$0.00
		$0.00	$0.00	$0.00
Net Income	(Revenue + Gains) - (Expenses + Losses)	$1,069,811.16	$2,977,960.22	$2,977,960.22

Future: Salton Sea Water Recycling

Basic Concept: Extract hypersaline water from the Salton Sea to remove salts. Return distilled water to habitat at no charge, Pay for the whole operation by separating purified salt. Use residual mixed salt brine for playa dust cover.

Pure Water to Habitat and Sea

Sell Purified Salt to Domestic Market

Salton Sea
Over 8% salts plus excess nutrients

Pure Water

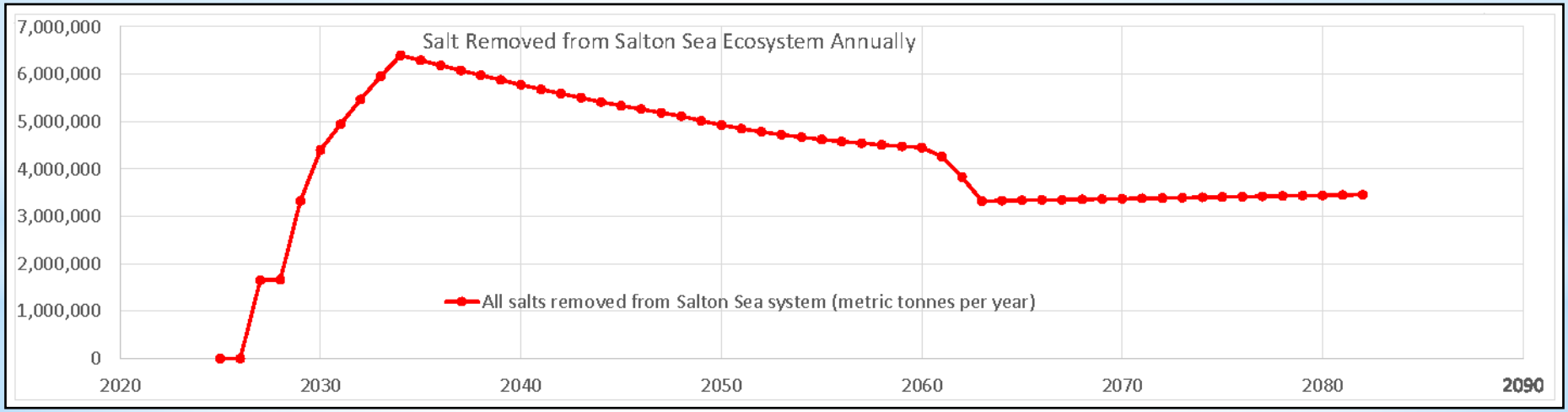
Pure Salt

Mixed Brine

Use Mixed Salt in Evaporation Ponds to Eliminate PM10 Dust from Playa

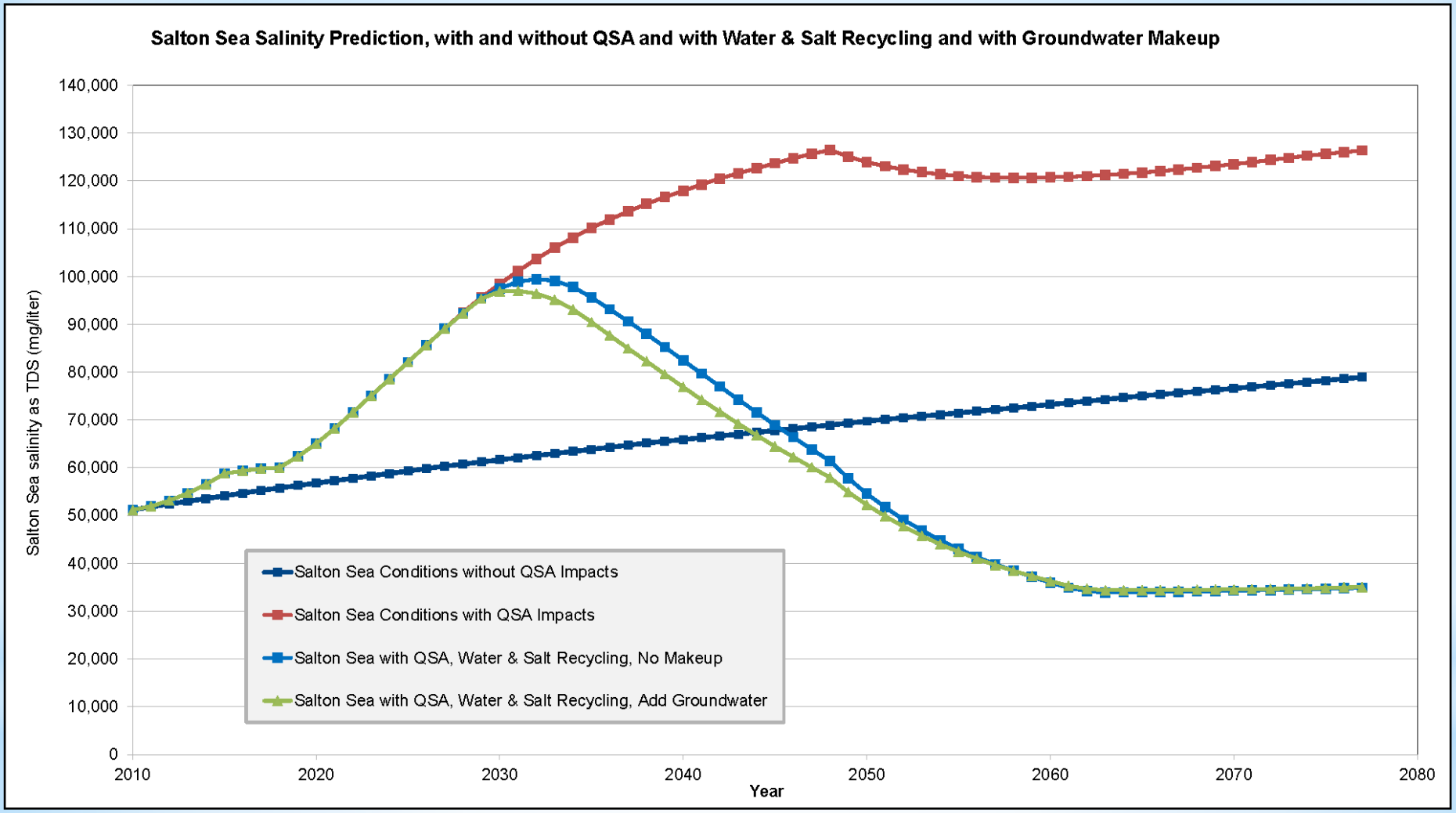
Groundwater Makeup

Long Term Salton Sea Water Quality Restoration



Remove excess nutrients along with 3 to 6 million tons of salt from Salton Sea yearly

Long Term Salton Sea Water Quality Restoration



Reduce nutrient load and return Salton Sea to marine salinity within 30 years

Mid Term Localized Water Quality Restoration

Supply selenium free distilled Salton Sea water to State aquatic habitat projects like Species Conservation Habitat

Questions or Comments?