CENTRAL VALLEY SALINITY ALTERNATIVES FOR LONG-TERM SUSTAINABILITY (CV–SALTS)

Strategic Salt Accumulation Land and Transportation Study (SSALTS)

Phase 3 Report – Evaluate Potential Salt Disposal Alternatives to Identify Acceptable Alternatives for Implementation

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Prepared for
SAN JOAQUIN VALLEY DRAINAGE AUTHORITY

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List of Acronyms or Abbreviations

µS/cm	micro Siemens per centimeter
AB	Assembly Bill
ABAG	Association of Bay Area Governments
AF	acre-feet
aka	also known as
BDCP	Bay Delta Conservation Plan
bgs	below ground surface
BMPs	Best Management Practices
BOD	biological oxygen demand
BPA	Basin Plan Amendment
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CVHM	Central Valley Hydrologic Model
CVBL	Central Valley Brine Line
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Central Valley Water Board	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWA	Clean Water Act
DAC	disadvantaged communities
Delta	Sacramento-San Joaquin River Delta
DIW	deep injection well
DOGGR	California Division of Oil, Gas & Geothermal Resources
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utility District
EC	Electrical Conductivity
EDR	Electrodialysis Reversal
FEIS	Final Environmental Impact Statement
FO	Forward Osmosis
GBP	Grassland Bypass Project
GDA	Grassland Drainage Area
gpm	gallons per minute
GRCD	Grasslands Resource Conservation District
GSAs	Groundwater Sustainability Agencies
GSPs	Groundwater Sustainability Plans

GWD	Grasslands Water District
HCC	Hilmar Cheese Company
HDPE	high-density polyethylene
HF	hydraulic fracturing
IAZ	Initial Analysis Zone
ICM	Initial Conceptual Model
IEBL	Inland Empire Brine Line
IFDM	Integrated On-Farm Drainage Management
IX	Ion exchange
JPA	joint powers authority
kg	kilogram
LSJR	Lower San Joaquin River
MCL	maximum contaminant level
MD	Membrane Distillation
MEB	Mid-Evaporation Basins
mgd	million gallons per day
MOU	Memorandum of Understanding
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NM	New Melones
NOAA	National Oceanic and Atmospheric Administration
NRW	Non-Reclaimable Wastewater
OAL	Office of Administrative Law
O&M	operation and maintenance
P&O Study	Prioritization and Optimization Study
Reclamation	US Bureau of Reclamation
RO	Reverse Osmosis
RRR	Red Rock Ranch
RTMP	Real-Time Management Program
SAMP	Surveillance and Monitoring Program
SARI	Santa Ana Regional Interceptor
SAWPA	Santa Ana Watershed Project Authority
SFEI	San Francisco Estuary Institute
SGMA	Sustainable Groundwater Management Act
SJRIP	San Joaquin River Water Quality Improvement Project
SMA	salt management area
SNMP	Salt and Nitrate Management Plan

SSALTS	Strategic Salts Accumulation Land and Transportation Study
SWP	State Water Project
State Water Board	State Water Resource Control Board
TAC	Technical Advisory Committee
TDS	total dissolved solids
TLBWSD	Tulare Lake Basin Water Storage District
TLDD	Tulare Lake Drainage District
TMDL	Total Maximum Daly Load
UIC	Underground Injection Control
USDW	underground source of drinking water
USEPA	US Environmental Protection Agency
USGS	US Geological Survey
WDRs	Waste Discharge Requirements
WQO	Water Quality Objectives
WWTP	Wastewater Treatment Plant
ZDD	Zero Discharge Distillation
ZLD	Zero Liquid Discharge

Section 1

Introduction

1.1 Project Purpose

The purpose of the Strategic Salt Accumulation Land and Transportation Study (SSALTS) is to identify the range of viable Central Valley alternatives for salt disposal to provide input for consideration during development of the Salt and Nitrate Management Plan (SNMP) for the region under the jurisdiction of the Central Valley Regional Water Quality Control Board (Central Valley Water Board). The findings have been used to guide discussions regarding establishment of regional salt management policies and the need for changes to the existing Central Valley Water Board Water Quality Control Plans (Basin Plans) to facilitate salt disposal in a manner that is most beneficial to the region and consistent with the State Water Resources Control Board's (State Water Board) Recycled Water Policy.

This work is being conducted under the direction of the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) initiative, which is developing the SNMP for the Central Valley. The SSALTS project has been conducted in three phases (**Figure 1-1**):

- *Phase 1: Identify and Characterize Existing Salt Accumulation Study Areas* – The selection of representative study areas served as archetype situational examples to facilitate discussions regarding salt accumulation and disposal in the Central Valley. Each of these study areas was characterized to establish baseline information that was subsequently used to support development of salt disposal alternatives in Phases 2 and 3.
- *Phase 2: Develop Potential Salt Management Strategies* – Phase 2 of SSALTS developed potential long-term salt disposal alternatives in three parts: (1) in-valley alternatives; (2) out-of-valley alternatives; and (3) hybrid alternatives that combined in-valley and out-of-valley salt disposal options.
- *Phase 3: Evaluate Potential Salt Disposal Alternatives to Identify Acceptable Alternatives for Implementation* – Alternatives developed under Phase 2 were evaluated in this report using selected feasibility criteria (*e.g.*, regulatory, institutional, economic, technological, *etc.*). The outcome of this evaluation was the identification and prioritization of acceptable salt disposal alternatives for potential incorporation into Central Valley SNMP as salt management implementation measures.

The Phase 1 and Phase 2 SSALTS final reports were submitted to the CV-SALTS Executive Committee in December 2013 and September 2014, respectively (CDM Smith 2013; CDM Smith 2014). The Phase 3 SSALTS draft report was submitted to the CV-SALTS Executive Committee in March 2015. Comments were received and incorporated into the Phase 3 SSALTS draft report. The Executive Committee recommended postponing the finalization of the Phase 3 SSALTS report until a draft of the Nitrate Implementation Measures Study (NIMS) report was completed, so that salt and nitrate implementation measures and mitigation strategies could be coordinated. While based on the March 2015 Phase 3 SSALTS draft report – and thus including the changes based on the original comments, the September 2016 Phase 3 SSALTS draft report had major changes in terms of content and structure. The September 2016 Phase 3 SSALTS draft report was sent to the Project Committee on September 20, 2016 and comments were received on October 5, 2016. The second set of comments were addressed and incorporated into this October 2016 Phase 3 SSALTS final report. Appendix E. provides the comments and responses on the September 2016 Phase 3 SSALTS draft report.

The Phase 3 SSALTS report provides a path forward, based on the foundation of Phases 1 and 2 and CV-SALTS Executive Committee discussions.

1.2 Phase 1 SSALTS Archetype Study Areas

The Phase 1 work revolved around the concept of an archetype study area, whereby a study area represents a geographic or situational example that can be used as a basis to develop salt management alternatives for the Central Valley. The Phase 1 activities included three key steps: (1) selection of representative study areas consistent with the goals of SSALTS; (2) characterization of the selected study areas; and (3) evaluation of the potential for long-term sustainable salt management given the characteristics of the study area. The 10 archetype study areas reviewed in the Phase 1 SSALTS study are:

- City of Dixon
- City of Tracy
- Grassland Water District – Real Time Management
- Hilmar Cheese Company
- Industrial Food Processing
- Red Rock Ranch
- San Luis Unit Ocean Disposal
- Stevinson Water District
- Tulare Lake Bed
- Westside Regional Drainage Plan

A summary of the Phase 1 analyses of the archetype study areas, along with each study area's ranking, is provided in Appendix A.

1.3 Phase 2 – Develop Potential Salt Management Strategies

Phase 2 focused on the development of potential salt management strategies to mitigate the salt accumulation in the Central Valley. Under Phase 2, alternatives that support these potential strategies for salt disposal were identified and characterized, through a review of literature and reports and information obtained from regional experts. **Table 1-1** summarizes the salt management and disposal options evaluated in Phase 2 of SSALTS.

Of these salt management and disposal options, only the out-of-valley salt disposal options were projected to dispose or manage significant percentages of the annual salt accumulation in the Central Valley; the ocean disposal option can transport and mitigate all of the salt mass that is currently accumulating. A regulated brine line (the Central Valley Brine Line, or CVBL) was evaluated for transportation of brine out of the valley, because of potential capacity limitations for the other WWTP-transportation options (truck and rail). Hence, all of the alternatives developed in Phase 2 include transportation of brine to San Francisco Bay[1] as the disposal option. The discharge would occur through a permitted Wastewater Treatment Plant (WWTP) outfall or a newly established outfall. Two of the alternatives developed in Phase 2 compared utilizing excess permitted capacity at East Bay Municipal Utilities District's (EBMUD) Main WWTP and a new permitted outfall.

Table 1.1 Salt Management Disposal Options Evaluated in Phase 2 SSALTS

Category	Disposal Option
Salt Accumulation/Management Options: In-Valley	**Agricultural Reuse Area**. San Joaquin River Water Quality Improvement Project (SJRIP) is the archetype project.
	Evaporation/Long Term Storage. Tulare Lake Bed is the archetype project.
Salt Storage/Disposal: In-Valley	**Deep Well Injection.** Hilmar Cheese Company is the archetype project.
	Hydraulic Fracturing.
Salt Disposal: Out-of-Valley	**Real-Time Management.** San Joaquin River Real-Time Management is the archetype project.
	Ocean Disposal.

For the purpose of developing cost estimates for the alternatives, reverse osmosis (RO) was selected as the treatment technology in Phases 2 and 3. However, as discussed in Section 2.3 of this report, emerging technologies will continue to evolve and scale up from pilot studies to mature, proven treatment technologies. The efficacy and economics of these technologies will continue to be evaluated.

The significant findings and the alternatives developed in Phase 2 are summarized in Section 2 of this report.

1.4 Phase 3 Scope of Work

Phase 3 builds upon the work completed under previous phases by evaluating the range of in-valley, out-of-valley and hybrid salt management alternatives developed under Phase 2. Under this phase, SSALTS developed feasibility criteria (*e.g.*, regulatory, institutional, economic,

[1] Although not evaluated in Phase 2 of SSALTS, an alternative brineline alignment that would go west/southwest to the ocean may also be feasible and evaluation of this alignment may be included in future phases of SSALTS.

technological, *etc.*) to provide a basis for evaluating each alternative and complete the feasibility analysis. The outcome of this evaluation is the identification and prioritization of acceptable salt disposal alternatives to be considered for inclusion into the SNMP as implementation measures for the management of salt in the Central Valley. Phase 3 includes the following tasks:

- *Task 3.1, Develop Planning Level Feasibility Criteria to Evaluate Alternatives* – Potential feasibility screening criteria for evaluation of salt management alternatives were developed. Consideration was also given to the potential for an identified salt management practice to have wide applicability in the Central Valley or only be useful within a narrow range of circumstances.

- *Task 3.2, Perform Screening Level Feasibility Analysis of Salt Management Alternatives* – Under this task, the project team evaluated individual and/or combinations of in-valley and out-of-valley salt management alternatives using the feasibility criteria developed under Task 3.1.

- *Task 3.3, Prepare Phase 3 SSALTS Report* – The Phase 3 Report is a cumulative extension of the Phase 1 and 2 Reports. The report (i) summarizes work completed to date under Phases 1 and 2; (ii) incorporates the results of the feasibility analysis completed under Phase 3; (c) develops conclusions and recommendations based on the work completed in Phase 3; and (d) provides recommendations for salt management alternatives for inclusion in the SNMP as acceptable implementation measures.

Following review by the CV-SALTS Project Committee, the proposed implementation strategy incorporated into the draft Phase 3 SSALTS Report was presented to the CV-SALTS Executive Committee on May 21, 2015. Following considerable discussion, it was agreed the draft findings in the Phase 3 Report be reconsidered after completion of the CV-SALTS Nitrate Implementation Measures Study (NIMS).[2] This approach would allow for consideration of both salinity management and nitrate management strategies at the same time. Based on the findings from NIMS, CV-SALTS developed a nitrate management strategy (aka Nitrate Permitting Strategy) for inclusion in the Central Valley SNMP. Similarly, based on the findings from SSALTS, especially the Phase 2 Report, the Executive Committee developed a Salinity Management Strategy that provides a phased path forward for the implementation of the findings from the SSALTS project. The draft May 21, 2015 draft Phase 3 Report was revised to incorporate this implementation approach.

1.5 Report Organization

Section 2 of this Phase 3 SSALTS report describes the technical work conducted in Phase 2 of SSALTS and includes brief summaries of:

- The Central Valley Salt Balance/Problem Statement

[2] *Nitrate Implementation Measures Study (NIMS) Final Report.* Report prepared by CDM Smith on behalf of CV-SALTS, March 31, 2016

- Reduction and Management of Salt Contributions to Groundwater: Land Management and Source Control Best Management Practices (BMPs)
- Treatment Technologies
- Salt Accumulation and Management Areas
- In-Valley Salt Storage and Disposal Options
- Out-of-Valley Disposal Options
- Salt Managed by Various Storage and Disposal Options
- Salt Management Alternatives

Section 3 is the feasibility analysis where the alternatives developed in Phase 2 of SSALTS were evaluated against weighted criteria. Each of the alternatives carried forward from Phase 2 included a regulated brine line/ocean disposal option, because the other management and disposal options did not have the capacity to manage or dispose of significant percentages of the salt mass accumulating annually in the Central Valley (Section 2.8). The regulated brine line/ocean disposal option is part of the long-term, sustainable solution, however, the implementation of any alternative with this salt disposal method will require many years of planning, design, permitting, and funding before construction and salt removal operations can begin. Hence, there is a need to evaluate all of the disposal options independent of the long-term, sustainable alternatives so that there is a menu of disposal options that can be utilized by local or regional agencies or project proponents in the short-term. Hence, Section 3 also includes a feasibility analysis of currently available salt management and disposal options.

Section 4 describes proposed short- and long-term strategies for the management of salt consistent with the CV-SALTS Salinity Management Strategy (CV-SALTS 2016a) and Draft SNMP (CV-SALTS 2016b). Specifically, this section summarizes the planned phased approach for the management of salt through implementation of the SNMP.

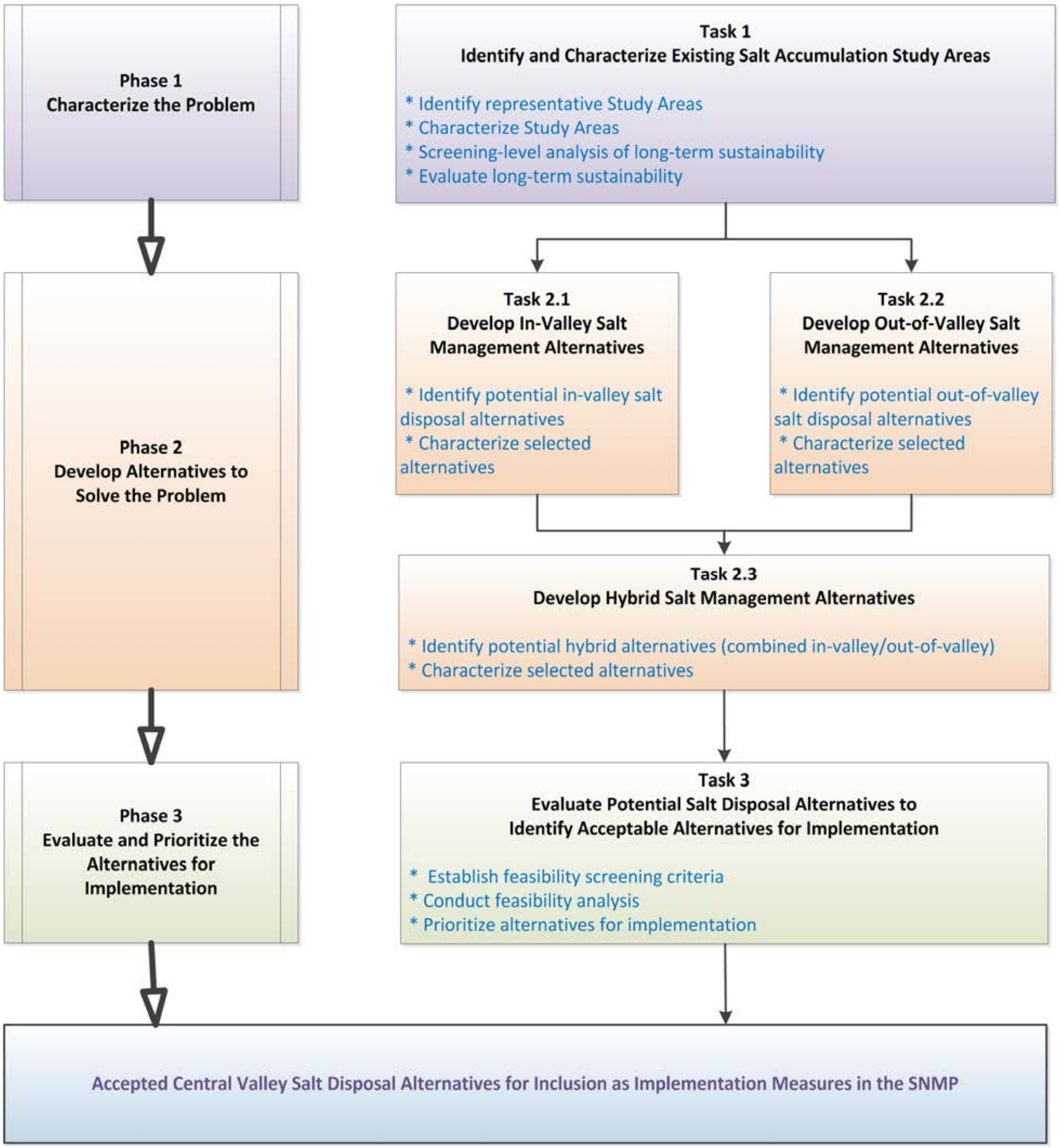

Figure 1-1 SSALTS Phases and Key Tasks

Section 2

Summary of Phase 2 - Develop Potential Salt Management Strategies

Phase 2 focused on the development of potential salt management strategies to mitigate the salt accumulation in the Central Valley. The Phase 2 report utilized the Initial Conceptual Model (ICM) (LWA 2013) to develop an estimate of salt accumulation in shallow groundwater throughout the Central Valley. Phase 2 also described options to reduce and manage salt accumulation in groundwater, treatment technologies, including mature and emerging technologies, options for salt accumulation and management, options for in-valley storage and disposal, and out-of-valley disposal.

The Phase 2 analysis of various alternative strategies for salinity management in the Central Valley is fundamentally dependent on the magnitude of the salt accumulation and meeting regulatory goals. This analysis has focused on identifying the range of viable Central Valley alternatives for salt disposal to support development of the SNMP consistent with the State Water Board Recycled Water Policy. In this regard – per the Recycled Water Policy – the regulatory goal is to manage salt on a basin-wide or watershed-wide basis through regional or subregional plans in a manner that ensures attainment of water quality objectives and protection of beneficial uses.

2.1 Salt Balance

2.1.1 Conceptual Approach

Figure 2-1 shows the Salt Flux-Salt Management Process Flow Diagram that allows for a conceptual-level estimate of the salt accumulation problem in the Central Valley, the source control BMPs, treatment options, and management/disposal/use options that would be relevant. As shown in Figure 2-1, the ICM (LWA 2013) provides information on the net salt flux into the shallow groundwater system in each Initial Analysis Zone (IAZ). This determines the mass of salt that would need to be removed from the system (or in the case of source control BMPs, prevented from entering groundwater) to achieve a zero salt balance (net inflows minus net outflows equal zero) or some other target for salt mitigation.

To refine this estimate, the Phase 2 study assumed that the entire IAZ would not be pumped and treated uniformly. To illustrate one salt management strategy, desalter wells or other extraction facilities could be strategically located and designed to extract groundwater in areas and aquifer zones where total dissolved solids (TDS) concentrations are elevated. While the concept-level salt mitigation alternatives discussed in this report focuses on achieving salt balance in the valley with minimal pumping, the ultimate objective will be to provide for the maximum benefit to the people of the State. As a starting point for the concept-level salt mitigation alternatives, ambient concentrations of TDS in pumped groundwater are estimated for areas that have relatively high concentrations of TDS. For the purpose of this study a TDS concentration of 1,000 mg/L – twice the secondary maximum contaminant level (MCL) – was used to define “relatively high.” These concentrations are then used to determine the volume of brackish groundwater or tile drain water that would need to be pumped and treated or removed by some means. The groundwater chemistry along with the volume of water to be treated will help to determine viability of the array of treatment technologies available, as well as the sizing of salt management or disposal facilities. Finally, the brine produced (volume, concentration, trace constituents) will inform the range of management/disposal/ use options.

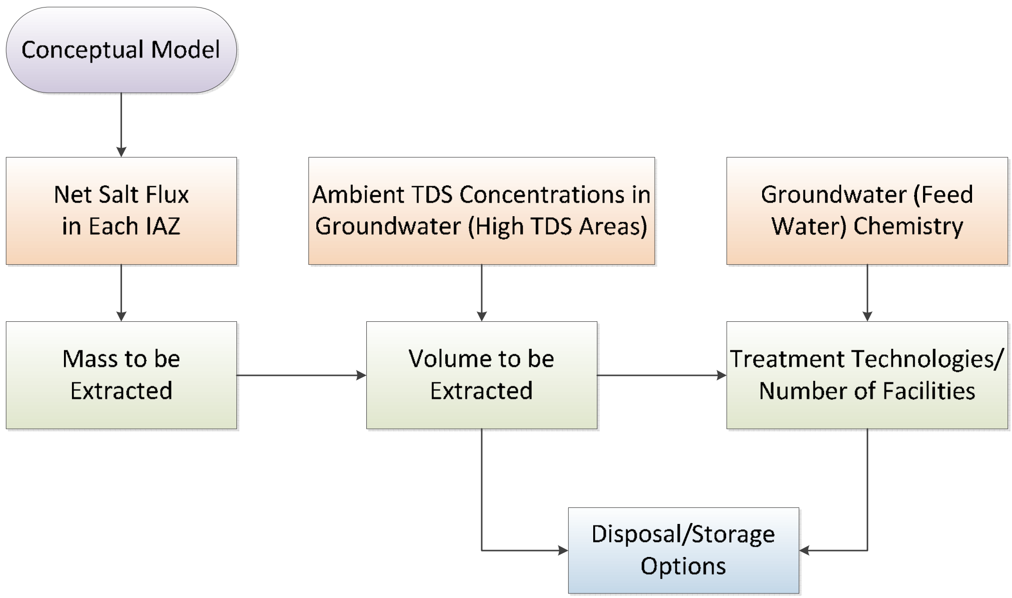

Figure 2-1 Salt Flux-Salt Management Process Flow Diagram

2.1.2 Estimates of Salt Accumulation and Salt Extraction

The Larry Walker Associates (LWA) Team developed the ICM "in a collaborative setting with stakeholders and regulatory agencies and partner agencies" (LWA 2013). As with SSALTS, the ICM is a "30,000-foot concept level" analysis – in the case of the ICM – of water balance in the Central Valley floor, in order to estimate salt and nitrate fluxes and loads to IAZs. The CV-SALTS Technical Advisory Committee (TAC) recommended that the Central Valley Hydrologic Model (CVHM) (Faunt *et al*. 2009), developed by the US Geological Survey (USGS), be used as the basis for water balance determinations. The CVHM Delta-Mendota Basin was subdivided into subbasins so that there are 22 IAZs in the ICM. The IAZs are depicted in **Figure 2-2**, and are grouped into Northern Central Valley, Middle Central Valley, and Southern Central Valley regions for discussion purposes (see, for example, **Tables 2-1** and **2-2**).

The spatial boundaries of the IAZs are derived from the CVHM model and these boundaries are related to water balance regions developed by the California Department of Water Resources (DWR). The ICM model performs water, salt and nitrate balance calculations for each quarter over a 20-year modeling period. The shallow groundwater zone is operationally defined as the distance that water would travel vertically over a 20-year period[3]. Table 10-4 "Annual Mass Loading of a Per Acre Basis for the Six (6) Nitrate and Three (3) TDS Loading Scenarios" from LWA (2013) contains the following information for each of the IAZs: area (thousands of acres or square miles) and the net mass loading of salt to shallow groundwater in kilograms (kg) per acre per year. The "Original TDS Loading" is the mass loading using the original input parameters to the model while the "50% of Original and "200% of Original" represents a model sensitivity analysis. Table 10-5 "Assimilative Capacity Based on Recent (2003-2012) Shallow Data for Nitrate and TDS" from LWA (2013) summarizes median ambient groundwater TDS for the shallow groundwater zone, based on groundwater well data for the period 2003 to 2012.

The information from Tables 10-4 and 10-5 in LWA (2013) was used as the basis for **Table 2-1** in this report. The TDS loading and area were used to estimate the mass loading of salt for each IAZ on an annual basis[4]. The shallow groundwater TDS data were then used in a mass balance analysis to determine the volume of shallow groundwater (or agricultural tail water) that would need to be extracted to achieve a policy compliance goal of balancing net salt inflows and outflows. As shown in Table 2-1, the current net salt accumulation in the entire Central Valley is about 7,000,000 tons annually, according to the ICM model. The salt accumulation in groundwater in the regional groupings of IAZs is:

- Northern Central Valley – 1,173,000 tons per year
- Middle Central Valley – 2,153,000 tons per year
- Southern Central Valley – 3,675,000 tons per year

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[3] "The vertical distance represents the distance that the water, at the water table, would travel downward or upward over a 20-year period. This defines the "shallow" portion of the subsurface where the ICM analysis is performed." (LWA 2013)

[4] The salt load is the net mass of salt that accumulates in the shallow groundwater annually. Sources are input from the vadose zone – ultimately from the land surface – and include returns from irrigated agriculture, wastewater discharge ponds, *etc*. and from subsurface inflows from adjacent IAZs. Losses from the shallow groundwater zone are subsurface outflows to adjacent IAZs and movement of TDS and nitrate to deep aquifer zones. While the overall salt and nitrate masses would be greater if deeper zones were included, the *net* accumulation would be the same. The exception would be if subsurface inflows and outflows in the deeper zone are significantly different than in the shallow zone.

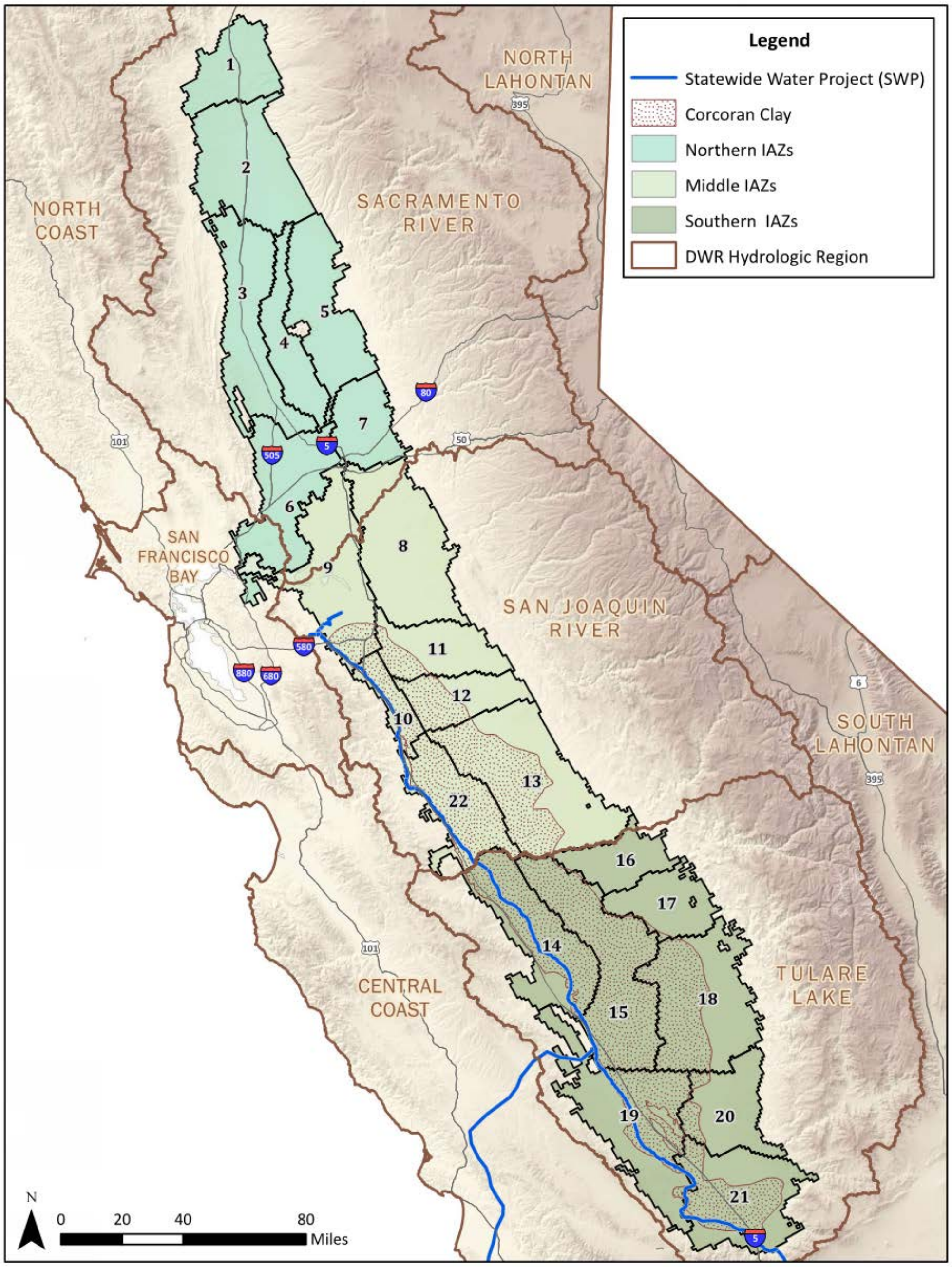

Figure 2-2 Map Depicting the Initial Analysis Areas (IAZs) in the Central Valley

Table 2-1 Annual Salt Loading and Salt Extraction by IAZ

Central Valley Zone	IAZ	Acres (x1000)	Square Miles	TDS Loading for IAZ (tons)			GW [TDS]	Pumped GW [TDS]	TDS Removal from each IAZ (tons)			Volume Needed to be Removed (MGD)			Volume Concentrate - 90% Efficiency (MGD)			Brine [TDS]
				50%	Original	200%	mg/L	mg/L	50%	Original	200%	50%	Original	200%	50%	Original	200%	mg/L
	1	391	611	26,722	53,444	107,320	370	370	26,722	53,444	107,320	47	95	190	5	9	19	3,700
	2	744	1,163	33,625	68,070	135,320	201	201	33,625	68,070	135,320	110	222	442	11	22	44	2,010
	3	712	1,112	138,133	275,480	550,961	583	583	138,133	275,480	550,961	155	310	620	16	31	62	5,830
Northern Central	4	358	560	27,624	55,248	110,496	761	761	27,624	55,248	110,496	24	48	95	2	5	10	7,610
	5	612	957	26,310	53,294	106,589	329	329	26,310	53,294	106,589	52	106	213	5	11	21	3,290
	6	668	1,044	320,309	640,618	1,280,501	1,060	1,060	320,309	640,618	1,280,501	198	397	793	20	40	79	10,600
	7	342	534	13,572	27,143	54,287	398	398	13,572	27,143	54,287	22	45	89	2	4	9	3,980
	8	872	1,362	41,332	82,664	165,329	438	438	41,332	82,664	165,329	62	124	248	6	12	25	4,380
	9	756	1,181	56,668	113,335	226,670	961	961	56,668	113,335	226,670	39	77	155	4	8	15	9,610
	10	180	282	110,518	220,837	441,674	842	842	110,518	220,837	441,674	86	172	344	9	17	34	8,420
Middle Central	11	425	664	151,320	302,639	605,278	565	565	151,320	302,639	605,278	176	351	703	18	35	70	5,650
	12	346	540	165,527	331,055	662,109	825	825	165,527	331,055	662,109	132	263	527	13	26	53	8,250
	13	1,055	1,648	105,827	211,655	422,146	648	648	105,827	211,655	422,146	107	214	427	11	21	43	6,480
	22	513	801	445,602	890,639	1,781,843	1,160	1,160	445,602	890,639	1,781,843	252	504	1,008	25	50	101	11,600
	14	685	1,071	565,557	1,131,113	2,262,982	3,375	3,375	565,557	1,131,113	2,262,982	110	220	440	11	22	44	33,750
	15	593	926	77,739	155,479	310,958	1,000	1,000	77,739	155,479	310,958	51	102	204	5	10	20	10,000
	16	306	478	59,029	69,485	90,736	575	575	59,029	69,485	90,736	67	79	104	7	8	10	5,750
Southern Central	17	364	569	77,841	155,681	310,962	520	520	77,841	155,681	310,962	98	196	392	10	20	39	5,200
	18	869	1,358	119,738	228,940	447,343	598	598	119,738	228,940	447,343	131	251	491	13	25	49	5,980
	19	874	1,365	744,723	1,489,446	2,979,855	11,300	11,300	744,723	1,489,446	2,979,855	43	86	173	4	9	17	113,000
	20	451	705	72,086	140,691	278,399	870	870	72,086	140,691	278,399	54	106	210	5	11	21	8,700
	21	707	1,105	162,101	303,940	588,397	335	335	162,101	303,940	588,397	317	595	1,152	32	60	115	3,350
Total/Average		**12,823**	**20,036**		**7,000,898**					**7,000,898**			**4,565**		**234**	**457**	**902**	**11,438**
				Northern CV	1,173,299				Northern CV	1,173,299					Northern CV	122		
				Middle CV	2,152,824				Middle CV	2,152,824					Middle CV	171		
				Southern CV	3,674,776				Southern CV	3,674,776					Southern CV	164		

Table 2-2 Annual Salt Loading and Salt Extraction by IAZ – High TDS (>1,000 mg/L) Areas Only

Central Valley Zone	IAZ	Acres (x1000)	Square Miles	TDS Loading for IAZ (tons)			GW [TDS]	Pumped GW [TDS]	TDS Removal from each IAZ (tons)			Volume Needed to be Removed (MGD)			Volume Concentrate - 90% Efficiency (MGD)			Brine [TDS]
				50%	Original	200%	mg/L	mg/L	50%	Original	200%	50%	Original	200%	50%	Original	200%	mg/L
Northern Central	1	391	611	26,722	53,444	107,320	370											
	2	744	1,163	33,625	68,070	135,320	201											
	3	712	1,112	138,133	275,480	550,961	583											
	4	358	560	27,624	55,248	110,496	761											
	5	612	957	26,310	53,294	106,589	329											
	6	668	1,044	320,309	640,618	1,280,501	1,060	2,509	320,309	640,618	1,280,501	84	168	335	8	17	33	25,090
	7	342	534	13,572	27,143	54,287	398											
Middle Central	8	872	1,362	41,332	82,664	165,329	438											
	9	756	1,181	56,668	113,335	226,670	961	1,001	56,668	113,335	226,670	37	74	149	4	7	15	10,010
	10	180	282	110,518	220,837	441,674	842	1,359	110,518	220,837	441,674	53	107	213	5	11	21	13,590
	11	425	664	151,320	302,639	605,278	565											
	12	346	540	165,527	331,055	662,109	825											
	13	1,055	1,648	105,827	211,655	422,146	648											
	22	513	801	445,602	890,639	1,781,843	1,160	5,845	445,602	890,639	1,781,843	50	100	200	5	10	20	58,450
Southern Central	14	685	1,071	565,557	1,131,113	2,262,982	3,375	4,987	565,557	1,131,113	2,262,982	74	149	298	7	15	30	49,870
	15	593	926	77,739	155,479	310,958	1,000	1,000	77,739	155,479	310,958	51	102	204	5	10	20	10,000
	16	306	478	59,029	69,485	90,736	575											
	17	364	569	77,841	155,681	310,962	520											
	18	869	1,358	119,738	228,940	447,343	598											
	19	874	1,365	744,723	1,489,446	2,979,855	11,300	11,300	744,723	1,489,446	2,979,855	43	86	173	4	9	17	113,000
	20	451	705	72,086	140,691	278,399	870											
	21	707	1,105	162,101	303,940	588,397	335	1,554	162,101	303,940	588,397	68	128	248	7	13	25	15,540
Total/Average*		**8,996**	**14,055**		**5,827,599**					**4,304,789**			**747**		**38**	**75**	**149**	**37,835**

Northern CV	1,173,299	Northern CV	640,618	Northern CV	17
Middle CV	2,152,824	Middle CV	1,224,811	Middle CV	28
Southern CV	3,674,776	Southern CV	3,079,978	Southern CV	47

**Totals/Aveages are for the Middle and Southern IAZs in the Central Valley*

If one were to pump each IAZ uniformly to remove an equivalent mass of salt, this would result in about 4,565 million gallons per day (mgd[5]) of extraction. At a treatment efficiency of 90 percent, this would create a brine concentrate discharge of 457 mgd and an average concentration of 11,400 mg/L. These totals could be slightly reduced to the extent that any source control measures could be feasibly implemented.

There are IAZs where – although salt is accumulating – the ambient groundwater quality is still excellent and responsible entities would not likely pump and treat that water. For example, in IAZ 2, Red Bluff to Chico Landing, 68,000 tons of salt are accumulating annually. However, the ambient groundwater TDS concentration is only 201 mg/L. In order to analyze the concept-level salt mitigation strategy of achieving salt balance with a minimal amount of groundwater pumping, only areas with TDS concentrations greater than 1,000 mg/L were considered for extraction and salt removal through desalters or other options. A series of figures (Figures 2-3 through 2-17 in the Phase 2 report) were prepared that show the areal distribution of TDS concentrations in shallow groundwater for each regional grouping of IAZs for the following periods:

- 1902 – 1949
- 1950 – 1969
- 1970 – 1989
- 1990 – 1999
- 2000 – 2014

The definition of shallow groundwater in this report is explicitly identical to the definition of shallow groundwater developed for the ICM (LWA, 2013) in that the TDS concentrations in groundwater in Table 2-2 and **Table 2-3** represents the ambient TDS based on the ICM's definition of shallow groundwater, which is the "vertical distance… that the water, at the water table, would travel downward or upward over a 20-year period." (LWA, 2013).

In some cases, the current data set did not show areas with TDS greater than 1,000 mg/L, because wells were not sampled during that period; in those cases, historical data were used to delineate the high TDS areas. Areas of high TDS groundwater are depicted in **Figures 2-3** through **2-5** – these are areas where there are (or historically were) significant clusters of wells with TDS concentrations over 1000 mg/L. Average TDS concentrations were then estimated for these areas. Table 2-2 summarizes the results of this analysis. In this scenario, pumping and desalting would be focused in the following IAZs:

- 6 – Cache-Putah area (IAZ 6 is treated separately in the alternatives analysis)
- 9 – Delta

[5] 1 mgd = 1120 acre-feet per year (AFY)

- 10 – Delta-Mendota Basin - Northwest Side
- 22 – Delta-Mendota Basin - Grassland
- 14 – Westside and Northern Pleasant Valley Basins
- 15 – Tulare Lake and Western Kings Basin
- 19 – Western Kern County and Southern Pleasant Valley Basin
- 21 – Southeastern Kern County Basin

In this scenario, there would need to be about 747 mgd of groundwater or drain water extraction to achieve the objective of balancing salt inflows and outflows in those IAZs. At a treatment efficiency of 90 percent, this would create a brine concentrate discharge of 75 mgd and a flow-weighted average concentration of 38,000 mg/L[6]. Pumping shallow groundwater or agricultural drainage water from these eight out of 22 IAZs would extract almost 4,300,000 tons of salt annually (about 74 percent of the total net salt influx in the southern and middle Central Valley). As noted above, this objective could potentially be reduced to the extent that any source control measures reduce the net influx to these IAZs.

Although the analyses in this report focusses on the eight IAZs with the most significant TDS issues in groundwater, the SNMP addresses salt management across the entire Central Valley Region. These eight IAZs were selected in order to maximize salt export in a cost effective and manageable manner. Salt accumulation in areas of high TDS within each of these eight IAZs is being addressed through a combination of source control measures and treatment/disposal options. In salt accumulation areas, *e.g.*, the Tulare Lake Bed, salt is being stored indefinitely.

[6] The actual brine concentration would need to be adjusted, perhaps through blending, in order to achieve compliance with receiving water limitations.

Table 2-3. Salt Managed by Various Disposal Options

Option	Volume of Water Treated/ Managed (AFY)	Mass of Salt Treated/ Managed (tons)	CV Salt Accumulation - Southern & Middle IAZs (tons)	IAZ Salt Accumulation (tons)	Percent of Salt in Southern & Middle CV IAZs Treated/ Managed (%)	Percent of Salt in IAZ Treated/ Managed (%)	Cost/AF ($/AF)	Cost/Ton of Salt ($/ton)	Equivalent Flow Reduction to CVBL (MGD)	Cost Reduction for EBMUD Disposal ($M)
SJR - RTMP										
TLB - Evap Ponds	17,240	139,897	4,304,789	155,479	3.2%	90.0%	$76.58	$9.62	2.43	$35
SJRIP	19,248	98,108	4,304,789	890,639	2.3%	11.0%	$129.62	$24.72	1.70	$25
HF	650	51,612	4,304,789		1.2%				0.58	$8
DIW	560	19,414	4,304,789		0.5%				0.50	$7

SJR - RTMP San Joaquin River Real Time Management Program
TLB - Evap Ponds Tulare Lake Bed
SJRIP San Joaquin River Water Quality Improvement Project
HF Hydraulic Fracturing
DIW Deep Injection Well - Numbers are on a per Well Basis

Based on flow and water quality conditions in the lower San Joaquin River at Vernalis, the New Melones model can be used to assess assimilative capacity and potential for discharges of high salinity water. At the time of the publication of the Phase 3 report, this modeling work has not been completed.

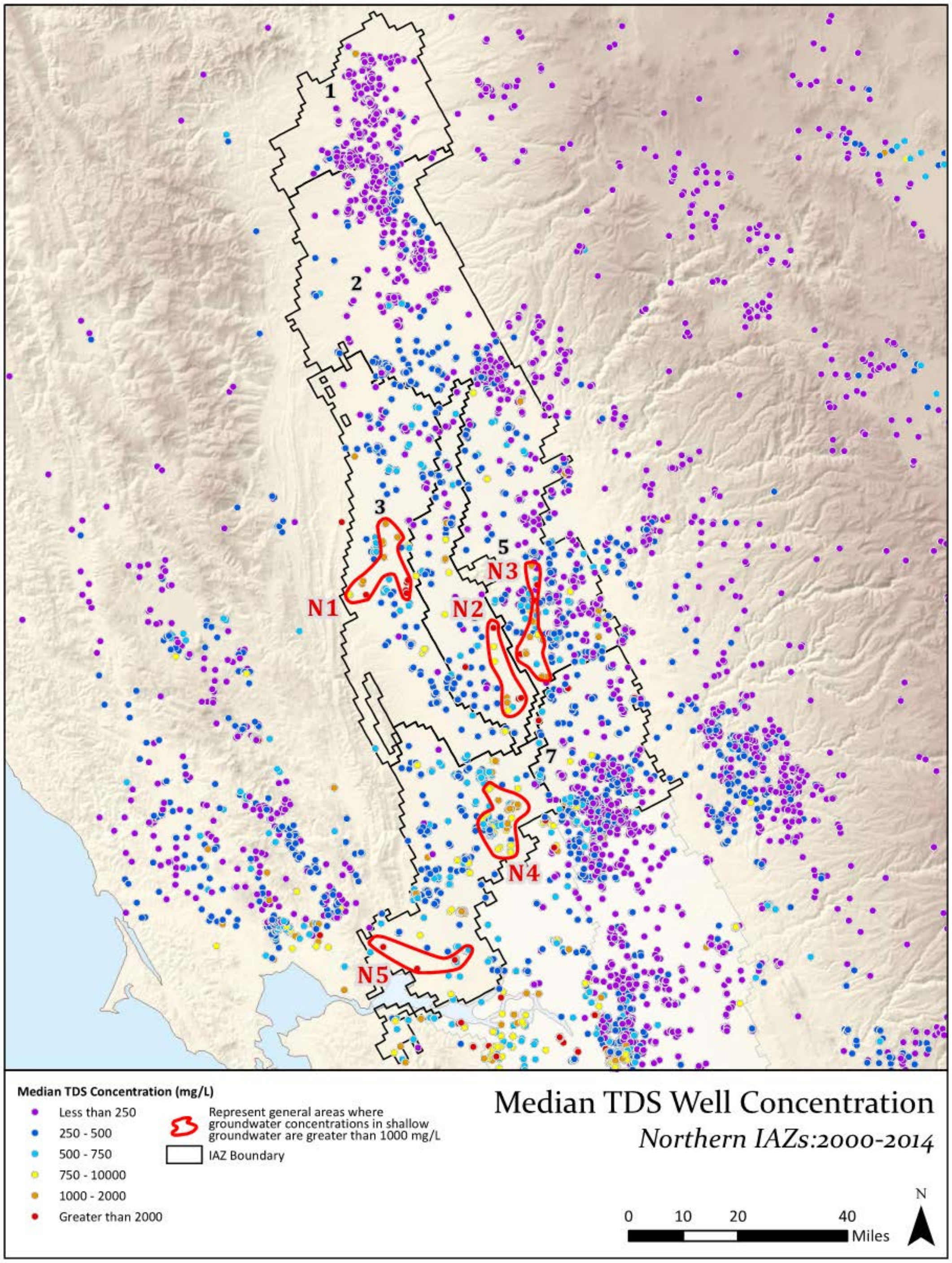

Figure 2-3 High TDS (>1,000 mg/L) Areas in the Northern Central Valley IAZs

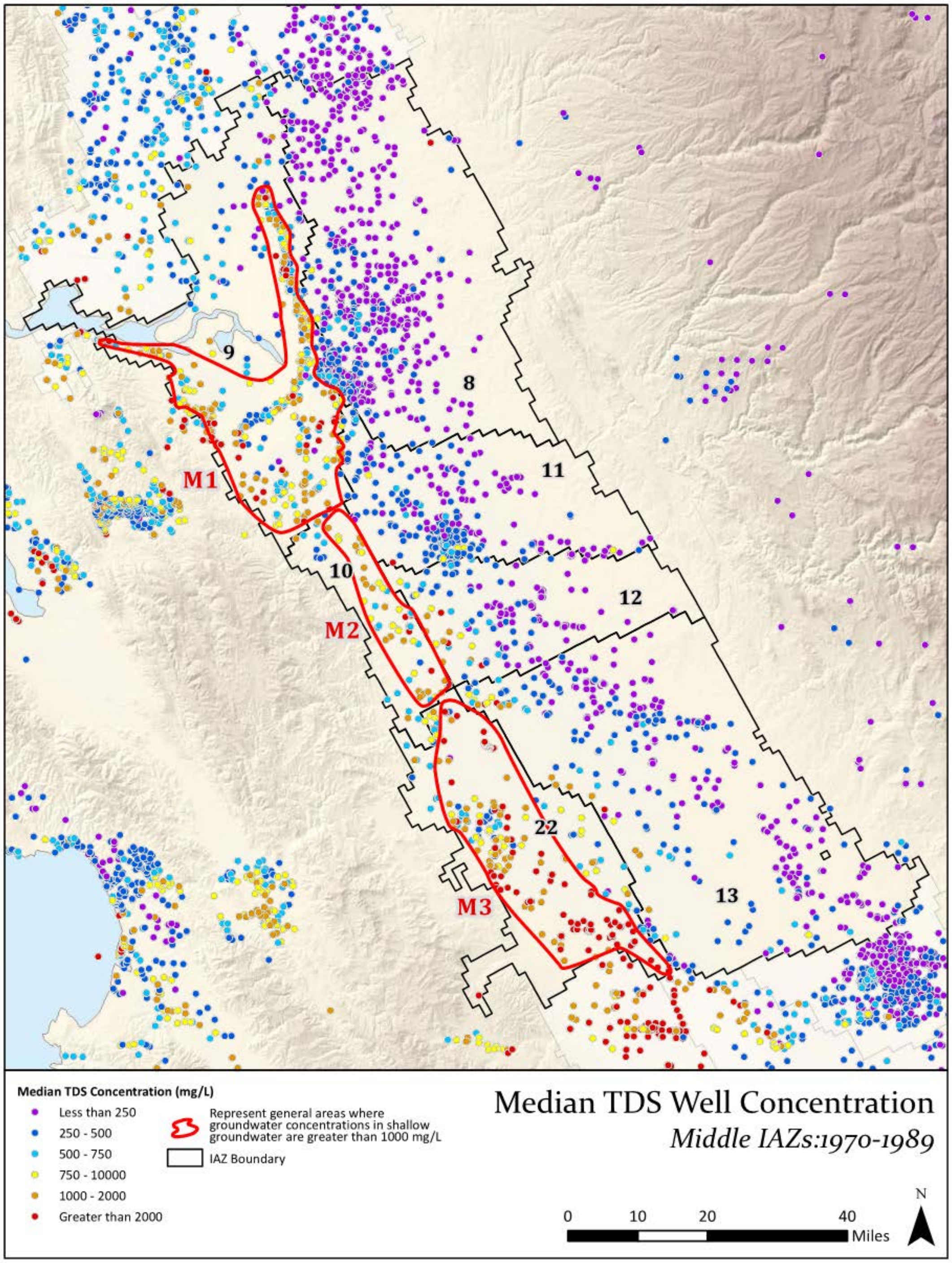

Figure 2-4 **High TDS (>1,000 mg/L) Areas in the Middle Central Valley IAZs**

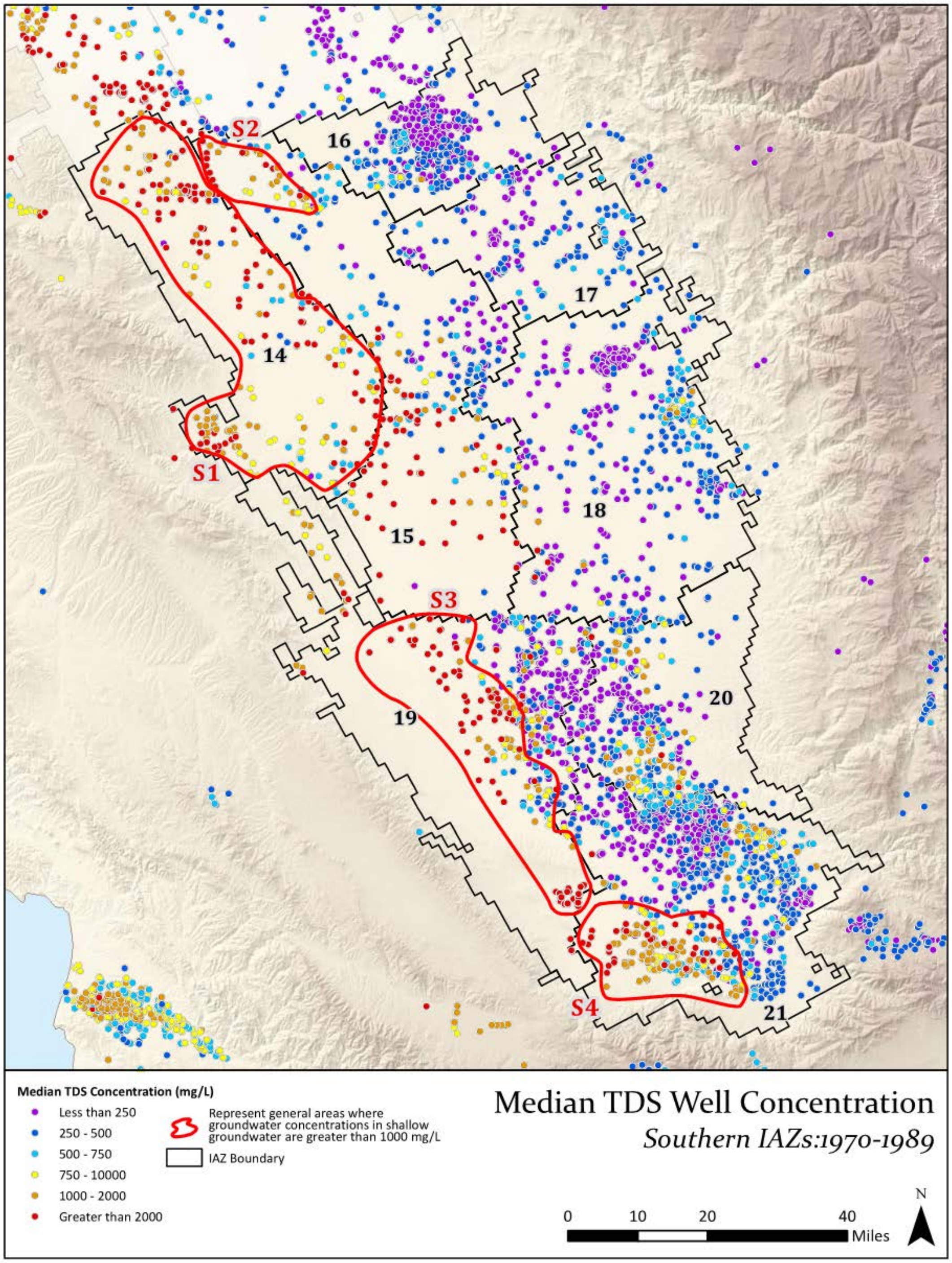

Figure 2-5 **High TDS (>1,000 mg/L) Areas in the Southern Central Valley IAZs**

2.2 Reduction and Management of Salt Contributions to Groundwater

The reduction of salt contributions to groundwater fall into two general categories:

- **Source Control BMPs.** Source control BMPs manage or limit anthropogenic sources of salt.
- **Land Management.** Land management activities help to manage naturally-occurring salts from being leached from marine sediments through irrigated agriculture.
- **Stormwater and Recycled Water Recharge.** The recharge of water into underlying groundwater basins does add a salt load, but if the TDS concentration is less than that of the groundwater basin or management zone, it would result in an improvement in groundwater quality.

2.2.1 Source Control BMPs

A number of source control BMPs have been developed to provide management and engineering guidance to limit salt and other constituents from entering the soil/groundwater system. BMPs that reduce salt at the source can be a more efficient means of salt reduction than treating salt in the perched zone or groundwater. BMPs provide the scientific and engineering basis and methods for controlling salt at the point of introduction into the natural system. BMPs may help achieve regulatory compliance and may be economical and sustainable solutions to salinity issues.

BMPs for salinity control have been developed for various sectors in California's economy, including: food processing, industrial (other than food processing), municipal, and irrigated agriculture. Source control measures range from water softener incentive program – such as the program recently developed by the City of Dixon – to peeling tomatoes using steam instead of caustics.

2.2.2 Land Management

Land management is a critical component of the overall salt management in the Central Valley. The soils on the west side of the valley are composed of marine sediments and are naturally saline. Irrigated agriculture leaches these salts (and trace elements like selenium) into the perched zone above the Corcoran clay and into groundwater. The Corcoran Clay unit is a laterally continuous, low-permeability, lacustrine clay layer within the Tulare Formation that extends across middle and southern portion of the San Joaquin Valley (Figure 2-2). The Corcoran clay acts as an aquitard within the San Joaquin and Tulare basins dividing the overlying unconfined aquifer and the underlying confined aquifer. Both the thickness and depth of this unit vary greatly with thickness ranging from 20 to 120 feet and depths to the top of the clay which decreases from approximately 850 feet deep along the Coast Range to 500 feet in the valley trough (DWR, 1981; DWR, 2006; and Faunt *et al.*, 2009). Strategic land retirement can reduce the overall salt loading to groundwater in the Central Valley. According to the US Bureau of Reclamation (Reclamation 2008), land retirement:

> *"Would consist of real estate interests that would be acquired through the purchase of non-irrigation covenants that restrict using irrigation water but permit the land to be used for grazing, fallowing, and dryland farming. Land retirement is considered a*

> *feature of drainage service because it reduces contributions of water to the shallow groundwater table."*

Land retirement or management will be a critical component of the SNMP in terms of limiting salt leached into groundwater.

2.2.3 Stormwater and Recycled Water Recharge

These projects would have multiple benefits – they will contribute to a more reliable and sustainable local water supply and they would improve ambient groundwater quality, providing the TDS of the recharged water is less than the underlying groundwater basins. In addition, stormwater recharge would improve surface water quality and will assist National Pollutant Discharge Elimination System (NPDES) permittees in complying with Municipal Separate Storm Sewer (MS4) permits. Recycled water recharge and indirect potable reuse (IPR) projects will likewise provide new local water supplies and improve groundwater quality in subbasins where the TDS of the recycled water is less than the ambient groundwater quality. Recharge master plans would be developed that would (i) quantify stormwater potential; (ii) identify potential recharge projects, prioritize based on water supply and water quality criteria; (iii) develop cost/benefits for proposed projects; (iv) identify funding opportunities; (v) identify project schedules and key milestones.

Some management zones may not be suitable candidates, based on benefit/cost analyses for RO/brine management through the regional brineline, due to distance to the brineline and lower – but still problematic – TDS concentrations in groundwater. Source control BMPs and stormwater/recycled water recharge would be critical to the sustainable management of salinity in these management zones.

Source control BMPs, land management, and groundwater recharge projects were addressed only qualitatively in the Phase 2 SSALTS report (CDM Smith 2014) – with the assumption that these measures would be addressed on local or subregional levels and would be based on benefit-cost analyses. The management of salt loading and water recharged will be defined for each groundwater basin, subbasin, or management zone as part of the P&O Study. The focus of SSALTS is the management and storage of salt in-valley and the transportation of salt out-of-valley.

2.3 Treatment Technologies and Potential Marketability

As discussed in Section 1.1, the primary focus of the three phase SSALTS study is to determine how salts can be managed or stored in-valley or transported out-of-valley in a sustainable manner. In Phase 2, a number of treatment technologies – both mature and emerging – were reviewed. Mature desalination technologies can be largely divided into two categories: membrane based technologies and thermal technologies. The membrane based technologies includes Reverse Osmosis (RO) and Electrodialysis Reversal (EDR). RO is the most widely used process to reduce dissolved solids from many different sources of water. In the RO process, water from a pressurized saline solution is separated from the dissolved salts by a semi-permeable membrane. The water is forced to flow through the semi-permeable membrane by the pressure differential created between the pressurized feed water and the product water. RO is well verified in the field with numerous applications installed and operating for many years throughout the world and it would be applicable to reduce TDS from high salinity source waters in the Central Valley. RO treatment capacity is easily scalable with modular system design from less than 1 mgd to more than 100 mgd. In certain circumstances, RO can achieve more than 95 percent salt reduction. However, RO has a limited recovery of 85 to 90 percent in typical brackish water applications and handling of the RO brine generated with 10 to 15 percent of feed volume is the critical issue to deal with for the implementation of RO.

Thermal desalination technologies include thermal evaporation and crystallization among other technologies. The thermal processes can typically achieve much higher recovery than reverse osmosis and generate highly purified water. However, the thermal processes are energy intensive and have very high operational costs. The operational cost of thermal evaporation processes is more than four to five times higher per acre-foot than the cost of membrane-based processes. A thermal evaporator combined with a crystallizer has been used to achieve a Zero Liquid Discharge (ZLD) system. ZLD is particularly applicable where solar evaporation pond construction is not feasible due to high construction costs, low evaporation rates, or limited treatment facility footprint.

Mature desalination technologies such as RO and EDR have worked well in various applications. However, the technologies produce significant volumes of brine waste with normal operation recoveries for single pass systems of 85 to 90 percent. Other new desalination technologies are being pilot tested with claim that these new systems can be operated at much higher recovery rates, thereby reducing the volume of the brine and concomitantly the brine management costs. Examples of emerging desalination technologies include[7]:

- Forward Osmosis (FO) technology relies on the osmosis phenomena of a semi-permeable membrane, similar to reverse osmosis, to effectively separate water and dissolved solutes. The driving force for this separation is an osmotic pressure gradient. In contrast, the reverse osmosis process uses hydraulic pressure as the driving force for separation. The FO process is less susceptible to the membrane fouling which is the main factor that limits the RO process efficiency. It is also reported that the FO can be operated with feed water whose TDS is more than 10 times of the RO feed water and this can significantly reduce the volume of the brine coming out of the process. The brine from the FO can be directly sent to the crystallizer to realize the ZLD system.

- Membrane Distillation (MD) is a low-temperature separation technology that takes place through the pores of a hydrophobic microporous membrane. The driving force for separation is a vapor pressure gradient, which is generated by facilitating a temperature differential across the membrane. MD could theoretically be used to reduce TDS from the water sources. However, considering the high cost in general for the system construction and operation compared to the RO process, MD may be more suitable for minimization of the brine from the front end process (such as RO and EDR). Using RO brine as a feed to MD has a great potential for MD utilization. This directly addresses the upper feedwater concentration limit of RO at around 70,000 mg/L, as MD is far less influenced by the salt concentration. MD can compete with other brine reduction technologies, such as thermal evaporators. Even though MD technology has been around for 40 years, both MD and RO

[7] This list is not meant to be complete or comprehensive, but it does provide examples of currently emerging desalination technologies.

are relatively new for the brine reduction applications and the costs of the technologies cannot be verified due to the limited numbers of full scale implementations.

- The Zero Discharge Distillation (ZDD) from Veolia Water utilizes electrodialysis metathesis to exchange scale forming ions in a brine solution for sodium and chloride. This process is used in conjunction with nanofiltration and reverses osmosis to increase total recovery and has the potential, under certain circumstances, to achieve up to 97 percent water recovery.

- The Aqua4 System from Water FX is a distillation process incorporating solar thermal power generation to remove all non-volatile materials from water. The process requires a large area of solar collectors to treat the water. It can also be combined with a crystallization and drying process to achieve a ZLD system.

- Sulfate-based electrolysis processing with flexible feed control is a process developed by New Sky Energy that uses electrochemical technology to treat the brine waste and produce valuable chemical products for sale. However, a mixed salt stream from a water treatment facility or from agricultural drainage containing varied dissolved salts would require many purification steps to produce usable salts or chemical products that would likely increase the cost of the process significantly.

- Element Renewal's system consists of four main processes: (i) pre-treatment, (ii) RO, (iii) self-generated power unit, and (iv) solids processing. Pre-treatment is a chemical/mechanical separation process, designed to maximize the flows, while selectively removing contaminants such as trace metals and organic chemicals present in the drainage water. The water is then treated with RO. On site power is self-generated with a natural gas fired stationary fuel cell power unit for cogeneration use of thermal energy with solids processing. Solids processing separates the water from the pre-treatment solids and RO brine. The solids and salts are reduced to dry concentrates by utilizing thermal energy from the power generation, and are separated into forms that may allow for their recycle and/or sale as commodities. The solids processing results in Element Renewal's system achieving ZLD. This technology is being pilot tested at Tulare Lake Bed.

- Ionex SG Limited, has developed and is currently testing a patented brine treatment system utilizing an electrochemical cell for the destruction of nitrate. The technology will help to minimize waste brine volume as well as the overall salt consumption of the ion exchange system. The brine treatment system is currently being pilot tested at a location in California through collaboration with UC Davis. A cost benefit analysis by Ionex suggests that brine disposal costs would be significantly reduced.

- Effluent Free Desalination (EFD) technology claims that it improves existing desalination methods in several unique ways. EFD technology solves the scaling problem by separating the heating of the water in one chamber from the vaporization of the water in a different chamber. EFD technology reuses the heat of the steam to reduce wasted thermal energy. The reuse of the latent heat of vaporization provides 90 to 95 percent of the thermal energy with only about five percent of the total energy being lost to radiation and other losses. Since the five percent make-up energy is provided by a vapor compressor that is fueled entirely by natural gas, the technology can save more than 50 percent of the energy compared with other desalination methods. The concept of the thermal desalination has been in the market for decades and been modified to improve the performance. It is hard to estimate the actual benefits of the technology before full-scale implementation.

- Calgon Carbon's Catalytic Treatment of Brine is new catalytic treatment process for removing multiple oxylation contaminants from waste form ion exchanger brine for brine reuse at small water treatment system. So far the technology is tested for nitrate and perchlorate treatment from the ion exchange brines and has shown promising performance. However, applicability of the technology for the brine treatment from the desalination process is not well understood yet.

- Lockheed Martin announced that they were developing a graphene membrane under the trademark Perforene. The research on graphene continues to increase and graphene has the potential to achieve improvement in conventional polymer-based membranes. However, it is still in the early stages of the laboratory-scale research and it will likely be some years before commercial products are available for desalination applications.

Until the concept design is started (see Section 4.3) CV-SALTS will continue to monitor, review, and analyze performance data from pilot- and full-scale desalination facilities utilizing emerging technologies. As part of the preliminary design, desalination technologies will be evaluated through a feasibility study. Current emerging technologies that are attempting to market salt – and secondary products derived from the salt – as a part of the treatment system may be fully viable by then – both from an engineering and a marketability/profit perspective.

2.4 Salt Accumulation/Management Options

The Phase 2 report analyzed two archetype study areas that manage and accumulate salt (in-valley): The San Joaquin River Water Quality Improvement Project (SJRIP) and the Tulare Lake Bed are two of the larger salt accumulation areas in the Central Valley and serve as archetypes for in-valley disposal/storage option. Salt is formed from solar evaporators at the Tulare Lake Bed and accumulates on the land surface and in the vadose zone. The SJRIP sequesters salt in the perched zone underlying the approximate 6000-acre project area.

2.4.1 San Joaquin River Water Quality Improvement Project

The SJRIP is a three phased project (see the fact sheet in Appendix B) (CDM Smith 2014):

- Phase 1: Purchase land/grow salt-tolerant crops
- Phase 2: Install tile drains and collection system/begin initial treatment
- Phase 3: Develop the full project treatment system and a salt disposal system

The SJRIP regional reuse facility will – at full project build out – utilize 100 percent of the total drain water produced in the Grasslands Drainage Area (GDA) – about 15,000 acre-feet per year (AFY) of drain water at an approximate TDS concentration of 5000 mg/L. Salt-tolerant crops, like Jose Tall Wheatgrass, are grown in the SJRIP area, which ultimately will consist of up to 6200 acres of fields, irrigation channels, drainage ditches, conveyance facilities and farm structures. The eastern project area is comprised of 3873 acres (out of about 4000) planted with salt-tolerant crop species. The western project area consists of 1901 acres that have been purchased, but have not yet been planted with salt-tolerant crops. Approximately 2000 acres of the SJRIP is tiled, some of which has operated since 2002. The Panoche Drainage District is the lead California Environmental Quality Act (CEQA) agency for the SJRIP.

The principal benefit of this approach is that it is a viable means of accumulation of salt in a relatively small lowland area. SJRIP – at a minimum – would receive about 15,000 AFY of agricultural drain water. Based on recent years' experience, however, the SJRIP has managed more than 20,000 AFY since 2011 (26,170 acre feet of drain water was managed in 2013), or about one-third of the drainage production. At full project build-out, the average reuse capacity of the SJRIP is likely to be between 25,000 and 30,000 AFY and possibly more. The GDA drain water, which has a current average TDS of about 3,500 to 4,000 mg/L will ultimately be retained on-site and not allowed to discharge to the San Luis Drain and Mud Slough through the Grassland Bypass and eventually to the San Joaquin River, thus helping to meet the compliance objective at Vernalis. The average TDS of drain water at the discharge from the San Luis Drain at Site B is 3300 mg/L (based on samples collected between 2005 and 2013).

Water is managed in the SJRIP by the planting and harvesting of salt-tolerant crops. While the plants take up some salt from the root zone, they consume water which allows the project to function. Since the crops consume water – but not much salt – an estimate was made of the increase in salinity in the perched zone over time in order to ascertain the sustainability of the SJRIP. The annual additional salt load to the SJRIP perched zone is estimated to be about 102,000 tons, based on an assumed 15,000 acre feet (AF) of GDA drain water at an estimated TDS of 5000 mg/L. The volume of perched water was also estimated, based on an assumed area of 6000 acres and a perched water depth of 40 feet[8].

Until Phases 2 and 3 are implemented salt is projected to accumulate in the shallow perched zone underlying the SJRIP area. It should be noted that although the readings vary significantly, none of the existing sumps show a clear upward trend in drain water electrical conductivity (EC) measurements over that last six years. While this short term trend is of interest, it is not realistic to assume this trend can continue indefinitely as continued addition of salts must eventually result in increased storage in the groundwater and/or an increase in the salt exported via the drain water. Table 5-8 in the Phase 2 SSALTS Report shows the salinity increases over a 25-year period in which 102,000 tons of salt are added to the SJRIP area, the water is managed by growing and harvesting salt-tolerant crops, and salt is successfully sequestered at the project site and not allowed to leave the system via the San Luis Drain, Mud Slough, and the San Joaquin River. Calculations of salt applied through the drain water in the last 2 years are around 118,000 tons per year, although this is based on a higher application volume than the report assumes. After 25 years, the TDS concentration in the perched zone is estimated to be greater than 60,000 mg/L, and may have deleterious effects on soil structure and plant growth. This assumes the following:

- 15,000 AF of GDA drain water added to SJRIP area annually
- assumed area of 6000 acres
- estimated TDS of 5000 mg/L

[8] Personal Communication, Joe McGahan, June 27, 2014

- perched water depth of 40 feet
- no salt is leached below the perched zone
- a significant mass of salts is not harvested by the crops

However, as noted in the previous paragraph, although the EC measurements vary significantly, none of the existing sumps show a clear upward trend in drain water EC measurements over that last six years.

Phases 2 and 3 include treatment of the drain water to remove salt, selenium, and boron and to *"dispose of the removed elements to prevent discharge into the San Joaquin River. The remaining salt will be deposited into approved waste units that will result in additional reductions in salt and selenium discharges into the San Joaquin River and will maximize improvement in water-quality and meet reductions needed for future water-quality objectives."* (Harvey & Associates 2012). Pilot tests are being conducted to determine the efficacy of certain treatment technologies. These pilot tests include those led by Reclamation (2011), the University of California Los Angeles, and WaterFX. The objectives of these pilot plants is to demonstrate and operate the treatment systems (RO and selenium biotreatment for the Reclamation pilot project) in order to develop cost and performance data for the final design.

Costs for the continued operation and expansion of SJRIP, including engineering, building and maintaining irrigation facilities, building and maintaining drains, treatment system costs (capital and operations and maintenance [O&M]), National Environmental Policy Act (NEPA), CEQA, and compliance monitoring have not yet been determined by Reclamation.

2.4.2 Tulare Lake Bed

The Tulare Lake Bed is located within the Tulare Lake Basin within the southern portion of the San Joaquin Valley. The Tulare Lake Basin, comprising approximately 10.5 million acres, is a mixture of federally-owned National Parks, agricultural land, and municipalities. The Tulare Lake Basin is essentially a closed system, draining only into the San Joaquin River in extreme wet years.

Underlying the majority of western and southern Tulare Lake Basin is the relatively impermeable Corcoran Clay, the primary of several clay layers which separates the groundwater into a perched aquifer zone and a deeper groundwater table. The perched groundwater table can be encountered as soon as 5 feet below ground surface. It is estimated that the EC of this shallow groundwater is in the range of 5,000 to more than 35,000 µS/cm (TLBWSD 2012).

The high salinity in the groundwater is a result of several factors. Since this a closed basin with negligible surface or groundwater discharges, salts accumulate in the perched groundwater beneath the lake basin. In the past 40+ years, application of water from the State Water Project (SWP) for irrigation has added salts to the basin, but the soils on the westside of the basin are marine in origin and contain naturally high levels of salt. In addition, without a drainage outlet salts continued to build up within the Tulare Lake Bed over time.

With no drain outlet readily available for the lake bed, stakeholders (through the Tulare Lake Drainage District [TLDD]) have constructed and operated a drainage system with three evaporation basins (North Evaporation Basin, Hacienda Evaporation Basin, and the South

Evaporation Basin) to accumulate salts and maintain agricultural productivity. Agricultural drainage water is conveyed to the evaporation basins through a series of sub-surface pipelines and open ditches. Water stored in the evaporation basins reaches the maximum storage capacity in the late spring as the demand for surface disposal of drainage water rises. It is estimated that the annual average evaporation capacity of the three basins is approximately 17,000 AF (TLDD 2012).

Ambient TDS concentrations of groundwater beneath the land where additional basins are proposed ranges from 6,600 to 12,000 mg/L[9] (Summers Engineering, Inc. 2014). For the purpose of estimating the salt accumulation at these evaporation basins, a TDS concentration of 6,400 mg/L was used. This is the measured TDS concentration in the main outlet structure in May 2013.

The primary costs for implementation[10] are:

- Administrative/contract costs
- Purchase land
- Provide engineering for evaporation basins and associated infrastructure
- Provide capital costs for new evaporation basins
- Provide O&M costs for existing and new evaporation basins
- NEPA/CEQA compliance
- Waste Discharge Requirements (WDRs)

2.5 In-Valley Salt Storage/Disposal Options

2.5.1 Deep Well Injection

Under this approach, brine from the RO facilities (or other concentration processes) would be injected into and stored in deeper aquifers isolated from the primary drinking water aquifers for disposal or potentially for storage and future recovery. Details of this approach are provided in the fact sheet in Appendix B. As discussed in the fact sheet, for preliminary planning purposes it was assumed that a single deep injection well could inject a minimum of 0.2 mgd, and if constructed in favorable locations and depths of formations, up to 0.5 mgd.

As shown in Table 5-1 of the Phase 2 SSALTS Report, the mass of salt that could be removed through storage in deep aquifers under this approach would range from about 4 to 10 tons per years per well assuming a brine concentration of 13,333 mg/L. It is difficult to project the maximum potential capacity of brine volume and therefore salt mass that could be stored in deep formations throughout the Central Valley, although it could theoretically be large and is not limited to areas where oil and gas exploration is occurring as is the case for the hydraulic

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[9] Additional testing shows TDS in some areas at the Mid-Evaporation Basins (MEB) site have groundwater with TDS ranges varying up to 25,000 mg/L.

[10] Costs for the construction and operation of brine evaporation basins will be highly variable and will depend to a large extent on land acquisition. As an example of a new evaporation basin, the construction costs are projected to be about $4500/acre. This does not include land acquisition or CEQA.

fracturing disposal option. However, assuming well capacity is limited to the range noted above, it would require from 2 to 5 wells to inject and store 1 mgd of brine. A set of hypothetical assumptions was used to develop order-of-magnitude unit costs. Assuming a desalter was constructed to treat 10 mgd of brackish groundwater that would result in approximately 1.5 mgd of brine produced. Using an estimate of 0.5 mgd/well, this would require three injection wells, assumed to be 4,000 feet deep. It is also assumed that the wells could be constructed within two miles of the desalter. The facilities that would be required would include a pump station, approximately two miles of delivery pipelines and three wells plus well head facilities. Estimated capital costs for a cluster of three wells plus piping and appurtenances would be approximately $7.6M including engineering and contingencies to serve a 10 mgd desalter. Of this cost, approximately 60 percent represents the cost of drilling the wells and the remainder is for well head facilities, piping and a pump station. Operating costs would include the delivery pump station power and maintenance and replacement costs, injection pumping power and well operation and maintenance costs. Assuming that annual operating costs would be approximately 10 percent of the capital cost, this would result in annual operating costs for the same facilities of approximately $600,000.

Injection wells can have useful lives of 30 to 40 years or longer if properly maintained. That said, there needs to be an on-going and regular program of maintenance and periodic rehabilitation, and careful thought must be given to the materials of construction, design issues, and brine quality to minimize fouling or mechanical plugging.

2.5.2 Supply for Hydraulic Fracturing

Under this approach, brine from the RO facilities (or other concentration processes) would be delivered to producers in the oil and gas industry for use in hydraulic fracturing. This is a type of "completion" technique where high pressure water, sand, and chemicals are injected thousands of feet below the surface into low permeability rock to create microscopic fractures that allow oil and natural gas trapped in small pores to migrate to the wellbore and be produced. Details of this approach are provided in the fact sheet in Appendix B.

As discussed in the fact sheet at the end of this subsection, for preliminary planning purposes it was assumed that each well developed by the oil and gas industry would require a one-time use of between 80,000 and 300,000 gallons over a period of 1 to 2 days. Assuming an industry-projected drilling rate of about 700 wells per year, and assuming drilling goes on essentially at a consistent rate over the year, this would effectively result in annual for demand for brine of between 172 and 644 AFY, or average flow rate of between 0.15 and 0.58 mgd.

As shown in Table 5-2 in the Phase 2 report, the mass of salt that could be removed through storage/disposal in deep aquifers under this approach would range from about 14,000 to 52,000 tons per year assuming a brine concentration of 59,000 mg/L which reflects the higher brine concentrations estimated from desalting in the southern IAZs that coincide with the industry needs. This represents a small fraction of the total salt inflow and accumulation in the southern IAZs. There is some potential revenue – ranging from $200K to $750K – from the sale of brine for hydraulic fracturing.

2.6 Out-of-Valley Disposal Options

2.6.1 San Joaquin Real-Time Management

The Lower San Joaquin River Real-Time Water Quality Monitoring Program (LSJR RTMP) is an umbrella program to ensure that salinity and boron water quality objectives are met at Vernalis and that that future salinity and boron objectives are achieved in the Lower San Joaquin River upstream of Vernalis to the mouth of the Merced River (Reach 83). The LSJR RTMP provides flexibility to export salt from groundwater, perched zones, and agricultural drain water from the Lower San Joaquin River (LSJR) Basin. The Central Valley Water Board has approved the RTMP in the Basin Plan as an alternative salt management strategy in lieu of monthly salt load allocations enforced by the agency.

The Vernalis objectives for EC are 30-day moving averages: 700 micro Siemens per centimeter (µS/cm) during the irrigation season (April to August) and 1,000 µS/cm during the non-irrigation season (September to March). According to the RTMP Draft Framework (Reclamation *et al.* 2014), "The goal under a real-time management program is to continue to meet the irrigation and non-irrigation season salinity water quality objectives by managing salt loads so they are discharged when there is assimilative capacity in the river, rather than be constrained by mandated monthly load allocations in WDRs. Managing the use of assimilative capacity is also anticipated to reduce reliance on fresh water releases from New Melones Reservoir to meet the salinity objectives at Vernalis and to provide a mechanism to maximize salt exports from the SJR Basin." The RTMP components include:

- Stakeholder participation
- Real time monitoring network
- Data Management
- Predictive modeling/forecasting of flows and salinity in the river in order to predict assimilative capacity
- Physical infrastructure (gates, inlets, rubber dams, etc.)
- Program and project management practices
- Funding

In 1995, prior to the implementation of the Grasslands By-Pass (GBP) project, the salt load to the LSJR was 237,530 tons. Through the San Joaquin River Water Quality Improvement Project (SJRIP), discussed in Section 2.4.1, there has been a steady reduction in the salt load to the LSJR (Figure 5-4 in SSALTS Phase 2 Report). In 2013, the salt load was approximately 54,574 tons, a 77 percent reduction (Grassland Area Farmers 2013). Salt load is a function of discharges to the river and there is a general correlation of increased salt load in wetter years. Overall, there is still a trend of decreasing salt load. The objective is to reach near zero discharge of salt and selenium by 2019.

In Phase 2 of SSALTS, a calculation was performed to determine what the salt export capacity of the LSJR could be if the RTMP could optimize salt loads based on assimilative capacity. In the draft Phase 2 SSALTS report, a calculation of average hydrologic year assimilative capacity and additional salt loads was developed. This estimate includes discharges of high quality (low TDS) water from the New Melones Reservoir. The Lower San Joaquin River Committee is currently developing estimates of assimilative capacity. As part of the Development of a BPA for Salt and Boron in the Lower San Joaquin River, the LWA team is collaborating with the San Joaquin Tributaries Authority to determine the effects of Stanislaus and Vernalis operations on water quality at Vernalis under various upstream management alternatives. The operation effects will be determined by updating and utilizing the New Melones Operation Model which uses river conditions upstream of Vernalis and a depiction of Stanislaus and Vernalis operations to provide flow and water quality conditions in the lower San Joaquin River at Vernalis. Based on flow and water quality conditions in the lower San Joaquin River at Vernalis, the New Melones model can be used to assess assimilative capacity. At the time of the publication of the Phase 3 report, this modeling work has not been completed.

2.6.2 Ocean Disposal

Another option for salt disposal is an out-of-valley solution: discharge to the ocean or bay. This could be done through an existing permitted WWTP with capacity to accept the brine and combine it with treated wastewater in the outfall pipeline, with or without additional treatment at the plant if necessary. Other options include discharge through a new regulated outfall at some alternative location, with treatment of the brine to meet receiving water limitations and to comply with a new permit.

The State Water Board has proposed new regulations concerning salinity limits on brine discharges. However, the draft amendment (State Water Board 2015) to the California Ocean Plan (State Water Board 2012) applies to “desalination facilities using seawater.” In addition, the Ocean Plan specifically excludes discharges to San Francisco Bay: “This plan is not applicable to discharges to enclosed bays[11] and estuaries or inland waters or the control of dredged material.” (State Water Board 2012).

2.6.2.1 Discharge through East Bay Municipal Utility District

A significant opportunity for discharge to an existing WWTP with an outfall to San Francisco Bay is EBMUD in Oakland which is a publicly-owned utility formed under the State of California’s Municipal Utility District Act (1921). EBMUD provides water service to more than 1.3 million customers and wastewater service to about 650,000 customers in the East Bay area (Oakland and surrounding areas). The WWTP was designed to meet the wastewater needs of residents, commercial enterprises, and the food processing industry at the time. The reduction in the food processing industry in Oakland has resulted in available capacity in EBMUD’s WWTP. For the purposes of this preliminary analysis, it is estimated that of about 80 to 100 mgd of brine could be discharged through EBMUD’s outfall, provided that it meets EBMUD’s permit requirements. Actual capacity and water quality requirements will be determined in future phases. The WWTP disposal option has challenges and ancillary opportunities.

[11] “Enclosed bays are indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.” (State Water Board 2012)

Challenges

- Transportation of the brine to EBMUD's WWTP is the major engineering and economic challenge. As discussed in Section 2.7, the transportation could be by truck, rail or a regional brine line. This would occur in phases (trucking until the rail is commissioned, rail transport until the brine line is constructed).
- The Central Valley brine would either need to meet EBMUD's permit requirements, or pretreatment systems would need to be designed.
- EBMUD must ensure that agricultural chemicals, nutrients, metals, and naturally-occurring trace elements, such as selenium and boron in brine streams do not interfere with its ability to meet permit requirements for discharge to San Francisco Bay. The existence of inorganic trace constituents in the brine concentrate has the potential to be problematic in terms of permit compliance for discharges from a WWTP. Some areas with subsurface agricultural drainage have elevated concentrations of one or more trace elements, *e.g.,* selenium, molybdenum, arsenic, uranium, and vanadium. These elements may not be adequately removed by RO alone. The specific treatment technology to remove trace constituents at any given location will depend on the specific elements found, the concentrations, competing ions, soluble ligands, *etc*. While there are significant amounts of groundwater data currently available, these data will need be incorporated into a synoptic groundwater trace element chemistry study for different IAZs and local basins as future phases of SSALTS are implemented. In addition, a study of additional treatment to reduce trace constituents that may be necessary to allow an existing WWTP such as EBMUD to meet its discharge requirements, or to meet anticipated requirements for any new outfall will need to be conducted.

  In general, several processes can be considered for the trace constituent removal, such as ion exchange, lime softening, and coagulation/co-precipitation. The processes can be applied either as a pre- or post-treatment to RO in the desalting process. Applying the process as post-treatment might be economically more feasible since only the brine concentrate would undergo this treatment process, not the entire feed water stream. Treating only the brine concentrate would greatly reduce the equipment size and footprint, as well as O&M costs. A possible downside of applying the process as a post-treatment is that other major and minor constituents are also concentrated in the brine and they can compete with the trace constituents, reducing the removal efficiency of the target trace constituents.

  The post-treatment process to remove the inorganic tracer constituents can be constructed at the local desalination facilities and operated and maintained by local plant staff or at a centralized downstream treatment facility. These treatment facilities are relatively complex, requiring well trained staff and frequent maintenance, perhaps making a central treatment facility more cost efficient. However, trace element chemistry of the pumped groundwater/feed water will be different at each desalination facility. There may be desalination facilities that do not need additional treatment for trace elements based on groundwater chemistry. Therefore, for the purposes of this concept-level alternatives analysis, it was assumed that the additional treatment for trace elements would be a post-RO process co-located at regional desalination facilities and would be required at 50 percent of those facilities. The cost to add treatment for trace constituents (ion exchange) at each desalination facility of a capacity equal to the expected brine flow rate ranges from $3/gpd to $4/gpd.

Opportunities

- Transportation of biosolids for use as soil amendments to the Central Valley (perhaps on the return run from delivering brine to EBMUD, either by truck or by rail) may provide a revenue stream to Central Valley entities. Currently, EBMUD is paying about $32 per ton to transport and apply biosolids to agricultural land outside of Alameda County. At 6 truckloads per day and 20 tons per truck (120 tons per day) – were Central Valley generators able to arrange for back-hauling of this end product – conceptually it could result in a cost offset to the Central Valley entities of about $1.4M per year.

- Highly treated, recycled water could be purchased by Central Valley entities for recharge into groundwater basins. As discussed in Section 8, a concept-level evaluation can be made of the efficacy and economics of purchasing recycled water from EBMUD (or another WWTP) and transporting that recycled water in parallel pipelines in the same trench/alignment as the CVBL. Salinity can be reduced by dilution (addition of water of higher quality), as well as by salt removal. The use of recycled water for recharge would have the additional benefit of stabilizing water supply reliability.

2.6.2.2 Other Ocean Disposal Options

While EMBUD offers a viable possibility, it is prudent to evaluate other possible options that could be considered in the event that EBMUD is unable to accept all or some of the brine at some point in the future.[12] This could potentially include constructing a new outfall off the shore of San Francisco Bay, San Pablo Bay or Suisun Bay[13], extending the brine line to the outfall, and, to the extent necessary constructing pre-treatment facilities along the pipeline route which could be near the outfall or further upstream within the Central Valley,

The other option that was discussed and evaluated in the Phase 1 Draft Final Report was the concept of the San Luis Ocean Disposal Outfall and was one of the major alternatives analyzed in Reclamation's San Luis Feature Re-Evaluation Environmental Impact Statement (EIS). This project has many challenges and has not moved forward, and was ranked low in the sustainability analysis in Phase 1 of SSALTS. Nonetheless, it is still an alternative that could be re-considered if conditions changed.

2.7 Brine and Salt Transportation Options

There are five ways to transport salt out of the valley:

- Surface water (*e.g.*, San Joaquin and Sacramento Rivers)

- Trucking dry salt

- Transporting brine concentrate to a WWTP via trucks

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[12] ABAG (2013) projects the population of Alameda County to increase from 1,510,270 to 1,987,950 – a 32 percent increase from 2010 to 2040.

[13] A Suisun Bay is less likely a viable option because of receiving water limitations for TDS.

- Transporting brine concentrate to a WWTP via rail
- Conveying brine through a regional brine line to an existing WWTP or to a new outfall pipeline with pre-treatment as needed

An option for a CVBL to pump brine to EBMUD or another bay/ocean disposal location was analyzed in Phase 2 of SSALTS. For the purpose of developing this as a concept-level planning option, only potential alignments to EBMUD were analyzed. Two alternative alignments were analyzed for this report: Alternative 1 follows a gas pipeline alignment (roughly paralleling the 5 Freeway) along the western side of the valley, turning west near Tracy and then north near Fremont. Alternative 2 crosses the coastal mountains further to the south near Panoche Junction. This alternative is not preferred, because it would not be able to collect brine concentrate from IAZs 22, 12, and 9. Also, the lift over the coastal range is greater than in Alternative 1. A task for a future phase of SSALTS would be to conduct a search to see if there is an abandoned pipeline that could be rehabilitated and repurposed for brine disposal.

There will also need to be a series of pump stations required along the CVBL to deliver the brine to EBMUD or other potential discharge locations. For the purposes of developing a cost estimate, the following assumptions were made:

- Seven pump stations would be required at strategic locations, ranging from 20 to 60 miles apart.
- Each pump station would function essentially as an in-line booster pump station.
- Pumping hydraulics assume that high-density polyethylene (HDPE) pipe is used, with dual lines for the last three pumping legs.
- Alignment Alternative 1 was used as described above.
- The total length of the pipeline alignment is 281 miles.
- The feed water volume and brine concentrate volumes are extracted from the salt balance analysis described in Section 2.1. Accumulation of salt on the Tulare Lake Bed was allowed to occur.
- The pipeline diameter is based on the estimated brine volumes and velocity in the brine line. Based on the estimates of volumes and flow rates derived from Table 2-2, and a target of maintaining velocities of approximately 6 ft/sect, a 24-inch diameter pipeline would be sufficient for the first 50 miles of the CVBL (through IAZs 21 and 19), a 36-inch pipeline would be sufficient for IAZ 15 (through mile 72) and a 48-inch pipeline would be required for miles 72 through 135. Two 48-inch pipelines would be required for the remainder of the pipeline – miles 135 to 281.
- A unit cost of $6/linear foot/diameter-inch was used for rural areas (up to mile 135). A unit cost of $15/linear foot/diameter inch for miles 135 to 281m because the pipeline crosses the coastal range (through a pass) and because of the urbanization in the East Bay.

- Based on assumptions in Section 6.2 in Phase 2 SSALTS Report, the pump station capital costs would be $258M. Annual power costs would be about $58.8M, and maintenance would be $13M, based on a 5 percent of capital cost basis.

The estimated capital cost of the CVBL to accommodate the potential flows is $771M. Together with the pump station capital cost of $258M, the total cost for the CVBL is $1029M.

Also, based on experience with other brine lines, in particular the Santa Ana Regional Interceptor (SARI line)[14] owned and operated by Santa Ana Watershed Project Authority (SAWPA), operation and maintenance of a brine line can be very challenging. Significant planning must be taken to anticipate the potential for chemical reactions, precipitation and scaling and pretreatment of brine at the desalters may need to be considered.

2.8 Salt Potentially Managed by Various Disposal Methods

As shown in Table 2-1 and discussed in Section 2.1.2, the total annual accumulation of salt for all of the IAZs in the Central Valley is estimated to be 7,000,898 tons. Table 2-2 indicates that the total annual accumulation of salt for the middle and southern IAZs is 5,827,599 tons. A treatment system[15] developed to mitigate salt accumulation for only the high TDS IAZs in the middle and southern IAZs, would need to extract and manage 4,304,789 tons of salt annually (Table 2-2) to achieve a balance of salt inflows and outflows.

In Phase 2 of SSALTS, the salt capacity of potential management and disposal options were analyzed. Table 2-3 provides summary information on the mass of salt managed from the following disposal options:

- San Joaquin River Real-Time Water Quality Monitoring Program (SJR – RTMP)
- Tulare Lake Bed Evaporation Basins (TLB – Evaporation Basins)
- San Joaquin River Water Quality Improvement Project (SJRIP)
- Hydraulic Fracturing (HF)
- Deep Injection Wells (DIW)

Information concerning the salt capacity of the RTMP is being developed as discussed in Section 2.6.1. Initial estimates from the Phase 2 SSALTS study suggested that RTMP could have the capacity to manage/dispose as much as 8 percent of the mass of salt currently accumulating. The tons of salt and percentage of salt accumulating in the southern and middle Central Valley IAZs are estimated to be:

- TLB – Evap Basins: 140,000 tons or 3.2 percent of salt accumulation
- SJRIP: 98,000 tons or 2.3 percent of salt accumulation

[14] This regional brine line is now called the Inland Empire Brine Line, or IEBL

[15] This would be an early phase mitigation, whose objective is to balance inflows and outflows of salt in certain areas of the Central Valley. Later phases would address valley-wide mitigation and balances of salt fluxes. Prioritization and phasing of areas to be mitigated are discussed in Sections 2.1 and 4.

- HF: 52,000 tons or 1.2 percent of salt accumulation
- DIW: 19,000 tons or 0.5 percent of salt accumulation (per deep injection well)

The TLB – Evaporation Ponds and SJRIP overlie single IAZs; Column 7 in Table 2-3 is an estimate of the mass of salt managed by these options as a percentage of salt accumulation in that specific IAZ. Note that while the TLB – Evaporation Ponds are currently managing 3.2 percent of the salt accumulation in the middle and southern IAZs, this mass of salt represents 90 percent of the salt accumulation in the IAZ that the TLB – Evaporation Ponds overlie. As discussed in Section 4, strategically located salt accumulation and management areas can be key component of salt management activities in the short-term before longer-term solutions are implemented. Concept level costs on a per AF and ton of salt removed basis are also provided in Table 2-3.[16] The last two columns represent the potential flow reduction to the CVBL and the concomitant cost reduction for disposal at EBMUD's Main WWTP (assuming a tipping fee of $0.04 per gallon).[17] The analyses summarized in Table 2-3 illustrate that these five management/disposal options collectively do not have the salt capacity to manage the current salt accumulation in the Central Valley, hence, each of the alternatives developed in Phase 2 include a regional brine line for a regulated discharge to the San Francisco Bay (or potentially to the ocean).

2.9 Salinity Management Alternatives

This subsection summarizes the development of the four alternatives analyzed in Phase 2 of SSALTS. All of the alternatives include transportation of brine to the San Francisco Bay Area – either to an existing WWTP, such as EBMUD or to an alternative outfall location. An out-of-valley brine line was included in each alternative because it was the only disposal option that had the capacity to dispose of a significant percentage of the net salt accumulating annually in the Central Valley.

A brine line, the CVBL, was evaluated for transportation because of potential capacity limitations for the other WWTP-transportation options (truck and rail). The Bay Area disposal option potentially has the capacity to manage all of the current salt accumulation in the Central Valley. The other disposal option for managing a significant percentage of the salt mass accumulation is the San Joaquin River RTMP. It is likely that a mixture of all salt disposal storage options will ultimately be implemented.

Implementation of source control BMPs are included in all of the alternatives and should be considered to the extent appropriate on a case-by-case basis. However, such practices can potentially have a very small cost-benefit ratio under certain circumstances and are not necessarily intended to be applied everywhere or as a first priority. It may be more beneficial to have the affected party participate in a regional project rather than invest in source control.

In Alternative 1, the brine from the middle and southern Central Valley IAZs would be transported to EBMUD for disposal through their WWTP. Brine generated as part of the treatment of groundwater in IAZ 6 is assumed to be disposed of through deep well injection. A

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[16] (D. Fuller, pers. comm., October 8, 2014; C. Linneman, pers. comm., October 8, 2014)

[17] Note that the flow and cost reduction for SJRIP was not carried forward to the cost analysis in the alternatives analysis, because it was assumed that brackish drain water would need to be transported out of the valley via the CVBL for the long-term sustainability of SJRIP.

northern CVBL to discharge to the Bay area is another option for evaluation in future phases of SSALTS. Alternative 2 is similar to Alternative 1, except that an alternative outfall in San Francisco Bay is proposed for discharge rather than through EBMUD's outfall. Another ocean disposal option that was discussed and evaluated in the Phase 1 Draft Final Report was the concept of the San Luis Ocean Disposal Outfall and was one of the major alternatives analyzed in Reclamation's San Luis Feature Re-Evaluation EIS. This project has many challenges and has not moved forward, and was ranked low in the sustainability analysis among all of the various salt management options. Nonetheless, it is still an alternative that could be re-considered if conditions changed. In Alternatives 3 through 4, the volume of brine transported to EBMUD is reduced through the introduction of other treatment, conveyance, and disposal options. For Alternative 3, the LSR-RTMP is added as a component to the menu of storage and disposal options.[18] In Alternative 4, SJRIP, hydraulic fracturing, and the Tulare Lake Bed evaporation basins have been added.

2.9.1 Alternative 1

Alternative 1 consists of the listed below components and has been divided geographically into the Middle and Southern Central Valley IAZs and IAZ 6 in the Northern Central Valley.

Middle and Southern Central Valley IAZs

- **Source control BMPS**. All appropriate source control BMPs would be evaluated as the project moves forward in the implementation plan time frame. The evaluation would include applicability, effectiveness, and cost-benefit analyses. Source control BMPs that manage or limit anthropogenic sources of salt, as well as land management activities that help to manage naturally-occurring salts from being leached from marine sediments through irrigated agriculture would be included. In addition, the Bay Delta Conservation Plan (BDCP) – although the benefit/costs are unquantified –would likely have a very significant positive impact on salt accumulation in the Central Valley through improvement of water quality delivered by the CVP.[19]

- **Extraction facilities**. Extraction would occur from shallow groundwater, perched water, and agricultural drain water. About 750 MGD would need to be produced from the middle and southern IAZs to balance salt inflows and outflows. At an assumed 750 gpm per extraction facility, this would require 693 wells at an assumed $1.4M per extraction facility.[20] (Section 4.3 of the SSALTS Phase 2 report.)

- **Regional desalters**. An extraction volume of 750 MGD would require 33 25-MGD desalter facilities (for a total capacity of 825 MGD). Each 25-MGD plant is assumed to be $150M. (Section 4.3 of the SSALTS Phase 2 Report.)

- **Post-RO treatment for trace constituents**. The cost to add treatment for trace constituents (ion exchange) at each desalination facility of a capacity equal to the expected

[18] The New Melones model is proposed to be used to assess assimilative capacity, based on flow and water quality conditions in the lower San Joaquin River at Vernalis. This estimate of assimilative capacity can be used to estimate the mass of salt that can be exported through the river, while still meeting compliance objectives. At the time of the publication of the Phase 3 report, however, this modeling work has not been completed.

[19] http://baydeltaconservationplan.com/Home.aspx

[20] There will be a combination of shallow and deep wells, along with extraction facilities that pump drain water from sumps and agricultural runoff collection facilities.

brine flow rate ranges from $3/gpd to $4/gpd. (Section 5.5.1 of the SSALTS Phase 2 Report.)

- **Central Valley Brine Line**. Alignment Alternative 1 was used as described in Section 2.7. The total length of the pipeline alignment is 281 miles. The feed water volume and brine concentrate volumes are extracted from the salt balance analysis described in Section 2.1. Accumulation of salt on the Tulare Lake Bed was allowed to occur. The pipeline diameter is based on the estimate brine volumes and velocity in the brine line. Based on the estimates of volumes and flow rates derived from Table 2-2, and a target of maintaining velocities of approximately 6 feet per second, a 24-inch diameter pipeline would be sufficient for the first 50 miles of the CVBL (through IAZs 21 and 19), a 36-inch pipeline would be sufficient for IAZ 15 (through mile 72) and a 48-inch pipeline would be required for miles 72 through 135. Two 48-inch pipelines would be required for the remainder of the pipeline – miles 135 to 281. A unit cost of $6/linear foot/diameter-inch was used for rural areas (up to mile 135). A unit cost of $15/linear foot/diameter inch for miles 135 to 281m because the pipeline crosses the coastal range (through a pass) and because of the urbanization in the East Bay. The capital costs for the CVBL are $771M. (Section 6.3 of the SSALTS Phase 2 report.)

- **CVBL pump stations**. Seven pump stations would be required at strategic locations, ranging from 20 to 60 miles apart. Each pump station would function essentially as an in-line booster pump station. Pumping hydraulics assume that HDPE pipe is used, with dual lines for the last three pumping legs. Based on these assumptions, the pump station capital costs would be $258M. Annual power costs would be about $58.8M, and maintenance would be $13M, based on a 5 percent of capital costs. (Section 6.3 of the SSALTS Phase 2 Report.)

- **Treatment/disposal at EBMUD**. At a tipping fee of $0.04/gallon and a brine volume of 74.654 MGD, the EBMUD fees would be $1,091M. (Section 6.1. of the SSALTS Phase 2 Report.)

- **Biosolids exported from EBMUD to the Central Valley**. There is a possible revenue stream by exporting biosolids from EBMUD to the Central Valley for use as soil amendments. The potential revenue would be $32 per ton to transport and apply biosolids to agricultural land outside of Alameda County. At 6 truckloads per day and 20 tons per truck (120 tons per day) could result in revenues of about $1.4M per year. (Section 5.5.1. of the SSALTS Phase 2 Report.)

- **Value of product water**. The middle and southern treatment systems could produce 909,000 AFY of product water, which would have a value of $909M at $1000/AF.

- **Revenue from hydraulic fracturing**. There is some potential revenue – ranging from $200K to $750K – from the sale of brine for hydraulic fracturing. (Table 5.3 of the SSALTS Phase 2 Report.)

IAZ 6

- **Source control BMPS**. See above for a description.

- **Extraction facilities**. Extraction would occur from shallow groundwater, perched water, and agricultural drain water. About 168 MGD would need to be produced from IAZ-6 to balance salt inflows and outflows. At an assumed 750 gpm per extraction facility, this would require 155 extraction facilities at $1.4M per extraction facility. (Section 4.3 of the SSALTS Phase 2 Report.)

- **Regional desalters**. 168 MGD would require 7 25-MGD desalter facilities (for a total capacity of 175 MGD). Each 25-MGD plant will be $150M. (Section 4.3 of the SSALTS Phase 2 Report.)

- **Deep injection wells (DIW).** At 90 percent efficiency, about 17.5 MGD of brine would be produced by RO facilities in IAZ 6. A cluster of 4 wells can inject about 1 MGD of brine. Eighteen deep well injection facilities at $7.6M would be required to dispose of the 17.5 MGD of brine concentrate produced for a total capital cost of $137M. (Section 5.1 of the SSALTS Phase 2 Report.)

- **Value of product water**. The IAZ 6 treatment systems could produce 204,000 AFY of product water, which would have a value of $204M at $1000/AF. (See Section 8 concerning potential beneficial uses of the product water.)

2.9.2 Alternative 2

This alternative is identical to Alternative 1, with the exception that the brine is discharged to a new outfall in the Bay Area rather than to EBMUD. This alternative was added to address concerns about potential population growth in the EBMUD service area and the long-term sustainability of their WWTP's excess capacity. ABAG (2013) projects the population of Alameda County to increase from 1,510,270 to 1,987,950 – a 32 percent increase from 2010 to 2040. Substantial engineering, land acquisition, CEQA, and permitting would be required for the outfall component of this alternative. A place-holder capital cost of $100M has been assumed. If this alternative is considered viable after the screening with the feasibility criteria in Phase 3, more detailed engineering will be required. Although the initial capital costs are higher, the O&M costs are substantially less, because tipping fees would not be paid.

2.9.3 Alternative 3

This alternative combines Alternative 1 and the components pertaining to the SJR RTMP into a salt management strategy. The Lower San Joaquin River Committee is currently developing estimates of assimilative capacity. As part of the development of a BPA for salt and boron in the LSJR, the LWA team is collaborating with the San Joaquin Tributaries Authority to determine the effects of Stanislaus and Vernalis operations on water quality at Vernalis under various upstream management alternatives. The operation effects will be determined by updating and utilizing the New Melones Operation Model which uses river conditions upstream of Vernalis and a depiction of Stanislaus and Vernalis operations to provide flow and water quality conditions in the lower San Joaquin River at Vernalis. Based on flow and water quality conditions in the lower San Joaquin River at Vernalis, the NM model can be used to assess assimilative capacity. The assimilative capacity will allow for the determination of the salt load that can be removed from the Central Valley through the LSJR RTMP and hence the estimated reduction in brine concentrate volume discharged through EBMUD or through an alternative discharge. This could also proportionately reduce the cost of infrastructure in the brine line and pump stations, for example. At this time, Reclamation has not developed a cost estimate for the LSJR RTMP.

2.9.4 Alternative 4

This alternative combines Alternative 1 and the components in the following tables pertaining to the archetype salt management areas (SMA): SJRIP and the Tulare Lake Bed into a salt management strategy. Costs for the continued operation and expansion of SJRIP, including engineering, building and maintaining irrigation facilities, building and maintaining drains, treatment system costs (capital and operations and maintenance [O&M]), NEPA/CEQA, and compliance monitoring have not yet been determined by Reclamation.

For the Tulare Lake Bed, the future proposed evaporation basin area is approximately 1,850 acres, with construction costs ranging from $3,500 to $4,500 per acre of developed basin. Capital costs for the current construction of a large evaporation basin will also vary depending on topography of the site. If the salt accumulation area is constructed in an area with increased land slope the size of the levees and pump station requirements can dramatically increase causing a need to reduce the area of a given evaporation basin The range of construction costs noted above is an estimate of construction costs only and does not include the cost to purchase the land and meet CEQA and other permitting requirements. The three existing basins – North Evaporation Basin, Hacienda Evaporation Basin, and the South Evaporation Basin – were constructed in previous years and therefore are not included in the cost for this alternative.

On-going operation and administration costs for the large agricultural drainage system operations in the Tulare Lake Bed range from approximately $70 to $90 per acre of drained land. For the purposes of **Table 2-4 (provided as Appendix D)**, construction costs for the new basin were estimated to be $8.33M (1850 acres * $4500/acre). O&M costs were estimated to be 10 percent of capital costs, since it is unknown how many additional acres of drained land will be handled by this evaporation basin. With an annual evaporation rate of around 5 feet per year, estimated annual evaporation capacity will be approximately 9250 AFY[21]. At an average TDS concentration, this evaporation capacity was converted to an equivalent flow reduction to the WWTP and is reflected in Table 2-4.

2.9.5 Alternative 2/4

This alternative is a hybrid of Alternatives 2 and 4. This alternative has all of the components of Alternative 4, but also includes an alternative San Francisco Bay outfall. Hence, the annual disposal fees and the revenue from importing biosolids are not included in this hybrid, but the construction and O&M costs for the outfall are included.

2.9.6 Summary of Cost for the Salt Management Alternatives

Table 2-4 is a summary of the concept level capital and O&M costs for each of the alternatives. Costs presented in this table are conceptual estimates that may change significantly when subject to further analysis. The components of each of the alternatives are explained in the preceding subsections. The bottom of Table 2-4 provides the summary cost information, including totals, contingency, and totals plus contingency. The present value of life cycle costs and revenues over 30 years are estimated at an interest rate of three percent. The present value of life cycle costs is the cost that would be required to conduct the salt mitigation (extraction, treatment, and disposal) of each of the alternatives over a 30-year life cycle. The present value of revenues is the

[21] Roger Reynolds, Pers. Comm. August 29, 2014.

value of water sales of the product water over 30 years as well as other miscellaneous revenues such as sale of water for hydraulic fracturing and payment for management of biosolids. The last two rows express these values on the basis of product water produced. For example, for Alternative 1, the present value of salt mitigation costs (extraction, treatment, and disposal) is $2186/AF over a 30-year life cycle. Likewise, the present value of future revenues from product water sales, brine water sales for hydraulic fracturing, and payment for management of biosolids from EBMUD is $655/AF over 30 years.

The approximate cost per ton of salt removed is $9.62 and $24.72 for Tulare Lake Bed and SJRIP, respectively (Table 2-3). Note that for an evaporation project like Tulare Lake, the water is ultimately lost from the hydrologic system of the Central Valley. At SJRIP, the water is used to grow crops, while with other treatment systems, the product water has an intrinsic value. By comparison, the costs for salt removed for Alternatives 1 and 2 through ocean disposal (existing WWTP and new regulated outfall) are $396/ton and $193/ton.

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Section 3

Planning Level Feasibility Criteria to Evaluate Alternatives

3.1 Feasibility Criteria

For the SSALT evaluation of the alternatives, factors were evaluated to facilitate an objective analysis of which salt disposal methods and alternatives best meet the criteria and will inform discussions regarding the establishment of regional salt management policies and the need for changes to the existing the Basin Plans to facilitate salt disposal in a manner that is most beneficial to the region and consistent with the State Water Board's Recycled Water Policy.

- ***Technical Feasibility or Implementability***. This criterion includes the ability to construct and operate the components of each alternative along with the long-term reliability of the technologies. Technical feasibility also incorporates the extent to which the alternative can be adapted to include other potential remedial actions (*e.g.*, other constituents of concern, including nitrate).

- ***Salt Capacity of the Salt Management or Disposal Method***. This criterion looks at the mass or concentration of salt that can be managed or disposed of by the method in question. For a given salt disposal method, the controlling factor might be a component part of the disposal method. For example, when analyzing a regulated brine line with an ocean outfall, the mass discharged into the ocean can be virtually limitless, because the ocean is the ultimate global salt sink (and source). The salt capacity of an ocean outfall brine line is limited by the WWTP capacity, pipe diameter, flow capacity, permitting, and/or receiving water quality limitations. For deep well injection it might be the injection capacity of the well field, the hydrogeology of the aquifer system, receiving water quality, formation pressures, or the governing permit. The capacity of a surface water discharge might be the ability of the project to meet the electrical conductivity (EC, or salt concentration) discharge limits.

- ***Regulatory challenges*****.** This factor reviewed pertinent regulatory challenges including Basin Plan water quality objectives, WWTP discharge limits, WWTP Resource Recovery permits, WDRs, Underground Injection Control (UIC) permits, proposed BPAs, NEPA/CEQA, water rights, *etc*.

- ***Institutional requirements.*** Institutional requirements speak to successfully bringing the project on-line, not from a technology standpoint (which is addressed by Technical Feasibility), but from a context of governance or management. What agency, group of agencies, coalition, joint powers authority, company or consortium of companies is responsible for the development and operation of the project?

- ***Capital and operation and maintenance costs.*** An objective evaluation of salt disposal cost is difficult because much of the cost information is not available, not separable from costs associated with the entire project (disposal vs. source control and/or treatment), and not able to be placed on the same cost basis (for example, dollars per ton of salt removed). Some SSALTS study area projects are underway and some are still in the planning stages.

- ***Potential environmental issues***. Aside from salinity, there are other constituents of potential concern that are evaluated in this section as well as other possible environmental concerns. For example, selenium accumulation in standing water in evaporation basins or discharge ponds provides a potential exposure pathway and ecological risk to certain species. Trucking waste as a disposal option – when expanded in scope and scale (*e.g.*, valley-wide) – may have air quality and carbon footprint issues. The act of groundwater pumping can have other environmental consequences, including impacts to surface water where there is connectivity with groundwater and land subsidence. Groundwater extractions will need to be coordinated with Groundwater Sustainable Agencies (GSAs) for the Sustainable Groundwater Management Act (SGMA). The construction of the CVBL, and its associated treatment facilities and extraction facilities will require numerous mitigation measures to address environmental issues.

- ***Public acceptance***. This factor takes into account public awareness and acceptance of the disposal method utilized by the alternatives.

- ***Funding***. This factor evaluates the likelihood of obtaining funding support from various stakeholders, including federal, state, and local agencies, as well private companies and the agricultural community. The ability to secure funding for the project is, of course, critical to efficacy of long-term salt management. State and local agencies may not have the authority to commit to capital projects of the scale proposed by CV-SALTS without partnership agreements and commitments from federal agencies. Likewise, state and local agencies as well as local stakeholders will need to commit to long-term O&M costs.

- ***Compliance Credits***. Compliance credits, or offsets provide the regulated community the flexibility to manage water resources in a given management zone, while assuring regulatory agencies that water quality objectives are being met. The use of compliance credits is an important component of CV-SALTS policies.

Each of the above criteria has a range of scores from one to five. Three is the default score for each of the criteria. For a criterion where an alternative clearly meets the factor, the score is five. Conversely, when an alternative clearly does not meet the criterion, the score is one.

3.2 Weights for the Feasibility Criteria

Weighting factors were developed for each of the criteria, ranging from one to five. Technical feasibility, salt capacity, and funding were all assigned a weighting factor of five. If any of those three criteria are not met, then the salt management alternative or salt disposal option is not feasible and will not move forward. Regulatory, cost, and compliance credits were assigned a weight of four. All of the other criteria were assigned a default weighting factor of three.

3.3 Feasibility Analysis of Alternatives and Salt Management and Disposal Options

Four alternatives were developed and analyzed in Phase 2 of SSALTS. These alternatives are reviewed and summarized in Section 2.9 of this report. All of the alternatives include transportation of brine to the San Francisco Bay Area – either to an existing WWTP, such as EBMUD or to an alternative outfall location. An out-of-valley regulated brine line was included in each alternative because *it was the only disposal option that had the capacity to dispose of a significant percentage of the net salt accumulating annually in the Central Valley* (Section 2.8). Section 3.3.1 below provides the feasibility analysis of the salt mitigation alternatives.

The implementation of any alternative with a regulated brine line/ocean disposal option will require many years of planning, design, permitting, and funding before construction and salt removal operations can begin. Hence, there is a need to evaluate all of the disposal options independent of the long-term, sustainable alternatives so that there is a menu of disposal options that can be utilized by local or regional agencies or project proponents in the short-term. Therefore, Section 3.3.2 includes a feasibility analysis of salt management and disposal options.

The Phase 2 alternatives are described in detail in Sections 2.9.1 through 2.9.4. Following is a synopsis of the alternatives:

Alternative 1 includes the following components: Source control BMPS; extraction facilities; regional desalters; post-RO treatment for trace constituents; CVBL; CVBL pump stations; treatment/disposal at EBMUD; biosolids exported from EBMUD to the Central Valley; value of product water; revenue from hydraulic fracturing; deep injection wells in IAZ 6.

Alternative 2 is identical to Alternative 1, with the exception that the brine is discharged to a new regulated outfall in the Bay Area rather than to EBMUD.

Alternative 3 combines Alternative 1 and the components pertaining to the SJR RTMP into a salt management strategy.

Alternative 4 combines Alternative 1 and the components pertaining to the SJR RTMP and the archetype salt management areas (SJRIP and the Tulare Lake Bed) into a salt management strategy.

3.3.1 Feasibility Analysis of Salt Mitigation Alternatives

Table 3-1 summarizes the results of the analysis and scoring of the alternatives developed in Phase 2 of SSALTS. The first column in the table lists the evaluation criteria, while the second column represents the weighting factor, as discussed in Section 3.2. There are a pair of columns associated with each of the four alternatives. The first column of each pair is the un-weighted score, from one to five and the second column is the weighted score (multiplying the un-weighted score by the weighting factor). The maximum weighted score is 175.

Table 3-1. SSALTS Alternatives Evaluation and Scoring

Criterion	Weighting Factor	Alternative									
		1		2		3		4		2/4	
Technical Feasibility	5	5	**25**	5	**25**	5	**25**	5	**25**	5	**25**
Capacity	5	4	**20**	4.5	**22.5**	4.6	**23**	4.6	**23**	4.6	**23**
Regulatory	4	3	**12**	2.5	**10**	3	**12**	3	**12**	3	**12**
Institutional	3	3	**9**	3	**9**	2.5	**7.5**	2.5	**7.5**	2.5	**7.5**
Costs	4	3	**12**	5	**20**	3.5	**14**	3.5	**14**	5	**20**
Environmental	3	3	**9**	2.5	**7.5**	3	**9**	3	**9**	3	**9**
Public Acceptance	3	3	**9**	2.5	**7.5**	3	**9**	3	**9**	3	**9**
Funding	5	3	**15**	3	**15**	3	**15**	3	**15**	3	**15**
Compliance Credits	4	3	**12**	3	**12**	3	**12**	3	**12**	3	**12**
	Totals		**123**		**129**		**127**		**127**		**133**

The scores are relatively close, which is not unexpected because the major components of each of the alternatives are the same or similar (see Table 3-1); this outcome also reflects the Phase 2 finding that a regulated brine line provides the only salt disposal option with the capacity to manage salts in the Central Valley. The overall weighted scores are:

- Alternative 1: 123 points
- Alternative 2: 129 points
- Alternative 3: 127 points
- Alternative 4: 127 points

The following is a summary of the feasibility analyses:

- All of the alternatives had the same score for technical feasibility, funding, and compliance credits. The core components of all of these alternatives are extraction and treatment facilities and an out-of-valley brine line.
- Alternative 2 scored higher because of the lower annual costs (not paying the tipping fee for discharge through an already permitted WWTP). Alternative 2, however, scored lower for regulatory, environmental and public acceptance – all associated with designing, permitting, and building a new outfall to San Francisco Bay.
- Alternative 1 scored lower than others for capacity due to projected population increases in Alameda County over the next 25 years. Although it is anticipated that a long-term memorandum of agreement (MOA) would be entered into by the brine line governance structure[22] and EBMUD (or another WWTP), the projected population increase does introduce some uncertainty into the capacity analysis through the EBMUD's Main WWTP.

[22] This may be CV-SALTS, state and federal partnership, a joint powers authority (JPA), or a coalition of agencies (see Section 4.3, in particular Table 4-4).

- Alternatives 3 and 4 scored slightly higher than Alternative 2 for capacity, because under these alternatives some salt can be transported out of the valley via the San Joaquin River under the RTMP and/or managed by facilities such as SJRIP or the Tulare Lake Bed Evaporation Basins.
- Alternatives 3 and 4 scored lower for costs than Alternative 2, but slightly higher than Alternative 1, because under these alternatives some salt can be transported out of the valley via the San Joaquin River under the RTMP and/or managed by facilities such as SJRIP or the Tulare Lake Bed Evaporation Basins.
- Alternatives 1 and 2 scored the same for institutional. Under Alternative 1, there would be on-going coordination and contract compliance issues between the governance structure established to implement a regulated brine line and EBMUD, while under Alternative 2, additional governance structures would need to be in place to manage the alternative San Francisco Bay outfall.
- Alternatives 3 and 4 scored lower for institutional than Alternatives 1 and 2, because of the additional coordination with agencies managing and transporting salt in other portions of the Central Valley.

While Alternative 2 had the highest score among alternatives developed in Phase 2, a hybrid Alternative 2/4, which combines the alternate San Francisco Bay outfall (from Alternative 2) with a menu of other salt management disposal options (from Alternative 4), had a feasibility score of 133.

3.3.2 Feasibility Analysis of Salt Management and Disposal Options

Table 3-2 summarizes the results of the analysis and scoring of the salt management and disposal options developed in Phase 2 of SSALTS and summarized in Section 2 of this report. The scoring was conducted at a subregional to regional level; at project-scale all of the salt management and disposal options will depend on site-specific conditions. These salt management and disposal options are carried forward into a menu of options described below in Section 4. The maximum weighted score is 175. The overall weighted scores are:

- Agricultural Reuse Area (Ag Reuse): 125 points
- Evaporation/Long Term Storage (Evap/Store): 125 points
- Deep Well Injection (DWI): 97 points
- Hydraulic Fracturing (HF): 101 points
- Real-Time Management Program (RTMP): 122 points
- Ocean Disposal, Discharge through an Existing WWTP[23] (Ocean/WWTP): 128 points

[23] Note that an ocean disposal with discharge through a new outfall is not considered a viable disposal option absent a regional regulated brine line, *e.g.*, the CVBL.

Table 3-2. SSALTS Salt Management and Disposal Options Evaluation and Scoring

Criterion	Weighting Factor	Salt Management and Disposal Options											
		Ag Reuse		Evap/Store		DWI		HF		RTMP		Ocean/WWTP	
Technical Feasibility	5	4	**20**	4	**20**	2	**10**	4	**20**	5	**25**	5	**25**
Capacity	5	3	**15**	3	**15**	2	**10**	1	**5**	3	**15**	5	**25**
Regulatory	4	4	**16**	4	**16**	3	**12**	3	**12**	4	**16**	2	**8**
Institutional	3	3	**9**	3	**9**	4	**12**	3	**9**	3	**9**	3	**9**
Costs	4	5	**20**	5	**20**	2	**8**	4	**16**	3	**12**	2	**8**
Environmental	3	3	**9**	3	**9**	3	**9**	2	**6**	3	**9**	3	**9**
Public Acceptance	3	3	**9**	3	**9**	3	**9**	2	**6**	3	**9**	3	**9**
Funding	5	3	**15**	3	**15**	3	**15**	3	**15**	3	**15**	3	**15**
Compliance Credits	4	3	**12**	3	**12**	3	**12**	3	**12**	3	**12**	5	**20**
	Totals		**125**		**125**		**97**		**101**		**122**		**128**

Salt Management and Disposal Options
Ag Reuse: Agricultural Reuse Area. San Joaquin River Water Quality Improvement Project (SJRIP) is the archetype project.
Evap/Store: Evaporation/Long Term Storage. Tulare Lake Bed is the archetype project.
DWI: Deep Well Injection
HF: Hydraulic Fracturing
RTMP: Real-Time Management Program. San Joaquin River Real-Time Management Program is the archetype project.
Ocean/WWTP: Ocean Disposal, Discharge through an Existing WWTP

The following is a summary of the feasibility analyses:

- RTMP and Ocean Disposal both scored "5" for technical feasibility. Ag Reuse and Evap/Store scored slightly lower because the current archetypes (SJRIP and a Tulare Lake Bed) exist in unique environments. Similar geography and hydrogeologic conditions would be required for similar projects to be as successful. DWI is often problematic and requires a high level of O&M. All of the salt management and disposal options will mitigate nitrate in drain water and groundwater either through treatment, storage, or disposal.

- Salt capacity of individual projects will be scored on a project- and site-specific basis. The scores shown in Table 3-2 are for regional and subregional projects. Each of the management and disposal options may have adequate salt capacities, based on the nature of an individual project.

- All of the salt management and disposal options will face regulatory challenges. The regulatory issues for DWI and HF will be greater than Ag Reuse, Evap/Store, and RTMP. The Ocean/WWTP will need to consider NEPA/CEQA, NPDES permit from the San Francisco Bay Regional Water Board and would need approval from the Coastal Commission.

- Costs per ton of salt removed data are provided in Section 2.9.5 for Ag Reuse, Evap/Store, and Ocean/WWTP[24]. The Bureau has not yet developed long-range planning cost opinions for the LSJR RTMP. Costs per DWI are site- and project-specific. HF should actually generate revenue, but the salt capacity is small.

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[24] Absent a brine line, brine from an individual project would need to be transported to the regulated ocean outfall or WWTP by truck or by rail.

- Each of the disposal options had similar scores for environmental and public acceptance (with HF scoring slightly lower).
- Funding scores were neutral for all of the management and disposal options, because funding strategies would depend on the type of project, whether it was regional, subregional or a local project.
- The ocean disposal option scored slightly higher for compliance credits, because it can dispose of a much greater mass of salt, thereby generating more potential compliance credits.

All of the salt management and disposal options will be part of a menu of potential salt management implementation measures, as described in Section 4.

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Section 4

Salinity Management Program

CV-SALTS has established goals to (a) ensure that everyone in the Central Valley has access to a safe, reliable, and affordable drinking water supply; and (b) preserve the global competitiveness and sustain the long-term viability of the region's world class agricultural industry. To that end, CV-SALTS is developing a comprehensive regulatory and programmatic approach to the management of salt and nitrate as nitrogen in the Central Valley that is not only consistent with the State Recycled Water Policy but meets the broader goals of CV-SALTS to develop a workable, comprehensive plan to address salinity, including nitrates, throughout the region in a comprehensive, consistent, and sustainable manner. The following sections provide this plan.

4.1 Salinity Management Framework

SSALTS Phase 2 identified and evaluated potential salt management strategies, including development of regional de-salters and a regulated brine line. These types of management strategies are long-term solutions that will require significant state and federal funding to implement. However, in the interim, the Central Valley Water Board must implement the Basin Plans through the adoption of WDRs that consider the beneficial uses to be protected and the water quality objectives associated with those beneficial uses.

The Nitrate Implementation Measures Study (NIMS) report includes a Program of Implementation for Nitrate and TDS (Section 6 of the NIMS Report) (CDM Smith 2016). The elements of the NIMS Report that pertain to nitrate have been used by CV-SALTS to support development of a Nitrate Permitting Strategy (CV-SALTS 2016a) that has been incorporated into the Central Valley SNMP. The TDS findings in the NIMS Report (either solely as TDS or as nitrate coupled with TDS) have since been superseded by CV-SALTS policy discussions which have established an alternative approach or Salinity Management Strategy (CV-SALTS 2016b) to guide the management of salinity through implementation of the SNMP.

The Salinity Management Strategy, to the extent developed as of September 12, 2016, is incorporated into this Phase 3 Report to provide the recommended path forward for the management of salt that is consistent with the findings of SSALTS and the direction of CV-SALTS. This strategy establishes a three-phased approach for the long-term management of salt in the Central Valley. The first phase consists of developing a Prioritization and Optimization Study (P&O Study) for salinity management. The overall goal of the P&O Study is to use the findings of the SSALTS work to further define the conceptual design of SSALTS into a feasibility study that identifies appropriate regional and subregional projects, including location, routing and implementation/operation of specific salt management projects. Phase II generally consists of environmental permitting, obtaining funding, and engineering and design of salt management projects identified in Phase I, while Phase III focuses on construction and operation of salt management projects.

The Central Valley Water Board needs innovative salt management strategies for implementation to address both short- and long-term salt management needs and additional regulatory flexibility with respect to the issuance of waste discharge requirements and conditional waivers (WDRs/Conditional Waivers) and the inclusion of salinity related requirements. Through the SNMP, various policies may be adopted that can provide some of this needed additional regulatory flexibility. In addition, incorporation of a Salinity Management Strategy into the SNMP provides a process for moving forward with long-term salinity management strategies (as identified in SSALTS Phase 2 and summarized herein) while at the same time establishing an interim permitting approach for salinity discharges. Section 4.2 below summarizes the types of salinity management measures that may be considered where needed by dischargers in the short-term, while longer, more permanent solutions to salt management develop through implementation of the Salinity Management Strategy. Section 4.3 describes the path forward for achieving these more permanent solutions through implementation of the strategy.

4.2 Short-Term Management of Salts in the Central Valley

SSALTS has identified a number of short-term implementation measures that may be applied where needed during the earlier phases of the implementation of the Salinity Management Strategy. However, as technical studies have shown, except in localized areas, these short-term measures will likely not be sufficient for achieving sustainable salt management or restoration, where it is determined that restoration is a feasible goal.

As discussed in the Phase 2 SSALTS report, the three categories of actions necessary to manage salt include:

- Reduction and management of salt contributions to groundwater (land management strategies, source water improvements and source control BMPs)
- Application of treatment technologies
- Salt management and disposal activities

Table 4-1 provides a menu of mitigation actions for salt management taking into account the three categories above. **Table 4-2** summarizes the results of the analysis and scoring specific to the salt management and disposal options category (as described in Section 3.3.2). Fact sheets for source control BMPs, treatment technologies, and salt management and disposal options are included in the Phase 2 SSALTS Report (CDM Smith 2014); fact sheets for salt management and disposal options are included in this report as Appendix B[25]. Note that emerging technologies continue to develop and, as a result, the applicability of these technologies to manage salt will require continual evaluation with regard to technical feasibility and costs as the emerging technologies scale up from pilot studies to become mature, proven treatment technologies become fully viable – both from an engineering and a marketability/profit perspective.[26]

[25] "This Phase 3 SSALTS report utilized existing archetype study areas developed in Phase 1 of SSALTS."

[26] The need for continual evaluation of emerging technologies has been incorporated into Phase I of the Salinity Management Strategy (see Section 4.3).

Table 4-1. Menu of Key Salt Mitigation Options

Reduction and Management of Salt Contributions to Groundwater	Treatment & Salt Recovery Technologies	Brine Disposal & Storage
▪ Strategic Land Management ▪ Source Water Improvements ▪ Source Control BMPs	▪ Mature Technologies - Reverse Osmosis - Ion Exchange - Lime Softening - Evaporation Ponds ▪ Emerging Technologies - Forward Osmosis (FO) - Membrane Distillation (MD) - Zero Discharge Distillation by Veolia – Electrodialysis Metathesis - WaterFX Aqua4 System – Multi-effect Distillation - New Sky Energy – Temperature Control and Electrodialysis - Element Renewal – addition of polymers to remove trace elements - Smart Integrated Membrane System (SIMS) - Ionex SG Limited - Effluent Free Desalination (EFD) - Calgon Carbon's Catalytic Treatment of Brine - Lockheed Martin's graphene membrane	▪ Brine Supply for Hydraulic Fracturing ▪ Deep Well Injection ▪ Salt Management Disposal Areas - Landfills - Dedicated Disposal Sites - San Joaquin River Improvement Project (SJRIP) ▪ Transport Brine Out of Valley - San Joaquin River Real Time Management - Truck/Rail Brine - Brine Line - Bay Area WWTP - New, permitted Bay Area Outfall

All of the following salt management and disposal options that were evaluated in Phase 2 of SSALTS could be implemented in the short-term while the Salinity Management Strategy is being implemented, including transportation (truck or rail) of brine to a WWTP for discharge to the San Francisco Bay or salt management areas (facilities such as SJRIP or the Tulare Lake Bed Evaporation Basins), transport of salt out of the Central Valley via the Lower San Joaquin River under the RTMP, hydraulic fracturing, and deep well injection. However, implementation of many of these salt management and disposal options, while technically viable in the short time, may not be appropriate (or even feasible) until elements of the Salinity Management Strategy are completed, *e.g.*, the Phase I efforts to better understand long-term salt management from a regional standpoint (see Section 4.3).

Table 4-2 SSALTS Salt Management and Disposal Options Evaluation and Scoring

Criterion	Weighting Factor	Salt Management and Disposal Options											
		Ag Reuse		Evap/Store		DWI		HF		RTMP		Ocean/WWTP	
Technical Feasibility	5	4	**20**	4	**20**	2	**10**	4	**20**	5	**25**	5	**25**
Capacity	5	3	**15**	3	**15**	2	**10**	1	**5**	3	**15**	5	**25**
Regulatory	4	4	**16**	4	**16**	3	**12**	3	**12**	4	**16**	2	**8**
Institutional	3	3	**9**	3	**9**	4	**12**	3	**9**	3	**9**	3	**9**
Costs	4	5	**20**	5	**20**	2	**8**	4	**16**	3	**12**	2	**8**
Environmental	3	3	**9**	3	**9**	3	**9**	2	**6**	3	**9**	3	**9**
Public Acceptance	3	3	**9**	3	**9**	3	**9**	2	**6**	3	**9**	3	**9**
Funding	5	3	**15**	3	**15**	3	**15**	3	**15**	3	**15**	3	**15**
Compliance Credits	4	3	**12**	3	**12**	3	**12**	3	**12**	3	**12**	5	**20**
	Totals		**125**		**125**		**97**		**101**		**122**		**128**

Salt Management and Disposal Options
Ag Reuse: Agricultural Reuse Area. San Joaquin River Water Quality Improvement Project (SJRIP) is the archetype project.
Evap/Store: Evaporation/Long Term Storage. Tulare Lake Bed is the archetype project.
DWI: Deep Well Injection
HF: Hydraulic Fracturing
RTMP: Real-Time Management Program. San Joaquin River Real-Time Management Program is the archetype project.
Ocean/WWTP: Ocean Disposal, Discharge through an Existing WWTP

Neither the findings from SSALTS nor the SNMP are proscriptive. However, during implementation of the Salinity Management Strategy, especially during Phase I, local agencies and permittees may choose from the menu of source control, treatment, and disposal options provided herein, with the applicability of any salt management option dependent on local conditions and circumstances. For example, geography, local hydrogeology, water quality (including trace constituents), and costs all would factor into the implementation of local and subregional project-based salt mitigation strategies in the short-term. Salt accumulation and management programs – using SJRIP and TLDD- Evaporation Ponds, which are strategically located within the Central Valley – could become important components of long-term management of salinity in the Central Valley, *e.g.*, salt can be concentrated and transported on a subregional level, in order to preserve and protect local groundwater basins. The findings from Phase I activities, as described by the Salinity Management Strategy, will consider how these subregional components fit into the long-term management of salt in the Central Valley.

Where dischargers need to manage salinity in the short-term during early implementation of the Salinity Management Strategy, the following list of actions may be considered as part of the effort to identify appropriate implementation measures:

- Identify salt sources, naturally-occurring, consumptive use/irrigated agriculture, and evaluate the impact of these various sources on the water bodies under the influence of the discharge.
- Identify and review emerging treatment technologies for TDS that may be used locally to manage salts.
- If the sources of salinity are predominantly non-point, continue to work with the ILRP Coalition groups.

It is expected that at least some local or subregional salt mitigation projects implemented during the earlier years of implementation of the Salinity Management Strategy could operate for a relatively long period of time and could be part of a longer-term solution for the area in which the project is built. These projects would be considered within the context and overall purpose of the Phase I Prioritization and Optimization Study. For example, local or subregional mitigation projects established early in the implementation of the Salinity Management Strategy could be integrated with long-term solutions, including the proposed Central Valley regulated brine line (*e.g.*, a new agricultural reuse area could be constructed and the brine ultimately discharged to the brine line after it is operational) or it could function autonomously (*e.g.*, a new solar evaporation pond could store salts independent of other long-term mitigation projects such as the regulated brine line).

Ideally, short-term projects to mitigate salt should be structured in a manner that facilitates implementation of long-term salt management solutions. For example, salt could be moved to designated salt accumulation and management areas in order to preserve and protect other groundwater basins. These accumulation areas could then be coordinated with the proposed Central Valley regulated brine line – if these sites are to be used for future regional desalters – their locations would be optimized to the extent possible. Water (*e.g.*, drain water) conveyance facilities should be analyzed for potential reuse and repurposing for the regulated brine line, *e.g.*, these facilities could become portions of the brine line infrastructure. Ultimately, opportunities to integrate ongoing or new measures to management salt in the shorter term will be a component of the prioritization and salinity management analyses completed under the Phase I Prioritization and Optimization Study.

4.3 Long-Term Management of Salts in the Central Valley

The Phase 2 SSALTS Report identified the construction of a regulated brine line as the best alternative to support the SNMP Management Goals for the Central Valley, especially in the southern portion of the Central Valley. Section 3 of this report further analyzed salt management alternatives identified in the Phase 2 SSALTS Report and found that even after considering a range of evaluation criteria, a regulated brine line remains the best alternative for the long-term, sustainable management of salt in the Central Valley to achieve the goals of the SNMP. Following completion of the Phase 2 SSALTS Report a number of questions regarding what this project might entail and how it might be implemented were raised by the CV-SALTS Executive Committee. Appendix C provides a response to those inquiries.

As envisioned by the findings from the Phase 2 SSALTS analyses, the regulated brine line would be implemented in a phased manner which would likely include:

- Initial planning and development phase to include planning/technical studies, engineering design, environmental permitting, and establishment of funding and a governance structure. Originally, this first phase was estimated to take up to 20 years to complete.
- Construction of the base regulated brine line including pipeline, extraction and treatment facilities. This second phase would begin around year 20 and continue for up to 10 years.

- Phased expansion of the system as needed to upstream reaches and the construction of laterals, a process that may occur over many decades beyond planning and construction phases as the needs for access to the regulated brine line increase.

The recommended CV-SALTS Salinity Management Strategy, proposed for implementation through the SNMP, is intended to:

- Control the rate of degradation ("managed degradation");
- Achieve long-term sustainability so that no further degradation occurs (salt balance); and
- Restore groundwater basins where feasible, practicable and reasonable.

To meet these objectives, the Salinity Management Strategy, which will evaluate a range of salt management projects, incorporates the proposed regulated brine line as a project for further study and development. The above conceptual phases, based on the Phase 2 SSALTS findings, have been incorporated into the Salinity Management Strategy with the original first 20-year initial planning and development phase being separated into two 10-year phases under the Salinity Management Strategy (Phases I and II, **Table 4-3**).

Table 4-4 provides additional information with regards to the types of tasks anticipated for completion under the Phase I study. **Table 4-5** illustrates how these tasks are proposed for implementation over the 10-year period. These tasks range from stakeholder coordination to technical/engineering studies to identify specific salt management projects and supporting water resource management studies. The estimated projected costs and level of effort are placeholders to provide an estimated cost for the Phase I study. CV-SALTS will continue to refine these tasks and costs in anticipation of, and during, implementation of the Salinity Management Strategy.

The estimated costs to complete the Phase I Prioritization and Optimization Study range from approximately $7 to $13 million (see Table 4-4), and as discussed above, is expected to take 10 years to complete. Given the cost and time associated with this comprehensive, valley-wide effort, CV-SALTS has recommended that (a) all (or almost all) dischargers of salinity help fund its implementation; (b) entities beyond dischargers that also benefit from salinity management in the Central Valley participate in funding the Priority and Optimization Study as well as implementation of Phases II and III as applicable; and (c) others that benefit from the Central Valley's *control* of salinity should also be part of this effort and assist in funding this Phase I Study. The CV-SALTS/CVSC framework can be enlisted to provide the governance structure and to seek the initial funding of the P&O Study.

While the Prioritization and Optimization Study is being implemented, CV-SALTS has recommended that the Basin Plans be amended to include an Interim Salinity Permitting Approach for discharges of salinity. This approach will allow the Central Valley Water Board to manage degradation while the long-term salinity efforts are being implemented. The Interim Salinity Permitting Approach is proposed to be set in place for 15 years to allow for completion of the Phase I studies. At the end of Phase I, it may be necessary to extend the Interim Salinity Permitting Approach to support implementation of Phase II, or to adjust the approach as deemed appropriate to implement Phase II.

Table 4-3. Salinity Management Strategy Phases

Strategy Phase	Key Activities
Phase I	▪ Prioritization and Optimization Study: - Evaluate the impact of all state policies that impact management of salinity in the Central Valley region (*e.g.*, Bay Delta Plan) to both surface and ground waters; - Identify physical projects and proposed locations for long-term management of salinity (*e.g.*, CVBL, salt-sinks, regional/subregional desalters, recharge areas, deep well injection, etc.); - Identify non-physical projects that help with managing salinity; - Develop governance structures for implementation of the physical projects; - Identify funding sources that will be necessary for implementation of large-scale capital physical projects (state and federal capital expenditures); - Identify the various environmental permits (and time-line for obtaining the permits) that will be needed to implement the preferred physical projects; - Identify any necessary Basin Plan changes that may be necessary to implement the next Phase or Phases of the Salinity Management Strategy; - Develop the conceptual design for applicable projects; and, - Other related activities. ▪ Implement Interim Salinity Permitting Approach
Phase II	▪ Environmental Permitting ▪ Engineering Design ▪ Obtain Funding ▪ Revises Interim Salinity Permitting Approach (as needed)
Phase III	▪ Salinity mitigation project construction including CVBL

Table 4-4. Phase I – Prioritization and Optimization Study Proposed Tasks

Task	Description	Range of Costs	Level of Effort (days)
Stakeholder Coordination			
1	**Stakeholder Meetings**. Input from CV-SALTS stakeholders through facilitated meetings to support implementation of the Prioritization & Optimization Study. These same stakeholder coordination meetings would serve as the mechanism for development of additional guidance/policies to further support SNMP implementation (*i.e.*, items identified for resolution after submittal of the SNMP) Costs based on consultant costs for meeting support; stakeholder participation would be considered in-kind contributions. Costs range from monthly to quarterly meetings for 10 years. Costs for development of additional policies/guidance, which may or may not be related to salt management are not included in this Phase I table.	\$616K – \$1.8M	360 – 1080
2	**Sustainable Groundwater Management Act (SGMA) Groundwater Sustainability Agencies (GSA) Meetings**. Coordination with GSAs: assume one meeting per quarter for all of the GSAs in each hydrologic region. For example, representatives from GSAs in the San Joaquin River Hydrologic Region will convene with CV-SALTS stakeholders once per quarter. The same assumption is made for the Tulare Lake Hydrologic Region. Fewer meetings are anticipated for the Sacramento River Hydrologic Region. It is critical that the Groundwater Sustainability Plans (GSPs) developed for each groundwater basin and the Salinity and Nitrate Management strategies be coordinated, both technically and institutionally.	\$424K – \$954K	240 – 540
Strategic Planning			
3	**Regulatory and Policy Evaluations.** This task serves a number of purposes: (a) Phase I strategic planning/management activities to ensure all work completed under Phase I is consistent with the needs and purpose of the Prioritization & Optimization Study (P&O Study); (b) evaluation of existing water management and state policies and requirements that could make implementation of a long-term salinity management strategy more difficult or challenging.	\$317K – \$634K	180 – 360
4	**Phase II Planning**. Based on the findings of other Phase I activities, (a) review the Central Valley Basin Plans to identify amendments required to continue implementation of the Salinity Management Strategy in Phase II; (b) determine the need to update the interim permitting strategy; (c) complete preliminary assessment of environmental permitting requirements that will need to be completed.	\$211K – \$422K	120 – 240
Governance			
5	**Governance Plan - Formation and Structure.** Develop the Governance Plan which will define the structure and roles and responsibilities of the key stakeholders. The Governance Plan will include the project objectives and a detailed plan describing how the salinity management strategy will be implemented over time. The structure of governance will be defined, including development of appropriate agreements, *e.g.*, memorandum of understanding, charter, joint powers authority, etc. The governance plan will also account for coordination with the GSAs formed under SGMA.	\$211K – \$528K	120 – 300

Table 4-4. Phase I – Prioritization and Optimization Study Proposed Tasks

Task	Description	Range of Costs	Level of Effort (days)
6	**Implementation and Refinement of the Governance Plan**. The agreed upon Governance Plan will be legally adopted and then implemented. As needed, additional stakeholders will join the governance structure during implementation. The administration of regional components of long-term salinity management projects conceptually developed during Phase I (*e.g.*, the Central Valley regulated brine line) will be refined during implementation of the Governance Plan. Memoranda of understanding with agencies that are not part of the original Governance Plan (*e.g.*, EBMUD for long-term agreements on brine disposal) would be written, negotiated, and executed. Refinement of the Governance Plan will continue as needed during Phases II and III of the Salinity Management Strategy.	$211 – $528K	120 – 300
Funding			
7	**Funding Plan and Financing Strategy**. Development of a Funding Plan will include a preparation of a financial strategy to determine potential sources of funding: including federal, state, local agencies, water purveyors, agricultural communities, grants, bonds, and low-interest loans and other strategies to support the development and implementation of salinity management facilities. The Funding Plan will include strategies for the equitable management and funding of long-term salinity management projects (*e.g.*, the Central Valley regulated brine line). Resources will be allocated where salt management needs are the greatest; different strategies may be developed for different Hydrologic Regions of the Central Valley.	$317K – $528K	180 – 300
8	**Implementation of the Funding and Financing Strategy**. This task includes the execution of the Funding Plan and the acquisition and administration of the funding dollars. In this task, it is anticipated that an independent, third-party audit firm will conduct a program-specific audit to ensure that the funds are administered in accordance with state and federal laws, regulations, using generally accepted auditing principles and government auditing standards, and other audit guides relative to the source of funding.	$317K – $528K	180 – 300
Prioritization and Salinity Management Analyses			
9	**Prioritization of Groundwater Basins and Subbasins.** This task involves reviewing and potentially revising groundwater basin and subbasins priorities that were developed for the SNMP, based on new information and on the stakeholder meetings.	$70K – $141K	40 – 80
10	**Prioritization *within* Groundwater Basins and Subbasins and Groundwater Modeling.** The Prioritization and Optimization Study will develop criteria for use in developing a master plan for prioritization and phasing of locations for extraction facilities and treatment facilities. This master plan will be organized by hydrologic region to take into account varying salt management priorities. This task will include reviewing hydrogeologic information and water quality data for each basin and subbasin. Current and projected land use and cropping patterns will be accounted for. The CV-SALTS groundwater model will be refined to estimate optimal areas to locate extraction facilities and to build regional/subregional treatment facilities (salinity and/or nitrate). Groundwater modeling must include current groundwater pumping for irrigation and potable supply, as well as planned pumping based on GSPs being developed under SGMA. Cost sharing with GSAs should be considered. Costs borne principally by stakeholders within each groundwater basin, subbasin or management zone.	$1.5M – $2. 3M	880 – 1320

Table 4-4. Phase I – Prioritization and Optimization Study Proposed Tasks

Task	Description	Range of Costs	Level of Effort (days)
11	**Salt Management Projects and Identification of Salt Storage Areas.** Delineate areas where salt can be stored and managed in a sustainable manner and identify projects for implementation in these delineated areas. Where appropriate, these localized salinity control projects can provide a bridge to the point in time when the Central Valley Brine Line (CVBL) is operational and available for use. This task involves hydrogeological investigation, land use and future land use studies, and the potential de-designation of the groundwater basin/subbasin from MUN and AGR beneficial uses. Salt management/storage areas will be strategically located in each Hydrologic Region. Where feasible, segments of the CVBL could be constructed to transport brine to the interim or permanent salt management/storage areas.	$211K – $422K	120 – 240
12	**Interim Truck or Rail Transport of Brine to a Regulated Wastewater Treatment Plant (WWTP), *e.g.*, East Bay Municipal Utilities District (EBMUD).** This task will involve a series of meetings with EBMUD or other facilities, a detailed estimate of trucking and rail costs and specific to an EBMUD disposal option, a study to re-operationalize the existing rail spur to EBMUD.	$141K – $352K	80 – 200
13	**Interim Phase I Report.** The findings from Tasks 9 through 12 will be compiled into a report that identifies recommended salt management projects for implementation by hydrologic region. Projects may range from those that would be implemented on a local or subregional basis separate from larger, regional projects (*e.g.*, CVBL) to the regional proposed CVBL. Ultimately the purpose of this report is to provide recommendations for the further development of projects under Tasks 14-15 that will result in sustainable salt management by hydrologic region.	$70K – $141K	40 – 80
Conceptual Design of Salt Management Projects			
14	**Concept Designs for Central Valley Subregional Salt Management. –** Based on the approved recommendations from Task 13, CV-SALTS will develop a concept design for each planned subregional project. Development of concept designs for these projects would include elements of a concept study, feasibility study, design requirements, and a preliminary design. The budget assumes that up to five projects would be developed further under this task.	$352K – $528K	200 – 300
15	**Concept Design for the Central Valley Regulated Brine Line**. Development of the Concept Design for a regulated brine line would include elements of a concept study, a feasibility study, design requirements, and a preliminary design. Included in this task are: (a) a fatal flaw analysis of the concept pipeline alignment that was described in SSALTS Phase 2 report (CDM Smith, 2014); and (b) consideration of alternate CVBL alignments. For example, there is a natural gas easement from Naval Air Station (NAS) Lemoore to Estero Bay in addition to other potential alignments identified in the development of the project. Additional environmental permitting would be required to implement this option (Note: Costs for environmental permitting of salt management projects is a Phase II element of the Salinity Management Strategy.	$704K - $1.3M	400 - 720
Special Studies			
16	**Groundwater Quality Characterization of Groundwater Basins and Subbasins for Trace Constituents.** CV-SALTS will conduct a study to characterize trace elements, contaminants of emerging concern (CECs), and low-concentration agricultural chemicals. This information will be used in coordination with the WWTPs and for permitting. This work will be coordinated (perhaps incorporated into the Surveillance and Monitoring Program [SAMP]) to minimize duplication of effort.	$522K - $945K	240 - 480

Table 4-4. Phase I – Prioritization and Optimization Study Proposed Tasks

Task	Description	Range of Costs	Level of Effort (days)
17	**Emerging Technologies.** A review of maturing and emerging technologies for salinity management and nitrate treatment will be completed in the tenth year of the 10-year P&O Study. The review of technologies will, however, be conducted over the course of the P&O Study.	$106K – $211K	60 – 120
18	**Recycled Water Imports.** This task will evaluate the efficacy and economics of importation of recycled water into the Valley through a pipeline in the same easement as the CVBL and the recycled water will be used directly or recharged through a series of Indirect Potable Reuse (IPR) projects.	$141K – $211K	80 – 120
19	**Stormwater Recharge Master Plan.** Develop a comprehensive assessment of stormwater recharge – current, planned and additionally needed – in order to enhance recharge of high quality stormwater and snowmelt to the extent possible. Plan will evaluate existing and planned efforts and account for water rights and environmental impacts.	$282K – $563K	160 – 320
	Totals	**$6.8M – $13.1M**	**3,800 – 7,400**

Table 4-5. Proposed Phase I Prioritization and Optimization Study Schedule (see Table 4-4 for task descriptions)

Category	Year of Implementation									
	1	2	3	4	5	6	7	8	9	10
Stakeholder Coordination	Stakeholder Coordination Meetings (as needed frequency) - ***Task 1***									
	SGMA GSA Coordination Meetings (as needed frequency) **–** ***Task 2***									
Strategic Planning	Regulatory and Policy Evaluations **–** ***Task 3***								Phase II Planning **–** ***Task 4***	
Governance	Governance Plan – Formation and Structure **–** ***Task 5***					Implementation and Refinement of Governance Plan **–** ***Task 6***				
Funding	Funding Plan and Financing Strategy **–** ***Task 7***					Implementation of the Funding Plan and Financing Strategy **–** ***Task 8***				
Prioritization & Salinity Management Analyses	Prioritization/Salt Management Analyses to Support Identification of Salt Management Projects **–** ***Tasks 9-12***				Interim Report **–** ***Task 13***					
Conceptual Design of Salt Management Project						Concept Design for Subregional Salt Management Projects and Regional CVBL Project **–** ***Tasks 14-15***				
Special Studies				Groundwater Quality Trace Constituent Study **–** ***Task 16***						
			Emerging Tech Update No. 1 **–** ***Task 17***			Emerging Tech Update No. 2 **–** ***Task 17***			Emerging Tech Update No. 3 **–** ***Task 17***	
						Recycled Water Imports Study **–** ***Task 18***				
								Stormwater Recharge Master Plan Study **–** ***Task 19***		

Section 5
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Appendix A

Summary of Phase 1 SSALTS Report

For the SSALT evaluation of the archetype study areas, factors were evaluated to facilitate a more objective analysis of which disposal methods and projects would be able to be maintained at a certain level into the future. The criteria used to evaluate the archetype study areas in Phase 1 are similar to the criteria used in the Phase 3 Report. In Phase 3, *Funding* and *Compliance Credits* were added as additional critical criteria.

- ***Implementability** of the salt disposal method*. This factor reviews the technical feasibility and efficacy of a given salt disposal method. In other words, given today's technology, how feasible or implementable is the given method? **Implementability** was rated from a high score of 4 (utilizes proven technologies and is readily implementable) to a low score of 1 (salt disposal method is not working or utilizes unproven technologies).
- *Salt **capacity** of the disposal method*. This factor looks at the mass or concentration of salt that can be disposed by the method in question. For a given salt disposal method, the controlling factor might be a component part of the disposal method. For example, when analyzing a brine line with an ocean outfall, the mass discharged into the ocean can be virtually limitless, because the ocean is the ultimate global salt sink (and source). The salt capacity of an ocean outfall brine line is limited by the wastewater treatment plant (WWTP) capacity, pipe diameter, flow capacity, permitting, and/or receiving water quality limitations. For deep well injection it might be the injection capacity of the well field, the hydrogeology of the aquifer system, receiving water quality, formation pressures, or the governing permit. The capacity of a surface water discharge might be the ability of the project to meet the electrical conductivity (EC, or salt concentration) discharge limits. Salt capacity was reviewed in terms of the proportion of salt load that can be reduced. Capacity was rated from a high score of 4 (the project's salt disposal load was not limited by the disposal method) to a low score of 1 (salt disposal method has a capacity less than the salt disposal load).
- ***Regulatory** challenges*. This factor reviewed pertinent regulatory challenges including Basin Plan water quality objectives, WWTP discharge limits, WWTP Resource Recovery permits, Waste Discharge Requirements (WDRs), Underground Injection Control (UIC) permits, proposed BPAs, National Environmental Policy Act (NEPA)/California Environmental Quality Act (CEQA), water rights, *etc*. **Regulatory** was rated from a high score of 4 (the project is readily permitable and is able to meet current regulatory requirements) to a low score of 1 (the project faces considerable regulatory challenges now or in the 50-year planning horizon).
- ***Institutional** requirements.* Institutional requirements speak to successfully bringing the project on-line, not from a technology standpoint (which is addressed by Implementability), but from a context of governance or management. What agency, group of agencies, coalition, joint powers authority, company or consortium of companies is

responsible for the development and operation of the project? **Institutional** was rated from a high score of 4 (bias toward fewer entities involved – unless they are part a group with a strong governance structure; bias was also given toward, in some cases, public sector project proponents with known or secure funding sources) to a low score of 1 (group of small, underfunded individual stakeholders).

- *Capital and operation and maintenance* ***costs***. An objective evaluation of salt disposal cost is difficult because much of the cost information is not present, not separable from costs associated with the entire project (disposal vs. source control and/or treatment), and not able to be placed on the same cost basis (for example, dollars per ton of salt removed). Some SSALTS study area projects are underway and some are still in the planning stages, so the costs will need to be reconciled to a common starting point in time. These are all issues that will be addressed in developing alternatives in the current phase (Phase 2) of SSALTS. In the meantime, the **cost** factor was rated from a high score of 4 (projects with lower anticipated costs) to a low score of 1 (projects with higher anticipated costs).
- *Potential* ***environmental issues***. Aside from salinity, there are other constituents of potential concern that are evaluated in this section as well as other possible environmental concerns. For example, selenium accumulation in standing water in evaporation basins or discharge ponds provides a potential exposure pathway and ecological risk to certain species. Trucking waste as a disposal option – when expanded in scope and scale (*e.g.*, valley-wide) – may have air quality and carbon footprint issues. **Environmental issues** were rated from a high score of 4 (little to no anticipated environmental issues) to a low score of 1 (reasonable potential for significant environmental issues to arise).
- ***Public acceptance***. This factor takes into account public awareness and acceptance of the disposal method utilized by the project. **Public acceptance** was rated from a high score of 4 (little to no public awareness and reasonable public acceptance) to a low score of 1 (high level of public awareness and little to no public acceptance).

The ten archetype study areas analyzed in the Phase 1 report were ranked in the following order (highest sustainability to lowest):

- **Tulare Lake Bed**. The Tulare Lake Bed is the salt sink/salt sequestering disposal archetype. This study area scored very well (4) for implementability **-** the construction, operation, and maintenance of the infrastructure for the evaporation basins utilizes proven technologies and is implementable for the Tulare Lake Bed. The study area scored well (3) for capacity, regulatory issues, institutional issues, and costs. There are potential environmental concerns about salt disposal at the Tulare Lake Bed including the control of salt at the evaporators (leaching, water and wind erosion). There is also potential concern about the formation of ponds of standing water which may lead to the bioaccumulation of certain trace constituents in the food chain. However, a number of the evaporation basins have been in operation for over 30 years at the Tulare Lake Bed and several environmental issues have been encountered and addressed previously, ameliorating some of the environmental concerns and leading to a score of 2. The public will be somewhat sensitive to the potential environmental issues associated with this project (2).

- **Hilmar Cheese Company– Trucking to WWTP**. HCC – Trucking to WWTP is the archetype for industrial plants in the Central Valley whose processes require the treatment of saline water and disposal of salt by trucking brine to a WWTP with an ocean disposal. This study area scored very well (4) for institutional issues because it is managed and operated by a single company. Trucking scored well (3) for implementability, capacity, regulatory, environmental issues, and public acceptance. The cost factor score was poor (1) because the 2012 processing fees paid to East Bay Municipal Utilities District (EBMUD) were about $1.9M, with an additional $1 million to $2 million in hauling costs paid by Hilmar to its contracted hauler.

- **Hilmar Cheese Company – Deep Well Injection**. HCC – Deep Well Injection is the archetype for industrial plants in the Central Valley whose processes require the treatment of saline water and disposal of salt by disposal by deep well injection. This study area scored very well (4) for institutional issues because it is managed and operated by a single company. Deep well injection also scored very well (4) for capacity; HCC is permitted to inject at a rate of 23 million gallons per month, which is more than 7 times the volume of brine HCC currently produces. However, every study area would require analyses, including the development of a hydrogeological conceptual model, development of a numerical simulation model, and pilot testing to determine site- and project-specific salt capacities. Deep well injection scored well (3) for regulatory, costs, and environmental issues. Deep well injection scored poorly for implementability and public acceptance. Deep well injection utilizes proven technologies; however, direct experience at HCC demonstrates that there can be technological challenges to be met. The implementability of deep well injection to other areas in the Central Valley is dependent on a deep aquifer of degraded water quality to inject into, capacity of the aquifer to accept the requisite volume of brine, permitting, compatibility of the water chemistries of the brine and the groundwater, and on-going maintenance to keep the injection wells operational. In terms of public acceptance, there may be confusion that wastes are being disposed of by injection into a potable aquifer. There also may be concerns about hydraulic fracturing (fracking) among the general public.

- **City of Dixon**. The City of Dixon is an archetype study area for the disposal of salt in municipal discharge ponds and ultimately to groundwater. This study area scored very well (4) for implementability and institutional issues. The construction, operation, and maintenance of municipal discharge ponds utilize proven technologies and the project is implemented by a single agency. This study area scored poorly (1) to fair (2) in terms of capacity, regulatory issues, and costs. These three factors are all related to the finding that TDS and nitrate in shallow groundwater continues to increase, due mostly to consumptive use by the surrounding irrigated agriculture. Depending on the water quality objectives developed by the Central Valley Water Board, there may not be assimilative capacity for TDS in groundwater. Permitting a waste discharge to groundwater where the waste's TDS is greater than the objective (there is no assimilative capacity) – even though it is less than the receiving water's TDS concentration – calls to mind the Rancho Caballero decision and does not comply with State Resolution 68-16. However, the basin plan water quality objective can be raised through a BPA process. Developing a new, higher quality source of water will be costly, whether deeper wells or surface water becomes a more dominant component of the supply mix.

- **Grassland Water District – Real-Time Management**. The GWD-RTMP is the archetype study area for the disposal of salt to a surface water body through the use of sophisticated modeling and operations to utilize assimilative capacity in the water body. The GWD-RTMP scored well (3) for implementability, capacity, and public acceptance and fair (2) for regulatory issues, institutional issues, costs, and environmental issues. One of the critical challenges of this archetype study area is aligning the goals of the RTMP and the goal of wetlands management by the GWD. The GWD wetlands drawdown in the spring is discharged into tributaries of the Lower San Joaquin River and is timed to meet wetland management objectives. The GWD wetlands drawdown in the spring does not coincide with higher assimilative capacity in the San Joaquin River (between January and April) which is the primary management goal of the RTMP. Another critical challenge includes balancing flows for the whole basin to maximize salt export, not just for the wetlands which only accounts for a small portion of the salt load. Most salt load comes from the surrounding agriculture of which there are numerous entities that will need to be coordinated in order to maximize salt export from the basin.

- **City of Tracy**. The City of Tracy is the municipal discharge to surface water archetype study area. Tracy scored very well (4) for implementability since the construction, operation, and maintenance of a municipal outfall to a surface water discharge point utilizes proven technologies. Tracy scored poorly (1) for salt capacity, regulatory issues and costs. The court entered a judgment and peremptory writ of mandate ruling that the South Delta salinity objectives do not apply to Tracy or other municipal discharges. However, the State Board is in the process of considering new flow and water quality objectives meaning that there is regulatory uncertainty. There is also a mass loading limitation in Central Valley Water Board Order R5-2012-0115 that may lead to compliance issues in the WWTP expansion (the mass or salt load does not increase with increasing permitted discharge volumes). Tracy is in the process of converting its water supply sources to surface water to improve source water quality, in part to meet the potential Water Quality Objectives (WQOs) at DP001. It should be noted, however, that surface water supplies continue to be limited and uncertain, particularly in drought periods, and may not always be reliable, particularly if a junior water right was used to secure the source of water.

- **Industrial Food Processing**. The Industrial Food Processors are the archetype for industries that produce high salinity waste water in the valley. The two primary disposal methods for salt (in industrial wastewater) are disposal to a WWTP and discharge to the land surface. The construction, operation, and maintenance of a service connection to a municipal WWTP utilize proven technologies and are implementable. Likewise, the construction, operation, and maintenance of land discharge methods (application directly to land, discharge ponds, *etc.*) utilized proven technologies and is implementable, hence this archetype study area scored very well (4) for implementability. Industrial food processing scored well (3) for public acceptance and fair (2) for capacity, institutional issues, and environmental issues. This archetype study area scored poorly (1) for regulatory issues and costs. It is anticipated that the future regulatory paradigm will be more restrictive and that projects under current permits will receive new permits with more stringent requirements. These future regulations may require substantive pre-treatment for industrial processors for both discharges to a WWTP and to the land surface.

- **San Luis Unit Ocean Disposal**. The San Luis Unit Ocean Outfall is the archetype study area for salt disposal through a newly-permitted ocean outfall. The study area scored very well (4) for implementability and capacity. The construction, operation, maintenance, and replacement of a conveyance system for ocean disposal – including pipelines, tunnels, lift, stations – utilizes proven technologies and is implementable. The pipeline capacity is sized to accommodate the anticipated drainage water, taking into account land retirement and regional reuse facilities. The San Luis Unit Ocean Outfall scored poorly (1) for regulatory issues, costs, environmental issues, and public acceptance. This project would be extremely difficult to permit and to demonstrate that it is consistent with the California Coastal Management Program. The Final Environmental Impact Statement (FEIS) determined that there would be water quality degradation in the vicinity of the outfall. The project is expected to significantly impact federal and state listed special-status species through construction and operation of the pipeline. High selenium levels in reuse facilities could impact sensitive habitat for aquatic or wetland-dependent species. The ocean outfall project is also very energy intensive because of the elevation differences between the San Joaquin Valley and the Coastal Ranges.

- **Westside Regional Drainage Plan**. The WRDP is the archetype study area for regional salt disposal. WRDP scored well (3) for institutional issues because the management of the salt should be coordinated under one stakeholder group. Implementability, regulatory issues, and public acceptance all scored fair (2). In terms of implementability, the salt disposal options range for (i) initial and indefinite storage at regional evaporation facilities, (ii) attempt to find or develop a commercial market, and (iii) ultimately remove the salt to a permitted disposal facility. The containment facilities would be regulated under Title 27. Depending on the nature of the containment facilities there may be air quality and erosion issues, as well as percolation to groundwater concerns. Capacity, costs, and environmental issues all scored poor (1) and are all related. One of the pillars of the salt disposal portion of both WRDP and the Red Rock Ranch (RRR) is for the development of a commercially-viable market for the salt produced from their operations. Absent this market, the salt disposal options for both become either on- or off-site storage. The lack of a viable market has a negative impact on capacity, costs, and environmental issues.

- **Red Rock Ranch**. RRR is the archetype study area for Integrated On-Farm Drainage Management (IFDM) systems in the Central Valley, characterized by zero-discharge, attempting to market the salt as a commercially-viable product or sequestering the salt at the site. RRR scored the same as WRDP for all factors save institutional – the assumption being that a regional coordinated program would function better than disconnected, individual IFDMs. There might also be economies of scale in developing future salt markets or pricing ultimate landfill-disposal options.

- **Stevinson Water District**. The salinity issues addressed by the SWD are primarily source control solutions. These solutions either prevent or reduce the volume of saline groundwater from entering the San Joaquin River (through the Lateral Canal Pipelining Project), or release saline agricultural drainage water during times of high assimilative capacity in the river (through the Agricultural Drainage Control Project). However, this project does not remove salt, although it does reduce salt entering into the water district by conserving water supplies. Hence, an evaluation of the sustainability of salt disposal methods could not be performed.

Appendix B

Salt Management/Disposal Fact Sheets

Salt Accumulation Areas: San Joaquin River Water Quality Improvement Project (SJRIP)

Description

The San Joaquin River Water Quality Improvement Project (SJRIP) and the Tulare Lake Bed are two of the larger salt accumulation areas in the Central Valley. The SJRIP is a three phased project:

- Phase 1: Purchase land/grow salt-tolerant crops
- Phase 2: Install tile drains and collection system/begin initial treatment
- Phase 3: Develop the full project treatment system and a salt disposal system

The SJRIP regional reuse facility will – at full project build out – manage between 25,000 AFY and 30,000 AFY or between 40 and 50 percent of the total historical drain water produced in the Grasslands Drainage Area (GDA) – about 60,000 AFY. The remainder has been reduced through conservation measures, including improved irrigation applications, tiered water pricing, and tail water controls.

The TDS concentration ranges from 3500 mg/L to 4000 mg/L. The average TDS of drain water at the discharge from the San Luis Drain at Site B is 3300 mg/L (2005-2013). Salt-tolerant crops, like Jose Tall Wheatgrass, are grown in the SJRIP area, which consists of up to 6200 acres of fields, irrigation channels, drainage ditches, conveyance facilities and farm structure; about 2000 acres of the SJRIP are tiled with some of these areas operating since 2002. The eastern project area is comprised of 3873 acres (out of about 4000) planted with salt-tolerant crop species. The western project area consists of 1901 acres that have been purchased, but have not yet been planted with salt-tolerant crops. The Panoche Drainage District has been the lead CEQA agency for the SJRIP.

Salt Accumulation Areas: San Joaquin River Water Quality Improvement Project (SJRIP)	
Constituent Salts or Nutrients Managed	Salt accumulation areas effectively manage all salts, nutrients and other constituents. However, management techniques such as habitat modification (modifying drains to discourage nesting, as well as the creation of a pilot mitigation site to provide clean-water nesting habitat), diligent water management, and bird hazing need are being and conducted and need to continue in order to limit the exposure of plants and animals (killdeer, black-necked stilts, American avocets, red-winged blackbirds, San Joaquin kit fox, etc.) to trace elements, such as selenium, boron, and mercury. The on-going biological monitoring program needs to be continued to document the impacts on sensitive species.
Applicability	The westside region is composed primarily of agricultural land, which has poor drainage and relatively high concentration of salts, selenium, boron, and other naturally-occurring constituents. The poor drainage is a result of the presence of impermeable shallow clay layers (including the Corcoran Clay) that prevent irrigation water from infiltrating into the deeper groundwater aquifers, resulting in trapped irrigation water forming a shallow, or perched, water table. Without an outlet, the highly saline waters accumulate in the root zone close to the ground surface and reduce crop productivity. The high selenium levels in the drainage water are toxic to wildlife at certain concentrations and create challenges for safe off-farm drainage and disposal of the water. The stakeholders of the drainage area are implementing activities, such as SJRIP, to maintain crop productivity in the region and to manage subsurface drainage water.
Practice Benefits and Impacts	The principal benefit of this approach is that it is a viable means of accumulation of salt in a relatively small lowland area. SJRIP would ultimately receive about 15,000 AFY of agricultural drain water. The GDA drain water, which has a current average TDS of about 5,000 mg/L is retained on-site and is not allowed to discharge to the San Luis Drain and Mud Slough through the Grassland Bypass and ultimately to the San Joaquin River, thus helping to meet the compliance objective at Vernalis. Phases 2 and 3 include treatment of the drain water to remove salt, selenium, and boron and to "dispose of the removed elements to prevent discharge into the San Joaquin River… The remaining salt will be deposited into approved waste units that will result in additional reductions in salt and selenium discharges into the San Joaquin River and will maximize improvement in water-quality and meet reductions needed for future water-quality objectives." (Harvey & Associates, 2012). Until Phases 2 and 3 are implemented salt will continue to accumulate in the shallow perched zone underlying the SJRIP area.

Salt Accumulation Areas: San Joaquin River Water Quality Improvement Project (SJRIP)	
Effectiveness Documentation	The effectiveness of the GBP in reducing salt and salinity loading to the San Joaquin River via the San Luis Drain and Mud Slough: SFEI. 2013. Grassland Bypass Project Annual Report 2010-2011. Prepared for the Grassland Bypass Project Oversight Committee. November 2013. http://www.sfei.org/gbp/reports
Supporting Documentation	Biological Monitoring Program: H. T. Harvey & Associates. 2012. San Joaquin River Water Quality Improvement Project, Phase I: Wildlife Monitoring Report, 2011. Prepared for the San Luis and Delta Mendota Water Authority and the Grassland Basin Drainers. File No. 1960-14. June 2012. http://www.sfei.org/gbp/sjrip Reclamation Pilot Study http://www.usbr.gov/mp/nepa/documentShow.cfm?Doc_ID=8298
Implementation: Planning Level Costs	The primary costs for implementation are: ▪ Administrative/contract costs ▪ Purchase land ▪ Provide engineering for irrigation and drainage systems ▪ Install and maintain irrigation channels ▪ Install and maintain drainage (drain lines and ditches) ▪ Plant selected forage crops ▪ Design treatment system ▪ Provide capital costs for treatment system ▪ Provide O&M Costs for treatment system ▪ Pay for salt disposal at approved waste units ▪ NEPA/CEQA compliance ▪ Other permitting

Salt Accumulation Areas: San Joaquin River Water Quality Improvement Project (SJRIP)	
Implementation: Status and Potential	SJRIP is currently in Phases 1 and 2. By the end of 2015 all 6000 acres should be developed, however Panoche Drainage District is considering purchasing additional lands. Less than 2000 acres currently have tile drainage systems; the ultimate goal is to have tile drains beneath about 3000 acres. Phase 3 will be designed based on information developed in the various pilot treatment systems that are currently underway.
Implementation: Monitoring Documentation	See Effectiveness Documentation and Supporting Documentation
Implementation: Other Regulatory Approvals or Requirements	NEPA/CEQA analysis will be required for the future phases of SJRIP.
Website:	http://www.sfei.org/gbp/sjrip http://www.waterboards.ca.gov/rwqcb5/water_issues/grassland_bypass/usfws_att_d.pdf

Salt Accumulation Areas: Tulare Lake Bed

Description

The San Joaquin River Water Quality Improvement Project (SJRIP) and the Tulare Lake Bed are two of the larger salt accumulation areas in the Central Valley. The Tulare Lakebed is located within the Tulare Lake Basin within the southern portion of the San Joaquin Valley. The Tulare Lake Basin, comprising approximately 10.5 million acres, is a mixture of federally owned National Parks, agricultural land, and municipalities. The Basin is essentially a closed system, draining only into the San Joaquin River in extreme wet years (Central Valley Regional Water Quality Control Board [RWQCB] 2004).

The historical Tulare Lakebed is a subarea of the Tulare Lake Basin located just southwest of the town of Corcoran. Prior to the twentieth century, lake levels and boundaries would fluctuate as a result of variations of inflow from the major tributaries, with a maximum area of approximately 800 square miles in 1868. The lakebed became dry in 1898 and 1899. Subsequently, the lakebed was developed for irrigated agriculture and, combined with upstream dam construction, the portion of the lakebed which can experience flooding in wet years has shrunk to less than 200,000 acres (Tulare Lake Basin Water Storage District [TLBWSD] 2012).

Underlying the majority of western and southern Tulare Lake Basin is the impermeable Corcoran Clay, the primary of several clay layers, which separates the groundwater into a perched groundwater table and a deeper groundwater table. In the vicinity of the Tulare Lake Bed, the Corcoran Clay is encountered at a depth of about 600-700 ft and is roughly 100 ft thick. The perched groundwater table above the clay can be encountered as shallow as 5 feet below ground surface. It is estimated that the EC of this shallow groundwater is in the range of 5,000 to more than 35,000 µS/cm (TLBWSD, 2012).

The high salinity in the groundwater is a result of several factors. Since this a closed basin with negligible surface or groundwater discharges, salts accumulate in the perched groundwater beneath the lake basin. In the past 40+ years, application of state project water for irrigation has added salts to the

Salt Accumulation Areas: Tulare Lake Bed

	basin, but the historic salt levels in the soils prior to agricultural development are the primary problem. This is why the Westside soils of the Central Valley have higher saline levels than the soils on the East side. This situation was created over thousands of years and without a drainage outlet salts continued to build up within the Tulare Lake Bed. With no drainage out of the Tulare Lake Basin, agricultural operations in the lakebed have constructed a drainage collection system and three evaporation basins for the accumulation of salts rather than allowing the salts to continue to increase in the groundwater. Under the existing Water Quality Control Plan for the Tulare Lake Basin (Second Edition) (Central Valley Water Board 2004), the groundwater basin under the lakebed has MUN, AGR, and IND2 beneficial uses. And as a result of its beneficial use designation as MUN, the groundwater underneath the Tulare Lakebed is currently protected by water quality objectives and criteria established to protect a drinking water supply. More stringent regulations related to selenium levels and potential impacts to waterfowl have caused many evaporation basins to close. With their closure, stakeholders are searching for a solution to their drainage problems.
Constituent Salts or Nutrients Managed	Salt accumulation areas effectively manage all salts, nutrients and other constituents. The Basin Plan (Central Valley Water Board, 2004) states that: *"the EIRs focused on impacts to wildlife and found all basins pose a risk to birds due to salinity and avian disease. To prevent and mitigate these impacts, waste discharge requirements for evaporation basins, adopted in 1993, include the following:* ▪ *Removal of attractive habitat, such as vegetation.* ▪ *A program for avian and waterfowl disease prevention, surveillance and control.* ▪ *Closure and financial assurance plans.* ▪ *Drainage operation plan to reduce drainage.* *Basins with concentrations of selenium greater than 2.7 µg/l in the drainage water have potential for reduced hatchability and teratogenic impacts on waterfowl. To prevent and mitigate these impacts, waste discharge requirements for these basins, adopted in 1993, include those listed above and the following:* ▪ *Intensive hazing prior to the breeding season.* ▪ *Egg monitoring.*

CDM Smith

Salt Accumulation Areas: Tulare Lake Bed

	▪ *Basin reconfiguration, if necessary, to minimize attractiveness to waterbirds.* ▪ *Wildlife enhancement program, alternative habitat and/or compensatory habitat."*
Applicability	The Tulare Lake Basin is a closed system, and there is currently no drain outlet. Salt is imported from surface water supplies, which are primarily used to irrigate the majority of the 3 million acres of agricultural land (Sholes 2006). Water that is not used by crops will eventually percolate into the ground, taking the imported salt from water supplies and leaching additional salt from areas with saline soils into the shallow groundwater. Within the closed Tulare Lakebed, groundwater is not able to drain out, and this increases the concentration of salt in groundwater. These high salt concentrations (ranging from 5,000 to 35,000 µS/cm [TLBWSD 2012]) reduce crop yields throughout the lakebed and make the shallow perched groundwater unusable for agriculture or municipal purposes. Currently the groundwater source under the Tulare Lakebed is designated as having MUN and AGR beneficial uses. A BPA to add a WILD beneficial use designation is being discussed due to the location of the evaporation basins in the Pacific Flyway. According to the current Basin Plan, the water quality objectives for salinity are: ▪ *All ground water shall be maintained as close to natural concentrations of dissolved matter as is reasonable considering careful use and management of water resources.* ▪ *The maximum annual increase in EC for Tulare Lake is 3 µmhos/cm (calculated using monitoring data for a cumulative average annual increase over a 5-year period).*
Practice Benefits and Impacts	With no drain outlet readily available for the lakebed, stakeholders (through the Tulare Lake Drainage District [TLDD]) have constructed and operate a drainage system with three evaporation basins (North Evaporation Basin, Hacienda Evaporation Basin, and the South Evaporation Basin) to accumulate salts and maintain agricultural productivity. Agricultural drainage water is conveyed to the evaporation basins through a series of sub-surface pipelines and open ditches. The water storage capacity of these three interconnected basins is approximately 17,000 AF. In recent years, the TLDD has filled their evaporation basins to capacity as a result of increased demand of sub-surface drainage water disposal. It is estimated that the annual average evaporation capacity of the three basins is approximately 17,000 AF (TLDD 2012).

Salt Accumulation Areas: Tulare Lake Bed	
	The TLDD is proposing to construct a new fourth evaporation basin, the Mid Evaporation Basin (MEB) to manage and dispose of additional drainage water. The new basin would encompass 1,800 acres, along with inlet, pipeline and control structures.
Effectiveness Documentation	
Supporting Documentation	
Implementation: Planning Level Costs	The primary costs for implementation are: ▪ Administrative/contract costs ▪ Purchase land ▪ Provide engineering for evaporation basins and associated infrastructure ▪ Provide capital costs for new evaporation basins ▪ Provide O&M costs for existing and new evaporation basins ▪ NEPA/CEQA compliance ▪ WDRs (see Implementation: Other Regulatory Approvals or Requirements)
Implementation: Status and Potential	The evaporation basins have been operating – in various configurations – for more than 30 years.
Implementation: Monitoring Documentation	See Effectiveness Documentation

Salt Accumulation Areas: Tulare Lake Bed	
Implementation: Other Regulatory Approvals or Requirements	The designation of the MUN beneficial use is allowed by the State Water Board under Resolution No. 88-63. Per this order, all surface or groundwater in the State is designated, by default, to have an MUN beneficial use with a few exceptions. The exceptions for both surface and groundwater include waters where: ▪ *The TDS exceeds 3,000 mg/L (an EC of 5,000 µS/cm) and it is not reasonably expected by Regional Boards to supply a public water system, or* ▪ *There is contamination, either by natural processes or by human activity (unrelated to a specific pollution incident), that cannot reasonably be treated for domestic use by using either Best Management Practices or best economically achievable treatment practices.* CV-SALTS, in collaboration with the TLDD and TLBWSD, is currently supporting a project intended to de-designate MUN and AGR from a portion of the Tulare Lakebed because it can serve as an appropriate archetype or template for studies in which the purpose is to evaluate the appropriateness of the MUN and AGR beneficial uses on a designated groundwater body. Moreover, the outcome of the de-designation effort can help advance the purpose and requirements associated with the development of the SNMP for the Central Valley region in that it may provide a template that can be utilized to identify areas that may serve as salt sinks until alternate treatment, disposal and/or export alternatives are developed. Environmental Compliance with NEPA and CEQA would be required in order to plan and implement any new evaporation basins. *"Persons proposing new evaporation basins and expansion of evaporation basins shall submit technical reports that assure compliance with, or support exemption from, Title 23, California Code of Regulations, Section 2510,* et seq.*, and that discuss alternatives to the basins and assess potential impacts of and identify appropriate mitigations for the proposed basins."* (Central Valley Water Board, 2004)
Website:	http://www.swc.org/about-us/member-agencies-list/55-tulare-lake-basin-water-storage-district http://www.epa.gov/region9/water/wetlands/tulare-hydrology/tulare-summary.pdf

San Joaquin River Real-Time Management Program

Description

The Real Time Management Program (RTMP) is an umbrella program to optimize/maximize the export of salt from groundwater, perched zones, and agricultural drain water from the Lower San Joaquin River (LSJR) Basin while ensuring that salinity and boron water quality objectives are met at Vernalis. RTMP must also ensure compliance with any future salinity objectives in the Lower San Joaquin River that may be adopted. RTMP involves efforts to control salt loadings. The Central Valley Water Board has approved RTMP in the Basin Plan as an alternative salt management strategy in lieu of monthly salt load allocations enforced by the agency.

The Vernalis objectives for EC are 30-day moving averages: 700 µS/cm during the irrigation season (April to August) and 1000 µS/cm during the non-irrigation season (September to March). According to the RTMP Draft Framework (Reclamation *et al.*, 2014), *"The goal under a real-time management program is to continue to meet the irrigation and non-irrigation season salinity water quality objectives by managing salt loads so they are discharged when there is assimilative capacity in the river, rather than be constrained by mandated monthly load allocations in WDR's. Managing the use of assimilative capacity is also anticipated to reduce reliance on fresh water releases from New Melones Reservoir to meet the salinity objectives at Vernalis and to provide a mechanism to maximize salt exports from the SJR Basin."* The RTMP components include:

- Stakeholder participation
- Real time monitoring network
- Data Management
- Predictive modeling/forecasting of flows and salinity in the river in order to predict assimilative capacity
- Physical infrastructure (gates, inlets, rubber dams, *etc.*)
- Program and project management practices
- Funding

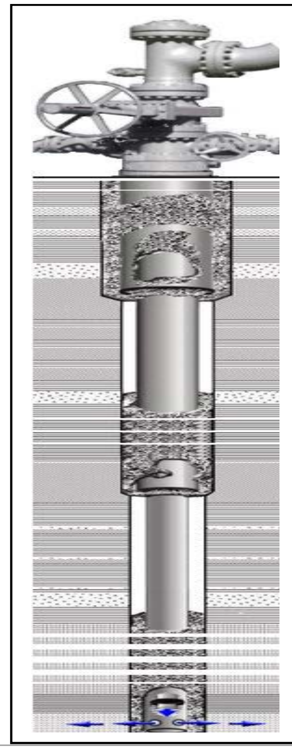
Examples of pilot studies of RTMP include:

San Joaquin River Real-Time Management Program	
	▪ Grassland Resource Conservation District Wetland Areas ▪ Grassland Bypass Project and Panoche Drainage District
Constituent Salts or Nutrients Managed	The RTMP effectively manages all salts, nutrients and other constituents, in that it is not a treatment process but a sophisticated management tool for managing and exporting salt loads to the river at times when there is assimilative capacity. Other WQOs (boron, selenium, *etc.*) must also be met.
Applicability	Federal Clean Water Act (CWA) §305(b) requires that each state assesses the water quality status of each waterbody under CWA jurisdiction and report these findings to EPA. For this assessment, the state reviews available water quality data, compares these data to water quality objectives, and evaluates whether the beneficial uses of each waterbody are supported. Through this process and pursuant to CWA §303(d) the state is required identify waterbodies not meeting water quality standards even after all required effluent limitations have been implemented (*e.g.*, through a WDR). These waters are often referred to as "303(d) listed" or "impaired" waters. Waterbodies placed on the 303(d) list may require development of a Total Maximum Daily Load (TMDL). A TMDL is a calculation of the maximum amount or load of a pollutant that a waterbody can receive and still meet water quality objectives; this load is allocated among the various sources of the pollutant. The Central Valley Water Board adopted a TMDL for salt and boron in the LSJR as a BPA on September 10, 2004. EPA approval occurred in 2006. The approved TMDL establishes a water quality control program for salt and boron to achieve existing salinity and boron WQOs in the San Joaquin River at the Airport Way Bridge near Vernalis ("Vernalis"). The adopted control program requires a second phase TMDL to address salinity and boron concerns in the LSJR upstream of Vernalis. Through CV-SALTS, a LSJR Committee was established to develop recommendations for updated WQOs that support the beneficial uses on the LSJR and an implementation plan to support those objectives. The outcome of this effort will have direct bearing on how salt is managed in the watershed draining to the San Joaquin River. The LSJR Committee effort is ongoing and salinity objectives are anticipated in the 2015/2016 time frame.
Practice Benefits and Impacts	The Central Valley Water Board provided for participation in the LSJR RTMP in lieu of load allocations: *"The Regional Water Board will adopt a waiver of waste discharge requirements for salinity management, or incorporate into an existing agricultural waiver, the conditions required to participate in a Regional Water Board approved RTMP. Load allocations for nonpoint source dischargers participating in a Regional Water Board approved RTMP are described in Table IV-4.4. Additional waiver conditions will include use of Regional Water Board approved methods to measure and report flow and electrical conductivity.*

San Joaquin River Real-Time Management Program	
	Participation in a Regional Water Board approved RTMP and attainment of salinity and boron water quality objectives will constitute compliance with this control program." The umbrella RTMP is an effective tool for exporting salt out of the LSJR basin, while being protective of WQO compliance at Vernalis.
Effectiveness Documentation	The effectiveness of the GBP in reducing salt and salinity loading to the San Joaquin River via the San Luis Drain and Mud Slough: SFEI. 2013. Grassland Bypass Project Annual Report 2010-2011. Prepared for the Grassland Bypass Project Oversight Committee. November 2013. http://www.sfei.org/gbp/reports
Supporting Documentation	U. S. Bureau of Reclamation, Central Valley Regional Water Quality Control Board, San Joaquin Valley Drainage Authority, Grassland Resource Conservation District, San Luis & Delta-Mendota Water Authority/Grassland Bypass Project. 2014. Draft Salinity Real-Time Management Program Framework. May 9, 2014.
Implementation: Planning Level Costs	The Grassland Resource Conservation District Wetland Areas RTMP has been in operation for over a decade and has over 45 monitoring stations that characterize discharge and water quality entering and leaving the Grassland Wetland Complex. Reclamation I (2013) states, *"GRCD can offer guidance to those who are implementing similar programs. Costs associated with this program, including equipment acquisition, installation, quality assurance, and data management are currently in excess of $5 million. Approximate annual programmatic costs are currently in the range of $500,000."* About $140M has been invested to date on the GBP and SJRIP. Estimated costs will be provided pertaining to the overall RTMP for the entire LSJR basin in Phase 3 of SSALTS.
Implementation: Status and Potential	The RTMP consists of four Phases: ▪ Phase 1 – Initiation Phase – to be completed prior to first compliance date of July 28, 2014 ▪ Phase 2 - Development Phase – begin at first compliance date and complete in 12 months ▪ Phase 3 – Early implementation Phase – complete 36 months from first compliance date. ▪ Phase 4 - Implementation Phase – completed 60 months from first compliance date

San Joaquin River Real-Time Management Program	
Implementation: Monitoring Documentation	http://www.sfei.org/projects/grassland-bypass-project http://www.sfei.org/gbp/sjrip
Implementation: Other Regulatory Approvals or Requirements	NEPA/CEQA analysis may be required for the future phases of RTMP.
Website:	http://www.water.ca.gov/waterquality/sjr_realtime/ http://www.sfei.org/projects/grassland-bypass-project https://www.usbr.gov/mp/watershare/wcplans/2010/Refuges/Grasslands%20RCD.pdf http://www.sfei.org/gbp/sjrip http://gwdwater.org/grcd/who-we-are.php

Deep Well Injection with Dedicated Wells

Description	Under this approach, brine from reverse osmosis treatment (or other concentration processes) of groundwater would be injected into deeper aquifers isolated from the primary drinking water aquifers for disposal or storage and future recovery. 
Constituent Salts or Nutrients Managed	Deep well injection would effectively manage all salts, nutrients and other constituents retained in the treatment process brine by storing them in deep aquifers that are unusable for most beneficial uses. Depending upon the deep aquifer properties where injection would take place, it might theoretically be possible at some point in the future to install extraction wells if an economical way was developed to extract and recover the saline water for commercial purposes. This option is distinct from Deep Well Injection for Oil and Gas Recovery in which the brine would be used by the oil and gas industry to assist with hydraulic fracturing to release oil and gas trapped in formations. See Deep Well Injection – Oil and Gas Recovery.
Applicability	To the extent that there is storage capacity in an underlying deep aquifer that is of poor quality and is geologically isolated from any overlying aquifer that has existing or potential beneficial use for municipal, industrial or agricultural purposes, it is possible to consider this approach. This method would inject concentrated brine into deep formations. The USGS has developed a Hydrologic Model of the Central Valley (http://ca.water.usgs.gov/projects/central-valley/central-valley-hydrologic-model.html) that assumes that the deepest layer of the "usable" groundwater aquifer where water is relatively fresh is approximately 2,700 feet below the surface at the center of the valley. Water that may be in formations deeper than this is considered to be saline. Therefore, injection wells may need to be in excess of 3,000 feet deep. Three injection wells that were installed by the

Deep Well Injection with Dedicated Wells	
	Hilmar Cheese Company near Hilmar, CA in 2009 to 2010 were completed to approximately 4,000 feet below ground surface (bgs). The areal extent and depths of the deeper formations are not mapped from a water resources point of view, but there has been extensive drilling, exploration and mapping of these formations by the oil and gas industry. See Deep Well Injection – Oil and Gas Recovery. While the areal extent of deep wells currently used by the oil and gas industry for both extraction and injection are somewhat concentrated in portions of the Central Valley, particularly in the southern portion, there is not necessarily any limitation as to where dedicated injection wells can be sited geographically other than by the nature of the deeper stratigraphy below the valley.
Practice Benefits and Impacts	If the underlying formation in the vicinity of the brine source(s) is capable of accepting injection, the practice could be accomplished at a number of distributed locations near the source of brine (*e.g.*, local or regional desalters). This would result in relatively limited piping infrastructure to deliver the brine to the wells compared to other options (*e.g.*, brineline to an ocean outfall wastewater treatment plant [WWTP]). Also, if there is significant storage capacity in the formation, this approach could provide substantial long-term storage capacity. Finally, if a market were to be developed for products created from the saline water in storage in the future, the saline water could potentially be recovered with recovery wells. Conversely, there are several issues and impacts that could potentially limit the usefulness of this option. In some areas, geophysical information may be available – particularly from oil and gas operations – to give some guidance as to the localized feasibility of installing injection wells, while in other areas there may be little to no information and significant new exploratory drilling and/or other geophysical testing may be necessary to determine the potential. For this to be a feasible option there would need to be sufficient storage available to sustain a number of years of injected water. Another major issue would be compatibility between the injected brine and the deep groundwater, and the geochemical interactions that may take place. Understanding these issues and planning to avoid such problems is essential to designing and operating a system that will have an extended useful life without excessive maintenance. Finally, approximately 15 percent of the pumped groundwater would not be able to be used and would effectively be lost "yield", similar to most other disposal options (ocean disposal, evaporation, *etc.*).
Effectiveness Documentation	There are thousands of deep injection wells in use throughout California by the oil and gas industry that have operated successfully for many years. These are used both as re-injection wells to replace the water separated from the oil

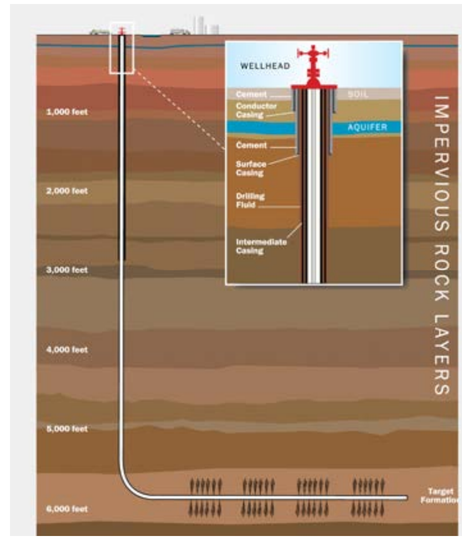
Deep Well Injection with Dedicated Wells	
	and gas brought to the surface, and for injection to fracture formations to open up the flow of oil and gas, as described under "Deep Well Injection for Oil and Gas recovery. Therefore, the use of injection wells in the deep formations in California has been well established for over 30 years. However, there no known examples of deep injection of brine from a groundwater treatment plant in California. The project at Hilmar Cheese is intended to use injection for brine from treatment of industrial wastewater which has very different characteristics, and a project at Terminal Island treatment plant in Los Angeles has been injecting biosludge slurry into depleted oil and gas wells screened at approximately 5,300 feet bgs for over four years in a demonstration project. Another example is a very deep injection well at the US Bureau of Reclamation's Paradox Valley Unit in western Colorado. This project intercepts very high TDS groundwater (brine) in excess of 250,000 mg/L to prevent the groundwater from rising into the Dolores River which is tributary the to the Upper Colorado River. The well injects the groundwater in a formation that is 16,000 feet bgs. Approximately 100,000 tons/yr of saline groundwater is currently injected into the formation. To date, the formation still has storage potential, although the USGS expects the storage may eventually become limiting and a new well would have to be drilled into a different portion of the formation. While deep well injection is a widely proven technology, the key concerns will be the chemical compatibility of the injected water and the formation to avoid plugging or fouling, and the long-term storage capacity of the formation into which the brine would be injected. Sources of power in remote areas is another potential concern that will need to be evaluated.
Supporting Documentation	
Implementation: Planning Level Costs	The primary costs for implementation is constructing delivery brine pipelines and pumping stations from regional or local desalters to injection well fields and drilling and operating the injection wells. It is not possible to develop any site-specific concepts at this point. A set of hypothetical assumptions was used to develop order-of-magnitude unit costs. Assuming a desalter was constructed to treat 10 mgd of brackish groundwater that would result in approximately 1.5 mgd of brine produced. Using an estimate of 0.5 mgd/well, this would require three injection wells, assumed to be 4,000 feet deep. It is also assumed that the wells could be constructed within two miles of the desalter. The facilities that would be required would include a pump station, approximately two miles of delivery pipelines and three wells plus well head facilities. Estimated capital costs for a cluster of three wells plus piping and appurtenances would be approximately $7.6M including engineering and

Deep Well Injection with Dedicated Wells	
	contingencies to serve a 10 mgd desalter. Of this cost, approximately 60% represents the cost of drilling the wells and the remainder is for well head facilities, piping and a pump station. Operating costs would include the delivery pump station power and maintenance and replacement costs, injection pumping power and well operation and maintenance costs. Assuming that annual operating costs would be approximately 10% of the capital cost, this would result in annual operating costs for the same facilities of approximately $600,000.
Implementation: Status and Potential	Only know similar project in California for deep well brine injection not associated with the oil and gas industry is the previously noted Hilmar Cheese project which is not currently operational. There could be significant potential, limited primarily by storage capacity of the deep formations.
Implementation: Monitoring Documentation	
Implementation: Other Regulatory Approvals or Requirements	Construction and operation of injection wells for brine will require permitting under the Underground Injection Control (UIC) Program. These would likely be permitted as Class 1 Injection Wells as defined by the US Environmental Protection Agency (USEPA). These are defined as wells that inject hazardous and non-hazardous wastes below the lowermost underground source of drinking water (USDW). Injection must occur into deep, isolated rock formations that are separated from the lowermost USDW by layers of impermeable clay and rock.
Website:	

Supply Brine to Oil and Gas Industry for Use in Hydraulic Fracturing

Description

Under this approach, brine from reverse osmosis (or other concentration processes) treatment of groundwater would be delivered to users in the oil and gas industry for use in hydraulic fracturing. This is a type of "completion" technique where high pressure water, sand, and chemicals are injected usually thousands of feet below the surface into low permeability rock to create microscopic fractures that allow oil and natural gas trapped in small pores to migrate to the wellbore and be produced. The vast majority of wells in California are not hydraulically fractured because the geologic zones that have historically been targeted and explored are highly permeable and capable of yielding oil and gas without hydraulic fracture stimulation. The practice is reserved for reservoirs where the geologic conditions are such that the oil and natural gas cannot be commercially produced without the benefit of some form of stimulation. For this process, the brine would be used in lieu of other sources of water.



Before hydraulic fracturing can begin, the drilling rig is removed from the well pad and replaced with highly specialized equipment designed to complete the well. While it may take a drilling rig 2-3 weeks to drill a well, the hydraulic fracturing process usually takes just 1-2 days. Therefore, this is a one-time use for each fracturing well site, but typically multiple sites will be under completion more or less in sequence and therefore the overall need for brine could be close to continuous.

Constituent Salts or Nutrients Managed

Deep well injection would effectively manage all salts, nutrients and other constituents retained in the treatment process brine by injecting them in deep aquifers that do not have assigned beneficial uses. This option is distinct from Dedicated Deep Well Injection in which the brine would be stored in deep aquifers over long time periods. See **Dedicated Deep Well Injection**.

Applicability

Assuming oil and gas exploration and development in California continues for the foreseeable future, the industry has estimated that there could up to 700 wells/year drilled that would require water for hydraulic fracturing. The typical single well one-time water requirement estimated by the industry ranges from 80,000 to 300,000 gal. Using a drilling rate of 700 wells per year, and assuming drilling goes on essentially at a consistent rate over the year, this would effectively result in annual for demand for brine of approximately between 172

Supply Brine to Oil and Gas Industry for Use in Hydraulic Fracturing

	and 644 AFY, or average flow rate of between 0.15 and 0.58 mgd. The USGS has developed a Hydrologic Model of the Central Valley Far (http://ca.water.usgs.gov/projects/central-valley/central-valley-hydrologic-model.html) that assumes that the deepest layer of the "usable" groundwater aquifer where water is relatively fresh is approximately 2,700 feet below the surface at the center of the valley. Water that may be in formations deeper that this is considered to be saline. In most cases, more than a mile of impermeable rock and earth separate the hydraulically fractured zones and the overlying groundwater so that even large fractures are very unlikely to result in upward migrate anywhere close to the groundwater zone. There has been extensively drilling, exploration and mapping of the formations in which hydraulic fracturing is used to release oil and gas deposits by the oil and gas industry. The primary area where hydraulic fracturing has been and will continue to be used is in the Monterrey formation in the southern central valley. Therefore, this approach for managing brine will only be considered in the near term for brine that would be produced from desalters in the portions of the southern central valley. This could potentially include use in portions of IAZs 15, 19, 20 and/or 21 where the predominant fracturing activity is occurring.
Practice Benefits and Impacts	The principal benefit for this approach, in addition to a means of disposal/storage of brine is that the brine would substitute for other water sources that would otherwise be needed. These include local groundwater and surface water and other sources that the oil and gas industry must currently obtain through purchase or lease of rights. Furthermore, the brine would have value to the industry, presumably equivalent to or greater than the cost to acquire other water sources. Furthermore, the need for the water at specific locations and depths will have already been determined by the industry as part of its exploration and drilling program and does not require independent investigation of the aquifer to accept the water. The most significant limitation of this approach compared to dedicated injection is the relatively small demand for water compared to other options. As noted previously, even if the practice continues for a number of years, and almost all the use shifted to brine as the primary supply of water, the demand would only be in the range of roughly 200 – 600 AFY, a small fraction of the total brine that might potentially be produced to meet the desalination needs of the southern central valley alone. A second major issue is that the location where the brine would be needed would be continually changing as new fracturing wells are continuously being drilled and developed. This would suggest some form of temporary storage and either temporary piping or truck hauling of the water to new sites as the need occurs.

Supply Brine to Oil and Gas Industry for Use in Hydraulic Fracturing	
Effectiveness Documentation	Since hydraulic fracturing is a long established and proven process over many years in California, this can be an effective, if limited, use for brine. Chemical compatibility of the injected water and the formation to avoid plugging or fouling is likely much less of an issue compared to dedicated injection since this a short term use at any given well.
Supporting Documentation	
Implementation: Planning Level Costs	The primary costs for implementation is constructing delivery brine pipelines and, as necessary, pumping stations from regional or local desalters to locations where the water can be made available for use. Unlike dedicated injection, the point of uses will be continuously changing over time, so it is not possible to develop any site-specific concepts at this point. It is possible that there may need to be temporary storage and temporary pipelines. Unlike dedicated injection, there would be no permanent injection wells constructed as theses would be part of the drilling and completion operations constructed by the drilling company. Estimating capital costs for the delivery facilities is difficult since the location of the need for injection water would be changing over time. Operating costs would include the pump station power and maintenance and replacement costs and well operation and maintenance costs. Preliminary discussions suggest that the oil and gas companies would likely pay for these conveyance facilities. The capital costs also assume that there is electrical power relatively close by and that extraordinary cost to extend power distribution are not needed. However, this is a very site-specific issue that would need to be considered for any specific area.
Implementation: Status and Potential	Only known similar project in CA for deep well brine injection is not associated with the oil and gas industry is the previously noted Hilmar Cheese project which is not currently operational but there are thousands of injection wells that have been installed over the years for hydraulic fracturing. The potential for brine use, as noted above is very limited
Implementation: Monitoring Documentation	
Implementation: Other Regulatory Approvals or Requirements	Hydraulic fracturing is considered a "completion technique" that is part of the overall process of drilling a new well. Drilling a well is regulated through and Permitted by DOGGR under CCR 1722.2.
Website:	

Ocean Disposal of Brine through a Regulated WWTP

Description	Under this disposal option, brine from reverse osmosis (or other concentration processes) treatment of groundwater would be transported to a permitted WWTP, for example the East Bay Municipal Utility District's Main WWTP in Oakland, California. The Main WWTP is at the foot of the San Francisco Bay Bridge in West Oakland. EBMUD's wastewater service area is about 88 square miles and covers parts of Alameda and Contra Costa Counties. The brine would need to meet the discharge requirements of EBMUD's permit, including trace constituents that will be concentrated during RO.  Alternately, an alternate outfall could be designed and constructed. The new outfall would need pre-treatment prior to discharging brine to the Bay and would need to be regulated by the San Francisco Bay Water Board. In addition, all of the construction for the treatment facility, the pipelines, and the outfall would be need to permitted.
Constituent Salts or Nutrients Managed	Ocean disposal would effectively manage all salts, nutrients and other constituents retained by pre-treating the brine for trace constituents and then discharging TDS into the San Francisco Bay.
Applicability	Utilizing an existing WWTP with an ocean outfall or construction of new facilities is applicable. One example of its successful implementation is the IEBL which discharges through Orange County Sanitation District's WWTP in Fountain Valley, CA.
Practice Benefits and Impacts	The principal benefit for this disposal option is that it can manage all of the salt mass that accumulates on an annual basis in the Central Valley. As the population of Alameda and Contra Costa counties grows over the next 30 years EBMUD's WWTP plant capacity may need to be expanded or an alternate treatment facility/outfall may need to be constructed.
Effectiveness Documentation	As an example: http://www.sawpa.org/brineline/.
Supporting Documentation	CDM Smith (2010)

Implementation: Planning Level Costs	EBMUD's tip fee is currently 4 to 8 cents per gallon depending on the TDS concentration – this fee may be negotiable is a long-term agreement can be reached. The planning level cost for a new outfall is $500M.
Implementation: Status and Potential	IEUA – Non-Reclaimable Wastewater (NRW) System SAWPA – IEBL Calleguas Municipal Water District – Salinity Management Pipeline
Implementation: Monitoring Documentation	
Implementation: Other Regulatory Approvals or Requirements	
Website:	

Appendix C

Regulated Brine Line Q&A

Discussions concerning the Phase 2 SSALTs Report raised a number of questions about phasing, prioritization, optimization, and other considerations regarding development of a Central Valley regulated brine lines. While these questions ultimately would be addressed during the development of brine line project, preliminary answers are provided in this appendix.

Timeframe/Sustainability/Water Resources

What is the timeframe for the Central Valley regulated brine line project? What is meant by sustainable?

> *The proposed timeframe* for *the project is greater than 150 years.*[27] *The concept-level implementation plan outlined in Section 4.3 extends through a 50-year horizon. With an aggressive maintenance program, the system should perform for many decades. The need for salinity management will not diminish over time. This is not a groundwater plume from an anthropogenic point source that can be pumped and treated over a finite (but long) period. Salinity management is a requirement for the sustainability of the Central Valley aquifers for agricultural and potable supply beneficial uses.*

What are the water resources benefits, including recycled water, and what happens to the product water from the treatment system?

> *The brine line project can be viewed as a water supply sustainability project, whereby the costs incurred in salt treatment and disposal are balanced – to some extent – by the creation of new sources of high quality water.*[28] *There are several potential uses for the product water:*
>
> - *The product water can be used as a potable supply for local communities, some of whom may be disadvantaged and lack sources of drinking water other than pumped groundwater that may be high in salts and nitrate.*
> - *The water can be blended with groundwater or Central Valley Project water to increase irrigation supplies for growers in the valley.*
> - *The water can be used for a direct or in lieu exchange program with municipal water agencies. This option would require that there is a water supply balance with water that meets certain quality requirements.*

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[27] For context, the Inland Empire Brine Line (IEBL) construction has occurred over a 23-year period and the IEBL has been in operation for 37 years. The IEBL was originally called the Santa Ana Regional Interceptor (SARI) and "is a unique and indispensable resource for the Inland Empire region [of southern California], providing a facility for exporting salt from inland areas to the ocean. Salt export is important for protecting water quality and meeting regulatory requirements." http://www.sawpa.org/brineline/ The IEBL was constructed by the Santa Ana Watershed Project Authority (SAWPA).

[28] The product water would have an annual benefit of close to $1B.

- *The product water can also be used for environmental purposes, likely through an in lieu exchange program.*

All of these alternative uses of the product water will need to undergo a rigorous benefit-cost analysis to ensure that the water is used to the maximum benefit of the people of the state of California and that no group of stakeholders is unreasonably harmed. In addition, the use of recycled water as a water supply source through indirect potable reuse (IPR) projects needs to be considered to augment future water supplies. This analysis would begin as part of the development of the Concept Design for the project and factor into the environmental analyses.

Regulatory

For a phased strategy to work, the Central Valley Water Board must think strategically with regard to permitting and expected salt impacts to groundwater. How can this be accomplished?

As discussed in Section 3, compliance credits, pollution offsets, alternative compliance projects, and regulatory flexibility are crucial to the implementation of the brine line project. For example, an outfall to the ocean or to San Francisco Bay would be a key regulatory hurdle to overcome. Other potential long-term management solutions could include de-designating certain groundwater subbasins from MUN and/or AGR beneficial uses (e.g., as currently proposed for a portion of the Tulare Lake Bed).

Prioritization and Phasing

How is the prioritization and phasing developed? Will the brine line remove salt in groundwater basins and geographic areas where the greatest benefit to the people of California is achieved?

Section 4.3 discusses a Phase 1 Prioritization and Optimization Study proposed as the first phase for implementation under the Salinity Management Strategy. A summary of analyses/activities to be completed during this Phase is provided which includes looking at salt management by hydrologic region so as to prioritize/optimize the need for salt management taking into account regional differences.

What are the criteria that will drive the prioritization process?

Examples of these criteria include: efficiency in removing salt from the Central Valley, providing new sources of water for potable and irrigation uses, protection of MUN and AGR beneficial uses, land management strategies, crop sustainability, and concerns about DACs and DUCs. All of these factors will need to be addressed. The overall greatest benefit will be optimized by taking into account input from stakeholders through facilitated meetings.

How will desalters be phased-in for priority areas along the regulated brine line as it is being constructed?

Phase 1 studies will look for project opportunities along the planned brine line alignment that are in the master plan for prioritization and phasing, again balancing salt removal efficiencies with other factors including crop sustainability and drinking water supplies.

Will existing projects and shovel-ready projects (so called, low-hanging fruit) be given a higher priority?

Yes, existing projects and projects that will be operational in the short-term will be given consideration in the master plan for prioritization and phasing. An example is SJRIP which is managing drain water that will be at RO-like brine TDS concentrations when the brine line is constructed. This early project will allow for the export of salt out of the valley without building a desalting facility.

How will development of a regulated brine line project ensure that it is addressing high salinity caused by urban or agricultural activities and not naturally-occurring salinity?

This will be addressed in the Phase I - Prioritization and Optimization Study, and Phase II Design activities where key land management decisions will be evaluated. A policy decision may need to be made regarding priority/approach for managing salts in areas where groundwater that underlies marine sediments contributes naturally-occurring salts to the salt load. These policy questions will need to be informed with an understanding of hydrogeological conditions and water quality at the local- or subregional scale. Siting extraction facilities and developing the drainage systems necessary to implement the development of treatment plants along the regulated brine line will be complicated and will occur during these first two phases. Also during these phases, areas where salt is naturally-accumulating will be identified, so that salt management areas (similar to SJRIP and the Tulare Evaporation Ponds) can be considered for construction and operation in the interim period while the brine line is constructed. These salt management areas will likely be necessary to sequester salts in-valley until the out-of-valley solution is completed.

Other Key Questions

How will nitrates in groundwater be dealt with?

Nitrate in groundwater and agricultural drain water will be removed as a salt through the treatment system (RO for the purposes of this concept-level implementation plan). Emerging technologies that will be considered in the future must treat nitrate efficiently, as well. The Prioritization and Optimization Study will review other studies and existing data to determine groundwater areas that have relatively high nitrate concentrations so that projects implemented to manage salts treat both TDS and nitrate.

How will the success of long-term salt management projects in mitigating salt accumulation in groundwater be measured?

A Surveillance and Monitoring Program (SAMP) is currently being developed for the Central Valley that will provide data for ambient water quality determinations and trend analyses. The SAMP, as part of the SNMP, will meet the monitoring requirements of the BPA and support its adoption and approval.

How does the Sustainable Groundwater Management Act (SGMA) of 2014 impact the regulated brine line?

The SGMA requires that local groundwater sustainability agencies (GSAs) be formed to assess groundwater basins and adopt groundwater sustainability plans (GSPs). GSAs with high- and medium-priority basins must adopt groundwater sustainability plans within five to seven years (five years if critically overdrafted and seven years if not). The SGMA allows for a period of 20 years for GSAs to implement those plans and achieve long-term groundwater sustainability. At a minimum, it is recommended that CV-SALTS work closely with the GSAs in order to ensure that the goals and objectives of the SNMP and the GSPs are aligned. In fact, local agencies charged with salt management responsibilities would likely join GSAs so that groundwater sustainability (water supply and water quality – along with other goals) is achieved.

How will the regulated brine line be funded?

This will be a large infrastructure project of national importance. The original SWP cost about $18B in today's dollars[29]; capital costs for the regulated brine line project are estimated at about $11B. Funding will need to come from various stakeholders, including federal, state, and local agencies, as well private companies and the agricultural community. State and local agencies may not have the authority to commit to capital projects of the scale proposed by the findings of SSALTS without partnership agreements and commitments from federal agencies. Likewise, state and local agencies as well as local stakeholders will need to commit to long-term O&M costs. Funding strategies will be developed during the development of the Funding Plan that will be developed under Phase I of the Salinity Management Strategy.

[29] http://blogs.kqed.org/science/2013/05/30/state-puts-25-billion-price-tag-on-water-tunnel-plan/

Appendix D

Table 2-4: SSALTS Alternatives and Summary of Costs

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Table 2-4
SSALTS Alternatives and Summary of Costs

Alternative 1 – San Francisco Bay Discharge EBMUD + DIW + HF

Component	Notes	Capacity (MGD)	Capacity (AFY)	Product Water (AFY)	Capital (x $1M)	O&M (x $1M)	Revenue (x $1M)
Source Control BMPs	a						
Deep Injection Wells - IAZ 6							
Extraction Wells	b	168	226,154	203,539	$217	$22	
Desalter Facilities	c	175	235,577		$1,050	$105	
DIW: IAZ 6	d	17.5	23,558		$137	$14	
Value of the Product Water - IAZ 6	e						$204
Central Valley Brine Line							
Extraction Wells	f	750	1,009,617	908,656	$972	$97	
Desalter Facilities	g	825	1,110,579		$4,950	$495	
Post-RO Treatment for Trace Constituents	h	75	100,962		$150	$15	
CVBL	i	75	100,962		$771	$77	
CVBL Pump Stations	j	75	100,962		$258	$72	
Disposal at WWTP	k	75	100,962			$1,096	
Biosolids Exported out of Alameda County	l						$1.40
Value of the Product Water - Other IAZs	m						$909
SF Bay Outfall	n						
Other Salt Transport Options							
LSJR RTMP	o						
Alternate Disposal Methods							
Hydraulic Fracturing	p	0.58	781				$0.75
SJRIP-Type Salt Storage Facilities	q						
Tulare Lake-Type Salt Storage Facilities	r						
Totals					$8,505	$1,992	$1,114
Contingency (30%)					$2,551	$598	
Totals Plus Contingency					$11,056	$2,590	$1,114
Interest Rate					3.0%		
Present value of life cycle costs over 30 Years					$73,054		
Present value of revenues over 30 Years					$21,842		
Net present value of life cycle costs over 30 Years					$51,212		
Present value of life cycle costs/AF of product water					$2,189		
Present value of revenue/AF of product water					$655		

Alternative 2 – SF Bay Alternative Outfall + DIW + HF

Component	Capacity (MGD)	Capacity (AFY)	Product Water	Capital (x $1M)	O&M (x $1M)	Revenue (x $1M)
Source Control BMPs						
Deep Injection Wells - IAZ 6						
Extraction Wells	168	226,154	203,539	$217	$22	
Desalter Facilities	175	235,577		$1,050	$105	
DIW: IAZ 6	17.5	23,558		$137	$14	
Value of the Product Water - IAZ 6						$204
Central Valley Brine Line						
Extraction Wells	750	1,009,617	908,656	$970	$97	
Desalter Facilities	825	1,110,579		$4,950	$495	
Post-RO Treatment for Trace Constituents	75	100,962		$150	$15	
CVBL	75	100,962		$771	$77	
CVBL Pump Stations	75	100,962		$258	$72	
Disposal at WWTP	75	100,962				
Biosolids Exported out of Alameda County						
Value of the Product Water - Other IAZs						$909
SF Bay Outfall				$500	$25	
Other Salt Transport Options						
LSJR RTMP						
Alternate Disposal Methods						
Hydraulic Fracturing	0.58	781				$0.75
SJRIP-Type Salt Storage Facilities						
Tulare Lake-Type Salt Storage Facilities						
Totals				$9,003	$921	$1,113
Contingency (30%)				$2,701	$276	
Totals Plus Contingency				$11,704	$1,198	$1,113
Interest Rate				3.0%		
Present value of life cycle costs over 30 Years				$46,777		
Present value of revenues over 30 Years				$21,814		
Net present value of life cycle costs over 30 Years				$24,963		
Present value of life cycle costs/AF of product water				$1,402		
Present value of revenue/AF of product water				$654		

Alternative 3 – SF Bay Discharge EBMUD + DIW + LSR RTMP + HF

Component	Capacity (MGD)	Capacity (AFY)	Product Water	Capital (x $1M)	O&M (x $1M)	Revenue (x $1M)
Source Control BMPs						
Deep Injection Wells - IAZ 6						
Extraction Wells	168	226,154	203,539	$217	$22	
Desalter Facilities	175	235,577		$1,050	$105	
DIW: IAZ 6	17.5	23,558		$137	$14	
Value of the Product Water - IAZ 6						$204
Central Valley Brine Line						
Extraction Wells	750	1,009,617	908,656	$972	$97	
Desalter Facilities	825	1,110,579		$4,950	$495	
Post-RO Treatment for Trace Constituents	75	100,962		$150	$15	
CVBL	75	100,962		$771	$77	
CVBL Pump Stations	75	100,962		$258	$72	
Disposal at WWTP	75	100,962			$1,096	
Biosolids Exported out of Alameda County						$1.40
Value of the Product Water - Other IAZs						$909
SF Bay Outfall						
Other Salt Transport Options						
LSJR RTMP						
Alternate Disposal Methods						
Hydraulic Fracturing	0.58	781				$0.75
SJRIP-Type Salt Storage Facilities						
Tulare Lake-Type Salt Storage Facilities						
Totals				$8,505	$1,992	$1,114
Contingency (30%)				$2,551	$598	
Totals Plus Contingency				$11,056	$2,590	$1,114
Interest Rate				3.0%		
Present value of life cycle costs over 30 Years				$73,054		
Present value of revenues over 30 Years				$21,842		
Net present value of life cycle costs over 30 Years				$51,212		
Present value of life cycle costs/AF of product water				$2,189		
Present value of revenue/AF of product water				$655		

Alternative 4 – SF Bay Discharge EBMUD + DIW + LSR RTMP + SAA + HF

Component	Capacity (MGD)	Capacity (AFY)	Product Water	Capital (x $1M)	O&M (x $1M)	Revenue (x $1M)
Source Control BMPs						
Deep Injection Wells - IAZ 6						
Extraction Wells	168	226,154	203,539	$217	$22	
Desalter Facilities	175	235,577		$1,050	$105	
DIW: IAZ 6	17.5	23,558		$137	$14	
Value of the Product Water - IAZ 6						$204
Central Valley Brine Line						
Extraction Wells	750	1,009,617	908,656	$970	$97	
Desalter Facilities	825	1,110,579		$4,950	$495	
Post-RO Treatment for Trace Constituents	71	95,577		$142	$15	
CVBL	71	95,577		$771	$77	
CVBL Pump Stations	71	95,577		$258	$72	
Disposal at WWTP	71	95,577			$1,037	
Biosolids Exported out of Alameda County						$1.40
Value of the Product Water - Other IAZs						$909
SF Bay Outfall						
Other Salt Transport Options						
LSJR RTMP						
Alternate Disposal Methods						
Hydraulic Fracturing	0.58	781				$0.75
SJRIP-Type Salt Storage Facilities	1.70	2,290				
Tulare Lake-Type Salt Storage Facilities	2.43	3,266		$8.33	$0.83	
Totals				$8,504	$1,934	$1,114
Contingency (30%)				$2,551	$580	
Totals Plus Contingency				$11,055	$2,515	$1,114
Interest Rate				3.0%		
Present value of life cycle costs over 30 Years				$71,568		
Present value of revenues over 30 Years				$21,842		
Net present value of life cycle costs over 30 Years				$49,727		
Present value of life cycle costs/AF of product water				$2,145		
Present value of revenue/AF of product water				$655		

Alternative 2/4 – SF Bay Alternative Outfall + DIW + LSR RTMP + SAA + HF

Component	Capacity (MGD)	Capacity (AFY)	Product Water	Capital (x $1M)	O&M (x $1M)	Revenue (x $1M)
Source Control BMPs						
Deep Injection Wells - IAZ 6						
Extraction Wells	168	226,154	203,539	$217	$22	
Desalter Facilities	175	235,577		$1,050	$105	
DIW: IAZ 6	17.5	23,558		$137	$14	
Value of the Product Water - IAZ 6						$204
Central Valley Brine Line						
Extraction Wells	750	1,009,617	908,656	$970	$97	
Desalter Facilities	825	1,110,579		$4,950	$495	
Post-RO Treatment for Trace Constituents	71	95,577		$142	$15	
CVBL	71	95,577		$771	$77	
CVBL Pump Stations	71	95,577		$258	$72	
Disposal at WWTP	71	95,577				
Biosolids Exported out of Alameda County						
Value of the Product Water - Other IAZs						$909
SF Bay Outfall				$500	$25	
Other Salt Transport Options						
LSJR RTMP						
Alternate Disposal Methods						
Hydraulic Fracturing	0.58	781				$0.75
SJRIP-Type Salt Storage Facilities	1.70	2,290				
Tulare Lake-Type Salt Storage Facilities	2.43	3,266		$8.33	$0.83	
Totals				$9,004	$922	$1,113
Contingency (30%)				$2,701	$277	
Totals Plus Contingency				$11,705	$1,199	$1,113
Interest Rate				3.0%		
Present value of life cycle costs over 30 Years				$46,799		
Present value of revenues over 30 Years				$21,814		
Net present value of life cycle costs over 30 Years				$24,985		
Present value of life cycle costs/AF of product water				$1,403		
Present value of revenue/AF of product water				$654		

AFY acre feet per year
BMPs best management practices
DIW Deep Injection Well
HF Hydraulic Fracturing
IAZ Initial Analysis Zone
LSJR RTMP Lower San Joaquin River Real Time Management Program
MGD million gallons per day
NPV net present value
SAA Salt Accumulation Area

4.375

Notes:
a The tons of salt potentially eliminated by source control measures and associated costs have not been determined at this time.
b About 168 MGD would need to be produced from IAZ-6 to balance salt inflows and outflows. At an assumed 750 gpm per well, this would require 155 wells at $1.4M per well. (Table 4-2 in the Phase 2 SSALTS Report
c 168 MGD would require 7 25-MGD desalter facilities (for a total capacity of 175 MGD). Each 25-MGD plant will be $150M. (Table 4-2 in the Phase 2 Report.
d At 90 percent efficiency, about 17.5 MGD of brine would be produced by RO facilities in IAZ 6. A cluster of 4 wells can inject about 1 MGD of brine. Eighteen deep well injection facilities at $7.6M would be required to dispose of the 17.5 MGD of brine concentrate produced for a total of $137M
e The product water will be put to beneficial uses. Assume it will be used for potable supply at $1000 per AF
f About 750 MGD would need to be produced from the middle and southern IAZs to balance salt inflows and outflows. At an assumed 750 gpm per well, this would require 693 wells at $1.4M per well. (Table 4-1 in the Phase 2 SSALTS Report
g 750 MGD would require 33 25-MGD desalter facilities (for a total capacity of 825 MGD). Each 25-MGD plant will be $150M. (Table 4-1 in the Phase 2 SSALTS Report
h The cost to add treatment for trace constituents (ion exchange) at each desalination facility of a capacity equal to the expected brine flow rate ranges from $3/gpd to $4/gpd.
i Per Table 6-1 in the Phase 2 SSALTS Report.
j Capital costs are based horsepower required, which is based on total dynamic head (static lift, friction loss, and minor losses. Maintenance at 5 percent; power costs based on horsepower
k EBMUD's tip fee is about $0.04 per gallon. No tip fee assumed for Alternative 2
l About $32 per ton to transport and apply biosolids to agricultural land outside of Alameda County. At 6 truckloads per day and 20 tons per truck (120 tons per day) = $1.4M per year
m The product water will be put to beneficial uses. Assume it will be used for potable supply at $1000 per AF
n Includes construction of the outfall, pipeline to the bay, CEQA, and permitting.
o Assimilative capacity is currently being determined by the LSJR committee.
p Tables 5-2 and 5-3 in the Phase 2 SSALTS Report.
q Costs and capacity have not been fully developed for the SJRIP area. Costs for reduction of flow to WWTP are accounted for
r The new evaporation basin will have an area of 1850 acres and an evaporation capacity of 9250 AFY. Construction costs at $4500/acre = $8.3M. Does not include land acquisition or CEQA. Capacity - 9250 AFY at 6400 mg/L converted to equiv. capacity of 1.73 MGD at 25,429 mg/L.

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Appendix E

Response to Comments on the September 2016 version of the Phase 3 SSALTS Report

Appendix E – Comments and Responses on the September 2016 Draft Phase 3 SSALTS Report

No.	Commenter	Page	Reference	Comment	Response
Glenn Meeks | Central Valley Regional Water Quality Control Board| October 5, 2016 | Comments on September 2016 version of the Phase 3 SSALTS Report					
1	Glenn Meeks	1-2	Section 1.3. Phase 2 – Develop Potential Salt Management Strategies	Right now, this document is very brine line centric. We need to talk about how this is the main focus, but that it doesn't work everywhere (e.g. the whole east side of the Central Valley, the Sac Valley, etc.). We need a more extensive section on other BMPs and projects, like storm water recharge projects, that work in these areas where the brine line doesn't make sense.	Subsection 2.2.3, addressing stormwater and recycled water recharge has been added.
2	Glenn Meeks	2-2	Section 2. Summary of Phase 2 - Develop Potential Salt Management Strategies	This is very brine-line oriented. I know the brine line is needed to handle the lion's share of the salt, but the discussed alternatives should be for the entire Central Valley, not just for the areas that a brine line works. We need to include other strategies as discussed earlier like storm water recharge.	Subsection 2.2.3, addressing stormwater and recycled water recharge has been added.
3	Glenn Meeks	2-13	Section 2.2 Reduction and Management of Salt Contributions to Groundwater	Need to discuss storm water recharge projects as a way of addressing salinity in groundwater somewhere in this area.	Subsection 2.2.3, addressing stormwater and recycled water recharge has been added.
4	Glenn Meeks	2-19	Section 2.4.2 Tulare Lake Bed	Do we have estimated costs for these items? If so, we should put them in.	A footnote has been added. "Costs for the construction and operation of brine evaporation basins will be highly variable and will depend to a large extent on land acquisition. As an example, a new evaporation basin is being constructed for TLDD – the construction costs are projected to be about $4500/acre. This does not include land acquisition or CEQA."
5	Glenn Meeks	2-30	Alternative 1 for IAZ 6	Couldn't we do storm water recharge in IAZ 6 also?	Subsection 2.2.3, addressing stormwater and recycled water recharge has been added.
6	Glenn Meeks	4-8	4.3 Long-Term Management of Salts in the Central Valley	Need to include reorganization of CV-SALTS and obtaining funding to perform the Phase I work.	Text describing the governance and funding of the P&O Study itself was added to this paragraph in Section 4.3. The estimated costs to complete the Phase I Prioritization and Optimization Study range from approximately $7 to $13 million (see

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					Table 4-4), and as discussed above, is expected to take 10 years to complete. Given the cost and time associated with this comprehensive, valley-wide effort, CV-SALTS has recommended that (a) all (or almost all) dischargers of salinity help fund its implementation; (b) entities beyond dischargers that also benefit from salinity management in the Central Valley participate in funding the Priority and Optimization Study as well as implementation of Phases II and III as applicable; and (c) others that benefit from the Central Valley's control of salinity should also be part of this effort and assist in funding this Phase I Study. *The CV-SALTS/CVSC framework can be enlisted to provide the governance structure and to seek the initial funding of the P&O Study.*
7	Glenn Meeks	4-8	4.3 Long-Term Management of Salts in the Central Valley	Is this for storm water recharge projects? While I understand that the main focus is on the brine line, we need to indicate somewhere in this document that the brine line doesn't work for everywhere in the Central Valley (e.g. the east side of the valley), so we need to elaborate a little more on the storm water recharge alternatives, as that is pretty much are other measure to address salinity in groundwater.	The following text was added to Section 2.2.3: "Some management zones may not be suitable candidates, based on benefit/cost analyses for RO/brine management through the regional brineline, due to distance to the brineline and lower – but still problematic – TDS concentrations in groundwater. Source control BMPs and stormwater/recycled water recharge would be critical to the sustainable management of salinity in these management zones.
Michael Nordstrom | Tulare Lake Drainage/Storage | October 5, 2016 | Comments on September 2016 version of the Phase 3 SSALTS Report. Verbal comments provided to Roger Reynolds and summarized below.					
8	Michael Nordstrom	Page 2-3		The salt loading in the Southern Central Valley is listed at 3,675,000 tons/yr. Mike felt this seems high.	The estimates of mass of salt accumulating in each IAZ is an outcome of the modeling work performed by CV-SALTS. These values are representations of salt fluxes based on the best input data available and using a calibrated and vetted numerical

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					model. *Initial Conceptual Model (ICM), Technical Services Tasks 7 and 8 – Salt and Nitrate Analysis for the Central Valley Floor and a Focused Analysis of Modesto and Kings Subregions. Final Report* (LWA Team, 2013)
9	Michael Nordstrom	Page 2-4	Figure 2-2	The Tulare Lake Bed is located in the southerly part of IAZ 15. Mike felt IAZ 15 covers the Northeast central portion of the valley above Tulare Lake Bed and the southerly part covers the Tulare Lake Bed. These are two different hydro-geologic areas and with the potential designation of the Tulare Lake Bed thought it would make more sense to split the IAZ in half.	The IAZs were defined in the ICM modeling work (LWA Team, 2013). Moving forward, the hydrogeologic discretization will be at the groundwater basin / subbasin or management zone scale.
10		Page 2-15	Section 2.3 Treatment Technologies and Potential Marketability	Mike mentioned the Element Renewal system will remove the heavy metals which will make it easier to handle and deal with salt storage	The following description is in Section 2.3, on Page 2-16 (emphasis added): "Element Renewal's system consists of four main processes: (i) pre-treatment, (ii) RO, (iii) self-generated power unit, and (iv) solids processing. *Pre-treatment is a chemical/mechanical separation process, designed to maximize the flows, while selectively removing contaminants such as trace metals and organic chemicals present in the drainage water.* The water is then treated with RO. On site power is self-generated with a natural gas fired stationary fuel cell power unit for cogeneration use of thermal energy with solids processing. Solids processing separates the water from the pre-treatment solids and RO brine. The solids and salts are reduced to dry concentrates by utilizing thermal energy from the power generation, and are separated into forms that may allow for their recycle and/or sale as commodities. The solids processing results in Element Renewal's system achieving ZLD. This

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					technology is being pilot tested at Tulare Lake Bed."
11	Michael Nordstrom	Page 2-19	Section 2.4.2 Tulare Lake Bed	In the first sentence of the last paragraph Mike noted the ranges of TDS in the groundwater at the future MEB site have a higher range than listed. I told him these were the values measured in the drainage water pumped from the existing subsurface drainage system in 2014 tests. Mike mentioned the District has had some additional testing done which shows TDS in some areas at the MEB site have groundwater with TDS ranges varying up to 25,000 mg/L.	Comment noted. This additional information will be added to the report.
12	Michael Nordstrom	Page 2-15	Section 2.7 Brine and Salt Transportation Options	Mike mentioned in the development of different brine line options there will still be a need for construction of brine line laterals and desalters, and commented there will be a need for some "short term" on site disposal facilities to store salt and brine water.	Comment noted. The plan includes salt management areas for storage of salt and brine in the interim period. The costs for the extraction facilities includes lateral pipelines and other appurtenances.
13	Michael Nordstrom	Page 3-5	Section 3.3.2 Feasibility Analysis of Salt Management and Disposal Options	Mike asked why none of the different treatment options listed in Table 4-1 for separating or removing salt from drainage or brine water listed or recommended in the Salt Management and Disposal Options summarized on page 3-5?	For the purpose of developing cost estimates for the alternatives, reverse osmosis (RO) was selected as the treatment technology in Phases 2 and 3. However, as discussed in Section 2.3 of this report, emerging technologies will continue to evolve and scale up from pilot studies to mature, proven treatment technologies. The efficacy and economics of these technologies will continue to be evaluated.