Memorandum

DATE:	October 5, 2015	
TO:	Michael Johnson, LSJRC Manager	
COPY TO:	Lower San Joaquin River Committee Larry Walker Associates (LWA) Team	

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SUBJECT: **Development of a Basin Plan Amendment for Salt and Boron in the Lower San Joaquin River (LSJR):**

Task 5 – Economic Analysis

INTRODUCTION

This memorandum is being submitted on behalf of the LWA Team[1] to fulfill the requirements of Task 5 in the Scope of Work for the *Development of a Basin Plan Amendment for Salt and Boron in the Lower San Joaquin River* (Workplan). The purpose of Task 5 is to conduct a planning level economic analysis showing the costs of implementation of selected project alternatives for various discharge sectors. In addition, the analysis must include the costs of alternative salinity water quality objectives (WQOs) that may provide a higher level of protection[2]. Information generated in *Task 4 – Implementation Planning for Proposed Salinity Objectives*, October 5, 2015, (Task 4 Report; LWA 2015a) was used to support the economic analyses.

BACKGROUND

The California Water Code and Public Resources Code require that the Central Valley Regional Water Quality Control Board (Regional Water Board) consider economics in adopting new water quality objectives. In considering economics, the Regional Water Board is required to examine

[1] The LWA Team consists of the following firms: Larry Walker Associates, Carollo Engineers, Kennedy/Jenks Consultants, Systech Water Resources, PlanTierra, Luhdorff and Scalmanini Consulting Engineers, Ascent Environmental, and Dr. Richard Howitt.

[2] Per personal communication with Betty Yee, Central Valley Regional Water Quality Control Board, the economic analysis does not need to include a qualitative cost benefit evaluation (May 15, 2013).

three statutory provisions as they relate to the actions contained in the proposed Basin Plan Amendment (BPA).

These statutory provisions include Water Code § 13241(d), Water Code § 13141, and Public Resources Code § 21159.

1. Water Code § 13241(d) requires that the Regional Water Board consider economics when establishing water quality objectives. This memorandum predicts that no additional cost will be required as a result of adoption of the proposed objectives. As such, it satisfies the subject Water Code requirement. **Attachment A** provides the Regional Water Board with supplemental information related to costs for specific implementation actions included in the preferred alternative.
2. Water Code § 13141 requires that, prior to the implementation of any agricultural water quality control program, the Regional Water Board must have an estimated cost of such a program, together with an identification of potential funding sources. This memorandum predicts that a new agricultural program will not be required to achieve the proposed electrical conductivity (EC) water quality objective. As such, it satisfies the subject Water Code requirement. **Attachment B** provides information regarding the overall cost of implementing an alternative EC objective of 1010 µmhos/cm in Reach 83. A portion of those overall costs would be the responsibility of the agricultural community, if the alternative objective was adopted.
3. Public Resources Code § 21159 requires the Regional Water Board, when adopting a BPA that includes installation of pollution control equipment, or a performance standard or treatment requirement, including a rule or regulation that requires the installation of pollution control equipment or a performance standard or treatment requirement pursuant to the California Global Warming Solutions Act of 2006 (Division 25.5 (commencing with Section 38500) of the Health and Safety Code), to conduct an environmental analysis of the reasonably foreseeable methods of compliance. This environmental analysis is required to take into account a reasonable range of environmental, economic, and technical factors, population and geographical areas, and specific sites. This memorandum explains that new pollution control equipment above already planned actions will not be required to implement the proposed water quality objective, and thereby satisfies the requirements of Public Resources Code § 21159 as it relates to the economics of the preferred alternative. **Attachment A** provides supplemental information regarding economic factors associated with the preferred alternative.

The Watershed Analysis Risk Management Framework (WARMF) modeling of the implementation of the three[3] salinity management alternatives described in the Task 4 Report (Section 4) provides information regarding the actions required to attain a range of ambient salinity levels (from 1,010 to 1,550 µmhos/cm) in Reach 83[4] of the LSJR (LWA 2015a). WARMF modeling results from one of the three salinity management alternatives, the Planned Plus Maximum Management Focus Alternative, which would divert all flows from Mud and Salt

[3] (1) Planned Alternative, (2) Planned Plus Maximum Treatment Focus Alternative, and (3) Planned Plus Maximum Management Focus Alternative. See Task 4 Report (Section 3) for a description of the implementation actions included in each alternative (LWA 2015).

[4] Reach 83 is defined as that segment of the San Joaquin River from the mouth of the Merced River to Vernalis.

sloughs and apply them to land in the Grassland Drainage Area as part of a San Joaquin River Basin Implementation Program-like project, showed that permanent diversion of water from the Lower San Joaquin River provides no significant additional EC improvement compared to the Preferred Alternative. For this reason, the Planned Plus Maximum Management Focus Alternative was eliminated from further consideration as a management alternative.

WARMF modeling information was used to assist in the development of seven distinct EC WQO alternatives in Reach 83 (see Task 4 Report, Tables 9 and 10; LWA 2015a).

The Lower San Joaquin River Committee (LSJRC) considered these seven WQO alternatives, using evaluation criteria and associated WARMF modeling results. Based on that information, the LSJRC identified four project alternatives (#'s 1, 2, 4, and 6) for more detailed examination and consideration in the Basin Planning process. These alternatives are listed below in **Table 1**. After further consideration, the LSJRC selected Project Alternative #4 as the preferred EC water quality objective (Preferred Alternative) for Reach 83.

Table 1: Lower San Joaquin River Committee Basin Plan Amendment Project Alternatives.

Project Alternatives **EC Water Quality Objective** **(as measured at Crow's Landing)**	**Technical Basis for the Water Quality Objective**
1. No EC Objective	Continue to regulate dischargers pursuant to the Salt and Boron TMDL
2. 1,550 µmhos/cm EC Objective	Hoffman Model Results • 15% leaching fraction • Protection of 95% of the most common crop (almonds) • 95% almond crop yield in all but the 5% driest years
4. 1,550 µmhos/cm EC Objective and a 1,350 µmhos/cm EC Performance Goal for Seasonal and Water Year Considerations **(see Table 2)**	Hoffman Model Results • 1,350 µmhos/cm – Leaching fraction between 10 – 15% with same crop protection and yield as option #2 • 1,550 µmhos/cm – same technical basis as WQO option #2
6. 1,010 µmhos/cm EC Objective	Hoffman Model Results • 10% leaching fraction • Protection of 95% of the most common crop (almonds) • 95% almond crop yield in all but the 5% driest years

The Preferred Alternative is to adopt an EC WQO and an EC Performance Goal for seasonal and water year considerations in Reach 83 of the LSJR, as shown in **Table 2**. The proposed EC WQO and EC Performance Goal are protective of the existing agricultural irrigation supply (AGR) beneficial use and the potential municipal and domestic supply (MUN) beneficial use designated in Reach 83. The WQO and Performance Goal consider agriculture's seasonal demands for water diverted from Reach 83, while at the same time accounting for the fact that ambient water quality conditions are greatly influenced by hydrologic conditions, including the presence of return flows, in the San Joaquin River Basin.

The Preferred Alternative includes a 30-day running average EC WQO of 1,550 µmhos/cm. Compliance with the WQO in Reach 83 shall be evaluated at Crows Landing. The WQO would apply as indicated in **Table 2**, except during an "extended dry period". An Extended Dry Period is defined as follows:

An Extended Dry Period is defined using the State Water Resources Control Board's (SWRCB's) San Joaquin Valley "60-20-20" Water Year Hydrologic Classification[5] included in Revised Water Right Decision 1641 to assign a numeric indicator to a water year type as follows (SWRCB 2000):

- Wet – 5
- Above Normal – 4
- Below Normal – 3
- Dry – 2
- Critically Dry – 1

The indicator values will be used to determine when an Extended Dry Period is in effect:

- An Extended Dry Period shall begin when the sum of the current year's 60-20-20 indicator value and the previous two year's 60-20-20 indicator values total six (6) or less.
- An Extended Dry Period shall be deemed to exist for one water year (12 months) following a period with an indicator value total of six (6) or less.

Table 2: LSJR Reach 83 EC Objective and Performance Goal for Seasonal and Water Year Considerations (μmhos/cm).

Water Year Type	Irrigation Season		Non-irrigation Season
	March – June	July – October	November – February
Wet	1350 (Performance Goal[1])		1550 (WQO[1])
Above Normal	1350 (Performance Goal[1])		1550 (WQO[1])
Below Normal	1350 (Performance Goal[1])	1550 (WQO[1])	
Dry	1350 (Performance Goal[1])	1550 (WQO[1])	
Critical	1550 (WQO[1])		

1. The EC Performance Goal and EC WQO are subject to relaxation during an Extended Dry Period (see definition above).

During an Extended Dry Period (defined above), the following shall be taken into consideration to ensure that beneficial uses are protected in Reach 83 of the LSJR (as monitored at Crows Landing):

- <u>Protection of the designated potential MUN beneficial use</u>: The EC WQO shall be the Short Term specific conductance secondary MCL level contained in the Water Quality Control Plan (Basin Plan) for the Sacramento River Basin and the San Joaquin River Basin. (Currently incorporated from Table 64449-B of 22 CCR §

[5] The method for determining the San Joaquin Valley Water Year Hydrologic Classification (e.g., critical, dry, below normal, above normal, wet) is defined in the SWRCB Revised Water Right Decision 1641, March 2000, Figure 2, page 189. This method uses the best available estimate of the 60-20-20 San Joaquin Valley water year hydrologic classification at the 75% exceedance level using the best available data published in the California Department of Water Resources' ongoing Bulletin 120 series.

64449 at the level of 2,200 µmhos/cm as the average of the previous four (4) consecutive quarterly samples).

- Protection of the AGR beneficial use: The EC WQO shall be 2,470 µmhos/cm as a 30-day running average. (Derived from the Hoffman model results for 75% crop yield for almonds, 5th percentile rainfall, and 15% leaching fraction).
- Implementation of the Extended Dry Period EC WQO relaxation and/or EC concentrations in Reach 83 above 1,550 µmhos/cm shall not result in requirements for increased water quality releases from New Melones Reservoir to meet Vernalis EC objectives.

The Preferred Alternative also includes the implementation of an EC Performance Goal[6] of 1,350 µmhos/cm that is recommended to be established throughout the irrigation season for specific water year types (see **Table 2**). Attainment of the EC Performance Goal in Reach 83 shall be evaluated using the 30-day running average calculated from monitoring data collected at Crows Landing. The 1,350 µmhos/cm EC value was established as a Performance Goal because:

- The WARMF modeling of the Planned Bundle (Preferred Alternative) indicates that, after full implementation of the key actions underway within the LSJR Basin, the ambient water quality within Reach 83 of the LSJR will not exceed an EC value of 1,350 µmhos/cm at Crows Landing. However, due to model uncertainty, the WQO was set at 1,550 µmhos/cm which is the value that is reasonably protective of the AGR (irrigation supply water) beneficial use based on Hoffman modeling results (95% crop yield for almonds, 5th percentile rainfall, 15% leaching fraction).
- Agricultural supply water at 1,350 µmhos/cm or lower would provide a higher level of protection during the irrigation season based on Hoffman modeling results.
- Water quality at 1,350 µmhos/cm or better would also help to maintain the soil salinity balance by flushing salt accumulated below the soil root zone during Extended Dry Periods.

The EC Performance Goal and the Extended Dry Period exception included in the Preferred Alternative are advanced in recognition of the existing AGR and potential MUN beneficial uses that must be supported for the water diverted from Reach 83, as well as the seasonal and annual hydrologic conditions that affect both the quantity and quality of the water in the LSJR. The Performance Goal will be used to measure progress toward achievement of EC levels during the irrigation season of non-Extended Dry Periods when EC levels lower than the EC WQO would be beneficial to agriculture and, based on WARMF modeling are considered achievable. The Extended Dry Period exception exists to allow discharges to the LSJR to occur under hydrologic conditions (e.g., low flows and elevated EC levels) when it is anticipated that agriculture may value water availability over then current water quality. A detailed discussion of the project alternatives considered, including the Preferred Alternative, is provided in Development of a

[6] The Performance Goal will be used to measure progress towards achievement of EC levels during certain water year types and times of the year that are of higher water quality than the proposed EC WQO for Reach 83 of the LSJR.

Basin Plan Amendment for Salt and Boron in the Lower San Joaquin River (LSJR): Task 4 – Implementation Planning for Proposed Salinity Objectives (LWA 2015a).

ECONOMIC CONSIDERATIONS OF PROPOSED EC WQO FOR REACH 83

Economic Considerations for Alternative 1 (No Action Alternative)

A decision not to implement a WQO for EC in Reach 83 of the LSJR may eventually require POTWs to implement additional salinity control measures for their discharges to the LSJR as a means to assist in the meeting of San Joaquin River at Vernalis EC objectives. POTW salinity load reductions to the LSJR have been achieved through acquisition of a new source water supply and other source control measures; other implementation measures such as reverse osmosis (RO) treatment and/or removal of discharges to the LSJR could be needed to reliably meet the Vernalis objectives at the end-of-pipe. The costs of such additional salinity load reduction strategies beyond those that have already been taken by the Cities of Modesto and Turlock have not been estimated as part of this analysis. The discussion of economic considerations for Alternative 4 does, however, include cost estimates for the Cities of Modesto and Turlock related to annual salinity control program costs and other existing salinity control projects.

Economic Considerations for Alternative 2

The only difference between Project Alternatives #2 and #4 is the inclusion of a 1,350 µmhos/cm EC Performance Goal in the latter alternative. As such, the economic considerations for Alternative #2 are the same as those described below for Alternative #4.

Economic Considerations for Alternative 4 (Preferred Alternative)

Based on WARMF modeling results, the 1,550 µmhos/cm EC WQO associated with Project Alternative #4 (Preferred Alternative) is expected to reliably be met at Crows Landing with implementation of a small number of planned implementation actions that were modeled for the Preferred Alternative (Planned Bundle). The implementation actions included in the Preferred Alternative are listed in **Table 3**, and described in detail in the Task 4 Report (Section 3; LWA 2015a). The implementation action expected to provide the most significant salinity load reductions to Reach 83 of the LSJR based on WARMF modeling is the completion of the Grassland Bypass Project (GBP). The GBP was initiated in 1995 and is scheduled to be completed at the end of 2019.

Planned salinity management actions for POTWs under this alternative included an analysis of a 3% load reduction over current levels of salinity discharges. The analysis was neither a projection of expected reductions nor a statement of future reductions that should be required. Current effluent data trends from the Cities of Modesto and Turlock indicate that neither POTW may be able to reliably comply in the future with the proposed EC WQO and Performance Goal if applied as end-of-pipe effluent limits, as a result of conservation mandates or restrictions on surface water diversions, even with the extensive source control efforts that have been implemented by both cities. Appendix D of the Task 4 Report (LWA 2015a) was prepared to provide an assessment of the overall contribution of these two POTWs to EC in Reach 83 of the LSJR. Appendix D provides recommended considerations that should be used in future permitting decisions to implement permit limits that would still result in compliance with the proposed EC WQO in Reach 83. It is anticipated that implementation of these considerations in the NPDES permitting process would not require significant new salinity control efforts by these POTWs. Therefore, the cost of such additional salinity load reduction strategies have not been estimated as part of this analysis.

The evaluation of compliance with a potential 1,550 µmhos/cm EC objective in Reach 83 is proposed to be accomplished by using water quality data collected at Crows Landing and Maze Road Bridge under existing monitoring programs. Thus, no additional costs are anticipated for a monitoring and surveillance program needed to track compliance with an EC WQO in Reach 83, as described in the Task 6 Memorandum (LWA 2015b). However, because the long-term funding of existing LSJR water quality monitoring programs is unknown, a need could arise in the future to fund water quality monitoring at Crows Landing and Maze Road Bridge specifically to evaluate compliance with Reach 83 WQOs. Furthermore, future monitoring efforts could reveal that additional monitoring, either in location or frequency, is needed to adequately evaluate compliance with Reach 83 WQOs. These future, potential monitoring activities are estimated to require an annual budget of approximately $111,000[7] to accomplish all data collection, instrument maintenance, quality assurance and quality control (QA/QC), data analysis, and report preparation collectively performed by the existing monitoring programs operating in the LSJR.

While the Planned Bundle included controlled timing of salinity discharges as one of its implementation actions, apart from the consideration of two tailwater recovery projects in the project area, controlled timing of salinity discharges as directed by a future Real-Time Management Program was not modeled in WARMF and did not affect modeled EC concentrations estimated in Reach 83 with implementation of the Planned Bundle. To this end, the $110,000 cost estimate for a monitoring and surveillance program noted above does not consider the costs of a cyberinfrastructure, coordination among participating stakeholders, or the forecasting of water quality conditions that will dictate when timed salinity discharges can or cannot occur under a Real-Time Management Program. It should be noted that implementation of the proposed EC WQO in Reach 83 will require coordination with the existing Real-Time Management Program. That program will ultimately include a cyberinfrastructure, salt assimilative capacity forecasting, and data dissemination activities – none of which are fully in place or funded at this time. Currently, the United States Bureau of Reclamation, the California Department of Water Resources, and Basin stakeholders are collectively spending in excess of $1,000,000 annually to begin development of the necessary cyberinfrastructure for the Real-Time Management Program. It is anticipated that this level of annual funding, if not greater, from these same stakeholder entities will be required on an ongoing basis to support the Real-Time Management Program.

All of the implementation actions included in **Table 3**, with the exception of 2c and 3a, are planned to occur in the project area during the next 5 – 10 years and implementation of the proposed EC WQO and Performance Goal are not expected to result in additional control facilities or actions, and are not expected to result in increased costs to parties in the basin. As such, there are no anticipated *additional* costs to the primary discharge sectors, POTWs and

[7] Monitoring and reporting costs were developed in consideration of EC and boron monitoring at Crows Landing Bridge and EC monitoring at Maze Road (see Appendix A).

agriculture[8], within the LSJR basin if the proposed EC WQO and Performance Goal are adopted and implemented.

Table 3: Implementation Actions to Manage/Reduce Salinity in Reach 83 of the Lower San Joaquin River included in the Preferred Alternative (Planned Bundle).

Implementation Action	Assumption
1. Controlled Timing of Salinity Discharges	Some irrigation districts in the Northwest and Grassland Drainage Area subareas, through the use of existing facilities, have the capability to withhold some of the discharge of saline drainage to the LSJR depending on water year. It is also assumed that small riparian areas would not hold back their discharges.
2c. Reduce Point Sources	In the analysis, a 3% reduction in POTW loads from the cities of Modesto and Turlock is modeled. This is neither a projection of expected reductions nor a statement on future reductions that should be required.
3a. Reduce Nonpoint Sources	In the analysis, a 10% reduction in the application of nitrogen-based fertilizers in select subareas is modeled. No change in the type or formulation of fertilizer is assumed. This is neither a projection of expected reductions nor a statement on future reductions that should be required.
8b. Water Conservation – Optimize Existing Irrigation Efficiency	It is assumed that any water conserved by an irrigation district or individual grower will be used by the entity who conserved the water or will be sold to another entity in the project area who will use the water. It is also assumed that any incremental decreases in salt loading to the LSJR will be small and will result in insignificant changes in ambient river concentrations.
9a. Installation of New High Efficiency Irrigation and Delivery Systems	Same assumption as 8b.
10b. Sequential Reuse and Volume Reduction – Salt Accumulation Area	There currently exists one salt accumulation area project in the project area as represented by the Grassland Bypass Project.
12a. Drainage Water Recirculation – Tailwater Recovery	Tailwater from planned tailwater recovery projects can be blended with irrigation supply to result in a reduction in tailwater discharge and usage of fresh irrigation supply water.
12b. Drainage Water Recirculation – Tilewater Recovery	Tilewater from planned tilewater recovery projects can be blended with irrigation supply to result in a reduction in tilewater discharge and usage of fresh irrigation supply water.

In the interest of documenting the costs associated with implementation of the various salinity control actions included as part of the Preferred Alternative (Planned Bundle) and planned to occur in the project area during the next 5 – 10 years, project stakeholders were contacted and asked to provide planning level cost estimates for those implementation actions amenable to cost estimate development. The cost of Implementation Action 8b (Water Conservation – Optimize

[8] Although Industrial Process Supply (PROC) is listed as a beneficial use of LSJR Reach 83, there are currently no uses or diversions of Reach 83 for industrial process supply. In addition, there are no known plans to develop new PROC uses along the river and there are no water right permits or applications pending for industrial process supply use. PROC is not likely to be a use in the future other than incidental use during agriculture field harvest activities.

Existing Irrigation Efficiency; see **Table 3**) was not estimated due to the complexity and information requirements needed to perform such a calculation. The cost of Implementation Action 12b (Drainage Water Recirculation – Tilewater Recovery; see **Table 3**) was not estimated because no tilewater recovery projects were identified in the project area for consideration in the WARMF modeling effort. The estimated planning levels costs of the implementation actions included in the Planned Bundle are provided in

Table 4.

Economic Considerations for Alternative 6

Among the four potential project alternatives selected by the LSJRC for consideration in the Basin Planning process, Project Alternative #6 (1,010 µmhos/cm) was the only alternative considered that would require new salinity control measures to attain the water quality objective.

Project Alternative #6 would require the construction and operation of a desalination facility in the Grassland Drainage Area in order to meet a 1,010 µmhos/cm EC objective at Crows Landing. This would result in significant, additional costs to the discharge sectors. The planning level cost analysis of Alternative #6 estimates the conceptual desalination facility total project cost at $900 million, the annual operations and maintenance cost at $16.1 million, and the 30-year life-cycle cost at $1.15 billion (see **Attachment B**). The economic analysis provided for Alternative #6 acts as an evaluation of the costs of an alternative salinity WQO. While the LSJRC has not discussed how such a desalination project would be funded if it were ever to be built, some level of cost-sharing between those entities that discharge to the LSJR, including POTWs, would likely be necessary.

Reverse osmosis (RO) at individual POTW facilities was not considered as part of the Planned Plus Maximum Treatment Focus Alternative as a means for POTWs to meet the 1,010 µmhos/cm EC objective as end-of-pipe effluent limits. Under Alternative #6, POTWs would either require a means to establish attainable effluent limits in implementing a 1,010 µmhos/cm EC objective, similar to the POTW permitting considerations provided in Appendix D of the Task 4 Report (LWA 2015a), or would be required to implement other compliance strategies including RO treatment, improvements to remove discharges from the LSJR on a year-round basis, or development of a specific pollutant trading program.

Similar to the discussion provided for the Preferred Alternative, evaluation of compliance with a potential 1,010 µmhos/cm EC objective in Reach 83 is proposed to be accomplished by using water quality data collected at Crows Landing and Maze Road Bridge by existing monitoring programs. The cost of any future monitoring that may be required to augment those water quality data collected by existing programs is unknown and thus, not included as part of this analysis. However, it is estimated that a single monitoring and surveillance program would require an annual budget of approximately $110,000 to accomplish all data collection, instrument maintenance, QA/QC, data analysis, and report preparation collectively performed by the existing monitoring programs operating in the LSJR.

Table 4: Cost Estimates of Specific Implementation Actions included in the Preferred Alternative (Planned Bundle).

<table>
<tr><th rowspan="2">Implementation Action</th><th rowspan="2">Cost Basis</th><th colspan="2">Cost Estimate</th></tr>
<tr><th>Annual Cost</th><th>Capital Cost</th></tr>
<tr><td>1. Controlled Timing of Salinity Discharges</td><td>Addressed under Implementation Action 12a as cost of tailwater recovery projects</td><td colspan="2">See 12a</td></tr>
<tr><td rowspan="4">2c. Reduce Point Sources</td><td>City of Modesto – Pretreatment Program costs^</td><td>$964,989[(1)]</td><td>-----</td></tr>
<tr><td>City of Modesto – Surface Water Expansion Projects: Phase 1 (top est.) and Phase 2 (bottom est.)</td><td></td><td>$105,000,000[(2)]
$113,000,000[(2)]</td></tr>
<tr><td>City of Turlock – Pretreatment Program costs^</td><td>$20,000[(3)]</td><td>-----</td></tr>
<tr><td>City of Turlock – Surface Water Supply Diversification Project</td><td>$1,350,000[(3)]</td><td>$89,000,000[(3)]</td></tr>
<tr><td>3a. Reduce Nonpoint Sources</td><td>In the analysis, 10% reduction in the application of nitrogen-based fertilizers in the Northwest, East Valley Floor, and Grassland Drainage Area subareas was modeled. (Implementation action would result in a cost savings and hence, a negative number is shown at right)</td><td>-$14,200,000[(4)]</td><td>-----</td></tr>
<tr><td>9a. Installation of New High Efficiency Irrigation and Delivery Systems</td><td>Retrofitting of existing irrigation systems with high efficiency systems (drip or microspray) in the Northwest, East Valley Floor, and Grassland Drainage Area subareas (includes cotton^)</td><td>$9,600,000[(4)]

$21,500,000^[(4)]</td><td>$26,800,000[(4)]

$59,700,000^[(4)]</td></tr>
<tr><td>10b. Sequential Reuse and Volume Reduction – Salt Accumulation Area</td><td>Total cost of Grassland Bypass Project (completion by December 2019; see Attachment A for cost itemization)</td><td>-----</td><td>$136,388,129[(5)]</td></tr>
<tr><td rowspan="2">12a. Drainage Water Recirculation – Tailwater Recovery</td><td>Patterson Irrigation District – Two Drains Project (cost range provided)</td><td>-----</td><td>$4,200,000 –
$4,300,000[(6)]</td></tr>
<tr><td>Grassland Water District – North Grasslands Water Conservation and Water Quality Control Project</td><td>-----</td><td>$7,000,000[(7)]</td></tr>
<tr><td>Monitoring and Surveillance Program</td><td>Compliance Monitoring and Surveillance Program costs</td><td>$111,000[(8)]</td><td>-----</td></tr>
<tr><td>Real-Time Management Program</td><td>Cost to maintain cyberinfrastructure, salt assimilative capacity forecasting, and data dissemination activities</td><td>$1,000,000[(9)]</td><td></td></tr>
</table>

Notes:

^ Implementation of POTW Pretreatment Programs/Salinity Management Plans is what was assumed to provide a possible 3% reduction in POTW salinity loads in the Planned Bundle.

Cost estimates provided by:

1. City of Modesto Annual Compliance Report for Conductivity, August 5, 2015.

2. Thomas Sinclair, Environmental Regulatory Compliance Manager, City of Modesto, Utilities Department Wastewater Division, August 26, 2015.

3. Dan Madden, City of Turlock, Municipal Services Water Quality Control Division, August 18, 2015.

4. Mark J. Roberson, PhD, CPSS, Senior Soil & Water Scientist, Formation Environmental, August 26, 2015 (see Attachment A for additional information).

5. David Cory, San Joaquin Valley Drainage Authority, July 24, 2015 (see Attachment A for additional information).

6. Peter Rietkerk, P.E., General Manager, Patterson Irrigation District, August 18, 2015.

7. Ken Swanson, P.E., District Engineer, Grassland Water District, August 4, 2015 (see Attachment A for additional information).

8. Brian Laurenson, P.E., Vice President, Larry Walker Associates, July 13, 2015.

9. Nigel W.T. Quinn, PhD, P.E., D.WRE, F.ASCE Research Group Leader, Lawrence Berkeley National Laboratory/US Bureau of Reclamation, September 10, 2015.

REFERENCES

Larry Walker Associates (LWA). 2015a. *Task 4 – Implementation Planning for Proposed Salinity Objectives.* Final Report. Prepared for San Joaquin Valley Drainage Authority. Submitted by Larry Walker Associates, in association with Systech Water Resources, Carollo Engineers, and PlanTierra. October 5, 2015.

Larry Walker Associates (LWA). 2015b. *Task 6 – Long-term Monitoring and Reporting Program.* Final Report. Prepared for San Joaquin Valley Drainage Authority. Submitted by Larry Walker Associates, in association with Systech Water Resources. October 5, 2015.

State Water Resources Control Board (SWRCB). 2000. *Water Right Decision 1641, Implementation of Water Quality Objectives for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*, Revised. Sacramento (CA): State Water Resources Control Board. March.

Attachment A: Supplemental Information Related to Cost Estimates for Specific Implementation Actions Included in the Preferred Alternative (Planned Bundle)

Estimated Annual Cost of Monitoring and Surveillance Program for Lower San Joaquin River Reach 83
Related to Compliance Assessment for Proposed Electrical Conductivity Water Quality Objective and Performance Goal

Task	Labor	Direct	Laboratory	Total	Notes
Preparation & Installation	$ 9,840	$ 32,000	$ 200	$ 42,040	Purchase of two sensors with telemetry
Monthly Maintenance & Sample Collection	$ 23,520	$ 1,800	$ 2,250	$ 27,570	Boron sample collection and sensor calibration
Data Review and Compilation	$ 29,520	$ 100	$ -	$ 29,620	
Annual Report	$ 12,000	$ 100	$ -	$ 12,100	
TOTAL	$ 74,880	$ 34,000	$ 2,450	**$ 111,330**	

Labor rate assumptions:
Field Engineer @ $150/hr
Field Technician @ $100/hr
Monitoring Manager @ $180/hr

Cost estimate developed by Brian Laurenson, P.E., Larry Walker Associates, July 13, 2015.

Nitrogen Application Rate for Sub Areas Used in WARMF Baseline Modeling

Fertilizer Category	lb/day	10% Reduction (lb/day)	Annual Reduction (Tons)/year
Ammonia as N	494,640	49,464	9,027
Nitrate as N	23,767	2,377	434
Total	518,407	51,841	9,461

Fertilizer Formulation	Ammonia	Nitrate	Urea	Cost/Ton	Nitrogen Compound	Local Use	Cost Portion
	%	%		$	$/Ton	%	$/ton
Anhydrous	82			750	915	10	91
UN32	7.6	7.6	16.8	500	1,563	85	1,328
Am-Nitrate 34-0-0	17	17		550	1,618	5	81
							1,500

Cost Reduction Estimate

Fertilizer Category	$/year
Ammonia as N	13,545,020
Nitrate as N	650,826
Total	14,195,846

Annual cost savings as presented in Table 4 of Task 5 Memo ($14,200,000)

Cost estimate developed by Mark J. Roberson, PhD, CPSS, Senior Soil & Water Scientist, Formation Environmental, August 26, 2015.

Assumptions used in the estimation of costs to install and operate drip/microspray irrigation in portions of select subareas currently not irrigated by this method (cotton NOT included)

Total Acreage with Drip Potential

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Acreage			
Almonds & Pistachios		3	0	0	3
Cotton		0	0	0	0
Cucurbits		16	0	0	16
Orchard (Other Deciduous)		22,172	32,492	73,496	128,160
Olives, citrus, and subtropicals (Subtropical Trees)		306	436	2	744
Vineyard		1,142	1,086	5,868	8,096
Total		23,639	34,014	79,366	137,019

Existing Drip/micro

	Portion Drip/Micro	Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro	%	Acreage			
Almonds & Pistachios	62%	2	0	0	2
Cotton	0%	0	0	0	0
Cucurbits	25%	4	0	0	4
Orchard (Other Deciduous)	38%	8,513	12,475	28,218	49,206
Olives, citrus, and subtropicals (Subtropical Trees)	3%	10	14	0	25
Vineyard	95%	1,086	1,032	5,577	7,695
Total		9,614	13,522	33,796	56,932

2014 DWR Prop 84 acres (proportional to existing)

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Acreage			
Almonds & Pistachios		0	0	0	0
Cotton		0	0	0	0
Cucurbits		0	0	0	0
Orchard (Other Deciduous)		791	1,159	2,621	3,953
Olives, citrus, and subtropicals (Subtropical Trees)		1	1	0	2
Vineyard		Prop 84 not applied to vineyard			
Total		792	1,160	2,621	4,574

Existing Plus DWR Prop 84 acres

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Acreage			
Almonds & Pistachios		2	0	0	2
Cotton		0	0	0	0
Cucurbits		4	0	0	4
Orchard (Other Deciduous)		9,304	13,634	30,840	53,778
Olives, citrus, and subtropicals (Subtropical Trees)		11	16	0	27
Vineyard		1,086	1,032	5,577	7,695
Total		10,407	14,682	36,417	61,506

Assumptions used in the estimation of costs to install and operate drip/microspray irrigation

in portions of select subareas currently not irrigated by this method (cotton NOT included)

Additional Potential Acreage (assumes all acreage goes to 100%)

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Acreage			
Almonds & Pistachios		1	0	0	1
Cotton		0	0	0	0
Cucurbits		12	0	0	12
Orchard (Other Deciduous)		12,868	18,858	42,656	74,382
Olives, citrus, and subtropicals (Subtropical Trees)		295	420	2	717
Vineyard		57	54	290	401
Total		13,233	19,332	42,949	75,513

Capital Cost (Based on Prop 84 capital, over seven year life)	355	$/acre/year
O&M Cost (Irrigated Lands Regulatory Program PEIS)	128	$/acre/year
Total Annual Cost/Acre	483	$/acre/year

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Cost/Year			
Almonds & Pistachios		$ 439	$ -	$ -	$ 439
Cotton		$ -	$ -	$ -	$ -
Cucurbits		$ 5,685	$ -	$ -	$ 5,685
Orchard (Other Deciduous)		$ 6,213,833	$ 9,106,019	$ 20,597,583	$ 35,917,436
Olives, citrus, and subtropicals (Subtropical Trees)		$ 142,414	$ 202,759	$ 1,041	$ 346,213
Vineyard		$ 27,296	$ 25,953	$ 140,235	$ 193,485
Total		$ 6,389,667	$ 9,334,731	$ 20,738,860	$ 36,463,258

Annual O&M cost as presented in Table 4 of Task 5 Memo	$ 9,600,000
Capital cost as presented in Table 4 of Task 5 Memo	$ 26,800,000

Cost estimate developed by Mark J. Roberson, PhD, CPSS, Senior Soil & Water Scientist, Formation Environmental, August 26, 2015.

Assumptions used in the estimation of costs to install and operate drip/microspray irrigation in portions of select subareas currently not irrigated by this method (cotton included)

Total Acreage with Drip Potential

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Acreage			
Almonds & Pistachios		3	0	0	3
Cotton		92,562	16	0	92,578
Cucurbits		16	0	0	16
Orchard (Other Deciduous)		22,172	32,492	73,496	128,160
Olives, citrus, and subtropicals (Subtropical Trees)		306	436	2	744
Vineyard		1,142	1,086	5,868	8,096
Total		116,201	34,029	79,366	229,596

Existing Drip/micro

	Portion Drip/Micro	Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro	%	Acreage			
Almonds & Pistachios	62%	2	0	0	2
Cotton	0%	0	0	0	0
Cucurbits	25%	4	0	0	4
Orchard (Other Deciduous)	38%	8,513	12,475	28,218	49,206
Olives, citrus, and subtropicals (Subtropical Trees)	3%	10	14	0	25
Vineyard	95%	1,086	1,032	5,577	7,695
Total		9,614	13,522	33,796	56,932

2014 DWR Prop 84 acres (proportional to existing)

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Acreage			
Almonds & Pistachios		0	0	0	0
Cotton		0	0	0	0
Cucurbits		0	0	0	0
Orchard (Other Deciduous)		791	1,159	2,621	3,953
Olives, citrus, and subtropicals (Subtropical Trees)		1	1	0	2
Vineyard		Prop 84 not applied to vineyard			
Total		792	1,160	2,621	4,574

Existing Plus DWR Prop 84 acres

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Acreage			
Almonds & Pistachios		2	0	0	2
Cotton		0	0	0	0
Cucurbits		4	0	0	4
Orchard (Other Deciduous)		9,304	13,634	30,840	53,778
Olives, citrus, and subtropicals (Subtropical Trees)		11	16	0	27
Vineyard		1,086	1,032	5,577	7,695
Total		10,407	14,682	36,417	61,506

Assumptions used in the estimation of costs to install and operate drip/microspray irrigation in portions of select subareas currently not irrigated by this method (cotton included)

Additional Potential Acreage (assumes all acreage goes to 100%)

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Acreage			
Almonds & Pistachios		1	0	0	1
Cotton		92,562	16	0	92,578
Cucurbits		12	0	0	12
Orchard (Other Deciduous)		12,868	18,858	42,656	74,382
Olives, citrus, and subtropicals (Subtropical Trees)		295	420	2	717
Vineyard		57	54	290	401
Total		105,795	19,347	42,949	168,090

Capital Cost (Based on Prop 84 capital, over seven year life) 355 $/acre/year
O&M Cost (Irrigated Lands Regulatory Program PEIS) 128 $/acre/year
Total Annual Cost/Acre 483 $/acre/year

		Grasslands	Northwest	East Valley Floor	Total
Crop categories amenable to drip/micro		Cost/Year			
Almonds & Pistachios		$ 439	$ -	$ -	$ 439
Cotton		$ 44,695,948	$ 7,571	$ -	$ 44,703,519
Cucurbits		$ 5,685	$ -	$ -	$ 5,685
Orchard (Other Deciduous)		$ 6,213,833	$ 9,106,019	$ 20,597,583	$ 35,917,436
Olives, citrus, and subtropicals (Subtropical Trees)		$ 142,414	$ 202,759	$ 1,041	$ 346,213
Vineyard		$ 27,296	$ 25,953	$ 140,235	$ 193,485
Total		$ 51,085,615	$ 9,342,302	$ 20,738,860	$ 81,166,776

Annual O&M cost as presented in Table 4 of Task 5 Memo	$ 21,500,000
Capital cost as presented in Table 4 of Task 5 Memo	$ 59,700,000

Cost estimate developed by Mark J. Roberson, PhD, CPSS, Senior Soil & Water Scientist, Formation Environmental, August 26, 2015.

Grassland Bypass Project

Project Funding from 1996 to 2015

Project	Funding Program	Funding Source	Grant Funding	Loan Funding	District Funding	Total
Grassland Bypass Construction	SWRCB State Revolving Fund	California		$ 600,000		$ 600,000
Charleston D.D. Recirculation System	SWRCB State Revolving Fund	California		$ 320,000		$ 320,000
Charleston D.D. Recirculation System : CH-3					$ 71,200	$ 71,200
Firebaugh Canal W.D. Recirculation Systems					$ 271,100	$ 271,100
Pacheco W.D. Drainwater Recirculation System	SWRCB State Revolving Fund	California		$ 1,375,000		$ 1,375,000
Panoche W.D. Drainwater Recirculation System	SWRCB State Revolving Fund	California		$ 4,228,000		$ 4,228,000
Panoche D.D. Road Watering Project	Panoche D.D.	District			$ 12,000	$ 12,000
Reuse Land Purchase & Initial Development	Prop 13 (Directed Action)	California	$ 17,500,000			$ 17,500,000
2004-05 Development Project	USBR	Federal	$ 970,000		$ 95,900	$ 1,065,900
GBP Operational Budget (FY 97 - FY 16)	Grassland Area Farmers	District			$ 18,373,156	$ 18,373,156
Halophyte Development Project	USBR	Federal	$ 290,000		$ 15,000	$ 305,000
Grassland Integrated Drainage Management Proj.	Prop 13	California	$ 987,200		$ 246,800	$ 1,234,000
PE-5 Pump Station	Panoche D.D.	District			$ 13,200	$ 13,200
Panoche D.D. SJRIP Reuse Development Project	SWRCB - Prop 50	California	$ 389,500		94,800	$ 484,300
SJRIP Reuse Expansion Project	USBR	Federal	$ 890,000			$ 890,000
USBR 1.65 Appropriations	USBR	Federal	$ 1,650,000			$ 1,650,000
USBR/CalFed Salinity Management Grant (2007/2008)	USBR	Federal	$ 7,000,000			$ 7,000,000
USBR/CalFed Salinity Management Grant (2009)	USBR	Federal	$ 6,384,719			$ 6,384,719
IRWM Grant: Reuse Land Purchase	SWRCB - Prop 50	California	$ 10,915,870			$ 10,915,870
IRWM Grant: Reuse Land Development	SWRCB - Prop 50	California	$ 3,628,000			$ 3,628,000
SJRIP Operations (FY 02 through FY 15)	Grassland Area Farmers	District			$ 6,000,000	$ 6,000,000
USBR SJR Salinity Management Program 2010	USBR	Federal	$ 4,000,000			$ 4,000,000
USBR SJR Salinity Management Program 2011	USBR	Federal	$ 4,245,000			$ 4,245,000
USBR SJR Salinity Management Program 2012	USBR	Federal	$ 4,200,000			$ 4,200,000
USBR SJR Salinity Management Program 2013	USBR	Federal	$ 3,900,000			$ 3,900,000
USBR SJR Salinity Management Program 2014	USBR	Federal	$ 3,800,000			$ 3,800,000
Algal-Bacterial Selenium Reduction Proj. (ABSR)	USBR/DWR/CalFed	Fed/Calif.	$ 3,352,000		$ 225,000	$ 3,577,000
IRWM Grant: Salt Disposal Development	SWRCB - Prop 50	California	$ 4,600,000			$ 4,600,000
Panoche W.D. Ag Drainage Loan Project - Irri. Imprvmnts	SWRCB	California		$ 1,800,000		$ 1,800,000
Pacheco W.D. Acquisition of Improved Irrigation Equipment	SWRCB State Revolving Fund	California		$ 737,500		$ 737,500
Panoche D.D. Acquisition of Improved Irrigation Equipment	SWRCB State Revolving Fund	California		$ 4,997,294		$ 4,997,294
Firebaugh Canal W.D. Irrigation Improvement Funding Prg.	Firebaugh Canal W.D.	District			$ 8,600,000	$ 8,600,000
Firebaugh Canal W.D. Irrigation Improvement Funding Prg.	SWRCB State Revolving Fund	California		$ 1,000,000		$ 1,000,000
IRWM Grant: Ground Water Pumping	SWRCB - Prop 50	California	$ 5,702,000		$ 457,890	$ 6,159,890
Distribution Facilities Improvement Grant	SWRCB - Prop 40/50	California	$ 1,000,000			$ 1,000,000
Firebaugh Canal W.D. Canal Lining Projects	Firebaugh Canal W.D./USBR	Federal/District	$ 300,000		$ 945,000	$ 1,245,000
Firebaugh Canal W.D. Shaw Avenue Pipeline	Firebaugh Canal W.D.	District			$ 205,000	$ 205,000
Total:			**$ 85,704,289**	**$ 15,057,794**	**$ 35,626,046**	**$ 136,388,129**

IRWM: Integrated Regional Water Management Program, California Proposition 50.

Local Funding:	$ 35,626,046
State Funding (Grant)	$ 46,398,570
State Funding (Loan)	$ 15,057,794
Federal Funding (Grant)	$ 39,305,719
	$ 136,388,129

Grassland Water District
North Grasslands Water Conservation and Water Quality Control Project

Project Purpose

The purpose of the North Grasslands Water Conservation and Water Quality Control Project (Project) is to develop additional water supply that will assist the Grasslands Water District (GWD or District) in meeting unmet demand for water within the Grassland Resource Conservation District (GRCD). The Project when completed will capture high quality maintenance flows from managed wetlands during fall and early winter in the northern portion of the District's water conveyance system. The recovered water will be returned into the conveyance system to meet a portion of fall and winter demand, effectively conserving a block of the District's external annual water supply for use during the spring and summer to offset a portion of the Incremental Level 4 water supply shortfall from the U.S. Bureau of Reclamation (Reclamation).

Background and Schedule

A Project Feasibility Assessment Report was prepared by GWD in accordance with their Cooperative Agreement with Reclamation as part of the first phase of the Project. GWD is nearing completion of Phase 2 of the Project which includes preparation of environmental compliance documents and design of Project facilities. GWD is preparing a CEQA document that is scheduled to be released for public review in 2015. The design of Project facilities will be completed once the CEQA document is adopted by the District. Phase 3 includes the construction of Project facilities that is scheduled to begin in May 2016 with Project operations beginning in September 2017.

Project Description

The Project will collect available water from Los Banos Creek at the confluence with Garzas Creek and from Eagle Ditch, Mud Slough-North (Mud Slough), Fremont Ditch, and maintenance flows from the privately managed wetlands along Gun Club Road. The recovered water will be returned via open channel and pipeline conveyance to the Santa Fe Canal for delivery by GWD to a portion of the northern GRCD. The major features of the Project include improvement to two GWD ditches and the construction of four pipelines, two or three pump stations, and various water control structures to capture water that would otherwise exit the District and return it to the conveyance system to meet a portion of the District's demands. The Project will typically begin operating in mid-September during wetland flood-up and finish operating in mid-February the following year.

Project Benefits

In addition to the improved water supply the Project will also create supplemental benefits such as improved operational flexibility in the GWD conveyance system and improved ability to manage water, including drawdown of wetlands and discharges to the San Joaquin River and reduction in operational spills. The Project will also include habitat improvements to be implemented as part of the proposed Project mitigation measures as well as construction of additional real-time monitoring stations. These monitoring stations will improve the ability of the District to use the sensor network to characterize the quality and quantity of water entering and leaving the wetland complex while providing decision support to optimize water quality and water use efficiency.

Project Yield and Costs

Project operations and therefore the amount of developed water will vary from year to year depending on the Level 2 water allocation, rainfall patterns and management of storm water flows in the GWD conveyance system. It is estimated that the volume of developed water will range from approximately 11,700 acre-feet (AF) to 16,000 AF in years with 100 percent Level 2 water supply and as low as 5,200 AF in years with reduced Level 2 water supply (75 percent allocation). Based on the historical reliability of Level 2 water supplies, it is estimated that the annual yield of the Project will be approximately 15,000 AF. The estimated capital cost for construction, including construction management, legal and administrative costs is approximately $7 million.

Attachment B: Cost Estimate for Preliminary Conceptual Desalination Project

LARRY WALKER ASSOCIATES

DEVELOPMENT OF A BASIN PLAN AMENDMENT FOR SALT AND BORON FOR THE LOWER SAN JOAQUIN RIVER

TASK 5 – ECONOMIC ANALYSIS: COST ESTIMATE FOR PRELIMINARY CONCEPTUAL DESALINATION PROJECT (PROJECT ALTERNATIVE # 6)

July 13, 2015

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1.0 PURPOSE

The purpose of this document is to:

1. Describe the preliminary concept for a regional desalination facility designed to control salinity inputs to Reach 83 of the Lower San Joaquin River (LSJR) to a level that would support the achievement of a potential salinity water quality objective (WQO) of 1,010 µmhos/cm EC as measured in the LSJR at Crows Landing.
2. Provide a planning level cost estimate for implementing the project.
3. Provide an estimate of the greenhouse gas emissions resulting from the operation of the facility.

The regional desalination facility is identified as potential Implementation Action 5a in Table 1 of the Report entitled "Task No. 4 – Implementation Planning for Proposed Salinity Objectives," (LWA, 2015). In addition, through the work conducted by the Lower San Joaquin River Committee (LSJRC) and its consultants, this potential implementation action was identified as a salinity management alternative ("Planned Plus Maximum Treatment Focus Alternative"[1]) that was modeled to determine if the diversion and treatment of agricultural drainage flows from upstream of Reach 83, followed by the discharge of treated, low total dissolved solids (TDS) water just downstream of the diversion points, could result in the achievement of a potential salinity WQO of 1,010 µmhos/cm EC as measured in the LSJR at Crows Landing[2].

The Maximum Treatment Alternative is considered a preliminary conceptual project at this planning level stage of analysis. The desalination facility, which is the major component of the Alternative, would pump all drainage water from three sources, Mud Slough, Salt Slough, and the Gustine Area, at two diversion points to a proposed 160 million gallons per day (mgd) reverse osmosis (RO) treatment facility located in the Grassland Drainage Area, outside of the 100-year floodplain (see **Figure 1, Appendix A**). The two diversion points would be located along Mud Slough and Salt Slough just upstream of the confluence with the LSJR. The project would remove salts from the diverted flows using a RO process, and then pump low TDS water back to Mud Slough and Salt Slough immediately downstream of the initial diversion points. Approximately 20 percent of the flows removed from the three drainage sources would be lost in the concentrated brine produced by the RO process. This concentrated brine would then have to be pumped out of the basin for ultimate disposal to the ocean via a proposed Central Valley Brine Line[3] as described in the Strategic Salt Accumulation Land and Transportation Study (SSALTS) Draft Final Phase 2 Report – Development of Potential Salt Management Strategies (CDM Smith, 2014).

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[1] Section 3.3.2 of the Task 4 Report (LWA, 2015)
[2] Section 4.1 of the Task 4 Report (LWA, 2015)
[3] A proposed Central Valley Brine Line is one of several salt disposal/out of basin transport mechanisms considered by SSALTS (CDM Smith, 2014).

2.0 DESCRIPTION OF DESALINATION FACILITIES

The facilities required to achieve desalination of the Mud and Salt Slough inputs to the Lower San Joaquin River include two pump stations, pipelines, and a RO treatment facility. The following major pipelines would be required:

- Raw water (feed to the RO treatment facility from the two drainage courses);
- Finished water return (low TDS product water from the RO treatment facility to the two drainage courses); and
- Concentrated brine (high TDS waste from the RO treatment facility).

A preliminary, planning level concept map of pipelines and facilities that would be needed is provided in **Figure 1** (**Appendix A)** and summarized in **Table 1**. The locations of the facilities and pipelines are shown for the purposes of developing the concept-level project to help inform and facilitate development of the treatment alternative, and are not intended to depict a fully developed alternative or recommendation. Development of the concept-level project did not include a comparison of siting options, facility siting or conveyance alternatives, field reconnaissance, considerations of environmental impacts or habitat impacts in affected waterways or lands, communication with land owners, etc.

Table 1 Estimated Capacities of Desalination Facilities
Cost Estimate for Preliminary Conceptual Desalination Project

Infrastructure Identification	Conceptual Capacity/Diameter	Conceptual Quantity
Desalination Facility	160 mgd(1)	100 acres
Raw Water Pipelines	84-inch	42,000 Linear Feet
Drainage Water Supply Lift Stations	160 mgd (each)	2 Lift Stations
Desalination Finished Water Pipelines	54 to 84-inch	40,000 Linear Feet
Desalination Concentrate Pipeline	42-inch	36,000 Linear Feet

(1) 160 mgd capacity is based on the peak flow to the desalination facility. On average, the desalination facility would treat 22 mgd.

2.1 Raw Water Conveyance

As shown in **Figure 1** (**Appendix A**), raw water would be pumped from two (2) pump stations: the Salt Slough Pump Station and Mud Slough Pump Station. The volume of raw water pumped would be determined by the mass of TDS removal needed upstream of Crows Landing in order to meet a potential EC WQO of 1,010 µmhos/cm as measured in LSJR at Crows Landing. The evaluation is based on the Watershed Analysis Risk Management Framework (WARMF) simulated results for Crows Landing generated from the Maximum Treatment Alternative modeling run, using a daily time step, and assumes that raw water would be pumped from each of the drainage courses with the following priority: Salt Slough then Mud Slough[4]. The daily flows and 30-day average TDS concentrations from the WARMF simulation for the drainage courses were used in this evaluation. It is important to note that on worst-case days (when highest TDS load reductions upstream of Crows Landing would be required), 100 percent of flow from both drainage courses would be pumped for treatment.

2.2 RO Treatment Facility

The raw water from the drainage courses would be desalinated in a RO treatment process. To operate an RO process effectively, the raw water requires pretreatment to remove particulate matter from the RO Feed. The planning level desalination process consists of coarse screening at each of the drainage course pump stations, fine screening at the treatment facility, followed by a coagulation/flocculation process, microfiltration, and RO. Ancillary facilities would include microfiltration backwash treatment, solids handling (from screening and microfiltration processes), and various chemical addition facilities including antiscalant, sulfuric acid, and lime.

Using baseline drainage water quality data for Salt Slough and Mud Slough included in the WARMF model and RO membrane modeling software, estimates for water recovery and salt rejection were made for the preliminary conceptual desalination project. The use of a standard brackish water RO membrane is assumed.

The preliminary estimates indicate that an 80-percent water recovery and 98-percent salt rejection could be achieved in the treatment facility. This indicates that, for every ten (10) gallons of water removed from the drainage courses, eight (8) gallons of low TDS product water would be returned and that for every ten (10) pounds of TDS removed from the drainage course, 9.8 pounds would be removed as brine. These estimated values for water recovery and salt rejection were then applied to the daily flow and TDS values provided in the WARMF simulation to estimate daily finished water flows and TDS returned to the LSJR. While the RO treatment process will remove TDS from the raw water pumped from Salt and Mud sloughs, constituents similar to boron will pass through the RO membrane (at a pH less than 9, boric acid has a neutral charge and is similar in size to water molecules).

The next step of this conceptual level analysis was to determine the required capacity of the treatment process. This was accomplished by using the Planned Alternative WARMF simulation results of the daily TDS loadings in excess of the potential EC WQO of 1,010 µmhos/cm that would need to be removed upstream of Crows Landing (LWA, 2015), and the estimated feed TDS concentration of the combined drainage courses to determine required daily treatment flows. The daily treatment flows were then used to estimate the maximum treatment flow required. A 30-day running average was calculated from the daily data to dampen the daily variation of flow and TDS in the drainage water to be treated.

[4] Section 4.1 of the Task 4 Report (LWA, 2015)

Using the WARMF simulated flow and TDS data from October 1995 to September 2013, it was determined that the desalination facility would need to have the capacity to treat 160 mgd of drainage water in order to reliably meet the potential EC WQO of 1,010 µmhos/cm during times when TDS load reductions upstream of Crows Landing are greatest. On average, it was estimated that the RO facility would treat 22 mgd. The conceptual desalination facility would be constructed as a modular system with the ability to bring modules online and offline, as needed, to treat flows necessary to meet the potential 1,010 µmhos/cm EC WQO. It should be noted that the RO facility would not be continuously operated, since, at times, the river meets the proposed EC objective without treatment. However, idling of facilities would be necessary when active treatment is not occurring, as a means to keep treatment processes operating as designed and available for treatment when required. The modular operation would increase the unit cost of the RO product due to the increased maintenance and membrane replacement costs of the 160 mgd facility.

2.3 Finished Water/Concentrate Conveyance

At the RO treatment facility, the raw water would be processed into two effluent streams: low TDS finished water (permeate) and high TDS concentrate. As shown on the concept map (**Figure 1, Appendix A**), the finished water pipeline would approximately follow the route of the raw water pipeline and discharge back into the two (2) drainage courses downstream of the intake locations on Salt Slough and Mud Slough. The concentrate pipeline would be routed west to discharge the concentrate waste into a proposed Central Valley Brine Line.

3.0 GREENHOUSE GAS EMISSION EVALUATION

The greenhouse gas (GHG) emissions estimate for this preliminary conceptual project is based on the estimated annual purchased energy consumption (40,000,000 kWh/year based on the annual average flow of 22 mgd) for the operation of the Salt Slough and Mud Slough pump stations and the RO treatment facility. The GHGs of concern at treatment plants include carbon dioxide (CO_2), and, to a lesser degree, methane (CH_4) and nitrous oxide (N_2O). Each of these can be emitted indirectly through the use of purchased electricity.

Emissions were converted into carbon dioxide equivalent (CO_2e) emissions. The major GHG in the atmosphere is CO_2. Other GHGs differ in their ability to absorb heat in the atmosphere. For example, CH_4 has 25 times the capacity to absorb heat relative to CO_2 over a hundred-year time horizon, so it is considered to have a global warming potential (GWP) of 25. N_2O has 298 times the capacity over a hundred-year time horizon and is given a GWP of 298. Therefore, a pound of emissions of CO_2 is not the same in terms of climatic impact as a pound of CH_4 or N_2O emitted. CO_2e emissions are calculated by multiplying the amount of emissions of a particular GHG by its GWP. These GWPs are taken from the Intergovernmental Panel on Climate Change Fourth Assessment Report (2007) for a 100-year time horizon. These GWPs are used today by international convention and the U.S. to maintain the value of the carbon dioxide “currency”, and are used in this evaluation to maintain consistency with international practice.

The GHG emissions resulting from the purchase of 40,000,000 kWh/year for the operation of the pump stations and the RO treatment facility would total 15,989 metric tons of CO_2e based on emission factors for the state of California. Because these are indirect emissions, they are not a regulated source and would not be reported to the State or EPA.

4.0 DESALINATION PROJECT COST ESTIMATE

Preliminary capital, operations and maintenance (O&M), and life-cycle costs were developed for the Preliminary Conceptual Desalination Project. The estimated costs are presented in the following sections.

4.1 Level of Accuracy

This cost estimate is considered a Class 5 (order-of-magnitude) estimate, as classified by the Association for the Advancement of Cost Engineering International. Class 5 cost estimates are suitable for concept screening. The expected accuracy range of a Class 5 estimate is within +50 percent and -30 percent.

4.2 Capital, O&M, and Life-Cycle Cost Assumptions

The assumptions used in the development of the Preliminary Conceptual Desalination Project capital and O&M costs are summarized in **Table 2**. The costs do not include any possible buy-in fees for the purchase of disposal capacity in a proposed Central Valley Brine line. However, due to the significant impact of residual management on annual O&M costs, estimates for concentrate disposal (salt removed from river) and solids hauling and disposal (solids removed from raw river water) have been included in the O&M estimate. These values were estimated based on typical costs for inland desalination facilities located in Southern California

Table 2 Capital, O&M, and Life-Cycle Cost Assumptions
Cost Estimate for Preliminary Conceptual Desalination Project

Parameter	Units	Value
Peak Flow to Treatment(1)	Mgd	160
Average Flow to Treatment(2)	mgd	22
Power	$/kWh	$0.125
Lime (slaked)	$/lb	$0.20
Sulfuric Acid	$/lb	$0.03
Scale Inhibitor	$/lb	$0.95
Membrane Elements - 8 inch diameter	$/element	$500.00
Membrane Elements - MF	$/element	$775.00
Cartridge Filters	$/filter	$12.00
Step 1 Cleaning Chemical Cost	$/lb	$2.82
Step 2 Cleaning Chemical Cost	$/lb	$3.16
Step 3 Cleaning Chemical Cost	$/lb	$2.00
Plant Operating Factor	-	0.98
O&M Inflation	%/year	0
Discount Rate	%/year	5
Term	years	30

(1) The peak flow was used to develop the Capital Costs.
(2) The average flow was used to develop the O&M Costs.

4.3 Capital Costs

The capital costs consist of all items that would be constructed/purchased for the Preliminary Conceptual Desalination Project. The direct cost of each process is based on the following:

- Vendor-quoted information.
- Cost curves based on historical costs from other projects.
- Typical planning level values.

The conceptual level capital costs are summarized in **Table 3**. Costs are based on 2015 dollars (20-City Engineering News-Record (ENR) Construction Cost Index, April 2015 - 9,992). Costs to purchase land for the facilities are not included.

Table 3 Capital Costs
Cost Estimate for Preliminary Conceptual Desalination Project

Component Description	Cost
Salt Slough Pump Station and Intake Structure	$22,000,000
Mud Sough Pump Station and Intake Structure	$22,000,000
Raw Water Pipelines	$30,300,000
MF/RO Desalination Facility(2)	$283,000,000
Desalination Finished Water Pipeline	$26,900,000
Desalination Concentrate Pipeline	$18,800,000
Total Direct Cost	**$403,000,000**
Project Level Allowance @ 50 percent	$201,500,000
Subtotal	**$604,500,000**
Sales Tax @ 9 percent(3)	$27,200,000
Subtotal	$631,700,000
Contractor General Conditions @ 6 percent	$37,900,000
Subtotal	**$669,600,000**
General Contractor Overhead and Profit @ 12 percent	$80,400,000
Total Estimated Construction Cost	**$750,000,000**
Engineering and Contract Administration @ 20 percent	**$150,000,000**
Total Estimated Project Cost	**$900,000,000**

(1) Capital costs are based on a peak capacity of 160 mgd.
(2) Conceptual facility design and cost estimate does not consider boron removal.
(3) Calculated assuming 50 percent of direct costs are taxable.

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers, Inc. have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices, or bidding strategies. Carollo Engineers, Inc. cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the costs presented as shown.

4.4 Operations and Maintenance Costs

O&M costs include the labor, utilities, chemicals, maintenance, membrane replacement, and brine disposal required to operate a MF/RO system. The conceptual level O&M costs are summarized in **Table 4**.

Table 4 O&M Costs
Cost Estimate for Preliminary Conceptual Desalination Project

Component Description		Cost
Total Power Cost ($/yr)		$4,900,000
Chemical Costs ($/yr)		$2,100,000
MF/RO Membrane Replacement Costs ($/yr)		$931,000
Cartridge Filter Costs ($/yr)		$51,000
Maintenance Costs ($/yr)		$1,300,000
Laboratory Costs ($/yr)		$50,000
Concentrate Disposal Costs ($/yr)		$4,600,000
Solids Hauling and Disposal Costs ($/yr)		$900,000
Labor Costs ($/yr)		$1,310,000
	Annual O&M Cost ($/yr):	**$16,100,000**
	Annual O&M Cost ($/kgal):	**$2.05**
	Annual O&M Cost ($/AF):	**$667**

(1) Due to the variability of EC in the LSJR, the RO treatment facility would not operate continuously. Flows could range from zero to 160 mgd when in operation. O&M costs are based on a yearly average flow of 22 mgd.

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers, Inc. have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices, or bidding strategies. Carollo Engineers, Inc. cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the costs presented as shown.

4.5 Life Cycle Costs

A life cycle cost analysis was performed for the Preliminary Conceptual Desalination Project. The life-cycle costs are based on a discount rate of 5 percent per year and the life-cycle period of 30 years. The life-cycle costs are summarized in **Table 5**.

Table 5 Life-Cycle Costs
Cost Estimate for Preliminary Conceptual Desalination Project

Component Description	Cost
Total Project Cost[(1)] ($)	$900,000,000
Annual O&M Cost[(2)] ($/yr)	$16,100,000
30-year Life-Cycle Cost ($)	$1,148,000,000

(1) Total Project costs are based on peak capacity of 160 mgd.
(2) O&M costs are based on an average flow of 22 mgd.

The cost estimate herein is based on our perception of current conditions at the project location. This estimate reflects our professional opinion of accurate costs at this time and is subject to change as the project design matures. Carollo Engineers, Inc. have no control over variances in the cost of labor, materials, equipment; nor services provided by others, contractor's means and methods of executing the work or of determining prices, competitive bidding or market conditions, practices, or bidding strategies. Carollo Engineers, Inc. cannot and does not warrant or guarantee that proposals, bids, or actual construction costs will not vary from the costs presented as shown.

5.0 REFERENCES

CDM Smith. 2014. Strategic Salt Accumulation Land and Transportation Study (SSALTS) Phase 2 – Development of Potential Salt Management Strategies. Draft Final Report. Prepared for San Joaquin Valley Drainage Authority. Submitted by CDM Smith. September 2014.

Larry Walker Associates (LWA) 2015. Task #4 – Implementation Planning for Proposed Salinity Objectives. Prepared for San Joaquin Valley Drainage Authority. Submitted by Larry Walker Associates, Inc., in association with Systech Water Resources, Carollo Engineers, and PlanTierra. July 2015.

APPENDIX A – CONCEPTUAL LAYOUT OF PROPOSED FACILITIES

Figure 1: Conceptual Layout of Proposed Facilities for Salinity Control - Planned Plus Maximum Treatment Focus Alternative